

## **E.7: West Angelas Beyond 2020: Level 2 Vertebrate and SRE Invertebrate Fauna Assessment Phase 1 and 2**



## West Angelas Beyond 2020: Level 2 Vertebrate and SRE Invertebrate Fauna Assessment Phase 1 & 2

Biologic Environmental Survey

Report to Rio Tinto Iron Ore

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## West Angelas Beyond 2020:

### Level 2 Vertebrate and SRE Invertebrate Fauna Assessment

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## GLOSSARY

<b>BC Act</b>	Western Australian Biodiversity Conservation Act 2016
<b>CSIRO</b>	Commonwealth Scientific and Industrial Research Organisation
<b>DBCA</b>	Department Biodiversity, Conservation and Attractions
<b>DPaW</b>	Department of Parks and Wildlife
<b>DEWHA</b>	Department of Environment, Water, Heritage and the Arts
<b>DoE</b>	Department of the Environment
<b>DoEE</b>	Department of the Environment and Energy
<b>DSEWPaC</b>	Department of Sustainability, Environment, Water, Population and Communities
<b>EPA</b>	Western Australian Environmental Protection Authority
<b>EP Act</b>	Environmental Protection Act 1986
<b>EPBC Act</b>	Environment Protection and Biodiversity Conservation Act 1999
<b>IUCN</b>	International Union for the Conservation of Nature
<b>MNES</b>	Matters of National Environmental Significance
<b>PEC</b>	Priority Ecological Communities
<b>RTIO</b>	Rio Tinto Iron Ore
<b>SRE</b>	Short-range Endemism
<b>TEC</b>	Threatened Ecological Communities
<b>WAM</b>	Western Australian Museum

## EXECUTIVE SUMMARY

Rio Tinto Iron Ore commissioned Biologic Environmental Survey Pty Ltd to undertake vertebrate and short-range endemic (SRE) invertebrate fauna assessment within the proposed West Angelas Beyond 2020 project area. This report documents the findings of a desktop assessment and two field surveys, which were conducted to investigate the potential impacts of the project on fauna species and fauna habitat. The field surveys were conducted between 10 and 22 October 2018, and between 11 and 22 March 2019. The area surveyed (the Study Area) is comprised of five separate iron ore deposits (Western Hill, Deposit J & Mt Ella East, Deposit F North and Deposit H), which encompass 11,570 hectares of land located approximately 130 km northwest of Newman in the Pilbara region of Western Australia.

### Vertebrate Fauna

A desktop assessment, comprising searches of four databases of fauna records and a review of 18 relevant surveys previously conducted in the region, was undertaken prior to the field surveys. The assessment identified a total of 298 vertebrate fauna species that potentially occur in the Study Area: 41 native mammal species, eight introduced mammal species, 135 bird species, 107 reptile species and seven amphibian species. A total of 24 of these species are of conservation significance: seven mammals, 13 birds and four reptiles.

A two-phase level 2 survey was conducted across the Study Area. Mapping of broad fauna habitats in the region were extrapolated from previous survey work to include the Study Area and subsequently verified during the field surveys. Seven broad fauna habitat types were identified within the Study Area. These were, in decreasing order of extent within the Study Area: Hilltop, Hillslope, Ridge or Cliff; Foothill and Plain; Drainage Area; Mulga Spinifex Woodland; Minor Drainage; Gorge or Gully; and Mixed Acacia Woodland. Within the Study Area, the Gorge or Gully and Drainage Area habitat types were considered to be of high significance as they were found to support species of conservation significance or contain core habitat for such species. Gorge or Gully habitat is considered to be particularly significant for fauna of conservation significance because it contains a concentration of caves, rocky crevices and water holes, which represent core habitat for species such as the Northern Quoll (*Dasyurus hallucatus*), Pilbara Leaf-nosed Bat (*Rhinochiropterus aurantia*), Ghost Bat (*Macroderma gigas*), and Pilbara Olive Python (*Liasis olivaceus barroni*), all of which were recorded in the Study Area during the field surveys. A number of caves identified during the field surveys should be considered regionally significant for the Ghost Bat because they either represent maternity roosts of the species or represent potential maternity or diurnal roosts of the species. Mulga Spinifex Woodland, Hilltop, Hillslope, Ridge or Cliff and Mixed Acacia Woodland habitats were considered to be of moderate significance as they provide habitat for species of conservation significance but do not represent core habitat for these species. The two remaining habitats, Foothill and Plain and Minor Drainage, are considered to be of low significance as they are relatively widespread in the surrounding region, do not provide core habitat for species of conservation significance and do not solely support any Department Biodiversity, Conservation and Attractions (DBCA) listed Priority fauna.

The field surveys recorded a total of 158 vertebrate fauna species in the Study Area: 26 native mammal species, four introduced mammal species, 67 bird species, 59 reptile species, and two amphibian species. This is comparable to the number of species recorded in the area during previous surveys of a similar size and scope to the current assessment.

Of the 24 species of conservation significance considered to potentially occur in the Study Area, seven were recorded in the Study Area during the current field surveys, and an eighth species has been recorded in the Study Area during a previous survey. The eight species of conservation significance known to occur in the Study Area are the:

- Northern Quoll, which is listed as Endangered under both the *Western Australian Biodiversity Conservation Act 2016* (BC Act) and the *Commonwealth Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act)-;
- Pilbara Olive Python, Ghost Bat and Pilbara Leaf-nosed Bat, which are listed as Vulnerable under both the BC Act and EPBC Act-;
- Pilbara Flat-headed Blind-snake (*Anilius ganei*), which is listed by the DBCA as a Priority 1 species;
- Pilbara Barking Gecko (*Underwoodisaurus seorsus*), which is listed by the DBCA as a Priority 2 species - recorded during a previous survey only;
- Western Pebble-mound Mouse (*Pseudomys chapmani*), which is listed by the DBCA as a Priority 4 species; and
- Fork-tailed Swift (*Apus pacificus*), which is listed under both the BC Act and EPBC Act as a Migratory species.

