Marillana Tenement and Infrastructure Corridor

Targeted Vertebrate Fauna Survey

Biologic Environmental Survey

BHP Western Australian Iron Ore

June 19

MARILLANA TENEMENT AND INFRASTRUCTURE CORRIDOR TARGETED VERTEBRATE FAUNA SURVEY

DOCUMENT STATUS				
Revision No.	**Author**	**Review / Approved for Issue**	**Approved for Issue to**	
			Name	**Date**
1	B. Downing M. O'Connell	C. Knuckey M. O'Connell	T. Carroll	30/07/2018
2	B. Downing	C. Knuckey C. Brooks T. Rudin	T. Carroll	29/04/2019
3	B. Downing	C. Knuckey	T. Carroll	10/06/2019
4	B. Downing	C. Knuckey	T. Carroll	27/06/2019

"IMPORTANT NOTE"

Apart from fair dealing for the purposes of private study, research, criticism, or review as permitted under the Copyright Act, no part of this report, its attachments or appendices may be reproduced by any process without the written consent of Biologic Environmental Survey Pty Ltd ("Biologic"). All enquiries should be directed to Biologic.

We have prepared this report for the sole purposes of BHP Western Australian Iron Ore ("Client") for the specific purpose only for which it is supplied. This report is strictly limited to the Purpose and the facts and matters stated in it, and does not apply directly or indirectly and will not be used for any other application, purpose, use or matter.

In preparing this report we have made certain assumptions. We have assumed that all information and documents provided to us by the Client or as a result of a specific request or enquiry were complete, accurate and up-to-date. Where we have obtained information from a government register or database, we have assumed that the information is accurate. Where an assumption has been made, we have not made any independent investigations with respect to the matters the subject of that assumption. We are not aware of any reason why any of the assumptions are incorrect.

This report is presented without the assumption of a duty of care to any other person (other than the Client) ("Third Party"). The report may not contain sufficient information for the purposes of a Third Party or for other uses. Without the prior written consent of Biologic:

a) This report may not be relied on by a Third Party; and

b) Biologic will not be liable to a Third Party for any loss, damage, liability or claim arising out of or incidental to a Third Party publishing, using or relying on the facts, content, opinions or subject matter contained in this report.

If a Third Party uses or relies on the facts, content, opinions or subject matter contained in this report with or without the consent of Biologic, Biologic disclaims all risk and the Third Party assumes all risk and releases and indemnifies and agrees to keep indemnified Biologic from any loss, damage, claim or liability arising directly or indirectly from the use of or reliance on this report.

In this note, a reference to loss and damage includes past and prospective economic loss, loss of profits, damage to property, injury to any person (including death) costs and expenses incurred in taking measures to prevent, mitigate or rectify any harm, loss of opportunity, legal costs, compensation, interest and any other direct, indirect, consequential or financial or other loss.

TABLE OF CONTENTS

TABLES

FIGURES

APPENDICES

EXECUTIVE SUMMARY

BHP Western Australian Iron Ore (BHP WAIO) commissioned Biologic Environmental Survey (Biologic) to undertake a targeted vertebrate fauna survey (the Survey) within the Marillana exploration lease (M270SA) and the Marillana to Yandi corridor (hereafter referred to as the Study Area) to support potential future environmental approvals. The Study Area is located approximately 100 kilometers (km) north-west of Newman in the Pilbara region of Western Australia and covers an area of 13,993 hectares (ha).

The main objectives of this assessment were to assess the occurrence of fauna conservation significance as well as their supporting habitats within the Study Area. The target fauna species for the survey comprised the Night Parrot (*Pezoporus occidentalis*), Northern Quoll (*Dasyurus hallucatus*), Pilbara Leaf-nosed Bat (*Rhinonicteris aurantia*), Ghost Bat (*Macroderma gigas*), Pilbara Olive Python (*Liasis olivaceus barroni*), Northern Brushtail Possum (*Trichosurus vulpecula arnhemensis*), Peregrine Falcon (*Falco peregrinus*), Pilbara Flat-headed Blind-snake (*Anilios ganei*) and the Western Pebble Mound Mouse (*Pseudomys chapmani*).

A desktop assessment was undertaken prior to the field survey to provide extensive local data for the assessment; comprising 13 surveys that have been conducted within or overlapping the Study Area, and a further 12 fauna surveys that have been conducted within 10 km of the Study Area. The current survey, undertaken over two field trips (16th - 28th April and 29th May - 2nd of June 2018), comprised habitat assessments, targeted searches, ultrasonic and acoustic recordings, motion cameras and opportunistic observations.

Nine major fauna habitats were identified within the Study Area. Two of the habitats recorded in the Study Area were deemed to be of high value to fauna of conservation significance: Gorge/ Gully and Major Drainage Line. Twenty-two caves are known from within the Study Area, one of which (MARI12) is considered a potential maternity roost for the Ghost Bat. An additional nine caves are likely to provide habitat as diurnal roosts and feeding roosts for Ghost Bat. No caves were deemed likely to provide suitable roosting habitat for the Pilbara Leaf-nosed Bat. A total of 15 water features are known within the Study Area, two of which were discovered during the current survey.

To date, six of the targeted species have been recorded within the Study Area including:

- Northern Quoll: recorded on three occasions within the Study Area, including twice during the current survey. Suitable habitat is provided by the Gorge/ Gully habitats within the Study Area. Owing to the rarity of this species within the Hamersley Ranges and the low number of records within the Study Area, despite the large amount of survey effort, it is likely that records in the Study Area represent individuals on the periphery of a permanent population (as it expands and contracts over time) and/or dispersing from a permanent population elsewhere, such as Koodaideri.
- Ghost Bat: recorded at 13 locations within the Study Area. During the current survey, 50 Ghost Bat scats were observed on sheet at MARI12. Suitable foraging and/or dispersal habitat may be provided by Gorge/ Gully, Sand Plain, Sand Dune, Major

Drainage Line, Minor Drainage Line, Drainage Area/ Floodplains and Mulga Woodland.

- Pilbara Olive Python: recorded at four locations within the Study Area during previous surveys. Denning and foraging habitat is provided by Major Drainage Line, Minor Drainage Line and Gorge/ Gully habitat within the Study Area (particularly those that contain permanent and semi-permanent water). Considering the presence of these habitat features and previous records, the species is highly likely to permanently reside in the Study Area.
- Peregrine Falcon: seven individuals have been recorded on five occasions within the Study Area during previous surveys. All habitat types within the Study Area may provide potential foraging habitat for this species. Nesting and foraging habitat is provided by Gorge/ Gully while foraging habitat is provided by the Major Drainage Line and Drainage Area/ Floodplain.
- Pilbara Flat-headed Blind Snake: two records exist within the Study Area from previous surveys. Suitable habitat for this species may be provided by Gorge/ Gully, Hillcrest/ Hillslope, Major Drainage Line, Minor Drainage Line, Drainage Area/ Floodplain and Stony Plain habitat types.
- Western Pebble-mound Mouse: known from 50 previous records within the Study Area. During the current survey, a further four recently inactive mounds were discovered within the Study Area. Suitable habitat for this species is provided by the Hillcrest/ Hillslope as well as Stony Plain habitat types.
- Chocolate Wattle Bat: Although not formally listed, the species is considered to be of local significance. Multiple calls of the Chocolate Wattled Bat have previously been recorded in the Study Area, from Gorge/ Gully habitat. Water features and riparian habitats within the Study Area may provide suitable foraging habitat for this species, particularly Gorge/ Gully habitat containing potentially permanent water with riparian vegetation (*Eucalyptus camaldulensis* and *Typha domingensis*), as is present in the south-western part of the Study Area. However, it was not possible to assess whether these recordings represented resident bats or foragers from other nearby populations at Marillana or Weeli Wolli Creeks (within 10 - 20 km away).

Despite extensive survey effort, Night Parrot, Pilbara Leaf-nosed Bat and Northern Brushtail Possum have not previously been recorded in the Study Area.

- Night Parrot: was not recorded during the current survey. The Study Area contains potentially suitable habitat for this species in Sand Plain and Drainage Area/ Floodplain habitats. While potential habitat for the species exists within the Study Area, the species is generally rare and not confirmed to reside within the Pilbara region, as such it is deemed unlikely that the species permanently resides within the Study Area.
- Pilbara Leaf-nosed Bat: has not been recorded in the Study Area. It is considered unlikely that a resident population exists in the Study Area. However, individuals may infrequently forage across Gorge/ Gully (Priority 1), Major Drainage Line, Minor

Drainage Line (Priority 4) and Drainage Area/ Floodplain (Priority 5) habitats as well as at the 15 water features that exist within the Study Area.

- Northern Brushtail Possum: The Study Area contains suitable denning habitat (contained within Gorge/ Gully, Major Drainage Line and Minor Drainage Line habitats, as well as caves) and suitable foraging habitat (contained within Gorge/ Gully, Major Drainage Lines and instances of Minor Drainage Lines) for the species. However, Northern Brushtail possum has not been recorded in the Study Area and the nearest record of the species is 60km to the south-west. Therefore, it is considered unlikely that a resident population exists.

1 INTRODUCTION

BHP Western Australian Iron Ore (BHP WAIO) commissioned Biologic Environmental Survey (Biologic) to undertake a targeted vertebrate fauna survey (the Survey) within the Marillana exploration lease (M270SA) and the Marillana to Yandi corridor (hereafter referred to as the Study Area) to support potential future environmental approvals. The Study Area is located approximately 100 kilometers (km) north-west of Newman in the Pilbara region of Western Australia and covers an area of 13,993 hectares (ha) (Figure 1.1).

1.1 Survey Objectives

The main objectives of this assessment were to assess the occurrence of fauna recognised as Matters of National Environmental Significance (MNES) and their supporting habitats within the Study Area. Fauna species considered as MNES relevant to the project were identified through a desktop assessment of the Study Area prior to the field survey (see Section 3.1). For the Study Area, this consisted of five species: Night Parrot (*Pezoporus occidentalis*); Northern Quoll (*Dasyurus hallucatus*); Pilbara Leaf-nosed Bat (*Rhinonicteris aurantia*); Ghost Bat (*Macroderma gigas*); Pilbara Olive Python (*Liasis olivaceus barroni*). Each of these targeted species is listed as 'Threatened' (i.e. Critically Endangered, Endangered or Vulnerable) under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) and/or the *Biodiversity Conservation Act 2016* (BC Act). Four additional species of conservation significance, also relevant to the project, were: the Northern Brushtail Possum (*Trichosurus vulpecula arnhemensis* – Vulnerable under the BC Act), the Peregrine Falcon (*Falco peregrinus* – Other specially protected species under the BC Act), Pilbara Flat-headed Blind Snake (*Anilios ganei* – Priority 1 by the Department of Biodiversity Conservation and Attractions [DBCA]) and Western Pebble Mound Mouse (*Pseudomys chapmani* – Priority 4). - see Appendix A for a full summary of conservation listings.

The specific objectives of the survey were to:

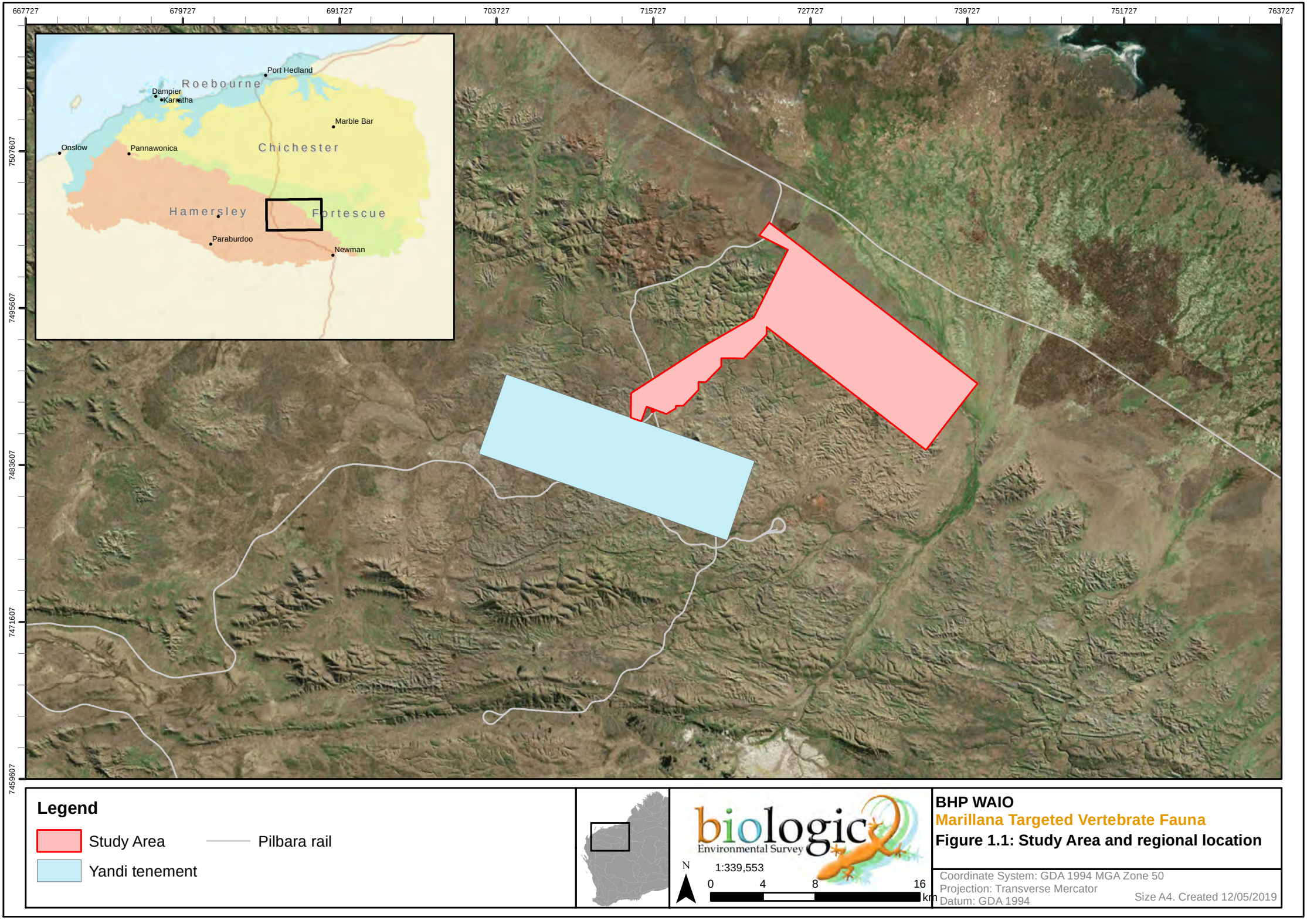
- conduct a literature and database review of all previous vertebrate fauna surveys undertaken within the Study Area and immediate surrounds;
- undertake a targeted fauna survey for a selection of fauna of conservation significance;
- provide detailed information on all records of the target species recorded within the Study Area, including from previous surveys; and
- map denning, foraging and dispersal habitats suitable for each of the target species within the Study Area.

1.2 Compliance

This assessment was carried out in a manner consistent with the following documents developed by the Western Australian Environmental Protection Authority (EPA), the Department of Biodiversity, Conservation and Attractions (DBCA - formally Department of Parks and Wildlife [DPaW]), the Department of Environment and Energy (DoEE- formally the Department of Environment [DoE]), Department of Sustainability, Water, Population, and

Communities (DSEWPaC) and Department of Environment, Water, Heritage and Arts (DEWHA):

- EPA (2016a) Technical Guidance: Survey Methods for Terrestrial Vertebrate Fauna (developed in collaboration with DBCA);
- EPA (2016b) Technical Guidance: Terrestrial Fauna Surveys;
- DPaW (2017) Interim guideline for the preliminary surveys of Night Parrot (*Pezoporus occidentalis*) in Western Australia;
- DoE (2016) EPBC Act referral guideline for the endangered Northern Quoll (*Dasyurus hallucatus);*
- DEWHA (2010a) Survey Guidelines for Australia's Threatened Bats;
- DEWHA (2010b) Survey Guidelines for Australia's Threatened Birds;
- DSEWPaC (2011b) Survey Guidelines for Australia's Threatened Reptiles; and
- DSEWPaC (2011a) Survey Guidelines for Australia's Threatened Mammals.


667727
679727
691727
703727
715727
727727
739727
751727
763727
7507607
7495607
7483607
7471607
7459607
Roebourne
Port Hedland
Dampier
Karratha
Marble Bar
Onslow
Pannawonica
Chichester
Hamersley
Fortescue
Paraburdoo
Newman
Legend
Study Area
Yandi tenement
Pilbara rail
N
1:339,553
0
4
8
16
km
biologic
Environmental Survey
BHP WAIO
Marillana Targeted Vertebrate Fauna
Figure 1.1: Study Area and regional location
Coordinate System: GDA 1994 MGA Zone 50
Projection: Transverse Mercator
Datum: GDA 1994
Size A4. Created 12/05/2019

2 CONSERVATION SIGNIFICANCE

Within Western Australia, native fauna are protected under the *Biodiversity Conservation Act 2016* (BC Act) and at a national level under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act). Any action that has the potential to impact on native fauna needs to be approved by relevant state and/or federal departments as dictated by the state *Environmental Protection Act 1986* (EP Act).

Some species of fauna that are determined to be at risk of extinction or decline are afforded extra protection under these Acts. For the purposes of this report, these species are deemed to be of conservation significance. A summary of applicable legislation and status codes is provided in Appendix A. For some species, there is insufficient information to determine their status. These species are also considered by the EPA and the Department of Biodiversity, Conservation and Attraction's (DBCA) as being of conservation significance for all development related approvals and are listed on a 'Priority List' that is regularly reviewed and maintained by the DBCA (Appendix A).

Such species were the target of this assessment, specifically those that have previously been identified as potentially occurring from other surveys or have previously been recorded within the Study Area. Background information on each of those species is detailed below.

2.1 Night Parrot (*Pezoporus occidentalis*)

The Night Parrot is listed as Endangered under the EPBC Act and by the International Union for Conservation of Nature (IUCN), and Critically Endangered under the BC Act. The Night Parrot was thought to be extinct but in 2013 it was rediscovered in Queensland (Pullen Pullen Reserve; DoEE, 2018c). Subsequently, the species has been found in Goneaway National Park and Diamantina National Park in Queensland (Palaszczuk & Miles, 2017), as well as the Kimberley and Murchison regions of Western Australia (Jackett *et al.*, 2017; Jones, 2017).

The Night Parrot is a small, elusive and ground dwelling parrot endemic to Australia (DPaW, 2017). This highly cryptic and nocturnal parrot inhabits arid and semi-arid areas that comprise dense, low vegetation. Based on accepted records, the habitat of the Night Parrot consists of *Triodia* grasslands in stony or sandy environments (McGilp, 1931; North, 1898; Whitlock, 1924; Wilson, 1937), and of samphire and chenopod shrublands, including genera such as *Atriplex*, *Bassia* and *Maireana*, on floodplains and claypans, as well as on the margins of salt lakes, creeks or other sources of water (McGilp, 1931; Wilson, 1937). The current interim guidelines for preliminary surveys of Night Parrot in Western Australia suggest this species requires old-growth (often more than 50 years unburnt) spinifex (*Triodia*) for roosting and nesting (DPaW, 2017). Although little is known about foraging sites, habitats that comprise various grasses and herbs are thought to be suitable. Foraging habitat is not necessarily within or adjacent to roosting habitat as the Night Parrot has been known to fly up to 40 km in a single night to forage (Murphy *et al.*, 2017). It is reasonably assumed that the species may fly cumulative distances of up to 100 km per night during productive seasons and considerably greater than 100 km per night during drought conditions between roosting habitat and foraging habitat (Night Parrot Recovery Team, 2017). *Triodia* is likely to provide a good food resource at least in times of mass flowering and seeding. The succulent *Sclerolaena* also provide a source of food and moisture and other succulent chenopods are also likely to be significant habitat (DPaW, 2017). Therefore, foraging areas include highly productive and floristically diverse alluvial habitats, stony herbfields, sparse ironstone pavements, and quaternary sand drifts and ridges (Night Parrot Recovery Team, 2017). Foraging habitat is likely to be more important if it is adjacent to or within about 10 km of suitable roosting habitat (DPaW, 2017). during adult or juvenile dispersal or nomadic movements, Night Parrots may travel distances in the order of several hundred kilometres,

The distribution of the Night Parrot is very poorly understood. The small number of confirmed or verifiable records prevents the population size from being assessed with any accuracy. However, the population size is speculatively estimated to consist of approximately 50 breeding birds that occur in five subpopulations. The largest of these subpopulations is estimated, with low reliability, to consist of 20 breeding birds (Garnett & Crowley, 2000).

2.2 Northern Quoll (*Dasyurus hallucatus*)

The Northern Quoll is listed as Endangered under the EPBC Act and BC Act. The species was once widely distributed across northern Australia, although is now restricted to three isolated populations; the Pilbara, the Kimberley and Northern Territory, and Queensland, in addition to a number of islands along the north coast (DoE, 2016).

In the Pilbara, abundance is lowest toward the end of winter into early spring after the mating season as a significant proportion of adult males die off and young have not yet begun to forage independently (Braithwaite & Griffiths, 1994; Oakwood, 2000).

Northern Quolls are opportunistic omnivores, consuming a wide range of invertebrates and small vertebrates but they also eat fruit, nectar, carrion and human refuse (van Dyck & Strahan, 2008). Home ranges in the western Pilbara, are 75 to 443 ha for females and 5 to 1,109 ha for males (King, 1989).

The Northern Quoll is both arboreal and terrestrial, inhabiting ironstone and sandstone ridges, scree slopes, granite boulders and outcrops, drainage lines, riverine habitats (Braithwaite & Griffiths, 1994; Oakwood, 2002), dissected rocky escarpments, open forest of lowland savannah and woodland (Oakwood, 2002, 2008). Rocky habitats tend to support higher densities, as they offer protection from predators and are generally more productive in terms of availability of resources (Braithwaite & Griffiths, 1994; Oakwood, 2000). Other microhabitat features important to the species include: rock cover; proximity to permanent water and time-since last fire (Woinarski *et al.*, 2008). Dens occur in a wide range of situations including rock overhangs, tree hollows, hollow logs, termite mounds, goanna burrows and human dwellings/infrastructure, where individuals usually den alone (Oakwood, 2002; Woinarski *et al.*, 2008). At present Northern Quolls are relatively common in the northern Pilbara region (generally within 150 km of the coast) but are much less common in southern and south-eastern parts of the region (Cramer *et al.*, 2016).

The species has experienced a precipitous decline in much of its former range in northern Queensland and the Northern Territory in direct association with the spread of the Cane Toad, *Bufo marinus* (Braithwaite & Griffiths, 1994; Fitzsimons *et al.*, 2010). Other threats include predation from feral predators such as foxes and cats, inappropriate fire regimes, disease, habitat degradation through grazing and weed invasion as well as habitat destruction through mining and agriculture (Woinarski *et al.*, 2011). The potential invasion of the Pilbara by the cane toad is regarded as the most significant future threat to the Northern Quoll in the Pilbara; however, there is little knowledge of the relative impact of the other key threats, and their interactive effects, currently and in the future (Cramer *et al.*, 2016).

2.3 Pilbara Leaf-nosed Bat (*Rhinonicteris aurantia*)

The Pilbara Leaf-nosed Bat (PLNB) is classified as Vulnerable under the EPBC Act and the BC Act (TSSC, 2016b). The population existing within the Pilbara is geographically isolated from the tropical populations of Orange Leaf-nosed Bat by approximately 400 km of the Great Sandy Desert (Armstrong, 2001). The Pilbara population is regarded as representing a single interbreeding population comprising multiple colonies (TSSC, 2016b). Recently updated conservation advice stated that there were at least 10 confirmed day roosts (including maternity roosts), and a further 23 unconfirmed roosts throughout the Pilbara region (TSSC, 2016b), although this is likely to be an underestimate based on unpublished data.

Pilbara Leaf-nosed Bats typically roost in undisturbed caves, deep fissures or abandoned mine shafts. The species' limited ability to conserve heat and water (Baudinette *et al.*, 2000) means it requires warm (28-32ºC) and very humid (85-100%) roost sites to persist in arid and semi-arid climates (Armstrong, 2001; Churchill, 1991). Caves with such attributes are relatively uncommon in the Pilbara, and the limiting factor of the species distribution (Armstrong, 2001). During the dry season (June to November) individuals are believed to aggregate in caves that provide a suitably warm, humid microclimate (Armstrong, 2000; Armstrong, 2001; Bullen & McKenzie, 2011). While in the wet season (December to May), when conditions are generally wetter and more humid, individuals typically disperse roosting in seasonally suitable caves (Armstrong, 2000; Armstrong, 2001; Bullen & McKenzie, 2011).

TSSC (2016b) categorised underground refuges used by PLNB into four categories: permanent diurnal roosts (Priority 1 – critical for daily survival) are occupied year-round and are likely to be the focus for some part of the 9-month breeding cycle; non-permanent breeding roosts (Priority 2 - critical for daily and long-term survival) are used during some part of the 9-month breeding cycle but not year-round; transitory diurnal roosts (Priority 3 – critical for daily and long-term survival) are occupied outside the breeding season and could facilitate long distance dispersal; and nocturnal refuges (Priority 4 – not considered critical but important for persistence in a local area) are occupied or entered at night for resting, feeding or other purposes. Additionally, foraging sites surrounding known or suspected roosts can be critical to the survival of the species. TSSC (2016b) categorised foraging habitat into five categories: gorges with pools (Priority 1); gullies (Priority 2); rocky outcrops (Priority 3); major watercourses (Priority 4); and open grassland and woodland (Priority 5) (TSSC, 2016b).

This species' susceptibility to heat and water loss plays a significant role in the processes that threaten it (TSSC, 2016b). The removal, modification or unmitigated disturbance of refuge considered critical to the survival of the species is likely to have long-term impacts on PLNB population size. Mining related activities (inclusive of clearing, excavation, blasting, drilling and rail and vehicle activity) as well as degradation caused by invasive species can destroy, alter or reduce suitable habitats. Moreover, development related disturbances can potentially disrupt the breeding cycle of the species (TSSC, 2016b).

2.4 Ghost Bat (*Macroderma gigas*)

The Ghost Bat is listed as Vulnerable under the EPBC Act, the BC Act and by the IUCN. In the Pilbara region, the species occurs in all four sub-regions (DBCA, 2018a). The Pilbara population is estimated to be between 1300 and 2000 individuals (TSSC, 2016a). The largest colonies occur within the Chichester subregion (total population estimated at approximately 1,500 individuals) where known colonies are known to occur within disused mines (TSSC, 2016a).

The distribution of Ghost Bats in the Pilbara is dependent on the presence of suitable roosting sites and foraging areas. Natural roosts generally comprise deep, complex caves beneath bluffs or low rounded hills (Armstrong & Anstee, 2000). There are few known maternity roosts in natural caves of the Pilbara (Armstrong & Anstee, 2000). Based on available data, breeding has been documented in natural caves at Mining Area C, Mt Brockman and West Angeles in the Hamersley sub-region, and at Callawa and Tambrey Station in the Chichester sub-region (Armstrong & Anstee, 2000). Ghost Bats move between a number of caves seasonally, or as dictated by weather conditions, and require a range of cave sites (Hutson *et al.*, 2001). Outside of the breeding season, male bats are known to disperse widely, most likely during the wet season when conditions would allow bats to use caves that would otherwise not be suitable (Worthington-Wilmer *et al.*, 1994). Genetic studies indicate that females are likely to stay close to the maternity roosts (Worthington-Wilmer *et al.*, 1994).

Caves used by the species can be classified into five types: Night Roosts (caves that are only utilised during the night, mostly to feed on prey items or to rest, and are typically shallow caves and shelters/overhangs that can be well lit during the day); Night Roost/possible Diurnal Roosts (in addition to being utilised to feed on prey items during the night, these caves are more complex in structure and provide suitable temperature and humidity conditions suitable for roosting during the day, but no Ghost Bats have been recorded using them during the day); Diurnal Roosts (caves that are used for shelter during the day); Diurnal Roosts/possible Maternity Roosts (in addition to being used for shelter during the day, support breeding and Ghost Bats have been recorded in such caves during the breeding season); and Maternity Roosts (in addition to being used for shelter during the day and supporting breeding, this caves contain pregnant females or females with pups) (Biologic, 2015).

