DECEMBER 2014

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ecologia
ENVIRONMENT

SHEFFIELD RESOURCES LTD
THUNDERBIRD PROJECT
SHORT RANGE ENDEMIC INVERTEBRATE TARGETED SURVEY

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ACRONYMS

BoM	Bureau of Meteorology
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*
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 targeted short range endemic invertebrate fauna assessment of its Thunderbird Project, located 70 kilometres west of Derby on the Dampier Peninsula. Sheffield seeks to broaden the understanding of the short range endemic invertebrate fauna that occurs in the Thunderbird area, and identify the environmental values present.

During the Level 2 terrestrial fauna assessment of the Thunderbird project, one confirmed and 19 potential SRE species were recorded. Further surveys where required to determine the distribution of these species in the region surrounding the project.

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

- 10 SRE dry pitfall trapping grids, open for four or five nights each, for a combined total of 705 individual trap nights;
- Two leaf litter samples were taken from each of the SRE dry pitfall grids, totalling 20 samples.
- 10 SRE foraging sites, actively searched for 60 minutes per site for a combined total of 600 minutes foraged

A total of 12 invertebrate taxa from five orders were submitted for identification and SRE status assessment. The results from these assessments indicated that nine of these taxa should be considered potential SREs (two mygalomorph spiders, two scorpions, four isopods and one opiliones). Seven of the nine potential SREs were also recorded during the previous Level 2 surveys.

All 12 invertebrate taxa were recorded outside of the potential impact area, providing important contextual data, particularly for three taxa that had previously only been recorded from within the proposed impact area.

Based on the results of the Level 2 and targeted surveys, as well as the habitat preferences for the invertebrate taxa recorded within the Thunderbird study area, no potential SRE taxa are expected to be restricted to the proposed impact area.

No significant limitations were experienced during the surveys. As a result, the survey can be considered adequate and to have met its objectives.

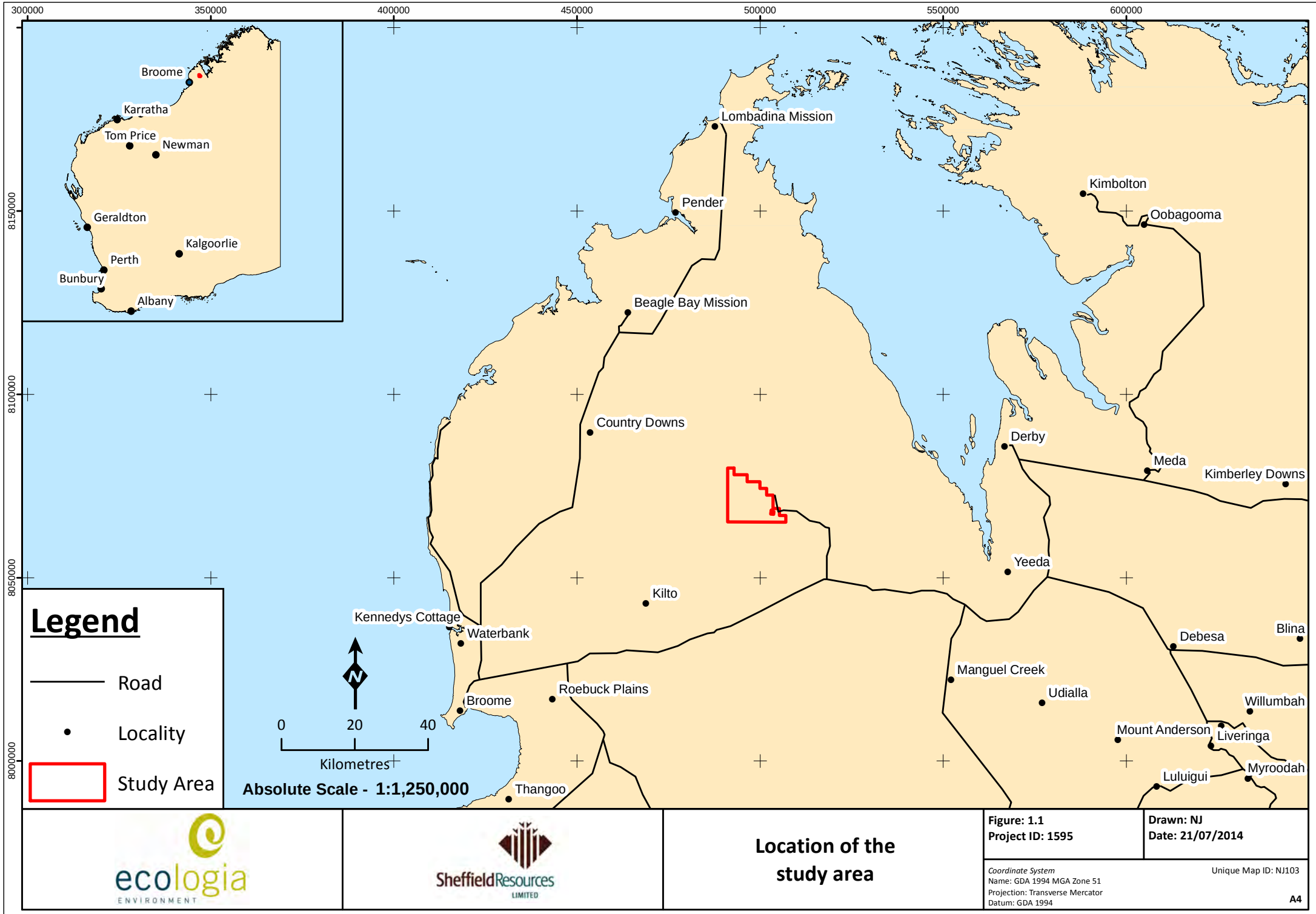
1 INTRODUCTION

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.