Four species of conservation significance were considered Likely, or to Possibly, occur in the Study Area. The other species considered Likely, or to Possibly, occur in the Study Area are the Grey Falcon (*Falco hypoleucos*) and Peregrine Falcon (*Falco peregrinus*); Brush-tailed Mulgara (*Dasycercus blythi*) and Short-tailed Mouse (*Leggadina lakedownensis*). The remaining species of conservation significance identified by the desktop assessment were considered Unlikely or Highly Unlikely to occur in the Study Area.

It is likely that additional survey effort, including spotlighting and sampling after a period of rainfall that is more reflective of long-term patterns, would increase the number of species known to occur in the Study Area, particularly among reptiles and amphibians. Even so, additional survey effort would be unlikely to alter conclusions regarding the likelihood of occurrence of species of conservation significance, or the level of significance attributed to fauna habitats identified in the Study Area.

### **SRE Invertebrates**

A desktop assessment was undertaken to determine potential short-range endemism (SRE) within the Study Area. Fifteen invertebrate taxa previously recorded within 10 km of the Study Area have been confirmed as SRE species.

Of the seven broad habitats recorded in the Study Area, one is regarded to be of high suitability (Gorge or Gully), one of moderate/high suitability (Mixed Acacia Woodland) and three of moderate suitability

(Mulga Spinifex Woodland, Drainage Area and Hilltop, Hillslope, Ridge or Cliff) for invertebrate fauna. The remaining habitats are not considered suitable for SRE invertebrate fauna as they lack protection, complexity and/or are widespread, common and continuous.

A total of 330 invertebrate specimens were collected during the field surveys, including 36 mygalomorph spiders, one selenopid spider, 102 pseudoscorpions, 29 scorpions, 60 myriapods, 15 gastropods and 87 isopods. These belonged to 36 unique taxa. While none of these taxa are Confirmed SRE, 17 were considered to be Potential SRE. The remaining 19 taxa were considered to be Widespread.

## 1. INTRODUCTION

### 1.1. Background

Rio Tinto Iron Ore (RTIO) commissioned Biologic Environmental Survey Pty Ltd (Biologic) to undertake a two-season Level 2 vertebrate and short-range endemic (SRE) invertebrate fauna assessment for the proposed West Angelas Beyond 2020 project. This report documents the findings of this assessment, which will be used to inform future environmental approvals for the area. The area assessed (the Study Area) encompasses 11,570 hectares (ha) and is located approximately 130 kilometres (km) north-west of Newman in the Pilbara region of Western Australia (WA). The Study Area consists of five separate iron ore deposits: Western Hill, Deposit J & Mt Ella East, Deposit F North and Deposit H (Table 1.1, Figure 1.1).

**Table 1.1: Study Area Deposit details**

Deposit	Size study area (ha)	Type of survey	Survey timing	Relevant EPA standards/ Guidance statements	Survey Limitations
Western Hill	4,322.87	Two season Level 2 Vertebrate & SRE Invertebrate Fauna survey <ul style="list-style-type: none"> <li>Phase 1 – 2018 (dry)</li> <li>Phase 2 – 2019 (wet)</li> </ul>	<ul style="list-style-type: none"> <li>Phase 1 – 10-22 Oct 2018</li> <li>Phase 2 – 11-22 Mar 2019</li> </ul>	Surveys were undertaken in accordance with EPA Technical Guides: <ul style="list-style-type: none"> <li>Terrestrial Fauna Surveys (EPA, 2016c);</li> <li>Sampling Methods for Terrestrial Vertebrate Fauna (EPA, 2016b);</li> <li>Sampling of Short-range Endemic Invertebrate Fauna (EPA, 2016b)</li> </ul>	N/A
Deposit J & Mt Ella East	2,898.24				
Deposit F North	644.25	Single season Level 2 Vertebrate & SRE Invertebrate Fauna survey <ul style="list-style-type: none"> <li>Phase 1 – 2018 (dry)</li> </ul>	<ul style="list-style-type: none"> <li>Phase 1 – 10-22 Oct 2018</li> </ul>		Wasn't surveyed during wet season 2019, due previous survey effort in the area
Deposit H	3,704.66	Two season Level 2 Vertebrate & SRE Invertebrate Fauna survey <ul style="list-style-type: none"> <li>Phase 2 – 2019 (wet)</li> </ul>	<ul style="list-style-type: none"> <li>Phase 2 – 11-22 Mar 2019</li> </ul>		Survey was only completed for the Wet season, due to previous survey effort in the area

## 1.2. Objectives

The overarching objective of this assessment was to describe the vertebrate fauna and SRE invertebrate fauna species, fauna assemblages and fauna habitat present in the Study Area. The specific objectives of the assessment were to:

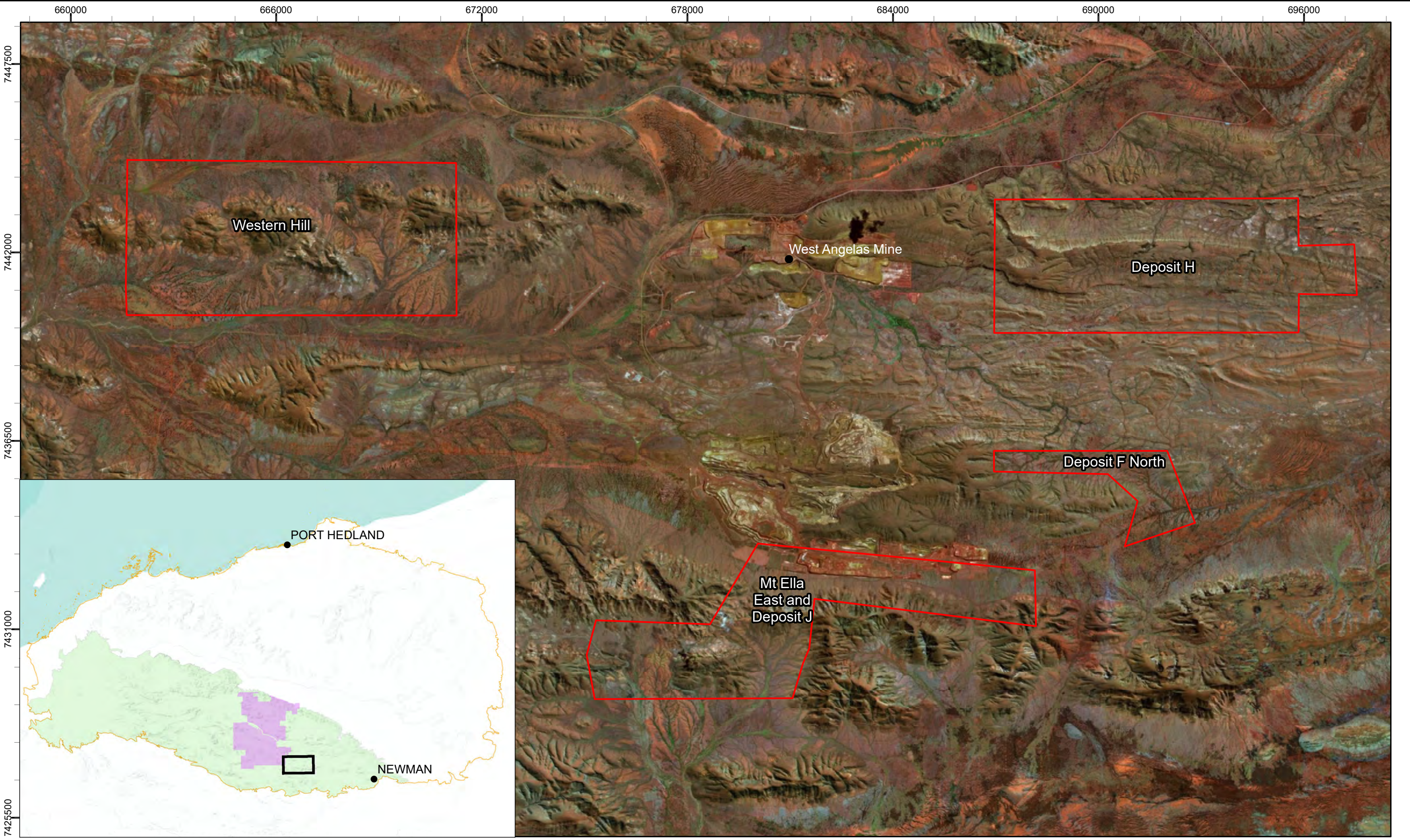
- conduct a comprehensive desktop assessment to identify vertebrate and SRE invertebrate fauna species which potentially occur within and within the vicinity of the Study Area;
- define and delineate broad fauna habitats occurring within the Study Area, and describe their significance to vertebrate and SRE invertebrate fauna;
- conduct a baseline survey to identify vertebrate fauna species and SRE invertebrate fauna occurring within the Study Area; and
- assess the likelihood and distribution of vertebrate fauna of conservation significance and SRE invertebrate fauna occurring within the Study Area.

## 1.3. Background to Protection of Fauna

### 1.3.1. Conservation Significance for Vertebrate Fauna

Native fauna in WA are protected at a state level under the *Biodiversity Conservation Act 2016* (BC Act) and at a national level under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act). Any action that has the potential to impact native fauna may need to be approved by relevant state and/or federal departments in accordance with the WA *Environmental Protection Act 1986* (EP Act) and the federal EPBC Act.


While all native fauna are protected under these Acts, some species are afforded extra protection. These include: species that are considered threatened under the BC Act and EPBC Act; migratory bird species that are protected under international agreements and subsequently listed as Migratory under the BC Act or EPBC Act; and species that may be threatened but for which there is not enough information available to allocate a threatened status, and which are subsequently listed as Priority species by the WA Department of Biodiversity, Conservation and Attractions (DBCA) (Table 1.2). For the purposes of this assessment, these Threatened, Migratory and Priority-listed species are considered to be of conservation significance.



**Legend**

- |                        |                        |
|------------------------|------------------------|
| Study Area             | <b>IBRA Subregions</b> |
| Karijini National Park | Hamersley              |
| Pilbara Bioregion      | Other                  |

**biologic**  
Environmental Survey



N  
1:100,000  
0 0.75 1.5 3 4.5 6 km

**RTIO – West Angelas Beyond 2020**  
**Terrestrial Fauna Assessment**  
**Figure 1.1: Study Area and regional location**