Average foraging area of 61 ha were recorded for Ghost Bats in the Northern Territory whereby Ghost Bats appear to have a short-range foraging strategy of up to 3 km (average 1.9 km), with vantage points changing approximately every 15 minutes. Moreover, the bats generally return to the same area each night (Tidemann *et al.*, 1985). Although it has been suggested that Ghost Bats in the arid zone are semi-transient through most areas and will readily travel large distances (>4 km) (Biologic, *in prep.*). Ghost Bats have a 'sit and inspect' foraging strategy; they hang on a perch where they visually inspect their surroundings for movement. Once their prey is detected it may be captured in the air, gleaned (taken from the surface of a substrate by a flying bat) from the ground or vegetation, or dropped on from a perch (Boles, 1999).

2.5 Pilbara Olive Python (*Liasis olivaceus barroni*)

The Pilbara Olive Python is listed as Vulnerable under the EPBC Act and the BC Act. The Pilbara Olive Python is Western Australia's largest snake, averaging 2.5 m with records up to 4.5 m (Bush & Maryan, 2011; Cogger, 2014). The species has a dull olive-brown upper surface and is pale cream below (Burbidge, 2004; Cogger, 2014). This python is endemic to the Pilbara region, distributed from Burrup Peninsula, Ord Ranges and Meentheena south to Nanutarra and Newman (Bush & Maryan, 2011)

This species is primarily nocturnal and tends to shelter in small caves or under vegetation during the day. During summer months they will emerge from daytime shelters soon after dark and continue to move until the early hours of the morning (DSEWPaC, 2011b). In the winter months, the species is primarily nocturnal although adult pythons can sometimes be found basking in the morning sun (DSEWPaC, 2011b; Pearson, 2001). The breeding season of the Pilbara Olive Python takes place in the cooler months, which extends from June to August. Males will travel up three kilometres in search of a mate (DSEWPaC, 2011b) The species is a well-adapted ambush predator and common prey items include rock-wallabies, small Euros, fruit bats, waterbirds, doves/pigeons and there are instances of Northern Quoll (Oakwood & Miles, 1998)

The species commonly inhabits moist areas such as gorges, rivers, pools and surrounding hills, but can be found in a range of habitats (Burbidge, 2004; DSEWPaC, 2011b). In the Hamersley region, the Pilbara Olive Python is most often encountered in the vicinity of permanent waterholes in rocky ranges or among riverine vegetation (DSEWPaC, 2011b; Pearson, 1993). It is a common misconception that the species is reliant and restricted to areas near permanent water; however, the species is attracted to these areas due only to the productivity and abundance of suitably-sized prey (Pearson, 2003). It is known to occur at 17 locations within the Pilbara (Pearson, 1993). Four populations occur at Pannawonica, Millstream, Tom Price and Burrup Peninsula (Pearson, 2003)

Threats to the species include major fire events, competition for prey with introduced predators, habitat loss (TSSC, 2008), predation of food sources (quolls and rock-wallabies) by foxes, habitat destruction by gas and mining development, deliberate and accidental road kills, and deliberate killings around tourist and residential areas associated with mistaken identification as a venomous brown snake (Pearson, 2006).

2.6 Northern Brushtail Possum (*Trichosurus vulpecula arnhemensis*)

The Northern Brushtail Possum is a recently listed WA species. It is not listed under the EPBC Act but is listed as Vulnerable under the BC Act. There is currently no information regarding the listing of this species on the BC Act, nor a recovery plan specific to this species. The WA Museum currently deems the species within the Pilbara to be the conservation significant northern subspecies, *Trichosurus vulpecula arnhemensis* (BC Act Schedule 3). However, the Action Plan for Australian Mammals (Woinarski et al., 2014) suggested the Brushtail Possum occurring in the Pilbara is the same subspecies as in the southwest '*hypoleucus*' while the Brushtail Possum occurring in the Kimberley belongs to the subspecies '*arnhemensis*'. Moreover, genetic studies have shown that possums occurring on Barrow Island are more closely related to the southern form (Woinarski et al., 2014). To determine if the representatives of this possum in the Pilbara are the listed northern form (*Trichosurus vulpecula arnhemensis*) or the southern form (*Trichosurus vulpecular hypoleucus), s*ubsequent genetic studies would be required.

The Brushtail Possum has a very restricted distribution and is infrequently recorded in the Pilbara region, with less than 20 records existing on NatureMap (DBCA, 2018a). Most records are from north of the Chichester Range and only a few are known from the Hamersley Range. Brushtail Possums generally exhibit flexibility in their habitat preferences (Kerle *et al.*, 1992) and occupy an array of habitat types provided enough tree hollows and ground refuges (such as hollow logs, rockpiles and the burrows of other animals) are available. On Barrow Island, Western Australia, little to no trees are available as refuge and therefore, Brushtail Possums are known to live on the ground (DEC, 2012). In the arid zone, Brushtail Possums were recorded and seemingly dense in rocky ranges, rocky outcrops, rivers with large *Eucalyptus* trees. Records also exist in coolabah claypans, limestone sinkholes and *Triodia* habitats within the arid zone (Kerle *et al.*, 1992). However, little ecological information is known about the Pilbara population, although it is most often recorded from gorges and major drainage lines that contain large hollow-bearing Eucalypts (DBCA, 2018a).

Several interacting ecological factors, primarily inappropriate fire regimes, feral predation by cats and foxes as well as habitat loss and fragmentation, are currently causing rapid and severe declines in the small and medium-sized mammal fauna of northern Australia (Woinarski *et al.*, 2014). The Northern Brushtail Possum is regarded as a 'critical weight range' mammal, and thus more susceptible to pressure from introduced predators (Burbidge & McKenzie, 1989). Within Western Australia, the former range of the Brushtail Possum has been considerably reduced by habitat clearing and fox predation, including in large areas of arid country. Predation by foxes, cats, dingos, large pythons and large monitors is particularly significant in areas where population numbers are low (DEC, 2012).

2.7 Peregrine Falcon (*Falco peregrinus*)

The Peregrine Falcon is listed as Other specially protected species under the BC Act. This medium sized raptor (length 35-55cm; wingspan 80-105cm) is heavily built with a black head, nape and cheeks, brown to grey back, wings and tail and cream underparts with darked banding across the chest. This species exhibits sexual dimorphism with the female being noticeably larger than the male (Johnstone & Storr, 1998) .

The Peregrine Falcon preys almost entirely on birds, usually the most common flocking birds in the area, and occasionally small reptiles, mammals (Olsen *et al.*, 2008) and insects, such as moths, cicadas and locusts (BirdLife Australia, 2012). The species has a home range of approximately 20 to 30 km^2. While the Peregrine Falcon is found throughout Australia it is typically absent in treeless and waterless deserts as well as dense forests. They also seldom breed above the snowline (BirdLife Australia, 2012). In arid areas it is most often encountered along cliffs above rivers, ranges and wooded watercourses where it hunts birds (Johnstone & Storr, 1998).

This aerial carnivore typically nests on inland cliffs, in tree hollows, in steep-sided rocky outcrops near water (Pizzey & Knight, 2007), granite outcrops and quarries and also occasionally within tall trees occurring along major drainage lines (Olsen & Olsen, 1989). This species is also known for nesting on radio-towers and other human built structures. Nest sites on cliffs have been recorded at heights of between 12-60 m and the same nest sites may be used for many years (Olsen *et al.*, 2004; Olsen *et al.*, 2008). This species breeds from August to November and lays up to three eggs which are incubated by both parents for 33 days. The female will feed the hungriest chick first and thus there is no sibling rivalry and all nestlings have an equal chance of fledging successfully (BirdLife Australia, 2012). Like other *Falco* species, the Peregrine Falcon does not build a nest (Olsen *et al.*, 2006) and instead digs a scrape on a high cliff ledge (BirdLife Australia, 2012) that are weatherproof.

Peregrine Falcon populations were in serious decline throughout the world because of the use of organochloride pesticides, such as DDT and Deildrin which cause a decrease in eggshell thickness (Garnett & Crowley, 2000). Following the banning of these organochloride pesticides and worldwide conservation efforts, most Peregrine Falcon populations have recovered, although they remain uncommon. However, the Australian population did not show the same level of decline (Garnett *et al.*, 2011). Threats faced by this species include collisions with powerlines, disturbance from bushwalkers/climbers, pesticides, fire and illegal killing from pigeon fanciers (Garnett *et al.*, 2011).

2.8 Pilbara Flat-headed Blind-snake (*Anilios ganei*)

Anilios ganei is listed as Priority 1 by DBCA and is endemic to the Pilbara. Given that this species has a cryptic fossorial habit, this species is rarely encountered. Little is known of this species' ecology but like most other blind snakes, it is insectivorous, feeding on termites and their eggs, and ant larvae and pupae (Wilson & Swan, 2014). *Anilios ganei* is associated with moist soils and leaf litter gorges and gullies (Wilson & Swan, 2014), and potentially with a wide range of other stony habitats and along drainage lines (DBCA, 2018a). This species is likely threatened by loss of habitat quantity and quality including habitat fragmentation and barriers to movement.

2.9 Western Pebble-mound Mouse (*Pseudomys chapmani*)

The Western Pebble-mound Mouse is listed as Priority 4 by the DBCA. The species is endemic to the Pilbara and is found in non-coastal, central and eastern parts of the district (Ford & Johnson, 2007; Start *et al.*, 2000). Its range is limited to the edge of the Great Sandy Desert to the north and the Gibson Desert to the east (Start *et al.*, 2000).

The species constructs mounds out of small pebbles covering an area of 0.5 to 9.0 m² (van Dyck & Strahan, 2008) with heaps up to 25 cm above ground surface (Dunlop & Pound, 1981). Active mounds have an external entrance hole that leads to a complex underground burrow system and nest chambers up to 0.5 m below ground level (Anstee, 1996). The prevalence of mounds is not necessarily a reliable indicator of abundance or presence, as mounds are often used by successive generations (Anstee, 1996; Ford & Johnson, 2007) and may persist in the landscape for many years. Moreover, the species utilise several mounds during a night, inclusive of the primary mound (Anstee, 1996). Anstee *et al.* (1997) found the average population density per active mound to be 2 per ha. The species maintains a large-home range whereby males cover more ground than females (Anstee *et al.*, 1997). Breeding for this species can occur throughout the year and females may produce several litters per year of up to four young each (van Dyck & Strahan, 2008).

The species occupies rocky, hummock grassland areas with little or no soil. The habitat is usually vegetated with an open to mid-dense *Triodia basedowii* hummock grassland and scattered emergent *Cassia*, *Acacia* and *Ptilotus* spp. (Start *et al.*, 2000). They have also known to occupy, at lower densities, ridges and outcrops where there is hummock grassland of *T. wiseana* with many emergent *Eucalyptus* and *Acacia* species (Dunlop & Pound, 1981; Start *et al.*, 2000). They more commonly inhabit lower land slopes where weathering produces pebbles of the preferred size (average 3.5 grams) (Start *et al.*, 2000). The persistence of abandoned mounds in the adjacent Gascoyne and Murchison regions as well as coastal regions of the Pilbara indicate that the mouse has contracted to 65 per cent of their former extent (340 00 km², Start *et al.*, 2000). Foxes and exotic herbivores (i.e. rabbits) are thought to attribute to most of this decline based on their distribution, although other introduced species including feral cats and livestock (Start *et al.*, 2000) may have also impacted on this species. Additionally, mounds are most common in areas of the Pilbara that contain economically significant iron ore deposits.

3 METHODS

3.1 Desktop Assessment

The following databases were previously searched (in Biologic, 2016a; Biologic, 2016b) to obtain information on species recorded within the Study Area or likely to occur in the wider area (Table 3.1). DBCA's NatureMap database and DoEE's Protected Matters Database were revisited during the current survey to obtain an updated list of species of conservation significance recorded or likely to occur within the Study Area.

Table 3.1 Database Sources

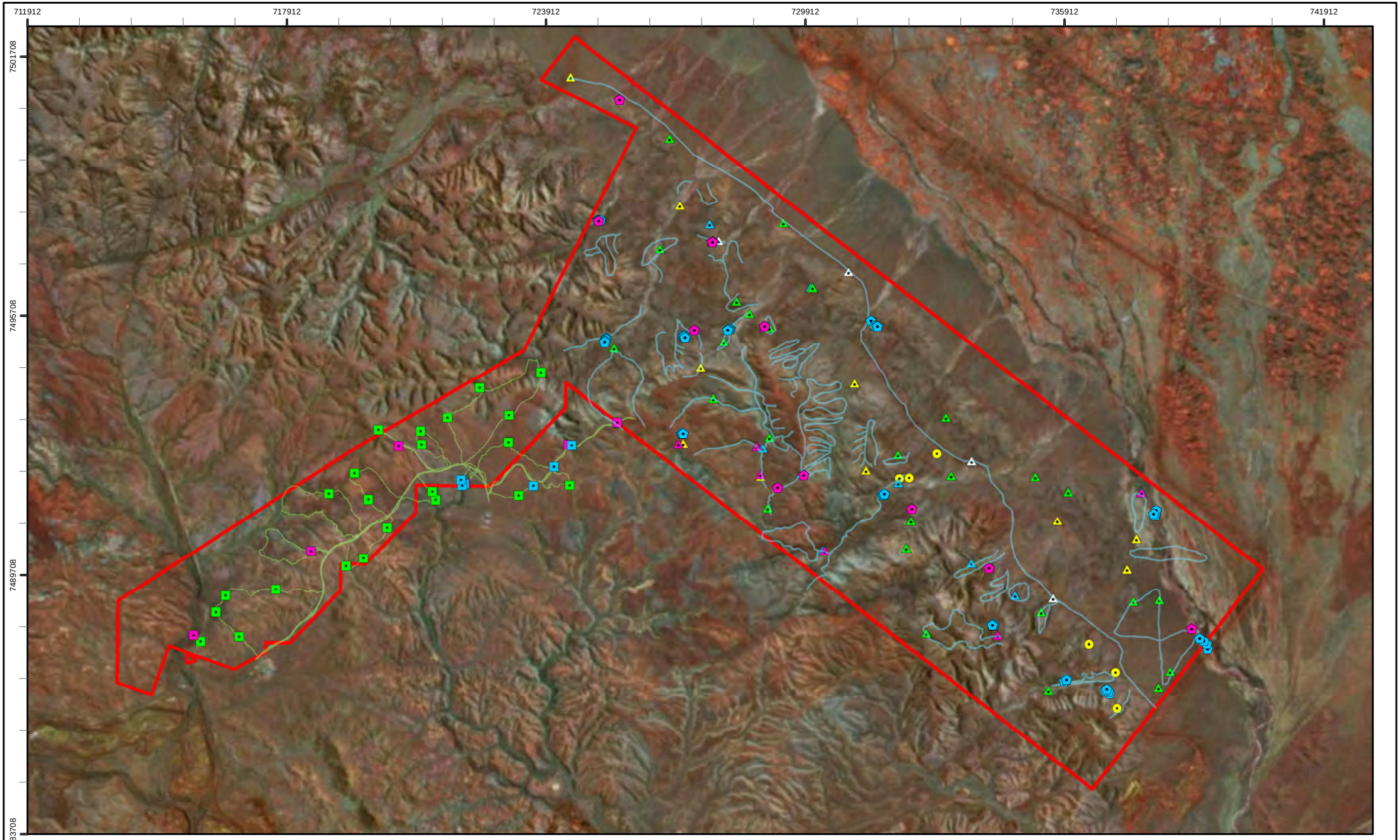
Provider	Database	Reference	Search parameter	Date accessed
Marillana Infrastructure Corridor Level 1 Vertebrate Fauna Survey (Biologic, 2016a)				
DBCA	Threatened Fauna Database	DBCA (2016)	50 km radius of -22.651658°, 119.243656°	7 April 2016
Marillana Targeted Vertebrate Fauna Survey (Biologic, 2016b)				
DBCA	Threatened Fauna Database	DBCA (2016)	30 km centred on the point - 22.657778° 119.253889°	19 April 2016
Current Survey				
DBCA	NatureMap	DBCA (2018b)	40 km centred on the point -22.644779°, 119.183304°	8 June 2018
DoEE	Protected Matters Database Search Tool	DoEE (2018b)	50 km centred on the point -22.644779°, 119.183304°	8 June 2018

Twenty-five relevant fauna surveys were previously reviewed (Biologic, 2013, 2016a, 2016b), and subsequently revised during the current survey, to detail the extent and intensity of previous survey effort undertaken within the vicinity of the Study Area, and to capture evidence of species of conservation significance (Table 3.2). Thirteen of these previous surveys were conducted within or overlapping the Study Area (refer to Figure 3.1 for previous sampling locations within the Study Area).

Table 3.2 Reports used for the review

Survey Title	Reference	Survey Type	Distance from Study Area
Within or Overlapping the Study Area			
Barimunya Camp Vertebrate Fauna Survey	Biologic (2011a)	Level 1 and Targeted	Within
Marillana Vertebrate Fauna Survey	Biologic (2013)	Two-season, Level 2	Within
Marillana Infrastructure Corridor Level 1 Vertebrate Fauna Survey	Biologic (2016a)	Level 1 and Targeted	Within

Survey Title	Reference	Survey Type	Distance from Study Area
Marillana Targeted Vertebrate Fauna Survey	Biologic (2016b)	Targeted Survey	Within
Marillana Terrestrial Vertebrate Fauna Survey	ecologia (2006)	Two-season, Level 2	Within
RPG5: M270SA Fauna Assessment	ENV (2008a)	Level 1	Within
Fauna Assessment, Nyidinghu Iron Ore Project	Bamford Consulting Ecologists (2012)	Single-season Level 2	Overlaps
RGP5 Fauna Survey Kurrajura Siding to Yandi WYE including Yandi Repeater 1	ecologia (2008b)	Level 1	Overlaps
Survey for conservation significant bats between Kurrajura siding and the Yandi WYE	Specialised Zoological (2008)	Targeted Survey	Overlaps
Koodaideri Vertebrate Fauna Integration Report	Biota (2012b)	Targeted survey	Overlaps
Yandi Vertebrate Fauna Review	Biologic (2011b)	Level 1 and Targeted	Overlaps
Marillana Creek (Yandi) Iron Ore Mine Modification Level 2 Fauna Survey	ecologia (2008a)	Single-season, Level 2	Overlaps with southern part of Study Area
Yandi Stage 2 Iron Ore Project Biological Assessment Survey	ecologia (1995)	Single season, Level 2	Overlaps with southern border
Outside the Study Area			
Marillana Creek Western Access Corridor Biological Assessment	Halpern Glick Maunsell (1999)	Level 1	Adjacent
Hope Downs Rail Corridor from Weeli Wolli to Port Hedland Vertebrate Fauna Survey	Biota (2002)	Two-season Level 2	Adjacent and extends north to Port Headland
Marillana Iron Ore Project Vertebrate Fauna Assessment	ecologia (2009)	Two-season Level 2	Adjacent
Jinidi to Mainline Vertebrate Fauna Survey	Biologic (2011b)	Two-season Level 2	Adjacent
Yandi Billiards Phase 1 Seasonal Fauna Survey	Biota (2014)	Level 2	~2 km E
Mainline Rail Expansion Vertebrate Fauna Survey	Biologic (2012a)	Level 1	~3 km N
Mindy North Exploration Lease Fauna Assessment	ENV (2007)	Level 1	~3 km E
RGP5: Jimblebar Junction to Yandi Junction Railway Reserve and Repeaters 6,7 and 8 Fauna Assessment	ENV (2008b)	Level 1	~3 km N
Yandicoogina Targeted Northern Quoll Survey	Biota (2009)	Targeted Survey	~6 km SW
Mindy-Coondiner Exploration Project Biological Survey	ecologia (2005)	Baseline Survey	~6 km E
Yandicoogina South West and Oxbow Fauna Survey	Biota (2010)	Level 2	~8 km S
Yandi Life of Mine Fauna and Flora	Maunsell (2003)	Targeted Reconnaissance	~8 km S and ~10 km SW



Legend

- Study Area
- **ecologia (2009)**
  - Trapping
- **Biologic (2016b)**
  - Recorder Ultrasonic
  - Motion Camera
  - Targeted Search
- **Biologic (2016a)**
  - Recorder Ultrasonic
  - Motion Camera
  - Habitat Assessment
  - Targeted Search
- **Biologic (2013)**
  - Trapping
  - Recorder Ultrasonic
  - Motion Camera
  - Nocturnal Search
  - Habitat Assessment

N

1:110,000

0 1.25 2.5 5 km

BHP WAIO

Marillana Targeted Vertebrate Fauna

Figure 3.1: Previous survey sampling locations in the Study Area

Coordinate System: GDA 1994 MGA Zone 50
Projection: Transverse Mercator
Datum: GDA 1994

Size A4. Created 14/02/2019

3.2 Field Survey

The overarching objective of this survey was to determine the occurrence of the targeted species of conservation significance within the Study Area (refer to Section 1.1). The primary survey techniques comprised motion cameras, ultrasonic bat recorders, acoustic recorders (for avifauna) and targeted searches.

The study was undertaken over two field trips; Phase 1 was undertaken by three experienced zoologists, Thomas Rasmussen, Arnold Slabber and Chris Knuckey, from the 16th to 28th of April 2018. Phase 2 was undertaken by experienced zoologists, Morgan O'Connell and Michael Brown, from the 29th of May to the 2nd of June 2018. The study was conducted under DBCA Regulation 17 license 08-001704-1 issued to Chris Knuckey and 08-002017-1 issued to Brighton Downing.

3.2.1 Survey Timing and Weather

The Study Area is located within the Hamersley subregion of the Pilbara bioregion (following Thackway & Cresswell, 1995) (Figure 1.1). The region features a semi-desert to tropical climate, with rainfall occurring sporadically during summer and winter, but mostly during the former season (Leighton, 2004). Summer rainfall is a result of either tropical storms in the north or tropical cyclones that impact upon the coast and move inland. The winter rainfall is generally lighter and is the result of cold fronts moving north easterly across the state (Leighton, 2004). The regional average annual rainfall ranges from about 200 to 500 mm, although there are significant fluctuations between years (Department of Water, 2012) with up to 1200 mm falling in some locations in some years (McKenzie *et al.*, 2009).

Except for January, which experienced above average rainfall (rainfall experienced in January 2018 equated to 84.2 mm while the LTA for January equates to 66.9 mm), 2018 exhibited below average rainfall around Newman Aero Station (nearest Bureau of Meteorology [BoM] weather station) (Figure 3.2). The wet season approximated the long-term average for the area and thus unlikely to impact on the ability to detect target fauna. Plants had flowered, likely increasing the breeding activity of vertebrate fauna species.

Minimum temperatures during the Phase 1 survey ranged from 15˚C to 21.7˚C, with an average minimum of 18.3˚C (Table 3.3). Maximum temperatures ranged from 30.1˚C to 37.4˚C with an average maximum of 35.5˚C (Table 3.3)(BoM, 2018). These temperatures are considered average for the time of year resulting in average activity patterns for species. Only 0.2 mm of rainfall was received during the Phase 1 survey, on the 26th of April 2018 (Table 3.3). Minimum temperatures during the Phase 2 survey ranged from 8.6˚C to 15.8˚C, with an average minimum of 10.9˚C (Table 3.3). Maximum temperatures ranged from 23.9˚C to 29.7˚C with an average maximum of 26.7ºC (Table 3.3). These conditions were typical for the time of year but given the cooler temperatures associated with the autumn/winter fauna activity may have resulted in reduced reptile activity during Phase 2. Only 1.2 mm of rainfall was received during the Phase 2 survey, on the 1st of June 2018 (Table 3.3).

Table 3.3 Daily weather recorded near the Study Area during the Survey

Date	Temperature (°C)		Rainfall (mm)
	Min	Max	
16/04/2018	15.9	34.3	0.0
17/04/2018	15.0	35.0	0.0
18/04/2018	15.2	35.7	0.0
19/04/2018	17.4	36.7	0.0
20/04/2018	17.9	37.1	0.0
21/04/2018	16.6	36.8	0.0
22/04/2018	18.9	37.4	0.0
23/04/2018	19.7	36.5	0.0
24/04/2018	18.7	36.0	0.0
25/04/2018	21.7	30.1	0.0
26/04/2018	20.2	34.8	0.2
27/04/2018	20.3	35.0	0.0
28/04/2018	20.7	35.5	0.0
Average	**18.3**	**35.5**	**0.2**
29/05/2018	8.6	25.5	0.0
30/05/2018	10.0	23.9	0.0
31/05/2018	10.2	29.7	0.0
01/06/2018	15.8	26.6	1.2
02/06/2018	10.0	27.8	0.0
Average	**10.9**	**26.7**	**0.2**

Source: BoM (2018)

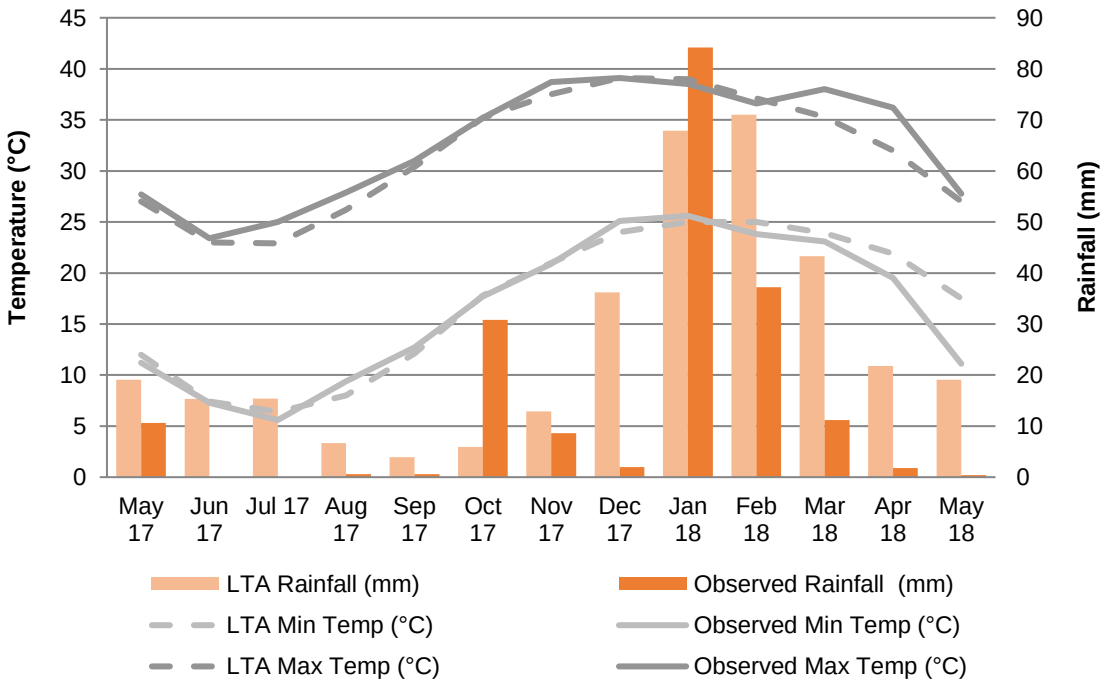


Figure 3.2: Long-term average (LTA) and recent climatic data for the Study Area

3.2.2 Sampling Techniques

Habitat Assessments and Mapping

Habitat assessments were undertaken at 40 locations across the Study Area, including at every sampling site (Figure 3.3). Habitats in the Study Area were assessed using methodology and terminology modified from the Australian Soil and Land Survey Field Handbook (National Committee on Soil and Terrain, 2009). The characteristics recorded during the habitat assessments were:

- site information, photo and location;
- landform: slope, relative inclination of slope, morphological type and landform type;
- vegetation: leaf litter %, twig litter %, wood litter, dead stags and hollow-bearing trees, broad floristic formation, vegetation structure (tall, mid and low), and dominant species;
- land surface: micro relief, sheet erosion, rill erosion, gully erosion, gully depth, abundance and size of coarse fragments, rock outcropping, water bodies, comments on nests, burrows, roosts and diggings;
- soil: texture, colour;
- substrate: bare ground, rock size, rock type, rock outcropping; and
- disturbance: time since last fire, evidence of weeds, grazing, or human disturbances.

Fauna habitats were assessed for their likelihood to support fauna of conservation significance; particularly fauna of conservation significance targeted during the current survey. All major fauna habitats present within the Study Area were rated (High, Medium or Low) per the criteria in Table 3.4.

Habitats were defined using habitat assessments undertaken during this assessment, as well as previous assessments (Biologic, 2013, 2016a, 2016b). Habitats were delineated and mapped across the Study Area at a scale of ~1:20,000, with the aid of high-resolution aerial imagery, vegetation, topographical, land system and drainage mapping.

