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SHEFFIELD RESOURCES LTD
THUNDERBIRD PROJECT
TERRESTRIAL AND SUBTERRANAEAN FAUNA ASSESSMENT

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ACRONYMS

BoM	Bureau of Meteorology
CAMBA	China-Australia Migratory Bird Agreement
DEC	Department of Environment and Conservation (now DPaW or DER)
DPaW	Department of Parks and Wildlife (formerly DEC)
DoE	Department of the Environment (formerly DSEWPaC)
DoW	Department of Water
DSEWPaC	Department of Sustainability, Environment, Water, Population and Communities (now DoE)
EIA	Environmental Impact Assessment
EP Act	*Environmental Protection Act 1986*
EPA	Environmental Protection Authority
EPBC Act	*Environment Protection and Biodiversity Conservation Act 1999*
JAMBA	Japan-Australian Migratory Bird Agreement
SAC	Species Accumulation Curve
WC Act	*Wildlife Conservation Act 1950*

EXECUTIVE SUMMARY

Sheffield Resources Limited is a rapidly emerging mineral sands company with significant additional nickel, talc and iron assets, all located within the state of Western Australia. Sheffield are currently validating extensive historical work and undertaking biological surveys at an early stage to aid their project pathway. Sheffield commissioned *ecologia* Environment to undertake a two-phase, Level 2 terrestrial (vertebrate and SRE invertebrate) and subterranean fauna assessment of its Thunderbird Project, located 70 kilometres west of Derby on the Dampier Peninsula. Sheffield seeks to gain an understanding of the fauna of the Thunderbird study area, and identify the environmental values present.

The potential vertebrate fauna assemblage identified during the literature review comprised 39 mammal species, 234 bird species, 81 reptile species and 12 amphibian species. Of these potential species, seven mammal, 15 bird (excluding wetland and coastal dependent species) and two reptile species are listed as conservation significant. Thirty invertebrate species from SRE groups previously recorded on the Dampier Penisula were also identified during the literature review, but no subterranean fauna have yet to be recorded.

The two-phase survey was undertaken using a variety of techniques, both systematic and opportunistic, in accordance with relevant guidelines. In summary, the fauna survey effort consisted of the following:

Vertebrate fauna:

- seven trapping grids were open for 14 nights over two seasons;
- approximately 29 hours were spent surveying for birds;
- 20 hours and 20 minutes were spent on opportunistic diurnal searching;
- 35 hours and 15 minutes were spent on opportunistic nocturnal searching;
- 385 hours and 15 minutes of camera trapping data was analysed; and,
- 180 hours of acoustic (SM2Bat) recordings were analysed to determine bat assemblage and distribution.

SRE Invertebrate Fauna:

- six SRE dry pitfall trapping grids were open for six nights;
- seven vertebrate fauna trapping grids, with pitfalls that doubled as invertebrate traps, were open for 14 nights over two seasons; and,
- three leaf litter samples were taken from each of the SRE dry pitfall grids, totalling 18 samples.

Stygofauna:

- a total of 90 net hauls from 15 drill holes were sampled for stygofauna.

Troglofauna

- a total of 12 traps and 12 scraping hauls at six drill holes were sampled for troglofauna.

A total of three broad-scale terrestrial habitat types have been determined to exist within the study area; pindan shrubland, savannah woodland and sandstone range. None of the habitats recorded are regarded as rare or unique to the study area. Statistical analysis of the systematic survey data

did not indicate a significant difference between the three habitat types in terms of their respective vertebrate or SRE invertebrate fauna assemblages.

A total of 16 native mammals, two introduced mammals, 107 bird species (27 only recorded at the Mount Jowlaenga homestead), 43 reptile species and eight amphibians were recorded during the survey.

Nine species of conservation significant vertebrate fauna (two mammal and seven bird species) were recorded during the survey, with an additional four species assessed as having a medium or high likelihood of occurrence. Three of the recorded species are wetland dependent species, and only recorded at the Mount Jowlaenga homestead, adjacent to (outside) the study area. The six species recorded within the study area included the Greater Bilby (EPBC Act Vulnerable), Short-tailed Mouse (DPaW Priority 4), Fork-tailed Swift (EPBC Act Migratory), Rainbow Bee-eater (EPBC Act Migratory), Australian Bustard (DPaW Priority 4) and Bush Stone-curlew (DPaW Priority 4).

A total of 28 invertebrate taxa from six orders were submitted for identification and SRE status assessment. The results from the identifications showed one taxon is a confirmed SRE (the land snail *Rhagada bulgana*). This taxon has previously been recorded on the Dampier Peninsula. Additionally, 20 taxa are considered potential SREs (seven mygalomorph spiders, one pseudoscorpion, seven scorpions, one harvestmen, three slaters and one land snail). Due to the lack of regional surveys on the Dampier Peninsula, it is not possible to assess the true SRE status of these taxa from the available data. However, as the vegetation communities and landforms present within study area do not appear to be unique, it is unlikely that any of these taxa are geographically confined to the boundary of the proposed impact area.

Two specimens of troglofauna were collected during the troglofauna survey including one specimen of the centipede *Cryptops '*sp. indet.', and a specimen of rove beetle from the family Staphylinidae (Staphylinidae 'sp. indet.'). Both taxa are considered to be potential SREs; however, the continuous sandstone strata are expected to extend well beyond the study area.

Ten specimens of Naididae worms were collected during the stygofauna survey, and are classified as opportunistically stygal. The absence of obligate stygofauna suggests there is a low likelihood of a diverse and abundant stygofauna community within the study area.

Systematically obtained data was analysed to determine the survey adequacy through SACs. Extrapolation of the Michaelis-Menten (MM) curve suggests that 93.8% of trappable terrestrial vertebrate fauna (reptiles and mammals), 97.2% of birds and 77.2% of SRE invertebrate fauna were recorded. These results indicate that the majority of species were recorded for all fauna groups. However, increased sampling is likely to record additional species, particularly within the SRE invertebrate group.

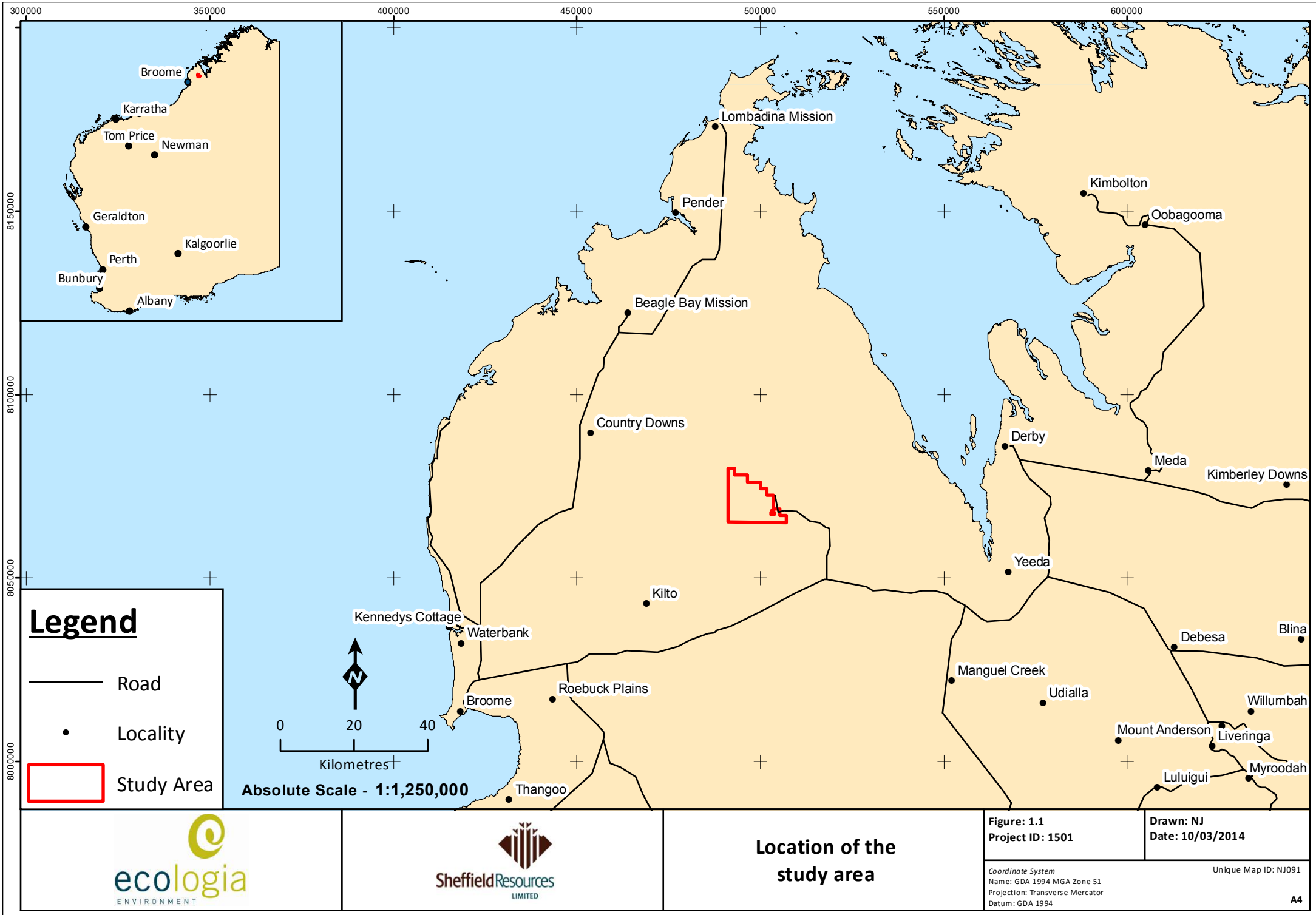
No significant limitations were experienced during the surveys. Given the lack of limitations and the fact that the majority of fauna were recorded, the surveys can be considered adequate and have met their objectives.

1 INTRODUCTION

1.1 PROJECT OVERVIEW

Sheffield Resources Limited (Sheffield) is a rapidly emerging mineral sands company with significant additional nickel, talc and iron assets, all located within the state of Western Australia. Sheffield are currently validating extensive historical work and undertaking biological surveys at an early stage to aid their project pathway.

Sheffield commissioned *ecologia* Environment (*ecologia*) to undertake a two-phase, Level 2 terrestrial (vertebrate and short range endemic (SRE) invertebrate) and subterranean fauna survey of its Thunderbird Project, located 70 kilometres west of Derby on the Dampier Peninsula (Figure 1.1). Sheffield seeks to gain an understanding of the fauna that occurs in the Thunderbird area (study area), and identify the environmental values present.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Kalgoorlie
Perth
Bunbury
Albany
Lombadina Mission
Pender
Beagle Bay Mission
Country Downs
Kimbolton
Oobagooma
Derby
Meda
Kimberley Downs
Yeeda
Kilto
Kennedys Cottage
Waterbank
Broome
Roebuck Plains
Thangoo
Manguel Creek
Udialla
Debesa
Blina
Willumbah
Mount Anderson
Liveringa
Myroodah
Luluigui
N
0
20
40
Kilometres
Absolute Scale - 1:1,250,000
Legend
Road
Locality
Study Area
ecologia
ENVIRONMENT
SheffieldResources
LIMITED
Location of the study area
Figure: 1.1
Project ID: 1501
Drawn: NJ
Date: 10/03/2014
Coordinate System
Name: GDA 1994 MGA Zone 51
Projection: Transverse Mercator
Datum: GDA 1994
Unique Map ID: NJ091
A4

1.2 LEGISLATION AND POLICY

The *Environmental Protection Act 1986* (EP Act) is "an Act to provide for an Environmental Protection Authority, for the prevention, control and abatement of environmental pollution, for the conservation, preservation, protection, enhancement and management of the environment and for matters incidental to or connected with the foregoing." Section 4a of this Act outlines five principles that are required to ensure that the objectives of the Act are addressed. Three of these principles are relevant to native fauna and flora:

- *The Precautionary Principle*

  Where there are threats of serious or irreversible damage, lack of full scientific certainty should not be used as a reason for postponing measures to prevent environmental degradation.

- *The Principle of Intergenerational Equity*

  The present generation should ensure that the health, diversity and productivity of the environment is maintained or enhanced for the benefit of future generations.

- *The Principle of the Conservation of Biological Diversity and Ecological Integrity*

  Conservation of biological diversity and ecological integrity should be a fundamental consideration.

In addition to these principles, projects undertaken as part of the Environmental Impact Assessment (EIA) process are required to address guidelines produced by the Environmental Protection Authority (EPA). In this case, principles outlined in following guidelines:

- Guidance for the Assessment of Environmental Factors, Statement No. 56: *Terrestrial Fauna Surveys for Environmental Impact Assessment in Western Australia* (EPA 2004);
- *Technical Guide – Terrestrial Vertebrate Fauna Surveys for Environmental Impact Assessment* (EPA and DEC 2010)*;*
- Guidance for the Assessment of Environmental Factors, Statement No. 20: *Sampling of Short range endemic Invertebrate Fauna for Environmental Impact Assessment in Western Australia* (EPA 2009);
- Environmental Assessment Guideline No. 12: *Consideration of Subterranean Fauna in Environmental Impact Assessment in Western Australia* (EPA 2013);
- Guidance for the Assessment of Environmental Factors, Statement No. 54a (Technical Appendix to Guidance Statement 54 - superseded by Environmental Assessment Guideline No. 12): *Sampling Methods and Survey Considerations for Subterranean Fauna in Western Australia* (EPA 2007); and,
- EPA Position Statement No. 3: *Terrestrial Biological Surveys as an Element of Biodiversity Protection* (EPA 2002b).

In relation to terrestrial SRE fauna, EPA Guidance Statement No. 56 states that:

> *"Comprehensive systematic reviews of different faunal groups often reveal the presence of short range endemic species (Harvey 2002). Among the terrestrial fauna there are numerous regions that possess short range endemics. Mountainous terrains and freshwater habitats often harbour short range endemics, but the widespread aridification and forest contraction that have occurred since the Miocene has resulted in the fragmentation of populations and the evolution of many new species. Particular attention should be given to these types of species in environmental impact assessment because habitat loss and degradation will further decrease their prospects for long-term survival."*

The State is committed to the principles and objectives for the protection of biodiversity as outlined in *The National Strategy for the Conservation of Australia's Biological Diversity* (Commonwealth Government 1996).

Native flora and fauna formally recognised as rare, threatened with extinction, or as having high conservation value are protected at a Commonwealth level under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) and at a state level under the *Wildlife Conservation Act 1950* (WC Act).

The EPBC Act also takes into consideration four international agreements related to migratory species which include the Convention on the Conservation of Migratory Species of Wild Animals (Bonn Convention), the Japan-Australian Migratory Bird Agreement, the China-Australia Migratory Bird Agreement and the Republic of Korea-Australian Migratory Bird Agreement.

The EPBC Act provides for the protection of the environment, especially those aspects of the environment that are matters of national environmental significance, to promote ecologically sustainable development through the conservation and ecologically sustainable use of natural resources, and to promote the conservation of biodiversity. The EPBC Act includes provisions to protect native species (and in particular to prevent the extinction and promote the recovery of threatened species) and to ensure the conservation of migratory species. In addition to the principles outlined in Section 4a of the EPBC Act, Section 3a includes a principle of ecologically sustainable development dictating that decision-making processes should effectively integrate both long-term and short-term economic, environmental, social and equitable considerations. Schedule 1 of the EPBC Act contains a list of species that are considered Extinct, Extinct in the Wild, Critically Endangered, Endangered, Vulnerable and Conservation Dependent. Definitions of categories relevant to fauna occurring or potentially occurring in the project area are provided in Appendix A.

The Western Australian WC Act provides for the conservation and protection of wildlife in Western Australia. Under Section 14 of this Act, all flora and fauna within Western Australia is protected; however, the Minister may, via a notice published in the *Government Gazette*, declare a list of fauna identified as rare, likely to become extinct, or otherwise in need of special protection (Appendix A). These species are considered Threatened Fauna. The current listing was gazetted on 17 September 2013.

In addition, the Department of Parks and Wildlife (DPaW), maintains a ranked list of specially protected fauna, which includes Threatened Fauna and Priority Fauna. These rankings dictate which species should receive the highest priority for conservation management. Threatened fauna that are listed as Schedule 1 under the WC Act are further ranked by the DPaW according to their level of threat using IUCN Red List categories and criteria. Schedule 1 species can be ranked as Critically Endangered (CR), Endangered (EN) or Vulnerable (VU).

Priority Fauna are placed into five categories. The first three Priority Fauna categories are species that have not yet been adequately surveyed to be listed under Schedule 1 or 2, and are ranked in order of priority for survey and evaluation of conservation status so that consideration can be given to their declaration as threatened fauna. Species that are adequately known and are rare but not threatened, meet IUCN criteria for Near Threatened, or that have been recently removed from the threatened list for other than taxonomic reasons, are placed in Priority 4. These species require regular monitoring. Species meeting criteria for the IUCN category of Conservation Dependent are placed in Priority 5. The three Threatened Fauna codes and five Priority codes are also summarised in Appendix A.

Some better known SRE species are listed as threatened or endangered under State or Commonwealth legislation in the WC Act and/or EPBC Act, but the majority are not. Often the lack of knowledge about these species precludes their consideration for listing as threatened or

endangered. Listing under legislation should therefore not be the only conservation consideration in environmental impact assessment.

1.3 SURVEY OBJECTIVES

Sheffield commissioned *ecologia* to undertake a comprehensive survey of the terrestrial and subterranean fauna of the Thunderbird study area to facilitate the EIA of the project. Faunal groups assessed include vertebrate fauna, terrestrial epigean SRE invertebrate fauna, troglofauna and stygofauna.

The aim of this study was to document and describe the fauna of the study area and provide sufficient information to enable an assessment of the impact of the project on fauna populations.

This report satisfies the requirements of relevant EPA Guidance documents by providing:

- a review of background information (including literature and database searches);
- an inventory of fauna species occurring in the study area, incorporating recent published and unpublished records;
- a discussion related to the species of biological and conservation significance recorded or likely to occur within the project area and the surrounding region;
- a description of fauna habitats occurring in the study area;
- a description of the characteristics of the invertebrate and vertebrate fauna assemblage;
- an appraisal of the current knowledge base for the area, including a review of previous surveys conducted in the area that are relevant to the current study; and,
- a review of regional and biogeographical significance, including the conservation status of species recorded in the study area.

1.4 BACKGROUND SUMMARY OF FAUNA GROUPS

1.4.1 Terrestrial fauna

1.4.1.1 Terrestrial vertebrate fauna

Australia's terrestrial vertebrate fauna assemblages include reptiles (917 species), birds (828 species), amphibians (227 species) and mammals (386 species), the latter of which is dominated by marsupials, bats, and rodents (Chapman 2009). The majority (80%) of Australia's terrestrial vertebrate fauna are endemic to Australia, with many species restricted to small areas or regions. Endemism refers to the restriction of species to a particular area, whether it is at a continental, national or local level (Allen *et al.* 2002). The cause of the high level of endemism in Australia is attributed to its long period of geographic isolation after the dividing of Gondwana.

Australia's vertebrate fauna, in particular mammal and bird species, have experienced a high rate of decline and extinction over the last two hundred years (Johnson 2006) with approximately 30 species of mammals and birds becoming extinct. A further 57 species of mammals, birds, reptiles, frogs and fish are considered endangered and likely to become extinct in the near future (Johnson 2006).

Changes in fire regime and the introduction of feral animals, such as the European Red Fox and the Cat, have also resulted in a decrease and the extinction of several species (Short and Smith 1994). A number of ground-dwelling birds, such as the Night Parrot and the Ground Parrot, and small to medium sized mammals (Lesser Greater Bilby and Greater Stick-nest Rat) have reduced drastically in numbers or even become extinct. With the onset of progressively more impact by human activity, already rare fauna species that are generally restricted to a particular habitat or microhabitat, have

been identified and protected to preserve existing populations within their habitat (Brown and Saunders 2013).

1.4.1.2 Terrestrial invertebrate fauna (Short Range Endemics)

Invertebrate fauna are characterised by the lack of a vertebral column. The vast majority of animal species are invertebrates with over 90% of all fauna belonging to this group.

This review focuses on SREs, outlines the major paths to short range endemism, the current knowledge of short range endemism in Australia and the conservation significance of such species. It is important to note that the individual taxa and broader groups discussed are not an exhaustive list of all SREs. This is due to the fact that SREs are dominated by invertebrate species, which are historically understudied and in many cases lack formal descriptions. An extensive, reliable taxonomic evaluation of these species has begun only relatively recently and thus the availability of literature relevant to SREs is relatively scarce.

Short range endemism is influenced by numerous processes, which generally contribute to the isolation of a species. A number of factors, including the ability and opportunity to disperse, life history, physiology, habitat requirements, habitat availability, biotic and abiotic interactions, and historical conditions, influence not only the distribution of a taxon, but also the tendency for differentiation and speciation (Ponder and Colgan 2002).

Many SREs are considered to be relict taxa (remnants of species that have become extinct elsewhere) and are confined to certain habitats, and in some cases, single geographic areas (Main 1996). Relict taxa include extremely old species that can be traced back to Gondwanan periods (180-65 million years ago) and have a very restrictive biology (Harvey 2002).

With the onset of progressively dryer and more seasonal climatic conditions since this time, suitable habitats have become increasingly fragmented in Western Australia. Relict species now generally persist in habitats characterised by permanent moisture and shade, maintained by high rainfall and/or prevalence of fog (Main 1996; Main 1999). However, hundreds of species of invertebrate are considered under threat and may soon become extinct.

1.4.2 Subterranean fauna

Subterranean fauna are characterised by the following traits (from Cho 2010):

- high endemism but low local diversity relative to regional diversity;
- a relatively small number of genetic lineages resulting in species dissimilar in appearance to related groups;
- many relicts from previous climatic conditions; and,
- truncated food webs.

Traditionally, arid and semi-arid areas were considered poor potential habitat for subterranean fauna as these organisms are moisture-dependent (Harvey *et al.* 2008). However, recent descriptions of subterranean fauna in the arid and semi-arid zone of WA have indicated the presence of a diverse fauna, with an estimate of 4,140 subterranean taxa found in the western half of Australia (Biota 2008). A total of 403 species has been described to date and additional 367 are known but undescribed (EPA 2012). Based on this estimate, over 80% of the subterranean fauna likely to be present has not yet been documented (Biota 2008).

1.4.2.1 Stygofauna

Stygofauna are generally thought of as fauna that live in subterranean water, and comprise three groups that relate to the species' affinity with groundwater. Stygofauna occurring in groundwater are either accidentals (*stygoxenes*) or with varying degrees of affinity for groundwater, inhabiting it on a permanent or temporary basis (*stygophiles*), but only *stygobites* are obligate inhabitants of groundwater (Gilbert *et al.* 1994)..

The subterranean environment is devoid of light, may have restricted available space (i.e. porous or fissured rock) and has a relatively constant temperature. These species have evolved unique features such as a lack of pigmentation, elongated appendages, filiform body shape (worm like) and reduced or absent eyes. Many species are believed to be relict taxa with affinities with Tethys, Pangea and derived landmasses (Humphreys 1993; Knott 1993; Danielopol and Stanford 1994; Humphreys 1999, 2001).

Stygofauna are known to be present in the groundwater associated with a variety of geologies. These include (but are not limited to) calcrete aquifers associated with palaeochannels, hematite sandstone aquifers (e.g. Koolan Island), clay-sandstone aquifers on the Swan and Scott Coastal Plains (ecologia 1998; Humphreys 2001; *ecologia* 2006a, b; Rockwater 2006), porous aquifers (e.g. alluvium) (Mamonier *et al.* 1993), fractured-rock aquifers, springs and hyporheic habitats (Eberhard *et al.* 2005). However, distribution patterns of stygofauna are determined by hydrogeological aquifer types rather than by affiliation of aquifers to a given geological unit. Two main types of aquifer relevant for stygofauna have been defined by Hahn and Fuchs (2009):

1. Compact aquifers (aquitard), comprise materials such as clay, loess, and very fine sands, as well as compact rocks, which have reduced pore spaces and thus a low hydraulic conductivity (kf < 10 -6 m sec-1). Exchange with surface water for food and oxygen supply is reduced and living space is minimal in this type of aquifer, which is why these aquifers are either devoid of fauna or have depleted taxonomic richness and abundance.
2. Open aquifers, comprise of porous, fractured and karstic groundwater circulation systems with at least moderate hydraulic conductivity (kf > 10 -6 m sec-1). There is continuous exchange with surface water for food and oxygen supply and more abundant living space, which is why stygofauna communities are often found in this aquifer type (Hahn and Fuchs 2009). In addition, communities of porous and karstic aquifers have been found to be more similar to each other than the communities of compact and fractured aquifers (Hahn and Fuchs 2009).

Stygofauna are found in oxygenated groundwater, usually ranging from fresh to hyposaline, but they can occur in salinities up to seawater (EC = 54,000 µS/cm) (Humphreys 1999). Recent experience west of Lake Way near Wiluna has recently shown that palaeochannel aquifers with an EC of 60,000 uS/cm can harbour diverse and abundant stygal assemblages (*ecologia* 2006a).

The presence of stygofauna in Western Australia has been well documented, especially from regions such as the Pilbara and Kimberley, and less so in the Midwest and South West regions of WA (De Laurentiis *et al.* 2001; Humphreys 2001; Wilson and Keable 2002; Eberhard 2004; Karanovic 2004; Cho *et al.* 2005). Australian stygofauna is dominated by crustaceans including Amphipoda (Bradbury and Williams 1997), Isopoda (Wilson 2001), Ostracoda (Karanovic and Marmonier 2002; Martens and Rossetti 2002; Karanovic and Marmonier 2003; Karanovic 2005) and Speleogriphacea (Poore and Humphreys 1998; Poore and Humphreys 2003).

1.4.2.2 Troglofauna

Troglofauna are terrestrial subterranean animals that inhabit air chambers in underground caves or small, humid voids. They are divided into three ecological categories (Howarth 1983):

- troglobites, obligate underground species that are unable to survive outside their subterranean environment;
- troglophiles, facultative species that live and reproduce underground but that are also found in similar dark, humid microhabitat on the surface; and,
- trogloxenes, species that regularly inhabit underground caves and cavities for refuge but normally return to the surface environment to feed.

A fourth group, 'accidentals', are vagrant individuals that might have wandered into a cave system but cannot survive there (Howarth 1983).

A species is considered truly troglobitic if it displays characteristics that appear to restrict it to subterranean habitats (Howarth 1983, 1993). These include a significant reduction or a complete loss of eyes, pigmentation, wings and circadian rhythm (24-hour biological cycle), as well as development of elongated appendages, slender body form and, in some species, a lower metabolism.

True troglobites are often spatially restricted because they are incapable of dispersing on the surface. Troglobitic species have extremely limited capacity for dispersal and are typically isolated within the extent of their habitat. Such dispersal limitations result in extremely small, fragmented species ranges and high levels of endemism (EPA 2003), and are a typical characteristic of subterranean fauna worldwide (Strayer 1994).

The presence of troglofauna in Western Australia is still poorly documented. To date, troglofauna have been recorded from karst limestone systems at Cape Range, Barrow Island and in the Kimberley (Harvey 1988; Humphreys 2001; Biota 2005), pisolitic mesa formations in the Pilbara (Biota 2006) and in the cave systems of Yanchep (EPA 2005), Margaret River (Eberhard 2006) and across the Nullarbor (Moore 1995).

2 ENVIRONMENT

2.1 CLIMATE

The study area is situated in the Kimberley region of Western Australia at the south-east edge of the Dampier Peninsula. The area has a dry, hot, tropical climate with two distinct seasons: the 'wet' from around December to March, and the 'dry' for the remainder of the year. Rainfall is highly variable in the region due to the inconsistent nature of the movement and occurrence of thunderstorms and tropical systems. Tropical cyclones can occur as late as April, but are most common in January and February. Rainfall during the cooler months is usually associated with cloud bands originating from tropical waters to the north-west (BoM 2013). The average temperature over summer is over 33 °C, with warm overnight minima of around 26 °C (BoM 2013). Winter temperatures are quite mild, with average maximum and minimum temperatures in July being 26.9 °C and 12.0 °C respectively (BoM 2013).

The Bureau of Meteorology (BoM) weather stations (with full data sets) closest to the study area are Derby Aero (BoM Station 3032) and Broome Airport (BoM Station 3003). Derby Aero is located 70 km east of the study area, with Broome Airport located 95 km to the south-west. These stations were selected as a reference to provide the best indication of the local climatic conditions of the study area (Figure 2.1)

The mean annual rainfall for Broome is 607.3 mm, but is highly variable with over 75% of the annual rainfall usually falling between January and March (BoM 2013). The mean number of rainfall days (≥1 mm) per year is only 35.1. Generally, the wettest month is February, with a mean of 179.1 mm falling over an average of 9.1 rainfall days. The hottest month is April and the coldest is July, with means of 34.3 °C and 28.8 °C, respectively (Table 2.1).

The mean annual rainfall for Derby is 690.8 mm, with over 75% of the annual rainfall usually falling between January and March (BoM 2013). The mean number of rainfall days (≥1 mm) per year is 38. January and February are generally the wettest months of the year, both recording a mean of 200.3 mm over an average of 10.1 and 9.7 rain days respectively. The hottest month is November and the coldest is June, with means of 38.0°C and 30.4°C, respectively (Table 2.1).

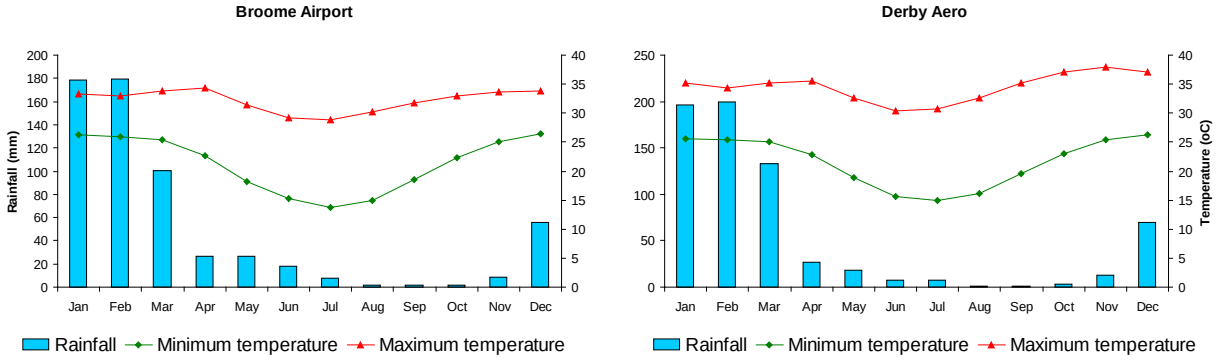


Figure 2.1 – Climate data for Broome Airport and Derby Aero Weather Stations (BoM 2013)

The weather conditions experienced during the field survey are presented in Appendix B. Both phases of the survey were conducted during hot and humid conditions with a small amount of rainfall (approx. 5 mm) at the start of the first phase.

Table 2.1 – Annual climate data for Broome Airport and Derby Aero weather stations (BoM 2013)

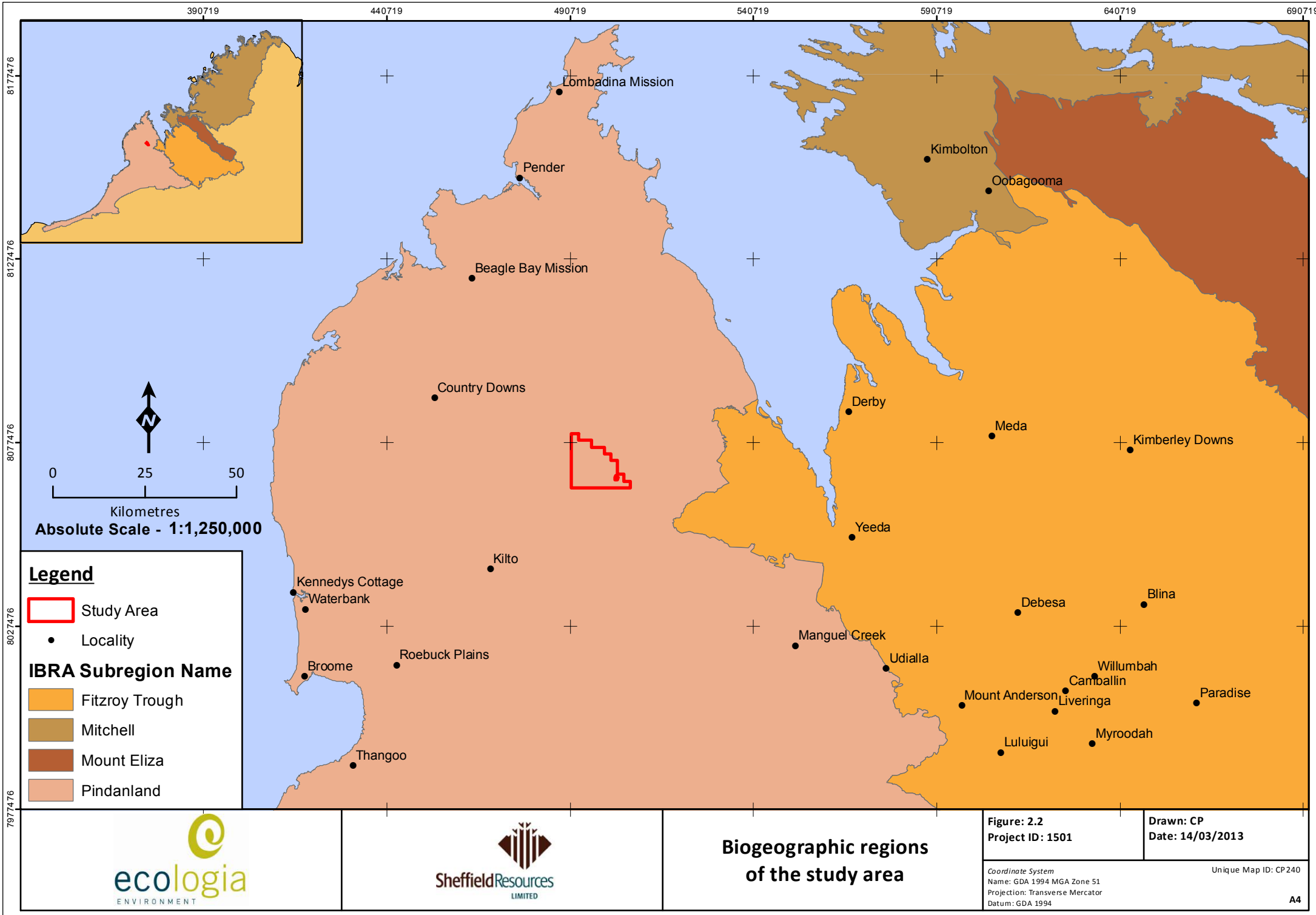
Broome Airport (003003)				**Commenced: 1939**					**Last record: 2012**				
51K 419520 8015182									**Elevation: 7 m**				
Derby Aero (003032)				**Commenced: 1951**					**Last record: 2012**				
51K 570115 8079392									**Elevation: 6 m**				
	Jan 13	**Feb 13**	**Mar 13**	**Apr 13**	**May 13**	**Jun 13**	**Jul 13**	**Aug 13**	**Sep 13**	**Oct 13**	**Nov 13**	**Dec 13**	**Annual**
Mean maximum temperature (°C)													
BME	33.3	32.9	33.9	34.3	31.5	29.1	28.8	30.3	31.8	32.9	33.6	33.8	32.3
DBY	35.2	34.3	35.1	35.5	32.7	30.4	30.6	32.6	35.2	37.0	38.0	37.1	34.5
Mean minimum temperature (°C)													
BME	26.3	26.0	25.4	22.6	18.2	15.2	13.7	14.9	18.5	22.3	25.1	26.5	21.2
DBY	25.6	25.4	25.0	22.7	18.8	15.6	14.7	16.0	19.6	23.0	25.4	26.3	21.5
Mean rainfall (mm)													
BME	178.5	179.1	102.8	26.4	26.0	17.5	7.2	1.7	1.4	1.4	8.9	55.6	607.3
DBY	200.3	200.3	135.8	26.1	17.8	7.7	7.6	0.8	1.1	2.6	12.8	70.1	690.8

Source: BoM (BoM 2013)

2.2 BIOGEOGRAPHY

The Interim Biogeographic Regionalisation for Australia (IBRA Version 7, Australian Government Department of Sustainability 2012) classifies the Australian continent into regions (bioregions) of similar geology, landform, vegetation, fauna and climate characteristics (DSEWPaC 2012). The study area lies within the Dampierland bioregion. The Dampierland bioregion is further divided into two subregions, these being the Fitzroy Trough (DL1) and Pindanland (DL2) subregions. The study area lies entirely within the Pindanland subregion of the Dampierland Bioregion (Figure 2.2).

The Pindanland subregion covers approximately 59% of the Dampierland bioregion (Figure 2.2). This subregion consists of sandplains of a fine-textured sand-sheet with subdued dunes and includes the paleodelta of the Fitzroy River. The vegetation is described primarily as pindan (Graham 2002). The dominant land uses are grazing, unallocated crown land, crown reserves and native pastures.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Kimbolton
Oobagooma
Beagle Bay Mission
Country Downs
Derby
Meda
Kimberley Downs
Yeeda
Kilto
Kennedys Cottage
Waterbank
Debesa
Blina
Manguel Creek
Roebuck Plains
Broome
Udialla
Willumbah
Camballin
Mount Anderson
Liveringa
Paradise
Myroodah
Luluigui
Thangoo
N
0
25
50
Kilometres
Absolute Scale - 1:1,250,000
Legend
Study Area
Locality
IBRA Subregion Name
Fitzroy Trough
Mitchell
Mount Eliza
Pindanland
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Biogeographic regions of the study area
Figure: 2.2
Project ID: 1501
Drawn: CP
Date: 14/03/2013
Coordinate System
Name: GDA 1994 MGA Zone 51
Projection: Transverse Mercator
Datum: GDA 1994
Unique Map ID: CP240
A4

2.3 LAND SYSTEMS

Land systems are described using the biophysical characteristic of geology, landform, vegetation and soils. The study area falls across four of these land systems (Figure 2.3), of which details are provided in Table 2.2 below.

Table 2.2 – Land systems of the study area

Land System	Description	Total area in Dampierland (ha)	Total area within Thunderbird study area (ha)	Percentage of land system in Thunderbird study area	Percentage of land system in Dampierland impacted
Fraser	Sand plain with irregular dunes and local stony surfaces, pindan and low grassy woodlands.	73,275	4,488.17	30.16%	6.13%
Reeves	Sand plain with scattered hills and minor plateaux, reddish sandy soils, pindan.	44,794	4,647.52	31.23%	10.38%
Waganut	Low lying sandplains and dune fields with through going drainage supporting pindan *Acacia* shrublands with emergent eucalypt trees.	518,511	3,011.66	20.24%	0.58%
Yeeda	Sandplains with red and yellow sands supporting pindan *Acacia* shrublands with emergent eucalypt trees.	1,653,086	2,734.03	18.37%	0.17%

2.3.1 Fraser Land System

The Fraser land system is characterised by sandplains and dunes with pindan woodlands and spinifex/tussock grasslands. Geologically, it is comprised of quaternary Aeolian sand with minor outcrops of gentle dipping Cretaceous sandstone.

2.3.2 Reeves Land System

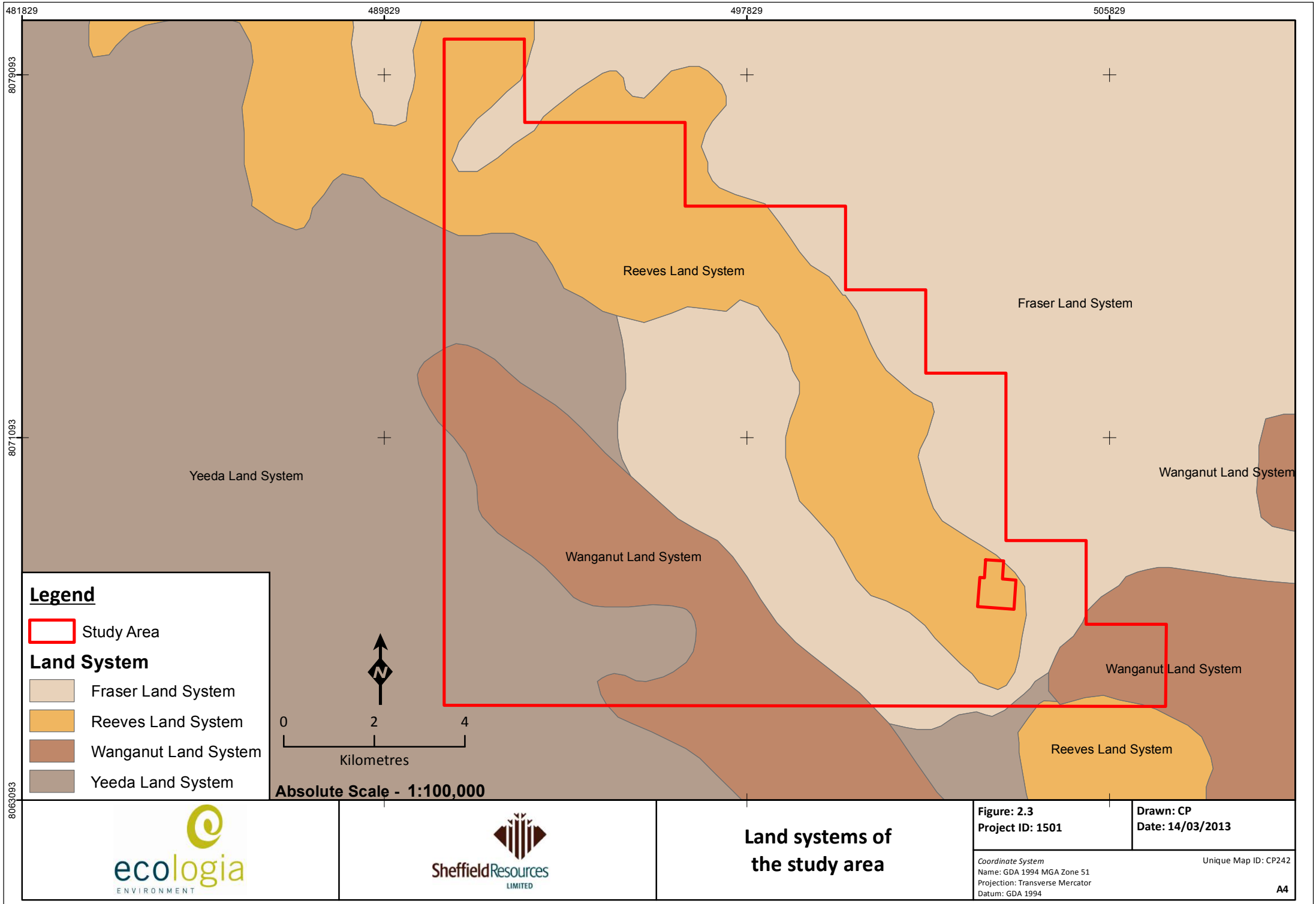
The Reeves land system is characterised by sandplains and scattered hills and minor plateaux, with pindan woodlands and spinifex/tussock grasslands. The geological formation is subhorizontal or gently dipping sandstone, sandy siltstone and silicified quartz sandstone of Cretaceous age, with Quaternary Aeolian sand. Pindan vegetation can be subject to frequent fires, which induce short term changes in botanical composition, density and structure. The sandplains have minor susceptibility to wind erosion immediately after fire but stabilise rapidly after rain.