During the Level 2 terrestrial fauna assessment of the Thunderbird project in 2013, one confirmed and 19 potential SRE species were recorded. Further surveys where required to determine the distribution of these species in the region surrounding the project.

Sheffield commissioned *ecologia* Environment (*ecologia*) to undertake a targeted short range endemic (SRE) invertebrate fauna survey of its Thunderbird project area, located 70 kilometres west of Derby on the Dampier Peninsula (Figure 1.1). Sheffield seeks to broaden the understanding of the SRE invertebrate fauna that occurs in the Thunderbird area (study area), and identify the environmental values present.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Tom Price
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Geraldton
Kalgoorlie
Perth
Bunbury
Albany
Lombadina Mission
Pender
Kimbolton
Oobagooma
Beagle Bay Mission
Country Downs
Derby
Meda
Kimberley Downs
Yeeda
Kilto
Kennedys Cottage
Waterbank
Broome
Roebuck Plains
Thangoo
Debesa
Blina
Manguel Creek
Udialla
Willumbah
Mount Anderson
Liveringa
Myroodah
Luluigui
Legend
Road
Locality
Study Area
N
0
20
40
Kilometres
Absolute Scale - 1:1,250,000
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LIMITED
Location of the study area
Figure: 1.1
Project ID: 1595
Drawn: NJ
Date: 21/07/2014
Coordinate System
Name: GDA 1994 MGA Zone 51
Projection: Transverse Mercator
Datum: GDA 1994
Unique Map ID: NJ103
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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);
- 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); and
- EPA Position Statement No. 3: *Terrestrial Biological Surveys as an Element of Biodiversity Protection* (EPA 2002).

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 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.

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 targeted short range endemic (SRE) invertebrate fauna survey of its Thunderbird project area. Sheffield seeks to broaden the understanding of the SRE invertebrate fauna that occurs in the Thunderbird area (study area), and identify the environmental values present.

The aim of this study was to clarify the distributions of the SRE fauna previously recorded within the Thunderbird study area (*ecologia* 2014) and provide sufficient information to enable an assessment of the impact of the project on SRE populations.

1.4 PREVIOUS SURVEYS AND LAND USE

Several databases were consulted in the preparation of potential invertebrate fauna lists, with search buffers around the Thunderbird study area ranging from 20–50 km (Table 1.1). In addition, three reports on various fauna surveys conducted on the Dampier Peninsula were consulted (Table 1.2). The results of all database searches and previous surveys are presented in Appendix C.

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 1.1 – Databases searched to determine the potential invertebrate fauna assemblage

Group	Database	Custodian	Search details
SRE Invertebrate fauna	Species Profile and Threats (SPRAT) Database	Department of the Environment (DoE)	Records within 50 km of the study area.

Group	Database	Custodian	Search details
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 1.2 – Previous biological survey reports within the region of the study area

Survey location and author(s)	Distance from study area	Comments
ecologia internal database; two published reports (*ecologia* 2011a, b)	85	One single-phase Level 2 survey; one two-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

2 METHODS

2.1 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 2.1). Based on the information gathered, it was deemed necessary for a targeted SRE survey to be conducted.

Table 2.1 – 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.	Seven previous biological surveys have been conducted within 100 km of the study area (Table 1.2Table 1.2).
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 targeted 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).
Level of existing knowledge and results of previous regional sampling (e.g. species accumulation curves, species/area curves).	The previous Level 2 fauna survey recorded 27 invertebrate SRE taxa, and indicated 77% of the local fauna assemblage was recorded.
Number of different habitats or degree of similarity between habitats within a survey area.	The majority of the study area is pindan shrubland on sandy soils, with a sandstone range in the eastern parts.
Climatic constraints (e.g. temperature or rainfall that preclude certain sampling methods).	The timing of the surveys was optimal, capturing data immediately after the wet 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 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 through management plans.

2.2 SURVEY TIMING

The targeted SRE survey was conducted following the wet season, from 13–19 May 2014 (Table 2.2). This period was selected to increase the probability of capturing the potential SRE fauna collected during the April 2013 Level 2 survey (*ecologia* 2014).

Table 2.2 – Summary of survey timing and duration

Survey	Dates of survey	Duration (days)	Person days
Targeted SRE	13-19 May 2014	7	14

2.3 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.

2.3.1.1 Systematic sampling

Dry Pitfall Trapping

A total of ten SRE trap sites were established as dry pitfall sites for SRE invertebrate fauna. Each dry pitfall site comprised five trap lines, with each trap line consisting of three pitfall traps and a six metre wire drift fence (Figure 2.1). These sites were checked daily and all invertebrate fauna groups potentially containing SRE species collected.