Table 3.4 Fauna habitat significance assessment criteria

Score	Possible criteria (score results from any possible criterion being met)
High	Fauna listed as threatened under the EPBC Act or BC Act have been recorded from this habitat type within the Study Area.
	Habitat known to be suitable core habitat[1] for EPBC Act and/or BC Act listed threatened fauna, and there are records of this species within 50 km [*2].
	Habitat is regionally uncommon and known to support species listed as: • Threatened fauna under the EPBC Act and/or BC Act, but it is not their core habitat (e.g. may be used periodically/ seasonally or for dispersal). • Species of Special Conservation Interest or Other Specially Protected Species under the BC Act. • DBCA listed Priority fauna, which are known to be solely reliant on this habitat.

Score	Possible criteria (score results from any possible criterion being met)
Moderate	Habitat known to support EPBC Act and/or BC Act listed Migratory fauna.
	Habitat that is regionally uncommon (e.g., occurs in small and isolated areas) and supports a particularly diverse and uncommon faunal assemblage.
	Habitat is widespread and known to support species listed as: • Threatened fauna under the EPBC Act and/or BC Act, but it is not their core habitat (e.g., may be used periodically/ seasonally or for dispersal). • Species of Special Conservation Interest or Other Specially Protected Species under the BC Act. • DBCA listed Priority fauna, which are known to be solely reliant on this habitat.
Low	Habitat that may meet the definition of core habitat[1] for EPBC Act and/or BC Act listed threatened fauna, however there are no records of this species within 40 kms.
	Habitat is widespread/common and does not solely support any DBCA listed Priority fauna.

1. Core habitat is defined as containing the critical habitat elements for survival and reproduction of a species (Bingham & Noon, 1997) or as otherwise defined within relevant species recovery plans and guidelines.
2. Note in instances where survey work over this area has been limited, then a precautionary approach is generally applied, and the species will be considered likely to be present.

Targeted Searches

A DJI Phantom 4 Remotely Piloted Aircraft (RPA) was used to conduct searches for important habitat features (i.e. caves, water features) and locate suitable habitat to perform targeted searches, such as cave-forming geology and rocky terrain for Northern Quoll (Figure 3.3). RPA flights were conducted within the most prospective areas in terms of microhabitat features and habitats suitable for species of conservation significance. The use of an RPA significantly increases survey effort and reduces field-time and ambiguity over the occurrence of roosting caves. Approximately 3 hours (hrs) of flight time were undertaken across nine discrete flight locations (Figure 3.3). All flights were undertaken in accordance with Civil Aviation Safety Authority's (CASA's) Standard Operating Conditions (CASA, 2017).

Where prospective habitat was identified by the RPA, on-foot searches were undertaken to identify the occurrence of fauna of conservation significance, as well as significant habitat features. Twelve targeted searches were conducted across the Study Area.

Cave Visitations

Ghost Bats have previously been recorded from 13 locations within the Study Area (Biologic, 2013, 2016a, 2016b). Four previously recorded caves within the Study Area were re-visited and inspected for Ghost Bat usage (inclusive of MARI04, MARI12, MARI14 and MARI15). As previously mentioned, searches were conducted on-foot and via RPA in areas that have not been searched previously to identify any further cave systems. Any caves identified were inspected for evidence of the species and further sampled if deemed suitable.

Ultrasonic Recordings – Bats

Overnight recordings of bat echolocation calls were undertaken using Song Meter units (SM; Wildlife Acoustics, USA) fitted with an external, omnidirectional SMX-US ultrasonic microphone. The location of each SM unit was selected based on prospective bat habitat. The unit was positioned to provide shelter from direct sun or rain whilst retaining an unobstructed 'line of sight' between the microphone and the likely bat flyway. Each SM was preconfigured to activate at astronomical sunset each day and deactivate at astronomical sunrise the following morning. Jumper settings, audio settings, selectable filters and selectable triggers used to preconfigure each SM unit, and hence define the volume and frequency ranges sought, followed the manufacturer's recommendations for bat detection (Wildlife Acoustics, 2017).

SM units were deployed at 11 locations within the Study Area for a total of 31 recording nights (Figure 3.3; Appendix B). Bat calls were analysed by Robert Bullen of Bat Call WA.

Acoustic Recordings – Night Parrot

Overnight recordings using Song Meter 4 (SM4) acoustic units were undertaken for the Night Parrot. The SM4 acoustic recorders were deployed in potential habitat recommended within the *Interim Guideline for Preliminary Surveys of Night Parrot (Pezoporus occidentalis) in Western Australia* (DPaW, 2017) – "stands of large, old clumps of spinifex (*Triodia*)... especially so if the identified area is part of a paleo-drainage system or contains healthy stands of samphire."

SM4 units were fitted with an inbuilt SMX-II acoustic microphones and set to record between 0-500 Hz each night. SM4 units targeting Night Parrot were deployed across the Study Area at 14 locations for a total of 138 recording nights (Figure 3.3; Appendix B). All recordings were analysed by Robert Bullen of Bat Call WA. Questionable recordings were further analysed by Nigel Jackett of Broome Bird Observatory.

Motion Cameras

Twenty-three motion cameras were established across the Study Area at 12 distinct locations (Figure 3.3; Appendix B) for a total of 73 sampling nights. Motion Cameras were deployed within Gorge/ Gully, Drainage Line, Sandy Plain and Stony Plain habitat targeting Northern Quoll, Northern Brushtail Possum and Western Pebble-mound Mouse. Each camera was baited with universal bait (a mixture of oats, sardines and peanut butter).

Opportunistic Records

While traversing the Study Area, the team recorded all vertebrate fauna of conservation significance encountered, either from primary (i.e. direct observation) or secondary (e.g. burrows, scratching's, diggings and scats) evidence. The locations of all fauna of conservation significance were recorded.

VHF Towers, Bat Capture and Tagging

The VHF identification process was run using the Motus Wildlife Tracking System. Motus is an international collaborative research network, primarily based in North America, that uses an automated radio telemetry array to track the movement and behaviour of small flying organisms (Taylor *et al.*, 2017). The purpose of Motus is to facilitate landscape-scale research and education on the ecology and conservation of migrating animals (Taylor *et al.*, 2017).

A total of 12 towers were setup in the Study Area for the monitoring of volant mammals, specifically the Pilbara Leaf-nosed Bat and Ghost Bat. The towers comprised three directional towers and nine omnidirectional towers (Table 3.5, Figure 3.3).

The omni-directional towers consisted of a single mast, measuring 3 to 6 meters (m) in height, which was fitted with a 3 m high collinear omni-directional antenna. The mast of each antenna was secured to the ground using a pegged baseplate and support struts and was weighed down with heavy material. The sensitivity of each omni-directional tower was adjusted to record transmissions within approximately 750 m, giving an approximate detection area of approximately 44 ha for each tower. It should be noted that this is an indicative distance only, as the detection area for each tower varies depending on surrounding terrain.

The directional tower consisted of a single mast, measuring 3 to 6 meters in height, and fitted with 2-3 custom tuned 8-element directional Yagi antennas. The mast of each tower was secured to the ground using a pegged baseplate and support struts and was weighed down with heavy material. Additional guy-wires fixed to the ground were also used to the support the main mast and/or antennas. Where multiple antennas were mounted to a single mast, antennas were directed with consideration to the study objectives and surrounding terrain. The accuracy and maximum detection distance of each antenna depends on the terrain, although it is

expected that the detection area for most directional tower antennas was approximately 2 km. It should be noted that this is an indicative distance only, and the detection area for each tower varies depending on surrounding terrain.

Plate 3.1 VHF receiver tower installed in the Study Area

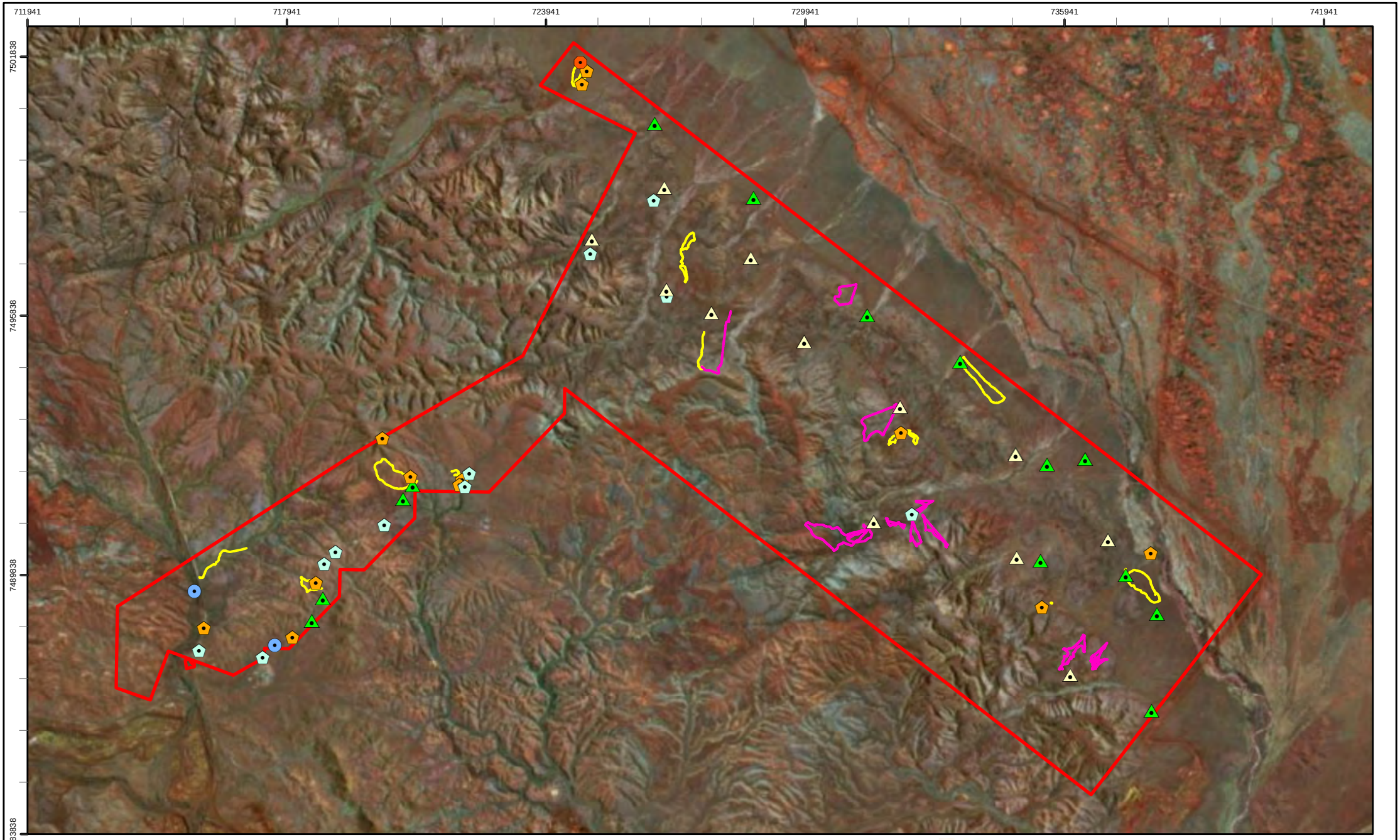
A similar array of VHF towers has also been established at the nearby Southern Flank project (35 km south-west), where one Ghost Bat has been tagged and where further tagging is likely to occur. As both systems operate using the same VHF frequency, future tagging of bats will allow insight into whether individuals move between the two areas. During the current survey, four caves (MARI-04, MARI-12, MARI-14 and MARI-15) were sheeted. No Ghost Bats or Pilbara Leaf-nosed Bats were observed during the survey and therefore tagged for VHF tracking.

Table 3.5 VHF towers installed in the Study Area

Tower name	Type	Antenna Direction	Latitude	Longitude
4B78	Directional	64º	-22.674715	119.306108
		140º		
		218º		
		285º		
AFB0	Directional	45º	-22.702995	119.298153
		120º		
		222º		
		340º		
4180	Directional	35º	-22.623834	119.205883
		120º		
		220º		
		329º		
1BDB	Omni-directional	-	-22.616956	119.224792
1FF8	Omni-directional	-	-22.647555	119.258910
8664	Omni-directional	-	-22.657143	119.285083
D812	Omni-directional	-	-22.602541	119.205104
3B27	Omni-directional	-	-22.613514	119.188964
69A2	Omni-directional	-	-22.628538	119.216108
602F	Omni-directional	-	-22.634286	119.237105
B8A3	Omni-directional	-	-22.678651	119.285611
3B01	Omni-directional	-	-22.671666	119.253333

3.2.2.1 Taxonomy and Nomenclature

BHP WAIO's checklist of vertebrate fauna was followed for nomenclature and taxonomy of mammals, birds, reptiles and amphibians. This list broadly follows the latest checklist published by the Western Australian Museum (WAM, 2018) (for mammals, reptiles and amphibians), and the current checklist of Australian birds maintained by Birds Australia (based on Christidis & Boles, 2008).



Legend

- Study Area
- **Sampling Methods**
- Acoustic
- Camera
- Habitat Assessment
- Targeted Search
- Ultrasonic
- VHF Tower
- Targeted Search - Drone
- Targeted Walks

biologic Environmental Survey

N

1:110,000

0 1.25 2.5 5 km

BHP WAIO

Marillana Targeted Vertebrate Fauna

Figure 3.3: Current survey sampling locations

Coordinate System: GDA 1994 MGA Zone 50
Projection: Transverse Mercator
Datum: GDA 1994

Size A4. Created 21/02/2019

3.3 Limitations of the survey

EPA (2016b) outlines several potential limitations to fauna surveys, which are presented and discussed in Table 3.6. It was considered that there were no material limitations to the targeted survey, and any limitations or constraints are nullified by the amount of survey work conducted in the Study Area to date.

Table 3.6 Survey limitations and constraints

Potential limitation or constraint	Applicability to this survey
Experience of personnel.	The field personnel involved in the survey each have an excess of ten years' experience undertaking fauna surveys in the Pilbara and have specific experience surveying for the target species.
Scope.	The primary objective of the survey was to determine the occurrence of vertebrate fauna species of conservation significance deemed possibly to occur within the Study Area. No factors impacted the ability to undertake this work.
Proportion of fauna identified.	Most vertebrate fauna species encountered during the survey and on motion camera were identified readily and with confidence. Detecting Ghost Bat by Song Meter recordings is limited by the fact that Ghost Bats do not always call when entering or exiting caves and their call can be variable and difficult to identify. Bat recordings from the Study Area were analysed by a well-known bat specialist, Mr Bob Bullen. All acoustic recordings were analysed by Robert Bullen of Bat Call WA. Questionable recordings were further analysed by Nigel Jackett of Broome Bird Observatory.
Sources of information (recent or historic) and availability of contextual information.	Thirteen relevant fauna surveys have been undertaken within or overlapping the Study Area and 12 surveys have been undertaken in the surrounding region. These reports were available prior to the survey and were used to inform the planning and conduct of the survey.
Proportion of the task achieved.	A targeted survey for the species of interest was completed successfully and all objectives were met effectively.
Disturbances (e.g. fire or flood).	Fire age of the Study Area was assessed at every sampling location. Such factors were taken into consideration when discussing the occurrence of target species. No disturbances impeded the completion of the survey.
Intensity of survey.	Previous trapping surveys and baseline surveys had been undertaken in the Study Area. The current survey focussed on targeted searches, ultrasonic recording, acoustic recordings and camera traps (DPaW, 2017). Therefore, the intensity was considered appropriate for the scope and in consideration of the previous work undertaken in the area.
Completeness of survey.	The Study Area, considering current and previous survey effort, has been adequately surveyed.
Resources (e.g. degree of expertise available).	All resources required to complete the survey were available.
Remoteness or access issues.	The majority of the Study Area was accessible either by vehicle or on foot, thus the sampling techniques used during this survey were unconstrained by accessibility or remoteness.

Potential limitation or constraint	Applicability to this survey
Timing of survey, weather, seasonality	Temperatures experienced during Phase 1 were considered average for the time of year, resulting in average activity patterns for species and satisfactory conditions for reptile activity. Conditions experienced during Phase 2 were considered normal for the time of year but given the cooler temperatures associated with the autumn/winter fauna activity may have resulted in reduced reptile activity. Overall, the timing of the surveys was adequate for most of the target species. Pilbara Olive Pythons are rarely encountered due to their cryptic nature, even during suitable conditions.

4 RESULTS AND DISCUSSION

4.1 Fauna Habitats

Previous habitat assessments (Biologic, 2013, 2016a, 2016b) identified nine major fauna habitat types within the Study Area: Gorge/ Gully, Hillcrest/ Hillslope, Stony Plains, Sand Plain, Sand Dunes, Mulga Woodland, Minor Drainage Lines, Major Drainage Lines, and Drainage Area/ Floodplain. The habitats mapped in Figure 4.1 have been adapted from previous work (Biologic, 2013, 2016a, 2016b) and refined to incorporate the results of additional on-site habitat assessments undertaken during the current survey. Consequently, disturbed habitats in the south western portion of the Study Area were included. Table 4.1 provides a basic description of habitat characteristics for each of the nine habitat types, along with details regarding their extent relative to the Study Area boundaries, and their suitability for the nine target fauna species. None of the habitats present are restricted to the Study Area.

Table 4.1 Fauna habitat descriptions and their extent

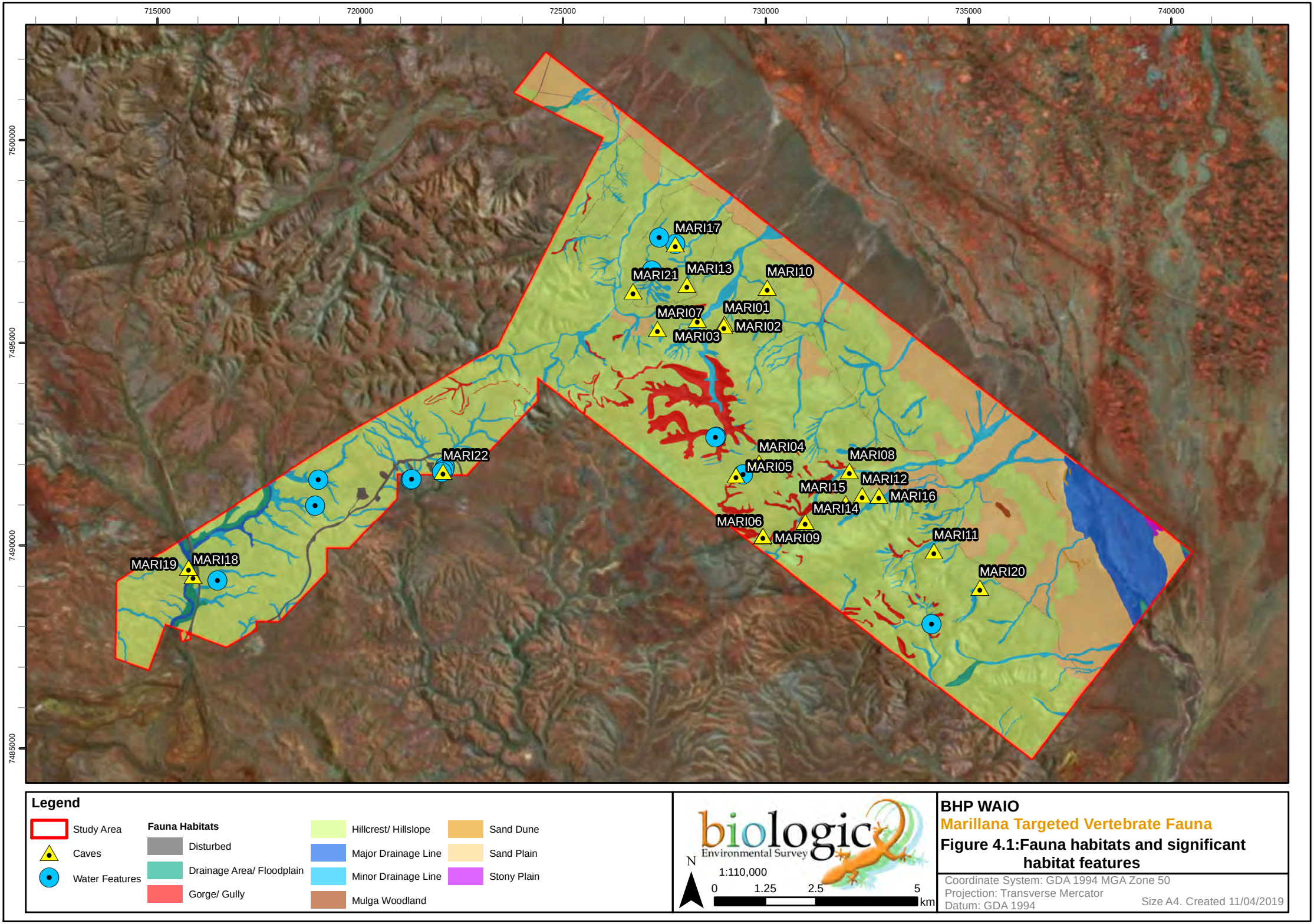
Habitat	Description	Extent within Study Area	Extent beyond Study Area	Photo
Hillcrest/ Hillslope **9,784.5 ha** **69.9%**	These fauna habitats tend to be more open and structurally simple than other fauna habitat types due to their position in landscape. A common feature of this habitat type is a rocky substrate, often with exposed bedrock, and skeletal red soils. These are usually dominated by *Eucalyptus* woodlands, *Acacia* and *Grevillea* scrublands and *Triodia* low hummock grasslands.	This habitat type occurs broadly throughout the Study Area.	A common habitat in the region, occurring wherever there are ranges. Extensive areas of Hillcrest/ Hillslope habitat occur outside the Study Area, throughout the Hamersley Range. Locally the ranges that comprise this habitat in the Study Area extend to the north-west and south-east. This habitat is well represented within national parks and conservation reserves in the Pilbara bioregion.	
Sand Plain **1,982.5 ha** **14.2%**	This habitat is characterised by relatively deep sandy soils supporting dense spinifex grasslands and sparse shrubs. This habitat often occurs as terraces along Major Drainage Lines and extensive plains.	Sand Plain occur as alluvial deposits fanning from Weeli Wolli Creek in the south east, and in the lower landscapes along the north eastern boundary. Sand Plain extend to the east and north of the Study Area.	Common habitat throughout the Fortescue and Chichester sub-regions of the Pilbara, especially in the north and east. Also common within the Augustus sub-region of the Gascoyne, which extends south and east of the Study Area. An infrequently encountered habitat in the region possibly formed as a river floodplain where fine material has been deposited. Occurs within national parks in the Pilbara.	

Habitat	Description	Extent within Study Area	Extent beyond Study Area	Photo
Minor Drainage Line **1,034.8 ha** **7.4%**	Located within the minor gullies and depressions, generally through the Hillcrest/ Hillslope habitat type. Consists primarily of *Eucalyptus xerothermica* and *Corymbia hamersleyana* woodland over broad-leafed *Acacia* shrubland. The substrate can be sandy in places but generally consists of a skeletal loam gravel or stone.	Many fragmented occurrences running throughout the Study Area. Each of these habitats appears to be well connected to other similar habitat types beyond the Study Area boundaries.	A common habitat type in the Hamersley Range adjacent to the northern parts of the Study Area. Occurs within national parks and conservation reserves in the Pilbara.	
Major Drainage Line **526.2 ha** **3.8%**	Major Drainage Lines comprise mature River Red Gums/ Coolabahs over dry river pools. Open, sandy or gravelly riverbeds characterise this habitat type. In non-grazed areas, the vegetation adjacent to the main channel or channels is denser, taller and more diverse than adjacent terrain. These large eucalypt species typically contain a number of significant hollows used by birds and mammals for roosting and nesting. Buffel Grass (**Cenchrus ciliaris*) occurs in varying densities along the banks of the major drainage line. May hold temporary waterbodies (days to weeks) following significant rainfall.	A broad patch of habitat is present in the far North east of the Study Area, which represents a very minor portion of Weeli Wolli Creek. This habitat type also occurs in the south west of the Study Area.	Common habitat type throughout the Pilbara and is generally associated with all major rivers in the Pilbara, such as the Fortescue, De Grey, Yule and Turner Rivers. Major Drainage Lines are inherently continuous and extensive (in a linear sense), but because they tend to be narrow, they represent a small proportion of the total land area. The habitat associated with Weeli Wolli Creek extends to the north and south of the Study Area. Occurs within national parks in the Pilbara.	

Habitat	Description	Extent within Study Area	Extent beyond Study Area	Photo
Gorge/ Gully **461.6 ha** **3.3%**	Gorges and gullies are rugged, steep-sided valleys incised into the surrounding landscape. Gorges tend to be deeply incised, with vertical cliff faces, while gullies are more open (but not as open as Minor Drainage Lines). Caves and rock pools are most often encountered in this habitat type. Vegetation can be dense and complex in areas of soil deposition or sparse and simple where erosion has occurred.	Fragmented occurrences within the mountainous areas in the south eastern parts of the Study Area. A series of large, steep sided gorges and deep gullies occur central part of the Study Area. These occurrences are spatially limited within the Study Area. A gorge containing potentially permanent water with riparian vegetation (*Eucalyptus camaldulensis* and *Typha domingensis*) was recorded in the south western part of the Study Area.	Gorges and gullies are a widespread features of the Hamersley Range, but because they tend to be narrow, linear features, they represent a small proportion of the total land area. These habitats are well represented to the north west and south east of the Study Area. Occurs within national parks and conservation reserves in the Pilbara.	
Drainage Area/ Floodplain **94.4 ha** **0.7%**	Characterised by *Eucalyptus xerothermica* and *Corymbia hamersleyana* woodland over broad-leafed *Acacia* shrubland on sandy loam soils. These can have high vegetation density, complexity and diversity, and because they tend to occur on accretional or depositional areas they often have deeper and richer soils than other fauna habitats. Grasses tend to be dominated by tussock grasses rather than spinifex, or the weed Buffel Grass (**Cenchrus ciliaris*).	Several small patches in the south east of the Study Area, one in the north and two small areas of this habitat type in the south east and south west of the Study Area, associated with the Major Drainage Lines. The latter two extents are well connected outside of the Study Area by a major tributary of Marillana Creek.	Moderately extensive along major rivers and creeks. The Fortescue Marsh is the most extensive form or this habitat within the wider region. Occurs within national parks in the Pilbara.	

Habitat	Description	Extent within Study Area	Extent beyond Study Area	Photo
Sand Dune **8.1 ha** **0.1%**	Dunes and ridges of loose sand supporting similar species to the surrounding Sand Plain, dominated by *Triodia* sp. grasslands and areas of *Acacia* spp. shrubland.	The habitat within the Study Area is small and restricted to five small patches in the eastern of the Study Area.	Sand Dunes are uncommon in the Pilbara. Sand Dunes are present in the Fortescue Plain to the north east of the Study Area. Occurs within national parks in the Pilbara.	
Stony Plain **7.9 ha** **0.1%**	Erosional surfaces of gently undulating plains, ridges and associated footslopes. Mainly support hard spinifex (and occasionally soft spinifex) with a mantle of gravel and pebbles.	Restricted to one small area in the north east of the Study Area.	Common habitat throughout the Pilbara, especially in the south east. Occurs within national parks in the Pilbara.	

Habitat	Description	Extent within Study Area	Extent beyond Study Area	Photo
Mulga Woodland **5.7 ha** **0.04%**	This habitat includes woodlands in which Mulga (formerly *Acacia aneura*) is dominant.	Restricted to one small area in the east of the Study Area. Mulga is also a component of Stony Plain habitat in the south east of the Study Area.	This habitat type is a common and widespread habitat of the region and of the Australian arid-zone generally. Mulga itself is believed to occupy ~20% of the continent and is keystone group for many ecosystems (Maslin & Reid, 2009). The Study Area is near the northern extent of Mulga distribution in Western Australia, but Mulga Woodlands cover much of the region and extend south and east across the central arid zone of the continent. Occurs within national parks in the Pilbara.	