2.3.3 Waganut Land System

The Waganut land system is characterised by low-lying sandplains and dunefields with through-going drainage, with pindan woodlands and spinifex/tussock grasslands. Its geological formation is made up of quaternary Aeolian sands. Vegetation is primarily dense wattle shrub with pindan pastures and is subject to fairly frequent fires, which induce short term changes in botanical composition, density and structure.

2.3.4 Yeeda Land System

The Yeeda land system is made up of sandplains and occasional dunes with shrubby spinifex grasslands or pindan woodlands. Geologically, it is comprised of quaternary Aeolian sands. It is generally not prone to degradation or erosion.



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Land systems of the study area

Figure: 2.3
Project ID: 1501

Drawn: CP
Date: 14/03/2013

Coordinate System
Name: GDA 1994 MGA Zone 51
Projection: Transverse Mercator
Datum: GDA 1994

Unique Map ID: CP242

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2.4 VEGETATION

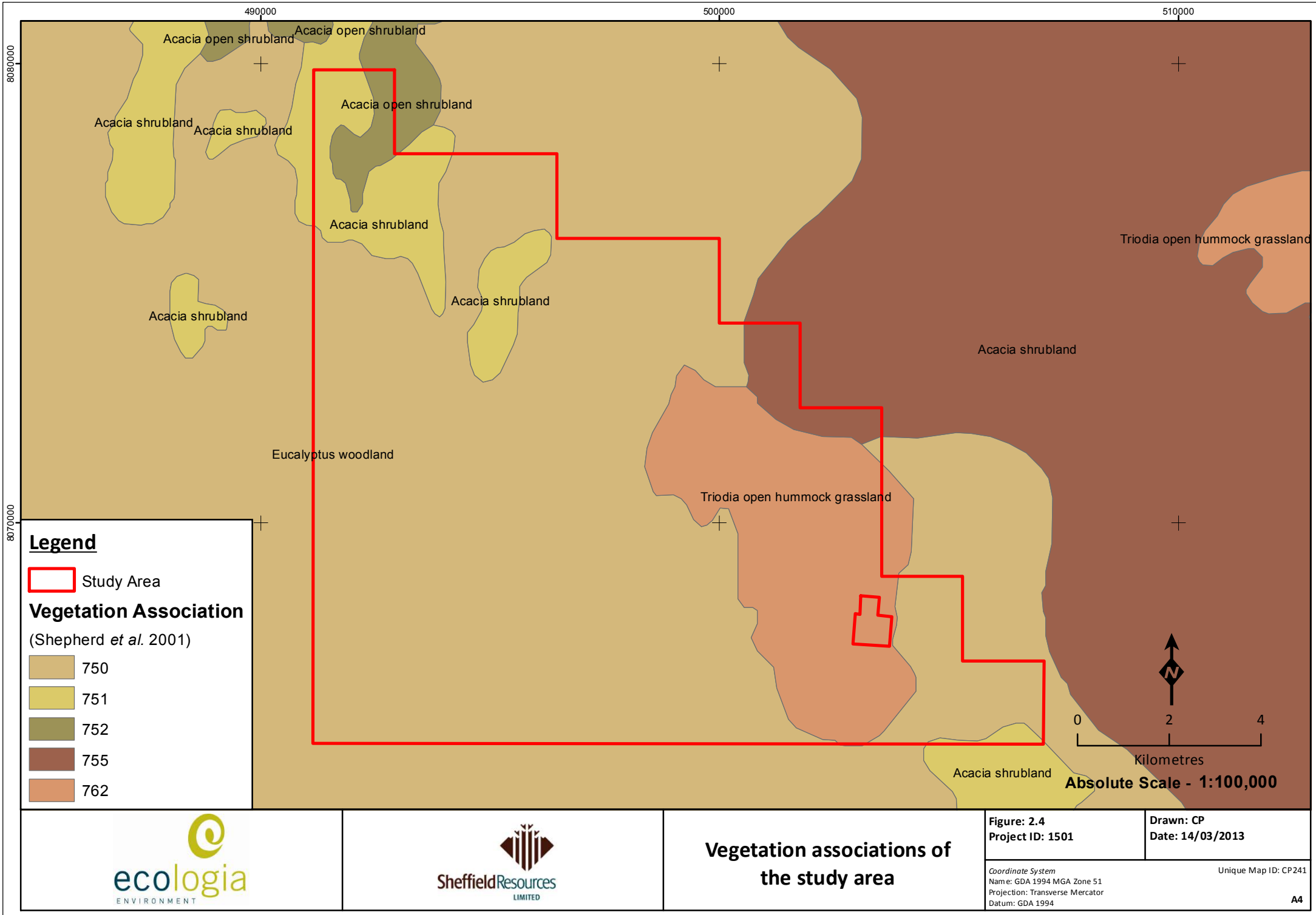
The Dampier Peninsula on which the study area is located lies within the Northern Botanical Province. The vegetation of Western Australia was originally mapped at the 1:1,000,000 scale by Beard (1979), and was subsequently reinterpreted and updated to reflect the NVIS standards (Shepherd *et al.* 2002). Five of the vegetation types identified by Shepherd *et al.* (2002) are found within the study area: Vegetation associations 750, 751, 752, 755 and 762. The majority of the study area (71.93%) consists of vegetation association 750, whereas vegetation association 752 is the least extensive, representing only 1.44% (Figure 2.4, Table 2.3).

Vegetation associations 750, 755 and 762 collectively comprise 91.04% of the study area. They are also described as having similar vegetation; typically that of pindan shrubland with *Acacia tumida* and other Acacia species, with open Eucalypt woodlands over ribbon grass and curly Spinifex (Shepherd *et al.* 2002). The other two vegetation associations (751 and 752) are also described similarly; they support hummock grasslands of Spinifex with *Acacia eriopoda* or *Acacia tumida* (Shepherd *et al.* 2002).

In a regional context, although over 70% of the study area comprises vegetation association 750, this is a common and widespread association, and represents only 0.88% of its total area within the Dampierland Bioregion (Table 2.3). Vegetation associations 751, 752 and 755 have smaller total areas, but none cover more than 7% of the study area. The smallest vegetation association is 762, so that 46.6% of its total occurs within the study area. However, this vegetation association is very similar to associations 750 and 755, so potential impacts to it should have minimal effect on local fauna habitat availability.

Table 2.3 – Vegetation associations of the study area

Vegetation Association	Description	Total area in the Dampierland Bio-region (ha)	Percentage of the total unit in the study area (%)	Total area in the Thunderbird study area (ha)	Percentage of the Thunderbird study area (%)
750	Shrublands, pindan; *Acacia tumida* shrubland with grey box & cabbage gum medium woodland over ribbon grass & curly Spinifex	1,232,039.34	0.88	10,812.22	71.93
751	Hummock grasslands, shrub steppe; *Acacia eriopoda* over soft Spinifex	16,193.97	6.97	1,128.19	7.5
752	Hummock grasslands, shrub steppe; *Acacia tumida* over *Triodia intermedia*	6,842.85	3.18	217.62	1.44
755	Shrublands, pindan; *Acacia tumida* & *A. oimpressa* shrubland with scattered low bloodwood & *Eucalyptus setosa* over ribbon & curly Spinifex	62,084.58	0.57	356.13	2.37
762	Shrublands, pindan; *Acacia eriopoda & A. tumida* shrubland with scattered low *Eucalyptus confertifolia* over curly Spinifex	5,401.68	46.6	2,516.96	16.74



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Vegetation associations of the study area

Figure: 2.4
Project ID: 1501

Drawn: CP
Date: 14/03/2013

Coordinate System
Name: GDA 1994 MGA Zone 51
Projection: Transverse Mercator
Datum: GDA 1994

Unique Map ID: CP241

A4

2.5 GEOLOGY, SOILS AND HYDROGEOLOGY

2.5.1 Geology and Soils

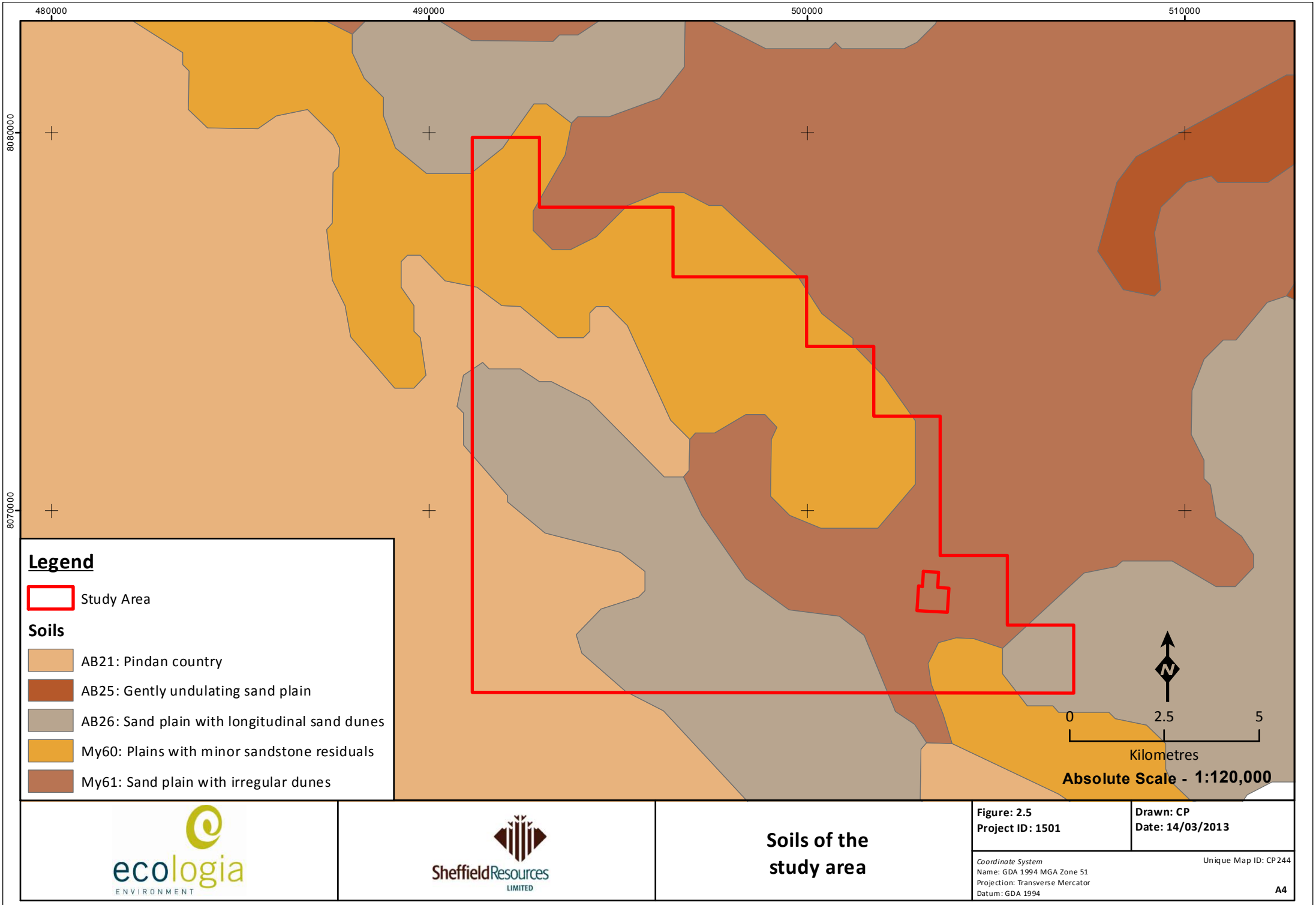
The Pindanland biogeographic subregion is situated on the north-western margin of the Canning Basin. This subregion is mainly quaternary sandplains over Jurassic and Mesozoic sandstones with pindan, as well as quaternary marine deposits on coastal plains and quaternary alluvial plains related to the Permian and Mesozoic sediments of the Fitzroy Trough (Graham 2001).

The Dampier Peninsula is underlain by Phanerozoic rocks in the north-west of the Canning Basin. The study area lies within a single geological unit (K), described as sedimentary rocks from the Cretaceous period (Hickman and Kranendonk 2008). The major soil type on the Peninsula is pindan, which developed during the Quaternary period (the past two million years) on desert dune sandstone (Figure 2.5). The pindan soils form extensive undulating plains with little or no organised surface drainage. When the pindan soils dry out, they become very hard with a dusty surface, and become soft and greasy when wet, with the potential to erode rapidly and form deep, steep-sided gullies (Kenneally *et al.* 1996). Based on the Atlas of Australian Soils (Bettenay *et al.* 1967), the dominant soil types within the study area comprise:

- AB21 - Pindan country; gently undulating sand plain with a few small rocky sandstone residuals; no external drainage: chief soils are red earthy sands with associated and hummocks of siliceous sands (18.86% of study area).
- AB26 - Sand plain with longitudinal sand dunes and some active drainage-ways: chief soils are red earthy sands associated with (Uc5.22) and (Uc5.1 l) soils on the plains, with dunes and hummocks of red sands. Some (Gn2.21) and (Dy5.32) soils occur in lower sites often with a heavy surface layer of ferruginous gravel (29.04% of study area).
- My60 - Plains with minor sandstone residuals on which there is extensive rock outcrop: main soils on the plains are neutral red earths and sandy neutral red soils (32.10% of study area).
- My61 - Sand plain with irregular dunes; active drainage systems: chief soils are neutral red earths and red earthy sands. Associated are deep red sand dunes and (Uc1.23). Some (Dy5.42) soils occur in low-lying areas. (20% of study area).

2.5.2 Hydrogeology

There are two groundwater resources present within the Dampier Peninsula; the unconfined Broome Sandstone aquifer and the extensive Wallal Sandstone aquifer, which is unconfined in the east (outside the Pindanland subregion), and confined and artesian on the Peninsula's west coast (Department of Water, 2010). The groundwater system is strongly connected to surface water expression in the form of mound springs, wetlands and small drainage lines in coastal areas, where groundwater discharge occurs from perched unconfined aquifers (DoW 2010). Drainage is poorly developed within the Dampier Peninsula with the main drainage pattern being sheet flooding, with much of the water infiltrating to groundwater (DoW 2012). There are numerous ephemeral creeks, with two main water courses: the Fraser River and Deep Creek.



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Soils of the study area

Figure: 2.5
Project ID: 1501

Drawn: CP
Date: 14/03/2013

Coordinate System
Name: GDA 1994 MGA Zone 51
Projection: Transverse Mercator
Datum: GDA 1994

Unique Map ID: CP244

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2.6 PREVIOUS SURVEYS AND LAND USE

Several databases were consulted in the preparation of potential fauna (and conservation significant fauna) lists, with search buffers around the Thunderbird study area ranging from 20–50 km (Table 2.4). In addition, 13 reports on various fauna surveys conducted on the Dampier Peninsula were consulted (Table 2.5). The locations of these surveys in relation to the study area are shown (Figure 2.6), and the results of all database searches and previous surveys are presented in Appendix C. As Figure 2.6 demonstrates, few of the previous regional surveys were near the study area, with the majority occurring along the western coastline of the peninsula. The online NatureMap database encompasses several datasets which include the WA Museum (WAM), DPaW threatened fauna database and DPaW survey return database.

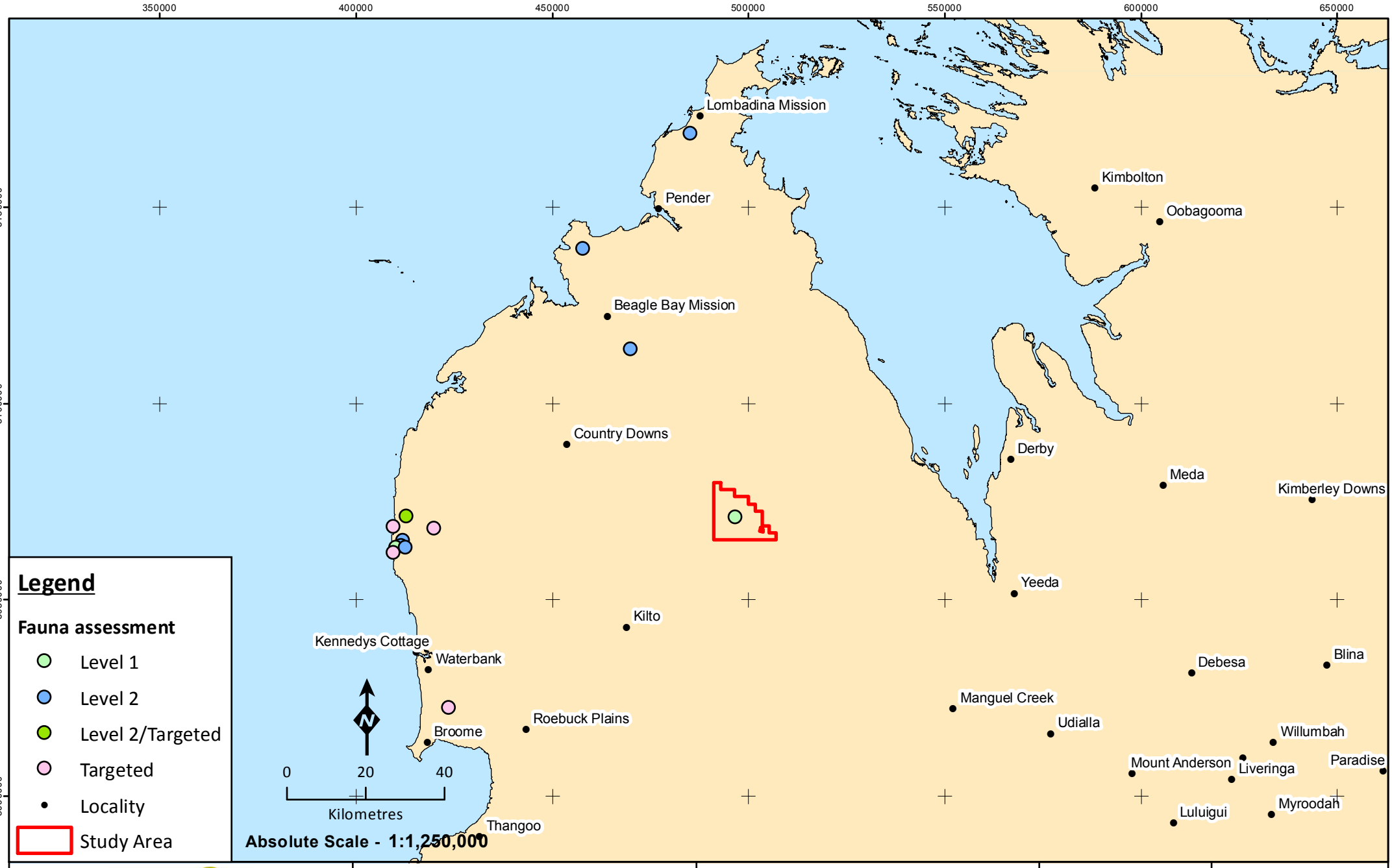
The study area is currently and historically used for pastoral purposes (Mount Jowlaenga Station), with cattle still present throughout. A small area within the study area boundary was also once used as a quarry, although this is excluded from the study area.

Table 2.4 – Databases searched to determine the potential vertebrate fauna assemblage

Group	Database	Custodian	Search details
Vertebrate fauna/ conservation significant fauna	NatureMap	DPaW	Records within 20 km of the study area. Date accessed: 24/05/12 URL:http://naturemap.dec.wa.gov.au
Vertebrate Fauna	Threatened Fauna Database	DPaW	Records within 20 km of the study area.
Vertebrate Fauna/ SRE Invertebrate fauna	Species Profile and Threats (SPRAT) Database	Department of the Environment (DoE)	Records within 50 km of the study area.
Vertebrate Fauna	Birdata	BirdLife Australia	Records within 50 km of the study area.
SRE Invertebrate fauna	WA Museum Arachnid Database	WAM	Search coordinates: 442969E, 8114590S (left top) and 518875E, 8030210S (bottom right) Zone 51, Date: 07/03/13
SRE Invertebrate fauna	WA Museum Crustacean Database	WAM	Search coordinates: 442969E, 8114590S (left top) and 518875E, 8030210S (bottom right) Zone 51, Date: 07/03/13
SRE Invertebrate fauna	WA Museum Mollusc Database	WAM	Search coordinates: 442969E, 8114590S (left top) and 518875E, 8030210S (bottom right) Zone 51, Date: 07/03/13

Table 2.5 – Previous biological survey reports within the region of the study area

Survey location and author(s)	Distance from study area	Comments
ecologia internal database	0-85	One Level 1 survey and three 1-phase Level 2 surveys
Perpendicular Head-North Head, Packer Island, Gourdon Bay and Coulomb-Quondong Vertebrate Fauna Assessment (ENV 2008)	70	1-phase Level 2 survey
James Price Point Terrestrial Fauna Survey (Biota 2009)	85	1-phase Level 2 survey
James Price Point Browse LNG Precinct Targeted Terrestrial Fauna Survey (Biota 2010)	85	1-phase Level 2 survey
Supplementary Terrestrial Fauna and Habitat Assessment (AECOM 2010)	85	1-phase Level 1 survey
Browse LNG Precinct Access Road: Targeted Fauna Survey – Greater Bilby (AECOM 2011)	85	Targeted Greater Bilby survey
Monitoring Yellow Sea Migrants in Australia (MYSMA) (Rogers *et al.* 2009)	85 – 435	Targeted shorebird survey
Assessment of Birds Utilising Habitat within the Vine Thickets and Woodlands of James Price Point (Bamford 2011)	85	Targeted bird survey
Browse Project Greater Bilby Survey of the James Price Point Area - Summary Report (ENV 2011)	85	Targeted Greater Bilby survey
Aquatic fauna and water chemistry of the mound springs and wetlands of Mandora marsh, north-western Australia (Storey *et al.* 2011)	240	Aquatic (stygofauna) survey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Beagle Bay Mission
Country Downs
Derby
Meda
Kimberley Downs
Yeeda
Kilto
Kennedys Cottage
Waterbank
Debesa
Blina
Manguel Creek
Roebuck Plains
Broome
Udialla
Willumbah
Mount Anderson
Liveringa
Paradise
Luluigui
Myroodah
Thangoo
Legend
Fauna assessment
Level 1
Level 2
Level 2/Targeted
Targeted
Locality
Study Area
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40
Kilometres
Absolute Scale - 1:1,250,000
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LIMITED
Previous biological survey locations
Figure: 2.6
Project ID: 1501
Drawn: NJ
Date: 10/03/2014
Coordinate System
Name: GDA 1994 MGA Zone 51
Projection: Transverse Mercator
Datum: GDA 1994
Unique Map ID: NJ090
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2.6.1 Potential Fauna Assemblage

Although the majority of prior survey effort for both vertebrates and invertebrates is concentrated on the western coastline of the Dampier Peninsula, this does not necessarily diminish the relevance of many of the potential species. Additionally, the ecology of some of these species is poorly known due the low number of surveys in the region. Since the habitat across the Dampier Peninsula is relatively homogeneous, being primarily sandy pindan shrubland (Sections 2.2–2.5), this means that many of the species known mainly from coastal areas may in fact occur across the peninsula.

2.6.1.1 Terrestrial Vertebrate Fauna

The results of previous surveys in the region provided an indication of the potential vertebrate fauna on the Dampier Peninsula (Table 2.6, Appendix C). Most of these surveys were conducted on or near the western coastline of the peninsula, for example the Rogers *et al.* (2009) and Bamford (2011) surveys, therefore many of the species recorded, particularly within the bird group, are specialised coastal species and are unlikely to occur as far inland as the study area. However, the relative homogeneity of the pindan shrubland habitat across the peninsula means that it is possible for many of the previously recorded species to occur in the study area.

Table 2.6 – Summary of previous vertebrate fauna biological surveys and database results

Survey location and author(s)	Mammals	Birds	Reptiles	Amphibians
Biological survey				
ecologia internal database	18	110	42	5
Supplementary Terrestrial Fauna and Habitat Assessment (AECOM 2010)	8	103	17	0
Browse LNG Precinct Access Road: Targeted Fauna Survey – Greater Bilby (AECOM 2011)	1	0	0	0
James Price Point Terrestrial Fauna Survey (Biota 2009)	12	68	39	1
James Price Point Browse LNG Precinct Targeted Terrestrial Fauna Survey (Biota 2010)	4	0	27	1
Perpendicular Head-North Head, Packer Island, Gourdon Bay and Coulomb-Quondong Vertebrate Fauna Assessment (ENV 2008)	33	176	56	8
Browse Project Greater Bilby Survey of the James Price Point Area - Summary Report (ENV 2011)	2	0	0	0
Monitoring Yellow Sea Migrants in Australia (MYSMA) (Rogers *et al.* 2009)	0	80	0	0
Assessment of Birds Utilising Habitat within the Vine Thickets and Woodlands of James Price Point (Bamford 2011)	0	46	0	0
Databases				
DPaW Naturemap	3	54	7	1
Birdlife Australia Birdata	0	219	0	0
DPaW Threatened and Priority Fauna Search	2	3	0	0
DoE Protected Matters Search	2	11	2	0
Total	**39**	**234**	**81**	**12**

2.6.1.2 SRE Invertebrate Fauna

There is limited knowledge concerning SRE invertebrate fauna on the Dampier Peninsula, with only data from three Level 2 surveys being available from the James Price Point area, north of Broome (Biota 2009, 2010, *ecologia* internal database). Despite the minimal prior survey effort, these surveys have identified that potential SRE invertebrate fauna occur in the region. Similarly, of the three WAM invertebrate database searches, only the Mollusc database provided results (Appendix C).

The studies at James Price Point (Biota 2009, 2010), located approximately 85 km west of the study area, recorded three species of land snails (*Rhagada bulgana*, *R. reinga* and *Quistrachia leptogramma*), six mygalomorph spiders (*Missulena* sp., *Synothele* 'MYG179', *Conothele* sp. 1 and sp. 2, ?*Aganippe* sp. and *Aname* sp.), two scorpions (*Urodacus* 'rugosus' and *U*. 'sp. JP'), one pseudoscorpion (*Euryolpium* sp.), one millipede (Pachybolidae genus indet.) and one centipede (*Pilbarascutigera incola*).

A further Level 2 survey at James Price Point (*ecologia* internal database) recorded 15 invertebrates from SRE groups. These included two land snails (*R. bulgana* and *Q. leptogramma*), one harvestmen (*Dampetrus* sp.), three scorpions (*Lychas multipunctatus*, *L*. 'JPP' and *Urodacus* sp. indet.), five pseudoscorpions (*Austrohorus* sp., *Beierolpium* sp. '8/4' and sp. 'juv', *Euryolpium* sp. and *Indolpium* sp.), one slater (*Buddelundia* sp. 1) and one centipede (*Scolopendra laeta*).

2.6.1.3 Subterranean Fauna

There is very limited knowledge concerning stygofauna in the Canning Basin, and there are no published subterranean fauna surveys from the Dampier Peninsula. However, patchy survey work has revealed the occurrence of stygofauna occurring in shallow aquifers and springs (DoW 2010).

One study of the Mandora Marsh aquatic system (Storey *et al.,* 2011) lies within the La Grange South groundwater subarea of the Canning Basin, on the northern edge of the Great Sandy Desert, located approximately 140 km south-south-west of Broome and lies in the transition between the Pilbara and Kimberley regions. The survey recorded one species of subterranean fauna, a bathynellid syncarid (*Kimberleybathynella mandorana*) (Storey *et al.* 2012), collected from the Mandora wetlands, and a new bathynellid syncarid from the freshwater Coolabah Claypan (Storey et al., 2012). Further, the survey recorded subterranean copepods (*Metacyclops brooki* and *M. mortoni*) and subterranean ostracods (*Vestalenula marmonieri* and *Candona* sp.) from this aquifer (a shallow superficial aquifer).

Another stygofauna survey conducted in the Canning Basin (Subterranean Ecology 2012), found a depauperate stygofaunal community comprising one species of aphanoneouran worm (Family Aelosomatidae) collected from the Wallal Sandstone aquifer, ca. 160 km east of Port Hedland (Subterranean Ecology 2012).

3 METHODS

3.1 DETERMINATION OF SURVEY SAMPLING DESIGN AND INTENSITY

Prior to the development of field survey methods, a review was undertaken of factors likely to influence survey design and intensity (Table 3.1), as well as an initial Level 1 survey. Based on the information gathered, it was deemed necessary for a Level 2 survey to be conducted.

Table 3.1 – Factors likely to influence survey design (EPA 2004)

Factor	Relevance
Bioregion – level of existing survey/knowledge of the region and associated ability to predict accurately.	11 previous biological surveys have been conducted within 100 km of the study area (Table 2.5).
Landform special characteristics/specific fauna/specific context of the landform characteristics and their distribution and rarity in the region.	Landforms of the project area are typical of the Pindanland subregion.
Lifeforms, life cycles, types of assemblages and seasonality (e.g. migration) of species likely to be present.	The initial survey was conducted at the optimal time to survey fauna groups in the Kimberley – in April, soon after the wet season (typically December to March). This was complemented by a dry season survey in October.
Level of existing knowledge and results of previous regional sampling (e.g. species accumulation curves, species/area curves).	Although a number of surveys have previously been conducted on the Dampier peninsula, none were as far inland as this survey.
Number of different habitats or degree of similarity between habitats within a survey area.	The majority of the study area is relatively homogeneous habitat, with a few water sources adding variety.
Climatic constraints (e.g. temperature or rainfall that preclude certain sampling methods).	The timing of the surveys was optimal, capturing data both immediately after the wet season and in the dry season.
Sensitivity of the environment to the proposed activities.	The study area covers a relatively small amount of a generally ubiquitous habitat across the inner Dampier Peninsula.
Size, shape and location of the proposed activities.	The triangular study area covers 148.81 km^2, and is located slightly south-east of the centre of the Dampier Peninsula.
Scale and impact of the proposal.	The study area covers a small proportion of the Dampier Peninsula, and potential impacts can be mitigated by management plans.

3.2 SURVEY TIMING

Survey timing is summarised in Table 3.2. The first phase of the terrestrial fauna survey was conducted immediately after the wet season, between 4–15 April 2013 (Table 3.2). The second phase occurred in the dry season between 14–23 October 2013 (Table 3.2), with the timing of both determined as per the relevant guidelines (EPA 2002a, 2004, 2007; EPA and DEC 2010; EPA 2013).

A single phase of troglofauna surveying was completed, with troglofauna traps deployed during the terrestrial fauna phase 2 survey, on 19 October 2013. Traps remained in situ for 45 days and were collected on 4 December 2013.

A single phase of stygofauna surveying was completed. This occurred from 2–6 December 2013.

Table 3.2 – Summary of survey timing and duration

Survey	Dates of survey	Duration (days)	Person days
Terrestrial vertebrate and SRE fauna			
Phase 1	4–15 April 2013	12	48
Phase 2	14–23 October 2013	10	40
Total		**22**	**88**
Troglofauna			
Phase 1 - Deployment	19 October 2013	45	
Phase 1 - Collection	4 December 2013		
Total		**45**	
Stygofauna			
Phase 1	2–6 December	5	10

3.3 SAMPLING METHODS

The sampling methods adopted by *ecologia* align with the relevant guidelines (Section 1.2). The survey was undertaken using a variety of sampling techniques, both systematic and opportunistic. Systematic sampling refers to data methodically collected over a fixed time period in a discrete habitat type, using an equal or standardised sampling effort. The resulting information can be analysed statistically, facilitating comparisons between habitats. Opportunistic sampling includes data collected non-systematically from chance encounters with fauna or evidence of fauna. Sampling methods for the various fauna groups are described in detail below.

3.3.1 Terrestrial Vertebrate Fauna

3.3.1.1 Systematic Sampling

Non-volant Mammals and Herpetofauna

Trapping for non-volant mammals and herpetofauna was undertaken using a standardised trapping format comprising a combination of pit-fall traps, Elliott box traps, funnel traps and cage traps.

Each trapping site consisted of the following (Figure 3.1):

- Pit-trap and drift fence: Five PVC pipe (16 x 50 cm) and five 20 L plastic buckets (30 x 40 cm) were established at each site. A 10 m flywire drift fence (30 cm high) bisected the pits, directing fauna into the traps.
- Elliott box traps: Ten medium sized Elliott box traps (9 x 9 x 32 cm) were placed at each site, and baited with universal bait (a mixture of peanut butter, rolled oats and sardines). Each Elliott trap was placed between the pit trap setups. Elliott traps were shaded using Air Cell roof insulation.
- Funnel traps: Funnel traps (Ecosystematica Type III) were placed in association with drift fences. Twenty funnel traps were used per site, with a trap being placed at each end of the drift fence. Funnel traps were shaded using Air Cell roof insulation.
- Cage traps: Two Sheffield small animal traps (22 cm x 22 cm x 55 cm) were used per site with one trap placed at each end of the trap line. Traps were baited with universal bait.

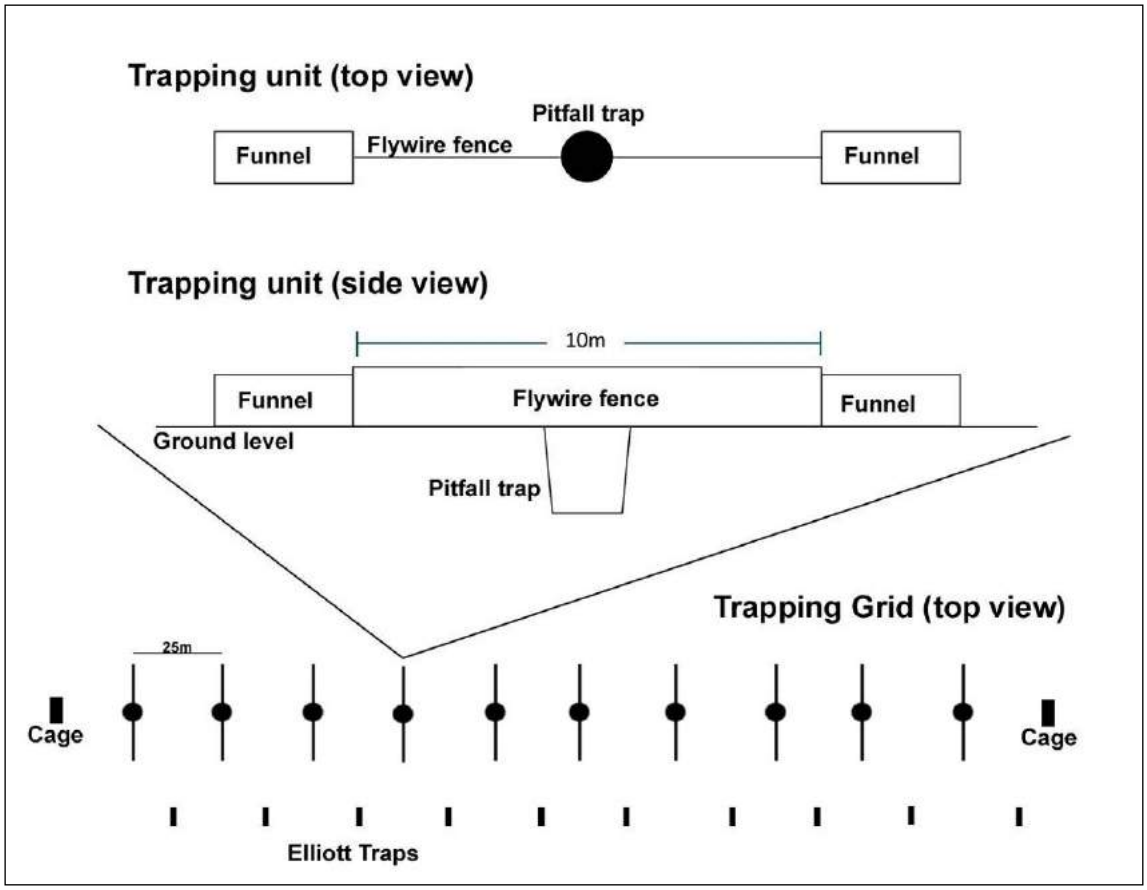


Figure 3.1 – Diagram of the systematic sampling trap arrangement

Figure 3.2 – Image of single *ecologia* trap point

Avifauna

Thirty minute set-time surveys were used to document the avifauna present at each of the fauna sites. During each set-time survey an ornithologist recorded the number of individuals of each species seen while actively searching similar habitat within 500 m of the survey site. This is aligned with survey methodology for the ongoing Birds Australia *Atlas of Australian Birds* project.

Survey effort was concentrated at survey sites within three hours of dawn, as this time is deemed to be the optimal times to record most bird species. Opportunistic surveys during the day and near dusk were also conducted, as they may yield species less frequently observed in the early morning, e.g. diurnal raptors.

Bats

Bat echolocation calls were recorded using SM2BAT 384 kHz long term passive recorder. The SM2BAT has a high sampling frequency, enabling the full spectrum of calls to be recorded without being transformed, allowing greater accuracy and sensitivity. The SM2BAT was programmed to record from dusk to dawn for each night that was surveyed.

3.3.1.2 Opportunistic Sampling

Nocturnal Searching

The study area was searched at night using a combination of road transects and opportunistic ground searches using head torches and hand held spotlights to uncover nocturnal species, including geckos, snakes, frogs and birds.

Diurnal Searching

Both trapping and opportunistic sites were searched by hand for cryptic species, which comprised searching beneath the bark of dead trees, breaking open old logs, stumps and dead free-standing trees, investigating burrows and over-turning logs and stones. Sites were selected on the basis of fauna habitat (targeting uncommon habitats or habitats poorly represented by trapping sites) and their possibility of harbouring conservation significant fauna.

Fauna were also recorded while searching, travelling and during trap establishment within the study area during the day and night. Tracks, diggings, scats, burrows and nests were recorded where possible.

Camera Trapping

Motion sensor cameras were used in areas with a high likelihood of animal activity such as burrows or crevices. The Bushnell Trophy Cam, model number 119415 was used. The camera is triggered by movement by a highly sensitive passive infra-red motion sensor and functions day and night taking either video footage or photos (Bushnell Outdoor Products 2009).

Targeted Conservation Significant Fauna Surveying

Prior to the commencement of survey activity, the preferred habitat of the conservation significant species that potentially occur in the study area was determined. These habitats were identified and targeted during survey activities using both systematic survey sites and opportunistic surveys.

On the basis of the habitats observed during surveying, specific opportunistic searches as well as motion camera trapping were also undertaken to determine the presence of potential conservation significant species (Figure 3.3, Figure 3.4).

Figure 3.3 – A motion camera monitoring a Greater Bilby burrow

Figure 3.4 – A motion camera monitoring a Rainbow Bee-eater nesting burrow

3.3.2 Short Range Endemic Invertebrate Fauna

3.3.2.1 Systematic sampling

Dry Pitfall Trapping

A total of four vertebrate fauna trap sites and six targeted SRE trap sites were established as dry pitfall sites for SRE invertebrate fauna, totalling 920 trap nights inside the potential impact area. In addition, three vertebrate fauna traps sites totalling 420 trap nights were established as dry pitfall trapping sites outside of the potential impact area (Table 3.1). These sites were checked daily and all invertebrate fauna groups potentially containing SRE species collected.

Foraging

One person hour per site was spent foraging for SREs at six sites. Opportunistic foraging involved physically searching through microhabitats for SRE's. The underside of rocks and logs were closely investigated for SRE invertebrates. Snail shells and trapdoor spiders were collected and documented where found.

Leaf Litter Collection

Three quadrats (3 m^2) of leaf litter were collected at each of the six targeted SRE trap sites during the first phase and separately placed into a leaf-litter reducer (Figure 3.5). The contents from each collection was placed into a paper bag inside a zip-lock bag and kept separate. A small amount of wet tissue paper was placed into each sample to maintain humidity. Samples were then transported back to Perth in a cool, dark container.

Figure 3.5 – Example of the leaf litter reducer

3.3.3 Stygofauna

A single survey (Level 1) of stygofauna sampling was completed in December 2013 (Section 3.2). Haul nets were used to sample the holes in accordance with the methods described in the *EPA Guidance Statement 54a* (EPA 2007). This technique involved dragging modified plankton nets through the entire water column.

Drill holes selected for stygofauna sampling consisted of cased drill holes with PVC pipes, with slits in piping throughout the length to ensure water flow through the piping. Drill hole diameter was 50 mm.

A standing water level dipper was used to determine the standing water level in each drill hole. This information assisted with information on the local aquifers for stygofauna. Water parameters such as conductivity (salinity), turbidity, temperature, dissolved oxygen and redox potential were collected *in situ* for each drill hole, using a portable water quality metre to assess habitat attributes related to water quality.

Sampling was conducted using haul nets of appropriate diameter (depending on water bore diameter), lowered slowly into bores using rope to prevent the net from free falling to the bottom of the bore. Six hauls were performed with a 50 µm mesh net at each site. All samples were washed in a 50µm sieve and preserved in a vial with 100% ethanol in case DNA assessment is required at a later date. After each drill hole was sampled, the sieve and nets were washed in Decon90® to prevent contamination between sites. All vials were labelled with the date, bore name and replicate number. Samples were stored in cool, dark conditions and returned to the *ecologia* Perth laboratory for sorting and identification.