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

Size A3. Created 25/01/2019

**Table 1.2: Definitions and terms for vertebrate fauna of conservation significance**

Agreement, Act or List	Status Codes <sup>1</sup>
<b>Federal</b>	
<p><b>Environment Protection and Biodiversity Conservation Act 1999 (EPBC Act)</b></p> <p>In Australia, native fauna are protected under the EPBC Act. This Act makes provisions for an independent committee (the Threatened Species Scientific Committee [TSSC]), which is charged with maintaining a list of threatened species. Threatened species are listed under one of six categories, depending on their specific conservation status.</p> <p>Migratory bird species are those listed under international agreements and protected under the EPBC Act as a Matter of National Environmental Significance (MNES). Relevant international agreements include the Convention on the Conservation of Migratory Species of Wild Animals (Bonn Convention), China-Australia Migratory Bird Agreement (CAMBA), Japan-Australia Migratory Bird Agreement (JAMBA), and Republic of Korea-Australia Migratory Bird Agreement (ROKAMBA).</p>	<p><i>Threatened:</i></p> <ul style="list-style-type: none"> <li>• EX – Extinct</li> <li>• EW – Extinct in the Wild</li> <li>• CR – Critically Endangered</li> <li>• EN – Endangered</li> <li>• VU – Vulnerable</li> <li>• CD – Conservation Dependent</li> </ul> <p><i>Other:</i></p> <ul style="list-style-type: none"> <li>• MI – Migratory</li> </ul>
<b>State</b>	
<p><b>Biodiversity Conservation Act 2016 (BC Act)</b></p> <p>In WA, native fauna are protected under the BC Act. Species in special need of protection are listed as being Extinct, Threatened or Specially Protected. Within these groups, species are listed under one of eight categories, depending on their specific conservation status. Migratory bird species are those listed under the Bonn Convention and/or CAMBA, JAMBA and ROKAMBA agreements.</p>	<p><i>Extinct:</i></p> <ul style="list-style-type: none"> <li>• EX – Extinct</li> <li>• EW – Extinct in the Wild</li> </ul> <p><i>Threatened:</i></p> <ul style="list-style-type: none"> <li>• CR – Critically Endangered</li> <li>• EN – Endangered</li> <li>• VU – Vulnerable</li> </ul> <p><i>Specially Protected:</i></p> <ul style="list-style-type: none"> <li>• MI – Migratory</li> <li>• CD – Conservation Dependent</li> <li>• OS – Other specially protected fauna</li> </ul>
<p><b>DBCA Priority List</b></p> <p>The DBCA maintains a list of Priority species that are considered to be possibly threatened but have not been assigned statutory protection under the BC Act, as not enough information is available for an accurate determination of conservation status. These species are generally in urgent need of survey to determine their distribution and abundance.</p>	<p><i>Poorly Known:</i></p> <ul style="list-style-type: none"> <li>• P1 – Priority 1</li> <li>• P2 – Priority 2</li> <li>• P3 – Priority 3</li> </ul> <p><i>Rare, Near Threatened and other species in need of monitoring:</i></p> <ul style="list-style-type: none"> <li>• P4 – Priority</li> </ul>

<sup>1</sup>See Appendix A for definitions of status codes

### 1.3.2. Short-range Endemism

Endemism refers to the restriction of a species to a particular area, whether it is at the continental, national or local scale, the latter being commonly referred to as short-range endemism (Allen, Midgley & Allen, 2006; Harvey, 2002). Short-range endemism is influenced by several factors including life history, physiology, habitat requirements, dispersal capabilities, biotic and abiotic interactions and historical conditions which not only influence the distribution of a species, but also the tendency for differentiation and speciation (Ponder & Colgan, 2002).

In recent years a number of taxonomic groups of invertebrates have been highlighted as comprising a high proportion of species likely to be regarded as SREs (i.e. Harvey, 2002; terrestrial snails, Johnson, Hamilton, Murphy, MacLeay, Roberts & Kendrick, 2004; Mygalomorph spiders, Main, Samprey & West, 2000; freshwater snails, Ponder & Colgan, 2002). This identification of restricted taxonomic groups has led to SRE invertebrate fauna being recognised as a potentially significant biodiversity issue, and that SRE fauna “may be at a greater risk of changes in conservation status as a result of habitat loss or other threatening processes” (EPA, 2016b).

Harvey (2002) proposed a range criterion for terrestrial short-range endemic (SRE) species at less than 10,000 km<sup>2</sup> (or 100 km x 100 km), which has been adopted by regulatory authorities in Western Australia (EPA, 2016b). SRE invertebrate species often share similar biological, behavioural and life history characteristics that influence their restricted distributions and limit their wider dispersal (Harvey, 2002). For example, burrowing taxa such as mygalomorph spiders and *Urodacus* scorpions may only leave their burrows (or a narrow home territory around the burrow) as juveniles dispersing from the maternal burrow, or when males search for a mate. In other cases, SRE taxa are dispersal-limited because of their slow pace of movement and cryptic habitats (such as isopods, millipedes and snails), while some specialised taxa can be limited by very specific habitat requirements, such as selenopid spiders within fractured rocky outcrops.

An increasingly large number of terrestrial invertebrates are discovered to exhibit short-range endemism in Western Australia. While protection for listed species (species of conservation significance) and/ or Threatened or Priority Ecological Communities is provided under state and federal legislation (see Section 1.3.1), the majority of SRE species and communities are not currently listed. This is due largely to incomplete taxonomic or ecological knowledge. As such, the assessment of conservation significance for SRE is guided primarily by expert advice provided by the Western Australian Museum (WAM) and other taxonomic experts.

The SRE status categories used in this report broadly follow the WAM's revised categorisation for SRE invertebrates. This system is based upon the 10,000 km<sup>2</sup> range criterion proposed by Harvey (2002), and uses three broad categories to deal with varying levels of taxonomic certainty that may apply to any given taxon (Table 1.3).