715000
720000
725000
730000
735000
740000
7500000
7495000
7490000
7485000
MARI17
MARI21
MARI13
MARI10
MARI07
MARI01
MARI02
MARI03
MARI22
MARI04
MARI05
MARI08
MARI12
MARI15
MARI16
MARI14
MARI06
MARI09
MARI11
MARI20
MARI19
MARI18
Legend
Study Area
Caves
Water Features
Fauna Habitats
Disturbed
Drainage Area/ Floodplain
Gorge/ Gully
Hillcrest/ Hillslope
Major Drainage Line
Minor Drainage Line
Mulga Woodland
Sand Dune
Sand Plain
Stony Plain
N
1:110,000
0
1.25
2.5
5
km
biologic
Environmental Survey
BHP WAIO
Marillana Targeted Vertebrate Fauna
Figure 4.1:Fauna habitats and significant habitat features
Coordinate System: GDA 1994 MGA Zone 50
Projection: Transverse Mercator
Datum: GDA 1994
Size A4. Created 11/04/2019

4.2 Potential Significance of Habitats Recorded in the Study Area

Each of the nine major fauna habitats identified in Table 4.1 was given a significance score of High, Medium or Low based on the likelihood of supporting conservation significant fauna, as outlined in Table 3.4, summarised in Table 4.2 and detailed in Section 4.4 Within the Study Area, Gorge/Gully and Major Drainage Line habitats were given High significance scores because they are most likely to support species of conservation significance.

Table 4.2: Potential significance of fauna habitat types and justification for significance

Habitat Type	Significance	Target Species Recorded within the Study Area	Target Species Potentially Supported	Justification for significance
Gorge/ Gully	High	• Northern Quoll (denning, foraging) · • Pilbara Olive Python (denning, foraging) · • Chocolate Wattle Bat (foraging) • Ghost Bat (*Macroderma gigas)* (Biologic, 2014, 2018) • Pilbara Flat-headed Blind-snake *(Anilios ganei)* (Biologic, 2013)	• Pilbara Leaf -nosed Bat (foraging [priority 1]) • Ghost Bat (foraging, dispersal) • Northern Brush-tailed Possum (denning, foraging) • Peregrine Falcon (nesting) • Pilbara Flat-headed Blind Snake	Whilst common, this habitat is limited in extent throughout the Pilbara and is prone to forming important habitat features such as overhangs, caves and water features. It is known to provide core habitat for the following EPBC Act and BC Act listed fauna that have been recorded within the Study area: Northern Quoll, Ghost Bat and Pilbara Olive Python. It is also potential core habitat for the EPBC Act and BC Act listed Pilbara Leaf-nosed Bat (recorded within 4 km of the Study Area) and Northern Brushtail Possum (recorded within 60 km of the Study Area). Furthermore, it provides potential nesting habitat for the Peregrine Falcon (Other Specially Protected Species under the BC Act), the Pilbara Flat-headed Blind Snake (DBCA priority listed species) as well as the Chocolate Wattle Bat (locally significant species).
Major Drainage Line	High	• Northern Quoll (foraging, dispersal) · • Peregrine Falcon (nesting, foraging)	• Pilbara Leaf-nosed Bat (dispersal and foraging [priority 4]) • Ghost Bat (foraging) • Pilbara Olive Python (foraging, dispersal) • Northern Brushtail Possum (denning, foraging, dispersal) • Pilbara Flat-headed Blind Snake • Chocolate Wattle Bat (foraging)	Whilst common, this habitat is limited in extent throughout the Pilbara. The habitat provides foraging and/or dispersal habitat for the following EPBC Act and BC Act listed fauna that have been recorded within the Study area: Northern Quoll, Ghost Bat and Pilbara Olive Python. It is also potential Priority 4 foraging habitat for the EPBC Act and BC Act listed Pilbara Leaf-nosed Bat (recorded within 4 km of the Study Area). Major Drainage Lines provide key denning habitat for the BC Act listed Northern Brushtail Possum - the nearest record of this species is 60 km to the south-west and is therefore valuable habitat. Additionally, Major Drainage Lines also provide habitat for Peregrine Falcon (Other Specially Protected Species under the BC Act), Pilbara Flat-headed Blind Snake (Priority 1) and Chocolate Wattle Bat (locally significant fauna).

Habitat Type	Significance	Target Species Recorded within the Study Area	Target Species Potentially Supported	Justification for significance
Sand Plain	Moderate	• Western Pebble Mound Mouse *(Pseudomys chapmani)* (Biologic, 2013)	• Night Parrot (nesting, foraging) • Ghost Bat (foraging)	Preferred habitat for the Night Parrot is thought to consist of *Triodia* grasslands in stony or sandy environments Therefore, this habitat is the most likely habitat to meet the definition of core habitat for the Night Parrot (refer to Section 4.4.1 for further detail). The nearest record of the species is located 20 km north of the Study Area. This species would have the capability to access the Sand Plain within the Study Area from other areas (such as the productive Fortescue Marsh to the north; Davis & Metcalf, 2008) if required. Night Parrot have been recorded flying up to 40 km per night foraging (Murphy et al., 2017). Due to this habitat being adjacent to the highly productive Fortescue Marsh as well as the habitats attributes and resulting assemblages, it has the potential to provide key foraging habitat for the Ghost Bat (refer to Section 4.4.4 for further detail). Sandplain may also provide core habitat for other species of conservation significance not assessed as part of this assessment but potentially solely reliant on this habitat type e.g. the Greater Bilby and Brush-tailed Mulgara.
Sand Dune	Moderate	• Peregrine Falcon	• Ghost Bat (foraging, dispersal)	This habitat is considered rare and unique within the region. Due to this habitat being adjacent to the highly productive Fortescue Marsh it has the potential to provide key foraging habitat for the Ghost Bat. However, this species is not solely reliant on this habitat type. Sand Dune may also provide core habitat for other species of conservation significance not assessed as part of this assessment but potentially solely reliant on this habitat type: the Greater Bilby and Brush-tailed Mulgara.

Habitat Type	Significance	Target Species Recorded within the Study Area	Target Species Potentially Supported	Justification for significance
Minor Drainage Line	Moderate	• Pilbara Olive Python (foraging, dispersal) · • Peregrine Falcon • Western Pebble Mound Mouse *(Pseudomys chapmani)* (Biologic, 2011c; ecologia, 2006) • Ghost Bat *(Macroderma gigas)* (Biologic, 2013, 2014)	• Northern Quoll (foraging, dispersal) • Pilbara Leaf-nosed Bat (dispersal, foraging [priority 4]) • Ghost Bat (foraging, dispersal) • Northern Brush-tailed Possum (denning, foraging) • Pilbara Flat-headed Blind Snake	Minor Drainage Line habitat does not support conservation listed species at the broad scale, and any conservation species occurring are not restricted to this habitat type. It is represented as an extension of the Gorge/ Gully habitat and thus provides similar habitat features to this habitat type, although to a much lesser extent. The habitat provides foraging and/or dispersal habitat (i.e. not core habitat) for the following EPBC Act and BC Act listed fauna that have been recorded within the Study area: Northern Quoll, Ghost Bat and Pilbara Olive Python. It is also potential Priority 4 foraging habitat for the EPBC Act and BC Act listed Pilbara Leaf-nosed Bat (recorded within 4 km of the Study Area). This habitat type also provides potential denning and foraging habitat for Northern Brushtail Possum - the nearest record of this species is 60 km to the south-west. Minor Drainage Lines also provide habitat Pilbara Flat-headed Blind Snake (Priority 1).
Drainage Area/ Floodplain	Moderate	-	• Night Parrot (nesting, foraging) • Ghost Bat (foraging, dispersal) • Pilbara Leaf-nosed Bat (dispersal, foraging [priority 5]) • Peregrine Falcon (foraging) • Pilbara Flat-headed Blind Snake • Chocolate Wattle Bat (foraging)	Palaeo-drainage systems or areas containing healthy stands of samphire provide potential habitat for Night Parrot (DPaW, 2017). Therefore, Drainage Area/ Floodplain habitat may provide potential roosting habitat for the Night Parrot (refer to Section 4.4.1 for further detail). The nearest record of the species is located 20 km north of the Study Area. This species would have the capability to access the Sand Plain within the Study Area from other areas (such as the productive Fortescue Marsh to the north; Davis & Metcalf, 2008) if required - Night Parrot have been recorded flying up to 40 km per night foraging (Murphy et al., 2017). It also provides potential foraging habitat for the Ghost Bat and Pilbara Leaf-nosed Bat, which are both listed as Vulnerable under the EPBC Act and BC Act. This habitat is utilised by several species listed as Other Specially Protected Species under the BC Act and Priority fauna, but these species are not restricted to this habitat type.

Habitat Type	Significance	Target Species Recorded within the Study Area	Target Species Potentially Supported	Justification for significance
Mulga Woodland	Moderate	-	• Ghost Bat (foraging and dispersal)	This habitat type is widespread regionally occurring both within and outside the Pilbara. This habitat type is known to provide for unique assemblages, whereby species known to occur within Mulga Woodland habitats are typically restricted to this habitat type, albeit common. Ghost Bats generally hunts via a sit and inspect'' foraging strategy (Boles, 1999) from vantage points (Tidemann *et al.*, 1985). Therefore, the Mulga Woodland is considered potential foraging habitat for the Ghost Bat which is listed as Vulnerable under the EPBC Act and BC Act.
Hillcrest/ Hillslope	Low	• Western Pebble Mound Mouse *(Pseudomys chapmani)* (Biologic, 2011a, 2011c, 2013, 2016a; ecologia, 2006) • Ghost Bat *(Macroderma gigas)* (Biologic, 2013, 2014, 2018) • Peregrine Falcon • Pilbara Flat-headed Blind-snake *(Anilios ganei)* (Biologic, 2013)	• Pilbara Flat-headed Blind Snake • Western Pebble-mound Mouse	Hillcrest/hillslope is a relatively common habitat type throughout the both the Pilbara and the local region. Hillcrest/slope habitat supports local populations of the Western Pebble-mound Mouse. Provides potential supporting habitat for some conservation listed species and may be used intermittently, however these species are not restricted to the habitat type.
Stony Plain	Low		Western Pebble-mound Mouse	Provides habitat for the Western Pebble-mound Mouse, listed by DBCA. This habitat is a relatively common habitat type throughout both the Pilbara and the local area.

4.3 Significant Habitat Features

4.3.1 Caves

Prior to the current survey, 19 caves were known from the Study Area, comprising three recorded by Biota (2012b), ten caves recorded by Biologic (2013), five caves recorded by Biologic (2016b) and one cave recorded by Biologic (2016a). The cave recorded by Biologic (2016a) is located above a large, potentially permanent water feature in Gorge/ Gully habitat (Figure 4.1). Due to cave morphology, the cave was not able to be fully assessed. However, it was considered to be a potential day roost owing to its reasonably large, horizontal entrance located approximately 50 m from a likely permanent water feature.

One cave (MARI21) was discovered during a previous survey (Biologic, 2013) and re-visited during the current survey. During the current survey the cave was deemed inaccessible due to barricading, and therefore could not be fully assessed. However, the cave is potentially suitable for Ghost Bat. This cave is a large upward facing sinkhole cavity that had species of *Taphozous* flying around and into it at the time of the survey.

During the current survey, three previously unrecorded caves (MARI18, MARI19 and MARI20) were discovered within the Study Area (Figure 4.1, Appendix C). MARI18 was not assessed as it was located below a rail line, and therefore could not be safely accessed. The first chamber was observed to span 10 meters where it came to a constriction that opened into a second chamber. As this cave appeared suitable from the outside, it has been deemed a potential day roost for the Ghost Bat on a precautionary basis.

Although neither of the remaining two caves (MARI19 and MARI20) contained any Ghost Bat scats, they were deemed potential day roosts. As outlined in Section 2.4, possible diurnal roosts have attributes that make them suitable for shelter during the day, but no Ghost Bats have been recorded using them during the day. MARI19 comprised a very high roof (5.5 metre) and a relatively deep chamber (20 metres). Water was also present within 50 metres of this cave. MARI20 comprised two chambers and was a relatively deep cave (18 metres) making it quite dark inside (Appendix C).

4.3.2 Water Features

Water sources are a limiting factor for many ecosystems (James *et al.*, 1995), particularly within arid-zone ecosystems, such as the Pilbara (Burbidge *et al.*, 2010; Doughty *et al.*, 2011), and often represent areas of comparatively high productivity (Murray *et al.*, 2003). Mammals and birds have endothermic metabolisms and thus require relatively continuous sources of food and moisture, while water for amphibians provides opportunities to forage (i.e. suitably wet periods) and breed (i.e. when water pools for long enough for them to complete the life cycle) (James *et al.*, 1995). These features are highlighted because they may provide important sources of shelter (for roosting, breeding, or dispersal), food and water for species of conservation significance.

Prior to the current survey, four water features were known from the Marillana Exploration Lease, two are potentially permanent and two are potentially semi-permanent (Biologic, 2013). A further nine water features were known from the Marillana Infrastructure Corridor (Biologic, 2016a) within Gorge/ Gully and Minor Drainage Line habitat types (Figure 4.1). Six of these water features were regarded as moderately large and potentially semi-permanent and may hold surface water following substantial rainfall events. Depending on the amount of rainfall and seasonality it is possible that the water features could retain surface water for several months (Biologic, 2016a).

The largest water feature is in a deep Gorge/ Gully habitat (Figure 4.1) and is potentially permanent, as it is possibly fed (or maintained) by groundwater seepage (Biologic, 2016a). Prior to the Biologic (2016a) survey there had only been 13.2 mm of rainfall recorded at Barimunya Airport in December 2015 and in the first half of January 2016, with no falls greater than 6.2 mm (BoM, 2016). Despite the lack of rainfall prior to the survey, water was observed flowing out of the rock at the head of this water feature. Surrounding the water feature were large stands of wetland vegetation such as *Typha domingensis* and *Eucalyptus camaldulensis*, while aquatic plants and fish (the Spangled Perch, *Leiopotherapon unicolour*) were present in the water. The Chocolate Wattle Bat was recorded near this water feature seepage (Biologic, 2016a). In addition, the current survey recorded a Northern Quoll individual (via motion camera) and scat near this water feature. The feature contained the same water level as previous surveys.

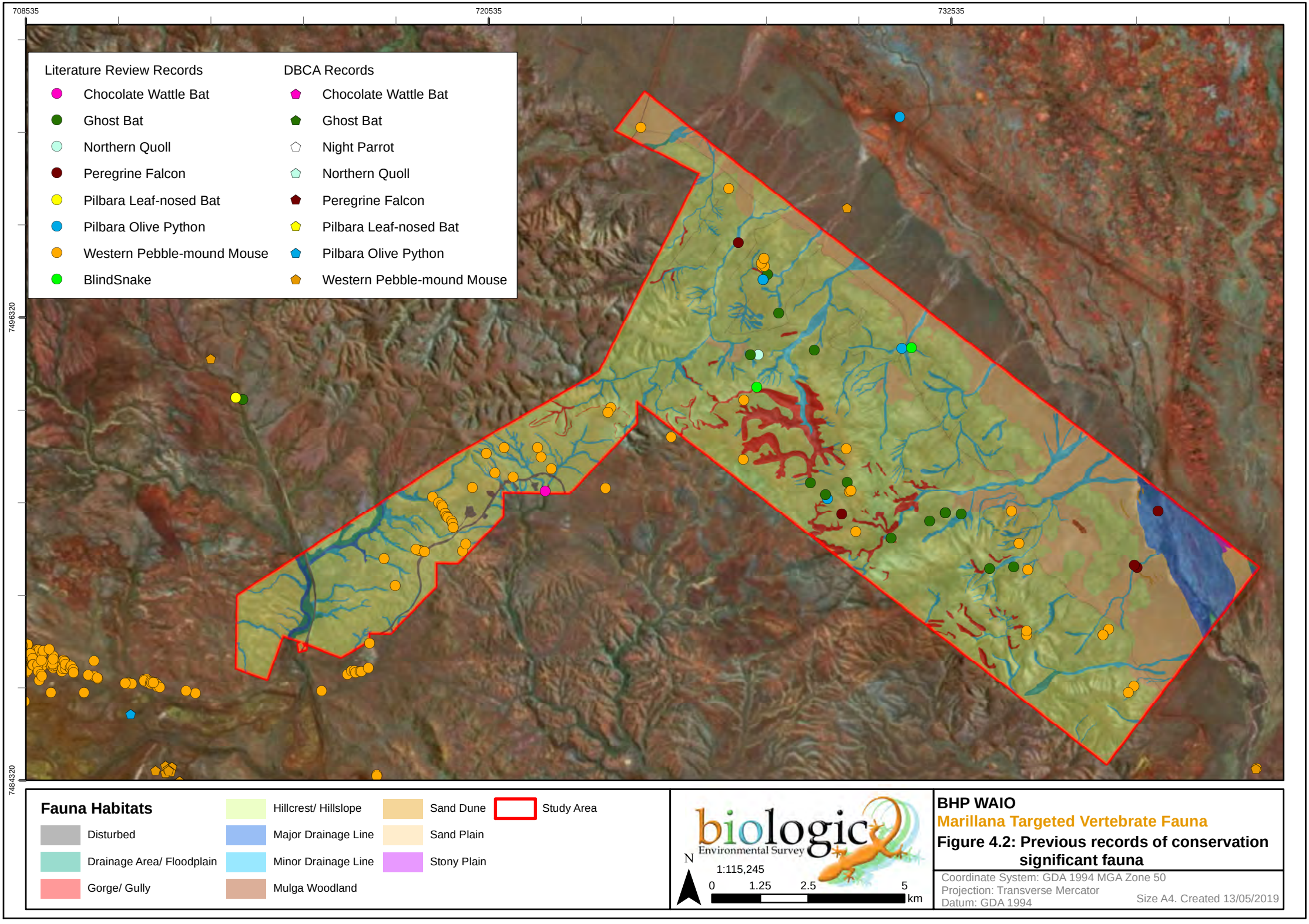
During the current survey, two additional water features were discovered within the Study Area (Figure 4.1, Appendix D). Although no species of conservation significance were recorded at these water features during the current survey period, there is potential that they may provide a resource for such species at other times of the year when water is scarce in the landscape and/or conditions are generally hotter and drier.

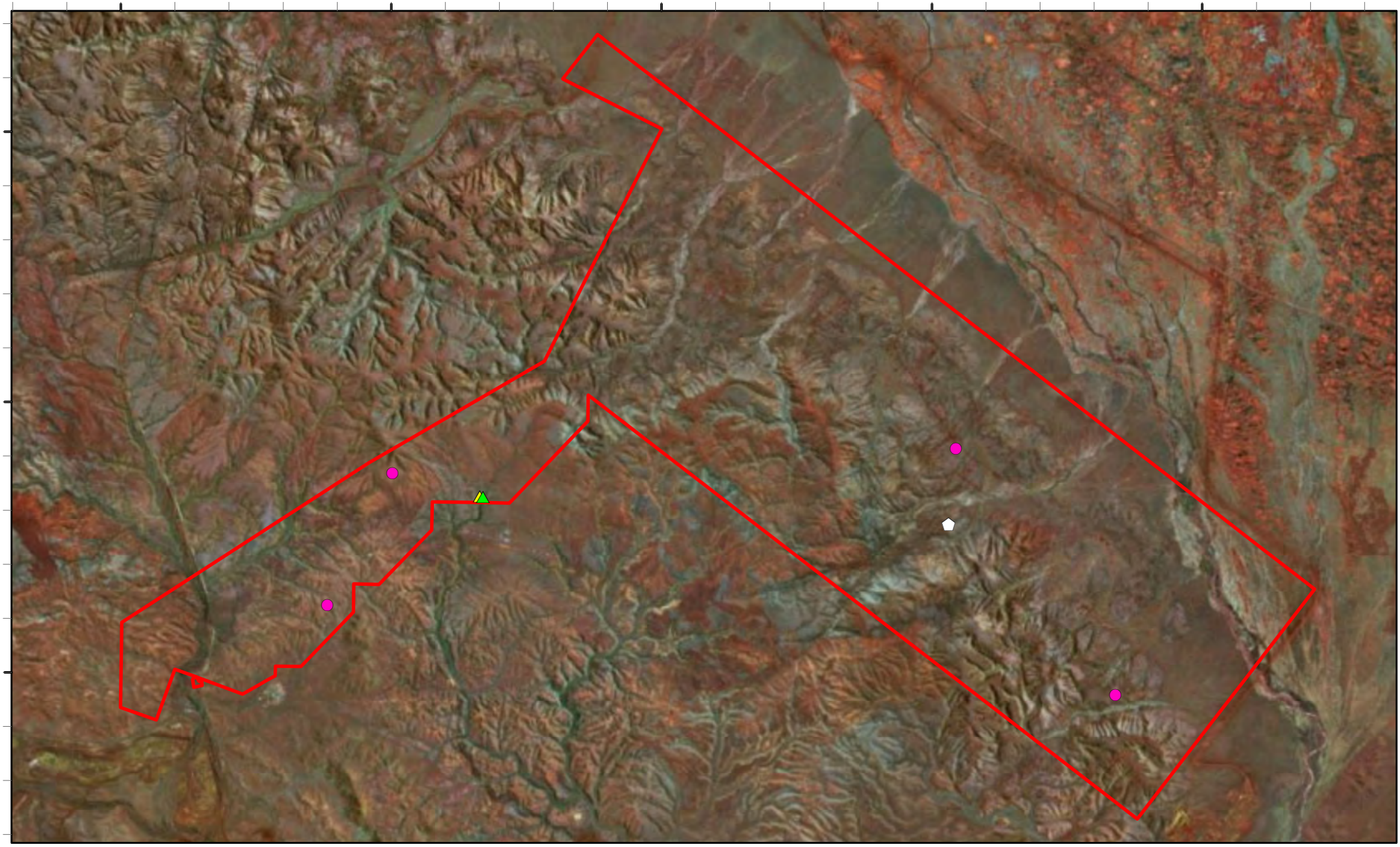
4.4 Occurrence of Conservation Significant Fauna

A total of 25 survey reports were assessed during the desktop component, 13 of which have been conducted within or overlapping the Study Area. A summary of survey intensity and key findings from these surveys is documented in Appendix F.

A total of 41 vertebrate fauna species of conservation significance, comprising nine mammal species, 26 bird species, six reptiles, have been recorded within the vicinity of the Study Area or have distributions that overlap the Study Area (Appendix G).

To date, six of the targeted species have been recorded within the Study Area (Figure 4.2, Figure 4.3): Northern Quoll (current survey; Biologic, 2013), Ghost Bat (current survey; Biologic, 2013; Biologic, 2016a, 2016b), Pilbara Olive Python (Biologic, 2013, 2016b), Peregrine Falcon (Biologic, 2013), Pilbara Flat-headed Blind Snake (Biologic, 2013) and Western Pebble-mound Mouse (current survey; Biologic, 2011a, 2013, 2016a, 2016b; ecologia, 2006). In addition, the Chocolate Wattle Bat is considered to be of local significance and has previously been recorded in the Study Area (Biologic, 2016a). Night Parrot and Pilbara Leaf-nosed Bat have not previously been recorded in the Study Area. Details of previous records and the extent of suitable habitat within the Study Area for each of the target species is detailed below.


708535
720535
732535
7496320
7484320
Literature Review Records
Chocolate Wattle Bat
Ghost Bat
Northern Quoll
Peregrine Falcon
Pilbara Leaf-nosed Bat
Pilbara Olive Python
Western Pebble-mound Mouse
BlindSnake
DBCA Records
Chocolate Wattle Bat
Ghost Bat
Night Parrot
Northern Quoll
Peregrine Falcon
Pilbara Leaf-nosed Bat
Pilbara Olive Python
Western Pebble-mound Mouse
Fauna Habitats
Disturbed
Drainage Area/ Floodplain
Gorge/ Gully
Hillcrest/ Hillslope
Major Drainage Line
Minor Drainage Line
Mulga Woodland
Sand Dune
Sand Plain
Stony Plain
Study Area
biologic Environmental Survey
N
1:115,245
0 1.25 2.5 5
km
BHP WAIO
Marillana Targeted Vertebrate Fauna
Figure 4.2: Previous records of conservation significant fauna
Coordinate System: GDA 1994 MGA Zone 50
Projection: Transverse Mercator
Datum: GDA 1994
Size A4. Created 13/05/2019



Legend

Species of Conservation Significance

- Northern Quoll - Individual (alive)
- Ghost Bat - Scat
- Western Pebble-mound Mouse - Mound (recently inactive)
- Northern Quoll - Scat
- Study Area

biologic Environmental Survey

N

1:108,599

0 1.25 2.5 5 km

BHP WAIO

Marillana Targeted Vertebrate Fauna

Figure 4.3: Records of target species recorded during the survey

Coordinate System: GDA 1994 MGA Zone 50
Projection: Transverse Mercator
Datum: GDA 1994

Size A4. Created 12/05/2019

4.4.1 Night Parrot

Previous Records

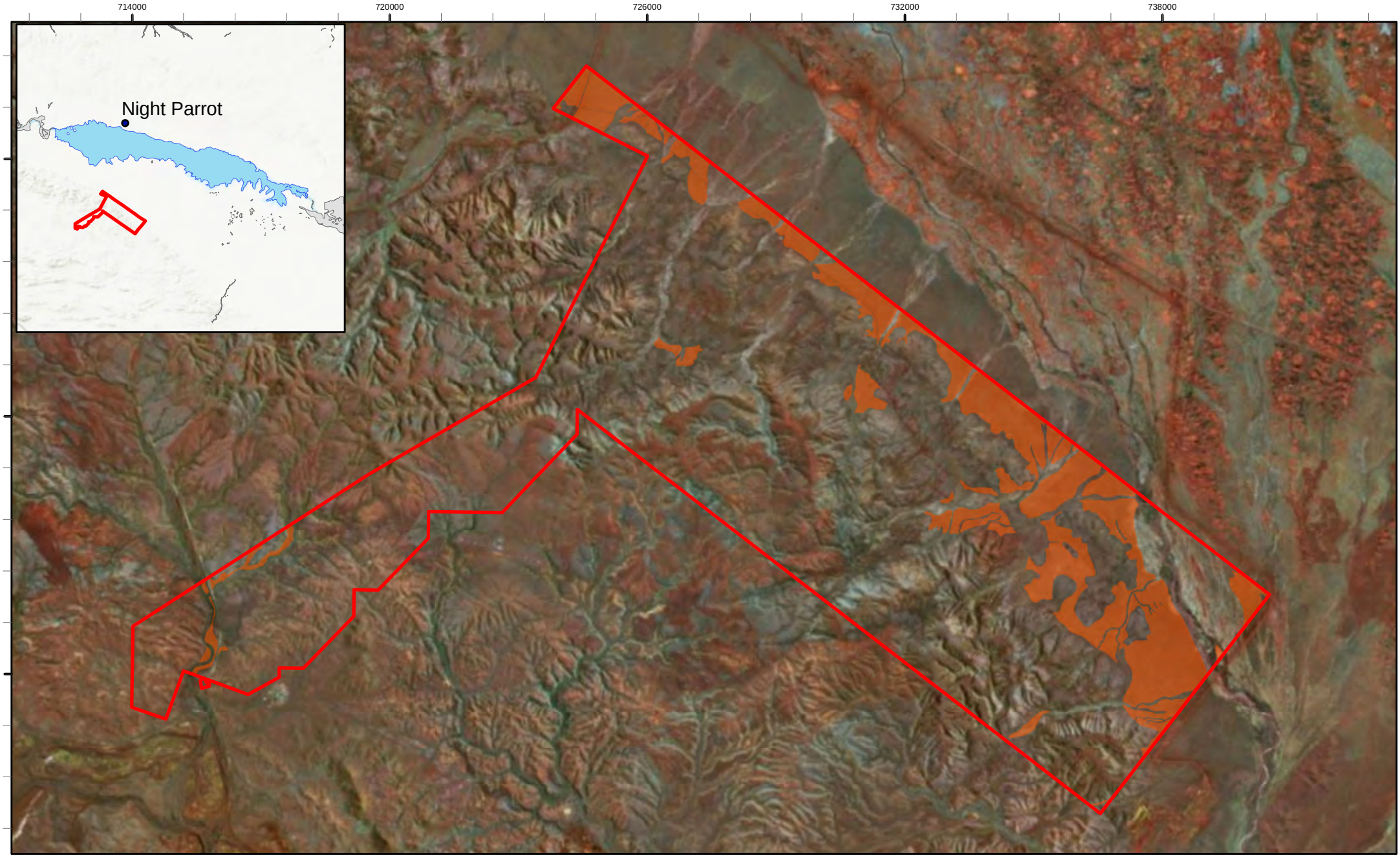
The Night Parrot is known from a few historical records within the Pilbara. The nearest contemporary record (April 2005) within the Pilbara region was located at Minga Well approximately 20 km north of the Study Area, on the northern side of the Fortescue Marsh (Davis & Metcalf, 2008). Records thereafter are approximately 148 km west of the Study Area from 1970 and approximately 173 km north of the Study Area from 1980 (DBCA, 2018a).