3.3.4 Troglofauna

3.3.4.1 Trapping

A single phase of troglofauna sampling was completed (Section 3.2). Only drill holes which were uncased up to six metres were used for sampling. Drill holes were sampled using custom-designed traps (DEC and EPA approved, Figure 3.6) filled with leaf litter and baited with banana and sweet potato. Leaf litter was soaked over several days and sterilised by microwaving at a high setting for three minutes (to destroy any terrestrial predators present in the leaf litter that could inhibit, predate or impact on troglofauna colonising the traps once in the ground). The leaf litter was then stored in an air-tight container to further develop over eight weeks before deployment.

The water level of each drill hole was measured using a standing water level metre prior to traps being deployed. This information aids positioning of troglofauna traps above the water table. Geology mapping for each drill hole was assessed. Traps were positioned within areas of sandstone geology as these areas were recognised as having the greatest potential for supporting troglofauna communities. Sandy substrates were avoided. Traps were positioned so that the trap rested against the wall of the hole.

The drill holes were re-sealed after the insertion of traps to maintain humidity levels and to reduce contamination from surface fauna. Each site was demarcated with flagging tape and a sign ("Do not disturb – Troglofauna trapping in progress"). Site management were informed of the areas where trapping was occurring to minimise accidental disturbance and tampering.

Traps were left in the ground for 45 days to ensure troglofauna colonisation. After this period, the traps were recovered and the leaf litter from each trap was placed into plastic bags, which were immediately sealed to avoid contamination. Samples were returned to the *ecologia* Perth laboratory for fauna extraction and sorting prior to being sent to relevant taxonomic specialists for identification.

Figure 3.6 – Custom built troglofauna trap

3.3.4.2 Scraping

Troglofauna scraping involved dragging haul nets along the walls of drill holes. The net was placed down the drillhole and hauled up twice, with the contents emptied into a vial after each haul. Each vial was then filled with 100% ethanol to preserve any animals present in the sample. These were then processed in the laboratory in Perth.

3.3.5 Laboratory Sorting and Specimen Identification

3.3.5.1 Short Range Endemic Invertebrate Fauna

Tullgren funnels were used to extract any animals from the collected leaf litter samples (Figure 3.7). The principle of Tullgren funnels is that a sample of leaf litter is suspended below an incandescent lamp or heat source, so that animals inhabiting the sample are forced downwards by progressive drying and ultimately fall into a collecting vessel located below. Samples are preserved in ethanol to allow DNA extraction if required.

Figure 3.7 – Tullgren funnels

After the leaf litter samples were processed on the Tullgren funnels, each sample was examined for any other animals that were not collected during Tullgren funnel extraction. Each sample was emptied into a tray and examined using a light magnifier. Any animals found were collected and immediately preserved in ethanol.

All samples were examined under a stereo microscope and sorted into related groups. Specimens were labelled with the project name, site number and coordinates, the trap number or leaf-litter sift number, date of collection and the initials of the collectors, and were sent to the relevant taxonomic expert for further identification. Table 3.17 shows a list of taxonomic specialists consulted for identifications.

3.3.5.2 Stygofauna

Stygofauna samples were sorted at *ecologia*'s Perth laboratory under a compound microscope. Any potential stygobitic specimens collected were placed in individual vials with absolute ethanol and labelled with the date, location, coordinates and names of collectors. The specimens were identified by *ecologia* taxonomists.

3.3.5.3 Troglofauna

Once processing of the samples in the Tullgren funnels was complete, all samples were sorted under a compound microscope and sorted into related groups. These specimens were labelled with the project name, site number, date of collection, coordinates and the initials of the collectors and were sent to the relevant taxonomic expert for further identification. Table 3.17 shows a list of taxonomic specialists consulted for identifications.

3.4 SITE SELECTION

3.4.1 Terrestrial Vertebrate Fauna

Seven terrestrial fauna survey sites were selected both to achieve geographic spread over the study area and to be representative of the habitat types present, although access was slightly limited by the location of existing tracks. Information from land system and habitat maps, as well as previous on-site observations made during the Level 1 survey, was also used to aid site selection. Habitat types occurring over a larger proportion of the study area (dominant habitat types) were sampled by a larger number of trapping sites than less widespread habitat types. Habitat types poorly represented by systematic sampling sites were further surveyed using opportunistic searches, targeting potentially sensitive habitats and habitats likely to support conservation significant species. Locations of all vertebrate fauna survey sites are listed in Table 3.3 and mapped in Figure 3.8. Detailed descriptions of the systematic survey sites are listed in Appendix D.

Table 3.3 – Vertebrate fauna sites

Site type	Location		Land system	Vegetation association
	Easting	Northing		
Systematic trapping				
TB S1	499584	8073492	Reeves	750
TB S2	496173	8073359	Fraser	750
TB S3	493352	8073219	Yeeda	750
TB S4	491858	8073144	Yeeda	750
TB S5	496965	8071200	Fraser	750
TB S6	496603	8068741	Wanganut	750
TB S7	496226	8066143	Yeeda	750
Opportunistic bat recording				
Bat 1	500580	8073560	Fraser	755
Motion camera				
MCB1	495001	8073488	Yeeda	751
MCB2	495019	8073532	Fraser	751
MCD1	499751	8072256	Reeves	762
MCD2	499752	8072269	Reeves	762
MCD3	497273	8071921	Fraser	750
MCD4	496737	8069634	Fraser	750
MCE	499892	8072225	Reeves	762
MCF1	499648	8072038	Reeves	762
MCF2	499886	8072214	Reeves	762
Opportunistic search				
TB OS1	497469	8074704	Reeves	750
TB OS2	500580	8073560	Fraser	755
TB OS3	499712	8067404	Fraser	750
TB OS4	503843	8067527	Reeves	750
TB OS5	493598	8074789	Reeves	750
TB OS6	494110	8073259	Yeeda	750
TB OS7*	504152	8072770	N/A	N/A

Site type	Location		Land system	Vegetation association
	Easting	Northing		
TB OS8	494284	8072508	Yeeda	750
TB OS9	497806	8070539	Fraser	750
TB OS10	495524	8070859	Fraser	750
TB OS11	500208	8073544	Reeves	750
TB OS12	499753	8072264	Fraser	750
TB OS13	494999	8073484	Yeeda	750
TB OS14	492505	8075036	Yeeda	750
TB OS15	491842	8073155	Yeeda	750
TB OS16	496965	8071200	Fraser	750
TB OS17	498074	8073444	Fraser	750
TB OS18	496849	8066580	Wanganut	750
TB OS19	497386	8069969	Fraser	750

Datum: GDA94
Zone: 51K
*Mount Jowlaenga homestead – outside the study area

3.4.2 Short Range Endemic Invertebrate Fauna

Survey site locations were selected based on the vegetation associations, areas of potential impact and habitat types present in the study area, focusing on the habitat types that were considered likely to support SRE invertebrates (e.g. south facing rocky hillslopes, drainage lines, eucalypt woodlands and sandy shrublands). A total of six SRE dry pitfall sites (comprising five dry pitfalls each) were established and a further 16 opportunistic foraging sites were searched for potential SRE species. Leaf litter was taken from near the six dry pitfall sites, to increase the likelihood of detecting terrestrial SRE species. The locations of all SRE survey sites are provided in Table 3.4 and mapped in Figure 3.9, whilst site habitat descriptions are listed in Appendix D.

Table 3.4 – SRE fauna sites

Site type	Location		Land system	Vegetation community
	Easting	Northing		
Dry pitfall and leaf-litter sample sites				
TB SRES1	497272	8073415	Fraser	750
TB SRES2	495622	8073290	Fraser	750
TB SRES3	494110	8073259	Yeeda	750
TB SRES4	497106	8072360	Fraser	750
TB SRES5	496819	8070453	Fraser	750
TB SRES6	496635	8069217	Fraser	750
Opportunistic foraging sites				
TB SREOS1	492897	8073352	Yeeda	750
TB SREOS2	493791	8073471	Yeeda	750
TB SREOS3	500586	8073561	Fraser	755
TB SREOS4	500580	8073560	Fraser	755
TB SREOS5	499712	8067404	Fraser	750
TB SREOS6	503843	8067527	Reeves	762

Site type	Location		Land system	Vegetation community
	Easting	Northing		
TB SREOS7	496589	8068738	Wanganut	750
TB SREOS8	494284	8072508	Yeeda	750
TB SREOS9	500208	8073544	Reeves	750
TB SREOS10	495524	8070859	Fraser	750
TB SREOS11	497806	8070539	Fraser	750
TB SREOS12	499753	8072264	Reeves	762
TB SREOS13	493574	8074765	Yeeda	750
TB SREOS14	494999	8073484	Yeeda	751
TB SREOS15	492505	8075036	Yeeda	750
TB SREOS16	497478	8074704	Reeves	750

Datum: GDA94
Zone: 51K

3.4.3 Stygofauna

Sample sites (drill holes) were selected based on ground water level information, and drill holes that were suitably cased for stygofauna sampling. A total of 15 drill holes were sampled for stygofauna, these locations are shown in Table 3.5 and mapped in Figure 3.10. Twelve sites were sampled inside the proposed potential impact area, while three sites were sampled outside the proposed potential impact area.

Table 3.5 – Stygofauna sample sites

Drill hole ID		Location		Depth to water (m)
Inside proposed impact (deposit area)	Outside proposed impact (deposit area)	Easting	Northing	
-	THAC 232	497155	8068154	22
THAC 235	-	498444	8069687	30
THAC 238	-	497037	8069562	28
THAC 241	-	498198	8072514	39
THAC 243	-	497168	8072072	32
THAC 245	-	495566	8072454	38
THAC 247	-	496671	8073794	41
THAC 252	-	493367	8072972	49
-	THAC 280	501617	8069966	42
-	THAC 285	502293	8069280	44
THAC 322	-	496939	8068666	23
THAC 357	-	495882	8070540	32
THAC 390	-	497644	8070677	33
THAC 406	-	495614	8069435	30
THAC 408	-	494763	8071525	39

Datum: GDA94
Zone: 51K

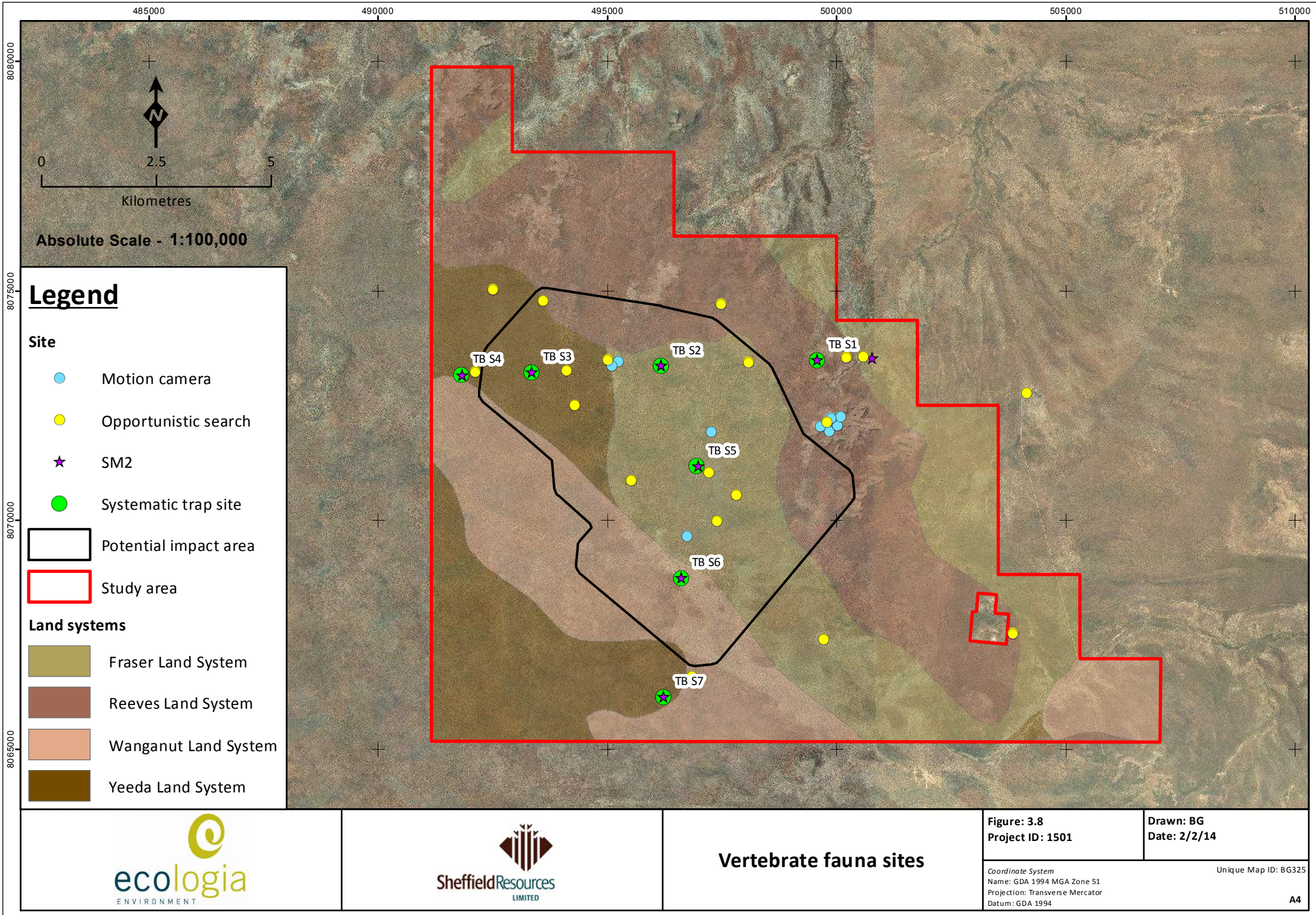
3.4.4 Troglofauna

Sample sites (drill holes) were selected based on geology, water table information, and whether they were cased. Based on the geology identified during exploratory drilling, the majority of drill holes contained only sand above the water table, and were therefore unsuitable for sampling. However, a total of six drill holes contained relatively narrow sandstone layers above the water table, and were targeted for troglofauna (Table 3.6 and Figure 3.10). Five drill holes were sampled inside the proposed potential impact area, and one drill hole was sampled outside.

Table 3.6 – Troglofauna sites

Drill hole ID	Location		Depth to water (m)	Relation to Impact Area	Number of traps	Depth of trap 1	Depth of trap 2	Depth of trap 3	Number of drill hole scraps
	Easting	Northing							
THAC 244	496364	8071105	34	Inside	1	25	-	-	2
THAC 248	495959	8073733	48	Inside	3	10	20	28.5	2
THAC 251	494452	8072706	41	Inside	2	6.5	10	-	2
THAC 266	494023	8073745	46	Inside	2	8.5	14	-	2
THAC 282	501749	8068557	36	Outside	2	10	20	-	2
THAC 407	494581	8071306	35	Inside	2	8	18	-	2

Datum: GDA94
Zone: 51K



ecologia ENVIRONMENT

Sheffield Resources LIMITED

Vertebrate fauna sites

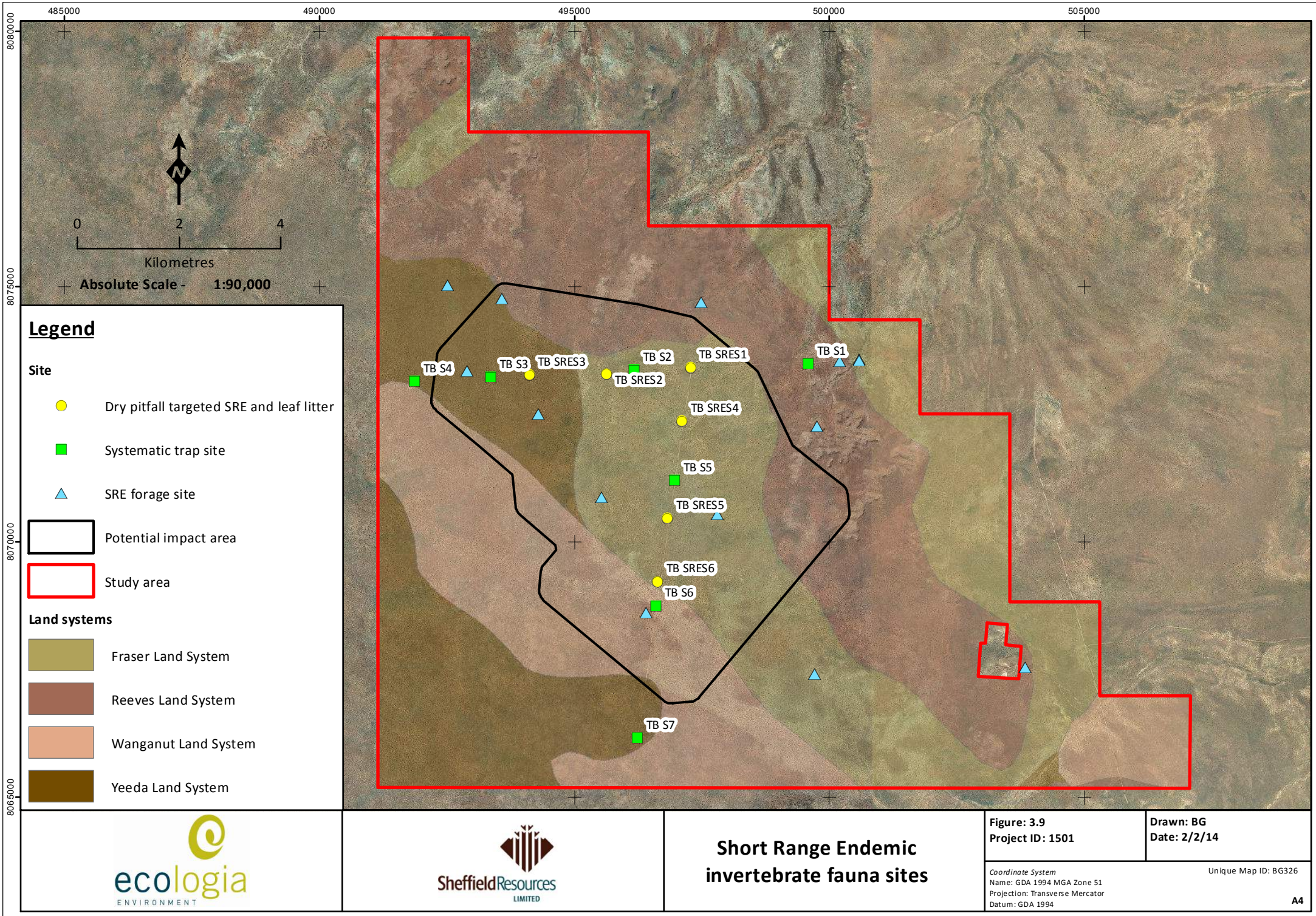
Figure: 3.8
Project ID: 1501

Drawn: BG
Date: 2/2/14

Coordinate System
Name: GDA 1994 MGA Zone 51
Projection: Transverse Mercator
Datum: GDA 1994

Unique Map ID: BG325

A4



ecologia ENVIRONMENT

Sheffield Resources LIMITED

Short Range Endemic invertebrate fauna sites

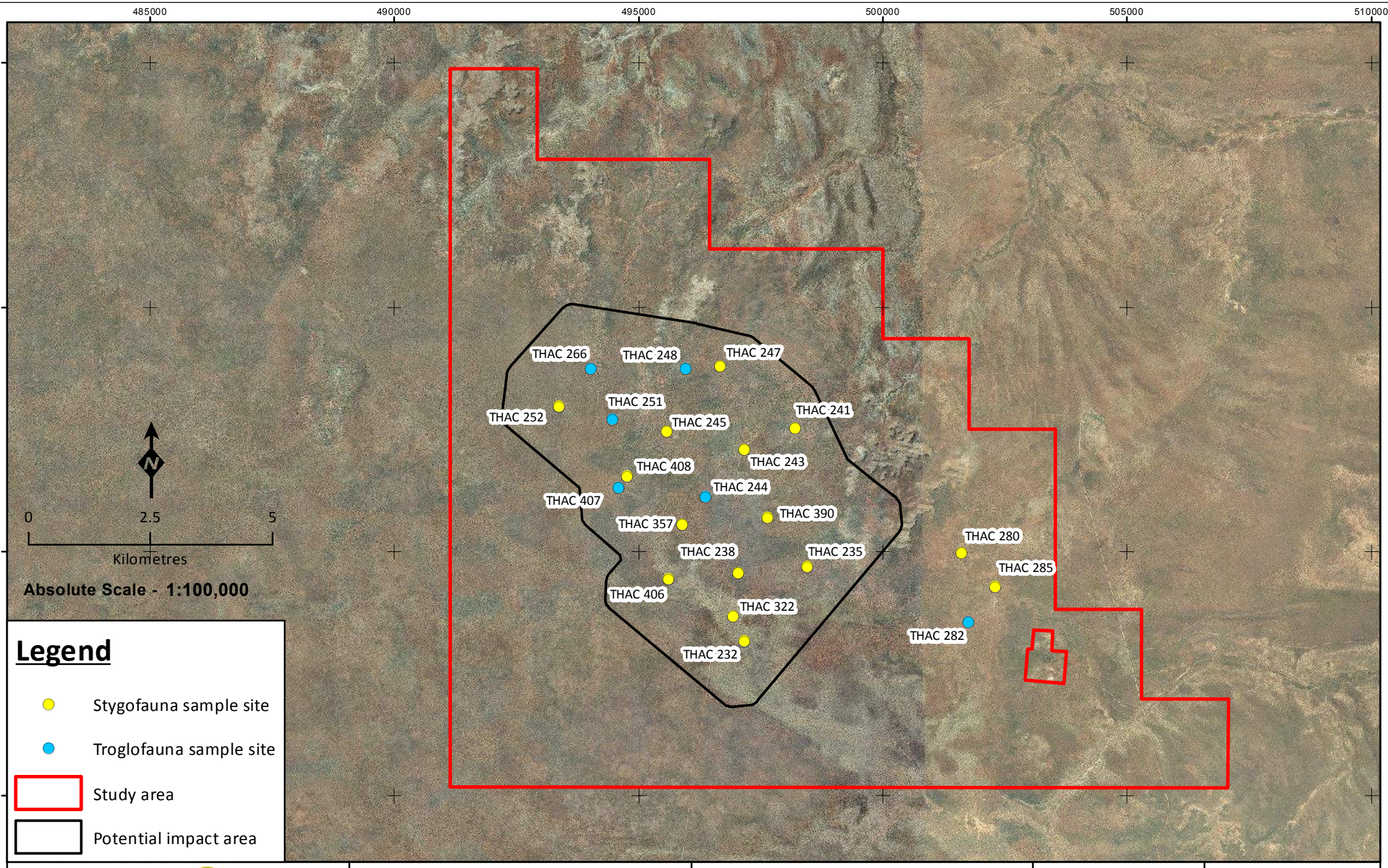
Figure: 3.9
Project ID: 1501

Drawn: BG
Date: 2/2/14

Coordinate System
Name: GDA 1994 MGA Zone 51
Projection: Transverse Mercator
Datum: GDA 1994

Unique Map ID: BG326

A4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THAC 266
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THAC 357
THAC 280
THAC 238
THAC 235
THAC 285
THAC 406
THAC 322
THAC 282
THAC 232
N
0
2.5
5
Kilometres
Absolute Scale - 1:100,000
Legend
Stygofauna sample site
Troglofauna sample site
Study area
Potential impact area
ecologia
ENVIRONMENT
Sheffield Resources
LIMITED
Stygofauna and troglofauna sample sites
Figure: 3.10
Project ID: 1501
Drawn: BG
Date: 2/2/14
Coordinate System
Name: GDA 1994 MGA Zone 51
Projection: Transverse Mercator
Datum: GDA 1994
Unique Map ID: BG327
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3.5 SURVEY EFFORT

Survey effort expended within the study area included the following:

Vertebrate fauna

- seven trapping grids were open for 14 trap nights;
- approximately 29 hours were spent surveying for birds;
- 20 hours and 20 minutes were spent on opportunistic diurnal searching;
- 35 hours and 15 minutes were spent on opportunistic nocturnal searching;
- 385 hours and 15 minutes of camera trapping data was analysed;
- 180 hours of recordings were analysed to determine bat assemblage and distribution; and,
- nine hours and 40 minutes were spent searching for signs of the Greater Bilby.

Total vertebrate fauna survey effort per site is presented in Table 3.7.

SRE invertebrate fauna

- six dry pitfall trapping grids were open for six nights;
- seven vertebrate fauna trapping grids were open for 14 trap nights; and,
- six leaf litter samples were taken from each of the SRE dry pitfall grids.

Total SRE invertebrate fauna survey effort per site is presented in Table 3.8.

Stygofauna

- a total of 90 net hauls from 15 drill holes were sampled for stygofauna.

Total stygofauna survey effort per site is presented in Table 3.9.

Troglofauna

- a total of 12 traps and 12 scraping hauls at six drill holes were sampled for troglofauna.

Total troglofauna survey effort per site is presented in Table 3.10.

Table 3.7 – Terrestrial vertebrate fauna survey effort

Site name	Pit traps (trap nights)	Funnels (trap nights)	Elliotts (trap nights)	Cages (trap nights)	Bird survey (min)	Diurnal opp search (min)	Nocturnal opp search (min)	Bat recording (hrs)	Camera trapping (hrs)
TB S1	140	280	140	28	240			24	
TB S2	140	280	140	28	240			24	
TB S3	140	280	140	28	240			24	
TB S4	140	280	140	28	240			24	
TB S5	140	280	140	28	240			24	
TB S6	140	280	140	28	240			24	
TB S7	140	280	140	28	240			24	
Opportunistic					54	1580	2115	12	385.25
Total	**980**	**1960**	**980**	**196**	**1734**	**1580**	**2115**	**180**	**385.25**

Table 3.8 – SRE fauna survey effort

Site name	Relation to potential impact area	Dry pit traps (trap nights)	Leaf litter Samples	Foraging
TB SRES1	Inside	60	1	60
TB SRES2	Inside	60	1	60
TB SRES3	Inside	60	1	60
TB SRES4	Inside	60	1	60
TB SRES5	Inside	60	1	60
TB SRES6	Inside	60	1	60
TB S1	Outside	140		
TB S2	Inside	140		
TB S3	Inside	140		
TB S4	Outside	140		
TB S5	Inside	140		
TB S6	Inside	140		
TB S7	Outside	140		
Opportunistic	Inside			3162
Total		**1340**	**6**	**3522**

Table 3.9 – Stygofauna survey effort

Site name	Net hauls
THAC 232	6
THAC 235	6
THAC 238	6
THAC 241	6
THAC 243	6
THAC 245	6
THAC 247	6
THAC 252	6
THAC 280	6
THAC 285	6
THAC 322	6
THAC 357	6
THAC 390	6
THAC 406	6
THAC 408	6
Total	**90**

Table 3.10 – Troglofauna survey effort

Site name	No. of Traps	Scraping hauls
THAC244	1	2
THAC248	3	2
THAC251	2	2
THAC266	2	2
THAC282	2	2
THAC407	2	2
Total	**12**	**12**

3.6 POTENTIAL CONSERVATION SIGNIFICANT VERTEBRATE FAUNA

After the results of the literature review, database searches and survey results were compiled, fauna species that are listed under current legislative frameworks were identified. Three conservation lists have been developed at national (EPBC Act) and State level (WC Act and DPaW priority list).

The likelihood of a conservation significant species being present within the project was determined by examining the following:

- fauna habitats and their condition known to exist within the study area;
- distance of previously recorded conservation significant species from the study area;
- frequency of occurrence of conservation significant species records in the region; and
- time passed since conservation significant species were recorded within, or surrounding, the study area.

Each conservation or biologically significant species potentially occurring in the study area, was assigned a likelihood of occurrence based on the below category (Table 3.11). The level of available information for each species was also taken into consideration so that species are not allocated a low likelihood of occurrence because of insufficient survey information or cryptic behaviours and ecology.

Table 3.11 – Likelihood of occurrence categories

RECORDED	Species recorded during current survey
HIGH	Species recorded within, or in proximity to, the study area within 20 years; suitable habitat occurs in the study area
MEDIUM	Species recorded within, or in proximity to, the study area more than 20 years ago. Species recorded outside study area, but within 50 km; suitable habitat occurs in the study area
LOW	Species rarely, or not recorded, within 50 km, and/or suitable habitat does not occur in the study area

3.7 DETERMINING SRE STATUS

SRE status of invertebrate fauna recorded is based on categories developed by the Western Australian Museum and modified by the consultant taxonomists in order to describe the SRE status of taxa using the current knowledge of the distribution and biology of each species. The likelihood is defined by one of the categories as listed in Table 3.12. The newly released 2013 WAM SRE categories, which have been developed to describe the SRE status of WA taxa, utilise: (a) unambiguous categories; and (b) explanations of uncertainty. This has been accomplished using a two-tier classification system. In the first tier of classification, geographic distribution and taxonomic certainty are the variables used to split taxa into “Confirmed SREs”, “Widespread (not SREs)”, and “Potential SREs”. In the second tier of classification, “Potential SREs” are categorised according to the reasons why they have been placed into this category and the presence of proxy-indicators for Confirmed SRE or Widespread status. In addition, taxonomists from Phoenix Environmental Sciences have adapted these categories and incorporated one additional category: “likely SRE”. Taxonomists from both organisations (WAM and Phoenix) undertook the identification of invertebrate fauna collected during this survey and therefore both SRE categories have been used to determine the SRE status (Table 3.12 and Table 3.13).

Table 3.12 – Western Australian Museum SRE categories (2013)

	Taxonomic Certainty	Taxonomic Uncertainty
Distribution < 10 000km^2	**Confirmed SRE** • A known distribution of <10 00km^2. • The taxonomy is well known. The group is well represented in collections and/ or via comprehensive sampling.	**Potential SRE** Patchy sampling has resulted in incomplete knowledge of the geographic distribution of the group. We have incomplete taxonomic knowledge. The group is not well represented in collections. This category is most applicable to situations where there are gaps in our knowledge of the taxon. **Sub-categories for this SRE designation are outlined below**
Distribution > 10 000km^2	**Widespread (not an SRE)** A known distribution of >10 000km^2. The taxonomy is well known. The group is well represented in collections and/ or via comprehensive sampling.	

3.7.1 SRE Sub-categories

If a taxon is determined to be a "Potential SRE", the following sub-categories will further elucidate this status.

A. Data Deficient:

- There is insufficient data available to determine SRE status.
- Factors that fall under this category include:
    - Lack of geographic information;
    - Lack of taxonomic information;
    - The group may be poorly represented in collections; and
    - The individuals sampled (e.g. juveniles) may prevent identification to species level.

B. Habitat Indicators:

- It is becoming increasingly clear that habitat data can elucidate SRE status; and
- Where habitat is known to be associated with SRE taxa and vice versa, it will be noted here.

C. Morphology Indicators:

- A suite of morphological characters are characteristic of SRE taxa; and
- Where morphological characters are known to be associated with SRE taxa and vice-versa, it will be noted here.

D. Molecular Evidence:

- If molecular work has been done on this taxon (or a close relative), it may reveal patterns congruent or incongruent with SRE status.

E. Research & Expertise:

- Previous research and/ or WAM expertise elucidates taxon SRE status; and
- This category takes into account the expert knowledge held within the WAM.

The SRE categories utilised by Phoenix include one additional category: "likely SRE". Fauna belonging to this category are included in WAM's "potential SRE" category (Table 3.12, Table 3.13).

Table 3.13 – Phoenix's SRE categories (2013)

SRE category	Criteria	Typical representative
Confirmed	Confirmed or almost certainly SRE; taxonomy of the group is well known (but not necessarily published); group well represented in collections, in particular from the region in question; high levels of endemism in documented species; inference is often possible from immature specimens.	*Antichiropus* millipedes (Paradoxosomatidae); scorpions in the genus *Aops* (Urodacidae)
Likely	Taxonomically poorly resolved group; unusual morphology for the group (i.e. some form of troglomorphism); often singleton in survey and few, if any, regional records.	Opiliones in the genus *Dampetrus*; some pseudoscorpions (*Synsphyronus*) and slaters (Philosciidae); araneomorph spiders in the genus *Karaops* (Selenopidae)
Potential	Taxonomically poorly resolved group; often common in certain microhabitats in SRE surveys (i.e. litter dwellers), but no other regional records; congeners often widespread.	Many mygalomorph spiders; some centipedes (Cryptopidae; Geophilomorpha)
Widespread/Not SRE	Taxonomically well resolved (but often not published) and demonstrated wide distribution (i.e. > 10,000 km2)	

All likely, potential and unknown SREs should be treated as confirmed SREs in accordance with the precautionary principle (Section 4a of the EP Act).

3.8 FAUNA HABITAT MAPPING

A fauna habitat type broadly describes an area of habitat that is distinguishable in its vegetation, soil characteristics and land features from its surroundings, and is likely to support a different fauna assemblage to that found in other fauna habitats. Particular attention is also paid to the likelihood that certain species are present which tend to be found only in that specific habitat. Fauna habitat types were identified, described and mapped partly using the following existing information:

- IBRA subregions;
- aerial photography;
- vegetation associations (Beard 1981; Shepherd et al. 2002);
- land systems (van Vreeswyk *et al.* 2004); and,
- on-ground observations.

During the survey, other information was also collected, including:

- landform;
- vegetation type and structure;
- soil characteristics (soil structure and substrate);
- composition of terrestrial fauna species; and,

- habitat condition (Table 3.14).

These observations did not take into account any degradation as a result of exploration or other recent mining activities (e.g. drilling, clearing).

Table 3.14 – Habitat condition assessment

Habitat Condition	Criteria
Excellent	Pristine or nearly so, no obvious sign of damage caused by modern humans or introduced fauna (cattle, feral cat, dog and rabbit). No signs of recent, extensive fires.
Very good	Some relatively slight signs of damage caused by the activities of modern humans. e.g. damage to tree trunks by repeated fires, no significant signs of introduced fauna or occasional vehicle tracks.
Good	More obvious signs of damage caused by the activities of modern humans, including some obvious impact to vegetation structure such as that caused by low levels of grazing or by selective logging. Some tracks or secondary evidence of introduced fauna. Some signs of recent fires.
Poor	Still retains basic vegetation structure or ability to regenerate it after very obvious impacts of modern humans such as partial clearing or very frequent fires. Presence of introduced fauna.
Very poor	Severely impacted by grazing, introduced fauna, fire, clearing or a combination of these activities. Scope for some regeneration but not to a state approaching good condition without intensive management.
Completely Degraded	Areas that are completely or almost completely without vegetation communities and are heavily impacted by extensive fires and/or introduced species e.g. cow paddock

3.9 DATA ANALYSIS

3.9.1 Survey Adequacy

There are three general methods of estimating species richness from sample data: extrapolating species-accumulation curves (SACs), fitting parametric models of relative abundance, and using non-parametric estimators (Bunge and Fitzpatrick 1993; Colwell and Coddington 1994; Gaston 1996). In this report, the level of survey adequacy was estimated using SACs, which graphically illustrate the accumulation of new species as more individuals are recorded. Ultimately, the asymptotic plateau is reached at the level at which no new species are present. To eliminate inconsistent values caused by random or periodic variation over time, an algorithm (Mao Tau) was applied to the sampling data using EstimateS (version 8, Colwell 2009). This algorithm effectively smooths the curve of the number of species observed by simulating an infinite number of randomisations of the sample order. In order to estimate the theoretical maximum number of species for each fauna group, a Michaelis-Menten enzyme kinetic curve was calculated and used as a stopping rule technique, as this provides the most accurate representation.

Only the results of systematic sampling are included in SAC calculations, since the algorithms assume a standard sampling effort. Therefore, species recorded through opportunistic methods are not included. Mammal, reptile and amphibian trapping data were combined for analysis as 'terrestrial vertebrates', as these groups were sampled using the same methods. Separate analyses were carried out for terrestrial vertebrates, birds, SRE invertebrates, stygofauna and troglofauna.

3.9.2 Habitat Assessment

Analysis of the fauna survey data was undertaken to determine potential differences in fauna communities and subsequently identify distinct fauna habitats.

The survey data was first subjected to a log+1 transformation, which prepares it for analyses that are not robust against outliers. To test whether the differences in species diversity between habitat types were significant, analyses of similarity (ANOSIM) (Clarke 1993) comparisons were made using the one-way ANOSIM function. ANOSIM was calculated using the Bray-Curtis Similarity Index with 999 permutations. Non-metric multidimensional scaling (MDS) was also applied to the Bray-Curtis similarity matrix. Resulting stress values below 0.2 were considered to indicate a good fit of the scaling to the matrix. The dimensions that reduced the majority of the "raw stress" were chosen for the final scaling. Analysis was undertaken using the PAST software package (Hammer *et al.* 2001).

Separate analyses were carried out for terrestrial fauna (mammal and reptile) and avifauna.

3.10 TAXONOMY AND NOMENCLATURE

3.10.1 Vertebrate Fauna

Nomenclature for mammals, reptiles and amphibians within this report is as per *Western Australian Museum Checklist of the Vertebrates of Western Australia*, birds according to Christidis and Boles (2008). References used for fauna identification are listed in Table 3.15.

Table 3.15 – References used for identification

Fauna Group	Reference
Mammals	Menkhorst and Knight (2011), Van Dyck and Strahan (2008)
Bats	Churchill (1998), Menkhorst and Knight (2011)
Birds	Simpson and Day (2004)
Reptiles	Cogger (2000), Wilson and Swan (2010)
Geckos	Storr *et al*. (1990), Wilson and Swan (2010)
Skinks	Storr *et al*. (1999), Wilson and Swan (2010)
Dragons	Storr *et al*. (1983), Wilson and Swan (2010)
Varanids	Storr *et al*. (1983), Wilson and Swan (2010)
Legless Lizards	Storr *et al*. (1990), Wilson and Swan (2010)
Snakes	Storr *et al*. (2002), Wilson and Swan (2010)
Amphibians	Tyler and Doughty (2009), Cogger (2000)

3.10.2 Invertebrate Fauna

All specimens collected during the SRE trapping, stygofauna and troglofauna sampling have been lodged with the WA Museum and identified by external specialists (Table 3.17).

3.11 ANIMAL ETHICS

Surveying was conducted as per *ecologia*'s Animal Ethics Code of Practice, which conforms to Section 5 of the *Australian code of practice for the care and use of animals for scientific purposes* (National Health and Medical Research Centre (2004).

In most cases, fauna were identified in the field and released at the point of capture. Where the taxonomy of specimens was not clearly discernable, or when species were collected that are known to exhibit significant morphological variation or are not yet fully described, vouchers specimens were lodged with the WA Museum (Appendix E). Voucher specimens were maintained according to WA Museum guidelines to ensure captured animals were subject to the least possible stress.

3.12 SURVEY TEAM AND LICENCES

Field survey team members are listed in Table 3.16 and external consultants listed in Table 3.17. The survey was conducted under DPaW Regulation 17 Licence SF009176.

Table 3.16 – Field survey personnel

Survey member	Expertise	Qualification	Experience (years)
Nigel Jackett	Ornithology	B.Sc. (Hons)	9
Bruce Greatwich	Ornithology	B.Sc.	5
Mimi d'Auvergne	Mammalogy	B.Sc. (Hons)	5
Frances Leng	Invertebrate Zoology	B.Sc. (Hons)	5
Leigh Smith	Herpetology	Cert. Vet Nursing	4
Jesse Forbes-Harper	Vertebrate Zoology	B.A., B.Sc. (Hons)	3

Table 3.17 – Taxonomic specialists

Specialist	Institution	Relevant Experience
Dr Mark Harvey	Western Australian Museum	Taxonomic specialist in arachnids and millipedes
Dr Amber Beavis	Western Australian Museum	Taxonomic specialist in pseudoscorpions
Dr Mark Castalanelli	Western Australian Museum	Taxonomic specialist in mygalomorphs
Julianne Waldock	Western Australian Museum	Taxonomic specialist in arachnids
Corey Whisson	Western Australian Museum	Taxonomic specialist in molluscs
Dr Erich Volschenk	Phoenix Environmental Sciences	Taxonomic specialist in scorpions
Dr Simon Judd	Phoenix Environmental Sciences	Taxonomic specialist in isopods
Dr Volker Framenau	Phoenix Environmental Sciences	Taxonomic specialist in spiders
Dr Karin Bankin	*ecologia* Environment	Taxonomic specialist in stygofauna
Bob Bullen	Bat Call WA	15 years – bat call identification

4 RESULTS

Three habitat types were identified within the study area based upon the information outlined in Section 3.8. The details of each habitat type are shown in Table 4.1 and mapped in Figure 4.1 below.

The study area contains the following habitat types:

- pindan shrubland;
- sandstone range; and,
- savannah woodland.

The majority of systematic survey effort was concentrated on the pindan shrubland habitat, which was the dominant habitat type (Table 4.1). Additional opportunistic effort was expended in less accessible areas, or where systematic trapping was not possible (Table 4.1, Figure 4.1).