**Table 1.3: SRE categorisation used by WAM taxonomists**

Distribution	Taxonomic Certainty	Taxonomic Uncertainty
< 10,000 km <sup>2</sup>	Confirmed SRE <ul style="list-style-type: none"> <li>• A known distribution of &lt; 10,000 km<sup>2</sup>.</li> <li>• The taxonomy is well known.</li> <li>• The group is well represented in collections and/ or via comprehensive sampling.</li> </ul>	Potential SRE <ul style="list-style-type: none"> <li>• Patchy sampling has resulted in incomplete knowledge of geographic distribution.</li> <li>• Incomplete taxonomic knowledge.</li> <li>• The group is not well represented in collections.</li> <li>• Category applies where there are significant knowledge gaps.</li> </ul>
> 10,000 km <sup>2</sup>	Widespread (not an SRE) <ul style="list-style-type: none"> <li>• A known distribution of &gt; 10,000 km<sup>2</sup>.</li> <li>• The taxonomy is well known.</li> <li>• The group is well represented in collections and/ or via comprehensive sampling.</li> </ul>	<b>SRE Sub-categories may apply:</b> <ul style="list-style-type: none"> <li>A) Data Deficient</li> <li>B) Habitat Indicators</li> <li>C) Morphology Indicators</li> <li>D) Molecular Evidence</li> <li>E) Research &amp; Expertise</li> </ul>

Under this system, "Potential SRE" status is the default categorisation for species within taxonomic groups prone to short-range endemism, including mygalomorph spiders, selenopid spiders, land snails, pseudoscorpions, scorpions, and isopods, unless sufficient evidence exists to confirm widespread or confirmed SRE status.

Potential SRE status is sub-categorised by what is currently known about the species in question; i.e. whether there are B) habitat indicators, C) morphology indicators, D) molecular evidence, or E) a weight of general knowledge and experience with the group that suggests a reasonable likelihood that the species could be SRE. In terms of SRE likelihood, the more evidence that exists under sub-categories 'B', 'C', 'D', and 'E', the greater the likelihood that further investigation would confirm that the species is an SRE.

However, the Potential SRE category 'A' - data deficient is unique; this category indicates that the current information is insufficient to adequately assess the SRE status of the taxa in question. In such cases, where the SRE status cannot be confirmed, a conservative approach would be unable to assess the species as high potential to be SRE where:

- A. the taxonomy of the genus (or family) requires significant review in order to make any statement on SRE status, and/or
- B. the genus is not known to include any confirmed SRE species within the region (subject to the extent of prior sampling / taxonomic effort).

To avoid confusion with other Potential SRE species for which there is some certainty and/or some precedent for their SRE status, this report represents the WAM's "Potential SRE - category 'A' - data deficient" only as "data deficient". The results from taxonomists are also presented within the broader

context of the results from habitat assessment, desktop review, habitat connectivity, and other ecological information collected during the survey. This approach aims to provide a more holistic assessment of SRE likelihood at scales relevant to the Study Area, as well as the standard SRE range criterion of <10,000 km<sup>2</sup> (Harvey, 2002).

#### 1.4. Compliance

This assessment was carried out in a manner consistent with the following guidelines and recommendations from the Western Australian Environmental Protection Authority (EPA), Department of Biodiversity Conservation and Attractions (DBCA) and the Department of the Environment and Energy (DoEE). Specifically, the assessment was undertaken with consideration of the following guidelines:

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

## 2. ENVIRONMENT

### 2.1. Biogeography

The Interim Biogeographic Regionalisation for Australia (IBRA) is a bioregional framework that divides Australia into 89 bioregions and 419 subregions on the basis of climate, geology, landforms, vegetation and fauna (Thackway & Cresswell, 1995). The Study Area falls within the Pilbara bioregion, which is characterised by vast coastal plains and inland mountain ranges with cliffs and deep gorges (Thackway & Cresswell, 1995). Vegetation is predominantly mulga low woodlands or snappy gum over bunch and hummock grasses (Bastin, 2008).

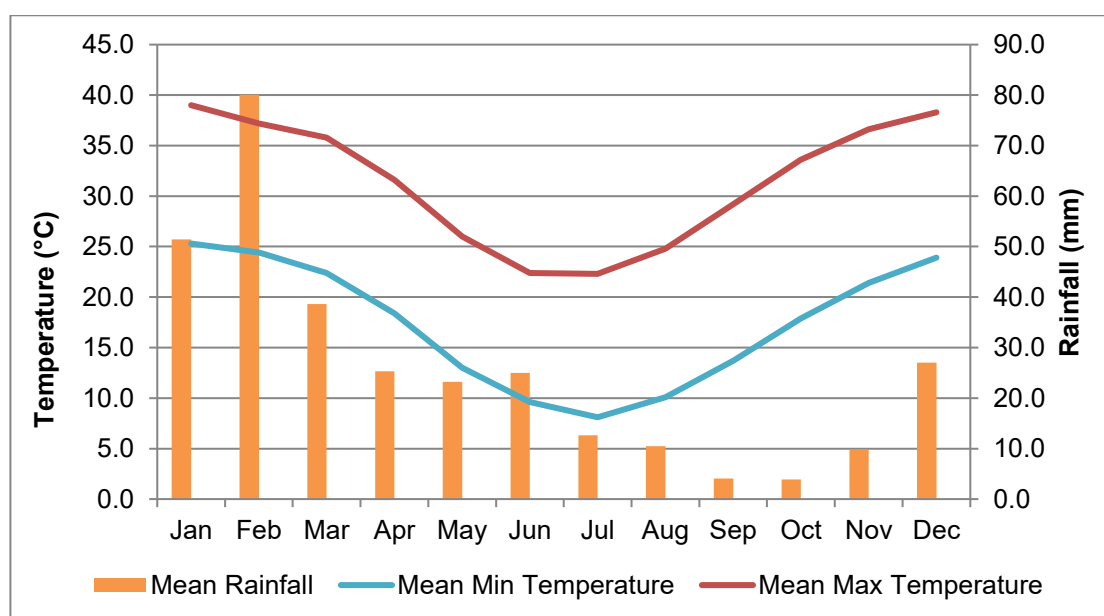
Within the Pilbara bioregion there are four subregions: Hamersley, Chichester, Roebourne and Fortescue Plains. The Study Area lies within the Hamersley subregion, which contains the southern section of the Pilbara Craton and consists of mountainous areas of Proterozoic sedimentary ranges and plateaus, dissected by gorges of basalts, shales and dolerite (Kendrick, 2001). The vegetation of the Hamersley subregion is predominantly mulga low woodlands over bunch grass on fine textured soils in valley floors, and *Eucalyptus leucophloia* over *Triodia* spp. on skeletal soils of the ranges (Kendrick, 2001). The Hamersley subregion drains into either the Fortescue River to the north, the Ashburton River to the south, or the Robe River to the west (Kendrick, 2001).