Habitats Within the Study Area

The Study Area falls within the potential distribution of Night Parrot (DPaW, 2017). As outlined in Section 2.1, the preferred habitat for the Night Parrot is thought to consist of *Triodia* grasslands in stony or sandy environments (McGilp, 1931; North, 1898; Whitlock, 1924; Wilson, 1937) and of samphire and chenopod shrublands on floodplains and claypans, as well as margins of salt lakes, creeks or other sources of water (McGilp, 1931; Wilson, 1937). The Study Area contains potentially suitable habitat for this species in Sand Plain, and Drainage Area/ Floodplain habitats (refer to Table 4.1 for extent of habitat) located along the north-eastern border and small central patches of the Study Area (Figure 4.4). More specifically, roosting and nesting habitat for this species requires old-growth spinifex (*Triodia*) (DPaW, 2017). Sand Plain and Drainage Area/ Floodplain habitat within the Study Area contain stands of *Triodia* hummock grasses that grow to a suitable size and therefore, may potentially provide nesting habitat for the species (Plate 4.1). However, not all instances of *Triodia* are suitable due to fire and thus are of an inappropriate age or size to support Night Parrot. However, burnt habitats would again become suitable for the species as the grasses regenerate in a burnt patch. In the case of Night Parrot, fire regimes and the reoccurring presence of fire needs to be considered. Therefore, this temporal snapshot of the habitat should not solely be used to exclude the potential of suitable habitat within the Study Area. It should be noted that that no available survey technique can irrefutably demonstrate that Night Parrots are absent from a site (DPaW, 2017).

Foraging habitats are thought to comprise various grasses and herbs (Murphy *et al.*, 2017). Therefore, *Triodia* grasslands in Sand Plain habitats seasonally provide seed. Moreover, Drainage Area/ Floodplain habitats typically contain annual and herbaceous plants that are thought to be suitable for Nigh Parrot. Foraging habitat is not necessarily adjacent to roosting habitat (Murphy *et al.*, 2017); although foraging habitat adjacent to or within about 10 km of suitable roosting habitat is likely to be more important (DPaW, 2017). The species has been proven to fly up to at least 40 km in a single night (Murphy *et al.*, 2017) and it is reasonably assumed that the species can fly a cumulative distance of at least 100km between roosting and foraging habitat (Night Parrot Recovery Team, 2017). Therefore, the Study Area is located within the nightly flight distance of suitable foraging grounds in the Fortescue Marshes (Davis & Metcalf, 2008). While potential habitat for the species exists within the Study Area, the species is generally rare and not confirmed to reside within the Pilbara region, as such it is deemed unlikely that the species permanently resides within the Study Area.

Plate 4.1 Sandy/Stony Plain habitat with large *Triodia* of a suitable size for Night Parrot (Sampling Site MARI.02)



Legend

- Study Area
- Night Parrot
- **Potential Night Parrot Habitat**
  - Nesting and Foraging (Sand Plain, Drainage Area/Floodplain)

biologic Environmental Survey

N

1:113,903

0 1.25 2.5 5 km

BHP WAIO

Marillana Targeted Vertebrate Fauna

Figure 4.4: Potential Night Parrot habitat within the Study Area

Coordinate System: GDA 1994 MGA Zone 50
Projection: Transverse Mercator
Datum: GDA 1994

Size A4. Created 13/05/2019

4.4.2 Northern Quoll

Previous Records

The Northern Quoll has been previously recorded numerously within 35 km of Study Area, at South Flank (Biologic, 2012b), Hope Downs (Biota, 2011) Camp Hill/ Tandanya (Onshore & Biologic, 2011), Yandi (Biologic, 2011b; BHP Biliton Iron Ore fauna database 2016) and Koodaideri (Biota, 2012b), which is thought to host a resident population.

Despite the extensive survey effort within the Study Area and the availability of suitable habitat, evidence of Northern Quoll has only been recorded on three occasions within the Study Area. The database searches and literature review returned one scat record for Northern Quoll within the Gorge/ Gully habitat of Study Area (Biologic, 2013). During the current survey, an individual was caught on motion camera and a scat was recorded within Major Drainage Line Habitat in the central to south western portion of the Study Area (Figure 4.3).

Plate 4.2: Northern Quoll caught on motion camera within the Study Area

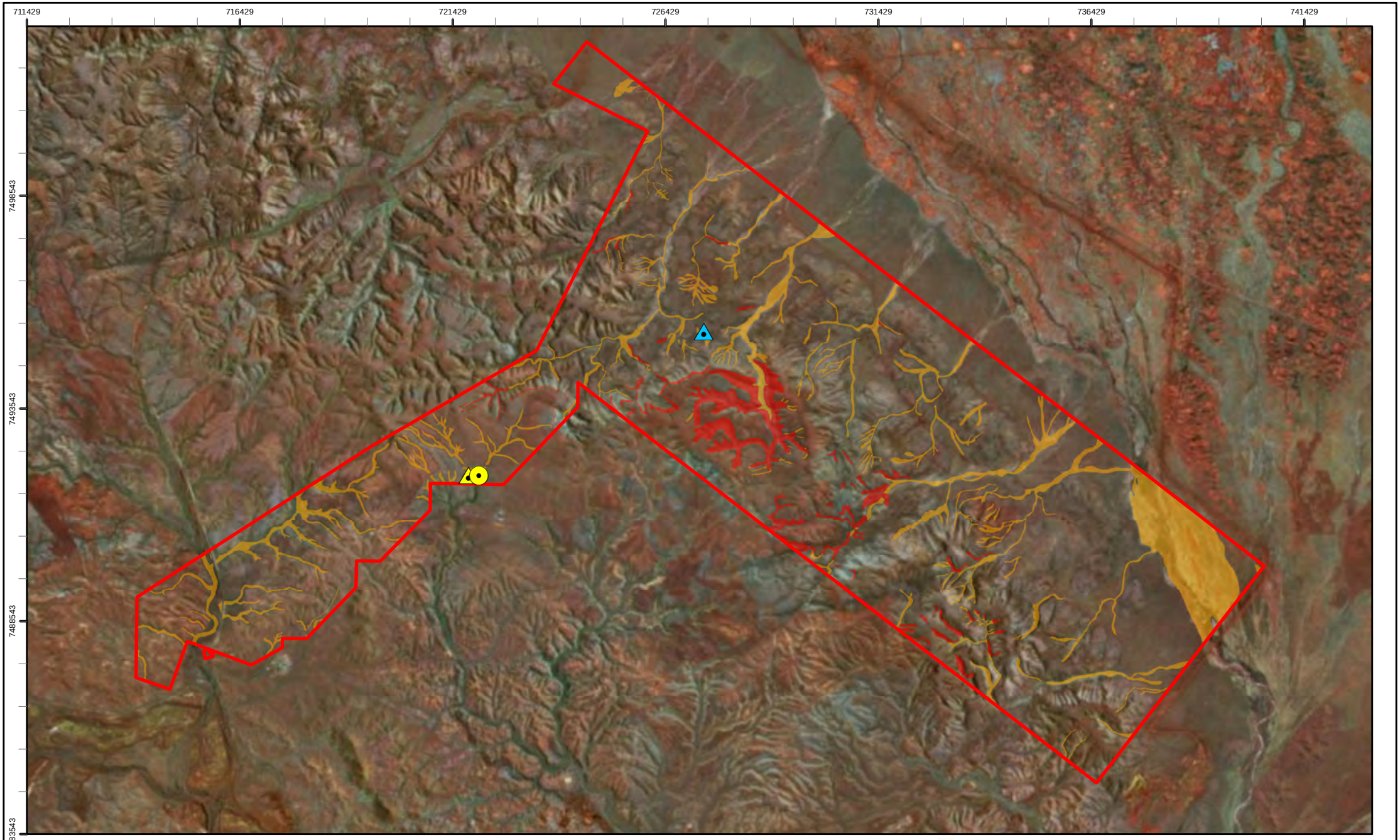
Habitats Within the Study Area

The Study Area falls within the distribution of Northern Quoll (DoE, 2016). As outlined in Section 2.2, rocky habitats tend to support higher densities of Northern Quoll, as they offer protection from predators and are generally more productive in terms of resources availability (Braithwaite & Griffiths, 1994; Oakwood, 2000). Therefore, within the Study Area denning habitat for Northern Quoll is provided by the Gorge/ Gully habitat (Figure 4.5). Gorge/ Gully (refer to Table 4.1 for extent of habitat) which is found throughout the higher elevations of the Hillcrest/ Hillslope area, along the southern border and the central portion of the Study Area.

Foraging habitat is typically provided by the Major Drainage Lines, and dispersal corridors are generally provided by Major Drainage Line and Minor Drainage Line habitats. The Major Drainage Line habitat is located in the north eastern corner (associated with Weeli Wolli Creek)

and south western portion of the Study Area while Minor Drainage Line habitat is scattered throughout the Study Area (Figure 4.5).

These habitats are contiguous with surrounding areas and are considered to be common in this part of the Hamersley Range. Based on the occurrence of suitable Gorge/ Gully habitats within the Study Area, it is possible that the Northern Quoll could occur occasionally whilst dispersing. Nevertheless, owing to the rarity of this species within the Hamersley Ranges and the low number of records within the Study Area despite the large amount of survey effort, it is likely that records in the Study Area represent individuals on the periphery of a permanent population (as it expands and contracts over time) and/or dispersing from a permanent population elsewhere, such as Koodaideri.



Legend

Northern Quoll Records - Biologic (2013)

- Scat

Northern Quoll Records - Current Survey

- Motion Camera
- Scat

Potential Northern Quoll Habitat

- Denning (Gorge/ Gully)
- Dispersal and Foraging (Major Drainage Line, Minor Drainage Line)

- Study Area

biologic Environmental Survey

N

1:111,639

0 1.25 2.5 5 km

BHP WAIO

Marillana Targeted Vertebrate Fauna

Figure 4.5: Potential Northern Quoll habitat within the Study Area

Coordinate System: GDA 1994 MGA Zone 50
Projection: Transverse Mercator
Datum: GDA 1994

Size A4. Created 11/04/2019

4.4.3 Pilbara Leaf-nosed Bat

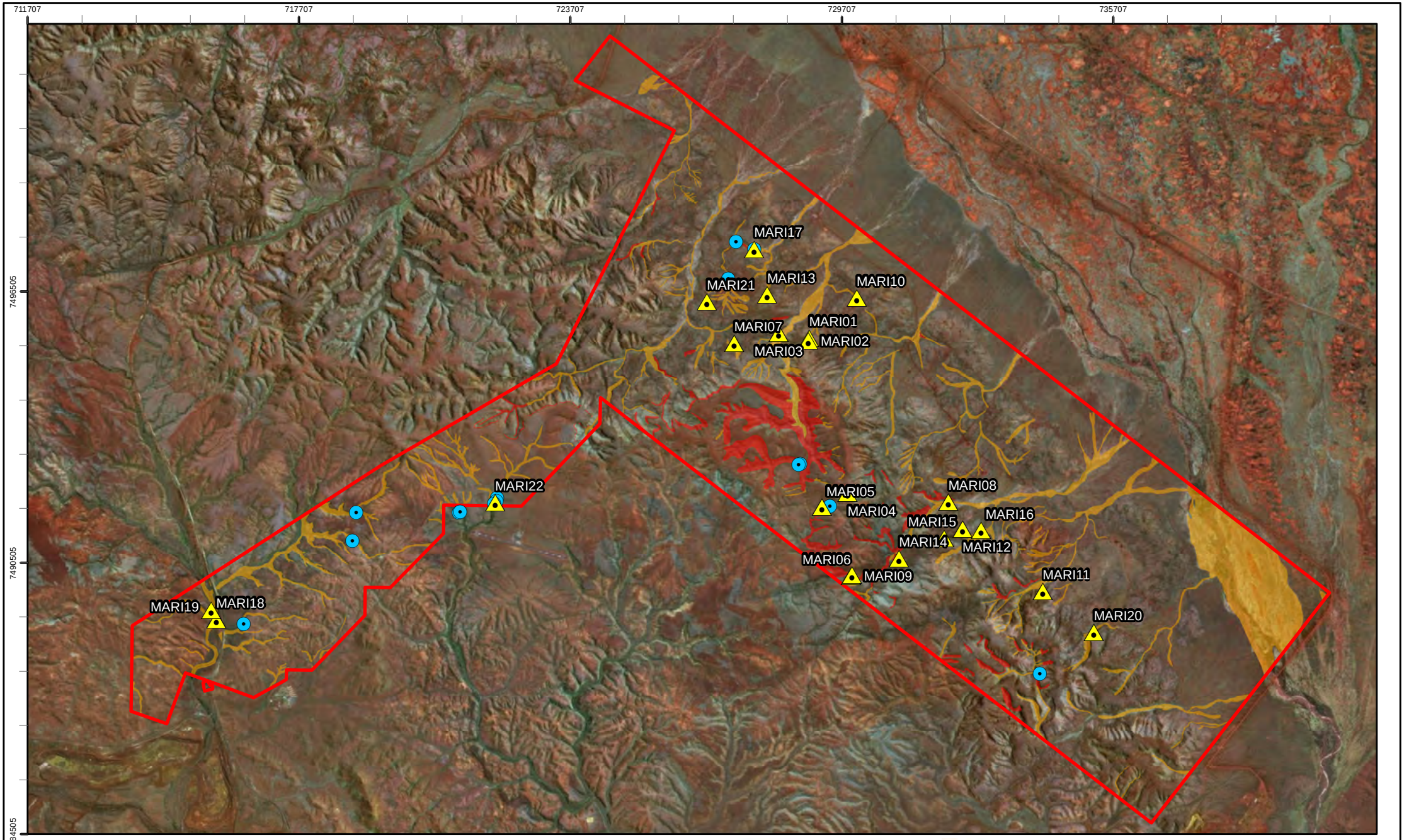
Previous Records

The Pilbara Leaf-nosed Bat has not been recorded within the Study Area from previous surveys (Biologic, 2013; Biota, 2012b) or during this Survey. Four records of the species are located approximately 4 km west of the Study Area (BHP Biliton Iron Ore fauna database 2016; ecologia, 2008b). Beyond 10 km, the species has been recorded from over 39 echolocations records and four individual specimens (WA Museum specimens) from 36 sampling sites – most of which have been collected between 13 to 40 km west and north west of the Study Area (Biota, 2012b). Additionally, DBCA (2018a) have 45 records of the species within 50 km of the Study Area. Of particular note is the Koodaideri adit: a disused mine adit with intersected natural cavities, which has been confirmed to host a population of more than 430 individuals (i.e. Priority 1 - Permanent Diurnal Roost) and is regarded as one of the largest colonies in the Hamersley Range (Biota, 2012c).

Habitats Within the Study Area

The Study Area falls within the distribution of the Pilbara Leaf-nosed Bat (DoEE, 2018a). As detailed in Section 2.3, Pilbara Leaf-nosed Bats roost in undisturbed caves, deep fissures or abandoned mine shafts. Based on the habitat priorities set out in the Conservation Advice (TSSC, 2016b), Gorge/ Gully habitat type can generally be regarded as habitat critical to the survival of Pilbara Leaf-nosed Bat (Figure 4.6), being the habitat most likely to contain caves that may support roosting of the species (refer to Table 4.1 for extent of habitat). Twenty-two caves are known from the Study Area (Figure 4.2, Figure 4.3). Of the caves that were able to be accessed and assessed, none were deemed likely to provide suitable roosting habitat for Pilbara Leaf-nosed Bat due to the lack of a unique microclimate. Two caves discovered during the current survey have not been thoroughly sampled for the species due to access restrictions (refer to section 4.3.1) and therefore it cannot be determined whether these caves provide habitat for the species. All caves within the Study Area may provide nocturnal refuges (occupied or entered at night for resting, feeding or other purposes but are not considered critical for persistence in a local area; TSSC, 2016b). However, no Pilbara Leaf-nosed Bat evidence has been recorded within the Study Area to date, suggesting the species is unlikely to occur except for transient or dispersing individuals (Biologic, 2013, 2016b; Biota, 2012a).

Gorge/ Gully habitat likely provides Priority 1 (gorges), Priority 2 (gully) and Priority 3 (rocky outcrop) foraging habitat within the Study Area. Moreover, Major Drainage Line and Minor Drainage Line habitats (particularly those with water features) can be regarded as potential Priority 4 foraging habitat for the species. Additionally, all the water features recorded in the Study Area provide a potential drinking and foraging resource for the species. Finally, open grasslands and woodlands contained within Hillcrest/ Hillslope, Sand Plain, Sand Dune, and Drainage Area/ Floodplain habitats provide potential Priority 5 foraging habitat for this species (TSSC, 2016b - refer to Section 2.3).



Legend

- Caves - Potential Nocturnal Refuges
- Water Features - Potential Drinking/Foraging Sources
- Study Area

Potential Pilbara Leaf-nosed Bat Habitat

- Priority 1 Foraging, Dispersal (Gorge/Gully)
- Priority 4 Foraging, Dispersal (Minor Drainage Line, Major Drainage Line)

biologic Environmental Survey

N

1:105,386

0 1 2 4 km

BHP WAIO

Marillana Targeted Vertebrate Fauna

Figure 4.6: Potential Pilbara Leaf-nosed Bat Habitat within the Study Area

Coordinate System: GDA 1994 MGA Zone 50
Projection: Transverse Mercator
Datum: GDA 1994

Size A4. Created 12/05/2019

4.4.4 Ghost Bat

Previous Records

Regionally, roosts are known from Koodaideri (Biota, 2012b), Mining Area C, South Flank, Mudlark (Biologic, 2016c) and West Angelas (Armstrong & Anstee, 2000). DBCA (2016) revealed 42 records within 40 km of the Study Area. Within 10 km of the Study Area, Ghost Bats have been recorded approximately 5 km to the south east (scats; Biologic, 2011b) and two calls were recorded approximately 4 km to the west (ecologia, 2008b). Ghost Bats have been recorded at 13 locations within the Study Area (Biologic, 2013, 2016b) (Figure 4.2). One cave (MARI12) discovered by (Biologic, 2016b) is regarded as a potential maternity cave owing to caves physical morphology and the number of scats (Biologic, 2016b; current)

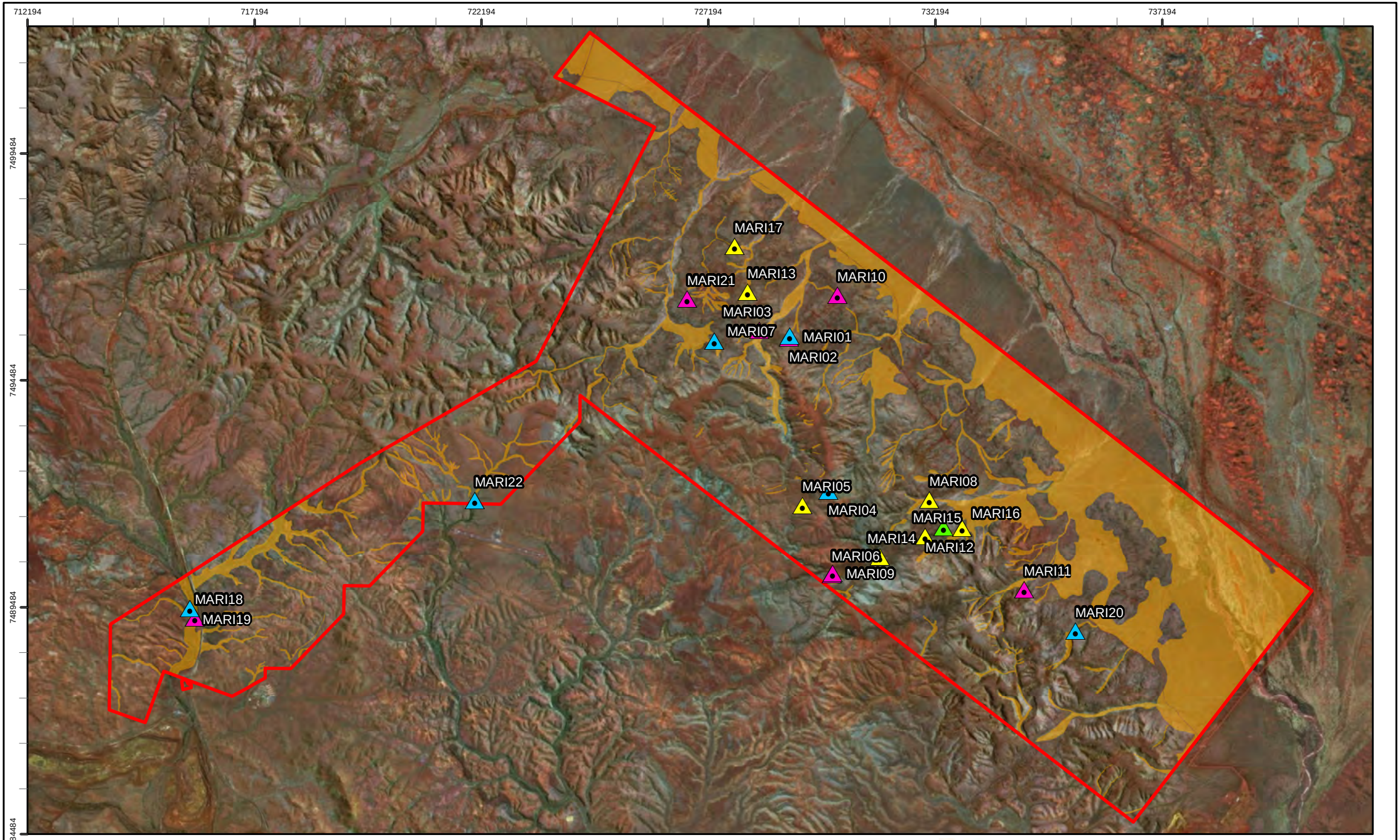
No Ghost Bats were recorded via ultrasonic recorders (deployed at 12 locations for a total of 33 nights) during the current survey. During the previous survey 501 to 1,000 Ghost Bat scats were observed at MARI12 (Biologic, 2016b). During the current survey, 50 Ghost Bat scats (approximately three to six months old) were observed on a sheet at MARI12. Ghost Bats move between a number of caves seasonally, or as dictated by weather conditions, and require a range of cave sites (Hutson *et al.*, 2001), with presence ranging from occasional visitation to persistence over a long period. Previous studies have suggested that Ghost Bats in the Hamersley Range occur in small family groups that move from cave to cave (Armstrong & Anstee, 2000; Biologic, 2014).

Habitats Within the Study Area

The Study Area falls within the distribution of the Ghost Bat (DoEE, 2018a). Gorge/ Gully habitat is likely to contain caves that support roosting of the species (refer to Section 2.4 for attributes of suitable Ghost Bat caves). The Gorge/ Gully habitat type is found throughout the higher elevations of the Hillcrest/ Hillslope areas, along the southern border and the central portion of the Study Area (Figure 4.7). Twenty-two caves are known from the Study Area (refer to Section 4.3.1), of which ten contained evidence of Ghost Bat. one of which (MARI12) is considered a potential maternity roost for the Ghost Bat. An additional nine caves are likely to provide habitat as diurnal roosts and feeding roosts for Ghost Bat. Two caves discovered during the current survey have not been thoroughly sampled for the species due to access restrictions (refer to Section 4.3.1) and therefore, it cannot be determined whether these caves provide habitat for the species.

The Ghost Bat is a generalist feeder. It relies on a large array of prey items from invertebrates to small vertebrates, some of which are strongly associated with specific habitats and soil types (Arteaga Claramunt *et al.*, 2018). Ghost Bats have a 'sit and inspect' foraging strategy; they hang on a perch (typically small branches or the main trunk in the mid-to-upper canopy of *eucalypts*; Tidemann *et al.*, 1985) where they visually inspect their surroundings for movement (refer to Section 2.4). Once their prey is detected it may be captured in the air, gleaned (taken from the surface of a substrate by a flying bat from the ground or vegetation), or dropped on from a perch (Boles, 1999). Therefore, suitable vantage points and prey items may be provided by Gorge/

Gully, Sand Dune, Minor Drainage Line, Drainage Area/ Floodplains and Mulga Woodland, making these habitat suitable foraging and dispersal habitats. Additionally, Major Drainage Line and Sand Plain habitats may provide foraging habitat for the species. Mulga woodland is isolated to the western portion of the Study Area. Sand Dunes are associated with the Major Drainage line in the north eastern corner of the Study Area while Sand Plain habitat exists along the north-eastern border and small patches in the central portions of the Study Area (refer to Table 4.1 for extent of habitat).



Legend

- Study Area
- Caves
  - Night Roost
- Other
- Potential Day Roost
- Potential Maternity
- **Potential Ghost Bat Habitat**
  - Foraging, Dispersal (Major Drainage Line, Minor Drainage Line, Drainage Line Floodplain, Mulga Woodland, Sand Dune, Sand Plain)

biologic Environmental Survey

N

1:104,717

0 1 2 4 km

BHP WAIO

Marillana Targeted Vertebrate Fauna

Figure 4.7: Potential Ghost Bat habitat within the Study Area

Coordinate System: GDA 1994 MGA Zone 50
Projection: Transverse Mercator
Datum: GDA 1994

Size A4. Created 21/02/2019

4.4.5 Pilbara Olive Python

Previous Records

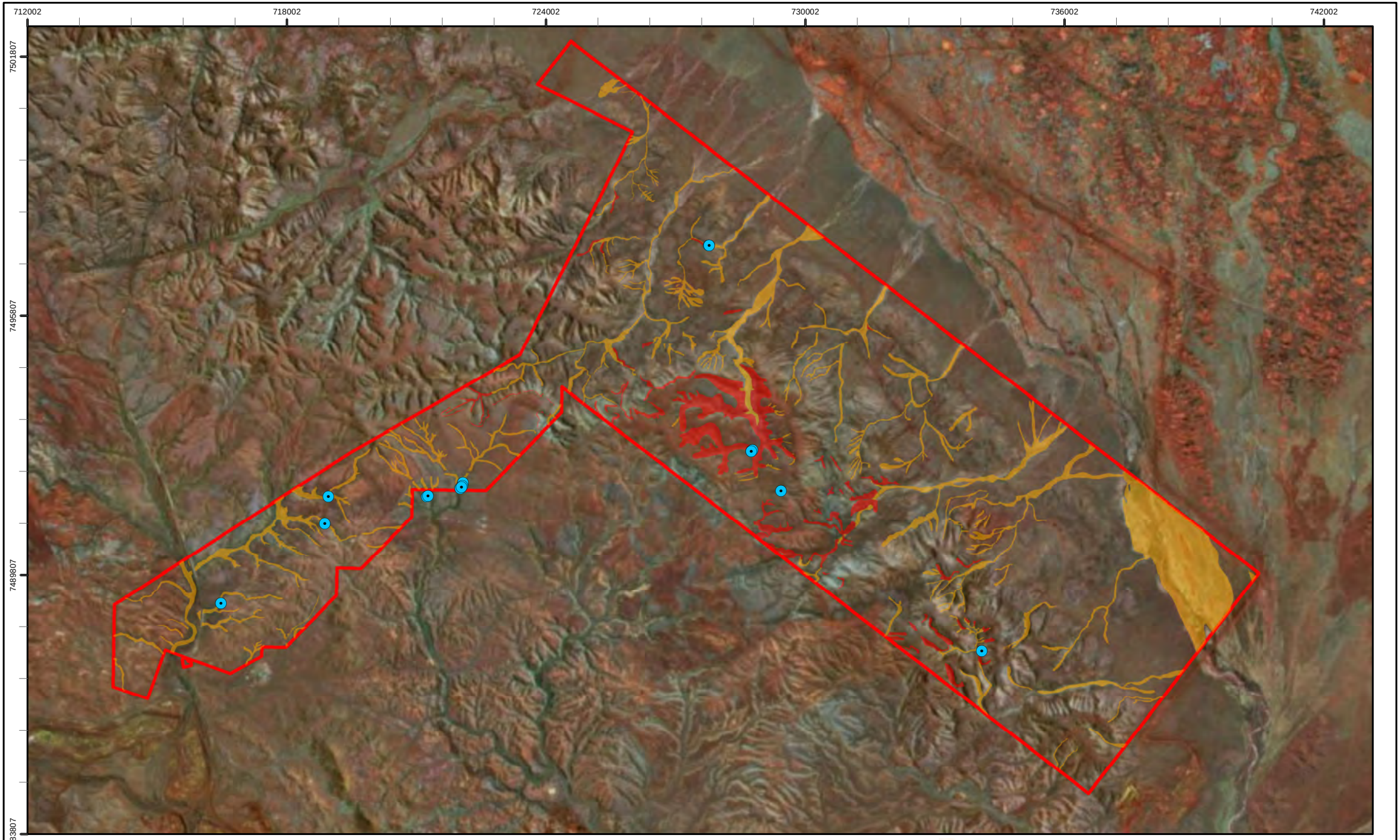
Numerous records of Pilbara Olive Python exist within 35 km of the Study Area, including at Yandi (Biologic, 2011b; Maunsell, 2003), Mining Area C (Biologic, 2015), Koodaideri (Biota, 2012b), Marillana Homestead (WA Museum specimen in 1980), and Weeli Wolli Creek (Biologic, 2011b; DBCA, 2018b). The nearest records of Pilbara Olive Python include a transient individual recorded approximately 4 km north of the Study Area near BHP WAIO's main rail line (ENV, 2008b) and Yandi Billiards (Biota, 2014).