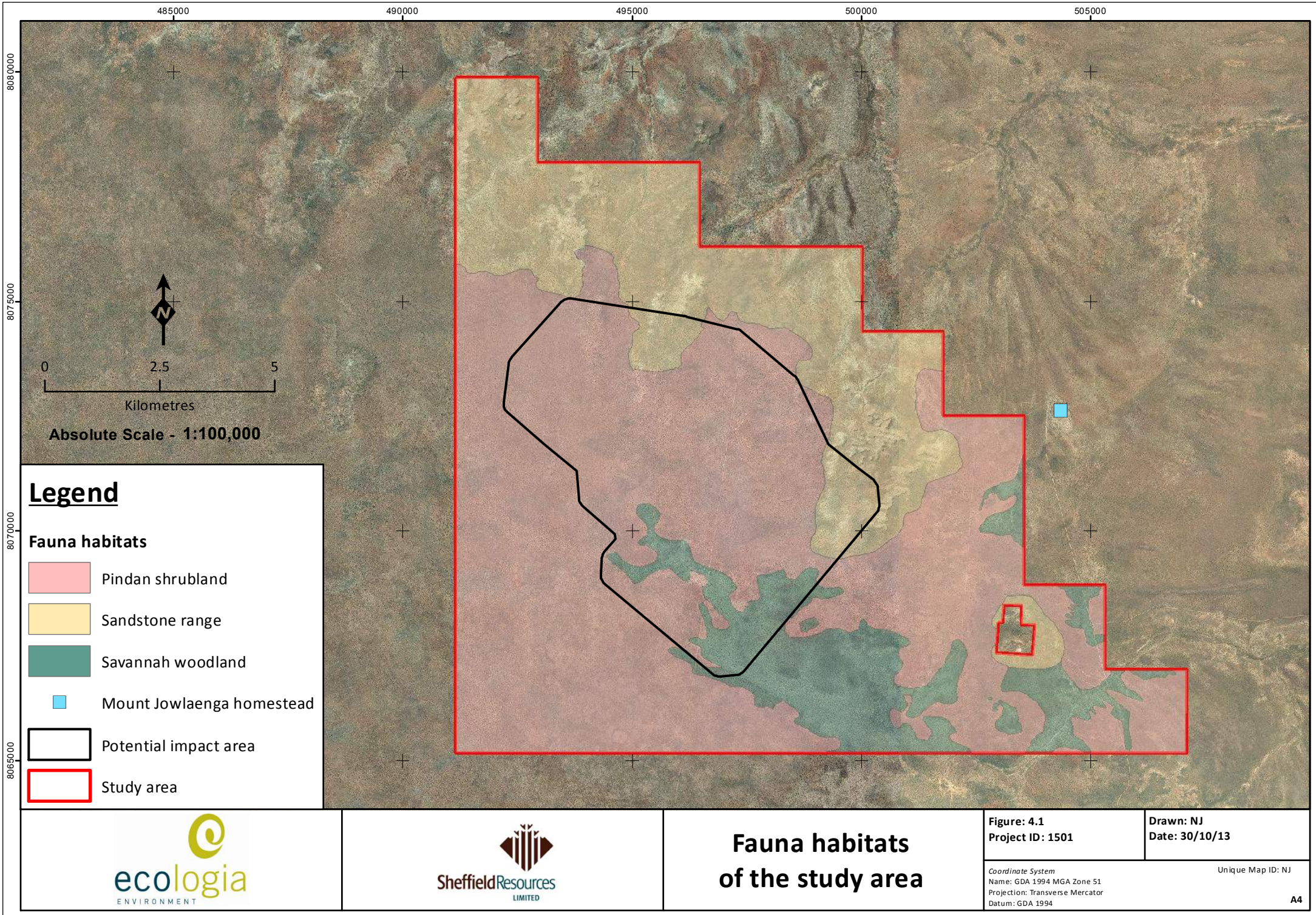
4.1 FAUNA HABITATS

Table 4.1 – Summary of fauna habitats

Fauna habitat	Area inside deposit area (ha)	Percentage of total deposit area (%)	Area inside study area (ha)	Percentage of total study area (%)
Pindan shrubland	3,125.57	78.62	9,225.24	61.95
Sandstone range	395.13	9.94	3,820.59	25.66
Savannah woodland	454.61	11.44	1,845.85	12.39
Total	**3,975.31**	**-**	**14,891.68**	**-**

Table 4.2 – Survey effort per habitat type

Fauna habitat type	Pit traps (trap nights)	Funnels (trap nights)	Elliotts (trap nights)	Cages (trap nights)	Leaf litter collection (no.)	Dry pitfall traps (trap nights)	Bird survey (min)	Diurnal opp search (min)	Nocturnal opps search (min)*	Bat recording (hrs)	Camera trapping (hrs)
Pindan shrubland	700	1,400	700	140	6	360	1,200	730		120	132.25
Sandstone range	140	280	140	28			14	420	1,380	36	253
Savannah woodland	140	280	140	28			294	70		24	



ecologia ENVIRONMENT

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Fauna habitats of the study area

Figure: 4.1
Project ID: 1501

Drawn: NJ
Date: 30/10/13

Coordinate System
Name: GDA 1994 MGA Zone 51
Projection: Transverse Mercator
Datum: GDA 1994

Unique Map ID: NJ

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4.1.1 Pindan shrubland

The pindan shrubland habitat is the most extensive type within the study area, comprising 61.95% (9,225.24 ha) of the total and covering most of the central and southern region (Figure 4.1). The geology of this habitat is flat plains, with weak orange to red sandy-loam soils. The dominant tree species is scattered *Corymbia greeniana*, over a moderately open to dense shrub layer consisting primarily of *Acacia tumida* var *tumida*, *Acacia platycarpa* and *Grevillea refracta*. The ground vegetation layer consists of a mix of grasses including *Triodia caelestialis*, *Aristida holathera* var *holathera*, *Crysopogon* sp., *Eriachne obtusa* and *Sorghum plumosum*. Leaf litter density is highly variable as a result of fire history and patchy shrub density.

Figure 4.2 – Example of the pindan shrubland habitat

4.1.2 Sandstone range

The sandstone range habitat is the second most widespread within the study area, covering 25.66% (3,820.59 ha) of the total. It is found mainly across the northern region of the study area, but also extends partly down into the east. The geology is primarily undulating hills, slopes and gullies of orange sandy soils with sandstone residuals ranging from moderately dense pebbles to dense rocks (Figure 4.3). Several rock outcrops are also present in the eastern region of the study area (Figure 4.4). The vegetation in this habitat is characterised by sparse *Corymbia dendromerinx* over moderately dense *Acacia drepanocarpa* subsp. *latifolia* over a ground vegetation layer of dense *Triodia caelestialis* hummock grassland and *Sorghum plumosum* tussock grassland.

Figure 4.3 – Example of undulating rocky hills in the sandstone range habitat

Figure 4.4 – Example of a rock outcrop in the sandstone range habitat

4.1.3 Savannah woodland

The savannah woodland habitat is the least extensive, covering only 12.39% (1845.85 ha) of the study area. It is characterised by plains in the low-lying areas to the south and east of the study area, with firm brown-white sandy clay soils. The dominant vegetation consists of scattered *Eucalyptus tectifica* and *Brachychiton diversifolius*, with open to moderately dense shrubs of mainly *Acacia platycarpa*. There is a ground vegetation layer of *Eriachne obtusa* tussock grassland and *Triodia caelestialis* hummock grassland, and termite mounds are frequently present.

Figure 4.5 – Example of the savannah woodland habitat.

4.2 FAUNA HABITAT ANALYSIS

Systematically obtained data (trapping results for terrestrial and SRE fauna, and set-time surveys for birds, excluding opportunistic data) was analysed to compare the three habitat types. A one-way ANOSIM test and MDS plot were completed separately for each group in order to determine any differences between habitat types based upon the fauna assemblages they support. The results from the one-way ANOSIM tests are shown in Table 4.3, and the MDS plots are presented in Figures 4.6 – 4.8.

When comparing trapped terrestrial fauna data against the different habitat types, the one-way ANOSIM test determined an R-value of 0.13 (R-value ranges from -1 to 1, with 1 indicating that the groups are dissimilar and -1 indicating that the groups are similar) and a p-value of 0.006 (a p-value of <0.05 indicates a significant difference). The positive R-value, close to 0 and the very low p-value from this analysis suggests some differences between habitat types, although they are not highly different, and that the data collected are sufficient to make this analysis. The MDS plot provides a visual representation of these differences, showing a large amount of overlap between the habitats in terms of terrestrial vertebrate fauna assemblages (Figure 4.6).

Statistical analysis of the avifauna data demonstrates greater differences between the assemblages recorded in each habitat type. The one-way ANOSIM test returned an R-value of 0.13, and a p-value

of 0.07, indicating no statistically significant difference between the habitats. This is also reflected in the MDS plot, which shows minimal separation of the three habitat types (Figure 4.7).

Statistical analysis of the SRE invertebrate data demonstrates greater differences between the assemblages recorded in each habitat type. The one-way ANOSIM test returned an R-value of -0.1229, and a p-value of 0.8516, indicating no statistically significant difference between the habitats. This is also reflected in the MDS plot, which shows minimal separation of the three habitat types (Figure 4.8).

Table 4.3 – One-way ANOSIM test results for fauna habitat comparisons

Fauna group	R-value	p-value
Terrestrial vertebrates	0.13	0.006
Avifauna	0.13	0.07
SRE invertebrates	-0.1229	0.8516

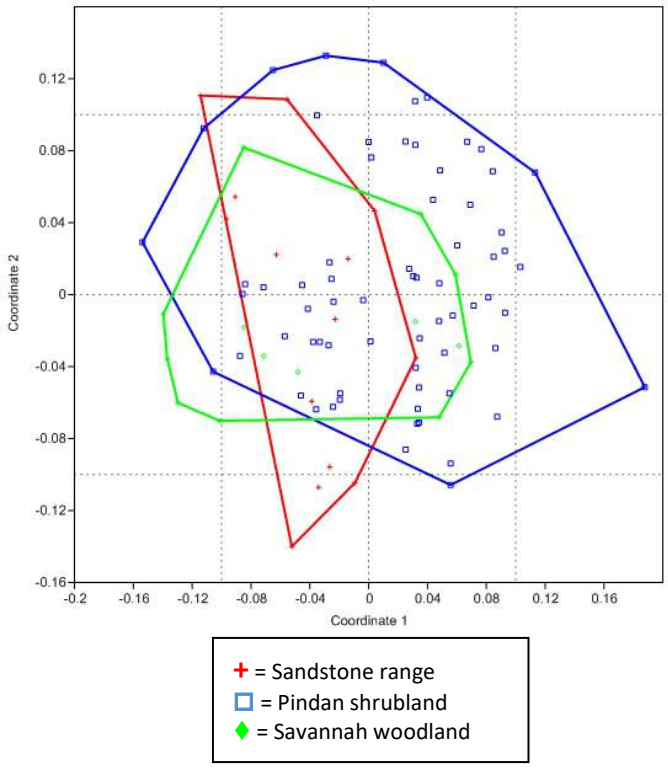


Figure 4.6 – Terrestrial vertebrates MDS plot

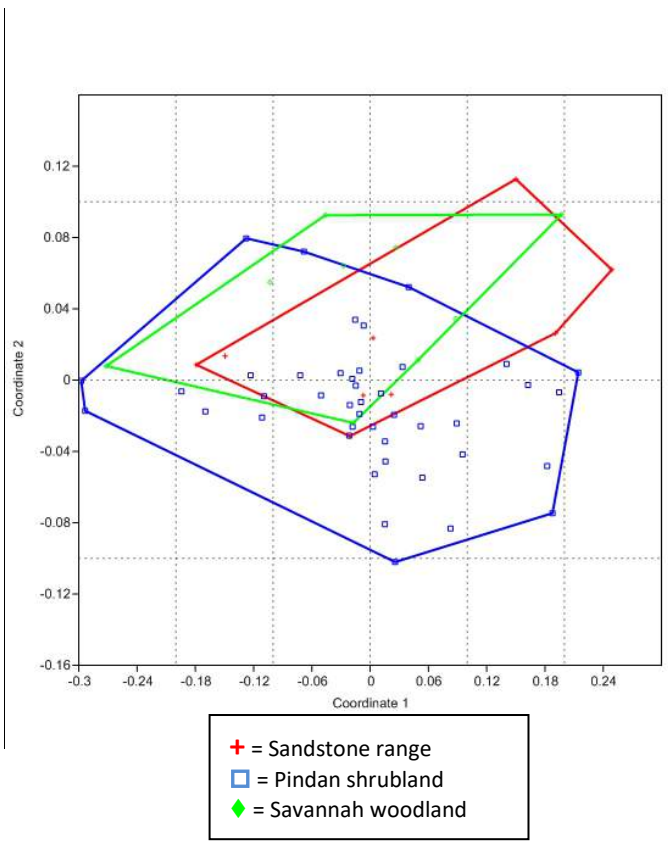


Figure 4.7 – Avifauna MDS plot

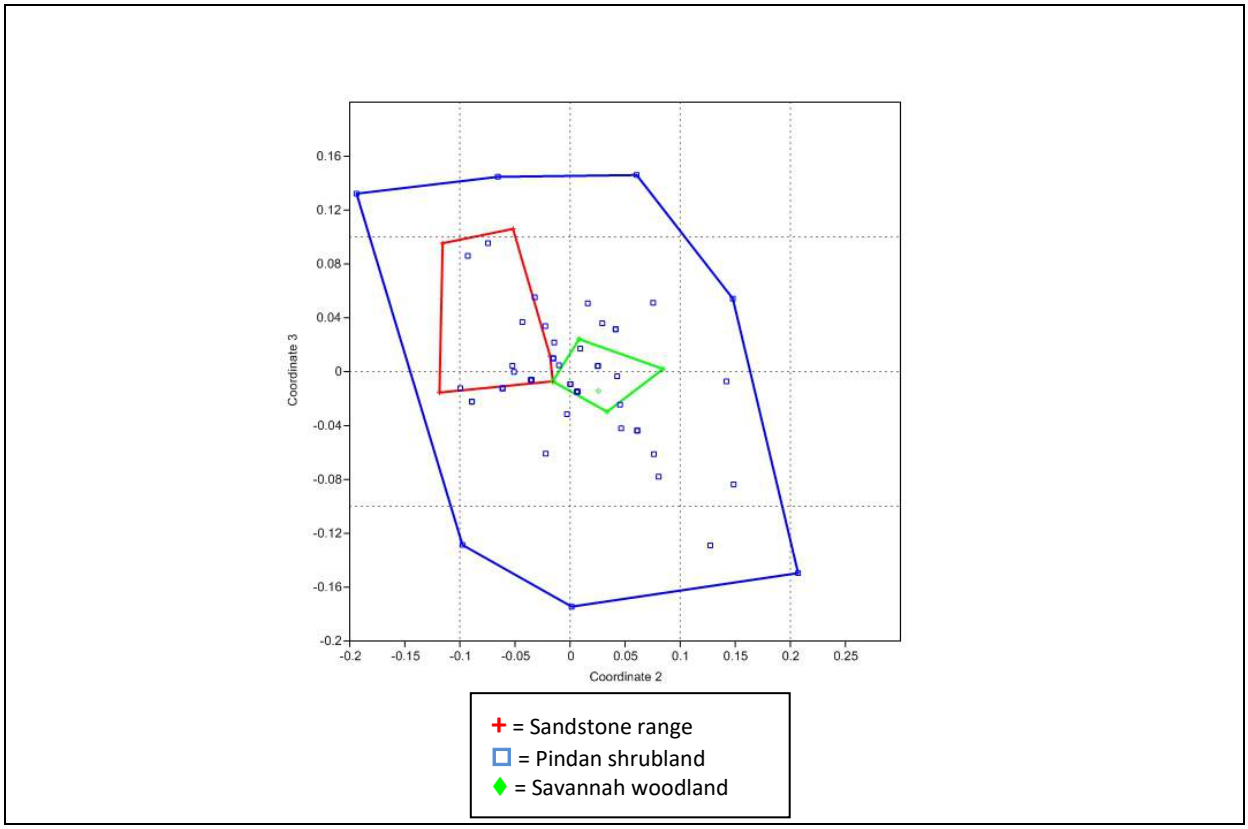


Figure 4.8 – SRE invertebrates MDS plot

4.3 FAUNA ASSEMBLAGES

A total of 16 native mammal species and four introduced mammal species, 107 bird species (27 species recorded from Mount Jowlaenga homestead only), 43 reptile species and eight frog species were recorded. All vertebrate fauna species records are shown in Appendix F, and are discussed in further detail below.

4.3.1 Mammals

A total of 16 native and four introduced mammal species were recorded during the survey. These species comprised one monotreme (egg laying mammal), one dasyurid (small, carnivorous marsupial), one peramelid (Bandicoot or Bilby), two macropods (kangaroo), eight microchiroptera (microbat), three murids (mice or rat) and four introduced mammals (Dog, House Mouse, Cat or Cow). All mammal records are shown in Appendix F. Small mammals such as murids and dasyurids were captured in pitfall and Elliott traps at systematic trapping sites. Larger mammals such as macropods were observed during diurnal and nocturnal opportunistic searches, nocturnal road spotting, secondary evidence and camera trapping. Bats were identified from calls recorded on SM2BAT recorders.

Mammal abundance was generally low, with all trappable and observable mammals recorded less than 10 times, with the exception of the Delicate Mouse, which had a total of 26 trap captures. A number of variances between the two phases of surveying are evident. The Lesser Hairy-footed Dunnart (two records), Large Footed Myotis (one site) and Dog (one record) were recorded during phase 1 only. While the Echidna (one record), Greater Bilby (one record), Euro (one record), Yellow-bellied Sheathtail Bat (two sites), Common Bentwing Bat (three sites), Short-tailed Mouse (one record) and House Mouse (nine records) were recorded during phase 2 only.

Two mammals of conservation significance were recorded, the Greater Bilby (EPBC Act Vulnerable, WC Act Schedule 1, DPaW Vulnerable) and Northern Short-tailed Mouse (DPaW Priority 4).

4.3.2 Birds

A total of 107 bird species (27 species recorded from Mount Jowlaenga homestead only) were recorded during the survey. The most well represented family of birds within the study area was the Meliphagidae family (honeyeaters), of which nine species were recorded. A further nine species were recorded from within the Anatidae family (ducks), however all these species were recorded from Mount Jowlaenga homestead only.

The most abundant species recorded was the Masked Woodswallow, with a total of 717 records made (706 records first phase, 11 records second phase). Other abundant species recorded included the Varied Lorikeet (449 records), Red-collared Lorikeet (150 records), Rufous Whistler (144 records), Brown Honeyeater (122 records), Little Corella (108 records) and Red-backed Fairy-wren (107 records).

A noticeable variation between phase one and phase two of surveying exists for the abundance and diversity of bird species recorded. Within the study area, 13 species of bird were recorded during phase 1 only, consisting of; Crested Pigeon, Tawny Frogmouth, Spotted Nightjar, Fork-tailed Swift, Spotted Harrier, Wedge-tailed Eagle, Nankeen Kestrel, Red-chested Button-quail, Little Button-quail, Budgerigar, Black Honeyeater, White-throated Honeyeater and Tree Martin. During phase 2, a total of nine bird species were recorded which weren't recorded during phase 1; Australian Hobby, Red-tailed Black Cockatoo, Varied Lorikeet, Pallid Cuckoo, Brush Cuckoo, Great Bowerbird, Variegated Fairy-wren, Banded Honeyeater and Olive-backed Oriole. Additionally, of the 27 bird species recorded from Mount Jowlaenga homestead only, 21 species were recorded only during phase 2.

Seven bird species of conservation significance were recorded (three wetland dependent species from Mount Jowlaenga homestead); Rainbow Bee-eater (EPBC Act Migratory, WC Act Schedule 3), Fork-tailed Swift (EPBC Act Migratory, WC Act Schedule 3), Wood Sandpiper (Mount Jowlaenga homestead only, EPBC Act Migratory, WC Act Schedule 3), Eastern Yellow Wagtail (Mount Jowlaenga homestead only, EPBC Act Migratory, WC Act Schedule 3), Grey Wagtail (Mount Jowlaenga homestead only, EPBC Act Migratory, WC Act Schedule 3), Bush Stone-curlew (DPaW Priority 4) and Australian Bustard (DPaW Priority 4).

4.3.3 Reptiles

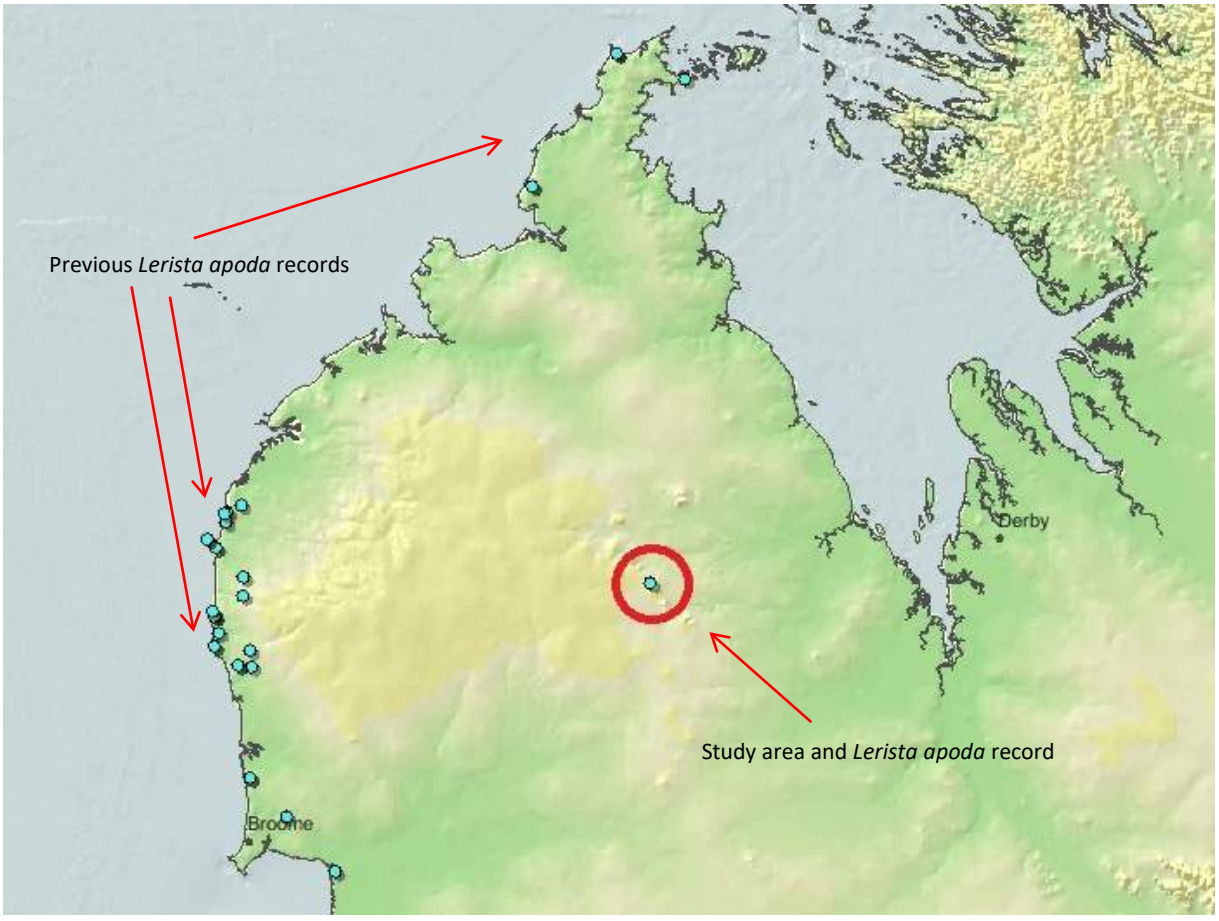
A total of 43 reptile species were recorded during the survey. These species comprised of three Diplodactylidae and three Gekkonidae (gecko) species, three Pygopodidae (legless lizard) species, 17 Scincidae (skink) species, five Agamidae (dragon) species, four Varanidae (goanna) species, one Typhlopidae (blind snake) species, one Boidae (python) species and six Elapidae (front-fanged venomous snake) species.

No reptiles of conservation significance were recorded.

4.3.4 Amphibians

A total of eight frog species from three families were recorded from the current survey (Appendix F). The abundance and diversity of frog species recorded was higher during phase one (Appendix F). Four species (Giant Frog, Long-footed Frog, Little Red Tree Frog and Mole Toadlet) were recorded during phase 1 only. One frog species was recorded during phase two only, the Northern Laughing Tree frog. The number of frog individuals for all species totalled 112 during phase one, while nine individuals were recorded during phase two. The most abundant frog species recorded were the Desert Spadefoot and Ornate Burrowing Frog. No amphibians of conservation significance were recorded.

Figure 4.9 – *Lerista apoda* recorded



Source: NatureMap (2013)

Figure 4.10 – Previous NatureMap *Lerista apoda* records

Figure 4.11 – *Ctenotus colletti* recorded

4.3.5 Short Range Endemic invertebrate fauna

The results of the SRE invertebrate fauna which were collected are summarised below and presented in Appendix F.

4.3.5.1 Mygalomorphae (Spiders)

During the survey, 13 mygalomorph specimens from the Nemesiidae family were collected. These were later classified into seven species, all of which are considered potential SREs.

4.3.5.2 Scorpiones (Scorpions)

Eighty scorpions from two families were collected. These included 77 specimens from the Buthidae family which were classified into seven species, five of which are considered potential SREs. A further three specimens from the Urodacidae family were classed into two potential SRE species.

4.3.5.3 Pseudoscorpiones (Pseudoscorpions)

The pseudoscorpion specimens include 21 individuals from three families; the Sternophoridae, Chernetidae and Olpiidae. The former two families recorded two specimens each, which were classified into two species, neither of which are considered SREs. However, 17 specimens from the Olpiidae family were classified into two species, one of which is considered a potential SRE.

4.3.5.4 Isopoda (Slaters)

Thirty six isopod specimens from the Armadillidae family were collected during the survey. These were classed into three species, all of which are considered potential SREs.

4.3.5.5 Gastropoda (Snails)

The mollusc specimens collected include 24 individuals from three families. Four specimens from the Subulinidae family and two from the Pupillidae family were classed into two species, neither of which are considered SREs. Eighteen specimens from the Camaenidae family were classified into two species, including a potential and a confirmed SRE species.

4.3.5.6 Diplopoda (Millipedes)

No diplopod specimens were collected during the survey.

4.3.5.7 Chilopoda (Centipedes)

No chilopod specimens were collected during the survey.

4.3.6 Stygofauna

Ten specimens of worm belonging to the family Naididae (Naididae sp. indet) were collected in a net haul sample from drill hole THAC 245 sampled at 60 metres (depth to water: 38 m), tapping the Broome Sandstone aquifer (Table 4.4).

Table 4.4 – Stygofauna sampling results

Sub-Phylum	Class	Family	Identification	Number of indiviuals	Site	Aquifer
Annelida	Polychaeta	Naididae	Naididae sp. indet	10	THAC 245	Broome Sandstone

4.3.6.1 Groundwater Physio-chemistry

Results of the groundwater physio-chemistry (electrical conductivity [EC], dissolved oxygen [DO], temperature [°C], acidity/alkalinity [pH], and redox potential [mV]) sampling are summarised in Table 4.5. Individual results for each bore hole are shown in Appendix G.

Table 4.5 – Summary of groundwater physio-chemistry

Bore ID	Depth to water (m)	Temp. (°C)	Conductivity (mS/cm)	DO (ppm) mg/L	pH	Salinity (PSS)	DO%	Redox (mV)	Depth of sample (m)
Average (mean)	34.80	32.44	0.23	4.06	5.60	0.12	34.56	113.29	59.64
Maximum	49	33.91	0.484	7.65	6.27	0.23	75.7	150	90
Minimum	22	30.88	0.043	2.04	5.26	0.03	3.6	24	350
Standard deviation	7.73	0.83	0.11	1.55	0.33	0.05	23.47	30.31	12.89
n	15	13	15	15	15	15	15	14	14

The pH of the groundwater measured showed slight acidic levels (average pH of 5.60), common in igneous and metamorphic sedimentary aquifers, which may not be suitable for all stygofauna (Humphreys 2008). However, during the DEC Pilbara stygofauna survey (Eberhard *et al*. 2009), stygofauna were sampled from bores where pH ranged from slightly acidic (pH 5.70). Overall, the remaining measured groundwater parameters were found to be within the habitable ranges for stygofauna (Humphreys 1999, Malard & Hervant 1999, Humphreys 2008).

4.3.7 Troglofauna

One specimen of centipede belonging to the family Cryptopidae (*Cryptops* sp.) was collected during scraping at drill hole THAC 282 (depth to water: 36 m). Additionally, a rove beetle (family Staphylinidae) was collected from a troglofauna trap at drill hole THAC 407, at a depth of 8 m (Table 4.6).

Table 4.6 – Troglofauna sampling results

Class	Order	Family	Identification	Number of indiviuals	Site	Geology
Chilopoda	Scolopendromorpha	Cryptopidae	*Cryptops* sp. indet.	1	THAC 282	Sedimentary - sandstone
Insecta	Coleoptera	Staphylinidae	Staphylinidae sp. indet.	1	THAC 407	Sedimentary - sandstone

4.4 POTENTIAL CONSERVATION SIGNIFICANT VERTEBRATE FAUNA

The literature review revealed seven mammal, 59 bird and three reptile species of conservation significance could potentially occur in the study area. A total of 44 of the 59 potential conservation significant bird species are restricted to wetland or coastal habitats. A number of these species may occur at nearby Mount Jowlaenga homestead, but will not utilise the study area directly. These wetland and coastal restricted bird species are shown separately in Table 4.8, with their conservation status shown in Appendix C. These species are therefore not discussed in further detail as they are not expected to utilise the study area directly.

All regional records of conservation significant mammals, reptiles and birds (excluding the coastal restricted birds) are mapped in Figure 4.12 and Figure 4.13.

An assessment of likelihood of occurrence of the potential seven mammal, 15 bird and two reptile species of conservation significance in the study area was completed, based on the categories outlined in Section 3.6, with the results summarised in Table 4.7.

A total of nine conservation significant species were recorded (three wetland dependent bird species from Mount Jowlaenga homestead only) during the current survey. A further four potential species are assessed as having a medium likelihood of occurrence, with none considered highly likely to occur. The remaining 15 species are considered to have a low likelihood of occurrence (Table 4.7) and are not discussed further.

Species that were recorded or assessed as having a medium likelihood of occurrence are discussed in further detail in Section 5.4

Table 4.7 – Assessment of likelihood of occurrence of potential conservation significant fauna

Species	Conservation significance			Habitat	Previous records	Likelihood of occurrence
	EPBC Act	WC Act	DPaW			
Mammals						
Northern Quoll *Dasyurus hallucatus*	EN	S1	EN	Rocky areas, also eucalypt forest and woodland.	Not previously recorded on the Dampier Peninsula, but has been recorded in similar habitat to that present, 90 km east of the study area in 2001 (NatureMap)	**LOW** Some suitable habitat in rocky hills, but not previously recorded on Dampier Peninsula.
Greater Bilby *Macrotis lagotis*	VU	S1	VU	Variety of habitats on soft soil, including spinifex grassland, acacia shrubland, open woodland, and cracking clays.	Numerous records within 100 km of study area (NatureMap), including eight records within 20 km of tenement E0402083 (DEC Rare Fauna Search), the most recent record being from 1996.	**RECORDED** Suitable habitat occurs within the study area.
Golden Bandicoot *Isoodon auratus auratus*	VU	S1		Rocky sandstone spinifex and vine thickets.	One record from 1971 on the Dampier Peninsula (NatureMap).	**LOW** Few records within 100 km, and limited suitable habitat.
Crest-tailed Mulgara *Dasycercus cristicauda*	VU	S1		Sandy areas predominately on the top of sand dunes at the base of large Canegrass clumps or Nitre Bush hummocks.	Not previously recorded within 100 km of the study area (NatureMap).	**LOW** No suitable habitat. Not previously recorded within 100 km of the study area.
Short-tailed Mouse *Leggadina lakedownensis*			P4	Spinifex and tussock grassland on cracking clays. Also acacia shrubland, samphire, woodlands, and stony ranges.	No previous records on the Dampier Peninsula (NatureMap).	**RECORDED** Recorded once at site 6, and suitable habitat occurs through most of the study area.
Mangrove Freetail Bat *Mormopterus loriae cobourgiana*			P1	Roost in mangrove stands, hunt in mangroves and forests.	Numerous recent coastal records from the northern tip of the Dampier Peninsula (NatureMap).	**LOW** No suitable habitat within the study area.
Yellow-lipped Cave Bat *Vespadelus douglasorum*			P2	Tropical woodlands of West Kimberley	Recorded near Beagle Bay, approximately 45 km north of the study area (NatureMap).	**LOW** No potential roost caves. Rarely recorded on Dampier Peninsula.

Species	Conservation significance			Habitat	Previous records	Likelihood of occurrence
	EPBC Act	WC Act	DPaW			
Birds						
Gouldian Finch *Erythrura gouldiae*	EN	S1	EN	Tropical savannahs; breed in rocky hills with hollow-bearing eucalypts near water.	Regularly recorded near Cape Leveque, 100 km north of the study area (NatureMap).	**MEDIUM** Suitable habitat occurs within the study area. However, known from very few locations on Dampier Peninsula.
Fork-tailed Swift *Apus pacificus*	M	S3		Almost entirely aerial, particularly associated with storm fronts.	Recorded 80 km west of the study area at James Price Point (*ecologia* internal database). Numerous records throughout Dampier Peninsula (NatureMap).	**RECORDED** Recorded once during the first phase, this is a relatively common summer migrant in the northwest of Australia that will occasionally forage in the aerial space above the study area.
Eastern Great Egret *Ardea modesta*	M	S3		Floodwaters, rivers, shallows of wetlands, intertidal mud-flats.	Numerous records throughout the Dampier Peninsula (NatureMap).	**LOW** Very little suitable habitat, but may occur during the wet season in flooded depressions.
Cattle Egret *Ardea ibis*	M	S3		Grassy habitats and wetlands, particularly damp pastures.	Recorded approximately 37 km south-west, and 65 km east (Derby) of the study area (NatureMap).	**LOW** Very little suitable habitat, but may occur during the wet season in open flooded depressions.
Glossy Ibis *Plegadis falcinellus*	M	S3		Shallows and adjacent flats of freshwater lakes and swamps; river pools; flooded samphire; sewage ponds. Nest in freshwater/brackish wetlands with tall, dense stands of emergent vegetation and low trees or bushes.	Recorded throughout the southern Dampier Peninsula, including a record 20 km east of the study area (NatureMap).	**LOW** Very little suitable habitat, but may occur during the wet season in flooded depressions.
Oriental Pratincole *Glareola maldivarum*	M	S3		Plains, shallow wet and dry edges in open bare wetlands, tidal mudflats, beaches.	Many recent records within 100 km (NatureMap).	**MEDIUM** Suitable habitat exists within the study area, and there are records nearby.

Species	Conservation significance			Habitat	Previous records	Likelihood of occurrence
	EPBC Act	WC Act	DPaW			
Rainbow Bee-eater *Merops ornatus*	M	S3		Open country, most vegetation types, dunes, banks.	Numerous records throughout the Dampier Penisula (NatureMap).	**RECORDED** This species was recorded throughout the study area numerous times. Some nesting habitat is present along drainage lines.
Barn Swallow *Hirundo rustica*	M	S3		Open country, agricultural land, especially near water.	Recorded approximately 37 km south-west, and 65 km east (Derby) of the study area (Birdata)	**LOW** Little suitable habitat within the study area.
Grey Falcon *Falco hypoleucos*		S1	VU	Lightly wooded coastal and riverine plains.	Two records approximately 37 km south-west, and 68 km south-east of the study area (NatureMap).	**LOW** Little suitable habitat within the study area.
Peregrine Falcon *Falco peregrinus*		S4	Other	Coastal cliffs, riverine gorges and wooded watercourses.	Recorded approximately 37 km south-west of the study area (NatureMap).	**LOW** Little suitable habitat within the study area.
Masked Owl (*Tyto novaehollandiae kimberli*)			P1	Forest, woodland, caves, mature trees with hollows.	Not recorded within 100 km of the study area (NatureMap).	**LOW** Little suitable habitat within the study area. Not known from Dampier Peninsula.
Flock Bronzewing *Phaps histrionica*			P4	Sparsely wooded plains near water. Nomadic visitor to areas of suitable habitat.	Numerous recent records within 100 km of the study area (NatureMap).	**LOW** Little suitable sparsely wooded habitat.
Australian Bustard *Ardeotis australis*			P4	Open grasslands, chenopod flats and low heathland.	Numerous records in southern Dampier Peninsula, including the nearest record of 35 km east of the study area (NatureMap).	**RECORDED** This species was recorded on six occasions during phase 1. Suitable habitat occurs throughout much of the study area.
Bush Stone-curlew *Burhinus grallarius*			P4	Lightly wooded country next to daytime shelter of thickets or long grass.	Several records approximately 37 km south-west, and 68 km south-east of the study area (NatureMap).	**RECORDED** This species was recorded numerous times across the study area. Suitable habitat occurs throughout much of the study area.

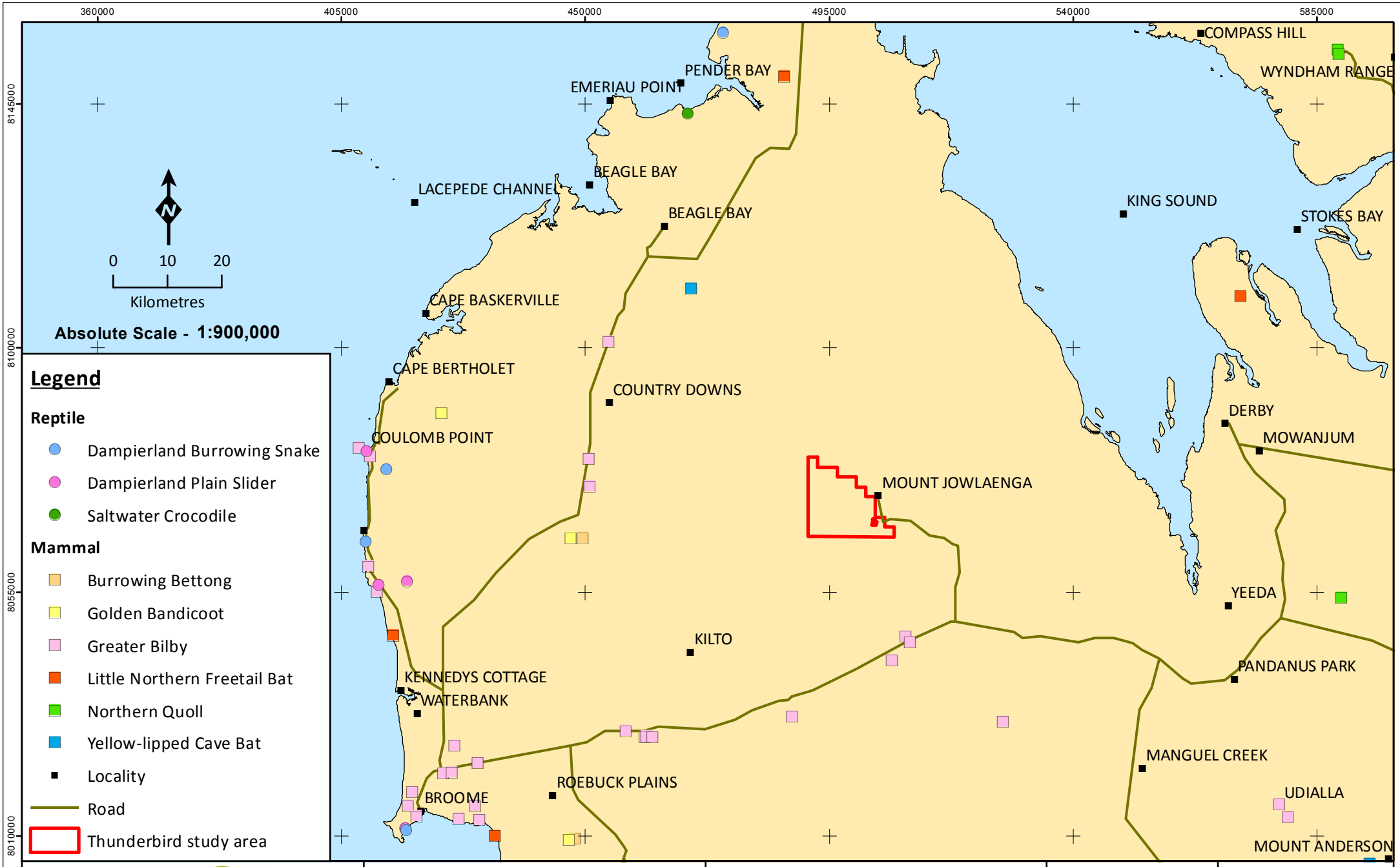
Species	Conservation significance			Habitat	Previous records	Likelihood of occurrence
	EPBC Act	WC Act	DPaW			
Chestnut-backed Button-quail *Turnix castanota*			P4	Savannah woodlands in sandstone and lateritic country.	No records on the Dampier Peninsula (NatureMap).	**LOW** Little suitable habitat and no records nearby.
Reptiles						
Saltwater Crocodile *Crocodylus porosus*		S4	Other	Tidal rivers, coastal floodplains and channels, billabongs and swamps up to 150 km inland.	Not recorded away from coast on Dampier Peninsula, with scarce records in the region (NatureMap)	**LOW** No suitable estuarine or billabongs habitat exists within the study area.
Dampierland Plain Slider *Lerista separanda*			P2	Sandy areas of Dampierland.	Several records along the north-west coast of the Dampier Peninsula, all greater than 85 km from the study area (NatureMap).	**MEDIUM** Apparently restricted to coastal habitats, however poorly known species and sandy habitat exists within study area.
Dampierland Burrowing Snake *Simoselaps minimus*			P2	Coastal dunes or sandy areas between dunes and adjacent acacia shrublands.	Five records within 100 km of study area, all coastal between Broome and Beagle Bay (NatureMap)	**MEDIUM** Apparently restricted to coastal habitats, however poorly known species and sandy habitat exists within study area.

* Refer to Appendix C for a complete list of migratory-listed shorebird or coastal species in the families Fregatidae, Sulidae, Accipitridae, Charadriidae, Rostratulidae, Scolopacidae, Stercorariidae, Laridae and Motacillidae.
Note: Description of conservation significant codes provided in Appendix A.