Figure 2.1 – Example of the targeted SRE trap site

Foraging

One person hour per site was spent foraging for SREs at ten 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

Two quadrats (2 m^2) of leaf litter were collected at each of the ten targeted SRE trap sites during the first phase and separately placed into a leaf-litter reducer. 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.

2.3.2 Laboratory Sorting and Specimen Identification

Tullgren funnels were used to extract any animals from the collected leaf litter samples (Figure 2.2). 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 2.2 – 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 2.8 shows a list of taxonomic specialists consulted for identifications.

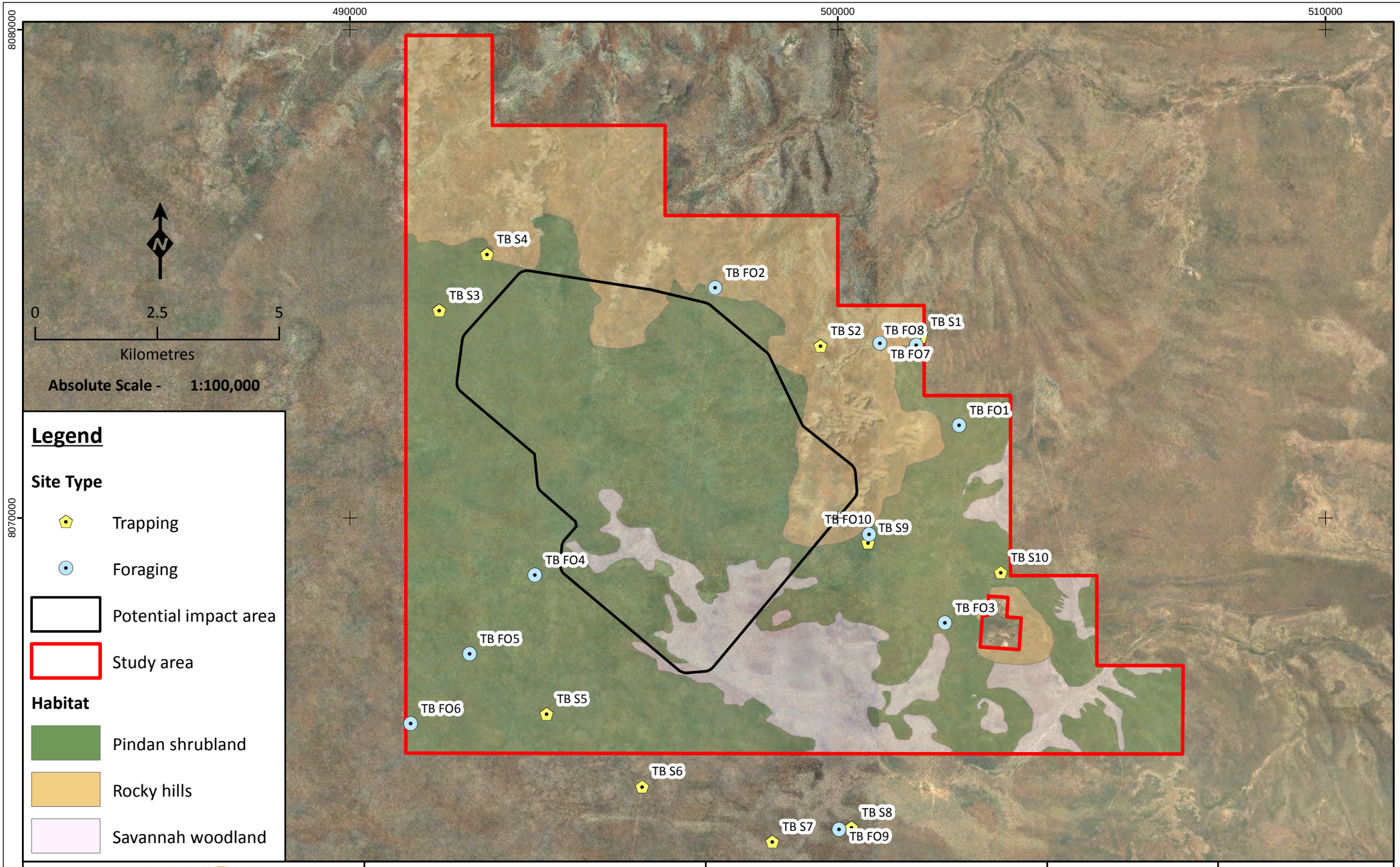
2.4 SITE SELECTION

Survey site locations were selected based on similar habitats to those where the targeted SRE fauna were collected during the Level 2 surveys (*ecologia* 2014). A total of ten SRE dry pitfall sites (comprising five dry pitfalls each) were established and a further 10 opportunistic foraging sites were searched for potential SRE species. Leaf litter samples were taken from the ten dry pitfall sites, to increase the likelihood of detecting terrestrial SRE species. The locations of all SRE survey sites are provided in Table 2.3 and mapped in Figure 2.3, whilst site habitat descriptions for trapping sites are listed in Appendix D.