Pilbara Olive Python is currently known from four locations within the Study Area, comprising three records in Gorge/ Gully habitat (Biologic, 2013, 2016b) and one record from Minor Drainage Line (Biologic, 2013). No Pilbara Olive Python was recorded during the current survey.

Habitats Within the Study Area

The Study Area falls within the distribution of Pilbara Olive Python (DoEE, 2018a). As outlined in Section 2.5 the Pilbara Olive Python is most often encountered in the vicinity of permanent water features in rocky ranges or among riverine vegetation (DSEWPaC, 2011b; Pearson, 1993). Gorge/ Gully habitat within the Study Area, particularly those that contain permanent and semi-permanent water features, provide suitable denning habitat for Pilbara Olive Python (Figure 4.8). Overall, 16 water features are known from the Study Area (refer to Appendix D - Biologic, 2013, current survey; 2016a). Six of these water features were regarded as moderately large and potentially semi-permanent (i.e. would be expected to hold water for several months following rainfall).

Foraging habitat and dispersal corridors are generally provided by Major Drainage Line and Minor Drainage Line habitats (Figure 4.8). These habitats are contiguous with similar habitats in areas beyond the Study Area and are considered common in this part of the Hamersley Range (refer to Table 4.1 for extent of habitat).



Legend

Study Area

Pilbara Olive Python Habitat Features

Water Features

Potential Pilbara Olive Python Habitat

Denning and Foraging (Gorge/ Gully)

Dispersal and Forgaing (Major Drainage Line, Minor Drainage Line)

biologic Environmental Survey

N

1:110,000

0 1.25 2.5 5 km

BHP WAIO

Marillana Targeted Vertebrate Fauna

Figure 4.8: Potential Pilbara Olive Python habitat within the Study Area

Coordinate System: GDA 1994 MGA Zone 50
Projection: Transverse Mercator
Datum: GDA 1994

Size A4. Created 21/02/2019

4.4.6 Northern Brushtail Possum

Previous Records

The Study Area falls within this species' range (DEC, 2012). The closest record of Northern Brushtail Possum is approximately 60 km south-west where scats were recorded within a cave near Southern Flank (Biologic, *in prep.*). A further record exists 70 km south-west where scats were recorded at the mouth of a large cave (Astron & Biologic, 2010) along the Packsaddle Range. Similarly distanced records exist to the north west (WA Museum specimens from Mulga Downs Homestead) and north east (WA Museum specimen from Bonney Downs Station) (DBCA, 2018a).

The Northern Brushtail Possum has not been recorded within the Study Area to date.

Habitats Within the Study Area

Northern Brushtail Possums occupy an array of habitat types, provided enough tree hollows in large *Eucalyptus* trees and ground refuges (such as hollow logs, rockpiles and the burrows of other animals) are available. However, as outlined in Section 2.6, little ecological information is known about the Pilbara population of the Northern Brushtail Possum. The species is most often recorded from gorges and major drainage lines that contain large hollow-bearing Eucalypts (DBCA, 2018a). Therefore, potential denning habitat for Northern Brushtail Possum is likely to be provided by the Gorge/ Gully, Major Drainage Line and Minor Drainage Line habitats within the Study Area (Figure 4.1). This habitat continues beyond the Study Area boundaries particularly to the north-west (refer to Table 4.1 for extent of habitat). Suitable tree hollows for Northern Brushtail Possum were noted in two habitat assessments conducted within the Study Area during the current survey (MARI-07 and MARI-28). Recent scats found within a cave near Southern Flank (Biologic, *in prep.*) suggests caves may also provide suitable refuge for this species. Potential foraging and dispersal habitat may occur within Gorge/ Gully, Major Drainage Lines and instances of Minor Drainage Lines, particularly where large *Eucalyptus* trees are available.

Despite the extensive survey effort and availability of suitable habitat, the Northern Brushtail Possum has not been recorded in the Study Area. Owing to the lack of records, it is considered unlikely that a resident population exists in the Study Area.

4.4.7 Peregrine Falcon

Previous Records

Fifteen records exist within the vicinity of the Study Area (DBCA, 2016). Furthermore, seven individuals were observed on five occasions within the Study Area during a previous survey (Biologic, 2013) in a diverse range of habitats including Sand Dunes, Major Drainage Lines, Minor Drainage Lines, and Hillcrest/ Hillslopes.

Habitats Within the Study Area

As outlined in Section 2.7, the Peregrine falcon typically nests on inland cliffs, in tree hollows, steep-sided rocky outcrops near water (Pizzey & Knight, 2007), granite outcrops and quarries and also occasionally within tall trees occurring along Major Drainage Lines (Olsen & Olsen, 1989). No nests belonging to this species have been found within the Study Area during any previous surveys. However, potential nesting habitat exists for this species along any tall cliffs present at the top of ranges. Suitable vertical rock faces with ledges are scattered throughout Gorge/ Gully habitat within the Study Area (refer to Table 4.1 for extent of habitat). Major Drainage Lines and instances of Minor Drainage as well as Drainage Area/ Floodplain provide suitable foraging habitats. However, all habitat types within the Study Area may provide potential foraging habitat for this species.

4.4.8 Pilbara Flat-headed Blind Snake

Previous Records

The desktop assessment revealed nine records within 35 km of the Study Area such as around South Flank (Biologic, 2012b), Mining Area C, Jinaryi (DBCA, 2016), Mainline (Biologic, 2011b) and Koodaideri mining areas (Biota, 2012b). As depicted in Figure 4.2, two records exist within the Study Area (Biologic, 2013).

No Pilbara Flat-headed Blind Snake was recorded during the current survey.

Habitats Within the Study Area

As outlined in Section 2.8, little is known of this species' ecology but *Anilios ganei* is associated with moist soils and leaf litter within gorges and gullies (Wilson & Swan, 2014), and potentially with a wide range of other stony habitats and along drainage lines (DBCA, 2018a). During a previous survey two individuals were recorded, one within Hillcrest/ Hillslope habitat and one within Major Drainage Line habitat associated with a rocky breakaway. Suitable habitat for this species may be provided by Gorge/ Gully, Hillcrest/ Hillslope, Major Drainage Line, Minor Drainage Line, Drainage Area/ Floodplain and Stony Plain habitat types.

4.4.9 Western Pebble-mound Mouse

Previous Records

There are many records of this species surrounding the Study Area, with dense clusters of mounds recorded at Yandi (Biologic, 2011b), along Weeli Wolli Creek, and at Yandicoogina and Koodaideri mining areas (Biota, 2012b). DBCA (2016) revealed 169 records within the vicinity of the Study Area (Figure 4.2).

Previously, forty-eight pebble mounds were recorded within the Study Area (Biologic, 2011a, 2013, 2016a, 2016b; ecologia, 2006); all but seven were active at the time of surveying. Furthermore, two individuals have been recorded within the north-western extent of the Study Area (Biologic, 2013). During the current survey, a further four recently inactive mounds were discovered within the Study Area (Figure 4.3).

Habitats Within the Study Area

As outlined in Section 2.9, the Western Pebble-mound mouse occupies rocky hummock grassland areas with little or no soil, usually on lower land slopes where weathering produces pebbles of the preferred size (Start ***et al.***, 2000). Therefore, Stony Plains and Hillcrest/ Hillslopes provide suitable habitat for this species. Hillcrest/ Hillslope occurs throughout much of the Study Area and Stony Plain habitat is isolated to the western corner of the Study Area (refer to Table 4.1 for extent of habitat). These habitats are widespread throughout the Study Area (Figure 4.1), the local area and widely in the Pilbara region.

4.4.10 Chocolate Wattle Bat

Previous Records

The Chocolate Wattled Bat is distributed across southern Australia, with isolated populations occurring in the Hamersley Ranges in Western Australia and central Australia in the Northern Territory (Churchill, 2008). In the Pilbara, this species is only known from the Weeli Wolli-Marillana Creek system (McKenzie & Bullen, 2009). Given its geographic separation from the main population in Western Australia, the Pilbara population may be genetically distinct, although this requires confirmation (Bullen & McKenzie, 2011). Therefore, although not formally listed as a conservation significant species, the species is considered locally significant.

Multiple calls of the Chocolate Wattled Bat have previously been recorded from an ultrasonic recorder located in Gorge/ Gully habitat by Biologic (2016a). The record from the Study Area is within the existing range of the species in the Pilbara region, approximately 9 km north-west of the nearest previous records in NatureMap. Within the broad local area, there are 19 records of the Chocolate Wattled Bat in the Pilbara region, all occurring along Marillana and Weeli Wolli Creeks within an approximate 20 km radius of the Study Area (DBCA, 2018a). It was not possible to assess whether these recordings represented resident bats or foragers from other nearby populations at Marillana or Weeli Wolli Creeks (within 10 - 20 km away).

Habitats Within the Study Area

The Chocolate Wattle Bat typically roosts in old tree hollows and disused birds' nests whereby roosts span from 20 to a few hundred bats in size (van Dyck & Strahan, 2008). The species is dependent on riparian vegetation (Bullen & McKenzie, 2011) with complex vegetation structures and permanent pools set in cavernous landscapes. The species hunts in cluttered airspaces close to surfaces mainly feeding on small moths (McKenzie & Bullen, 2009). Water features and riparian habitats within the Study Area may provide suitable foraging habitat for this species, particularly Gorge/ Gully habitat containing potentially permanent water with riparian vegetation (*Eucalyptus camaldulensis* and *Typha domingensis*), as is present in the south-western part of the Study Area.

In the Pilbara, this species is only known from the Weeli Wolli-Marillana Creek system (McKenzie & Bullen, 2009). Therefore, it is likely that individuals are foraging through sections of the Study Area from Weeli Wolli Spring. The Major Drainage Line habitat located in the north eastern corner (associated with Weeli Wolli Creek) and south western portion of the Study Area may

provide foraging habitat for the species. Additionally, small areas of Drainage Area/Floodplain associated with Major Drainage lines, such as in the south eastern and south-western corners of the Study Area, may also be used for foraging (Figure 4.1).

5 CONCLUSIONS

Nine major fauna habitats were identified within the Study Area. Two of the habitats recorded in the Study Area were deemed to be of high value to fauna of conservation significance: Gorge/ Gully and Major Drainage Line. Five habitats were deemed to be of moderate value: Sand Plain, Sand Dune, Minor Drainage Line, Drainage Area/ Floodplain and Mulga Woodland. Two habitats were deemed to be of low value: Stony Plain and Hillcrest/ Hillslope. To date, six of the targeted species have been recorded within the Study Area including Northern Quoll, Ghost Bat, Pilbara Olive Python, Peregrine Falcon, Pilbara Flat-headed Blind Snake and Western Pebble-mound Mouse as well as the locally significant Chocolate Wattle Bat. Night Parrot, Pilbara Leaf-nosed Bat and Northern Brushtail Possum have not previously been recorded in the Study Area and are considered unlikely to occur.

The Night Parrot was not recorded during the current survey, although a contemporary record is located approximately 20 km north of the Study Area. While potential habitat for the species exists within the Study Area, the species is generally rare and not confirmed to reside within the Pilbara region, as such it is deemed unlikely that the species permanently resides within the Study Area.

Northern Quoll has been recorded on three occasions within the Study Area, including twice during the current survey. Based on the occurrence of suitable Gorge/ Gully habitats within the Study Area, it is possible that the Northern Quoll could occur occasionally whilst dispersing. Nevertheless, owing to the rarity of this species within the Hamersley Ranges and the low number of records within the Study Area despite the large amount of survey effort, it is likely that records in the Study Area represent individuals on the periphery of a permanent population (as it expands and contracts over time) and/or dispersing from a permanent population elsewhere, such as Koodaideri.

Despite the extensive survey effort and availability of suitable foraging habitat, the Pilbara Leaf-nosed Bat has not been recorded in the Study Area. Twenty-two caves were recorded in the Study Area. No caves were deemed likely to provide suitable roosting habitat for the Pilbara Leaf-nosed Bat. It is considered unlikely that a resident population exists in the Study Area. However, a permanent population is known to exist within 18 km and individuals may infrequently forage across Gorge/ Gully (Priority 1), Major Drainage Line, Minor Drainage Line (Priority 4) and Drainage Area/ Floodplain (Priority 5) habitats as well as at the 15 water features that exist within the Study Area.

Ghost Bat has been recorded at 13 locations within the Study Area. Twenty-two caves are known from within the Study Area, one of which (MARI12) is considered a potential maternity roost for the Ghost Bat. An additional nine caves are likely to provide habitat as diurnal roosts and feeding roosts for Ghost Bat. During the current survey, 50 Ghost Bat scats were observed on sheet at MARI12. Suitable foraging and dispersal habitat may be provided by Gorge/ Gully, Sand Dune, Minor Drainage Line, Drainage Area/ Floodplains and Mulga Woodland. Additionally, Major Drainage Line and Sand Plain habitats may provide foraging habitat for the species.

Although the current survey did not record Pilbara Olive Python, the species has been recorded at four locations within the Study Area during previous surveys. Denning and foraging habitat is provided by Major Drainage Line, Minor Drainage Line and Gorge/ Gully habitat within the Study Area (particularly those that contain permanent and semi-permanent water - six water features within the Study Area were regarded as moderately large and potentially semi-permanent). Considering these habitat features and previous records, the species is highly likely to permanently reside in the Study Area.

Despite extensive survey effort, the availability of suitable denning habitat (contained within Gorge/ Gully, Major Drainage Line and Minor Drainage Line habitats, as well as caves) and the availability of suitable foraging habitat (contained within Gorge/ Gully, Major Drainage Lines and instances of Minor Drainage Lines), the Northern Brushtail Possum has not been recorded in the Study Area, and it is considered unlikely that a resident population exists.

Seven Peregrine Falcon individuals have been recorded on five occasions within the Study Area during previous surveys within a diverse range of habitats such as Sand Dunes, Major Drainage Lines, Minor Drainage Lines and Hillcrest/ Hillslopes. All habitat types within the Study Area may provide potential foraging habitat for this species. Nesting and foraging habitat is provided by Gorge/ Gully while foraging habitat is provided by the Major Drainage Line and Drainage Area/ Floodplain.

Two records of the Pilbara Flat-headed Blind Snake exist within the Study Area from previous surveys. Suitable habitat for this species may be provided by Gorge/ Gully, Hillcrest/ Hillslope, Major Drainage Line, Minor Drainage Line, Drainage Area/ Floodplain and Stony Plain habitat types.

Previously, forty-eight pebble mounds were recorded within the Study Area; all but seven were active at the time of surveying. Furthermore, two individuals have been recorded within the north-western extent of the Study Area (Biologic, 2013). During the current survey, a further four recently inactive mounds were discovered within the Study Area. Suitable habitat for this species is provided by the Hillcrest/ Hillslope as well as Stony Plain habitat types.

Although not formally listed, the Chocolate Wattle Bat is considered to be of local significance. Multiple calls of the Chocolate Wattled Bat have previously been recorded in the Study Area, from Gorge/ Gully habitat. The record from the Study Area is within the existing range of the species in the Pilbara region, approximately 9 km north-west of the nearest previous records in NatureMap. Water features and riparian habitats within the Study Area may provide suitable foraging habitat for this species, particularly Gorge/ Gully habitat containing potentially permanent water with riparian vegetation (*Eucalyptus camaldulensis* and *Typha domingensis*), as is present in the south-western part of the Study Area.

Numerous targeted surveys have been conducted over the Study Area. Therefore, additional targeted survey work for the nine species of conservation significance investigated during the current survey is unlikely to provide further detail on their occurrence and extent within the Study Area.

6 REFERENCES

Anstee, S. D. (1996). Use of external mound structures as indicators of the presence of the Pebble-Mound Mouse, *Pseudomys Chapmani*, in mound systems. *Wildlife Research, 23*(4), 429-434. doi:http://dx.doi.org/10.1071/WR9960429

Anstee, S. D., Roberts, J. D., & O'Shea, J. E. (1997). Social structure and patterns of movement of the Western Pebble-mound Mouse, *Pseudomys chapmani*, at Marandoo, Western Australia. *Wildlife Research, 24*(3), 295-305. doi:http://dx.doi.org/10.1071/WR96093

Armstrong, K. N. (2000). Roost microclimates of the bat *Rhinonicteris aurantius* in a limestone cave in Geike Gorge, Western Australia. *Australian Mammalogy, 22*, 69-70. doi:https://doi.org/10.1071/AM00069

Armstrong, K. N. (2001). The distribution and roost habitat of the orange leaf-nosed bat, *Rhinonicteris aurantius*, in the Pilbara region of Western Australia. *Wildlife Research, 28*(95-104).

Armstrong, K. N., & Anstee, S. D. (2000). The Ghost Bat in the Pilbara: 100 years on. *Australian Mammalogy, 22*, 93-101.

Arteaga Claramunt, A. M., White, N. E., Bunce, M., O'Connell, M., Bullen, R. D., & P.R, M. (2018). Determination of the diet of the Ghost bat (*Macroderma gigas*) in the Pilbara region of Western Australia from dried prey remains and DNA metabarcoding. *Australian Journal of Zoology*.

Astron, Environmental Services, & Biologic, Environmental Survey. (2010). *West Packsaddle Flora and Fauna Assessment*. Unpublished report prepared for BHP Billiton Iron Ore.

Bamford Consulting Ecologists. (2012). *Fauna Assessment, Nyidinghu Iron Ore Project*. Unpublished report prepared for Fortescue Metals Group.

Baudinette, R. V., Churchill, S. K., Christian, K. A., Nelson, J. E., & Hudson, P. J. (2000). Energy, water balance and the roost microenvironment in three Australian cave-dwelling bats (Microchiroptera). *Journal of Comparative Physiology. B, Biochemical, Systemic, and Environmental Physiology, 170*, 439-446. doi:http://10.1007/s003600000121

Bingham, B. B., & Noon, B. R. (1997). Mitigation of Habitat "Take": Application to Habitat Conservation Planning. *11*(1), 127-139. doi:doi:10.1046/j.1523-1739.1997.95331.x

Biologic, Environmental Survey. (2011a). *Barimunya Camp Vertebrate Fauna Survey*. Unpublished report to BHP Billiton Iron Ore.

Biologic, Environmental Survey. (2011b). *Jinidi to Mainline Vertebrate Fauna Survey*. Unpublished report for BHP Billiton Iron Ore.

Biologic, Environmental Survey. (2011c). *Yandi Vertebrate Fauna Review*. Unpublished report prepared for BHP Billiton Iron Ore.

Biologic, Environmental Survey. (2012a). *Mainline Rail Expansion Vertebrate Fauna Survey.* . Unpublished report prepared for BHP Billiton Iron Ore.

Biologic, Environmental Survey. (2012b). *South Flank Vertebrate Fauna Survey*. Unpublished report prepared for BHP Billiton Iron Ore.

Biologic, Environmental Survey. (2013). *Marillana Vertebrate Fauna Survey*. Report to BHP Billiton Iron Ore.

Biologic, Environmental Survey. (2014). *Pilbara Regional Ghost Bat Review*. Unpublished report prepared for BHP Billiton Iron Ore.

Biologic, Environmental Survey. (2015). *Mining Area C - Life of Project Environmental Management Plan Revision 6: Environmental Impact Assessment of Vertebrate Fauna*. Unpublished report prepared for BHP Billiton Iron Ore.

Biologic, Environmental Survey. (2016a). *Marillana Infrastructure Corridor Level 1 Vertebrate Fauna Survey*. Unpublished report for BHP Billiton Iron Ore.

Biologic, Environmental Survey. (2016b). *Marillana Targeted Vetebrate Fauna Survey*. Unpublished report for BHP Billiton Iron Ore.

Biologic, Environmental Survey. (2016c). *Mining Area C - Southern Flank Environmental Impact Assessment for Ghost Bat (Macroderma gigas)*. Unpublished report for BHP Biliton Iron Ore.

Biologic, Environmental Survey. (2018). *Marillana Targeted Fauna Survey*. Unpublished report prepared for BHP WA Iron Ore.

Biologic, Environmental Survey. (*in prep.*). *Central Pilbara Ghost Bat Monitoring: 2017 – 2018*. Unpublished report prepared for BHP WAIO.

Biota, Environmental Sciences. (2002). *Proposed Hope Downs Rail Corridor From Weeli Wolli Siding to Port Hedland - Vertebrate Fauna Survey*. Unpublished report prepared for Hope Downs Management Services.

Biota, Environmental Sciences. (2009). *Milyeannup Wind Farm Terrestrial Fauna Survey*. Unpublished report prepared for Verve Energy.

Biota, Environmental Sciences. (2011). *Hope Downs Project Life of Mine Targeted Fauna Survey.* . Unpublished report prepared for Rio Tinto Iron Ore. Perth WA:

Biota, Environmental Sciences. (2012a). *Koodaideri Iron Ore Project Short-range Endemic Invertebrate Fauna Integration Report*. Unpublished report prepared for Rio Tinto Iron Ore.

Biota, Environmental Sciences. (2012b). *Koodaideri Iron Ore Project Vertebrate Fauna Integration Report*. Unpublished report prepared for Rio Tinto Iron Ore.

Biota, Environmental Sciences. (2012c). *Koodaideri Orange Leaf-nosed Bat Colony Assessment*. Unpublished report prepared for Rio Tinto Iron Ore.

Biota, Environmental Sciences. (2014). *Yandi Billiards Phase 1 Seasonal Fauna Survey*. Unpublished report prepared for Rio Tinto Iron Ore.

Biota, Environmental Service. (2010). *Yandicoogina South West and Oxbow Fauna Survey*. Unpublished report prepared for Rio Tinto Iron Ore.

BirdLife Australia. (2012). *Peregrine Falcon*. Collingwood Australia:

Boles, W. (1999). Avian prey of the Australian Ghost Bat *Macroderma gigas* (Microchiroptera: Megadermatidae): prey characteristics and damage from predation. *Australian Zoologist, 31*, 82-91.

BoM, Bureau of Meteorology. (2016). Climate Data Online. Retrieved 2016 http://www.bom.gov.au./climate/data/index.shtml

BoM, Bureau of Meteorology. (2018). Climate Data Online. Retrieved 2018 http://www.bom.gov.au./climate/data/index.shtml

Braithwaite, R. W., & Griffiths, A. D. (1994). Demographic variation and range contraction in the northern quoll, *Dasyurus hallucatus* (Marsupialia : Dasyuridae). *Wildlife Research, 21*, 203-217.

Bullen, R. D., & McKenzie, N. L. (2011). Recent developments in studies of the community structure, foraging ecology and conservation of Western Australian bats. In B. Law, P. Eby, D. Lunney, & L. Lumsden (Eds.), *The Biology and Conservation of Australasian Bats* (pp. 31-43). Mosman, New South Wales: Royal Zoological Society of NSW.

Burbidge, A. A. (2004). *Threatened Animals of Western Australia*. Kensington, Western Australia: Department of Conservation and Land Management.

Burbidge, A. A., & McKenzie, N. L. (1989). Patterns in the modern decline of western Australia's vertebrate fauna: Causes and conservation implications. *Biological Conservation, 50*(1–4), 143-198. doi:10.1016/0006-3207(89)90009-8

Burbidge, A. H., Johnstone, R. E., & Pearson, D. J. (2010). Birds in a vast arid upland: avian biogeographical patterns in the Pilbara region of Western Australia. *Records of the Western Australian Museum Supplement, 78*, 247-270.

Bush, B., & Maryan, B. (2011). *Field Guide to Snakes of the Pilbara, Western Australia*. Perth: Western Australian Museum.

CASA, Civil Aviation Safety Authority. (2017). Commercial Unmanned Flight - Remotely Piloted Aircraft Under 2kg. Retrieved from https://www.casa.gov.au/standard-page/commercial-unmanned-flight-remotely-piloted-aircraft-under-2kg

Christidis, L., & Boles, W. E. (2008). *Systematics and Taxonomy of Australian Birds*. Melbourne, Victoria: CSIRO Publishing.

Churchill, S. K. (1991). Distribution, abundance and roost selection of the Orange Horseshoe-bat, *Rhinonycteris aurantius*, a tropical cave-dweller. *Wildlife Research, 18*, 343-353.

Churchill, S. K. (2008). *Australian Bats* (Second Edition ed.). Crow's Nest, New South Wales: Allen and Unwin.

Cogger, H. G. (2014). *Reptiles and Amphibians of Australia* (Seventh ed.). Collingwood, Victoria: CSIRO Publishing.

Cramer, V. A., Dunlop, J., Davis, R. A., Ellis, R., Barnett, B., Cook, A., . . . van Leeuwen, S. (2016). Research priorities for the northern quoll (*Dasyurus hallucatus*) in the Pilbara region of Western Australia. *Australian Mammalogy, 38*(2), 135-148. doi:https://doi.org/10.1071/AM15005

Davis, R. A., & Metcalf, B. M. (2008). The Night Parrot (*Pezoporus occidentalis*) in northern Western Australia: a recent sighting from the Pilbara region. *Emu, 108*(3), 233-236. doi:http://dx.doi.org/10.1071/MU07058

DBCA, Department of Biodiversity, Conservation and Attractions. (2016). Threatened and Priority Fauna Database (custom search). Retrieved 17 April 2016 http://www.dpaw.wa.gov.au/plants-and-animals/threatened-species-and-communities/threatened-animals

DBCA, Department of Biodiversity, Conservation and Attractions. (2018a). NatureMap: Mapping Western Australia's Biodiversity (custom search). Retrieved 2018 http://naturemap.dec.wa.gov.au./default.aspx

DBCA, Department of Biodiversity, Conservation and Attractions. (2018b). Threatened and Priority Fauna Database (custom search). Retrieved 2018 http://www.dpaw.wa.gov.au/plants-and-animals/threatened-species-and-communities/threatened-animals

DEC, Department of Environment and Conservation. (2012). Fauna Profile. Brushtail Possum Trichosurus vulpecular (Kerr 1792). Retrieved from https://www.dpaw.wa.gov.au

Department of Water. (2012). Pilbara. Retrieved 25 September 2012 http://www.water.wa.gov.au/Understanding+water/Priority+water/Pilbara/default.aspx

DEWHA, Department of Environment, Water, Heritage and the Arts. (2010a). *Survey Guidelines for Australia's Threatened Bats*. Canberra, Australian Capital Territory:

DEWHA, Department of Environment, Water, Heritage and the Arts. (2010b). *Survey Guidelines for Australia's Threatened Birds*. EPBC Act survey guidelines 6.2. Canberra, Australian Capital Territory:

DoE, Department of the Environment. (2016). *EPBC Act referral guideline for the endangered northern quoll Dasyurus hallucatus*. Canberra, Australian Capital Territory:

DoEE, Department of the Environment and Energy. (2018a). *Australia - Species of National Environmental Significance Database (Public Grids)*. Retrieved from: http://www.environment.gov.au/fed/catalog/search/resource/details.page?uuid=%7B337B05B6-254E-47AD-A701-C55D9A0435EA%7D

DoEE, Department of the Environment and Energy. (2018b). Protected Matters Search Tool (*custom search*). Retrieved 2018 www.environment.gov.au/erin/ert/epbc/index.html

DoEE, Department of the Environment and Energy. (2018c). Species Profile and Threats Database: *Pezoporus occidentalis* — Night Parrot. Retrieved 21/03/2018, from Department of the Environment and Energy http://www.environment.gov.au/cgi-bin/sprat/public/publicspecies.pl?taxon_id=59350

Doughty, P., Rolfe, J. K., Burbidge, A. H., Pearson, D. J., & Kendrick, P. G. (2011). Herpetological assemblages of the Pilbara biogeographic region, Western Australia:

ecological associations, biogeographic patterns and conservation. *Records of the Western Australian Museum, Supplement, 78*, 315-341.