Table 4.8 – Coastal and wetland conservation significant bird species

Species name	Common name	Species name	Common name
Fregata ariel	Lesser Frigatebird*	*Arenaria interpres*	Ruddy Turnstone*
Sula leucogaster	Brown Booby*	*Limnodromus semipalmatus*	Asian Dowitcher*
Egretta sacra	Eastern Reef Egret*	*Calidris tenuirostris*	Great Knot*
Haliaeetus leucogaster	White-bellied Sea-Eagle[J]	*Calidris canutus*	Red Knot*
Pluvialis fulva	Pacific Golden Plover[J]	*Calidris alba*	Sanderling*
Pluvialis squatarola	Grey Plover[J]	*Calidris ruficollis*	Red-necked Stint[J]
Charadrius leschenaultii	Greater Sand Plover*	*Calidris subminuta*	Long-toed Stint[J]
Charadrius mongolus	Lesser Sand Plover*	*Calidris melanotos*	Pectoral Sandpiper*
Charadrius veredus	Oriental Plover[J]	*Calidris acuminata*	Sharp-tailed Sandpiper[J]
Rostratula australis	Australian Painted Snipe[J]	*Calidris ferruginea*	Curlew Sandpiper[J]
Gallinago megala	Swinhoe's Snipe[J]	*Limicola falcinellus*	Broad-billed Sandpiper*
Limosa limosa	Black-tailed Godwit*	*Philomachus pugnax*	Ruff[J]
Limosa lapponica	Bar-tailed Godwit[J]	*Stercorarius parasiticus*	Arctic Jaeger*
Numenius minutus	Little Curlew[J]	*Sternula albifrons*	Little Tern*
Numenius phaeopus	Whimbrel*	*Hydroprogne caspia*	Caspian Tern*
Numenius madagascariensis	Eastern Curlew*	*Chlidonia leucopterus*	White-winged Black Tern[J]
Xenus cinereus	Terek Sandpiper*	*Sterna dougallii*	Roseate Tern*
Actitis hypoleucos	Common Sandpiper[J]	*Sterna sumatrana*	Black-naped Tern*
Tringa brevipes	Grey-tailed Tattler*	*Sterna hirundo*	Common Tern*
Tringa glareola	Wood Sandpiper[JR]	*Thalasseus bengalensis*	Lesser Crested Tern*
Tringa nebularia	Common Greenshank[J]	*Motacilla cinerea*	Grey Wagtail[JR]
Tringa stagnatilis	Marsh Sandpiper[J]	*Motacilla tschutschensis*	Eastern Yellow Wagtail[JR]

*Coastal species, unlikely to occur at Mount Jowlaenga homestead
[J]Potentially could occur at Mount Jowlaenga during suitable conditions
[JR]Recorded at Mount Jowlaenga homestead on current survey



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Regional conservation signficant mammal and reptile records

Figure: 4.12
Project ID: 1501

Drawn: NJ
Date: 25/02/2014

Coordinate System
Name: GDA 1994 MGA Zone 51
Projection: Transverse Mercator
Datum: GDA 1994

Unique Map ID: NJ013

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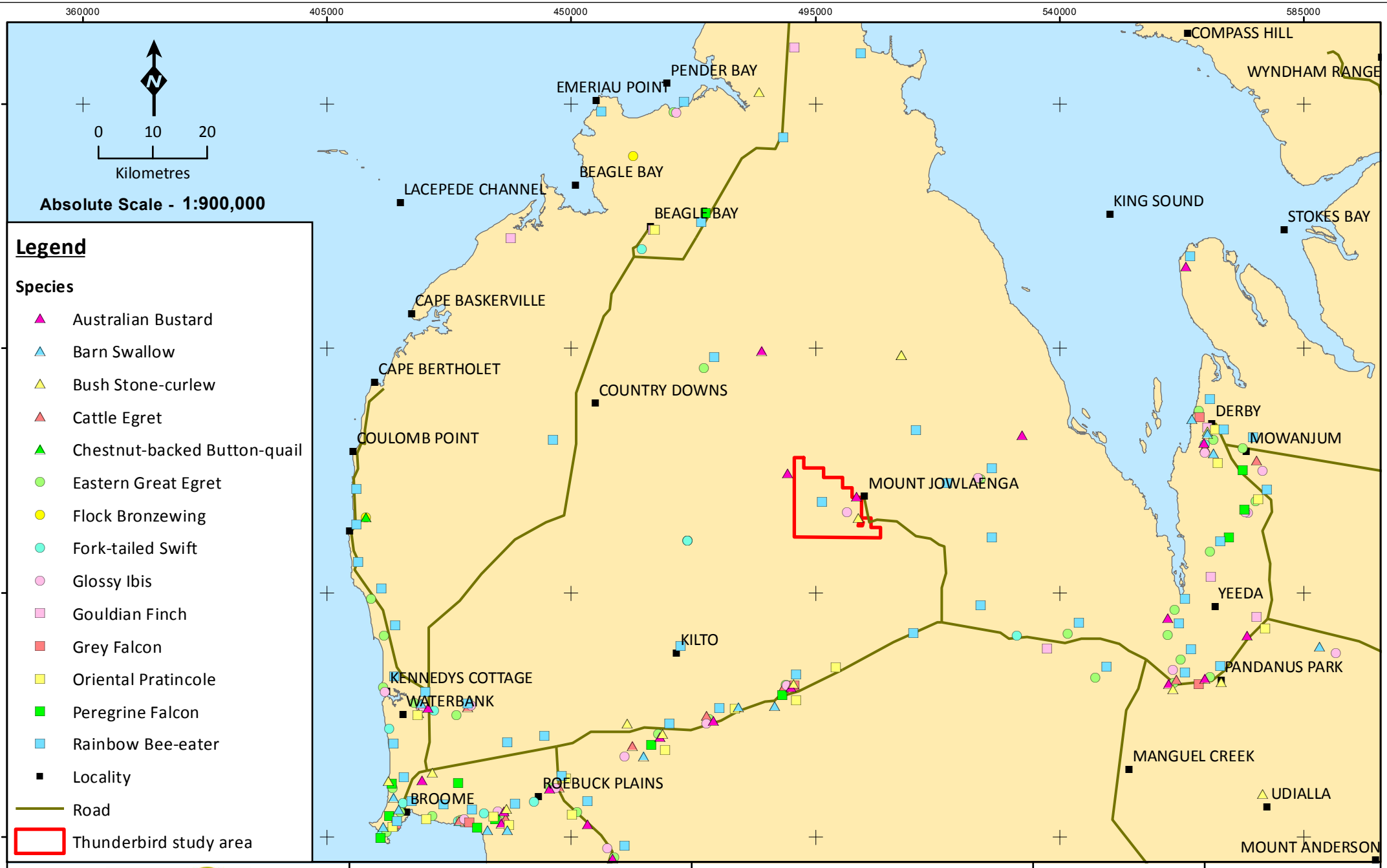

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Regional conservation signficant bird records

Figure: 4.13
Project ID: 1501

Drawn: NJ
Date: 25/02/2014

Coordinate System
Name: GDA 1994 MGA Zone 51
Projection: Transverse Mercator
Datum: GDA 1994

Unique Map ID: NJ013

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4.5 CONSERVATION SIGNIFICANT VERTEBRATE FAUNA RECORDED

Based on database searches and the results of previous biological surveys in the surrounding region, seven mammal, 15 bird (excluding wetland and coastal dependent bird species) and three reptile species of conservation significance could potentially occur within the study area.

Nine species of conservation significance were recorded (two mammals and seven bird species (three wetland dependent bird species) during the survey. These records are summarised in Table 4.7 and mapped in Figure 4.22.

Table 4.9 – Conservation significant fauna recorded

Species	Conservation status			Location			Date	Comments
	EPBC Act	WC Act	DPaW	Easting	Northing	Site		
Mammals								
Greater Bilby	S1	VU	S1	495001	8073488	TB Opp	22/10/13	Three captures (photos) of large, male Greater Bilby at entrance to small burrow. Captures on morning of 22/10/13 at 0432 & 0436 and evening at 1852 (Figure 4.14
Greater Bilby (Burrow)	S1	VU	S1	495001	8073488	TB Opp	20/10/13	Small sized burrow (Figure 4.15). Greater Bilby individual recorded at entrance of burrow.
Greater Bilby (Burrow)	S1	VU	S1	494116	8073268	TB Opp	8/4/13	Inactive burrow
Greater Bilby (Burrow)	S1	VU	S1	494166	8073394	TB Opp	9/4/13	Inactive burrow
Greater Bilby (Burrow)	S1	VU	S1	493555	8074935	TB Opp	9/4/13	Inactive burrow
Greater Bilby (Burrow)	S1	VU	S1	496881	8071087	TB Opp	19/10/13	Inactive burrow
Greater Bilby (Burrow)	S1	VU	S1	494116	8073268	TB Opp	18/10/13	Inactive burrow
Greater Bilby (Burrow)	S1	VU	S1	494166	8073394	TB Opp	19/10/13	Inactive burrow
Greater Bilby (Burrow)	S1	VU	S1	496807	8071018	TB Opp	18/10/13	Inactive burrow
Greater Bilby (Burrow)	S1	VU	S1	494085	8073523	TB Opp	20/10/13	Inactive burrow
Greater Bilby (Burrow)	S1	VU	S1	495000	8073488	TB Opp	19/10/13	Inactive burrow
Greater Bilby (Scat)	S1	VU	S1	495015	8073510	TB Opp	20/10/13	Associated with fresh diggings (Figure 4.16)
Greater Bilby (Scat)	S1	VU	S1	494911	8073733	TB Opp	20/10/13	Associated with fresh diggings
Greater Bilby (Scat)	S1	VU	S1	494996	8073723	TB Opp	20/10/13	Associated with fresh diggings
Greater Bilby (Digging)	S1	VU	S1	494978	8073558	TB Opp	20/10/13	16 separate diggings within 190 metres (Figure 4.17)
Greater Bilby	S1	VU	S1	496881	8071087	TB Opp	20/10/13	Six separate diggings within

Species	Conservation status			Location			Date	Comments
	EPBC Act	WC Act	DPaW	Easting	Northing	Site		
(Digging)								260 metres
Greater Bilby (Digging)	S1	VU	S1	494169	8073407	TB Opp	20/10/13	Seven separate diggings within 160 metres
Northern Short-tailed Mouse			P4	496603	8068741	TB S6	20/10/13	One individual trapped
Birds								
Fork-tailed Swift	M	S3		503429	8067414	TB Opp	9/4/13	Two individuals recorded flying over
Wood Sandpiper[J]	M	S3		504152	8072770	Mt J	16/10/13	12 individuals recorded (Figure 4.18)
Wood Sandpiper	M	S3		503429	8067414	TB Opp	22/10/13	One individual recorded flying over
Eastern Yellow Wagtail	M	S3		504152	8072770	Mt J	20/10/13	Two individuals recorded
Grey Wagtail	M	S3		504152	8072770	Mt J	16/10/13	One individual recorded
Rainbow Bee-eater	M	S3		504152	8072770	TB OS7	7/4/13	10 individuals records
Rainbow Bee-eater	M	S3		499712	8067404	TB OS3	9/4/13	Two individuals recorded
Rainbow Bee-eater	M	S3		499903	8073523	TB Opp	15/10/13	Four individuals recorded
Rainbow Bee-eater	M	S3		499584	8073492	TB S1	9/04/13	One individual recorded
Rainbow Bee-eater	M	S3		499584	8073492	TB S1	13/04/13	Two individuals recorded
Rainbow Bee-eater	M	S3		499584	8073492	TB S1	19/10/13	Three individuals recorded
Rainbow Bee-eater	M	S3		499584	8073492	TB S1	21/10/13	Two individuals recorded
Rainbow Bee-eater	M	S3		496173	8073359	TB S2	15/10/13	One individual recorded
Rainbow Bee-eater	M	S3		496173	8073359	TB S2	19/10/13	One individual recorded
Rainbow Bee-eater	M	S3		496173	8073359	TB S2	20/10/13	One individual recorded
Rainbow Bee-eater	M	S3		496173	8073359	TB S2	18/10/13	Two individuals recorded
Rainbow Bee-eater	M	S3		493352	8073219	TB S3	11/04/13	Two individuals recorded
Rainbow Bee-eater	M	S3		493352	8073219	TB S3	14/04/13	One individual recorded
Rainbow Bee-eater	M	S3		493352	8073219	TB S3	18/10/13	One individual recorded
Rainbow Bee-eater	M	S3		491858	8073144	TB S4	19/10/13	Two individuals recorded
Rainbow Bee-eater	M	S3		491858	8073144	TB S4	11/04/13	One individual recorded

Species	Conservation status			Location			Date	Comments
	EPBC Act	WC Act	DPaW	Easting	Northing	Site		
Rainbow Bee-eater	M	S3		491858	8073144	TB S4	14/04/13	One individual recorded
Rainbow Bee-eater	M	S3		491858	8073144	TB S4	18/10/13	Two individuals recorded
Rainbow Bee-eater	M	S3		491858	8073144	TB S4	20/10/13	Four individuals recorded
Rainbow Bee-eater	M	S3		491858	8073144	TB S4	21/10/13	Three individuals recorded
Rainbow Bee-eater	M	S3		496965	8071200	TB S5	18/10/13	Two individuals recorded
Rainbow Bee-eater	M	S3		496965	8071200	TB S5	21/10/13	One individual recorded
Rainbow Bee-eater	M	S3		496965	8071200	TB S5	7/04/13	Three individuals recorded
Rainbow Bee-eater	M	S3		496965	8071200	TB S5	8/04/13	Four individuals recorded
Rainbow Bee-eater	M	S3		496965	8071200	TB S5	12/04/13	Two individuals recorded
Rainbow Bee-eater	M	S3		496965	8071200	TB S5	17/10/13	Two individuals recorded
Rainbow Bee-eater	M	S3		496965	8071200	TB S5	19/10/13	Three individuals recorded
Rainbow Bee-eater	M	S3		496603	8068741	TB S6	15/10/13	One individual recorded
Rainbow Bee-eater	M	S3		496603	8068741	TB S6	17/10/13	Two individuals recorded
Rainbow Bee-eater	M	S3		496603	8068741	TB S6	7/4/13	Eight individuals recorded
Rainbow Bee-eater	M	S3		496603	8068741	TB S6	8/4/13	One individual recorded
Rainbow Bee-eater	M	S3		496603	8068741	TB S6	9/4/13	Three individuals recorded
Rainbow Bee-eater	M	S3		496603	8068741	TB S6	12/4/13	One individual recorded
Rainbow Bee-eater	M	S3		496603	8068741	TB S6	19/10/13	Two individuals recorded
Rainbow Bee-eater	M	S3		497272	8071921	TB Opp	22/10/13	Nest on flat ground (Figure 4.19)
Rainbow Bee-eater	M	S3		496213	8066048	TB Opp	20/1013	Nest within road verge
Australian Bustard			P4	493689	8073231	TB Opp	5/4/13	Two individuals recorded
Australian Bustard			P4	495867	8063689	TB S1	5/4/13	One individual recorded
Australian Bustard			P4	498080	8073444	TB Opp	6/4/13	One individual recorded
Australian Bustard			P4	501623	8073615	TB Opp	7/4/13	One individual recorded

Species	Conservation status			Location			Date	Comments
	EPBC Act	WC Act	DPaW	Easting	Northing	Site		
Australian Bustard			P4	503137	8073511	TB Opp	8/4/13	One individual recorded
Australian Bustard			P4	498858	8073480	TB Opp	14/4/13	Two individuals recorded
Australian Bustard			P4	497167	8073401	TB Opp	15/10/13	One individual recorded
Australian Bustard			P4	499925	8073532	TB Opp	21/10/13	One individual recorded
Bush Stone-curlew			P4	504998	8067975	TB Opp	6/4/13	One individual recorded
Bush Stone-curlew			P4	503429	8067414	TB Opp	4/4/13	One individual recorded
Bush Stone-curlew			P4	503429	8067414	TB Opp	8/4/13	One individual recorded
Bush Stone-curlew			P4	503429	8067414	TB Opp	12/4/13	One individual recorded
Bush Stone-curlew			P4	496173	8073359	TB S2	15/10/13	One individual recorded
Bush Stone-curlew			P4	496173	8073359	TB S2	20/10/13	One individual recorded
Bush Stone-curlew			P4	496173	8073359	TB S2	21/10/13	One individual recorded
Bush Stone-curlew			P4	493352	8073219	TB S3	19/10/13	One individual recorded
Bush Stone-curlew			P4	491858	8073144	TB S4	15/10/13	One individual recorded
Bush Stone-curlew			P4	491858	8073144	TB S4	19/10/13	One individual recorded
Bush Stone-curlew			P4	491858	8073144	TB S4	18/10/13	One individual recorded
Bush Stone-curlew			P4	496603	8068741	TB S6	15/10/13	One individual recorded

Zone 51K
Datum GDA 94
[J]Recorded at Mount Jowlaenga homestead

Figure 4.14 – Greater Bilby recorded at active burrow via motion camera

Figure 4.15 – Active Greater Bilby burrow where an individual was recorded

Figure 4.16 – Greater Bilby scat

Figure 4.17 – Fresh digging signs from Greater Bilby

Figure 4.18 – Wood Sandpiper recorded at Mount Jowlaenga homestead

Figure 4.19 – Rainbow Bee-eater recorded at nesting burrow via motion camera

Figure 4.20 – Australian Bustard recorded

Figure 4.21 – Bush Stone-curlew recorded

485000 490000 495000 500000 505000 510000

8080000 8075000 8070000 8065000

Legend

Conservation significant species

- Northern Short-tailed Mouse
- Fork-tailed Swift
- Wood Sandpiper
- Eastern Yellow Wagtail
- Grey Wagtail
- Rainbow Bee-eater
- Rainbow Bee-eater (nest)
- Australian Bustard
- Bush Stone-curlew
- Greater Bilby (see Figure 4.22)
- Pindan shrubland
- Sandstone range
- Savannah woodland
- Mount Jowlaenga homestead
- Potential impact area
- Study area

N

0 2 4

Kilometres

Absolute Scale - 1:70,000

ecologia ENVIRONMENT

Sheffield Resources LIMITED

Conservation significant fauna recorded

Figure: 4.22
Project ID: 1501

Drawn: BG
Date: 02/02/14

Coordinate System
Name: GDA 1994 MGA Zone 51
Projection: Transverse Mercator
Datum: GDA 1994

Unique Map ID: BG324

A3

490000

495000

500000

8075000

8070000

N

0 1 2

Kilometres

Absolute Scale - 1:40,000

Legend

Evidence

- Greater Bilby individual
- Scat
- Digging
- Inactive burrow
- Pindan shrubland
- Sandstone range
- Savannah woodland
- Potential impact area
- Study area

ecologia ENVIRONMENT

Sheffield Resources LIMITED

Locations of Greater Bilby evidence recorded during the survey

Figure: 4.23
Project ID: 1501

Drawn: NJ
Date: 24/02/14

Coordinate System
Name: GDA 1994 MGA Zone 51
Projection: Transverse Mercator
Datum: GDA 1994

Unique Map ID: NJ084

A3

490000 495000 500000 505000

8075000

8070000

N

0 1 2

Kilometres

Absolute Scale - 1:60,000

Legend

Mygalomorph taxa

- *Aname* 'MYG284'
- *Aname* 'MYG285'
- *Aname* 'MYG387'
- *Aname* 'MYG387?'
- *Aname* 'MYG388'
- *Aname* 'sp. indet.'
- *Aname* 'sp. juv.'
- Pindan shrubland
- Sandstone range
- Savannah woodland
- Potential impact area
- Study area

ecologia ENVIRONMENT

SheffieldResources LIMITED

Locations of potential SRE mygalomorph spiders recorded during the survey

Figure: 4.24
Project ID: 1501

Drawn: NJ
Date: 24/02/14

Coordinate System
Name: GDA 1994 MGA Zone 51
Projection: Transverse Mercator
Datum: GDA 1994

Unique Map ID: NJ081

A3

490000 495000 500000 505000

8075000

8070000

N

0 1 2

Kilometres

Absolute Scale - 1:60,000

Legend

Scorpion taxa

- *Lychas* 'JPP'
- *Lychas* 'JPP1'
- *Lychas* 'JPP2'
- *Lychas* 'JPP3'
- *Lychas* 'broome'
- *Urodacus* 'kraepelini'
- *Urodacus* 'sp. indet.'

Pseudoscorpion taxa

- Olpiidae 'gen. indet. (juvenile)'
- Pindan shrubland
- Sandstone range
- Savannah woodland
- Potential impact area
- Study area

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Locations of potential SRE scorpions and pseudoscorpions recorded during the survey

Figure: 4.25
Project ID: 1501

Drawn: NJ
Date: 24/02/14

Coordinate System
Name: GDA 1994 MGA Zone 51
Projection: Transverse Mercator
Datum: GDA 1994

Unique Map ID: NJ082

A3

490000 495000 500000 505000

8075000 8070000 8065000

0 1 2

Kilometres

Absolute Scale - 1:60,000

Legend

Isopod taxa

- Armadillidae 'EE1501C'
- *Buddelundia* '74'
- Buddelundinae 'NE Broome'

Opilion record

- *Dampetrus* 'sp. indet.'

Land snail taxa

- *Quistrachia leptogramma*
- *Rhagada bulgana* - Confirmed SRE
- Pindan shrubland
- Sandstone range
- Savannah woodland
- Potential impact area
- Study area

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Locations of potential SRE isopods, opilions and land snails recorded during the survey

Figure: 4.26
Project ID: 1501

Drawn: NJ
Date: 24/02/14

Coordinate System
Name: GDA 1994 MGA Zone 51
Projection: Transverse Mercator
Datum: GDA 1994

Unique Map ID: NJ083

A3

490000
495000
500000
505000
8075000
8070000

N

0 1 2
Kilometres

Absolute Scale - 1:60,000

Legend

Species

Cryptops 'sp. indet.'

Staphylinidae 'sp. indet.'

Potential impact area

Study area

ecologia ENVIRONMENT

Sheffield Resources LIMITED

Locations of troglofauna recorded during the survey

Figure: 4.27
Project ID: 1501

Drawn: NJ
Date: 24/02/14

Coordinate System
Name: GDA 1994 MGA Zone 51
Projection: Transverse Mercator
Datum: GDA 1994

Unique Map ID: NJ085

A3

4.6 SURVEY ADEQUACY

All systematically obtained data sets were analysed for survey adequacy, including trapping results for terrestrial fauna and set-time surveys for birds, excluding any opportunistic data. As the subterranean fauna assessment was a pilot study, and sampling was of relatively low intensity, these analyses were excluded. Table 4.10 provides a summary of the theoretical maximum number of species resulting from seven different methods of estimating richness. The Michaelis-Menten (MM) equation is considered to provide the most accurate representation of the potential species number.

Table 4.10 – Mean estimates of total species richness of systematically sampled fauna

Richness estimators	Total richness estimate		
	Terrestrial vertebrates	Birds	SRE invertebrates
ACE	51	73	31
ICE	49	73	36
Chao-1	49	71	35
Jack-1	52	75	27
Jack-2	54	75	37
Bootstrap	48	72	21
Michaelis-Menten	48	71	22
Species Observed	**45**	**69**	**17**

4.6.1 Terrestrial vertebrates

Analysis of the terrestrial vertebrate trapping data produced a steady SAC, nearing the asymptotic plateau (Figure 4.28). At the completion of 98 trap nights, extrapolation of the MM curve suggests that 93.75% of the theoretical total of trappable terrestrial fauna species were captured (Table 4.10). These results indicate that, although the majority of species were recorded during the survey, additional trapping may detect a further three species.

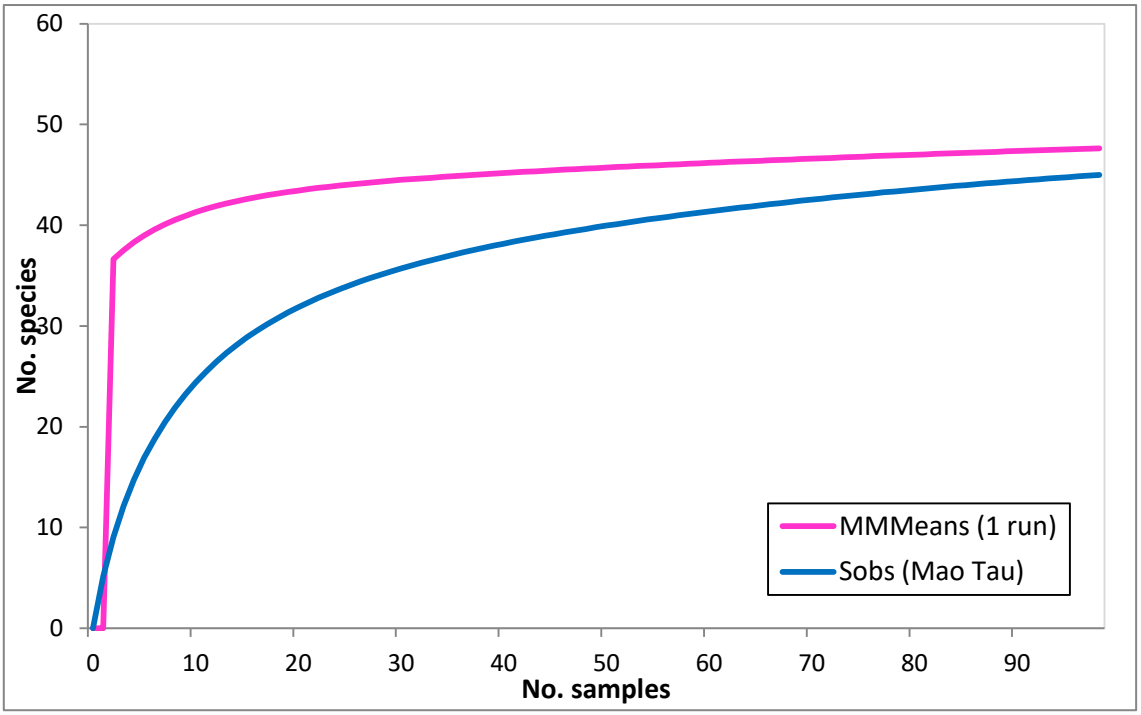

Figure 4.28 – Species accumulation curve for terrestrial vertebrates

4.6.2 Birds

Species accumulation curve analysis of the bird set-time survey dataset also produced a typical SAC, coming close to the asymptotic plateau (Figure 4.29, Table 4.10). Used as a stopping rule, the MM estimator indicated that the survey was 97.18% adequate at the completion of 57 set-time surveys, which is an unusually high result.

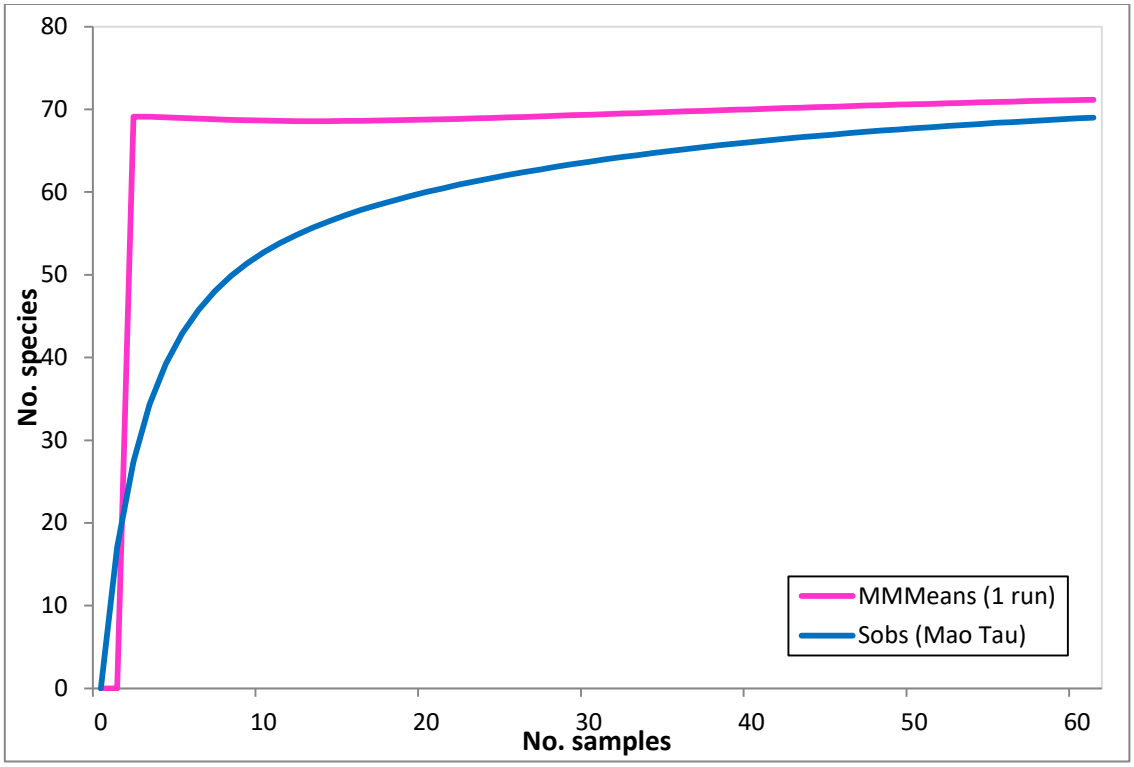

Figure 4.29 – Species accumulation curve for birds

4.6.3 SRE Invertebrate Fauna

SAC analysis of the SRE invertebrate trapping data produced a curve beginning to level to the asymptotic plateau (Figure 4.30). Used as a stopping rule, the MM estimator indicated that the survey was 77.24% adequate at the completion of 69 systematic trapping (Table 4.10), indicating further sampling may yield an additional five species. Other estimators suggest theoretical maximums of 21–37 species occur.

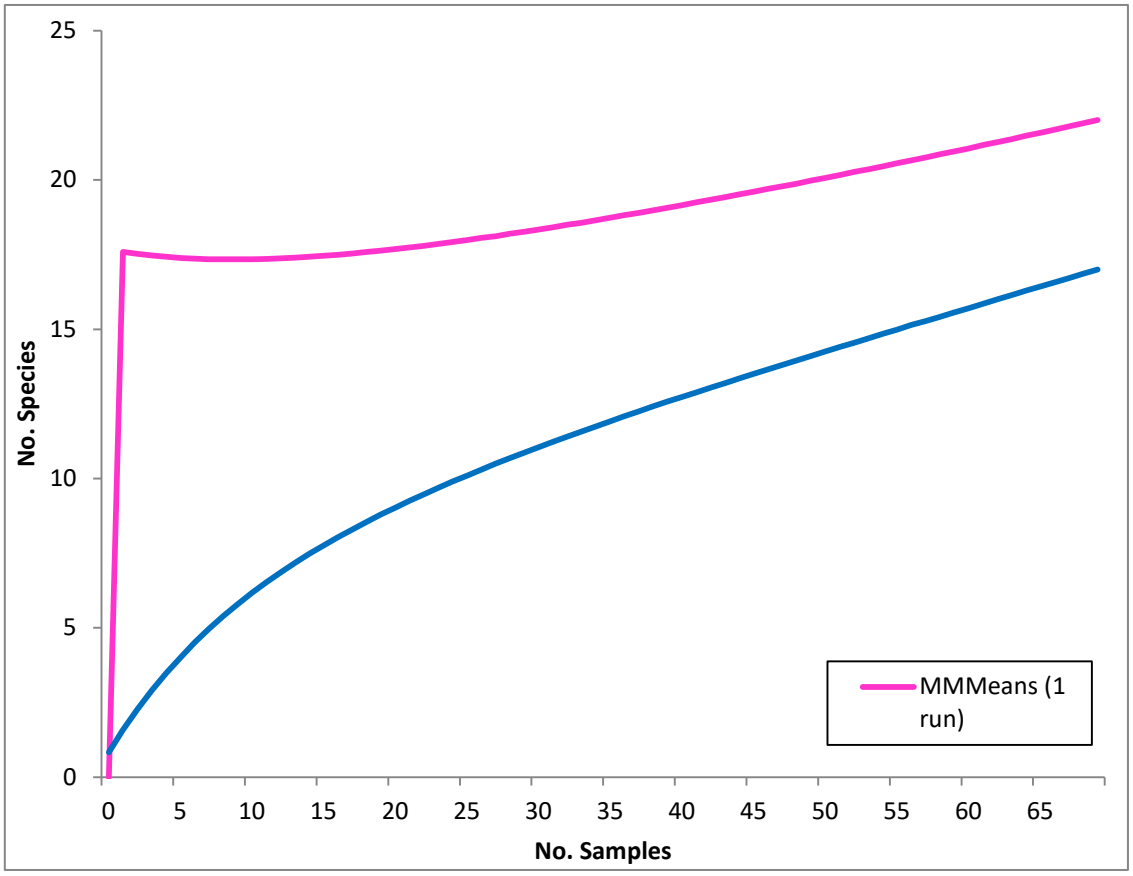

Figure 4.30 – Species accumulation curve for SRE invertebrates

5 DISCUSSION

5.1 HABITATS AND ASSOCIATED FAUNA

5.1.1 Pindan shrubland

Due to the weak soil substrate of the pindan shrubland habitat, a number of small burrowing mammals are likely to occur, including the Delicate Mouse, Western Chestnut Mouse, and Lesser Hairy-footed Dunnart. The Euro and Agile Wallaby may also occur in this habitat.

A diverse range of bird species are expected to occur in pindan shrubland, including the Red-backed Fairy-wren, Long-tailed Finch, Little Friarbird, Red-winged Parrot, Budgerigar and Zebra Finch.

Reptile species expected to favour this habitat include skinks which prefer sandy areas with leaf litter, such as *Eremiascincus isolepis*, *Morethia storri*, *Carlia munda* and *Lerista bipes*. Other skinks like *Ctenotus pantherinus* and *Ctenotus inornatus*, and the dragon *Diporiphora pindan* and the Dwarf Bearded Dragon, prefer the areas of spinifex grassland which may occur in this habitat. Similarly, the Frilled Lizard, Sand Goanna, Short-tailed Pygmy Monitor, the gecko *Strophurus ciliaris*, the Sand-plain Gecko, the Black-headed Python, Northern Shovel-nosed Snake, Mulga Snake and the whipsnake *Demansia angusticeps* are all relatively common in this habitat.

The dense vegetation and associated leaf litter contributes to high SRE invertebrate diversity within this habitat. The majority of mygalomorph spider, pseudoscorpion, scorpion, harvestmen, slater and land snail species were recorded within the pindan shrubland.

In terms of species of conservation significance, the Greater Bilby (EPBC Act Vulnerable), Short-tailed Mouse (DPaW Priority 4), Australian Bustard (DPaW Priority 4), Bush Stone-curlew (DPaW Priority 4), Fork-tailed Swift (EPBC Act Migratory, WC Act Schedule 3) and Rainbow Bee-eater (EPBC Act Migratory, WC Act Schedule 3), *Lerista separanda* (DPaW Priority 2) and the Dampierland Burrowing Snake (DPaW Priority 2) are also likely to be found within this habitat.

5.1.2 Sandstone range

The rocky substrate of the sandstone range habitat is less suitable for small mammals, although the Delicate Mouse and Western Chestnut Mouse may still occur. However, within the study area it is the preferred habitat for the Agile Wallaby and Euro, which use crevices and overhangs for shelter. Bat species such as the Northern Freetail Bat may also use crevices and caves in rock outcrops for roosting.

Bird diversity within the study area is lowest in this habitat, due to the dry, open nature of the vegetation. However, this habitat provides foraging opportunities for raptors, and during flowering periods, many honeyeaters species will be present. The Little Woodswallow is likely to nest locally on the faces of large rock outcrops.

Reptile species expected to favour this habitat include the skinks *Ctenotus pantherinus*, *Ctenotus inornatus* and *Cryptoblepharus ruber*, the Short-tailed Pygmy Monitor and Black-headed Monitor, the Dwarf Bearded Dragon, the Fat-tailed Gecko and Bynoe's Gecko, the gecko *Gehyra nana*, the Spotted Snake and the Stimson's Python.

The rocky substrate and outcrops provide cover for several SRE invertebrate species. An interesting slater (Armadillidae 'EE1501C') was observed and collected from within a rock crevice near the top of an outcrop. The termite mounds associated with the range also contained an abundance of another slater species (*Buddelundia* sp.74). Generally, leaf litter is sparse, but where it is found (i.e. under figs), species such as land snails were recorded.

Conservation significant species which may occur include the Short-tailed Mouse (DPaW Priority 4), Australian Bustard (DPaW Priority 4), Bush Stone-curlew (DPaW Priority 4), Fork-tailed Swift (EPBC Act Migratory, WC Act Schedule 3) and Rainbow Bee-eater (EPBC Act Migratory, WC Act Schedule 3), with potential for the latter to nest along drainage lines. The study area also provides suitable breeding habitat for the Gouldian Finch (EPBC Act Endangered, DPaW Priority 4).

5.1.3 Savannah woodland

Mammal species expected to occur in the savannah woodland habitat include grassland generalists such as the Delicate Mouse and Dingo. Several bat species that roost in tree hollows are likely to occur, including Gould's and Hoary Wattled Bats, and Little Broad-nosed Bats.

A diverse range of bird species are expected to occur within this habitat, including the Red-tailed Black-cockatoo, Red-winged Parrot, Varied Lorikeet, Rufous Songlark, Double-barred Finch, Australian Owlet-nightjar and Southern Boobook. Several species of raptor may also nest and forage in this habitat.

Reptile species expected to favour this habitat include the skinks *Lerista bipes*, *Ctenotus robustus* and *Carlia rufilatus*, the Frilled Lizard and *Diporiphora pindan*, the Sand Goanna, the geckos *Strophurus ciliaris* and *Lucasium stenodactylum*, the Northern Shovel-nosed Snake and the whipsnake *Demansia angusticeps*. The Ornate Burrowing Frog will also prefer the low-lying sandy areas common in this habitat.

The savannah woodlands provide good cover for SRE invertebrates, particularly around the bases, and exfoliating bark, of *Corymbia*. Five species of scorpions (*Lychas* spp. and *Urodacus* 'kraepelini') and one harvestmen (*Dampetrus* sp.) were recorded at the vertebrate trapping site in this habitat, and the confirmed SRE land snail *Rhagada bulgana* was collected from underneath fallen bark.

Of conservation significance, the Australian Bustard (DPaW Priority 4), Bush Stone-curlew (DPaW Priority 4), Fork-tailed Swift (EPBC Act Migratory, WC Act Schedule 3), Rainbow Bee-eater (EPBC Act Migratory, WC Act Schedule 3), Oriental Pratincole (EPBC Act Migratory, WC Act Schedule 3) and Gouldian Finch (EPBC Act Endangered, DPaW Priority 4) may occur in this habitat. Although it may be found in the other habitat types, the Short-tailed Mouse (DPaW Priority 4) is most likely to be found in savannah woodland within the study area.

5.2 HABITAT ANALYSIS

Statistical analysis of the systematic survey data did not indicate a significant difference between the three habitat types in terms of their respective vertebrate or SRE invertebrate fauna assemblages. This similarity between habitat types is most likely a product of two main causes: Firstly, the dominant tree, shrub and grass species of each habitat type are generally also present within the others, meaning there is relatively little niche separation between each habitat. Secondly, systematic sampling was not possible at locations with more distinct niches, such as the semi-permanent spring or rock outcrops where more highly specialised species may occur. As a result, many of the species recorded were found in all three habitat types in inconsistent abundances.

5.3 FAUNA ASSEMBLAGES

5.3.1 Vertebrate Fauna

A total of 13 previous surveys were conducted and consulted as part of the literature review (Table 2.5). The locations of these previous surveys are restricted to mainly coastal regions to the west and north of the study area. Very little information and previous survey data exists for the inland regions of the Dampier Peninsula, and as a result, it is not unexpected that a number of range extension records were made.

5.3.1.1 Mammals

When compared to the number of potential species of the region, compiled during the literature review, this survey recorded a total of 20 out of a potential 39 species. When compared to previous surveys of the region, this total is relatively high (Table 2.6).

Mammal abundance was generally low, with all trappable and observable mammals recorded less than 10 times, with the exception of the Delicate Mouse, which had a total of 26 trap captures. A number of variances between the two phases of surveying are evident. Lesser Hairy-footed Dunnart (two records), Large Footed Myotis (one site) and Dog (one record) were recorded during phase 1 only. While Echidna (one record), Greater Bilby (one record), Euro (one record), Yellow-bellied Sheathtail Bat (two sites), Common Bentwing Bat (three sites), Short-tailed Mouse (one record) and House Mouse (nine records) were recorded during phase 2 only.

A number of noteworthy records were made within the mammal fauna assemblage. The Echidna was recorded during phase 2, with a scat found within the sandstone range habitat type. There are no previous records of the Echidna shown on NatureMap, however this species was recorded on two other occasions during previous surveys (Appendix C). The Lesser Hairy-footed Dunnart has also only once been recorded in the region on one other occasion during a previous survey (Appendix C), with this species recorded twice from TB S4 during Phase 1 (Appendix F). The Common Bentwing Bat was recorded from three sites during phase 2 only (Appendix F). Although the study area falls within the known distribution of this species (Richards 2008), no previous records are shown on NatureMap on the Dampier Peninsula, with a single record from previous surveys (Appendix C). Likewise, the Northern Short-tailed Mouse was recorded once during phase 2 (Appendix F), with this species only recorded once on a previous survey (Appendix C), within the study area outside its general distribution (Moro and Kutt 2008).

5.3.1.2 Birds

When compared to the number of potential species of the region, compiled during the literature review, this survey recorded a total of 107 out of a potential 232 species. When compared to previous surveys in the region, this total is relatively high (Table 2.6).

The Hooded Robin was recorded a total of six times, from three locations (Appendix F). This species has been recorded just twice in the region during previous surveys and from Birdata (Appendix C). The Black Honeyeater was also recorded, both from this survey and the Level one assessment of the study area. The only other records for this species in the region are from the Birdata database (Appendix C).

The high quality wetland habitat at Mount Jowlaenga homestead observed during phase 2 is reflected in the records which included all nine potential waterfowl (family Anatidae) species at this location (Appendix C). Additionally, two Wagtail (*Moticilla* spp.) species were recorded at Mount Jowlaenga homestead, Eastern Yellow Wagtail and Grey Wagtail. Typically, the distribution limit of both species is southern Asia, with sightings in northern Australia regular for Eastern Yellow Wagtail but rare for Grey Wagtail (ebird 2014). Other noteworthy records from Mount Jowlaenga homestead included a high count of 25 Freckled Ducks recorded, with this species not previously recorded by previous regional surveys (Appendix C), and Comb-crested Jacana, recorded only once on a previous survey and from the Birdata database (Appendix C).