Table 2.3 – SRE fauna sites

Site type	Location		Broad habitat unit*
	Easting	Northing	
Trapping site			
TB SRE S1	501733	8073610	Pindan shrubland
TB SRE S2	499649	8073519	Rocky hills
TB SRE S3	491834	8074250	Pindan shrubland
TB SRE S4	492811	8075400	Pindan shrubland
TB SRE S5	494035	8065985	Pindan shrubland
TB SRE S6	495989	8064501	Pindan shrubland
TB SRE S7	498657	8063368	Pindan shrubland
TB SRE S8	500265	8063650	Pindan shrubland
TB SRE S9	500627	8069492	Pindan shrubland
TB SRE S10	503344	8068890	Pindan shrubland
Opportunistic foraging sites			
TB SRE FO1	502488	8071895	Pindan shrubland
TB SRE FO2	497483	8074705	Rocky hills
TB SRE FO3	502196	8067851	Pindan shrubland
TB SRE FO4	493793	8068827	Pindan shrubland
TB SRE FO5	492454	8067215	Pindan shrubland
TB SRE FO6	491246	8065779	Pindan shrubland
TB SRE FO7	500866	8073579	Rocky hills
TB SRE FO8	501733	8073610	Pindan shrubland
TB SRE FO9	500265	8063650	Pindan shrubland
TB SRE FO10	500627	8069492	Pindan shrubland

*Based on habitat mapping from Level 2 survey (*ecologia* 2014-in press).
Datum: GDA94
Zone: 51K



ecologia ENVIRONMENT

Sheffield Resources LIMITED

Short Range Endemic invertebrate fauna sites

Figure: 2.3
Project ID: 1595

Drawn: NJ
Date: 21/07/14

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

Unique Map ID: NJ099

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2.5 SURVEY EFFORT

Survey effort expended within the study area included the following:

- six dry pitfall trapping grids were open for five nights, and four dry pitfall trapping grids were open for four nights;
- Twenty leaf litter samples were taken from the SRE dry pitfall grids; and
- 600 minutes were spent opportunistically foraging for SREs in suitable habitats.

Total survey effort per site is presented in Table 2.4.

Table 2.4 – SRE fauna survey effort

Site name	Relation to potential impact area	Dry pit traps (trap nights)	Leaf litter Samples	Foraging
TB SRE S1	Outside	75	2	-
TB SRE S2	Outside	75	2	-
TB SRE S3	Outside	75	2	-
TB SRE S4	Outside	75	2	-
TB SRE S5	Outside	75	2	-
TB SRE S6	Outside	75	2	-
TB SRE S7	Outside	60	2	-
TB SRE S8	Outside	60	2	-
TB SRE S9	Outside	60	2	-
TB SRE S10	Outside	75	2	-
TB SRE FO1	Outside	-	-	60
TB SRE FO2	Outside	-	-	60
TB SRE FO3	Outside	-	-	60
TB SRE FO4	Outside	-	-	60
TB SRE FO5	Outside	-	-	60
TB SRE FO6	Outside	-	-	60
TB SRE FO7	Outside	-	-	60
TB SRE FO8	Outside	-	-	60
TB SRE FO9	Outside	-	-	60
TB SRE FO10	Outside	-	-	60
Total		**705**	**20**	**600**

2.6 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 2.5. 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 2.5 and Table 2.6).

Table 2.5 – 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.	

2.6.1 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 2.5, Table 2.6).

Table 2.6 – 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).

2.7 DATA ANALYSIS

2.7.1 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.

2.8 TAXONOMY AND NOMENCLATURE

All specimens collected during the targeted SRE survey have been lodged with the WA Museum and identified by external specialists (Table 2.8).

2.9 SURVEY TEAM AND LICENCES

Field survey team members are listed in Table 2.7 and external consultants listed in Table 2.8. The survey was conducted under DPaW Regulation 17 Licence SF009836.

Table 2.7 – Field survey personnel

Survey member	Expertise	Experience (years)
Sean White	Entomology	12
Jordan Vos	Entomology/Herpetology	6

Table 2.8 – 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

3 RESULTS

3.1 FAUNA ASSEMBLAGES

A total of 12 invertebrate morphospecies were recorded during the targeted survey. All invertebrate fauna morphospecies records are shown in Appendix E, and are discussed in further detail below.

3.1.1 Mygalomorphae (Spiders)

During the survey, 34 mygalomorph specimens from the Nemesiidae family were collected. These were later classified into two species (*Aname* 'MYG284' and *Aname* 'MYG285'**)**, both of which are considered potential SREs.

3.1.2 Scorpiones (Scorpions)

44 specimens from two families were collected. 42 of the specimens belonged to the family Buthidae, and comprised two species (*Lychas* 'broome' and *Lychas* 'multipunctatus'), of which *Lychas* 'broome' was considered to be a potential SRE. The remaining two specimens belonged to the family Urodacidae; both represented the same species (*Urodacus* 'kraepelini') and were classed as a potential SRE.

3.1.3 Pseudoscorpiones (Pseudoscorpions)

Two pseudoscorpion specimens were collected. Both were identified as belonging to the genus *Indolpium* and were not considered to be SREs.