The Hamersley subregion contains important fauna habitats that support a variety of species of conservation significance. Springs and pools of the Robe River represent significant wetlands; deep gorges provide a refuge from fire and sources of water, and support relictual populations; calcrete deposits represent centres of invertebrate endemism; isolated mulga woodlands support assemblages that are rare in the surrounding region (Kendrick, 2001). Key threats to fauna and fauna habitat within the subregion include grazing pressure, mining and mine-dewatering.

## 2.2. Climate

The Pilbara region experiences a semi-desert to tropical climate with highly variable, mostly summer rainfall (McKenzie, May & McKenna, 2002) (Leighton, 2004). The Pilbara climate is heavily influenced by tropical cyclones that develop over the Indian Ocean in the north of Australia (Leighton, 2004). These sometimes cross the northwest coastline, bringing heavy rainfall to inland areas. The average annual rainfall across the Pilbara region ranges between 200 and 350 millimetres (mm) and, while most rain falls between January and March, rainfall can be highly localised and unpredictable, with substantial fluctuations occurring from year to year (van Etten, 2009).

The Newman airport weather station (located 109 km southeast of the Study Area) provides information about long-term temperature and rainfall patterns in the area (Figure 2.1). Summer occurs from November to February and has mean maximum and minimum temperatures of 38.3°C and 23.6°C, respectively. Winter occurs from June to August and has mean maximum and minimum temperatures of 24.0°C and 7.23°C, respectively. Rainfall primarily occurs in the first half of the year and averages 329.5 mm on an annual basis.



**Figure 2.1: Average monthly climate data recorded at Newman**

Source: BoM (2019), weather station 7176 (1971-2019)

### 2.3. Land Systems

A regional survey was undertaken in the Pilbara region between 1995 and 1999 by the Department of Agriculture (now the Department of Primary Industries and Regional Development) and the Department of Land Administration (now Landgate), to develop a comprehensive description of biophysical resources and assess the vegetation composition and soil condition within the region. This information was used by to classify and map the land systems of the Pilbara region according to similarities in landform, soil, vegetation, geology and geomorphology (Curry, Payne, Leighton, Hennig & Blood, 1994; Payne, Mitchell & Holman, 1988; Van Vreeswyk, Leighton, Payne & Hennig, 2004)

The Study Area occurs across six land systems (Table 2.1; Figure 2.2). The majority (44%) of the Study Area occurs within the Newman land system, which consists of rocky uplands supporting spinifex. The second most extensive land system is the Boolgeeda land system (29% of the Study Area), while the remaining four land systems within the Study Area each occupy less than 13% of the Study Area.