5.3.1.3 Herpetofauna

A number of noteworthy herpetofauna records were made from the survey. A total of three capture records of the burrowing fossorial skink *Lerista apoda* (Figure 4.9) were made (Appendix F). Captures were made from pitfall traps and opportunistically through raking leaf litter. Although *Lerista apoda* had been recorded on a number of previous surveys within the literature review (Appendix C), the

location of these records were all from the coastal areas of the west coast of Dampier Peninsula. Previous records from NatureMap (DPaW 2014) also show this species has previously been restricted to coastal regions (Figure 4.10), with the records from the current survey representing an approximate 80 km range extension.

Several individuals of the monitor *Varanus* aff. *brevicauda* were recorded during the survey, including one specimen vouchered at the Western Australian Museum. This taxon may represent a cryptic species, and in the future could be split from the Short-tailed Monitor (*Varanus brevicauda*). *Varanus* aff. *brevicauda* is previously known from the Kimberley (P. Doughty pers. comm.)

Frog abundance and diversity was highest following the wet season, when seven of the eight species, and 88 burrowing frog individuals were recorded. These results contrast with only four frog species, and three burrowing frog individuals recorded during the dry season survey.

5.3.1.4 SRE Invertebrate Fauna

A high diversity of invertebrate fauna from SRE groups were recorded during the survey, when compared to previous studies on the Dampier Peninsula (Appendix C). The mygalomorph spiders (*Aname* spp.) were particularly well-represented, with at least four morphospecies recorded. Within the genus, there appeared to be seasonal variations in the movements of males, as two taxa were only recorded after the wet season during phase one (*A.* 'MYG284' and *A.* 'MYG285), while two taxa were only recorded during the dry season (*A.* 'MYG387' and *A.* 'MYG388).

Scorpions were also well-represented, particularly within the pindan shrubland habitat, with five species of *Lychas* and two species of *Urodacus* collected. The sandy soils and abundant leaf litter provide suitable habitat for this group.

Termite mounds and rock crevices contained several species of isopods. One unusual species, Armadillidae 'EE1501C' was collected from inside a rock crevice near the top of a sandstone escarpment. It is likely this taxon is found in similar habitats within the sandstone range habitat.

The dense leaf litter contained four species of land snails, including the confirmed SRE *Rhagada bulgana*. Land snails were also found underneath bark in well-vegetated areas, where humidity is highest.

5.3.1.5 Subterranean Invertebrate Fauna

During the stygofauna survey (December 2013), ten specimens of Naididae worm were collected from the Broome Sandstone aquifer. Subterranean worms of the Kimberley are very poorly known, and recently barcode analyses of oligochaete species (in the Pilbara) revealed that morphological identifications are often inadequate for resolving species. To verify morphology-based identification, DNA analyses are recommended. The specific identification, distribution and conservation status of the Naididae collected therefore remains undefined, however, members of this group are commonly collected in stygofauna and other aquatic surveys, as they are opportunistically stygal.

Overall, physio-chemical groundwater parameters measured were within the tolerable ranges for stygofauna, although pH was recorded to be at acidic levels (pH 5.26–6.27). Although not all groups of stygobitic fauna can tolerate these acidic environments, surveys have sampled stygofauna from slightly acidic bores (DEC 2009).

Groundwater habitats for stygofauna are defined by hydrogeological characteristics, biogeography and hydrological exchange with the surface (Hahn and Matzke 2005). The distribution of stygofauna is controlled by the physical attributes of aquifers, physio-chemical characteristics of groundwater, historical/evolutionary factors, biological interactions, and interactions among these broad classes of elements (Strayer 1994).

The stygofauna sampling was expected to be tapping the Broome Sandstone aquifer, a non-karstic, unconfined aquifer. The majority of the study area is dominated by clays and sand strata (pindan units), which consequently suggests limited saturated habitat space beneath the water-table. Some stygal taxa, like oligochaetes and copepods, may still occur in these sand aquifers; however in these settings the individual species are (usually) not restricted at small spatial scales. At this point in time, given the absence of a diverse and abundant stygofauna community present within the study area, no stygofauna are likely to be of conservation concern in relation to the project. However, should the Broome Sandstone aquifer have secondary porosity developed in the form of fractures, and/or evidence of restricted calcareous sandstone geology with evidence of karst solution, then this could potentially provide habitat for stygofauna.

Similarly to the stygofauna, there appears to be a low diversity and abundances of troglofauna present. This is potentially due to the study area being dominated by pindan sand plain, which have little or no cavernous or vuggy habitat space and also due to the fact that the study area is relatively low-lying and of flat topography (i.e. subjected to eustatic changes, for example). At this point in time, the only species that could be of conservation concern in relation to the project are *Cryptops* sp. indet. and Staphylinidae sp. indet.. However, given the relatively continuous and expansive geology outside the potential impact area, with no obvious dispersal barriers, these species are unlikely to have restricted distributions.

5.4 CONSERVATION SIGNIFICANT VERTEBRATE FAUNA

Based on database searches and the results of previous biological surveys in the surrounding region, seven mammals, 15 birds (excluding wetland and coastal dependent bird species) and two reptile species of conservation significance could potentially occur within the study area. Nine species of conservation significance were recorded (two mammals and seven bird species (three wetland dependent bird species from Mount Jowlaenga homestead)) during this survey, with an additional four species assessed as having a medium likelihood of occurrence (Section 4.4). Species that were recorded or assessed as having a medium likelihood of occurrence are discussed in greater detail below.

5.4.1 Mammals

5.4.1.1 Greater Bilby (*Macrotis lagotis*)

Conservation status: EPBC Act Vulnerable, WC Act Schedule 1 (Vulnerable).

Distribution and habitat: Once common over 70% of mainland Australia's arid and semiarid regions, Bilbies are currently patchily distributed through the Tanami, Great Sandy and Gibson Deserts (Maxwell *et al.* 1996). Isolated populations also occur in south-west Queensland and to the north-east of Alice Springs. Bilbies occur in a variety of habitats, including spinifex grassland, *Acacia* shrubland, open woodland and cracking clays (Maxwell *et al.* 1996; Johnson 2008). The species underwent a sudden and widespread collapse in population size in the early 1900s, and the distribution may still be contracting and fragmenting. Reasons for the decline include predation by feral predators on both young and adult bilbies, competition from rabbits and livestock, reduced food as a result of changed fire regimes, and drought (Maxwell *et al.* 1996; O'Malley 2006a; Johnson 2008).

Ecology: The Greater Bilby is a nocturnal marsupial with soft, silky fur (Pavey 2006). It uses its strong forelimbs and claws to construct an extensive tunnel system of up to 3 m long and 1.8 m deep in which it shelters during the day. Its long tongue is an adaptation to its specialised diet of seeds, insects, bulbs, fruit and fungi (Johnson 2008).

Likelihood of occurrence: Recorded. An individual was recorded via a motion camera during phase 2, with a total of three captures (photos) recorded (Section 4.5). Motion camera capture records included two records from early morning (0432, 0436) on the 22/10/13, and a single evening record (1852) on the 22/10/13 (Table 4.9, Figure 4.14). The individual recorded appears to be a fully grown male, based on the size of the individual in relation to other features within the photo. This male was not observed entering the burrow, and based on three images captured, appeared to be investiagting the burrow entrance only. The active burrow it was investigating appears to be too small for a fully grown male, with this burrow more likley to be occuppied by a female or juvenile, suggesting at least two individuals were present within this immediate location.

The amount of foraging activity present also suggests multiple individuals are present within the immediate area, with a total of 16 separate diggings recorded (Table 4.9, Figure 4.22). Additionally, analysis of the separate scats recorded show a variation in size between scats, potentially representing different individuals. Scats recorded are shown in Figure 5.1, which shows larger Greater Bilby scat on the left, with smaller scats in the middle and right.

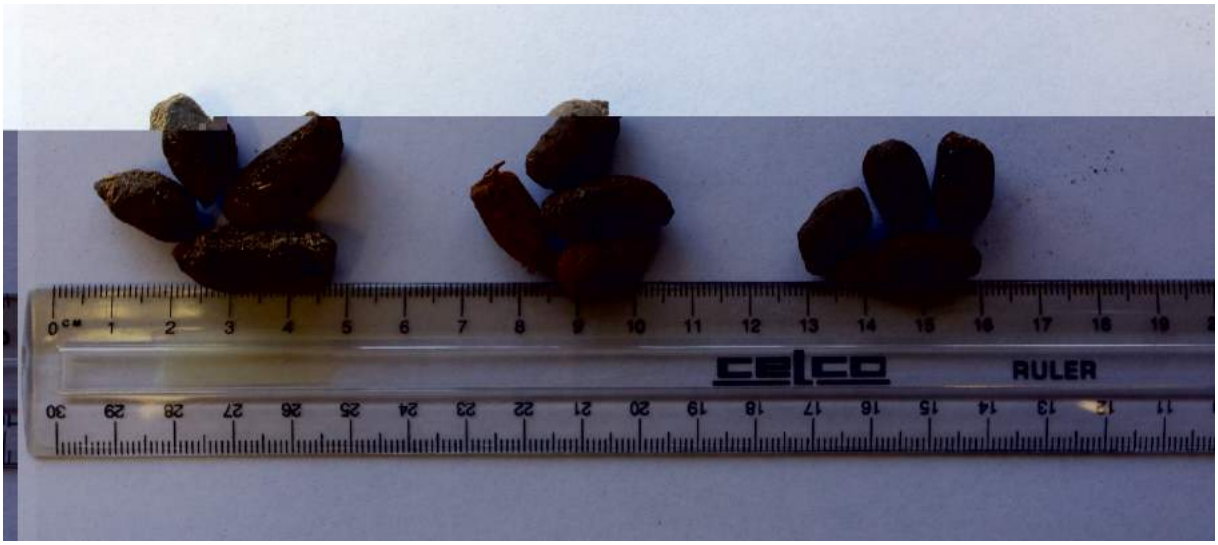

Figure 5.1 – Greater Bilby scats recorded

Three locations of clusters of activity were recorded within the study area (Figure 4.23), all within the pindan shrubland habitat type. A noticeable preference of the Greater Bilby within this habitat was a strong feeding association with tall, dense *Acacia tumida*. Consistently, diggings were found at the base of this shrub (Figure 5.2), often with extensive leaf litter. The diet of the Greater Bilby varies accordingly to availability of food items, with root-dwelling insect larvae (particularly those within *Acacia* spp.) utilised when plant foods are scarce (Southgate 2013). This is consistent with findings from this study, with the feeding association with *Acacia tumida* only recorded during phase 2.

The open understorey structure of the *Acacia tumida* microhabitat also appeared to influence the presence of the Greater Bilby. Evidence was only recorded in patches of *Acacia tumida* that had very open ground cover, which allows easy movement. Other habitat types within the study area typically contain denser ground cover, which may be less attractive to the Greater Bilby.

Active Greater Bilby evidence was only recorded during phase 2, with only old burrows recorded during phase 1. This suggests Greater Bilby activity and habitat utilisation within the study area may vary seasonally. This is consistent with literature which identifies detection of Greater Bilbies being complicated due to their mobility and spatial and temporal habitat utilisation (Southgate 2013).

Figure 5.2 – Greater Bilby diggings in *Acacia tumida* root stock

Based on the evidence recorded from the current survey, it can be confirmed the Greater Bilby is present within the study area and actively utilises areas of the pindan shrubland habitat, particularly the *Acacia tumida* microhabitat.

5.4.1.2 Short-tailed Mouse (*Leggadina lakedownensis*)

Conservation status: DPaW Priority 4.

Distribution and habitat: Populations of this small, elusive rodent are distributed across northern Australia, but records have been sporadic (Moro and Kutt 2008). They occupy a diverse range of habitats from the monsoon tropical coast to semi-arid climates, including spinifex and tussock grasslands, samphire and sedgelands, *Acacia* shrublands, tropical eucalypt and *Melaleuca* woodlands and stony ranges. However, Short-tailed Mice are usually found in seasonally inundated habitats on red or white sandy-clay soils (Moro and Kutt 2008).

Ecology: The diet of the Short-tailed Mouse consists primarily of invertebrates, with plants supplementing their water requirements (Moro and Kutt 2008). Populations fluctuate greatly in response to rainfall, sometimes reaching plague proportions. The species is nocturnal and solitary, spending the day in simple, single-chambered burrows (Moro and Kutt 2008).

Likelihood of occurrence: Recorded. – one individual was recorded at site 6 on the second phase of the survey. Within the study area, this species should predominantly occur in low-lying areas with tussock grasses. Population size will also vary considerably depending upon seasonal food availability.

5.4.2 Birds

5.4.2.1 Gouldian Finch (*Erythrura gouldiae*)

Conservation status: EPBC Act Endangered, DPaW Priority 4.

Distribution and habitat: The Gouldian Finch was formally distributed throughout the tropical savannahs of northern Australia. It is now restricted to isolated areas mostly within the Northern Territory and the Kimberley region of Western Australia (Woinarski and Palmer 2006). Known breeding habitat is characterised by rocky hills with hollow-bearing, smooth-barked gums that are close to small waterholes or springs that persist through the dry season (O'Malley 2006b).

Ecology: Gouldian finches forage on the ground, feeding on seeding grasses, particularly native *Sorghum* spp. (Pizzey and Knight 2003). Due to the restricted diet of Gouldian Finches, they are particularly vulnerable to seed shortages (O'Malley 2006b). The decline in populations of the Gouldian Finch is representative of the general decline of granivorous birds occurring as a result of current land management practices. Ongoing key threats to the Gouldian Finch are vegetation change through inappropriate fire regimes, and grazing impacts of stock and feral herbivores (O'Malley 2006b).

Likelihood of occurrence: Medium – suitable breeding and foraging habitat occurs within the study area, although vegetation degradation by livestock may be diminishing the chance Gouldian Finches occur there. Gouldian Finches have also been recorded at relatively few locations on the Dampier Peninsula, with most records at the northern tip.

5.4.2.2 Fork-tailed Swift (*Apus pacificus*)

Conservation status: EPBC Act Migratory, WC Act Schedule 3.

Distribution and habitat: The Fork-tailed Swift is a small, insectivorous species with a white throat and rump, and a deeply forked tail (Morcombe 2000). Its distribution spans from central Siberia and throughout Asia, breeding in north-east and mid-east Asia, and wintering in Australia and south New Guinea. It is a relatively common trans-equatorial migrant from October to April throughout mainland Australia (Simpson and Day 2004). In Western Australia the species begins to arrive in the Kimberley in late September, the Pilbara in November and the South-west by mid-December (Johnstone and Storr 1998). In Western Australia the Fork-tailed Swift is considered uncommon to moderately common near the north-west, west and south-east coasts, common in the Kimberley and rare or scarce elsewhere (Johnstone and Storr 1998).

Ecology: Fork-tailed swifts are nomadic in response to broad-scale weather pattern changes. They are attracted to thunderstorms where they can be seen in flocks, occasionally of up to 2,000 birds. They rarely land, living almost exclusively in the air and feeding entirely on aerial insects, especially nuptial swarms of beetles, ants, termites and native bees (Simpson and Day 2004).

Likelihood of occurrence: Recorded – one individual was recorded on the first phase. Most commonly occurring during summer, Fork-tailed Swifts may be found in varying numbers foraging in the air above the study area.

5.4.2.3 Oriental Pratincole (*Glareola maldivarum*)

Conservation status: EPBC Act Migratory, WC Act Schedule 3.

Distribution and habitat: The Oriental Pratincole is a non-breeding migrant to Australia. The species breeds from Mongolia, Siberia and China, south to Sri Lanka, Thailand and Vietnam. It then spends the winter period (late October to May) in northern Australia (Johnstone and Storr 1998). Oriental Pratincoles occur on open plains, bare ground around swamps, and claypans.

Ecology: Oriental Pratincoles hawk insects from the ground and can sometimes occur in huge flocks. Birds may feed in the evening until nearly dark (Johnstone and Storr 1998).

Likelihood of occurrence: Medium – although not ideal, suitable habitat exists within the study area. There are also numerous recent records around the Dampier Peninsula, where they are most likely to be recorded during summer.

5.4.2.4 Rainbow Bee-eater (*Merops ornatus*)

Conservation status: EPBC Act Migratory, WC Act Schedule 3.

Distribution and habitat: The Rainbow Bee-eater is scarce to common throughout much of Western Australia, except for the arid interior, preferring lightly wooded, preferably sandy country near water (Johnstone and Storr 1998).

Ecology: In Western Australia the Rainbow Bee-eater can occur as a resident, breeding visitor, post-nuptial nomad, passage migrant or winter visitor. It nests in burrows usually dug at a slight angle on flat ground, sandy banks or cuttings, and often at the margins of roads or tracks (Simpson and Day 2004). Eggs are laid at the end of the metre-long tunnel from August to January (Boland 2004). Rainbow Bee-eaters are most susceptible to predation during breeding, as it spends significantly more time on the ground in this period.

Likelihood of occurrence: Recorded – this species was seen numerous times across the study area, which is mostly suitable habitat. Rainbow Bee-eaters may also breed there, particularly in the banks of drainage lines.

5.4.2.5 Australian Bustard (*Ardeotis australis*)

Conservation status: DPaW Priority 4.

Distribution and habitat: The Australian Bustard occurs Australia-wide and utilises a number of open habitats, including open or lightly wooded grasslands, chenopod flats, plains and heathlands (Johnstone and Storr 1998).

Ecology: It is a nomadic species, ranging over very large areas, and its abundance varies locally and seasonally from scarce to common, largely dependent on rainfall and food availability. The Australian Bustard has an omnivorous diet, feeding on grasses, seeds, fruit, insects and small vertebrates.

Although the population size is still substantial, there has been a large historical decline in abundance, particularly south of the tropics, but also across northern Australia (Garnett and Crowley 2000). This is a result of hunting, degradation of its grassland habitat by sheep and rabbits, and predation by foxes and cats (Frith 1976; Garnett and Crowley 2000). Australian Bustards readily desert nests in response to disturbance by humans, sheep or cattle (Garnett and Crowley 2000).

Likelihood of occurrence: Recorded – six records were taken during the first phase, although it is likely there were less individuals than this. Seasonal variability in abundance of Australian Bustards is reflected in the lack of records during the second phase. Feral species, particularly cattle, may also be diminishing their chance of occurrence in the study area.

5.4.2.6 Bush Stone-curlew (*Burhinus grallarius*)

Conservation status: DPaW Priority 4.

Distribution and habitat: The Bush Stone-curlew occurs across much of Australia, except the arid interior and central south coast, preferring lightly wooded country near thickets or long grass that acts as daytime shelter (Johnstone and Storr 1998). Historically, this species was widely distributed throughout most of WA, but has since declined, particularly in the southern part of the State. Recent

estimates indicate an Australian population of 15,000 individuals (Garnett and Crowley 2000). The Bush Stone-curlew inhabits woodlands, dry and open grasslands, and croplands with cover nearby (NSW National Parks and Wildlife Service 1999).

Ecology: The species is insectivorous, preying primarily upon beetles, although they will also eat seeds and shoots, frogs, lizards and snakes (Marchant and Higgins 1993; NSW National Parks and Wildlife Service 1999). They are usually seen in pairs, although may occasionally flock together during the breeding season (August to January) and are generally nocturnal, being especially active on moonlit nights (NSW National Parks and Wildlife Service 1999).

Since Bush Stone-curlews are a ground-dwelling and non-migratory species, they are quite susceptible to local disturbances by humans and to predation by cats and foxes (Frith 1976; Johnstone and Storr 1998). They are most common where land disturbance is minimal, and generally become rare or extinct around human settlements (Johnstone and Storr 1998).

Likelihood of occurrence: Recorded – this species was recorded a number of times during both phases. As there is also a large amount of suitable habitat, Bush Stone-curlews may occur fairly commonly in the study area, depending how heavily they are disturbed by livestock.

5.4.3 Reptiles

5.4.3.1 Dampierland Plain Slider (*Lerista separanda*)

Conservation status: DPaW Priority 2.

Distribution and habitat: *Lerista separanda* is currently known to be found in sandy soils along the south-west Kimberley coastline, between Kimbolton and Nita Downs (Wilson and Swan 2010).

Ecology: There is little information on the ecology of this species. *L. separanda* is one of the smallest species in the genus and has a fused lower eyelid (Wilson and Swan 2010). Whereas most other *Lerista* species have greatly reduced or only two limbs, *L. separanda* has four of the relatively largest limbs. This strongly suggests that it is not only able to push its way through sand but also walk across it.

Likelihood of occurrence: Medium – although the only records are from the western coast of the Dampier Peninsula, they are from a sandy loam soil with pindan shrubland habitat. This habitat is widespread and abundant across the peninsula, and is present within the study area. It is therefore possible for the distribution of *Lerista separanda* to include the study area. Similarly, *Lerista apoda* and *Lerista greeri* were previously only known from the western coastline and to the east of the Dampier Peninsula respectively, yet both were recorded during this survey.

5.4.3.2 Dampierland Burrowing Snake (*Simoselaps minimus*)

Conservation status: DPaW Priority 2.

Distribution and habitat: This snake is currently known only from the western side of the Dampier Peninsula. Its preferred habitat is on coastal dunes or the sandy areas between dunes and adjacent *Acacia* shrublands (Wilson and Swan 2010).

Ecology: Little is known of the Dampierland Burrowing Snake's ecology, but it is presumably similar to other *Simoselaps* species, which are sand-swimmers that feed mostly on *Lerista* skinks (Wilson and Swan 2010).

Likelihood of occurrence: Medium – although previous records are from the western coast of the Dampier Peninsula, they are from sandy soils. However, sandy soils extend across much of the peninsula, and are characteristic of the pindan shrubland and savannah woodland habitats found within the study area. The Dampierland Burrowing Snake may therefore occur within the study area.

5.5 SRE INVERTEBRATE FAUNA

The survey yielded a total of 178 invertebrate specimens which represented six orders, 11 families and 28 taxa. As typical in SRE surveys, 11 species were recorded in low abundance, being represented only by singletons and/or doubletons (Appendix F). One species (the land snail *Rhagada bulgana*) was assessed as a confirmed SRE, while 20 taxa were considered potential SREs. In accordance with the precautionary principle, all potential SREs should be treated as confirmed SREs. The taxonomy, distribution and SRE status of these species are discussed in the following sections.

5.5.1 Mygalomorphae (Trapdoor Spiders)

5.5.1.1 Family: Nemesiidae (Wishbone Spiders)

The most significant SRE invertebrate findings from the study included the collection of seven taxa of mygalomorph spiders of the genus *Aname*. At least four of these taxa represent distinct morphospecies based on male morphology, while the remaining three taxa were represented by female and juvenile specimens that could not be identified lower than the genus without DNA analysis.

***Aname* 'MYG284'**

SRE Status: Potential.

Four male *Aname* 'MYG284' where collected from site TB S2 (inside the potential impact area). Specimens of this morphospecies were only collected during the first phase, indicating males may be more likely to move during, or nearing the end of, the wet season. This species lacks geographical information and its current distribution is 8.5 km squared and **therefore considered a potential SRE** (WAM 2013a). Given this taxon was recorded from the extensive pindan shrubland habitat, it is likely to have a distribution that extends well beyond the study area boundary.

***Aname* 'MYG285'**

SRE Status: Potential.

One male *Aname* 'MYG285' was collected from site TB S4 (outside the potential impact area). This is a new species and therefore **considered a potential SRE** (WAM 2013a). Specimens of this morphospecies were only collected during the first phase, indicating males may be more likely to move during, or nearing the end of, the wet season. Given this taxon was recorded from the extensive pindan shrubland habitat, it is likely to have a distribution that extends well beyond the study area boundary.

***Aname* 'MYG387'**

SRE Status: Potential.

One male *Aname* 'MYG387' was collected from site TB S1 (outside the potential impact area). This species is not present in the WAM reference collection and potentially a new species, therefore **considered a potential SRE** (Phoenix 2013a). Specimens of this morphospecies were only collected during the second phase, indicating males may be more likely to move during the dry season. It is possible that the female Aname 'MYG387?' is conspecific with this taxon, which would indicate that its habitat preference includes both the extensive pindan shrubland and sandstone range habitats, and is therefore widespread in the study area.

***Aname* 'MYG387?'**

SRE Status: Potential.

A single female was collected from site TB S5 (inside the potential impact area) and has been tentatively identified as *Aname* 'MYG387'; however, conspecifity with the male species is not certain.

It is **considered a potential SRE** (Phoenix 2013a). It is possible that the female *Aname* 'MYG387?' is conspecific with this taxon, which would indicate that its habitat preference includes both the extensive pindan shrubland and sandstone range habitats, and is therefore widespread in the study area.

***Aname* 'MYG388'**

SRE Status: Potential.

A total of four specimens (two males and two females) were collected from sites TB S1, TB S2 and TB S6 (both inside and outside of the impact are). The two females show morphological characteristics conspecific with the male morphotype (Phoenix 2013a), and can therefore be identified to species level. . This species is not present in the WAM reference collection and potentially a new species, therefore **considered a potential SRE** (Phoenix 2013a). Specimens of this morphospecies were only collected during the second phase, indicating males may be more likely to move during the dry season. Given this taxon was recorded from the extensive pindan shrubland and sandstone range habitats, it is likely to have a distribution that extends well beyond the study area boundary.

***Aname* 'sp. juv.'**

SRE Status: Potential.

One juvenile specimen was collected from TB SRE6 (inside the potential impact area). Due to a lack of morphological data and sub adult stage this specimen could not be identified to species level. This specimen is **considered a potential SRE** (WAM 2013a). Given this taxon was recorded from the extensive pindan shrubland habitat, it is likely to have a distribution that extends well beyond the study area boundary.

***Aname* 'sp. indet.'**

SRE Status: Potential.

One juvenile specimen was collected opportunistically inside the potential impact area. Due to a lack of morphological data and sub adult stage this specimen could not be identified to species level. This specimen is **considered a potential SRE** (Phoenix 2014). Given this taxon was recorded from the boundary of the pindan shrubland and sandstone range habitats, it is likely to have a distribution that extends well beyond the study area boundary.

5.5.2 Pseudoscorpiones (False Scorpions or Pseudoscorpions)

5.5.2.1 Family: Olpiidae

Olpiidae 'genus indet.' (juvenile)

SRE Status: Potential.

Fifteen juvenile Olpiidae species were collected from sites TB SRE3, TB SRE4, TB SRE5 and TB SRE6 (inside the potential impact area). Some of these species may be range restricted (Harvey and Leng 2008), and due to lack of morphological data these specimens **are considered a potential SRE** (WAM 2013a). Given this taxon was recorded from the extensive pindan shrubland habitat throughout the potential impact area, it is likely to have a distribution that extends well beyond the study area boundary.

5.5.3 Scorpiones (Scorpiones)

5.5.3.1 Family: Buthidae

***Lychas* 'broome'**

SRE Status: Potential.

Lychas 'broome' is a well-defined and clearly recognised morphospecies. Few specimens are known and all records are restricted to the Broome area of WA. Insufficient records are available to assess this species as a SRE. Based on distribution patterns of species in the genus, *Lychas* 'broome' is **considered a potential SRE** (Phoenix 2013b). Within the study area, this morphospecies was only recorded at site TB S2 (inside the potential impact area). Given this taxon was recorded from the extensive pindan shrubland habitat, and is known in other locations on the Dampier Peninsula, its distribution is expected to extend well beyond the study area boundary.

***Lychas* 'JPP', 'JPP1', 'JPP2' and 'JPP3'**

SRE Status: Potential.

Four species of *Lychas* (Figure 5.3) were recorded for the first time and are only known from the study area. Three of the morphospecies were recorded both inside and outside of the potential impact area, while *Lychas* 'JPP2' was only recorded within the potential impact area at TB S2. These are **considered potential SREs** taking distribution patterns of *Lychas* into account (Phoenix 2013a). Given these taxa were recorded from the extensive pindan shrubland and savannah woodland habitats, the distributions for the four taxa are expected to extend well beyond the study area boundary.

Figure 5.3 – Representative image of *Lychas* 'JPP'

5.5.3.2 Family: Urodacidae

***Urodacus* 'kraepelini'**

SRE Status: Potential.

Urodacus 'kraepelini' was recorded during the first phase at site TB S7 (outside of the potential impact area) and is a well-defined and clearly recognised morphospecies. It is only known from around Broome. Based on distribution patterns of species in the genus, *Urodacus* 'kraepelini' is **considered a potential SRE** (Phoenix 2013b). Given this taxon was recorded from the extensive pindan shrubland habitat, and is known in other locations on the Dampier Peninsula, its distribution is expected to extend well beyond the study area boundary.

***Urodacus* 'sp. indet.'**

SRE Status: Potential.

The material included two specimens of *Urodacus* scorpions from sites TB S5 and TB SRE2 (both within the potential impact area) that could not be identified to species level. Based on distribution patterns of species with the genus and the rating of *Urodacus* 'kraepelini' from this survey as potential SRE, these two specimens are here also **considered potential SREs** (Phoenix 2013b). Given this taxon was recorded from the extensive pindan shrubland habitat, its distribution is expected to extend well beyond the study area boundary.

5.5.4 Opiliones (Harvestmen)

5.5.4.1 Family: Assamiidae

***Dampetrus* sp.**

SRE Status: Potential.

One species of *Dampetrus* (Figure 5.4) was recorded at sites TB S6 and TB S7, outside and inside of the potential impact area respectively. This morphospecies lacks taxonomic and geographical context, and as such, is **considered a potential SRE** (WAM 2013a). Given this taxon was recorded from the extensive pindan shrubland and savannah woodland habitats, its distribution is expected to extend well beyond the study area boundary.

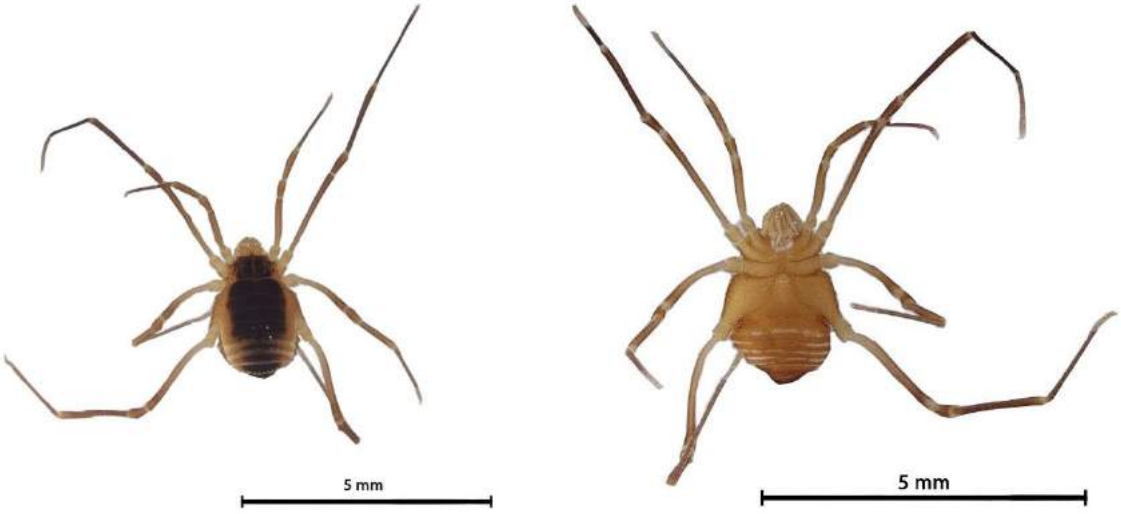

Figure 5.4 – Representative image of the harvestmen *Dampetrus* sp.

5.5.5 Isopoda (Slaters)

5.5.5.1 Family: Armadillidae

Armadillidae 'EE1501C'

SRE Status: Potential.

Armadillidae 'EE1501C' is an isopod with affinities to the genus *Cubaris*. It is only known from the single male specimen (partly damaged) from this survey. However, many individuals of this morphospecies were observed within a rock crevice where the individual was collected. This is an unusual species as it has noticeably longer uropod exopodites than other species of this type. It is

here **considered a potential SRE** based on distribution patterns seen within this group; however, the isopod fauna of the region is poorly known (Phoenix 2013a). Given this taxon was recorded in the sandstone range habitat, its distribution is likely to extend beyond the study area boundary, particularly to the north.

Buddelundiinae 'gen. indet. NE Broome'

SRE Status: Potential.

Buddelunidiinae gen. indet. represents an undescribed genus of isopods that is closely related to *Buddelundia*. *Buddelundia albomarginata*, originally described from Broome belongs to this genus. The genus is found in the Pilbara and Kimberley. Based on the original description, it remains doubtful if Buddelundiinae 'gen. indet. NE Broome' is conspecific with *B. albomarginata*. It is here considered a different species and based on the distribution patterns of other species in the Buddelundiinae gen. indet. **considered a potential SRE** (Phoenix 2013b). Given this taxon was recorded in the savannah woodland habitat, its distribution is likely to extend beyond the study area boundary, particularly to the south-east.

***Buddelundia* sp.74**

SRE Status: Potential.

Buddelundia '74' is a well-recognised morphospecies and currently only known from this survey. It was collected mainly from the sandstone range habitat outside of the potential impact area. Its SRE status can currently not be determined based on the paucity of isopod collections in the area. Based on distribution patterns within *Buddelundia*, *Buddelundia* '74' should be **considered a potential SRE** (Phoenix 2013a). Given this taxon was recorded throughout the sandstone range habitat, and adjacent pindan shrublands, its distribution is likely to extend beyond the study area boundary, particularly to the north.

5.5.6 Gastropoda (Snails)

5.5.6.1 Family: Camaenidae

Quistrachia leptogramma

SRE Status: Potential.

Ten specimens of the land snail *Quistrachia leptogramma* were collected during the survey both inside and outside the potential impact area. *Quistrachia leptogramma* has been recorded in previous surveys on the Dampier Peninsula, but is a data deficient taxon, and as such is **considered a potential SRE** (WAM 2013b). Given this taxon was recorded within the extensive pindan shrubland habitat, and is known from other locations on the Dampier Peninsula, its distribution is highly likely to extend well beyond the study area boundary.

Rhagada bulgana

SRE Status: Confirmed.

Eight specimens of the land snail *Rhagada bulgana* (Figure 5.5) were collected during the survey both inside and outside the potential impact area. *Rhagada bulgana* has been recorded in previous surveys on the Dampier Peninsula, and is a **confirmed SRE** (WAM 2013b). Given this taxon was recorded within the extensive pindan shrubland habitat, and is known from other locations on the Dampier Peninsula, its distribution is highly likely to extend well beyond the study area boundary.

Figure 5.5 – Representative image of the confirmed SRE *Rhagada bulgana*

5.6 STYGOFAUNA

Despite widespread sampling within the potential impact area, no stygofauna were recorded during the survey. It is therefore unlikely that a significant or diverse stygofauna assemblage exists within the study area.

5.7 TROGLOFAUNA

5.7.1 Scolopendromorpha (Centipedes)

5.7.1.1 Family: Cryptopidae

***Cryptops* 'sp. indet.'**

SRE Status: Potential.

One specimen of the centipede *Cryptops* sp. was collected during the survey from outside the potential impact area, at a regional drill site specially designed for troglofauna sampling. Although the geology of this drill hole is unknown, the *Cryptops* was likely inhabiting a sandstone layer up to 36m in depth (water table level). This individual lacked pigmentation, and is therefore likely to be troglobitic. The genus *Cryptops* has not previously been recorded on the Dampier Peninsula, and as it may represent an undescribed species, it is considered a **potential SRE** (WAM 2013b). However, given this taxon was recorded within the sandstone strata, which continues extensively to the east and north, its distribution is unlikely to be confined to the study area.

5.7.2 Coleoptera (Beetles)

5.7.2.1 Family: Staphylinidae

Staphylinidae 'sp. indet.'

One specimen of the rove beetle from the family Staphylinidae was collected during the survey from inside the potential impact area, at a relatively shallow depth of 8m. The likely habitat this individual was occupying is a sandstone stratum. Although this individual had eyes present, it is considered to be either a troglophile or troglobite, and not a trogloxene. Due to a lack of geographic context and resolution of taxonomy, this taxon is considered a **potential SRE** (WAM 2013b). However, given this taxon was recorded within the sandstone strata, which continues extensively to the east and north, its distribution is unlikely to be confined to the study area.

5.8 SURVEY ADEQUACY

5.8.1 Vertebrate Fauna

The results presented in Section 4.6 demonstrate that systematic survey effort was adequate for both terrestrial vertebrates and birds. Table 4.2 also shows that, although less systematic survey effort was expended in the sandstone range and savannah woodland habitats, this was supplemented by opportunistic diurnal and nocturnal searches, and motion camera trapping. Consequently, as Figure 4.28 suggests, most of the trappable terrestrial vertebrate fauna assemblage was recorded. Opportunistic survey effort recorded a further 14 species, but the majority of these are not considered trappable. Similarly, Figure 4.29 shows that nearly all of the theoretical maximum number of bird species was recorded, although the additional 11 species recorded opportunistically actually exceeds this amount. Overall, the current survey can be considered more than adequate for recording the potential vertebrate fauna assemblage of the study area.

5.8.2 SRE Invertebrate Fauna

The results presented in section 4.6 demonstrate that systematic survey effort was adequate for the SRE invertebrate fauna. Trapping effort for this fauna group was focused on the pindan shrubland habitat (Table 4.2), which comprises 79% of the potential impact area. However, additional trapping was also conducted in the savannah woodland and sandstone range habitats, and was complemented by widespread foraging in both habitats. As Figure 4.30 suggests, the majority (77%) of the estimated SRE invertebrate assemblage was recorded. As opportunistic foraging and leaf litter sampling recorded a further 11 species, the current survey can be considered more than adequate for recording the potential invertebrate fauna assemblage of the study area.

5.8.3 Subterranean fauna

Due to the absence of previous records of subterranean fauna on the Dampier Peninsula, the current survey identified that a pilot study would be sufficient in determining subterranean values. Generally, the majority of the potential impact area provides little habitat for troglofauna, and is comprised solely of sand above the water table. However, the five drill holes that do contain rock strata were sampled. Only a single specimen was recorded from within the potential impact area, while a second specimen was recorded in the sandstone ranges to the east of the potential impact area. As such, it is likely that little habitat exists for troglofauna within the potential impact area, but may occur within the extensive sandstone habitats in the ranges to the east and north. The sampling identified that the potential impact area is unlikely to contain a diverse or significant troglofauna community, and as such, no further sampling is required.

Stygofauna sampling was well spread across the potential impact area, with a total of 15 drill holes sampled. Despite the excellent coverage, no stygofauna were recorded, and it is therefore unlikely that a significant or diverse stygofauna community exists within the study area. The stygofauna survey can therefore be deemed adequate in identifying stygofauna values.

5.9 SURVEY LIMITATIONS

Limitations of the current survey are summarised below in Table 5.1. Given the few limitations encountered, it can be confirmed that an adequate level of survey has been undertaken for the purpose of this report.

Table 5.1 – Summary of survey limitations

Limitation	Relevant (yes/no)	Comment
Competency/experience of the consultant carrying out the survey.	No	All key members of the survey team were experienced in Kimberley fauna identification and fauna surveys, including subterranean fauna.
Scope (what faunal groups were sampled and were some sampling methods not able to be employed because of constraints such as weather conditions).	Yes	All vertebrate fauna groups were adequately sampled. Stygofauna sampling was considered adequate for identifying stygofauna values. The limited availability of drill holes that were sealed up to six metres restricted troglofauna sampling to six drill holes (five within the impact area and one outside). Troglofauna sampling represented a dry season survey only.
Proportion of fauna identified, recorded and/or collected.	No	The majority of fauna species expected to occur within the survey area were recorded, as indicated by SACs (Section 4.6). Most captured vertebrate species were identified in the field. For troglofauna species, as the majority of the impact area is not associated with troglofauna habitat, only a single specimen was recorded.
Sources of information (previously available information as distinct from new data).	No	Thirteen other relevant biological surveys have been conducted on the Dampier Peninsula. Data from these surveys were included to provide regional context.
The proportion of the task achieved and further work which might be needed.	No	A two-phase Level 2 fauna assessment was successfully completed. All fauna habitats and groups were adequately sampled.
Timing/weather/season/cycle.	Yes	For vertebrate fauna component of the survey, two survey phases optimally cover both seasons; one immediately following the wet season, and one at the end of the dry. While only dry season sampling was conducted for troglofauna, the absense of suitable habitat within the impact area indicated that it is unlikely to support a diverse or significant troglofauna community and therefore further wet season sampling was deemed unnecessary
Disturbances which affected results of the survey (e.g. fire, flood, accidental human intervention).	No	There were no disturbances during or between the survey phases.
Intensity (in retrospect was the intensity adequate).	No	The survey intensity was adequate, all habitat types were surveyed systematically and opportunistically, and most of the species expected to occur were recorded.
Completeness (e.g. was relevant area fully surveyed).	No	The survey area was comprehensively surveyed.
Resources (e.g. degree of expertise available in animal identification to taxon level).	No	All key zoologists were suitably qualified and experienced in identification of Kimberley fauna. There were no resource issues encountered.
Remoteness and/or access problems.	No	Most of the study area was accessible. Areas that were not accessed were in habitat that was well surveyed elsewhere.

Limitation	Relevant (yes/no)	Comment
Availability of contextual (e.g. biogeographic) information on the region.	No	There are few prior regional studies and/or limited knowledge of some taxa. There is sufficient contextual biogeographical information available on the Dampier Peninsula and the study area.
Efficacy of sampling methods (i.e. any groups not sampled by survey methods).	No	Survey methods were suitable to sample all fauna groups present.