3.1.4 Isopoda (Slaters)

Thirteen isopod specimens from the Armadillidae family were collected during the survey. These were classed into four species (Buddelundiinae 'gen. indet. NE Broome', *Buddelundia* sp.74, *Buddelundia* sp.90 and *Buddelundia* sp.91), all of which are considered potential SREs. In addition, a single specimen could not be conclusively identified as only a single, small male was collected; however, the specimen was considered to represent a potential SRE (Armadillidae 'sp. indet.') as several other isopods with the same general morphology are considered SRE species (Phoenix 2014)

3.1.5 Opiliones (Harvestmen)

Eight opiliones specimens from the Assamiidae family were collected during the survey. All specimens were identified as belonging to the genus *Dampetrus* and were classed as a potential SRE.

485000 490000 495000 500000 505000 510000

8080000 8075000 8070000 8065000

N

0 1 2

Kilometres

Absolute Scale - 1:75,000

Legend

Mygalomorph taxon

- *Aname* 'MYG284'
- *Aname* 'MYG285'
- Pindan shrubland
- Sandstone range
- Savannah woodland
- Potential impact area
- Study area

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Locations of potential SRE mygalomorph spiders recorded during the survey

Figure: 3.1
Project ID: 1595

Drawn: NJ
Date: 21/07/14

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

Unique Map ID: NJ101

A3

485000 490000 495000 500000 505000 510000

8080000 8075000 8070000 8065000

N

0 1 2

Kilometres

Absolute Scale - 1:75,000

Legend

Scorpion taxon

- Lychas 'broome'
- Urodacus 'kraepelini'

Pseudoscorpion taxon

- Indolpium sp. indet.

- 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: 3.2
Project ID: 1595

Drawn: NJ
Date: 21/07/14

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

Unique Map ID: NJ100

A3

485000 490000 495000 500000 505000 510000

8080000 8075000 8070000 8065000

N

0 2 4

Kilometres

Absolute Scale - 1:75,000

Legend

Isopod taxon

- *Buddelundia* '74'
- *Buddelundia* '90'
- *Buddelundia* '91'
- Buddelundinae 'NE Broome'

Opiliones taxon

- *Dampetrus* sp.
- Potential impact area
- Pindan shrubland
- Sandstone range
- Savannah woodland
- Study area

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Locations of potential SRE isopods and opiliones recorded during the survey

Figure: 3.3
Project ID: 1595

Drawn: NJ
Date: 21/07/14

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

Unique Map ID: NJ102

A3

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4 DISCUSSION

A moderate diversity of invertebrate fauna from SRE groups was recorded during this survey, when compared to previous studies on the Dampier Peninsula (Appendix C). The isopods (family Armadilidae) were particularly well-represented, with at least four morphospecies recorded, and a further specimen whose identity could not be determined with certainty which is likely to represent a fifth taxon. In addition, three scorpion taxa were collected, including representatives from both the genus *Lychas* and the genus *Urodacus*, as well as two mygalomorph spiders from the genus *Aname*.

The survey yielded a total of 102 invertebrate specimens representing five orders, six families and 12 taxa. No species were identified as confirmed SREs, but nine taxa were considered potential SREs. In accordance with the precautionary principle, all potential SREs should be treated as confirmed SREs. Seven taxa collected from within the potential impact area during previous surveys (*ecologia* 2014), were confirmed outside of this area during the targeted survey. The taxonomy, distribution and SRE status of these species are discussed in the following sections.

4.1 MYGALOMORPHAE (TRAPDOOR SPIDERS)

4.1.1 Family: Nemesiidae (Wishbone Spiders)

***Aname* 'MYG284'**

SRE Status: Potential.

Aname 'MYG284' is a medium-sized species with reddish-brown carapace and light abdomen with a darker median band. This species was previously known only from the Thunderbird study area (*ecologia* 2014). The taxon is **considered a potential SRE** (Phoenix 2014). 16 specimens were collected from seven sites during this survey (all outside the potential impact area), confirming its presence outside the impact area.

***Aname* 'MYG285'**

SRE Status: Potential.

Aname 'MYG285' is a small species of *Aname* with morphological similarities to members of the genus *Teyl*. This species was also previously known only from the Thunderbird study area (*ecologia* 2014), and is **considered a potential SRE** (Phoenix 2014). 18 specimens were collected from nine locations during this survey (all outside the potential impact area), confirming its presence outside the impact area.

4.2 SCORPIONES (SCORPIONES)

4.2.1 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 and based on distribution patterns of species within the genus, *Lychas* 'broome' is **considered a potential SRE** (Phoenix 2014). Eight specimens of this taxon were recorded during this study, across five locations (all outside the potential impact area). This taxon was also recorded from within the potential impact area during the Level 2 surveys (*ecologia* 2014), and these records confirm its presence outside of this area.

4.2.2 Family: Urodacidae

***Urodacus* 'kraepelini'**

SRE Status: Potential.

Urodacus 'kraepelini' is a well-defined and clearly recognised morphospecies, known only from the vicinity of Broome. Based on distribution patterns of species in the genus, *Urodacus* 'kraepelini' is **considered a potential SRE** (Phoenix 2014). Two specimens of this taxon were recorded from two locations within the study area (both outside of the potential impact area). This taxon was also recorded from within the potential impact area during the Level 2 surveys (*ecologia* 2014), and these records confirm its presence outside of this area.

4.3 ISOPODA (SLATERS)

4.3.1 Family: Armadillidae

Armadillidae 'sp. indet.'

SRE Status: Potential.