DPaW, Department of Parks and Wildlife. (2017). *Interim guideline for the preliminary surveys of Night Parrot (Pezoporus occidentalis) in Western Australia*. Kensington, Western Australia:

DSEWPaC, Department of Sustainability, Environment, Water, Population and Communities. (2011a). *Survey Guidelines for Australia's Threatened Mammals*. Canberra, Australian Capital Territory:

DSEWPaC, Department of Sustainability, Environment, Water, Population and Communities. (2011b). *Survey Guidelines for Australia's Threatened Reptiles*. Canberra, Australian Capital Territory:

Dunlop, J. N., & Pound, L. R. (1981). Observations on the Pebble·mound Mouse *Pseudomys chapmani* Kitchener, 1980. *Records of the Western Australian Museum, 9*(1), 1-5.

ecologia, Environmental Consultants. (1995). *Yandi Stage II Iron Ore Project: Biological Assessment Survey. Unpublished report to BHP Iron Ore Pty. Ltd.* Perth, Western Australia:

ecologia, Environmental Consultants. (2005). *Mindy-Coondiner Exploration Project Biological Survey*. Unpublished report prepared for BHP Billiton Iron Ore.

ecologia, Environmental Consultants. (2006). *Marillana Terrestrial Vertebrate Fauna Survey*. Unpublished report prepared for BHP Billiton Iron Ore.

ecologia, Environmental Consultants. (2008a). *Marillana Creek (Yandi) Iron Ore Mine Modification - Level 2 Fauna Survey.* . Unpublished report prepared for BHP Billiton Iron Ore.

ecologia, Environmental Consultants. (2008b). *RGP5 Fauna Survey Kurrajura Siding to Yandi WYE including Yandi Repeater 1*. Unpublished report prepared for BHP Billiton Iron Ore.

ecologia, Environmental Consultants. (2009). *Marillana Iron Ore Project Vertebrate Fauna Assessment*. Unpublished report prepared for Brockman Resources.

ENV, Australia. (2007). *Mindy North Exploration Lease Fauna Assessment*. Unpublished report prepared for BHP Billiton Iron Ore.

ENV, Australia. (2008a). *Rapid Growth Project 5: M270SA Fauna Assessment*. Unpublished report prepared for BHP Billiton Iron Ore.

ENV, Australia. (2008b). *RGP5 Jimblebar Junction to Yandi Junction Railway Reserve and Repeaters 6, 7 and 8 Fauna Assessment*. Unpublished report prepared for BHP Billiton Iron Ore.

EPA, Environmental Protection Authority. (2016a). *Technical Guidance: Sampling Methods for Terrestrial Vertebrate Fauna*. Perth, Western Australia.

EPA, Environmental Protection Authority. (2016b). *Technical Guidance: Terrestrial Fauna Surveys*. Guidance Statement No.56. Perth, Western Australia:

Fitzsimons, J., Legge, S., Traill, B., & Woinarski, J. (2010). *Into Oblivion? The disappearing native mammals of northern Australia.* Melbourne, Vic.: http://www.australianwildlife.org/images/file/Into_Oblivion_-_Nth_Aus_Mammal_Decline_Report.pdf

Ford, F., & Johnson, C. N. (2007). Eroding abodes and vanished bridges: historical biogeography of the substrate specialist pebble-mound mice (*Pseudomys*). *Journal of Biogeography, 34*(3), 514-523. doi:https://doi.org/10.1111/j.1365-2699.2006.01649.x

Garnett, S., & Crowley, G. (2000). *The Action Plan for Australian Birds*. Canberra, A.C.T.: Environment Australia and the Royal Australia Ornithologists Union.

Garnett, S., Szabo, J., & Dutson, G. (2011). *Action Plan for Australian Birds 2010*. Collingwood, Victoria: CSIRO Publishing.

Halpern Glick Maunsell. (1999). *Marillana Creek Western Access Corridor - Biological Assessment*. Perth, Western Australia:

Hutson, A. M., Mickelburgh, S. P., & Racet, P. A. (2001). *Microchiropteran Bats: Global Status Survey and Conservation Action Plan*.

Jackett, N. A., Greatwich, B. R., Swann, G., & Boyle, A. (2017). A nesting record and vocalisations of the Night Parrot *Pezoporus occidentalis* from the East Murchison, Western Australia. *Australian Field Ornithology, 34*, 144-150.

James, C., Landsberg, J., & Morton, S. (1995). Ecological functioning in arid Australia and research to assist conservation of biodiversity. *Pacific Conservation Biology, 2*, 126-142.

Johnstone, R., & Storr, G. M. (1998). *Handbook of Western Australian Birds Volume 1 - Non-passerines (Emu to Dollarbird)*. Perth, Australia: Western Australian Museum.

Jones, A. (2017). Night parrot sighting in Western Australia shocks birdwatching world. Retrieved from Available from: http://www.abc.net.au/news/2017-03-23/night-parrot-sighting-in-wa-shocks-birdwatching-world/8377624.

Kerle, J., Foulkes, J., Kimber, R., & Papenfus, D. (1992). The decline of the Brushtail Possum, Trichosurus vulpecula (Kerr 1798), in arid Australia. *The Rangeland Journal, 14*(2), 107-127. doi:https://doi.org/10.1071/RJ9920107

King, D. (1989). An assessment of the hazard posed to northern quolls (*Dasyurus hallucatus*) by aerial baiting with 1080 to control dingoes. *Australian Wildlife Research, 16*(5), 569-574.

Leighton, K. A. (2004). Climate. In A. M. E. van Vreeswyk, A. L. Payne, K. A. Leighton, & P. Hennig (Eds.), *An Inventory and Condition Survey of the Pilbara Region, Western Australia*. Perth, Western Australia: Technical Bulletin No. 92. Western Australian Department of Agriculture.

Maslin, B., & Reid, J. (2009). Understanding Mulga. Retrieved from www.worldwidewattle.com/infogallery/projects/mulga.php

Maunsell. (2003). *Yandi Life of Mine Fauna and Flora*. Unpublished report prepared for BHP Billiton Iron Ore:

McGilp, J. N. (1931). Geopsittacus occidentalis, Night-Parrot. *South Australian Ornithologist, 11*, 68-70.

McKenzie, N. L., & 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.

McKenzie, N. L., van Leeuwen, S., & Pinder, A. M. (2009). Introduction to the Pilbara Biodiversity Survey, 2002-2007. *Records of the Western Australian Museum Supplement, 78*, 3-89.

Murphy, S. A., Silcock, J., Murphy, R., Reid, J., & Austin, J. J. (2017). Movements and habitat use of the night parrot Pezoporus occidentalis in south-western Queensland. *Austral Ecology, 42*(7), 858-868. doi:https://doi.org/10.1111/aec.12508

Murray, B. R., Zeppel, M. J. B., Hose, G. C., & Eamus, D. (2003). Groundwater-dependent ecosystems in Australia: It's more than just water for rivers. *Ecological Management & Restoration, 4*(2), 110-113. doi:10.1046/j.1442-8903.2003.00144.x

National Committee on Soil and Terrain. (2009). *Australian Soil and Land Survey Field Handbook* (Third Edition ed.). Collingwood, Victoria: CSIRO Publishing.

Night Parrot Recovery Team. (2017). Leading Night Parrot Conservation. Retrieved from https://nightparrot.com.au/

North, A. J. (1898). List of birds collected by the Calvert Exploring Expedition in Western Australia. *Transactions of the Royal Society of South Australia, 22*, 125-192.

Oakwood, M. (2000). Reproduction and demography of the Northern Quoll, *Dasyurus hallucatus*, in the lowland savanna of northern Australia. *Australian Journal of Zoology, 48*, 519-539.

Oakwood, M. (2002). Spatial and social organization of a carnivorous marsupial *Dasyurus hallucatus* (Marsupialia: Dasyuridae). *Journal of Zoology, 257*, 237-248.

Oakwood, M. (2008). Northern Quoll Dasyurus hallucatus. In R. Strahan (Ed.), *The Mammals of Australia* (3rd ed.). Sydney: Reed new Holland.

Oakwood, M., & Miles, G. L. (1998). Predation of a marsupial carnivore by an Olive Python (*Liasis olivaceus*) and a King Brown snake (*Pseudechis australis*). *Herpetofauna, 28*(1), 19-21.

Olsen, J., Debus, S., Rose, A. B., & Hayes, G. (2004). Breeding success, cliff characterisation and diet of Peregrine Falcon at high altitude in the Australian Capital Territory. *Corella, 28*(2), 33-37.

Olsen, J., Fuentes, E., Bird, D. M., Rose, A. B., & Judge, D. (2008). Dietary shifts based upon prey availability in Peregrine Falcons and Australian Hobbies breeding near Canberra, Australia. *Jounral of Raptor Research, 42*(2), 125-137.

Olsen, J., Fuentes, E., Dykstra, R., & Rose, A. B. (2006). Male Peregrine Falcon *Falco peregrinus* fledged from a cliff-nest found breeding in a stick-nest. *Australian Field Ornithology, 23*, 8-14.

Olsen, P. D., & Olsen, J. (1989). Breeding of the Peregrine Falcon *Falco peregrinus*. III. Weather, nest quality and breeding success. *Emu, 89*(1), 6-14. doi:https://doi.org/10.1071/MU9890006

Onshore, Environmental Consultants., & Biologic, Environmental Survey,. (2011). *Camp Hill Exploration Leases Level 2 Flora & Vegetation Survey and Level 1 Fauna Assessment.* Unpublished report prepared for BHP Billiton Iron Ore.

Palaszczuk, A., & Miles, S. (2017). *New night parrot community discovered in central west Queensland.* Available from: http://statements.qld.gov.au/Statement/2017/3/22/new-night-parrot-community-discovered-in-central-west-queensland.

Pearson, D. (2001). *Potential occurrence of the Pilbara Olive Python and its habitat on the proposed Burrup Ammonia Plant site near Hearson Cove.* Unpublished Report for Burrup Fertilisers Pty. Ltd.

Pearson, D. (2003). Giant Pythons of the Pilbara. *Landscape, 19*(1).

Pearson, D. J. (1993). Distribution, status and conservation of pythons in Western Australia. In D. Lunney & D. Ayers (Eds.), *Herpetology in Australia: a Diverse Discipline* (pp. 383-395). Sydney, New South Wales: Royal Zoological Society of NSW.

Pearson, D. J. (2006). Giant Pythons of the Pilbara. *Landscope, 19*, 32-39.

Pizzey, G., & Knight, F. (2007). *Field Guide to the Birds of Australia* (Eighth Edition ed.). Sydney, New South Wales: Harper Collins Publishers.

Specialised Zoological. (2008). *Survey for conservation significant bats between Kurrajura siding and the Yandi WYE*. Unpublished report prepared for BHP Billiton Iron Ore.

Start, A. N., Anstee, S. D., & Endersby, M. (2000). A review of the biology and conservation status of the Ngadji, *Pseudomys chapmani* Kitchener, 1980 (Rodentia: Muridae). *CALMScience, 3*(2), 125-147.

Taylor, P. D., Crewe, T. L., Mackenzie, S. A., Lepage, D., Aubry, Y., Crysler, Z., . . . Woodworth, B. K. (2017). The Motus Wildlife Tracking System: a collaborative research network to enhance the understanding of wildlife movement. [Le Système de suivi de la faune Motus : un réseau de recherche collaboratif visant à mieux comprendre le déplacement des animaux]. *Avian Conservation and Ecology, 12*(1). doi:10.5751/ACE-00953-120108

Thackway, R., & Cresswell, I. D. (1995). *An Interim Biogeographic Regionalisation for Australia: a Framework for Setting Priorities in the National Reserves System Cooperative Program*. Canberra, Australian Capital Territory: Australian Nature Conservation Agency.

Tidemann, C. R., Priddel, D. M., Nelson, J. E., & Pettigrew, J. D. (1985). Foraging behaviour of the Australian Ghost Bat, *Macroderma gigas* (Microchiroptera: Megadermatidae). *Australian Journal of Zoology, 33*(5), 705-713. doi:http://dx.doi.org/10.1071/ZO9850705

TSSC, Threatened Species Scientific Commitee. (2008). *Approved conservation advice for Liasis olivaceus barroni (Olive Python – Pilbara subspecies)*. Commonwealth of Australia, Canberra.:

TSSC, Threatened Species Scientific Commitee. (2016a). *Conservation Advice: Macroderma gigas, Ghost Bat*. Canberra, Australian Capital Territory:

TSSC, Threatened Species Scientific Commitee. (2016b). *Conservation Advice: Rhinonicteris aurantia (Pilbara form), Pilbara Leaf-nosed Bat*. Canberra, Australian Capital Territory:

van Dyck, S., & Strahan, R. (2008). *Mammals of Australia* (Third Edition ed.). Sydney, New South Wales: Australian Museum.

WAM, Western Australian Museum. (2018). Checklist of the Vertebrates of Western Australia (February 2018). http://museum.wa.gov.au/research/departments/terrestrial-zoology/checklist-terrestrial-vertebrate-fauna-western-australia

Whitlock, F. L. (1924). Journey to central Australia in search of the Night Parrot. *Emu, 23*, 248-281.

Wildlife Acoustics, Inc. (2017). *Song Meter SM4BAT FS Bioacoustics Recorder User Guide*. Massachusetts, United States of America:

Wilson, H. (1937). Notes on the Night Parrot, with references to recent occurrences. *37*, 79-87.

Wilson, S., & Swan, G. (2014). *A Complete Guide to Reptiles of Australia*. Sydney, New South Wales: New Holland Publishers.

Woinarski, J. C. Z., Burbidge, A. A., & Harrison, P. L. (2014). *The Action Plan for Australian Mammals 2012*. Collingwood, Victoria: CSIRO Publishing.

Woinarski, J. C. Z., Legge, S., Fitzsimons, J. A., Traill, B. J., Burbidge, A. A., Fisher, A., . . . Ziembicki, M. (2011). The disappearing mammal fauna of northern Australia: context, cause, and response. *Conservation Letters, 4*(3), 192-201. doi:10.1111/j.1755-263X.2011.00164.x

Woinarski, J. C. Z., Oakwood, M., Winter, J., Burnett, S., Milne, D., Foster, P., . . . Holmes, B. (2008). *Surviving the Toads: Patterns of Persistence of the Northern Quoll Dasyurus Hallucatus in Queensland*. Report to The Australian Government's Natural Heritage Trust. http://www.nt.gov.au/nreta/wildlife/programs/quoll/pdf/qld_quolls_finalreport.pdf

Worthington-Wilmer, J., Moritz, C., Hall, L., & Toop, J. (1994). Extreme population structuring in the threatened ghost bat, *Macroderma gigas*: evidence from mitochondrial DNA. *Proceeding of the Royal Society of London B, 257*, 193-198.

7 APPENDICES

Appendix A Conservation Status Codes

International Union for Conservation of Nature

Category	Definition
Extinct (Ex)	A taxon is Extinct when there is no reasonable doubt that the last individual has died. A taxon is presumed Extinct when exhaustive surveys in known and/or expected habitat, at appropriate times (diurnal, seasonal, annual), throughout its historic range have failed to record an individual. Surveys should be over a time frame appropriate to the taxon's life cycle and life form.
Extinct in the Wild (Ew)	A taxon is Extinct in the Wild when it is known only to survive in cultivation, in captivity or as a naturalized population (or populations) well outside the past range. A taxon is presumed Extinct in the Wild when exhaustive surveys in known and/or expected habitat, at appropriate times (diurnal, seasonal, annual), throughout its historic range have failed to record an individual. Surveys should be over a time frame appropriate to the taxon's life cycle and life form.
Critically Endangered (Ce)	A taxon is Critically Endangered when the best available evidence indicates that it meets any of the criteria A to E for Critically Endangered (see Section V), and it is therefore considered to be facing an extremely high risk of extinction in the wild.
Endangered (En)	A taxon is Endangered when the best available evidence indicates that it meets any of the criteria A to E for Endangered (see Section V), and it is therefore considered to be facing a very high risk of extinction in the wild.
Vulnerable (Vu)	A taxon is Vulnerable when the best available evidence indicates that it meets any of the criteria A to E for Vulnerable (see Section V), and it is therefore considered to be facing a high risk of extinction in the wild.
Near Threatened (NT)	A taxon is Near Threatened when it has been evaluated against the criteria but does not qualify for Critically Endangered, Endangered or Vulnerable now, but is close to qualifying for or is likely to qualify for a threatened category in the near future
Data Deficient (DD)	A taxon is Data Deficient when there is inadequate information to make a direct, or indirect, assessment of its risk of extinction based on its distribution and/or population status. A taxon in this category may be well studied, and its biology well known, but appropriate data on abundance and/or distribution are lacking. Data Deficient is therefore not a category of threat. Listing of taxa in this category indicates that more information is required and acknowledges the possibility that future research will show that threatened classification is appropriate. It is important to make positive use of whatever data are available. In many cases, great care should be exercised in choosing between DD and a threatened status. If the range of a taxon is suspected to be relatively circumscribed, and a considerable period of time has elapsed since the last record of the taxon, threatened status may well be justified.

Environment Protection and Biodiversity Conservation Act 1999

Category	Definition
Extinct (Ex)	Taxa not definitely located in the wild during the past 50 years.
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 high risk of extinction in the wild in the medium-term future.

Category	Definition
Migratory (Mi)	Consists of species listed under the following International Conventions: Japan-Australia Migratory Bird Agreement (JAMBA) China-Australia Migratory Bird Agreement (CAMBA) Convention on the Conservation of Migratory Species of Wild animals (Bonn Convention)

Biodiversity Conservation Act 2016

Category	Definition
CR	Rare or likely to become extinct, as *critically endangered* fauna.
EN	Rare or likely to become extinct, as *endangered* fauna.
VU	Rare or likely to become extinct, as *vulnerable* fauna.
EX	Being fauna that is presumed to be extinct.
MI	Birds that are subject to international agreements relating to the protection of migratory birds.
CD	Special conservation need being species dependent on ongoing conservation intervention. (Conservation Dependent)
OS	In need of special protection, otherwise than for the reasons pertaining to Schedule 1 through to Schedule 6 Fauna. (Other specially protected species

Department of Environment and Conservation Priority codes

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

Appendix B Sampling Site Locations

Site Name	Habitat	Sampling Method	Latitude	Longitude	Start Date	End Date
MARI-01	Minor Drainage Line	Ultrasonic	-22.60518	119.20273	29/5/18	31/5/18
MARI-02	Sand Plain	Targeted Search	-22.57662	119.18583	29/5/18	29/5/18
MARI-03	Sand Plain	Camera, Targeted Search	-22.57842	119.18728	29/5/18	31/5/18
MARI-04	Sand Plain	Camera, Targeted Search	-22.58116	119.18620	29/5/18	31/5/18
MARI-05	Sand Dune	Acoustic, Targeted Search	-22.68204	119.31027	29/5/18	30/5/18
MARI-06	Disturbed	Acoustic, Targeted Search	-22.66539	119.14948	29/5/18	30/5/18
MARI-07	Major Drainage Line	Camera	-22.67737	119.31586	30/5/18	31/5/18
MARI-08	Sand Plain	Acoustic	-22.69000	119.31742	29/5/18	31/5/18
MARI-09	Sand Plain	Acoustic	-22.71027	119.31652	30/5/18	31/5/18
MARI-10	Sand Plain	Acoustic, Targeted Search	-22.63797	119.27227	29/5/18	30/5/18
MARI-11	Hillcrest/ Hillslope	Camera, Targeted Search	-22.65291	119.25922	30/5/18	1/6/18
MARI-12	Sand Plain	Acoustic	-22.62856	119.25120	30/5/18	31/5/18
MARI-13	Minor Drainage Line	Camera, Cave Assessment	-22.68901	119.29148	30/5/18	1/6/18
MARI-14	Disturbed	Ultrasonic	-22.70194	119.11626	30/5/18	1/6/18
MARI-15	Hillcrest/ Hillslope	Acoustic	-22.58910	119.20272	31/5/18	1/6/18
MARI-16	Minor Drainage Line	Camera, Targeted Search	-22.66369	119.14894	31/5/18	1/6/18
MARI-17	Hillcrest/ Hillslope	Camera, Targeted Search	-22.66413	119.16055	31/5/18	22/6/18
MARI-18	Disturbed	Ultrasonic	-22.67389	119.14319	1/6/18	2/6/18
MARI-19	Gorge/ Gully	Ultrasonic	-22.61657	119.18869	20/4/18	26/4/18
MARI-20	Hillcrest/ Hillslope	Ultrasonic	-22.66992	119.26192	19/4/18	27/4/18
MARI-21	Disturbed	Acoustic	-22.60429	119.22519	31/5/18	1/6/18
MARI-22	Gorge/ Gully	Camera, Targeted Search	-22.66520	119.15999	31/5/18	1/6/18
MARI-23	Gorge/ Gully	Ultrasonic, Targeted Searches	-22.66558	119.16121	31/5/18	1/6/18
MARI-24	Disturbed	Acoustic	-22.66835	119.14729	31/5/18	1/6/18
MARI-25	Hillcrest/ Hillslope	Habitat Assessment	-22.69929	119.11890	1/6/18	1/6/18
MARI-26	Hillcrest/ Hillslope	Camera, Targeted Search	-22.68609	119.12798	31/5/18	1/6/18
MARI-27	Hillcrest/ Hillslope	Camera	-22.65574	119.14254	1/6/18	2/6/18
MARI-28	Disturbed	Ultrasonic	-22.66277	119.16219	26/4/18	27/4/18
MARI-29	Disturbed	Ultrasonic	-22.67955	119.13229	1/6/18	2/6/18
MARI-30	Disturbed	Ultrasonic	-22.68217	119.12981	1/6/18	2/6/18
MARI-31	Disturbed	Acoustic	-22.68940	119.12957	1/6/18	2/6/18
MARI-32	Disturbed	Acoustic	-22.69408	119.12715	1/6/18	2/6/18
MARI-33	Disturbed	Camera	-22.69762	119.12288	1/6/18	2/6/18
MARI-34	Hillcrest/ Hillslope	Ultrasonic	-22.70056	119.10191	1/6/18	2/6/18
MARI-35	Disturbed	Camera	-22.69594	119.10293	1/6/18	2/6/18

Site Name	Habitat	Sampling Method	Latitude	Longitude	Start Date	End Date
MARI-36	Hillcrest/ Hillslope	Cave Assessment	-22.68840	119.10060	1/6/18	1/6/18
MARI-37	Minor Drainage Line	Acoustic	-22.65789	119.30071	17/4/18	29/5/18
MARI-38	Sand Plain	Acoustic	-22.67926	119.29101	17/4/18	29/5/18
MARI-39	Hillcrest/ Hillslope	Ultrasonic, Cave Assessment	-22.62525	119.20597	19/4/18	27/4/18
MARI-40	Sand Plain	Acoustic	-22.65918	119.29214	17/4/18	29/5/18
MARI-41	Hillcrest/ Hillslope	VHF Tower	-22.702995	119.298153	23/4/18	23/4/18
MARI-42	Hillcrest/ Hillslope	VHF Tower	-22.678651	119.285611	23/4/18	23/4/18
MARI-43	Hillcrest/ Hillslope	VHF Tower	-22.671666	119.253333	24/4/18	24/4/18
MARI-44	Hillcrest/ Hillslope	VHF Tower	-22.656859	119.285043	24/4/18	24/4/18
MARI-45	Hillcrest/ Hillslope	VHF Tower	-22.616956	119.224792	20/4/18	20/4/18
MARI-46	Hillcrest/ Hillslope	VHF Tower	-22.647555	119.25891	17/4/18	17/4/18
MARI-47	Hillcrest/ Hillslope	VHF Tower	-22.657143	119.285083	18/4/18	18/4/18
MARI-48	Hillcrest/ Hillslope	VHF Tower	-22.602541	119.205104	20/4/18	20/4/18
MARI-49	Hillcrest/ Hillslope	VHF Tower	-22.613514	119.188964	21/4/18	21/4/18
MARI-50	Hillcrest/ Hillslope	VHF Tower	-22.628538	119.216108	22/4/18	22/4/18
MARI-51	Hillcrest/ Hillslope	VHF Tower	-22.634286	119.237105	22/4/18	22/4/18
MARI-52	Hillcrest/ Hillslope	VHF Tower	-22.674715	119.306108	22/4/18	22/4/18
MARI-53	Hillcrest/ Hillslope	VHF Tower	-22.623834	119.205883	24/4/18	24/4/18

Appendix C Caves Recorded in the Study Area

Cave ID	Latitude, Longitude	Date Assessed	Roost Type	Cave Position	Floor Slope	Aspect	Cave Exposure	Entrance Type	Entrance Shape	Entrance Width (m)	Entrance Height (m)	Cave Depth (m)	No Cham	Cham Height (m)	Water Present	Scat Count	Count/ Estimate	Scat Age	Comments	Photo
Discovered by Biota (2012)																				
MARI01	-22.632288, 119.228024	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MARI02	-22.63276, 119.227876	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MARI03	-22.631368, 119.221463	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Discovered by Biologic (2013)																				
MARI01	-22.632271, 119.228012	05/08/11	Potential Day Roost	Mid slope	-	-	-	-	-	10	5	15	-	-	-	Ghost Bat scats present 201-500	Estimate	Ancient		
MARI04	-22.663078, 119.236786	08/08/11	Potential Day Roost	Upper slope	-	-	-	-	-	12	4	20	-	-	None	Ghost Bat scats present 51-100	Estimate	Fresh / old	Three feeding areas with scats	
MARI05	-22.665987, 119.2313	08/08/11	Night Roost	Upper slope	-	-	-	-	-	4	1.5	15	-	-	Semi-present	Ghost Bat scats present	Estimate	Old		
MARI06	-22.679655, 119.237793	08/08/11	-	Lower slope	-	-	-	-	-	3	5	30	-	-	Within 300m	No scats present	-	-		
MARI07	-22.633604, 119.211919	-	Potential Day Roost	Lower slope	-	W	-	Two entrances	-	3	1.5	15	-	-	None	A few Ghost Bat scats present	Estimate	-		
MARI08	-22.664583, 119.258481	14/3/11	Feeding roost	-	-	-	-	-	-	2	2	-	-	-	-	No scats present	-	-		
MARI09	-22.679389, 119.23797	16/3/11	-	-	-	-	-	Multiple entrances	Complex	4	3	25	Complex	-	Within 500m	-	-	-		
MARI10	-22.624076, 119.238123	18/03/11	-	-	-	-	-	-	-	1	1	20	Sink hole	-	Yes – water seeps in hole	-	-	-		
MARI11	-22.682177, 119.279065	28/03/11	-	Mid slope	-	-	-	-	-	2.5	1.5	25	2	-	None	Two piles of Ghost Bat scats present and two fresh kills	Estimate	-		
MARI17	-22.614714, 119.215934	07/02/11	Feeding roost	-	-	-	-	-	-	0.5	2	4	Complex	-	Yes – 10m pool	Ghost Bat scats present	Estimate	-		

Cave ID	Latitude, Longitude	Date Assessed	Roost Type	Cave Position	Floor Slope	Aspect	Cave Exposure	Entrance Type	Entrance Shape	Entrance Width (m)	Entrance Height (m)	Cave Depth (m)	No Cham	Cham Height (m)	Water Present	Scat Count	Count/ Estimate	Scat Age	Comments	Photo
MARI21	-22.62528, 119.205959	18/03/11 and 19/04/18	-	Upper Slope	-	Flat	Exposed	Cavity	Other	3	8	20	-	-	-	-	-	-	Not Accessible! East-west upward facing cavity	 
Discovered by Biologic (2016a)																				
MARI22	-22.6660555, 119.161054	16/01/16	Potential Day Roost	Mid slope	Decline	NW	Sheltered	Cavity	Horizontal	12	4	-	-	-	Within 50m	No scats present	-	-	Unable to enter cave due to small entrance	
Discovered by Biologic (2016b)																				
MARI12	-22.6699631, 119.261628	19/12/15	Potential maternity	Upper slope	Incline	N	Sheltered	Cavern	Horizontal	5	1.5	30	-	5	None	501-1000	Estimate	Fresh	Two adult ghost bats present.	
MARI13	-22.6237212, 119.2188556	19/12/15	Night roost	Mid slope	Incline	W	Sheltered	Cavity	Horizontal	5	1.5	23	-	1.6	Within 50m	1-5	Estimate	Old/ Very old		
MARI14	-22.6760036, 119.2480472	17/01/16	Night roost	Lower slope	Decline	S	Sheltered	Cavity / cavern	Horizontal	8	3	28	-	1.6	None	No scats present	-	-	Reasonable cave	
MARI15	-22.6718159, 119.257717	21/01/16	Night roost	Upper slope	Flat	E	Semi exposed	Cavity	Horizontal / Round	4	3	15	-	6	None	1-5	Estimate	Very old	Cave is shallow but high ceiling.	
MARI16	-22.6700667, 119.2655933	21/01/16	Night roost	Lower slope	Incline	E	Sheltered	Cavern	Horizontal	10	3	30	-	2.5	None	1-5	Estimate	Very old		

Cave ID	Latitude, Longitude	Date Assessed	Roost Type	Cave Position	Floor Slope	Aspect	Cave Exposure	Entrance Type	Entrance Shape	Entrance Width (m)	Entrance Height (m)	Cave Depth (m)	No Cham	Cham Height (m)	Water Present	Scat Count	Count/ Estimate	Scat Age	Comments	Photo
Discovered During the Current Survey																				
MARI18	-22.690, 119.1014	1/06/18	Could not be assessed	Lower Slope	Could not be assessed	W	Sheltered	Cavity	Horizontal	4.5	1	Could not be assessed	Could not be assessed	Could not be assessed	Could not be assessed	Could not be assessed	Could not be assessed	Could not be assessed	Below rail line so not accessed. About 10m to a bricked constriction then a second chamber. Possibly a good cave.	
MARI19	-22.6883, 119.1003	1/06/18	Potential Day Roost	Mid Slope	Incline	E	Sheltered	Cavity	Horizontal	3.5	0.75	20	1	5.5	Within 50m	0	Count	No Scats	*Taphozous georgianus*, *Vespadelus finlaysoni* present. Very high roof. Excellent quality Ghost Bat habitat. Very little scar material which is hard to explain.	
MARI20	-22.6902, 119.2902	30/05/18	Potential Day Roost	Upper Slope	Flat	W	Sheltered	Cavity	Round/ Oval	2.5	1.6	18	2	1.5	None	0	Count	No Scats	*Taphozous georgianus*, *Vespadelus finlaysoni* present. No ghost bat scats – however, a distinctive lack of scats belonging to , any species of bat. Quite dark so quite a valuable cave.	 