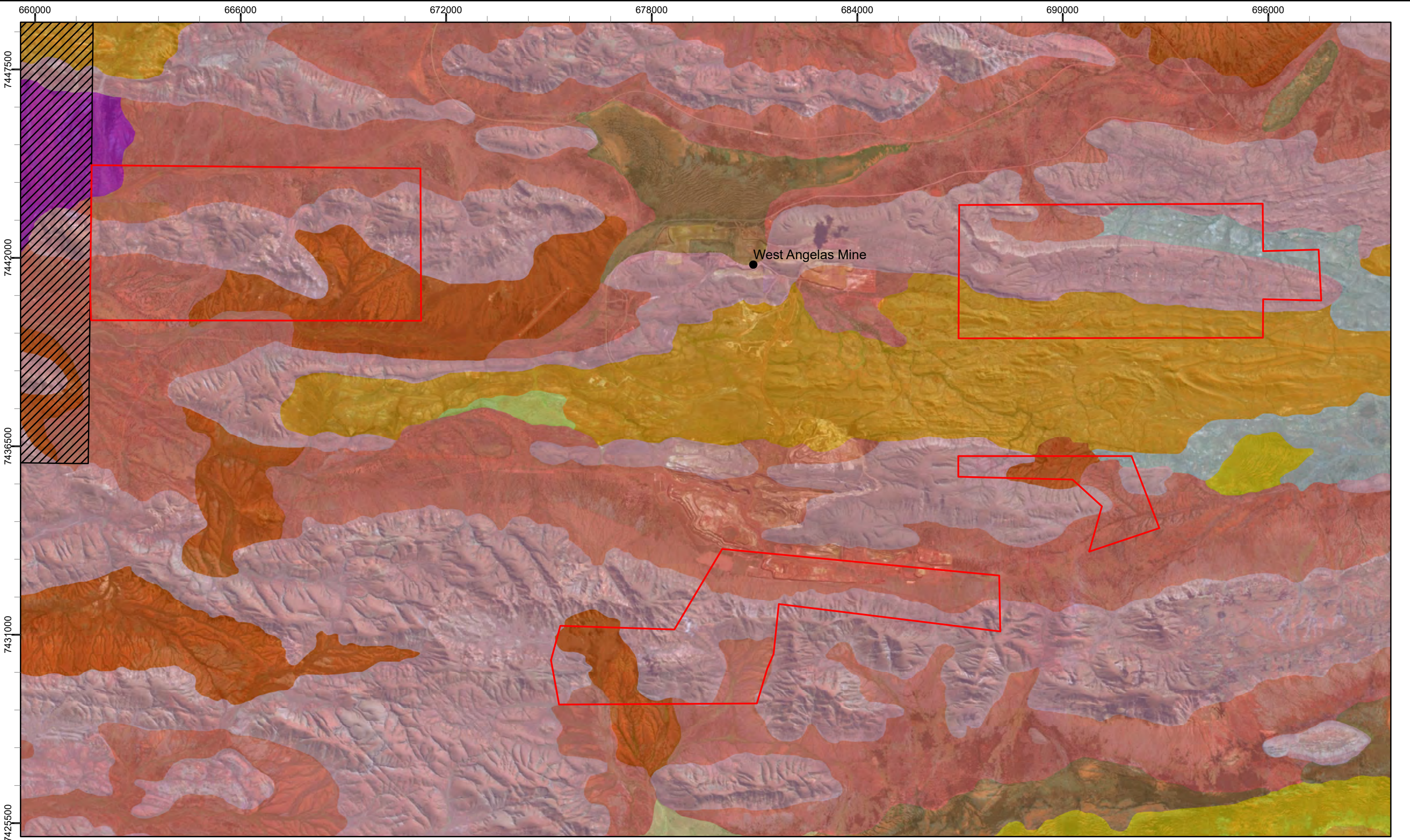
The elevated rocky landforms of the Newman land system are unique to the Pilbara and a defining feature of the Hamersley subregion. They are particularly important to fauna species of conservation significance as they contain a concentration of habitat features which are not found elsewhere. Rocky ridges host caves and rocky crevices which can be used as roosts and den sites by the Northern Quoll (*Dasyurus hallucatus*), Pilbara Leaf-nosed Bat (*Rhynonictis aurantia*), Ghost Bat (*Macroderma gigas*), and Pilbara Olive Python (*Liasis olivaceus barroni*). Rocky gorges and gullies also support the formation of water pools, which can often persist into dry periods and therefore provide an important source of water within the arid landscape. Water sources are particularly important as foraging sites for the above-mentioned species as they support a variety of prey species.

The rocky and stony terrain of the Newman and other land systems in the Study Area are also relied upon by various other species of conservation significance restricted to the region, including the Pilbara Barking Gecko (*Underwoodisaurus seorsus*) and Pilbara Flat-headed Blind-snake (*Anilius ganei*).


Mulga shrublands within the Boolgeeda, Egerton and Jamindie land systems provide important habitat features such as leaf litter accumulations, woody debris, small hollows, peeling bark, and a thick upper canopy; however, these shrublands are generally common and widespread across the Pilbara region, particularly to the south within the Fortescue subregion. Mulga shrublands are also relatively widespread across other parts of Western Australia, such as the Gascoyne and Murchison bioregions.


**Table 2.1: Land Systems mapped within the Study Area and their extent**

Land System	Description	Extent in Study Area	
		Area (ha)	%
<b>Newman</b>	Rugged jaspilite plateaux, ridges and mountains supporting hard spinifex grasslands.	5,095	44.0
<b>Boolgeeda</b>	Stony lower slopes and plains below hill systems supporting hard and soft spinifex grasslands or mulga shrublands.	3,408	29.5
<b>Platform</b>	Dissected slopes and raised plains supporting hard spinifex grasslands.	1,478	12.8
<b>Rocklea</b>	Basalt hills, plateaux, lower slopes and minor stony plains supporting hard spinifex (and occasionally soft spinifex) grasslands.	980	8.5
<b>Egerton</b>	Highly dissected hardpan plains supporting mulga shrublands and hard spinifex hummock grasslands.	534	4.6
<b>Jamindie</b>	Stony hardpan plains and rises supporting groved mulga shrublands, occasionally with spinifex understorey.	75	0.7
<b>Total</b>		11,570	100