The identity of a single isopod specimen collected from TB SRE 3 (outside of the potential impact area) could not be resolved because the only specimen was a single, small male. However, isopods of similar general morphology contain known SRE species, so this taxon is **considered a potential SRE** (Phoenix 2014).

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., it is **considered a potential SRE** (Phoenix 2014). Two specimens of this taxon were collected during this survey from TB SRE 2 (outside the potential impact area). This taxon was also recorded from within the potential impact area during the Level 2 surveys (*ecologia* 2014), and these records confirm its presence outside of this area.

***Buddelundia* sp.74**

SRE Status: Potential.

Buddelundia '74' is a well-recognised morphospecies and currently only known from this survey and the previous Level 2 survey of the area. During the Level 2 surveys (*ecologia* 2014), it was collected mainly from the sandstone range habitat outside of the potential impact area. A further specimen was collected during this survey from Quarry Camp (outside the potential impact area). Its SRE status cannot currently be determined due to the paucity of isopod collections in the area; however, based on distribution patterns within *Buddelundia*, *Buddelundia* '74' should be **considered a potential SRE** (Phoenix 2014). 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.

***Buddelundia* sp.90**

SRE Status: Potential.

Buddelundia '90' is a morphospecies distinguished by a number of unusual morphological characters notably the telson, uropod exopodites and the unusual shape of the clypeus (Phoenix 2014). It is currently known only from the single specimen collected during this survey, which was collected from TB SRE S2 in the ecotone between the rocky hill and pindan shrubland habitats (outside of the potential impact area). Its SRE status cannot currently be determined as the records from this area are the only records of the taxon thus far; however, based on distribution patterns within *Buddelundia*, *Buddelundia* '90' should be **considered a potential SRE** (Phoenix 2014).

***Buddelundia* sp.91**

SRE Status: Potential.

Buddelundia '91' is a morphospecies known only from eight specimens collected during this survey. These were collected from three sites in pindan woodland habitat outside of the potential impact area. The taxon was not recorded on previous surveys within the potential impact area. Its SRE status cannot currently be determined as the records from this area are the only records of the taxon thus far; however, based on distribution patterns within *Buddelundia*, *Buddelundia* '91' should be **considered a potential SRE** (Phoenix 2014).

4.3.2 Pseudoscorpiones (False Scorpions or Pseudoscorpions)

4.3.2.1 Family: Olpiidae

***Indolpium* 'sp. indet.'**

SRE Status: Not SRE.

Two specimens (an adult and juvenile) were collected from TB SRE S5 and TB SRE S7 (both outside the impact area). The previously collected pseudoscorpion from Thunderbird, Olpiidae 'genus indet.' (juvenile) (*ecologia* 2014), is potentially conspecific with this taxon, as it was collected from similar habitats through leaf-litter sampling. However, DNA analysis would be required to determine the relationship between these specimens. This taxon is **not considered a potential SRE** (Phoenix 2014).

4.3.3 Opiliones (Harvestmen)

4.3.3.1 Family: Assamiidae

***Dampetrus* sp.**

SRE Status: Potential.

One species of *Dampetrus* was recorded at seven sites during the targeted survey, all outside of the potential impact area. This taxon was recorded during the previous Level 2 fauna survey (*ecologia* 2014). *Dampetrus* sp. lacks taxonomic and geographical context, and as such, is **considered a potential SRE** (WAM 2013). This taxon was recorded from the extensive pindan shrubland and rocky hills habitats during the current survey, and has now been recorded from all three fauna habitat types present within the study area.

4.4 SUMMARY OF SHORT RANGE ENDEMIC INVERTEBRATE FAUNA AT THUNDERBIRD

Based on the results of the Level 2 and targeted surveys, 30 invertebrate taxa from SRE groups have been recorded from the Thunderbird study area (Table 4.1). Of these, 24 taxa have been recorded outside of the proposed impact area, with an additional five taxa (identified from female or juvenile specimens only) potentially conspecific with taxa occurring outside of the proposed impact area. However, genetic studies would be required to confirm the taxonomic relationships of these five taxa. A single distinctive taxon, *Lychas* 'JPP2', has only been recorded from within the proposed study area. However, based on its presence within the extensive pindan shrublands habitat, it is likely to occur well beyond the Thunderbird study area.

Table 4.1 – Summary of invertebrate fauna from SRE groups at Thunderbird

Class/Order, Family and Species	SRE Status	Thunderbird Fauna Assessment (2013)	This Survey	Presence confirmed outside potential impact area
Arachnida (Mygalamorphae) - Nemesiidae				
Aname 'MYG284'	Potential	●	●	●
Aname 'MYG285'	Potential	●	●	●
Aname 'MYG387'	Potential	●		●
Aname 'MYG387?'	Potential	●		Likely conspecific with *Aname* 'MYG387' (genetic work required to ascertain this)
Aname 'MYG388'	Potential	●		●
Aname 'sp. indet.'	Potential	●		Potentially conspecific with other *Aname* taxon (genetic work required to ascertain this)
Aname 'sp. juv'	Potential	●		Potentially conspecific with other *Aname* taxon (genetic work required to ascertain this)
Arachnida (Pseudoscorpiones) - Sternophoridae				
Afrosternophorus 'sp. indet.'	No	●		●
Arachnida (Pseudoscorpiones) - Olpiidae				
Beierolpium 'sp. 8/4'	No	●		●
Olpiidae 'genus indet. (juvenile)'	Potential	●		Potentially conspecific with *Indolpium* 'sp. indet.' (genetic work required to ascertain this)
Indolpium 'sp. indet.'	Not SRE		●	●
Arachnida (Pseudoscorpiones) - Chernetidae				
Haplochernes 'sp. Indet'	No	●		●
Arachnida (Scorpiones) - Buthidae				
Lychas 'annulatus'	No	●		●
Lychas 'broome'	Potential	●	●	●
Lychas 'JPP'	Potential	●		●
Lychas 'JPP2'	Potential	●		Likely to occur outside of proposed impact area based on habitat suitability. Recorded at