Appendix D Water Features Recorded in the Study Area

Water Feature ID	Latitude, Longitude	Estimated Permanency	Photos
Discovered by Biologic (2013)			
WMAR-01	-22.657385, 119.226463	Most likely permanent	-
WMAR-02	-22.698551, 119278725	-	-
WMAR-03	-22.614714, 119.215775	-	-
WMAR-04	-22.665842, 119.233022	-	-

Water Feature ID	Latitude, Longitude	Estimated Permanency	Photos
Discovered by Biologic (2016a)			
WMAR-05	-22.6740914, 119.1304412	~1/4 of year	
WMAR-06	-22.6683514, 119.1311356	~3/4 of year	-

Water Feature ID	Latitude, Longitude	Estimated Permanency	Photos
WMAR-07	-22.66506997, 119.1614057	Permanent	
WMAR-08	-22.66572234, 119.1612866	Permanent	

Water Feature ID	Latitude, Longitude	Estimated Permanency	Photos
WMAR-09	-22.66626016, 119.160797	Permanent	
WMAR-10	-22.6681203, 119.1532792	Not permanent	

Water Feature ID	Latitude, Longitude	Estimated Permanency	Photos
WMAR-11	-22.6910273, 119.1072828	Permanent	
WMAR-12	-22.66791624, 119.1535621	Permanent	
WMAR-13	-22.65757571, 119.2261961	-	

Water Feature ID	Latitude, Longitude	Estimated Permanency	Photos
Discovered During the Current Survey			
MAR-WH-03	-22.6207, 119.2104	~1/3 of year	 
MAR-WH-05	-22.6133, 119.212	~1/4 of year	 

Appendix E Conservation Significant Fauna Recorded during the Survey

Site ID	Sampling Method	Observed	Record Type	Genus	Species	Abundance	Comments	Latitude	Longitude
MARI.17	Motion Camera	26/04/2018	Individual (alive)	*Dasyurus*	*hallucatus*	1		-22.66544	119.16024
MARI.17	Opportunistic	02/06/2018	Scat	*Dasyurus*	*hallucatus*	1		-22.66544	119.16024
Cave MARI12	Opportunistic	26/04/2018	Scat	*Macroderma*	*gigas*	50		-22.6696	119.2615
OPP	Opportunistic	27/04/2018	Mound (recently inactive)	*Pseudomys*	*chapmani*	1	Recently Active	-22.7032	119.2981
OPP	Opportunistic	31/05/2018	Mound (recently inactive)	*Pseudomys*	*chapmani*	1		-22.661	119.1413
OPP	Opportunistic	31/05/2018	Mound (recently inactive)	*Pseudomys*	*chapmani*	1		-22.6876	119.1277
OPP	Opportunistic	1/06/2018	Mound (recently inactive)	*Pseudomys*	*chapmani*	1		-22.6544	119.2629

Appendix F Previous survey effort and key findings

Surveys

A. ecologia (2006) - Marillana Terrestrial Vertebrate Fauna Survey;
B. Biota (2012b) - Koodaideri Iron Ore Project Vertebrate Fauna Integration Report.;
C. Biologic (2013) - Marillana Vertebrate Fauna Survey.;
D. Biota (2002) Proposed Hope Downs Rail Corridor from Weeli Wolli Siding to Port Hedland - Vertebrate Fauna Survey;
E. Maunsell (2003) Yandi Life of Mine Fauna and Flora;
F. Biota (2010) Yandicoogina South West and Oxbow Fauna Survey;
G. Biota (2009) Yandicoogina Targeted Northern Quoll survey;
H. ecologia (2009) Marillana Iron Ore Project Vertebrate Fauna Assessment;
I. Biologic (2012a) - Mainline Rail Expansion Vertebrate Fauna Survey;
J. Biologic (2011a) - Barimunya Camp Vertebrate Fauna Survey;
K. Biologic (2011b) - Yandi Vertebrate Fauna Review
L. Biologic (2011b) - Jinidi to Mainline Vertebrate Fauna Survey;
M. ENV (2008a) - Rapid Growth Project 5: M270SA Fauna Assessment;
N. ENV (2007) - Mindy North Exploration Lease Fauna Assessment;
O. ecologia (2005) Mindy-Coondiner Exploration Project Biological Survey;
P. ecologia (2008b); RGP5 Fauna Survey Kurrajura Siding to Yandi WYE including Yandi Repeater 1;
Q. ENV (2008b) - RGP5 Jimblebar Junction to Yandi Junction Railway Reserve and Repeaters 6, 7 and 8 Fauna Assessment;
R. Specialised Zoological (2008) - Survey for conservation significant bats between Kurrajura siding and the Yandi WYE;
S. Bamford Consulting Ecologists (2012) - Fauna Assessment, Nyidinghu Iron Ore Project;
T. Biota (2014) - Yandi Billiards Phase 1 Seasonal Fauna Survey;
U. Biologic (2016a) - Marillana Infrastructure Corridor Level 1 Vertebrate Fauna Survey;
V. Biologic (2016b) – Marillana Targeted Vertebrate Fauna Survey;
W. ecologia (1995) - Yandi Stage II Iron Ore Project: Biological Assessment Survey;
X. Halpern Glick Maunsell (1999) - Marillana Creek Western Access Corridor - Biological Assessment*;*
Y. ecologia (2008a) - Marillana Creek (Yandi) Iron Ore Mine Modification - Level 2 Fauna Survey and;
Z. Current Survey

Survey	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z
Experience Level of Consultant	Appropriate training, experience and mentoring. Senior personnel undertaken numerous similar surveys	22 zoologists totalling 140 years of collective fauna survey experience	5+ years of experience. Specialist experience in all the vertebrate fauna groups was available within the team.	Unknown	Unknown	Unknown	Unknown	Appropriate training, experience and mentoring in fauna identification and fauna assemblage surveys.	Ecologists had extensive experience with the fauna in the Pilbara	Field person had five+ years of fauna survey experience	Field person had five+ years of fauna survey experience	Biologists were suitably qualified in their respective fields.	Biologists were suitably qualified in their respective fields.	Biologists were suitably qualified in their respective fields.	Qualified Staff	Zoologists had several years' experience and have conducted many similar surveys in the Pilbara.	Biologists were suitably qualified in their respective fields.	Unknown	Consultants had extensive experience in conducting fauna assessments	Unknown	The two field personnel collectively had 23 years of fauna survey experience in the Pilbara.	The field personnel had ten+ years' experience undertaking fauna surveys in the Pilbara and have specific experience surveying for the target species.	Unknown	Unknown	All personnel are experienced in fauna surveys in the Pilbara having worked in the industry for at least two years.	The field personnel involved in the survey each have in excess of ten years' experience undertaking fauna surveys in the Pilbara and have specific experience surveying for the target species.
Type	2 season, Level 2	2 season, Level 2	2 season, Level 2	2 season, Level 2 and Targeted	Targeted	2 season, Level 2	Targeted	Two season Level 2	Level 1 and targeted	Level 1 and Targeted	Level 1 and Targeted	Two season Level 2	Level 1	Level 1	Level 1, no trapping	Level 1, no trapping	Level 1	Targeted	Level 2	Level 2	Level 1 and Targeted	Targeted survey	1 season, Level 2	Level 1 no trapping	1 season, Level 2	Targeted
Duration	2-9 Oct 2005 & 10-17 Mar 2005	2010- August 2011-Mar, May, Oct, Nov 2012-March, May	7-20 Mar 2011 & 1-14 Aug 2011	29 April - 14 May 2001, 23 June - 1 July 2001, 30-31 July 2001, October 2001 and November 2001	23-28 September 2003	5th July and 12th July 2008 & March 4th and 7th 2010.	6th – 12th of October 2009	25 April – 7 May 2008 and 30 August – September 2008	16-29 February, 8-21 March and 12-25 April 2012	19-Apr-14	10 – 17 Dec 2010	15 February – 9 April and 24 August – 2 September 2011	21, 22 and 25 May 2008	19 – 24 April 2007	7th November 2005 and 11th November 2005	9 - 13 May 2008	21-28 May 2008	2 - 8 Oct 2008	7-17 of April 2011 16-24 of June	8 - 18 March 2014	19 Dec 2015, 15-20 Jan 2016 & 10 Mar 2016	17-19 December 2015 to 9 March 2016	14 May – 8 Jun 1995	23 – 30 Apr 1999	19 – 30 Mar 2008	16 - 28 Apr 2018 and 29 May - 2 June 2018
Seasonal Conditions	Conducted over two seasons. Combining both surveys ensured that all vertebrate groups were adequately surveyed.	**Koodaideri lease Survey** - Dry Season was atypical (maximum temperatures slightly below the long term and rainfall was approximately double long-term monthly average. Wet season no rain during the survey but 26-50mm received prior. **Northern extent**: survey was conducted following a period slightly below average rainfall. **Infrastructure corridor:** Phase 1A conducted a period of above average rainfall. Phase 2A slightly above average rainfall. Phase 1B: conducted following a wet period of above average rainfall. **Western Corridor:** warm to hot conditions, following a period of significantly higher than average rainfall.	Phase 1 temperatures were warm. 5.4 mm rain fell on the first day and 33.2mm fell in the last few days of the Phase 1 survey. Phase 2 temperatures were cooler, and no rain fell.	Unknown	Unknown	Minimum temperatures ranged from 2.3°C to 11.5°C and maximum temperatures ranged from 20.4°C to 26.6°C. No rainfall was recorded, Weather was comparable to the long-term climatic averages for Newman	Minimum temperatures fluctuated from 9.8 °C to 22.1 °C. Maximum temperature ranged from 30.9 °C to 36.8 °C. No rain was recorded 2009	Ambient air temperatures did not inhibit fauna activity. No rainfall during the first phase of the survey, and two very minor rainfall events during the second phase, which were unlikely to have influenced fauna activity.	Given the elongated shape and the length of the Study Area, the climatic conditions significantly change between the northern and southern ends.	Rainfall was higher than expected and minimum and maximum temperatures were lower than expected.	Rainfall was recorded over 6 days during December, (17 mm) Heavy rain fell on two days during the survey. Temperatures were within the average range for this time of year.	Rainfall was below average during survey except for Wittenoom that received above average rainfall for February. Maximum temperatures were above average for Wittenoom but as expected for Hillside and Port Headland. Minimum temperatures were above average except for March and April at Wittenoom that were as expected.	36 mm of rainfall in the 3 months preceding the survey and day temperatures were in the high 20°C, with night temperatures falling just below 10°C	124.8mm of rainfall in the three months preceding the survey. The day temperatures were in the low to mid 30s, with night temperatures falling just below 20°C.	Survey was undertaken under favourable conditions. Mean monthly maximum 40.5 °C during January 23.7 °C in July. Mean monthly minima 24.9 °C in January 8.9 °C in July. Annual rainfall is 337 mm occurs in the summer period between December and March.	Daytime temperatures were mild to hot, consequently reptile activity was high. Pools in gorges remained after rainfall preceding the survey which made suitable habitat for frogs.	~ 36 mm of rainfall in the 3 months preceding the survey. Day temperatures were in the high 20°C, Night temperatures falling just below 10°C.	Unknown	Conditions were generally dry.	Unknown	Hot and humid. Maximum daytime temperatures between 34 and 38 °C. Rainfall ~ 3.8 mm. Considerable rainfall in January that mostly occurred in the two weeks following the survey. Would have positively affected fauna activity and detectability. Following late January, there were no further significant rainfall events, and the remainder of the wet season was drier than average.	Maximum temperatures were consistent with average for the region. Rainfall at Marillana BoM station during and within the six months prior to the survey was above the long-term average.	Unknown	Unknown	Weather conditions during the survey were excellent for all vertebrate forms -hot, humid days and nights in the initial half of the survey, with significant thunderstorms and rainfall.	The wet season approximated the long-term average thus unlikely to impact the ability to detect target fauna. Plants had flowered likely increasing the breeding activity of vertebrate fauna species. Phase 1 temperatures were considered average for the time of year resulting in average activity patterns for species and satisfactory for reptile activity. Phase 2 cool temperatures may have reduced in fauna activity during
Approximate Distance from Study Area	Within Study Area	Overlap with northern part of Study Area	Within Study Area	Borders and extends north to Port Headland	~8km S and ~ 10 km SW	~8km south	~6 km SW	Borders Study Area	~3km north	Within	Small section overlaps	Borders Study Area	Within Study Area	~3 km east of Study Area	¬6km east of Study Area	Overlaps	¬3km north	Overlaps	Within and adjacent	~2km east	Within Study Area	Within Study Area	Intersects southern border	Border	Border and overlaps SLIGHTLY in one corner	-
No. Trapping Sites	6	116	8	38	0	11	8	6	3	N/A	N/A	17	0	0	10	N/A	Unknown	N/A	5	11	N/A	N/A	10	N/A	6	N/A

Survey	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z
Site Type	Linear transect of 10 pit traps, 20 Elliott traps, 1 funnel trap and 2 cage traps	10 pit traps alternating 20L bucket with PVC tubes, Elliot traps spaced 10-15m, Funnel traps placed in pairs 10m intervals.	7 transects: 10 pits, 20 Elliots, 10 pits, 20 Elliots, 20 funnels and 2 cages. 1 site with 20 Elliots, 20 funnels and 2 cages	33 sites with row of 10 pitfall traps and 5 sites with 20-25 Elliot traps spaced 1m apart	No trapping was conducted	Six grids of 10 pit-traps, three funnel trap sites of 20 traps each, and two lines of Elliott traps	Trapping transect sites were selected as the best options available.	Linear transect of 5 PVC pipe and 5 bucket pit traps, 20 Elliott traps, 20 funnel traps and 2 cage traps	Meandering transects with six people, three on each side of the rail track, trapping sites comprised fence lines, funnel traps and Elliott traps 10 transect lines per site. Twenty funnels, 10 Elliots.	Opportunistic only	Opportunistic only	Linear transect. Per site: 5 buckets, 5 PVC pipes, 20 funnel traps, 20 medium Elliotts, 2 cages.	No trapping was conducted	No trapping was conducted	Hand Foraging for Mammals, Reptiles and Amphibians	Opportunistic only	Opportunistic only	Opportunistic only (bat survey)	20 pitfall traps, 3 one to two metre drift-fences placed in a Y-shape around trap. 1 funnel and Elliot trap associated with one drift-fence arm of each pitfall.	Five pitfall trapping grids (10 traps spaced 10m connected 100m flywire fence), Four funnel trapping grids (8-10 pairs along 100m flywire fence), Two Elliott trap transects (25med, 10Lg Elliots 4x cage)	Opportunistic only: sound recorders at seven (7) locations, Cameras were deployed at six (6) locations	Four baited motion-sensitive cameras (50 m apart) were placed at twelve sites and Ten (10) sites were set up with SM2BAT+ recorders for two nights	CALM Pilbara grid	Opportunistic only	20 Elliot traps, 20 funnel traps, 2 cage traps, 5 PVC and 5 20L bucks per site	No Trapping was conducted
Elliot trap nights	1680	5378	2240	590	N/A	310	11357	2400	160	0	0	4200	N/A	N/A	0	0	0	N/A	1085	507	0	0	1260	N/A	960	N/A
Pitfall trap nights	840	8547	490	2310	N/A	360	0	2400	0	0	0	1920	N/A	N/A	0	0	0	N/A	700	350	0	0	612	N/A	960	N/A
Funnel trap nights	840	1980	2240	0	N/A	360	0	2400	160	0	0	4200	N/A	N/A	0	0	0	N/A	700	216	0	0	N/A	N/A	960	N/A
Cage trap nights	168	0	434	0	N/A	0	0	240	0	0	0	420	N/A	N/A	0	0	0	N/A	175	52	0	0	0	N/A	96	N/A
Diurnal search (hrs)	27	unknown	144	Unknown	Unknown	unknown	0	90	1152	10	47.5	55	43	31	9.5	16	57.5	~80	50+	32	~100	35	>40	0	61	12
Nocturnal search (hrs)	17.16	unknown	~48	0	10	0	0	28.2	48	0	0	~48	20	9	0	14.5	11.75	9	20	unknown	0	8	20	0	30.5	0
Bird surveys (hrs)	29.66	161.5	26.3	Unknown	Unknown	10.16	0	41.7	Not stated	0	0	63.1	50	44.5	4.66	11	50	N/A	26.25	11.5	N/A	N/A	58.8	0	27	98 nights
Bird Survey method	20 min 2 ha search	Unbounded Area Censuses	20 min 2 ha search	Censusing and Opportunistic	Unknown	unbounded area searches within systematic sampling grids & opportunistic survey	N/A	20 min 2 ha search	Systematic/opportunistic searches	Traversing the Study Area	Traversing the Study Area	20 min 2 ha search	Opportunistic	Opportunistic	20-minute bird census	20 min 2 ha search	Unknown	N/A	45 min each morning within 25 m of trap sites	unbounded habitat-specific searches 30mins & opportunistic	20 min 2 ha search	N/A	3 x1 hr set-time period surveys in AM, and 2 x1 hr surveys in PM	0	20 min 2 ha search	Acoustic recorders for Night Parrot
Bat survey effort	12.75 hrs	67 (nights)	14	14 mist net nights, 6 harp trap nights, unknown number of recordings but 158 call sequences analysed	Unknown	11 (nights)	N/A	46.6 hrs	264hrs accumulative	0	4	20 nights / 160 hrs	33.8 hrs	N/A	N/A	4	N/A	18	12 nights	12 nights	65	20	0	0	4	33 nights
Bat survey method	Anabat	Anabat SD2 and SM2 Song Meter and Harp trap	Anabat, SM2Bat+	Trapping (Harp traps and mist nets) and Anabat II	Anabat II	Anabat	N/A	Anabat	SM2BAT detectors	N/A	Anabat	Anabat, SM2Bat	Anabat	N/A	N/A	Anabat	N/A	Anabat	Harp trap, Anabat SD, PMC recorder	Song Meter SM2BAT	SM2Bat+	SM2BAT+	N/A	N/A	Anabat	SMBAT+
Camera nights	0	17	0	0	N/A	0	0	N/A	5 cameras 648 h	0	0	28	N/A	N/A	N/A	0	0	N/A	22	6	111	3988	N/A	N/A	0	31
Threatened and Priority Ecological Communities	Within 25km: Coolibah-Lignum Flats and West-Angelas Cracking Clays	None	None	None	None	None	None	N/A	-	None	None	N/A	None	N/A	None	-	None	-	None	None	-	-	Marillana Creek represents a unique habitat with high conservation value (only permanent body of fresh water within the area).	-	Not mentioned	

Survey	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z
Survey Limitations	Some limited access during phase 1. Periodic rainfall reduced reptile activity (< 20% of potential fauna not sampled)	Habitats were not equally sampled (some areas inaccessible) . Biases in individual sampling methods may influence richness estimates.	Large Study Area and lack of road access during Phase 1 not all areas of Gorge and Gully habitat were searched.	Significant rain event in April May diminished some reptile activity	Lack of trapping or use of motion cameras would have reduced the detectability of conservation significant fauna	Represents a single phase of sampling only. Seasonal survey could augment the number of species recorded	Many creekline and drainage traplines showed evidence of recent burns and invasive species	Rainfall was insufficient to stimulate amphibian emergence.	Nothing of note	Nocturnal work did not occur; this reduced the ability for opportunistic detection of nocturnally active species.	Access to areas to significant heritage value was denied. Nocturnal work did not occur; this reduced the ability for opportunistic detection of nocturnally active species.	Rain was encountered towards the end of the second field survey so surveying was scheduled for the third trip to defer any limitation to the survey. There were no other disturbances that had the potential to affect the completeness of the survey.	Nocturnal searches were restricted to road cruises along access tracks and roads. Weather conditions were good but not ideal Nocturnal reptiles and bats are likely to be less active on cool nights. Dry conditions reduce frog activity. The project area was disturbed by road and rail infrastructure, earth works and quarries.	Nothing of note	Nocturnal foraging did not occur. Some of the sites were quite barren and appeared to have been burnt previously. Reptile fauna could have been sampled over a longer duration using pit-trapping methods and further bird censuses could be done.	In some areas access was limited to one side of the railway. Fauna on the other side using binoculars was conducted. A number of Aboriginal Heritage areas were not available for survey. Mammals tend to be poorly represented in any opportunistic survey.	These weather conditions were not ideal. Many nocturnal reptiles and bats are likely to be less active on cool nights. Conditions were quite dry, so frog activity was limited. The project area is disturbed by road and rail infrastructure, earth works and quarries, so the level of vegetation and soil disturbance is high.	Cave assessments were limited to the most prospective structures that could be located and accessed given the large survey area, the available timeframe, and limited accessibility in the rough terrain.	Conditions were generally dry, which may have affected the presence and/or abundance of some species	A broad seasonal survey may augment the number of species recorded from the Study Area. Not all sections of the Study Area were ground-truthed or equally sampled for fauna. Parts of the Study Area were inaccessible by vehicle However, systematic fauna sampling was completed in habitats considered to be representative of the range of units present. Night spotting was not undertaken.	All recorded bat calls were identified; however, it was not possible to differentiate all species. However, conservation significant species can be readily distinguished from other species; therefore, this wasn't a limitation.	Detecting Ghost Bat by audio recording is limited as Ghost Bats do not always call when entering or exiting caves and their call can be variable and difficult to identify.	Not specified	Not specified	Wet weather prohibited deployment of bat detector at all sites. The area north of the access road had been extensively burnt and habitat in this area was patchy and disjunct making it unsuitable for trapping survey. Heritage constraints restricted access to some northern areas	There were no material limitations to the targeted survey and any limitations or constraints are nullified by the amount to Survey work conducted in the Study Area to date.

Appendix G Fauna of conservation significance recorded in the desktop assessment

Species	Common name	Conservation status				Database searches (Biologic, 2016a)	Database searches (Biologic, 2016b)	Database searches (Current Survey)			Previous reports																								
		EPBC Act 1999	*BC Act 1950*	DBCA Priority	IUCN Red List	DBCA Threatened sp.	DBCA Threatened sp.	DBCA NatureMap	EPBC Protected Matters	BHP Database	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z
MAMMALS																																				
Dasyurus hallucatus	Northern Quoll	EN	EN		EN	●	●	●	●	●		●	●	●					●																●
Macrotis lagotis	Bilby	VU	VU		VU		●	●	●					●					●																
Macroderma gigas	Ghost Bat	VU	VU		VU	●	●	●	●	●		●	●	●								●				●						●			●
Rhinonicteris aurantia	Pilbara Leaf-nosed Bat	VU	VU			●	●		●	●		●							●							●									
Trichosurus vulpecula arnhemensis	Northern Brush-tailed Possum		VU																																
Dasycercus blythi	Brush-tailed Mulgara			P4			●	●		●				●					●			●								●				
Pseudomys chapmani	Western Pebble-mound Mouse			P4		●	●			●	●	●	●	●	●	●			●	●	●	●			●	●				●	●	●	●	●	●	●
Leggadina lakedownensis	Short-tailed Mouse			P4										●																					
Chalinolobus morio	Chocolate Wattle Bat	Locally significant																				●									●				
BIRDS																																				
Numenius madagascariensis	Eastern Curlew	CR/MI	VU/MI											●																					
Calidris ferruginea	Curlew Sandpiper	CR/MI	VU/MI		NT				●																										
Macronectes giganteus	Southern Giant-Petrel	EN/MI	MI				●	●																											
Falco hypoleucos	Grey Falcon		VU		VU	●	●	●				●							●																
Apus pacificus	Fork-tailed Swift	MI	MI					●	●	●		●	●						●		●									●	●				
Pandion haliaetus	Eastern Osprey	MI	MI			●	●			●																									
Glareola maldivarum	Oriental Pratincole	MI	MI		LC														●																
Charadrius veredus	Oriental Plover	MI	MI						●																										
Tringa glareola	Wood Sandpiper	MI	MI			●	●	●																											
Tringa hypoleucos	Common Sandpiper	MI	MI						●					●	●																				
Tringa nebularia	Common Greenshank	MI	MI			●	●	●		●									●																
Calidris acuminate	Sharp-tailed Sandpiper	MI	MI						●																										
Calidris melanotos	Pectoral Sandpiper	MI	MI						●																										
Tringa brevipes	Grey-tailed Tattler	MI	MI	P4	NT									●																					
Numenius phaeopus	Whimbrel	MI	MI											●																					

Species	Common name	Conservation status				Database searches (Biologic, 2016a)	Database searches (Biologic, 2016b)	Database searches (Current Survey)			Previous reports																													
		EPBC Act 1999	*BC Act 1950*	DBCA Priority	IUCN Red List	DBCA Threatened sp.	DBCA Threatened sp.	DBCA NatureMap	EPBC Protected Matters	BHP Database	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z
Pezoporus occidentalis	Night Parrot	EN	CR		EN		●	●	●																													
Rostratula benghalensis australis	Australian Painted Snipe	EN	EN		EN	●	●		●																													
Gelochelidon nilotica	Gull-billed Tern	MI	MI							●				●																								
Sterna bergii	Crested Tern	MI	MI											●																								
Sterna caspia	Caspian Tern	MI	MI											●																								
Hirundo rustica	Barn Swallow	MI	MI						●																													
Motacilla cinereal	Grey Wagtail	MI	MI						●																													
Motacilla flava	Yellow Wagtail	MI	MI						●																													
Falco peregrinus	Peregrine Falcon		OS			●	●	●		●		●	●	●					●										●				●				
Heteromunia pectoralis	Pictorella Manniki				NT														●																		
Ephippiorhynchus asiaticus	Black-necked Stalk				NT									●					●																		
REPTILES																																					
Liasis olivaceus barroni	Pilbara Olive Python	VU	VU			●	●	●	●	●		●	●		●						●	●					●		●	●		●	●				
Cyclodomorphus branchialis	Gilled Slender Blue-Tongue		VU																																		
Anilios ganei	Pilbara Flat-headed Blind-snake			P1		●	●	●		●		●	●									●															
Ctenotus nigrilineatus	Black-lined Ctenotus			P1															●																		
Ctenotus uber johnsoni				P2			●	●														●															
Underwoodisaurus seorsus	Pilbara Barking Gecko			P2		●	●																														
Total	**41 species**					**13**	**18**	**13**	**16**		**1**	**9**	**7**	**15**	**3**	**11**	**0**	**0**	**13**	**1**	**3**	**6**	**0**	**0**	**1**	**3**	**1**	**0**	**3**	**5**	**2**	**3**	**3**	**1**	**1**	**3**