6 CONCLUSIONS

The main conclusions from the study are as follows:

- A total of three broad-scale terrestrial habitat types have been identified within the study area; pindan shrubland, savannah woodland and sandstone range. No habitats recorded are regarded as rare or unique to the study area.
- A total of 16 native mammals, two introduced mammals, 107 bird species (27 only recorded at the Mount Jowlaenga homestead), 43 reptile species and eight amphibians were recorded during the survey.
- Nine species of conservation significant vertebrate fauna (two mammal and seven bird species) were recorded during the survey, with an additional four species assessed as having a medium likelihood of occurrence. Three of the recorded species were wetland dependent species, and only recorded at the Mount Jowlaenga homestead adjacent to the study area. The six species recorded within the study area included the Greater Bilby (EPBC Act Vulnerable), Short-tailed Mouse (DPaW Priority 4), Fork-tailed Swift (EPBC Act Migratory), Rainbow Bee-eater (EPBC Act Migratory), Australian Bustard (DPaW Priority 4) and Bush Stone-curlew (DPaW Priority 4).
- A total of 28 invertebrate taxa from six orders were submitted for identification and SRE status assessment. The results from the identifications showed one taxon is a confirmed SRE (the land snail *Rhagada bulgana*). This taxon has previously been recorded on the Dampier Peninsula. Additionally, 20 taxa are considered potential SREs (seven mygalomorph spiders, one pseudoscorpion, seven scorpions, one harvestmen, three slaters and one land snail). Due to a lack of regional surveys on the Dampier Peninsula, it is not possible to assess the true SRE status of these taxa from the available data. However, as the vegetation communities and landforms present within study area do not appear to be unique, it is unlikely that any of these taxa are geographically confined to the boundary of the proposed impact area.
- Two specimens of troglofauna were collected during the troglofauna survey including one specimen of the centipede *Cryptops '*sp. indet.', and a specimen of rove beetle from the family Staphylinidae (Staphylinidae 'sp. indet.'). Both taxa are considered to be potential SREs; however, the continuous sandstone strata are expected to extend well beyond the study area.
- Ten specimens of Naididae worms were collected during the stygofauna survey, and are opportunistically stygal. The absence of obligate stygofauna suggests there is a low likelihood of a diverse and abundant stygofauna community present within the study area.
- Systematically obtained data was analysed to determine the survey adequacy through SACs. Extrapolation of the Michaelis-Menten (MM) curve suggests that 93.8% of trappable terrestrial vertebrate fauna (reptiles and mammals), 97.2% of birds and 77.2% of SRE invertebrate fauna were recorded. These results indicate that the majority of species were recorded for all fauna groups. However, increased sampling is likely to record additional species, particularly within the SRE invertebrate group.
- No significant limitations were experienced during the surveys. Given the lack of limitations and the fact that the majority of fauna were recorded, the surveys can be considered adequate and have met their objectives.

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APPENDIX A EXPLANATION OF CONSERVATION CODES

Appendix A1 Definitions of categories under the *Environment Protection and Biodiversity Conservation Act 1999*

Category	Definition
Endangered (EN)	The species is likely to become extinct unless the circumstances and factors threatening its abundance, survival or evolutionary development cease to operate; or its numbers have been reduced to such a critical level, or its habitats have been so drastically reduced, that it is in immediate danger of extinction.
Vulnerable (VU)	Within the next 25 years, the species is likely to become endangered unless the circumstances and factors threatening its abundance, survival or evolutionary development cease to operate.
Migratory (M)	Species are defined as migratory if they are listed in an international agreement approved by the Commonwealth Environment Minister, including: • the Bonn Convention (Convention on the Conservation of Migratory Species of Wild Animal) for which Australia is a range State; • the agreement between the Government of Australian and the Government of the Peoples Republic of China for the Protection of Migratory Birds and their environment (CAMBA); or • the agreement between the Government of Japan and the Government of Australia for the Protection of Migratory Birds and Birds in Danger of Extinction and their Environment (JAMBA).

Appendix A2 Definition of Schedules under the *Wildlife Conservation Act 1950*

Schedule	Definition
Schedule 1 (S1)	Fauna which are rare of likely to become extinct, are declared to be fauna that is in need of special protection.
Schedule 2 (S2)	Fauna which are presumed to be extinct, are declared to be fauna that is in need of species protection.
Schedule 3 (S3)	Birds which are subject to an agreement between the governments of Australia and Japan relating to the protection of migratory birds and birds in danger of extinction, are declared to be fauna that is in need of species protection.
Schedule 4 (S4)	Declared to be fauna that is in need of species protection, otherwise than for the reasons mentioned above.

Appendix A3 Definition of DPaW Threatened and Priority Fauna Codes

Threatened	**Definition**
Critically Endangered (CR)	Considered to be facing an extremely high risk of extinction in the wild.
Endangered (EN)	Considered to be facing a very high risk of extinction in the wild.
Vulnerable (VU)	Considered to be facing a high risk of extinction in the wild.
Priority	**Definition**
Priority 1 (P1)	*Taxa with few, poorly known populations on threatened lands.* Taxa which are known from few specimens or sight records from one or a few localities, on lands not managed for conservation, e.g. agricultural or pastoral lands, urban areas, active mineral leases. The taxon needs urgent survey and evaluation of conservation status before consideration can be given to declaration as threatened fauna.
Priority 2 (P2)	*Taxa with few, poorly known populations on conservation lands.* Taxa which are known from few specimens or sight records from one or a few localities, on lands not under immediate threat of habitat destruction or degradation, e.g. national parks, conservation parks, nature reserves, State forest, vacant crown land, water reserves, etc. The taxon needs urgent survey and evaluation of conservation status before consideration can be given to declaration as threatened fauna.
Priority 3 (P3)	*Taxa with several, poorly known populations, some on conservation lands.* Taxa which are known from few specimens or sight records from several localities, some of which are on lands not under immediate threat of habitat destruction or degradation. The taxon needs urgent survey and evaluation of conservation status before consideration can be given to declaration as threatened fauna.
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 if present circumstances change. These taxa are usually represented on conservation lands.
Priority 5 (P5)	*Taxa in need of monitoring.* Taxa which are not considered threatened but are subject to a specific conservation program, the cessation of which would result in the species becoming threatened within five years.

APPENDIX B DAILY WEATHER DATA DURING THE SURVEY

Broome				Derby		
	Temperature (°C)		Rainfall (mm)	Temperature (°C)		Rainfall (mm)
	Min	Max		Min	Max	
April						
4th	22.6	27.2	7	23.5	27.7	0.4
5th	22.6	32.4	0.2	22.9	32.7	2.2
6th	22	33.7	0	22.3	34.5	0
7th	23.1	35.6	0	24.5	36.2	0
8th	25.7	36.7	0	26.2	36.7	0
9th	27	36.9	0	24.7	36.9	0
10th	25.4	37	0	22.7	37.3	0
11th	21.3	36.7	0	23.2	37	0
12th	19	35.8	0	20.4	36	0
13th	19.2	34.9	0	19.5	36.3	0
14th	20.6	34.5	0	18.5	37	0
15th	20.6	35.2	0	18.4	37	0
October						
14th	21.8	41	0	24.4	38.3	0
15th	24.5	35.8	0	25.2	35.8	0
16th	24	32.6	0	24.4	37.2	0
17th	22.6	33	0	23.2	39.7	0
18th	26.7	34.9	0	25.9	43	0
19th	27.5	36.3	0	28.2	36.6	0
20th	23.5	34.4	0	25.6	39.3	0
21th	24.3	33.5	0	23.6	38.6	0
22th	25	39.1	0	24.9	42.9	0
23th	22	38	0	23.2	42.5	0

Note: climate data recorded from Broome (3003) and Derby Aero (3032) weather stations (BoM 2014).

APPENDIX C RESULTS OF LITERATURE REVIEW AND DATABASE SEARCHES

Appendix E1: Mammals

Family and Species	Common name	Conservation Status			*ecologia* internal database	James Price Point (AECOM 2010)	James Price Point (AECOM 2011)	James Price Point (Biota 2009)	James Price Point (Biota 2010)	Dampier Peninsula (ENV 2008)	James price Point (ENV 2011)	NatureMap	DEC Threatened and Priority Fauna Search	DSEWPaC Protected Matters Search	This survey
		EPBC Act	WC Act	DPaW											
TACHYGLOSSIDAE															
Tachyglossus aculeatus	Echidna					S				●					S
DASYURIDAE															
Dasyurus hallucatus	Northern Quoll	EN	S1	EN										●	
Dasycercus cristicauda	Crest-tailed Mulgara	VU	S1	VU										●	
Sminthopsis youngsoni	Lesser Hairy-footed Dunnart				●										●
PERAMELIDAE															
Isoodon auratus	Golden Bandicoot	VU	S1	VU									●		
THYLACOMYIDAE															
Macrotis lagotis	Greater Bilby	VU	S1	VU	S	S	S			S	S	●	●		●
PHALANGERIDAE															
Trichosurus vulpecula arnhemensis	Northern Brushtail Possum				●					●					
POTOROIDAE															
Bettongia lesueur	Burrowing Bettong	VU	S1	VU								●			
MACROPODIDAE															
Macropus agilis	Agile Wallaby				S	●		●	●	●					●
Macropus robustus	Euro				●					●		●			●
Macropus rufus	Red Kangaroo									●					
EMBALLONURIDAE															

Family and Species	Common name	Conservation Status			*ecologia* internal database	James Price Point (AECOM 2010)	James Price Point (AECOM 2011)	James Price Point (Biota 2009)	James Price Point (Biota 2010)	Dampier Peninsula (ENV 2008)	James price Point (ENV 2011)	NatureMap	DEC Threatened and Priority Fauna Search	DSEWPaC Protected Matters Search	This survey
		EPBC Act	WC Act	DPaW											
Saccolaimus flaviventris	Yellow-bellied Sheathtail Bat				●			●		●					●
Taphozous georgianus	Common Sheathtail Bat									●					
MOLOSSIDAE															
Chaerophon jobensis	Northern Freetail Bat				●			●		●					●
Mormopterus beccarii	Beccari's Freetail Bat									●					
Mormopterus loriae	Little Northern Freetail Bat			P1						●					
Tadarida australis	White-striped Freetail Bat									●					
VESPERTILIONIDAE															
Chalinolobus gouldii	Gould's Wattled Bat				●			●		●					●
Chalinolobus nigrogriseus	Hoary Wattled Bat				●			●		●					●
Miniopterus schreibersii orianae	Common Bentwing Bat									●					●
Myotis macropus	Large-footed Myotis														●
Nyctophilus arnhemensis	Arnhem Land Long-eared Bat							●		●					
Nyctophilus geoffroyi	Lesser Long-eared Bat				●					●					●
Pipistrellus westralis	Northern Pipistrelle									●					
Scotorepens greyii	Little Broad-nosed Bat				●			●		●					●
Scotorepens sanborni	Northern broad-nosed Bat							●		●					
Vespadelus caurinus	Western Cave Bat									●					
Vespadelus douglasorum	Yellow-lipped Cave Bat			P2	●										
Vespadelus finlaysoni	Finlayson's Cave Bat									●					
MURIDAE															

Family and Species	Common name	Conservation Status			*ecologia* internal database	James Price Point (AECOM 2010)	James Price Point (AECOM 2011)	James Price Point (Biota 2009)	James Price Point (Biota 2010)	Dampier Peninsula (ENV 2008)	James price Point (ENV 2011)	NatureMap	DEC Threatened and Priority Fauna Search	DSEWPaC Protected Matters Search	This survey
		EPBC Act	WC Act	DPaW											
Leggadina lakedownensis	Lakeland Downs Mouse			P4						●					●
Pseudomys delicatulus	Delicate Mouse				●	S		●	●	●					●
Pseudomys nanus	Western Chestnut Mouse				●					●		●			●
Rattus tunneyi	Pale Field Rat									●	●				
CANIDAE															
Canis lupus dingo	Dog/Dingo				●	●		●	●	●					●
INTRODUCED MAMMALS															
Mus musculus	House Mouse							●		●					●
Rattus rattus	Black Rat					●				●					
Vulpes vulpes	Red Fox									●					
Felis catus	Cat				●	●		●	●	●					●
Equus asinus	Donkey				●					●					
Bos taurus	Cow				●	●				●					●

S = signs only (scats/tracks etc.)

Appendix E2: Birds

Family and Species	Common name	Conservation Status			*ecologia* internal database	James Price Point (AECOM 2010)	James Price Point (Biota 2009)	James Price Point (Bamford 2011)	Dampier Peninsula (ENV 2008)	North-West WA (Rogers *et al.* 2009)	NatureMap	DEC Threatened and Priority Fauna Search	DSEWPaC Protected Matters Search	Birdata	This survey
		EPBC Act	WC Act	DPaW											
PHASIANIDAE															
Coturnix ypsilophora	Brown Quail				●	●	●	●	●		●			●	●
ANSERANATIDAE															
Anseranas semipalmata	Magpie Goose										●			●	●
ANATIDAE															
Dendrocygna eytoni	Plumed Whistling-duck								●	●	●			●	J
Dendrocygna arcuata	Wandering Whistling-duck								●	●				●	J
Stictonetta naevosa	Freckled Duck														J
Chenonetta jubata	Australian Wood Duck									●				●	J
Malacorhynchus membranaceus	Pink-eared Duck									●				●	J
Nettapus pulchellus	Green Pygmy-Goose									●				●	J
Anas gracilis	Grey Teal				●				●	●	●			●	J
Anas superciliosa	Pacific Black Duck				●				●	●				●	J
Aythya australis	Hardhead								●	●	●			●	J
PODICIPEDIDAE															
Tachybaptus novaehollandiae	Australasian Grebe								●	●	●			●	J
Poliocephalus poliocephalus	Hoary-headed Grebe									●				●	
COLUMBIDAE															
Phaps histrionica	Flock Bronzewing			P4	●				●					●	

Family and Species	Common name	Conservation Status			*ecologia* internal database	James Price Point (AECOM 2010)	James Price Point (Biota 2009)	James Price Point (Bamford 2011)	Dampier Peninsula (ENV 2008)	North-West WA (Rogers *et al.* 2009)	NatureMap	DEC Threatened and Priority Fauna Search	DSEWPaC Protected Matters Search	Birdata	This survey
		EPBC Act	WC Act	DPaW											
Ocyphaps lophotes	Crested Pigeon				●	●	●	●	●		●			●	●
Geopelia cuneata	Diamond Dove				●		●	●	●		●			●	●
Geopelia striata	Peaceful Dove				●	●	●	●	●		●			●	●
Geopelia humeralis	Bar-shouldered Dove				●	●	●	●	●					●	
PODARGIDAE															
Podargus strigoides	Tawny Frogmouth				●	●	●	●	●		●			●	●
EUROSTOPODIDAE															
Eurostopodus argus	Spotted Nightjar					●			●					●	●
AEGOTHELIDAE															
Aegotheles cristatus	Australian Owlet-nightjar				●	●		●	●		●			●	●
APODIDAE															
Apus pacificus	Fork-tailed Swift	M	S3		●	●		●					●	●	●
FREGATIDAE*															
Fregata ariel	Lesser Frigatebird	M	S3		●	●	●		●	●			●	●	
SULIDAE*															
Sula leucogaster	Brown Booby	M	S3		●				●	●				●	
ANHINGIDAE															
Anhinga novaehollandiae	Australasian Darter								●	●				●	
PHALACROCORACIDAE															
Microcarbo melanoleucos	Little Pied Cormorant				●				●	●				●	J

Family and Species	Common name	Conservation Status			*ecologia* internal database	James Price Point (AECOM 2010)	James Price Point (Biota 2009)	James Price Point (Bamford 2011)	Dampier Peninsula (ENV 2008)	North-West WA (Rogers *et al.* 2009)	NatureMap	DEC Threatened and Priority Fauna Search	DSEWPaC Protected Matters Search	Birdata	This survey
		EPBC Act	WC Act	DPaW											
Phalacrocorax carbo	Great Cormorant													●	
Phalacrocorax sulcirostris	Little Black Cormorant								●	●				●	
Phalacrocorax varius	Pied Cormorant					●			●	●				●	
PELECANIDAE															
Pelecanus conspicillatus	Australian Pelican				●	●			●	●	●			●	J
CICONIIDAE															
Ephippiorhynchus asiaticus	Black-necked Stork								●	●				●	
ARDEIDAE															
Ardea pacifica	White-necked Heron				●				●	●	●			●	J
Ardea modesta	Eastern Great Egret	M	S3						●	●			●	●	
Egretta picata	Pied Heron								●					●	
Egretta novaehollandiae	White-faced Heron				●	●			●	●				●	J
Ardea ibis	Cattle Egret	M	S3						●				●	●	
Butorides striatus	Striated Heron								●	●				●	
Egretta garzetta	Little Egret								●	●				●	
Egretta sacra	Eastern Reef Egret	M	S3						●	●				●	
Nycticorax caledonicus	Nankeen Night Heron						●							●	
THRESKIORNITHIDAE															
Plegadis falcinellus	Glossy Ibis	M	S3						●	●	●			●	
Threskiornis molucca	Australian White Ibis								●	●	●			●	

Family and Species	Common name	Conservation Status			*ecologia* internal database	James Price Point (AECOM 2010)	James Price Point (Biota 2009)	James Price Point (Bamford 2011)	Dampier Peninsula (ENV 2008)	North-West WA (Rogers *et al.* 2009)	NatureMap	DEC Threatened and Priority Fauna Search	DSEWPaC Protected Matters Search	Birdata	This survey
		EPBC Act	WC Act	DPaW											
Threskiornis spinicollis	Straw-necked Ibis				●	●			●	●	●			●	J
Platalea regia	Royal Spoonbill									●				●	J
ACCIPITRIDAE*															
Pandion cristatus	Eastern Osprey					●	●		●					●	
Elanus axillaris	Black-shouldered Kite					●			●					●	
Lophoictinia isura	Square-tailed Kite				●		●		●					●	
Hamirostra melanosternon	Black-breasted Buzzard				●						●			●	
Haliaeetus leucogaster	White-bellied Sea-Eagle	M	S3		●	●	●	●	●				●	●	
Haliastur sphenurus	Whistling Kite				●	●			●		●			●	J
Haliastur indus	Brahminy Kite				●	●		●	●					●	
Milvus migrans	Black Kite				●	●			●		●			●	J
Accipiter fasciatus	Brown Goshawk				●	●	●	●	●		●			●	●
Accipiter cirrhocephalus	Collared Sparrowhawk				●				●					●	●
Circus assimilis	Spotted Harrier								●					●	●
Circus approximans	Swamp Harrier								●					●	
Aquila audax	Wedge-tailed Eagle				●						●			●	●
Hieraaetus morphnoides	Little Eagle				●				●					●	
FALCONIDAE															
Falco cenchroides	Nankeen Kestrel				●	●	●		●		●			●	●
Falco berigora	Brown Falcon				●	●	●	●	●		●			●	●

Family and Species	Common name	Conservation Status			*ecologia* internal database	James Price Point (AECOM 2010)	James Price Point (Biota 2009)	James Price Point (Bamford 2011)	Dampier Peninsula (ENV 2008)	North-West WA (Rogers *et al.* 2009)	NatureMap	DEC Threatened and Priority Fauna Search	DSEWPaC Protected Matters Search	Birdata	This survey
		EPBC Act	WC Act	DPaW											
Falco longipennis	Australian Hobby					●								●	●
Falco hypoleucos	Grey Falcon			P4										●	
Falco peregrinus	Peregrine Falcon		S4			●	●		●			●		●	
GRUIDAE															
Grus rubicunda	Brolga				●				●	●	●			●	
RALLIDAE															
Porphyrio porphyrio	Purple Swamphen								●					●	
Rallina fasciata	Red-legged Crake								●						
Gallirallus philippensis	Buff-banded Rail								●					●	
Fulica atra	Eurasian Coot									●				●	J
OTIDIDAE															
Ardeotis australis	Australian Bustard			P4	●				●			●		●	●
BURHINIDAE															
Burhinus grallarius	Bush Stone-curlew			P4	●		●		●			●		●	●
Esacus magnirostris	Beach Stone-curlew					●			●					●	
HAEMATOPODIDAE															
Haematopus longirostris	Australian Pied Oystercatcher				●	●	●		●	●				●	
Haematopus fuliginosus	Sooty Oystercatcher				●	●			●	●				●	
RECURVIROSTRIDAE															
Himantopus himantopus	Black-winged Stilt								●	●	●			●	J

Family and Species	Common name	Conservation Status			*ecologia* internal database	James Price Point (AECOM 2010)	James Price Point (Biota 2009)	James Price Point (Bamford 2011)	Dampier Peninsula (ENV 2008)	North-West WA (Rogers *et al.* 2009)	NatureMap	DEC Threatened and Priority Fauna Search	DSEWPaC Protected Matters Search	Birdata	This survey
		EPBC Act	WC Act	DPaW											
Recurvirostra novaehollandiae	Red-necked Avocet									●				●	
CHARADRIIDAE*															
Pluvialis fulva	Pacific Golden Plover	M	S3						●	●				●	
Pluvialis squatarola	Grey Plover	M	S3						●	●				●	
Charadrius leschenaultii	Greater Sand Plover	M	S3			●			●	●				●	
Charadrius mongolus	Lesser Sand Plover	M	S3			●				●				●	
Charadrius ruficapillus	Red-capped Plover				●				●	●				●	
Charadrius veredus	Oriental Plover	M	S3							●			●	●	
Elseyornis melanops	Black-fronted Dotterel				●	●			●	●				●	J
Erythrogonys cinctus	Red-kneed Dotterel								●	●				●	J
Vanellus miles	Masked Lapwing				●	●			●	●	●			●	J
JACANIDAE															
Irediparra gallinacea	Comb-crested Jacana								●					●	J
ROSTRATULIDAE*															
Rostratula australis	Australian Painted Snipe	VU	S1	VU									●	●	
SCOLOPACIDAE*															
Gallinago megala	Swinhoe's Snipe	M	S3							●				●	
Limosa limosa	Black-tailed Godwit	M	S3							●				●	
Limosa lapponica	Bar-tailed Godwit	M	S3			●			●	●				●	
Numenius minutus	Little Curlew	M	S3							●				●	

Family and Species	Common name	Conservation Status			*ecologia* internal database	James Price Point (AECOM 2010)	James Price Point (Biota 2009)	James Price Point (Bamford 2011)	Dampier Peninsula (ENV 2008)	North-West WA (Rogers *et al.* 2009)	NatureMap	DEC Threatened and Priority Fauna Search	DSEWPaC Protected Matters Search	Birdata	This survey
		EPBC Act	WC Act	DPaW											
Numenius phaeopus	Whimbrel	M	S3			●			●	●				●	
Numenius madagascariensis	Eastern Curlew	M	S3	P4		●			●	●				●	
Xenus cinereus	Terek Sandpiper	M	S3							●				●	
Actitis hypoleucos	Common Sandpiper	M	S3				●		●	●				●	
Tringa brevipes	Grey-tailed Tattler	M	S3			●			●	●				●	
Tringa glareola	Wood Sandpiper	M	S3			●				●				●	●
Tringa nebularia	Common Greenshank	M	S3			●			●	●				●	
Tringa stagnatilis	Marsh Sandpiper	M	S3							●				●	
Arenaria interpres	Ruddy Turnstone	M	S3			●			●	●				●	
Limnodromus semipalmatus	Asian Dowitcher	M	S3							●				●	
Calidris tenuirostris	Great Knot	M	S3						●	●				●	
Calidris canutus	Red Knot	M	S3							●				●	
Calidris alba	Sanderling	M	S3			●			●	●				●	
Calidris ruficollis	Red-necked Stint	M	S3			●			●	●				●	
Calidris subminuta	Long-toed Stint	M	S3							●				●	
Calidris melanotos	Pectoral Sandpiper	M	S3							●				●	
Calidris acuminata	Sharp-tailed Sandpiper	M	S3			●				●				●	
Calidris ferruginea	Curlew Sandpiper	M	S3							●				●	
Limicola falcinellus	Broad-billed Sandpiper	M	S3							●				●	
Philomachus pugnax	Ruff	M	S3							●				●	

Family and Species	Common name	Conservation Status			*ecologia* internal database	James Price Point (AECOM 2010)	James Price Point (Biota 2009)	James Price Point (Bamford 2011)	Dampier Peninsula (ENV 2008)	North-West WA (Rogers *et al.* 2009)	NatureMap	DEC Threatened and Priority Fauna Search	DSEWPaC Protected Matters Search	Birdata	This survey
		EPBC Act	WC Act	DPaW											
TURNICIDAE															
Turnix maculosus	Red-backed Button-quail							●	●					●	
Turnix castanotus	Chestnut-backed Button-quail			P4		●									
Turnix pyrrhothorax	Red-chested Button-quail				●	●								●	●
Turnix velox	Little Button-quail				●				●					●	●
Turnix sp.	Button-quail sp.														●
GLAREOLIDAE															
Glareola maldivarum	Oriental Pratincole	M	S3							●			●	●	
Stiltia isabella	Australian Pratincole								●	●	●			●	
STERCORARIIDAE*															
Stercorarius parasiticus	Arctic Jaeger	M	S3											●	
LARIDAE*															
Sternula albifrons	Little Tern	M	S3			●			●	●				●	
Sternula nereis	Fairy Tern								●					●	
Gelochelidon nilotica	Gull-billed Tern					●			●	●				●	
Hydroprogne caspia	Caspian Tern	M	S3							●				●	
Chlidonias hybrida	Whiskered Tern								●	●				●	
Chlidonia leucopterus	White-winged Black Tern	M	S3						●	●				●	
Sterna dougallii	Roseate Tern	M	S3						●	●				●	
Sterna sumatrana	Black-naped Tern	M	S3						●						

Family and Species	Common name	Conservation Status			*ecologia* internal database	James Price Point (AECOM 2010)	James Price Point (Biota 2009)	James Price Point (Bamford 2011)	Dampier Peninsula (ENV 2008)	North-West WA (Rogers *et al.* 2009)	NatureMap	DEC Threatened and Priority Fauna Search	DSEWPaC Protected Matters Search	Birdata	This survey
		EPBC Act	WC Act	DPaW											
Sterna hirundo	Common Tern	M	S3		●	●				●				●	
Thalasseus bengalensis	Lesser Crested Tern	M	S3		●	●			●	●				●	
Thalasseus bergii	Crested Tern				●	●			●	●				●	
Chroicocephalus novaehollandiae	Silver Gull					●			●	●				●	
CACATUIDAE (PSITTACIDAE)															
Calyptorhynchus banksii	Red-tailed Black-Cockatoo				●	●			●					●	●
Eolophus roseicapillus	Galah				●				●					●	●
Cacatua sanguinea	Little Corella				●	●			●		●			●	●
Nymphicus hollandicus	Cockatiel				●									●	●
PSITTACIDAE															
Trichoglossus haematodus	Rainbow Lorikeet				●		●	●						●	
Trichoglossus haematodus rubritorquis	Red-collared Lorikeet				●	●			●		●				●
Psitteuteles versicolor	Varied Lorikeet				●		●		●					●	●
Aprosmictus erythropterus	Red-winged Parrot				●	●	●	●	●					●	●
Melopsittacus undulatus	Budgerigar				●				●					●	●
CUCULIDAE															
(Centropodidae) *Centropus phasianinus*	Pheasant Coucal				●	●	●	●	●					●	●
Scythrops novaehollandiae	Channel-billed Cuckoo					●								●	
Chalcites basalis	Horsfield's Bronze-Cuckoo				●	●	●		●					●	●
Chalcites osculans	Black-eared Cuckoo					●	●							●	

Family and Species	Common name	Conservation Status			*ecologia* internal database	James Price Point (AECOM 2010)	James Price Point (Biota 2009)	James Price Point (Bamford 2011)	Dampier Peninsula (ENV 2008)	North-West WA (Rogers *et al.* 2009)	NatureMap	DEC Threatened and Priority Fauna Search	DSEWPaC Protected Matters Search	Birdata	This survey
		EPBC Act	WC Act	DPaW											
Chalcites minutillus	Little Bronze-Cuckoo				●				●					●	●
Cacomantis pallidus	Pallid Cuckoo				●	●			●					●	●
Cacomantis variolosus	Brush Cuckoo				●	●	●		●					●	●
Cuculus optatus	Oriental Cuckoo					●								●	
STRIGIDAE															
Ninox connivens	Barking Owl								●					●	
Ninox novaeseelandiae	Southern Boobook				●				●					●	●
TYTONIDAE															
Tyto longimembris	Eastern Grass Owl								●					●	
Tyto novaehollandiae	Masked Owl			P4									●		
HALCYONIDAE															
Dacelo leachii	Blue-winged Kookaburra				●	●	●		●					●	●
Todiramphus pyrrhopygius	Red-backed Kingfisher					●	●		●					●	●
Todiramphus sanctus	Sacred Kingfisher				●	●	●	●	●					●	●
Todiramphus chloris	Collared Kingfisher								●					●	
MEROPIDAE															
Merops ornatus	Rainbow Bee-eater	M	S3		●	●	●	●	●				●	●	●
CORACIIDAE															
Eurystomus orientalis	Dollarbird				●	●	●							●	●
CLIMACTERIDAE															

Family and Species	Common name	Conservation Status			*ecologia* internal database	James Price Point (AECOM 2010)	James Price Point (Biota 2009)	James Price Point (Bamford 2011)	Dampier Peninsula (ENV 2008)	North-West WA (Rogers *et al.* 2009)	NatureMap	DEC Threatened and Priority Fauna Search	DSEWPaC Protected Matters Search	Birdata	This survey
		EPBC Act	WC Act	DPaW											
Climacteris melanura	Black-tailed Treecreeper				●				●		●			●	●
PTILINORHYNCHIDAE															
Ptilonorhynchus nuchalis	Great Bowerbird				●	●	●	●	●					●	●
MALURIDAE															
Malurus lamberti	Variegated Fairy-wren				●	●	●	●	●					●	●
Malurus melanocephalus	Red-backed Fairy-wren				●	●	●		●		●				●
ACANTHIZIDAE															
Smicrornis brevirostris	Weebill				●		●		●		●			●	●
Gerygone levigaster	Mangrove Gerygone					●			●					●	
Gerygone fusca	Western Gerygone								●					●	
Gerygone tenebrosa	Dusky Gerygone								●					●	
Gerygone albogularis	White-throated Gerygone				●	●	●	●	●					●	●
PARDALOTIDAE															
Pardalotus rubricatus	Red-browed Pardalote				●	●	●		●		●			●	●
Pardalotus striatus	Striated Pardalote				●		●	●	●		●			●	●
MELIPHAGIDAE															
Certhionyx variegatus	Pied Honeyeater								●						
Lichenostomus virescens	Singing Honeyeater				●	●	●	●	●		●			●	●
Lichenostomus unicolor	White-gaped Honeyeater				●	●	●	●	●					●	
Lichenostomus plumulus	Grey-fronted Honeyeater						●								

Family and Species	Common name	Conservation Status			*ecologia* internal database	James Price Point (AECOM 2010)	James Price Point (Biota 2009)	James Price Point (Bamford 2011)	Dampier Peninsula (ENV 2008)	North-West WA (Rogers *et al.* 2009)	NatureMap	DEC Threatened and Priority Fauna Search	DSEWPaC Protected Matters Search	Birdata	This survey
		EPBC Act	WC Act	DPaW											
Lichenostomus flavescens	Yellow-tinted Honeyeater				●		●		●		●			●	●
Lichenostomus penicillatus	White-plumed Honeyeater					●	●								
Manorina flavigula	Yellow-throated Miner								●					●	
Conopophila rufogularis	Rufous-throated Honeyeater				●	●	●		●		●			●	●
Epthianura tricolor	Crimson Chat								●						
Sugomel niger	Black Honeyeater				●									●	●
Myzomela erythrocephala	Red-headed Honeyeater					●			●					●	
Cissomela pectoralis	Banded Honeyeater				●						●			●	●
Lichmera indistincta	Brown Honeyeater				●	●	●	●	●		●			●	●
Melithreptus gularis	Black-chinned Honeyeater				●	●	●	●	●					●	●
Melithreptus albogularis	White-throated Honeyeater				●	●			●		●			●	●
Philemon argenticeps	Silver-crowned Friarbird					●			●						
Philemon citreogularis	Little Friarbird				●	●	●	●	●		●			●	●
POMATOSTOMIDAE															
Pomatostomus temporalis	Grey-crowned Babbler				●	●	●	●	●		●			●	●
NEOSITTIDAE															
Daphoenositta chrysoptera	Varied Sittella				●	●	●		●		●			●	●
CAMPEPHAGIDAE															
Coracina novaehollandiae	Black-faced Cuckoo-shrike				●	●	●	●	●		●			●	●
Lalage sueurii	White-winged Triller				●	●		●	●					●	●

Family and Species	Common name	Conservation Status			*ecologia* internal database	James Price Point (AECOM 2010)	James Price Point (Biota 2009)	James Price Point (Bamford 2011)	Dampier Peninsula (ENV 2008)	North-West WA (Rogers *et al.* 2009)	NatureMap	DEC Threatened and Priority Fauna Search	DSEWPaC Protected Matters Search	Birdata	This survey
		EPBC Act	WC Act	DPaW											
PACHYCEPHALIDAE															
Pachycephala melanura	Mangrove Golden Whistler								●					●	
Pachycephala rufiventris	Rufous Whistler				●	●	●	●	●					●	●
Pachycephala lanioides	White-breasted Whistler								●					●	
Colluricincla harmonica	Grey Shrike-thrush				●	●	●	●	●					●	●
Oreoica gutturalis	Crested Bellbird								●						
ORIOLIDAE															
Oriolus sagittatus	Olive-backed Oriole				●	●			●					●	●
ARTAMIDAE															
Artamus leucorhynchus	White-breasted Woodswallow					●	●	●	●					●	J
Artamus personatus	Masked Woodswallow				●			●	●					●	●
Artamus superciliosus	White-browed Woodswallow				●				●					●	
Artamus cinereus	Black-faced Woodswallow				●	●	●	●	●					●	●
Artamus minor	Little Woodswallow				●	●	●	●	●					●	●
Cracticus torquatus	Grey Butcherbird						●							●	
Cracticus nigrogularis	Pied Butcherbird				●	●	●	●	●		●			●	●
RHIPIDURIDAE (DICRURIDAE)															
Rhipidura albiscapa	Grey Fantail				●				●					●	
Rhipidura phasiana	Mangrove Grey Fantail								●					●	
Rhipidura rufiventris	Northern Fantail				●	●	●	●	●					●	

Family and Species	Common name	Conservation Status			*ecologia* internal database	James Price Point (AECOM 2010)	James Price Point (Biota 2009)	James Price Point (Bamford 2011)	Dampier Peninsula (ENV 2008)	North-West WA (Rogers *et al.* 2009)	NatureMap	DEC Threatened and Priority Fauna Search	DSEWPaC Protected Matters Search	Birdata	This survey
		EPBC Act	WC Act	DPaW											
Rhipidura leucophrys	Willie Wagtail				●	●	●		●		●			●	●
CORVIDAE															
Corvus bennetti	Little Crow				●				●					●	
Corvus orru	Torresian Crow				●	●	●	●	●		●			●	●
MONARCHIDAE (DICRURIDAE)															
Myiagra ruficollis	Broad-billed Flycatcher								●					●	
Myiagra rubecula	Leaden Flycatcher				●	●	●							●	
Myiagra nana	Paperbark Flycatcher				●	●	●	●	●		●			●	●
Grallina cyanoleuca	Magpie-lark				●	●			●		●			●	●
PETROICIDAE															
Microeca fascinans	Jacky Winter				●	●	●		●		●			●	●
Microeca flavigaster	Lemon-bellied Flycatcher								●					●	
Melanodryas cucullata	Hooded Robin				●				●					●	●
ALAUDIDAE															
Mirafra javanica	Horsfield's Bushlark								●					●	
CISTICOLIDAE (SYLVIIDAE)															
Cisticola exilis	Golden-headed Cisticola						●							●	
ACROCEPHALIDAE (SYLVIIDAE)															
Acrocephalus australis	Australian Reed-Warbler								●					●	
MEGALURIDAE (SYLVIIDAE)															

Family and Species	Common name	Conservation Status			*ecologia* internal database	James Price Point (AECOM 2010)	James Price Point (Biota 2009)	James Price Point (Bamford 2011)	Dampier Peninsula (ENV 2008)	North-West WA (Rogers *et al.* 2009)	NatureMap	DEC Threatened and Priority Fauna Search	DSEWPaC Protected Matters Search	Birdata	This survey
		EPBC Act	WC Act	DPaW											
Megalurus timoriensis	Tawny Grassbird								●					●	
Cincloramphus mathewsi	Rufous Songlark				●			●	●					●	●
Cincloramphus cruralis	Brown Songlark				●				●					●	
TIMALIIDAE (ZOSTEROPIDAE)															
Zosterops luteus	Yellow White-eye					●		●	●					●	
HIRUNDINIDAE															
Hirundo rustica	Barn Swallow	M	S3								●			●	
Petrochelidon ariel	Fairy Martin				●				●					●	
Petrochelidon nigricans	Tree Martin				●		●	●	●					●	●
NECTARINIIDAE (DICAEIDAE)															
Dicaeum hirundinaceum	Mistletoebird				●	●		●	●					●	●
ESTRILDIDAE															
Taeniopygia guttata	Zebra Finch				●		●	●	●		●			●	●
Taeniopygia bichenovii	Double-barred Finch				●		●		●		●			●	
Poephila acuticauda	Long-tailed Finch				●	●	●		●		●			●	●
Emblema pictum	Painted Finch													●	
Erythrura gouldiae	Gouldian Finch	EN	S1	EN		●	●	●	●				●	●	
Lonchura castaneothorax	Chestnut-breasted Mannikin													●	
MOTACILLIDAE*															
Motacilla cinerea	Grey Wagtail	M	S3												J

Family and Species	Common name	Conservation Status			*ecologia* internal database	James Price Point (AECOM 2010)	James Price Point (Biota 2009)	James Price Point (Bamford 2011)	Dampier Peninsula (ENV 2008)	North-West WA (Rogers *et al.* 2009)	NatureMap	DEC Threatened and Priority Fauna Search	DSEWPaC Protected Matters Search	Birdata	This survey
		EPBC Act	WC Act	DPaW											
Motacilla tschutschensis	Eastern Yellow Wagtail	M	S3						•	•				•	J

* = Families incorporating shorebird or coastal species not included in Table 4.7
J = Found at Mt. Jowleanga homestead only

Appendix E3: Reptiles

Family and Species	Common name	Conservation Status			*ecologia* internal database	James Price Point (AECOM 2010)	James Price Point (Biota 2009)	James Price Point (Biota 2010)	Dampier Peninsula (ENV 2008)	NatureMap	DEC Threatened and Priority Fauna Search	DSEWPaC Protected Matters Search	This survey
		EPBC Act	WC Act	DPaW									
CROCODYLIDAE													
Crocodylus porosus	Salt-water Crocodile		S4						●			●	
DIPLODACTYLIDAE													
Diplodactylus conspicillatus	Fat-tailed Gecko				●	●	●	●	●				●
Lucasium stenodactylum	Sand-plain Gecko				●		●	●	●				●
Oedura rhombifer						●			●				
Rhynchoedura ornata	Beaked Gecko				●								
Strophurus ciliaris					●	●	●	●	●				●
Strophurus jeanae									●				
Strophurus taeniatus									●				
GEKKONIDAE													
Gehyra australis					●								
Gehyra nana									●				●
Gehyra pilbara					●		●		●				●
Gehyra punctata							●		●				
Gehyra variegata						●			●				
Heteronotia binoei	Bynoe's Gecko				●		●	●	●				●
**Hemidactylus frenatus*	Asian House Gecko								●				
PYGOPODIDAE													
Delma borea									●				
Delma tincta							●		●				●
Lialis burtonis					●	●	●	●	●				●

Family and Species	Common name	Conservation Status			*ecologia* internal database	James Price Point (AECOM 2010)	James Price Point (Biota 2009)	James Price Point (Biota 2010)	Dampier Peninsula (ENV 2008)	NatureMap	DEC Threatened and Priority Fauna Search	DSEWPaC Protected Matters Search	This survey
		EPBC Act	WC Act	DPaW									
Pygopus nigriceps					●								
Pygopus steelescotti	Northern Hooded Scaly-foot						●						●
SCINCIDAE													
Carlia munda					●				●				●
Carlia rufilatus					●		●	●	●				●
Carlia triacantha					●								
Cryptoblepharus carnabyi					●								
Cryptoblepharus metallicus									●				
Cryptoblepharus ruber	Tawny Snake-eyed Skink				●		●	●	●				●
Cryptoblepharus sp.													●
Ctenotus colletti									●				●
Ctenotus helenae									●				
Ctenotus inornatus					●	●	●	●	●	●			●
Ctenotus pantherinus					●								●
Ctenotus robustus													●
Ctenotus serventyi					●		●						●
Eremiascincus isolepis					●	●	●	●	●				●
Eremiascincus richardsonii	Banded Skink								●				
Lerista apoda					●		●	●					●
Lerista bipes					●		●	●	●				●
Lerista greeri									●				●
Lerista griffini					●		●	●					
Lerista labialis									●				

Family and Species	Common name	Conservation Status			*ecologia* internal database	James Price Point (AECOM 2010)	James Price Point (Biota 2009)	James Price Point (Biota 2010)	Dampier Peninsula (ENV 2008)	NatureMap	DEC Threatened and Priority Fauna Search	DSEWPaC Protected Matters Search	This survey
		EPBC Act	WC Act	DPaW									
Lerista separanda	Dampierland Plain Slider			P2			●		●				
Menetia greyii								●					
Menetia maini													●
Morethia ruficauda									●				
Morethia storri					●		●						●
*Morethia*sp.					●								
Proablepharus tenuis							●						●
Tiliqua multifasciata	Central Blue-tongue						●		●				
Tiliqua scincoides	Common Blue-tongue				●	●	●	●	●				●
AGAMIDAE													
Amphibolurus gilberti	Gilbert's Dragon				●	●	●	●	●				●
Chelosania brunnea	Chameleon Dragon								●				
Chlamydosaurus kingii	Frilled Lizard				●	●	●	●	●	●			●
Ctenophorus caudicinctus	Ring-tailed Rock Dragon								●				
Ctenophorus isolepis	Military Dragon								●	●			
Ctenophorus nuchalis	Central Netted Dragon								●				
Diporiphora magna					●					●			●
Diporiphora pindan					●	●	●	●	●				●
Diporiphora sp.					●								
Pogona minor	Dwarf Bearded Dragon				●	●	●	●	●				●
VARANIDAE													
Varanus acanthurus	Spiny-tailed Monitor					●			●				●
Varanus brevicauda	Short-tailed Pygmy Monitor				●		●						●