Class/Order, Family and Species	SRE Status	Thunderbird Fauna Assessment (2013)	This Survey	Presence confirmed outside potential impact area
				end of dry season only.
Lychas 'JPP3'	Potential	●		●
Lychas 'multipunctatus'	No	●	●	●
Arachnida (Scorpiones) - Urodacidae				
Urodacus 'kraepelini'	Potential	●	●	●
Urodacus 'sp. indet.'	Potential	●		Potentially conspecific with *Urodacus* 'kraepelini' (genetic work required to ascertain this)
Arachnida (Opiliones) - Assamiidae				
Dampetrus sp.	Potential	●	●	●
Malacostraca (Isopoda) - Armadillidae				
Armadillidae 'EE1501C'	Potential	●		●
Buddelundiinae 'Gen. indet. NE Broome'	Potential	●	●	●
Buddelundia 'sp.74'	Potential	●	●	●
Buddelundia '90'	Potential		●	●
Buddelundia '91'	Potential		●	●
Mollusca (Gastropoda) - Subulinidae				
Eremopeas interioris	No	●		●
Mollusca (Gastropoda) - Pupillidae				
Pupoides pacificus	No	●		●
Mollusca (Gastropoda) - Camaenidae				
Quistrachia leptogramma	Potential	●		●
Rhagada bulgana	Confirmed	●		●

4.5 SURVEY LIMITATIONS

Limitations of the current survey are summarised below in Table 4.2. Few limitations were encountered, confirming that an adequate level of survey has been undertaken for the purpose of this report.

Table 4.2 – Summary of survey limitations

Limitation	Relevant (yes/no)	Comment
Competency/experience of the consultant carrying out the survey.	No	All members of the survey team were experienced in targeted SRE surveys.
Scope (what faunal groups were sampled and were some sampling methods not able to be employed because of constraints such as weather conditions).	No	All targeted fauna groups were adequately sampled. Representative specimens from all targeted fauna groups were collected during the survey.
Proportion of fauna identified, recorded and/or collected.	No	All specimens from targeted fauna groups were collected and identified to the lowest taxonomic rank by taxonomic specialists.
Sources of information (previously available information as distinct from new data).	No	Seven 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 targeted SRE assessment was successfully completed. All fauna habitats and groups where the targeted fauna were previously recorded were sampled.
Timing/weather/season/cycle.	No	The timing of the survey was consistent with the first phase of the Level 2 survey (end of wet season), when the targeted SRE fauna were first collected. This timing is consistent with survey guidelines.
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 the majority of previously collected taxa 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	Identification of specimens was undertaken by personnel with significant experience in invertebrate classification. 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.
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.

5 CONCLUSIONS

The main conclusions from the study are as follows:

- A total of 12 invertebrate taxa from five orders were submitted for identification and SRE status assessment. The results from these assessments indicated that nine of these taxa should be considered potential SREs (two mygalomorph spiders, two scorpions, four isopods and one opiliones). Seven of the nine potential SREs were also recorded during the previous Level 2 surveys.
- All 12 invertebrate taxa were recorded outside of the potential impact area, providing important contextual data, particularly for three taxa that had previously only been recorded from within the proposed impact area.
- Based on the results of the Level 2 and targeted surveys, as well as the habitat preferences for the invertebrate taxa recorded within the Thunderbird study area, no potential SRE taxa are expected to be restricted to the proposed impact area.
- No significant limitations were experienced during the surveys. As a result, the survey can be considered adequate and to have met its 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	
May						
13th	21.7	33.5	0	24.1	35.9	0
14th	20.4	35.1	0	22.9	36.0	0
15th	20.6	33.6	0	20.0	34.6	0
16th	21.6	31.3	0	20.1	33.9	0
17th	21.3	32.2	9.8	22.4	34.0	0
18th	21.6	31.6	0	23.4	31.4	0
19th	20.4	34.6	0	20.6	35.4	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

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	Thunderbird Fauna Assessment (2013)	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	Thunderbird Fauna Assessment (2013)	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	●							
Indolpium 'sp. indet.'	Not SRE								●
Arachnida (Pseudoscorpiones) - Chernetidae									
Haplochernes 'sp. Indet'	No							●	
Arachnida (Scorpiones) - Buthidae									
Lychas 'annulatus'	No							●	
Lychas 'broome'	Potential							●	●
Lychas 'JPP'	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	Thunderbird Fauna Assessment (2013)	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							●	●
Buddelundia '90'	Potential								●
Buddelundia '91'	Potential								●
Mollusca (Gastropoda) - Subulinidae									
Eremopeas interioris	No							●	
Mollusca (Gastropoda) - Pupillidae									
Pupoides pacificus	No							●	
Mollusca (Gastropoda) - Camaenidae									
Quistrachia leptogramma	Potential	●	●	●	●			●	
Quistrachia sp.	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	Thunderbird Fauna Assessment (2013)	This Survey
Rhagada bulgana	Confirmed	●	●	●	●			●	
Rhagada reinga	No		●						
Rhagada sp.	Potential			●	●				
Mollusca (Gastropoda) – Punctidae									
Magilaoma sp. nov.	Potential				●				

APPENDIX D SURVEY SITE DESCRIPTIONS

Vegetation and Fauna Habitat Description	Site Photo
Dry Pitfall Sites	
TB SRE S1 **Fauna habitat type: Pindan shrubland** Moderately dense acacia woodland on a flat plain, with sparse ground cover of sorghum grass. Soil consisting of firm, fine grain sand with loose surface layer. No obvious disturbance beyond animal tracks.	
TB SRE S2 **Fauna habitat type: Rocky hills** Open woodland on a flat plain with dense acacia understorey and dense ground cover of sorghum. Soil firm and yellow-brown, with loose surface layer. No obvious disturbance beyond animal tracks.	

Vegetation and Fauna Habitat Description	Site Photo
TB SRE S3 **Fauna habitat type: Pindan shrubland** Tussock grassland on a flat sandplain with dense ground cover of sorghum. Isolated acacias and eucalypts present. Soil consisting of firm fine-grain sand with loose surface layer. No obvious disturbance beyond animal tracks.	
TB SRE S4 **Fauna habitat type: Pindan shrubland** Open eucalypt woodland on a flat plain with isolated acacias in the mid-storey. Ground cover dense sorghum. Soil consisting of sandy loam of firm strength, with a loose surface layer. No obvious disturbance beyond animal tracks.	

Vegetation and Fauna Habitat Description	Site Photo
TB SRE S5 **Fauna habitat type: Pindan shrubland** Open eucalypt woodland on a flat plain with dense ground cover of sorghum, and scattered grevilleas in the mid-storey. Soil consisting of fine-grain sand of firm strength, with loose surface layer. Relatively recent fire evidence (1-5 years fire age). No obvious disturbance beyond animal tracks	
TB SRE S6 **Fauna habitat type: Pindan shrubland** Moderately dense acacia woodland on a flat plain, with dense ground cover of sorghum. Soil consisiting of fine-grain orange sand of firm strength, with loose surface layer. No obvious signs of disturbance beyond animal tracks.	

Vegetation and Fauna Habitat Description	Site Photo
TB SRE S7 **Fauna habitat type: Pindan shrubland** Open eucalypt woodland on a gently sloping plain, with dense ground cover of sorghum and scattered acacias in the mid-storey. Soil consisting of orange fine-grain sand of firm strength, with loose surface layer. No obvious disturbance beyond animal tracks.	
TB SRE S8 **Fauna habitat type: Pindan shrubland** Moderately dense acacia woodland on flat plain, with dense ground cover of sorghum. Soil consisting orange fine-grain sand of firm strength, with loose surface layer. No obvious disturbance beyond animal tracks.	

Vegetation and Fauna Habitat Description	Site Photo
TB SRE S9 **Fauna habitat type: Pindan shrubland** Dense acacia shrubland on a flat plain, with moderately dense ground cover of spinifex (*Triodea* sp.). Soil consisting of orange sandy loam of firm strength, with a loose surface layer. No obvious disturbance beyond animal tracks.	
TB SRE S10 **Fauna habitat type: Pindan shrubland** Open eucalypt woodland on flat plain, with dense ground cover of sorghum and sparsely distributed acacias in the mid-storey. Soil consisting of weak sandy loam with loose surface layer. No obvious disturbance beyond animal tracks.	

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APPENDIX E FAUNA RECORDED DURING THE SURVEY

Class/Order, Family & Species	SRE Status	TB SRE S1	TB SRE S2	TB SRE S3	TB SRE S4	TB SRE S5	TB SRE S6	TB SRE S7	TB SRE S8	TB SRE S9	TB SRE S10	Foraging	Total
Araneae													
Aname 'MYG284'	Potential		2	3	5	1	1	3	1				16
Aname 'MYG285'	Potential	1		3	1	3	4	1		1		4	18
Pseudoscorpiones													
Indolpium 'sp. indet.'	Not SRE					1		1					2
Scorpiones													
Lychas 'broome'	Potential	1		2	1	3			1				8
Lychas 'multipunctatus'	No	21	2		3		1	3	3		1		34
Urodacus 'kraepelini'	Potential	1						1					2
Isopoda													
Armadillidae 'sp. indet.'	Unknown			1									1
Buddelundiinae 'genus indet. NE Broome'	Potential		2										2
Buddelundia sp.74	Potential											1	1
Buddelundia sp.90	Potential		1										1
Buddelundia sp.91	Potential			3	3					2			8
Opiliones													
Dampetrus sp.	Potential		2	1	2	1	1					2	8