Family and Species	Common name	Conservation Status			*ecologia* internal database	James Price Point (AECOM 2010)	James Price Point (Biota 2009)	James Price Point (Biota 2010)	Dampier Peninsula (ENV 2008)	NatureMap	DEC Threatened and Priority Fauna Search	DSEWPaC Protected Matters Search	This survey
		EPBC Act	WC Act	DPaW									
Varanus gouldii	Gould's Monitor				●	●	●		●				●
Varanus panoptes	Yellow-spotted Monitor					●	●						
Varanus scalaris	Spotted Tree Monitor				●								
Varanus tristis	Black-headed Monitor				●	●	●	●	●				●
TYPHLOPIDAE													
Ramphotyphlops diversus					●		●	●	●				
Ramphotyphlops sp.													●
BOIDAE													
Antaresia stimsoni	Stimson's Python				●	●	●		●				●
Aspidites melanocephalus	Black-headed Python				●			●	●	●			
Liasis olivaceus	Olive Python								●				
COLUBRIDAE													
Dendrelaphis punctulata	Common Tree Snake							●	●				
ELAPIDAE													
Brachyurophis roperi	Northern Shovel-nosed Snake				●		●	●					●
Demansia angusticeps					●		●	●					●
Demansia olivacea	Olive Whipsnake								●				
Demansia psammophis	Yellow-faced Whipsnake								●				
Ephalophis greyae	Mangrove Sea Snake											●	
Furina ornata	Moon Snake				●		●	●	●				●
Pseudechis australis	Mulga Snake				●		●	●	●	●			●
Pseudonaja mengdeni	Western Brown Snake				●								●
Pseudonaja nuchalis	Northern Brown Snake						●		●				

Family and Species	Common name	Conservation Status			*ecologia* internal database	James Price Point (AECOM 2010)	James Price Point (Biota 2009)	James Price Point (Biota 2010)	Dampier Peninsula (ENV 2008)	NatureMap	DEC Threatened and Priority Fauna Search	DSEWPaC Protected Matters Search	This survey
		EPBC Act	WC Act	DPaW									
Simoselaps anomalus	Desert Banded Snake								•				
Simoselaps minimus	Dampierland Burrowing Snake			P2			•		•				
Suta punctata	Spotted Snake						•	•	•	•			•

Appendix E4: Amphibians

Family and Species	Common name	Conservation Status			*ecologia* internal database	James Price Point (Biota 2009)	James Price Point (Biota 2010)	Dampier Peninsula (ENV 2008)	NatureMap	DEC Threatened and Priority Fauna Search	DSEWPaC Protected Matters Search	This survey
		EPBC Act	WC Act	DPaW								
HYLIDAE												
Cyclorana australis	Giant Frog				●	●		●				●
Cyclorana longipes	Long-footed Frog					●						●
Litoria caerulea	Green Tree Frog				●	●		●				●
Litoria coplandi	Rock Frog							●				
Litoria meiriana	Rockhole Frog							●				
Litoria rothii	Northern Laughing Tree Frog							●				●
Litoria rubella	Little Red Tree Frog				●			●				●
LIMNODYNASTIDAE												
Notaden nichollsi	Desert Spadefoot											●
Platyplectrum ornatum	Ornate Burrowing Frog				●	●	●	●				●
MYOBATRACHIDAE												
Uperoleia talpa	Mole Toadlet				●			●	●			●

Appendix E5: SRE invertebrates

Class/Order, Family and Species	SRE Status	*ecologia* internal database	James Price Point (Biota 2009)	James Price Point (Biota 2010)	WAM Mollusc Database	WAM Arachnid Database	WAM Crustacean Database	This survey
Arachnida (Mygalamorphae) - Actinopodidae								
Missulena 'sp. (female)'	Undetermined			●				
Arachnida (Mygalamorphae) - Barychelidae								
Synothele 'MYG179'	Potential	●		●				
Synothele 'MYG179 female'	Potential			●				
Arachnida (Mygalamorphae) - Ctenizidae								
Conothele 'sp. (female sp. 1)'	Undetermined			●				
Conothele 'sp. (female sp. 2)'	Undetermined			●				
Conothele 'sp. (juv sp. 1)'	Undetermined			●				
Conothele 'sp. (juv sp. 2)'	Undetermined			●				
Arachnida (Mygalamorphae) - Nemesiidae								
Aname 'MYG231'	Potential	●						
Aname 'MYG232'	Potential	●						
Aname 'MYG284'	Potential							●
Aname 'MYG285'	Potential							●
Aname 'MYG387'	Potential							●
Aname 'MYG387?'	Potential							●
Aname 'MYG388'	Potential							●
Aname 'sp. indet.'	Potential							●
Aname 'sp. juv'	Potential							●
Aname 'sp. (female'	Undetermined			●				
Aname 'sp (juv).'	Undetermined			●				

Class/Order, Family and Species	SRE Status	*ecologia* internal database	James Price Point (Biota 2009)	James Price Point (Biota 2010)	WAM Mollusc Database	WAM Arachnid Database	WAM Crustacean Database	This survey
Arachnida (Mygalamorphae) - Scytodidae								
Scytodes sp.	No			●				
Arachnida (Mygalamorphae) - Idiopidae								
?*Aganippe* 'sp. (female)'	Undetermined			●				
Arachnida (Pseudoscorpiones) - Sternophoridae								
Afrosternophorus 'sp. indet.'	No							●
Arachnida (Pseudoscorpiones) - Olpiidae								
Austrohorus sp.	No	●						
Beierolpium 'sp. 8/4'	No	●						●
Beierolpium 'sp. (juv)'	No	●						
Olpiidae 'genus indet. (juvenile)'	Potential							●
Euryolpium sp.	No	●		●				
Indolpium sp.	No	●						
Arachnida (Pseudoscorpiones) - Chernetidae								
Haplochernes 'sp. Indet'	No							●
Arachnida (Scorpiones) - Buthidae								
Lychas 'annulatus'	No							●
Lychas 'broome'	Potential							●
Lychas 'JPP'	Potential	●						●
Lychas 'JPP1'	Potential							●
Lychas 'JPP2'	Potential							●
Lychas 'JPP3'	Potential							●
Lychas 'multipunctatus'	No	●						●
Arachnida (Scorpiones) - Urodacidae								
Urodacus 'kraepelini'	Potential							●
Urodacus 'sp. indet.'	Potential							●

Class/Order, Family and Species	SRE Status	*ecologia* internal database	James Price Point (Biota 2009)	James Price Point (Biota 2010)	WAM Mollusc Database	WAM Arachnid Database	WAM Crustacean Database	This survey
Urodacus 'rugosus'	Potential	●		●				
Urodacus 'sp, JP'	Potential	●		●				
Urodacus 'sp. indet.'	Undetermined	●						
Arachnida (Opiliones) - Assamiidae								
Dampetrus sp.	Potential	●						●
Chilipoda - Scutigeridae								
Pilbarascutigera incola	No			●				
Chilipoda - Scolopendridae								
Scolopendra laeta	No	●						
Diplopoda (Spirobolida) - Pachybolidae								
Pachybolidae 'genus?' 'sp. (female)'	Undetermined			●				
Pachybolidae 'genus?' 'sp. (juv)'	Undetermined			●				
Pachybolidae 'genus?'	Undetermined			●				
Malacostraca (Isopoda) - Armadillidae								
Armadillidae 'EE1501C'	Potential							●
Buddelundiinae 'Gen. indet. NE Broome'	Potential							●
Buddelundia 'sp. 1'	Potential	●						
Buddelundia 'sp.74'	Potential							●
Mollusca (Gastropoda) - Subulinidae								
Eremopeas interioris	No							●
Mollusca (Gastropoda) - Pupillidae								
Pupoides pacificus	No							●
Mollusca (Gastropoda) - Camaenidae								
Quistrachia leptogramma	Potential	●	●	●	●			●
Quistrachia sp.	Potential				●			
Rhagada bulgana	Confirmed	●	●	●	●			●
Rhagada reinga	No		●					

Class/Order, Family and Species	SRE Status	*ecologia* internal database	James Price Point (Biota 2009)	James Price Point (Biota 2010)	WAM Mollusc Database	WAM Arachnid Database	WAM Crustacean Database	This survey
Rhagada sp.	Potential			●	●			
Mollusca (Gastropoda) – Punctidae								
Magilaoma sp. nov.	Potential				●			

APPENDIX D SURVEY SITE DESCRIPTIONS

Vegetation and Fauna Habitat Description	Site Photo
Systematic trap site	
TBS1 **Fauna habitat type: Sandstone range** Open eucalypt woodland on flat gently sloping plain. Scattered tree species consisting of *Eucalyptus tectifica* and *Corymbia greeniana* over shrub species consisting of *Acacia platycarpa, Bauhinia cunninghamii* and *Dolichandrone heterophylla* over *Chrysopogon pallidus, Triodia sp.* and *Eriachne obtusa* open tussock grassland. Soil consisting of lose sandy clay of pinkish colour with some surface crusting. Isolated minor sandstone outcropping and stones. No obvious disturbance.	
TBS2 **Fauna habitat type: Pindan shrubland** Low, open woodland on flat plain. Dominant tree species *Corymbia greeniana* and *Grevillea pyramidalis* over various shrub species including; *Acacia monticola, Erythrophlem chlorostachys, Acacia hippuroide* and *Grevillea refracta*. Sparse tussock grass of *Sorghum timorense* and sparse hummock grass of *Triodia caelestialis*. Soil consisting of red-brown sandy loam of firm strength. No rocks present. No obvious disturbance.	

Vegetation and Fauna Habitat Description	Site Photo
TBS3 **Fauna habitat type: Pindan shrubland** Moderately dense shrubland on flat plain. Dominant tree species consisting of *Corymbia greeniana* and *Corymbia zygophylla,* scattered throughout. Moderately dense *Acacia tumida*, with other shrub species consisting of *Acacia monticola, Erythrophlem chlorostachys, Acacia hippuroide* and *Grevillea refracta.* Sparse tussock grass of *Sorghum timorense* and sparse hummock grass of *Triodia caelestialis*. Soil consisting of red-brown sandy loam of firm strength. No rocks present. No obvious disturbance.	
TBS4 **Fauna habitat type: Pindan shrubland** Open shrubland on flat plain. Dominant shrub species *Acacia tumida,* with other species consisting of *Acacia monticola, Erythrophlem chlorostachys, Acacia hippuroide* and *Grevillea refracta.* Sparse tussock grass of *Sorghum timorense* and sparse hummock grass of *Triodia caelestialis*. Soil consisting of red-brown sandy loam of firm strength. No rocks present. No obvious disturbance.	

Vegetation and Fauna Habitat Description	Site Photo
TBS5 **Fauna habitat type: Pindan shrubland** Dense shrubland on gently sloping plain. Dominant shrub species *Acacia tumida,* with scattered shrub species consisting of *Dodonaea hispidula, Erythrophlem chlorostachys* and *Grevillea refracta.* Scattered tussock grass consisting of *Sorghum timorense* and scattered hummock grass of *Triodia caelestialis*. Soil consisting of red-brown sandy loam of firm strength. No rocks present. Relatively recent fire evidence (0-5 years fire age).	
TBS6 **Fauna habitat type: Savannah woodland** Open woodland on flat plain. Scattered tree species consisting of *Eucalyptus tectifica* and *Brachychiton diversifolius.* Open to moderate dense shrubs, with dominant species being *Acacia platycarpa.* Other shrub species consisting of *Bauhinia cunninghami* and *Dolichandrone heterophyll*. Grasses consisting of tussock *Sorghum timorense*. Soil consisiting of brown-white sand clay of firm strength. No rocks present. No obvious signs of disturbance.	

Vegetation and Fauna Habitat Description	Site Photo
TBS7 **Fauna habitat type: Pindan shrubland** Dense shrubland on flat plain. Few tree species present, with scattered *Brachychiton diversifolius* and *Eucalyptus tectifica*. Dominant shrub species of dense *Acacia tumida,* other shrub species including *Acacia platycarpa, Bauhinia cunninghami, Dolichandrone heterophyll* and *Erythrophleum chlorostachys*. Scattered tussock grass consisting of *Sorghum timorense* and scattered hummock grass of *Triodia caelestialis*. Soil consisting of red-brown sandy loam of firm strength. No rocks present. No obvious disturbance.	

Vegetation and Fauna Habitat Description	Site Photo
Targeted SRE dry pitfall	
TB SRE1 **Fauna habitat type: Pindan shrubland** Open shrubland on flat plain. Dominant tree species *Corymbia greeniana*. Various shrub species including *Acacia* tumida, *Grevillea pyramidalis Acacia monticola, Erythrophlem chlorostachys, Acacia hippuroide* and *Grevillea refracta*. Sparse tussock grass of *Sorghum timorense* and sparse hummock grass of *Triodia caelestialis*. Soil consisting of red-brown sandy loam of firm strength. No rocks present. No obvious disturbance.	
TB SRE2 **Fauna habitat type: Pindan shrubland** Open woodland on flat plain. Dominant tree species consisting of *Corymbia greeniana* and *Corymbia zygophylla,* scattered throughout. Scattered shrub species consisiting of *Acacia tumida*, *Acacia monticola, Erythrophlem chlorostachys, Acacia hippuroide* and *Grevillea refracta.* Dense tussock grass of *Sorghum timorense* and sparse hummock grass of *Triodia caelestialis*. Soil consisting of red-brown sandy loam of firm strength. No rocks present. No obvious disturbance.	

Vegetation and Fauna Habitat Description	Site Photo
TB SRE3 **Fauna habitat type: Pindan shrubland** Dense shrubland on flat plain. Dense *Acacia tumida*, with other shrub species consisting of *Acacia monticola, Erythrophlem chlorostachys, Acacia hippuroide* and *Grevillea refracta.* Sparse tussock grass of *Sorghum timorense* and sparse hummock grass of *Triodia caelestialis*. Soil consisting of red-brown sandy loam of firm strength. No rocks present. No obvious disturbance. Abundant leaf litter covering ground surface.	
TB SRE4 **Fauna habitat type: Pindan shrubland** Open shrubland on flat plain. Dominant tree species *Corymbia greeniana*. Various shrub species including *Acacia* tumida, *Grevillea pyramidalis Acacia monticola, Erythrophlem chlorostachys, Acacia hippuroide* and *Grevillea refracta*. Sparse tussock grass of *Sorghum timorense* and sparse hummock grass of *Triodia caelestialis*. Soil consisting of red-brown sandy loam of firm strength. No rocks present. No obvious disturbance.	

Vegetation and Fauna Habitat Description	Site Photo
TB SRE5 **Fauna habitat type: Pindan shrubland** Dense shrubland on flat plain. Dominant shrub species *Acacia tumida,* with scattered shrub species consisting of *Dodonaea hispidula, Erythrophlem chlorostachys* and *Grevillea refracta.* Scattered tussock grass consisting of *Sorghum timorense* and scattered hummock grass of *Triodia caelestialis*. Soil consisting of red-brown sandy loam of firm strength. No rocks present. Relatively recent fire evidence (0-5 years fire age). Dense leaf litter on ground surface.	
TB SRE6 **Fauna habitat type: Pindan shrubland** Shrubland on flat plain. Dominant tree species *Corymbia greeniana*. Various shrub species including *Acacia* tumida, *Grevillea pyramidalis Acacia monticola, Erythrophlem chlorostachys, Acacia hippuroide* and *Grevillea refracta*. Sparse tussock grass of *Sorghum timorense* and sparse hummock grass of *Triodia caelestialis*. Soil consisting of red-brown sandy loam of firm strength. No rocks present. No obvious disturbance. Abundant leaf litter on the ground surface.	

APPENDIX E VOUCHER SPECIMENS LODGED WITH WA MUSEUM

WAM Voucher Number	Species
R173110	*Ctenotus colletti*
R173111	*Proablepharus tenuis*
R173112	*Morethia storri*
R173113	*Morethia storri*
R173114	*Morethia storri*
R173115	*Varanus* aff. *brevicauda*

APPENDIX F FAUNA RECORDED DURING THE SURVEY

Appendix F1: Mammals

Family and species	Common name	Conservation status			Site 1		Site 2		Site 3		Site 4		Site 5		Site 6		Site 7		Opp	
		EPBC Act	WC Act	DPaW	Ph 1	Ph 2	Ph 1	Ph 2	Ph 1	Ph 2	Ph 1	Ph 2	Ph 1	Ph 2	Ph 1	Ph 2	Ph 1	Ph 2	Ph 1	Ph 2
TACHYGLOSSIDAE																				
Tachyglossus aculeatus	Echidna																			S
DASYURIDAE																				
Sminthopsis youngsoni	Lesser Hairy-footed Dunnart										2									
THYLACOMYIDAE																				
Macrotis lagotis	Greater Bilby	VU	S1	VU																1
MACROPODIDAE																				
Macropus agilis	Agile Wallaby																		1	S
Macropus robustus	Euro																			1
EMBALLONURIDAE																				
Saccolaimus flaviventris	Yellow-bellied Sheathtail Bat									•				•						
MOLOSSIDAE																				
Chaerophon jobensis	Northern Freetail Bat				•	•	•	•	•		•	•	•	•	•	•			•	
VESPERTILIONIDAE																				
Chalinolobus gouldii	Gould's Wattled Bat						•	•	•	•	•	•		•	•	•	•	•		
Chalinolobus nigrogriseus	Hoary Wattled Bat					•	•	•	•	•		•	•	•	•	•		•	•	
Miniopterus schreibersii orianae	Common Bentwing Bat													•		•		•		
Myotis macropus	Large-footed Myotis				•															
Nyctophilus geoffroyi	Lesser Long-eared Bat				•						•			•		•	•			
Scotorepens greyii	Little Broad-nosed Bat				•	•	•	•	•	•	•	•	•	•	•	•	•	•		
MURIDAE																				

Family and species	Common name	Conservation status			Site 1		Site 2		Site 3		Site 4		Site 5		Site 6		Site 7		Opp	
		EPBC Act	WC Act	DPaW	Ph 1	Ph 2	Ph 1	Ph 2	Ph 1	Ph 2	Ph 1	Ph 2	Ph 1	Ph 2	Ph 1	Ph 2	Ph 1	Ph 2	Ph 1	Ph 2
Leggadina lakedownensis	Short-tailed Mouse			P4												1				
Pseudomys delicatulus	Delicate Mouse					4	1		7	1	3	2	2	1	2	3				
Pseudomys nanus	Western Chestnut Mouse										1	3				1				
CANIDAE																				
Canis lupus	Dog/Dingo																		1	
INTRODUCED MAMMALS																				
Mus musculus	House Mouse					1				1		5						1		1
Felis catus	Cat																	1	1	2
Bos taurus	Cow																		20	2

● = bat species recorded on SM2s at these locations

Appendix F2: Birds

Family and species	Common name	Conservation status			TB S1		TB S2		TB S3		TB S4		TB S5		TB S6		TB S7		TB Opp		TB J	
		EPBC Act	WC Act	DPaW	Ph1	Ph2	Ph1	Ph2	Ph1	Ph2	Ph1	Ph2	Ph1	Ph2	Ph1	Ph2	Ph1	Ph2	Ph1	Ph2	Ph1	Ph2
PHASIANIDAE																						
Coturnix ypsilophora	Brown Quail					3	2	2														
ANSERANATIDAE																						
Anseranas semipalmata	Magpie Goose																		2			
ANATIDAE																						
Dendrocygna eytoni	Plumed Whistling-Duck*																				25	2
Dendrocygna arcuata	Wandering Whistling-Duck*																					84
Stictonetta naevosa	Freckled Duck*																					63
Chenonetta jubata	Australian Wood Duck*																					1
Malacorhynchus membranaceus	Pink-eared Duck*																					9
Nettapus pulchellus	Green Pygmy-Goose*																					5
Anas gracilis	Grey Teal*																					140
Anas superciliosa	Pacific Black Duck*																				1	20
Aythya australis	Hardhead*																					60
PODICIPEDIDAE																						
Tachybaptus novaehollandiae	Australasian Grebe*																				5	39
COLUMBIDAE																						
Ocyphaps lophotes	Crested Pigeon														1				1			
Geopelia cuneata	Diamond Dove				10	1	9		2		6		4	2	6	2	12	3	3			
Geopelia striata	Peaceful Dove				5	3	4	6	2				3	2	4	7		4				21
PODARGIDAE																						

Family and species	Common name	Conservation status			TB S1		TB S2		TB S3		TB S4		TB S5		TB S6		TB S7		TB Opp		TB J	
		EPBC Act	WC Act	DPaW	Ph1	Ph2	Ph1	Ph2	Ph1	Ph2	Ph1	Ph2	Ph1	Ph2	Ph1	Ph2	Ph1	Ph2	Ph1	Ph2	Ph1	Ph2
Podargus strigoides	Tawny Frogmouth																		2			
EUROSTOPODIDAE																						
Eurostopodus argus	Spotted Nightjar																		1			
AEGOTHELIDAE																						
Aegotheles cristatus	Australian Owlet-nightjar											1			1		1			3		
APODIDAE																						
Apus pacificus	Fork-tailed Swift	M	S3																2			
PHALACROCORACIDAE																						
Microcarbo melanoleucos	Little Pied Cormorant*																					3
PELECANIDAE																						
Pelecanus conspicillatus	Australian Pelican*																					2
ARDEIDAE																						
Ardea pacifica	White-necked Heron*																				1	5
Egretta novaehollandiae	White-faced Heron*																					3
ACCIPITRIDAE																						
Threskiornis spinicollis	Straw-necked Ibis*																				3	41
Platalea regia	Royal Spoonbill*																					2
ACCIPITRIDAE																						
Haliastur sphenurus	Whistling Kite*																					1
Milvus migrans	Black Kite*																				4	
Accipiter fasciatus	Brown Goshawk									1					1							
Accipiter cirrhocephalus	Collared Sparrowhawk				1			1														
Circus assimilis	Spotted Harrier														1							

Family and species	Common name	Conservation status			TB S1		TB S2		TB S3		TB S4		TB S5		TB S6		TB S7		TB Opp		TB J	
		EPBC Act	WC Act	DPaW	Ph1	Ph2	Ph1	Ph2	Ph1	Ph2	Ph1	Ph2	Ph1	Ph2	Ph1	Ph2	Ph1	Ph2	Ph1	Ph2	Ph1	Ph2
Aquila audax	Wedge-tailed Eagle																		1			
FALCONIDAE																						
Falco cenchroides	Nankeen Kestrel										1						1			1		
Falco berigora	Brown Falcon								1	2						3				1	1	
Falco longipennis	Australian Hobby																					
RALLIDAE																						
Fulica atra	Eurasian Coot*																					50
OTIDIDAE																						
Ardeotis australis	Australian Bustard			P4		1													8	1		
BURHINIDAE																						
Burhinus grallarius	Bush Stone-curlew			P4				3		1		3				1			4			
RECURVIROSTRIDAE																						
Himantopus himantopus	Black-winged Stilt*																					1
CHARADRIIDAE																						
Elseyornis melanops	Black-fronted Dotterel*																					2
Erythrogonys cinctus	Red-kneed Dotterel*																					13
Vanellus miles	Masked Lapwing*																					8
JACANIDAE																						
Irediparra gallinacea	Comb-crested Jacana*																					4
SCOLOPACIDAE																				**1**		
Tringa glareola	Wood Sandpiper	M	S3																1			12
TURNICIDAE																						
Turnix pyrrhothorax	Red-chested Button-quail																		1			

Family and species	Common name	Conservation status			TB S1		TB S2		TB S3		TB S4		TB S5		TB S6		TB S7		TB Opp		TB J	
		EPBC Act	WC Act	DPaW	Ph1	Ph2	Ph1	Ph2	Ph1	Ph2	Ph1	Ph2	Ph1	Ph2	Ph1	Ph2	Ph1	Ph2	Ph1	Ph2	Ph1	Ph2
Turnix velox	Little Button-quail								1													
Turnix sp.	Button-quail sp.				1		1															
CACATUIDAE (PSITTACIDAE)																						
Calyptorhynchus banksii	Red-tailed Black-Cockatoo											3										
Eolophus roseicapillus	Galah						2								5	3				4		
Cacatua sanguinea	Little Corella					27		9				3		10		4						55
Nymphicus hollandicus	Cockatiel				2						8				8				2			
PSITTACIDAE																						
Trichoglossus haematodus	Red-collared Lorikeet				12	13	2	10	8	3		4	8	24		13	2	51				
Psitteuteles versicolor	Varied Lorikeet					94		76		55		42		81		42		39		20		
Aprosmictus erythropterus	Red-winged Parrot				5	17	6	3	1	3			3		2	10						
Melopsittacus undulatus	Budgerigar				8		4		4		37		23		23		1		2			
CUCULIDAE																						
Centropus phasianinus	Pheasant Coucal					2		4		2			1	3		2			1			1
Chalcites basalis	Horsfield's Bronze-Cuckoo					2		2				2		3	1	3		1		1		
Chalcites minutillus	Little Bronze-cuckoo																					
Cacomantis pallidus	Pallid Cuckoo					3		2		1		7		4		3		1		5		
Cacomantis variolosus	Brush Cuckoo					3		3		3		4		8		1		3				
STRIGIDAE																						
Ninox novaeseelandiae	Southern Boobook																		2	1		
HALCYONIDAE																						
Dacelo leachii	Blue-winged Kookaburra					6		9						5		1			1	2		
Todiramphus pyrrhopygius	Red-backed Kingfisher				1	2				1						1			1			

Family and species	Common name	Conservation status			TB S1		TB S2		TB S3		TB S4		TB S5		TB S6		TB S7		TB Opp		TB J	
		EPBC Act	WC Act	DPaW	Ph1	Ph2	Ph1	Ph2	Ph1	Ph2	Ph1	Ph2	Ph1	Ph2	Ph1	Ph2	Ph1	Ph2	Ph1	Ph2	Ph1	Ph2
Todiramphus sanctus	Sacred Kingfisher					7		1		2		4		1		3		4	1	2		
MEROPIDAE																						
Merops ornatus	Rainbow Bee-eater	M	S3		3	5		5	3	1	2	11	9	8	13	5	3		2	4	10	
CORACIIDAE																						
Eurystomus orientalis	Dollarbird							1								3		1	1			
CLIMACTERIDAE																						
Climacteris melanura	Black-tailed Treecreeper				1	1						2			3	4			1			
PTILINORHYNCHIDAE																						
Ptilonorhynchus nuchalis	Great Bowerbird					1						1										
MALURIDAE																						
Malurus lamberti	Variegated Fairy-wren													10								
Malurus melanocephalus	Red-backed Fairy-wren				8	7	12	6		2	7	17	6	12	9	5	9	4	3			
ACANTHIZIDAE																						
Smicrornis brevirostris	Weebill				1	7		1			3	3	9	2	10	4			2			
Gerygone albogularis	White-throated Gerygone				3				1	5			1	1	2	5		3				
PARDALOTIDAE																						
Pardalotus rubricatus	Red-browed Pardalote				1						1									3		
Pardalotus striatus	Striated Pardalote				3	1			2		1		6	2	4	2	1		1			
MELIPHAGIDAE																						
Lichenostomus virescens	Singing Honeyeater					3	6	23	4	8	7	13		3	1		7	8				
Lichenostomus flavescens	Yellow-tinted Honeyeater				6	3							4		2	4		1	2			10
Conopophila rufogularis	Rufous-throated Honeyeater				3	12		4				2		2		13	1	2				

Family and species	Common name	Conservation status			TB S1		TB S2		TB S3		TB S4		TB S5		TB S6		TB S7		TB Opp		TB J	
		EPBC Act	WC Act	DPaW	Ph1	Ph2	Ph1	Ph2	Ph1	Ph2	Ph1	Ph2	Ph1	Ph2	Ph1	Ph2	Ph1	Ph2	Ph1	Ph2	Ph1	Ph2
Sugomel niger	Black Honeyeater								1													
Cissomela pectoralis	Banded Honeyeater					4						11				11		6				
Lichmera indistincta	Brown Honeyeater				17	5	17	5	7	2	1	11	13	9	3	2	8	14	1		5	2
Melithreptus gularis	Black-chinned Honeyeater				2	6	4		1				2		4	2		4	1			
Melithreptus albogularis	White-throated Honeyeater																		1			
Philemon citreogularis	Little Friarbird				4	18	3	14		7		8	3	13	2	13		6				
POMATOSTOMIDAE																						
Pomatostomus temporalis	Grey-crowned Babbler				5	10	4	11		2	4	2	14	10	13			2	4			
NEOSITTIDAE																						
Daphoenositta chrysoptera	Varied Sittella					10	2	6			2	1		5	2	7	3	2				
CAMPEPHAGIDAE																						
Coracina novaehollandiae	Black-faced Cuckoo-shrike				2	6		4		3	1	3	3	4	2	6	1			5		
Lalage sueurii	White-winged Triller					10		3	1	3	2	7	2	2		12	1	10		3		
PACHYCEPHALIDAE																						
Pachycephala rufiventris	Rufous Whistler				7	7	2	12	7	19	3	15	6	11	4	9	6	19	2	15		
Colluricincla harmonica	Grey Shrike-thrush				1	5	3	7	3	5	2	4	3		4	4		5				
ORIOLIDAE																						
Oriolus sagittatus	Olive-backed Oriole					2		4						6		6		3				
ARTAMIDAE																						
Artamus leucorhynchus	White-breasted Woodswallow*																					12
Artamus personatus	Masked Woodswallow				90		35		103		181		12	6	117	5	130		38			
Artamus cinereus	Black-faced Woodswallow					7	3	5		3		4	5	11	1	10	10	1		4		

Family and species	Common name	Conservation status			TB S1		TB S2		TB S3		TB S4		TB S5		TB S6		TB S7		TB Opp		TB J	
		EPBC Act	WC Act	DPaW	Ph1	Ph2	Ph1	Ph2	Ph1	Ph2	Ph1	Ph2	Ph1	Ph2	Ph1	Ph2	Ph1	Ph2	Ph1	Ph2	Ph1	Ph2
Artamus minor	Little Woodswallow					6		1				7			4	1						
Cracticus nigrogularis	Pied Butcherbird				3	4	3	4	5	1	1	2	6	7	3	9						
RHIPIDURIDAE (DICRURIDAE)																						
Rhipidura leucophrys	Willie Wagtail				1	1	1	3	3	2	1	3	1	1	1	2	2	3	1			
CORVIDAE																						
Corvus orru	Torresian Crow					1		4		5				3		3					2	24
MONARCHIDAE (DICRURIDAE)																						
Myiagra nana	Paperbark Flycatcher				1	8	1		1			1	2		2	3					2	7
Grallina cyanoleuca	Magpie-lark				1	1								2	3	2			2			5
PETROICIDAE																						
Microeca fascinans	Jacky Winter				3	13	1	6	1	3		4		5		5	4	1	3	4		
Melanodryas cucullata	Hooded Robin												2				1	3				
MEGALURIDAE (SYLVIIDAE)																						
Cincloramphus mathewsi	Rufous Songlark					7		1					1			5						
HIRUNDINIDAE																						
Petrochelidon nigricans	Tree Martin										2						2		5			
NECTARINIIDAE (DICAEIDAE)																						
Dicaeum hirundinaceum	Mistletoebird				1	1	2	3	1	1		4	1	5	1	1	1	6				
ESTRILDIDAE																						
Taeniopygia guttata	Zebra Finch					4		6				14			10	6	4		3			
Poephila acuticauda	Long-tailed Finch					9		2			4		2	7	6	2	1		6			
MOTACILLIDAE																						
Motacilla cinerea	Grey Wagtail*	M	S3																			1

Family and species	Common name	Conservation status			TB S1		TB S2		TB S3		TB S4		TB S5		TB S6		TB S7		TB Opp		TB J	
		EPBC Act	WC Act	DPaW	Ph1	Ph2	Ph1	Ph2	Ph1	Ph2	Ph1	Ph2	Ph1	Ph2	Ph1	Ph2	Ph1	Ph2	Ph1	Ph2	Ph1	Ph2
Motacilla tschutschensis	Eastern Yellow Wagtail*	M	S3																			2

*Recorded from Mount Jowlaenga homestead only

Appendix F3: Reptiles

Family and species	Common name	Conservation status			Site 1		Site 2		Site 3		Site 4		Site 5		Site 6		Site 7		Opp	
		EPBC Act	WC Act	DEC	Ph 1	Ph 2	Ph 1	Ph 2	Ph 1	Ph 2	Ph 1	Ph 2	Ph 1	Ph 2	Ph 1	Ph 2	Ph 1	Ph 2	Ph 1	Ph 2
DIPLODACTYLIDAE																				
Diplodactylus conspicillatus	Fat-tailed Gecko									6	3	2	1	2						
Lucasium stenodactylum	Sand-plain Gecko					4	1	2	2	2	1	1				1			1	2
Strophurus ciliaris						2		3	1	11	1	8		8		2		8		1
GEKKONIDAE																				
Gehyra nana						1	2	1		1		1	1			1	1		18	2
Gehyra pilbara																			4	
Heteronotia binoei	Bynoe's Gecko				2	12	1	5					1	2		3			14	1
PYGOPODIDAE																				
Delma tincta									1		1									
Lialis burtonis							1	2		4								2		1
Pygopus steelescotti	Northern Hooded Scaly-foot									1		1				1		1		
SCINCIDAE																				
Carlia munda						1	4	3		1	1	1	2	1	2	3		1	1	
Carlia rufilatus						1	4	2	1	6		2	5	1	9	1	5	1		1
Cryptoblepharus ruber	Tawny Snake-eyed Skink					1										1				
Cryptoblepharus sp.																			1	
Ctenotus colletti								1	1	1			1							
Ctenotus inornatus					17	2	17	24	9	4	11	6	9	10	3	11	6	8		1
Ctenotus pantherinus					4		1	1		1										
Ctenotus robustus					11	5	21		6		6		18	3	25	1	3		3	
Ctenotus serventyi					1		1						1		3	1	3			1
Eremiascincus isolepis								2			3	2	2		2	2		1	1	

Family and species	Common name	Conservation status			Site 1		Site 2		Site 3		Site 4		Site 5		Site 6		Site 7		Opp	
		EPBC Act	WC Act	DEC	Ph 1	Ph 2	Ph 1	Ph 2	Ph 1	Ph 2	Ph 1	Ph 2	Ph 1	Ph 2	Ph 1	Ph 2	Ph 1	Ph 2	Ph 1	Ph 2
Lerista apoda																1			2	
Lerista bipes										6		2		11		9		7		
Lerista greeri									2				1		4		6		1	
Menetia maini										1										
Morethia storri					3			1	9	3	4	1		1	3	1	7	7		
Proablepharus tenuis							1		1	2				5		1	1	1		
Tiliqua scincoides	Common Blue-tongue								1										2	1
AGAMIDAE																				
Amphibolurus gilberti	Gilbert's Dragon																		1	1
Chlamydosaurus kingii	Frilled Lizard																		2	3
Diporiphora magna								1	1	2	1			4			2	3		
Diporiphora pindan					3	2	4	4	1	10		6	8	5		3	5	7	3	
Pogona minor	Dwarf Bearded Dragon				1	1	1		1	2	1			2	1	1		2		
VARANIDAE																				
Varanus acanthurus	Spiny-tailed Monitor				1		3	1		1										
Varanus brevicauda	Short-tailed Pygmy Monitor					2					2	2	1	1	1		3			
Varanus gouldii	Gould's Monitor																		2	1
Varanus tristis	Black-headed Monitor					1		1	1										1	
TYPHLOPIDAE																				
Ramphotyphlops sp.						1										1				
BOIDAE																				
Antaresia stimsoni	Stimson's Python																		3	
ELAPIDAE																				

Family and species	Common name	Conservation status			Site 1		Site 2		Site 3		Site 4		Site 5		Site 6		Site 7		Opp	
		EPBC Act	WC Act	DEC	Ph 1	Ph 2	Ph 1	Ph 2	Ph 1	Ph 2	Ph 1	Ph 2	Ph 1	Ph 2	Ph 1	Ph 2	Ph 1	Ph 2	Ph 1	Ph 2
Brachyurophis roperi	Northern Shovel-nosed Snake				1		2			3		4		1	1	2		1		
Demansia angusticeps					1		5			1	1				3		1	1		
Furina ornata	Moon Snake													1				2		
Pseudechis australis	Mulga Snake																		1	
Pseudonaja mengdeni	Western Brown Snake																		1	
Suta punctata	Spotted Snake				1															

Appendix F4: Amphibians

Family and species	Common name	Conservation status			Site 1		Site 2		Site 3		Site 4		Site 5		Site 6		Site 7		Opp	
		EPBC Act	WC Act	DEC	Ph 1	Ph 2	Ph 1	Ph 2	Ph 1	Ph 2	Ph 1	Ph 2	Ph 1	Ph 2	Ph 1	Ph 2	Ph 1	Ph 2	Ph 1	Ph 2
HYLIDAE																				
Cyclorana australis	Giant Frog																		8	
Cyclorana longipes	Long-footed Frog												1							
Litoria caerulea	Green Tree Frog				1														10	4
Litoria rothii	Northern Laughing Tree Frog																			3
Litoria rubella	Little Red Tree Frog																		1	
LIMNODYNASTIDAE																				
Notaden nichollsi	Desert Spadefoot				43	1							1						1	
Platyplectrum ornatum	Ornate Burrowing Frog				1		1						7		24		9		2	2
MYOBATRACHIDAE																				
Uperoleia talpa	Mole Toadlet				1										1					

Appendix F5: SRE Invertebrates

Class/Order, Family & Species	SRE Status	TB S1		TB S2		TB S3		TB S4		TB S5		TB S6		TB S7		SRE 1		SRE 2		SRE 3		SRE 4		SRE 5		SRE 6		Opp	
		P1	P2	P1	P2	P1	P2	P1	P2	P1	P2	P1	P2	P1	P2	P1	P2	P1	P2	P1	P2	P1	P2	P1	P2	P1	P2	P1	P2
Arachnida (Mygalamorphae) - Nemesiidae																													
Aname 'MYG284'	Potential			4																									
Aname 'MYG285'	Potential							1																					
Aname 'MYG387'	Potential		1																										
Aname 'MYG387?'	Potential										1																		
Aname 'MYG388'	Potential		1		1								2																
Aname 'sp. indet.'	Potential																												1
Aname 'sp. juv.'	Potential																									1			
Arachnida (Pseudoscorpiones) - Sternophoridae																													
Afrosternophorus sp. indet.	No																												2
Arachnida (Pseudoscorpiones) - Olpiidae																													
Beierolpium 'sp. 8/4'	No																							1					4
Olpiidae 'genus indet. (juvenile)'	Potential																			1		5		4		2			
Arachnida (Pseudoscorpiones) - Chernetidae																													
Haplochernes sp. Indet	No																												2
Arachnida (Scorpiones) - Buthidae																													
Lychas 'annulatus'	No			1				26				3		9															
Lychas 'broome'	Potential			4																									
Lychas 'JPP'	Potential				1		3		2		1		2		2														
Lychas 'JPP1'	Potential								1																				
Lychas 'JPP2'	Potential				6																								
Lychas 'JPP3'	Potential				1		2				1		2		1														
Lychas 'multipunctatus'	No			1		1		1		1		1		3				1											

Class/Order, Family & Species	SRE Status	TB S1		TB S2		TB S3		TB S4		TB S5		TB S6		TB S7		SRE 1		SRE 2		SRE 3		SRE 4		SRE 5		SRE 6		Opp	
		P1	P2	P1	P2	P1	P2	P1	P2	P1	P2	P1	P2	P1	P2	P1	P2	P1	P2	P1	P2	P1	P2	P1	P2	P1	P2	P1	P2
Arachnida (Scorpiones) - Urodacidae																													
Urodacus 'kraepelini'	Potential													1															
Urodacus sp. indet.	Potential									1								1											
Arachnida (Opiliones) - Assamiidae																													
Dampetrus sp.	Potential											3		1															
Malacostraca (Isopoda) - Armadillidae																													
Armadillidae 'EE1501C'	Potential																												1
Buddelundiinae 'genus indet. NE Broome'	Potential											1							5										
Buddelundia sp.74	Potential																											16	13
Mollusca (Gastropoda) - Subulinidae																													
Eremopeas interioris	No																					4							
Mollusca (Gastropoda) - Pupillidae																													
Pupoides pacificus	No																									2			
Mollusca (Gastropoda) - Camaenidae																													
Quistrachia leptogramma	Potential								1											7								1	1
Rhagada bulgana	Confirmed								2																			2	4

APPENDIX G STYGOFAUNA DRILL HOLE GROUNDWATER PHYSIO-CHEMICAL RESULTS

Bore ID	Depth to water (m)	Temperature (°C)	Conductivity (mS/cm)	DO (ppm) mg/L	pH	Salinity (PSS)	DO%	Redox (mV)	Depth of sample taken (m)
THAC 243	32	32.34	0.258	3.6	5.42	0.13	4.5	128	55
THAC232	22	32.07	0.309	7.65	5.67	0.15	6.03	106	60
THAC235	30	32.64	0.244	4.17	6.13	0.12	53.2	108	35
THAC238	28	32.97	0.171	4.21	5.38	0.09	56.5	118	60
THAC241	39	33.91	0.224	3.28	5.34	0.11	40.9	150	53
THAC245	38	31.8	0.297	2.82	5.35	0.15	31.5	132	60
THAC247	41	33.21	0.27	5.54	5.27	0.14	59.2	145	60
THAC252	49	32.72	0.04	2.32	5.26	0.03	30.20	128	90
THAC280	42	31.45	0.484	2.04	5.98	0.23	26.8	-	60
THAC285	44	30.88	0.32	2.08	6.27	0.15	21.2	98	52
THAC322	23	33.1	0.273	5.89	5.58	0.13	75.7	105	50
THAC357	32	-	0.235	4.21	5.57	0.12	3.6	24	60
THAC390	33	31.75	0.111	5.09	5.46	0.06	5	115	-
THAC406	30	32.9	0.045	3.52	5.96	0.03	44.5	100	60
THAC408	39	-	0.182	4.52	5.39	0.09	59.6	129	80
Average (mean)	**34.80**	**32.44**	**0.23**	**4.06**	**5.60**	**0.12**	**34.56**	**113.29**	**59.64**
Maximum	**49**	**33.91**	**0.484**	**7.65**	**6.27**	**0.23**	**75.7**	**150**	**90**
Minimum	**22**	**30.88**	**0.043**	**2.04**	**5.26**	**0.03**	**3.6**	**24**	**350**
Standard deviation	**7.73**	**0.83**	**0.11**	**1.55**	**0.33**	**0.05**	**23.47**	**30.31**	**12.89**
Total	**15**	**13**	**15**	**15**	**15**	**15**	**15**	**14**	**14**

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