**Legend**  


 StudyArea


 Karijini National Park


**Land System**  


 Boolgeeda


 Egerton


 Elimunna


 Jamindie


 Newman


 Pindering

 Platform

 Rocklea

 Spearhole

 Wannamunna



N

1:100,000

0

0.75

1.5

3

4.5

6

km

**RTIO – West Angelas Beyond 2020**  
**Terrestrial Fauna Assessment**  
**Figure 2.2: Land Systems of the Study Area**

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

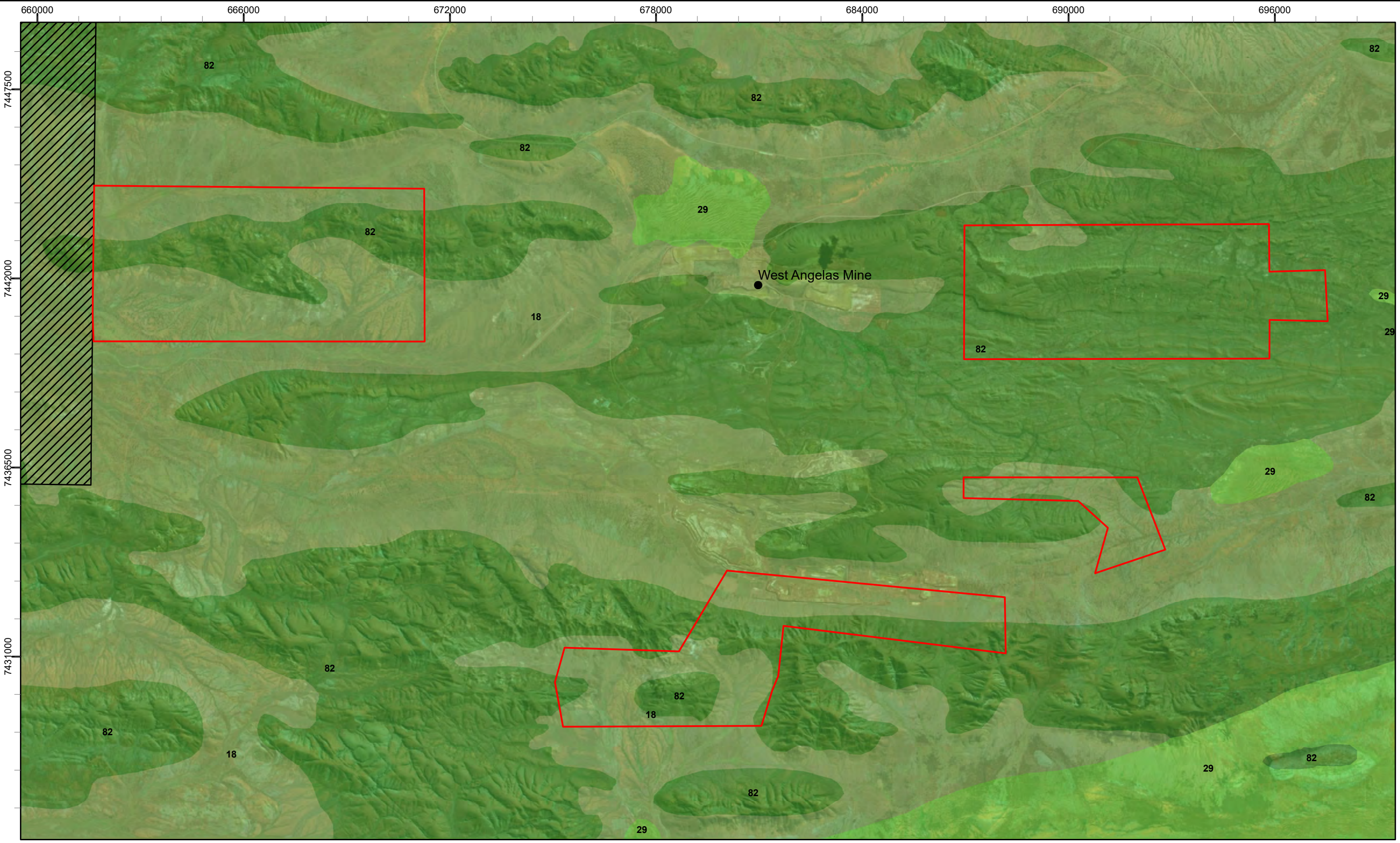
Size A3. Created 28/01/2019

## 2.4. Pre-European Vegetation

The Study Area is located within the Eremaean Botanical Province, which is generally characterised by vegetation adapted to an arid environment. Extensive mapping projects have provided detailed information about the vegetation of Western Australia, including the Study Area. Specifically, Beard (1975) broadly mapped the major structural vegetation types of Western Australia and Shepherd, Beeston and Hopkins (2002) updated the mapping to reflect the National Vegetation Information System (NVIS) standards (ESCAVI, 2003). These efforts describe the vegetation of Western Australia in terms of vegetation associations.

Two vegetation associations mapped by Shepherd, Beeston and Hopkins (2002) occur within the Study Area. These are 'Acacia open shrubland / *Ptilotus* mixed open forbland', which covers 47.2% of the Study Area, and 'Eucalyptus open woodland / *Senna* mixed sparse shrubland / *Triodia* open hummock grassland' which covers 52.8% of the Study Area (Figure 2.3).

In general, the 'Eucalyptus open woodland / *Senna* mixed sparse shrubland / *Triodia* open hummock grassland' vegetation association occurs within the rocky upland areas of the Study Area, being closely aligned with the Newman, Egerton and Rocklea land systems. The *Acacia* open shrubland / *Ptilotus* mixed open forbland' vegetation association generally occurs on the lower-lying foothills and plains areas of the Study Area.



**Legend**

- Study Area
- Karijini National Park

**Vegetation Association**

- 18 - *Acacia* open shrubland/ *Ptilotus* mixed open forbland
- 29 - *Acacia* sparse shrubland/ *Ptilotus* mixed open forbland
- 82 - *Eucalyptus* open woodland/ *Senna* mixed sparse shrubland/ *Triodia* open hummock grassland

**biologic**  
Environmental Survey

N  
1:100,000  
0 0.75 1.5 3 4.5 6 km

**RTIO – West Angelas Beyond 2020**  
**Terrestrial Fauna Assessment**  
**Figure 2.3: Pre-European Vegetation of the Study Area**

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

Size A3. Created 28/01/2019

## 2.5. Geology

The geology of the West Angelas area, including the Study Area, is dominated by the Wonmunna Anticline, which has an east-west axis and plunges towards the west (Figure 2.4). The centre of the Anticline comprises a low lying plateau of Jeerinah Formation which is bounded to the north and south by younger units of the Hamersley Group (Dodson 2006). Northern and a southern flanking valleys lie either side of the Anticline. On the southern and northern catchment margins, the valleys are bound by high ridges of Brockman Iron Formation (Table 2.2; Figure 2.4).

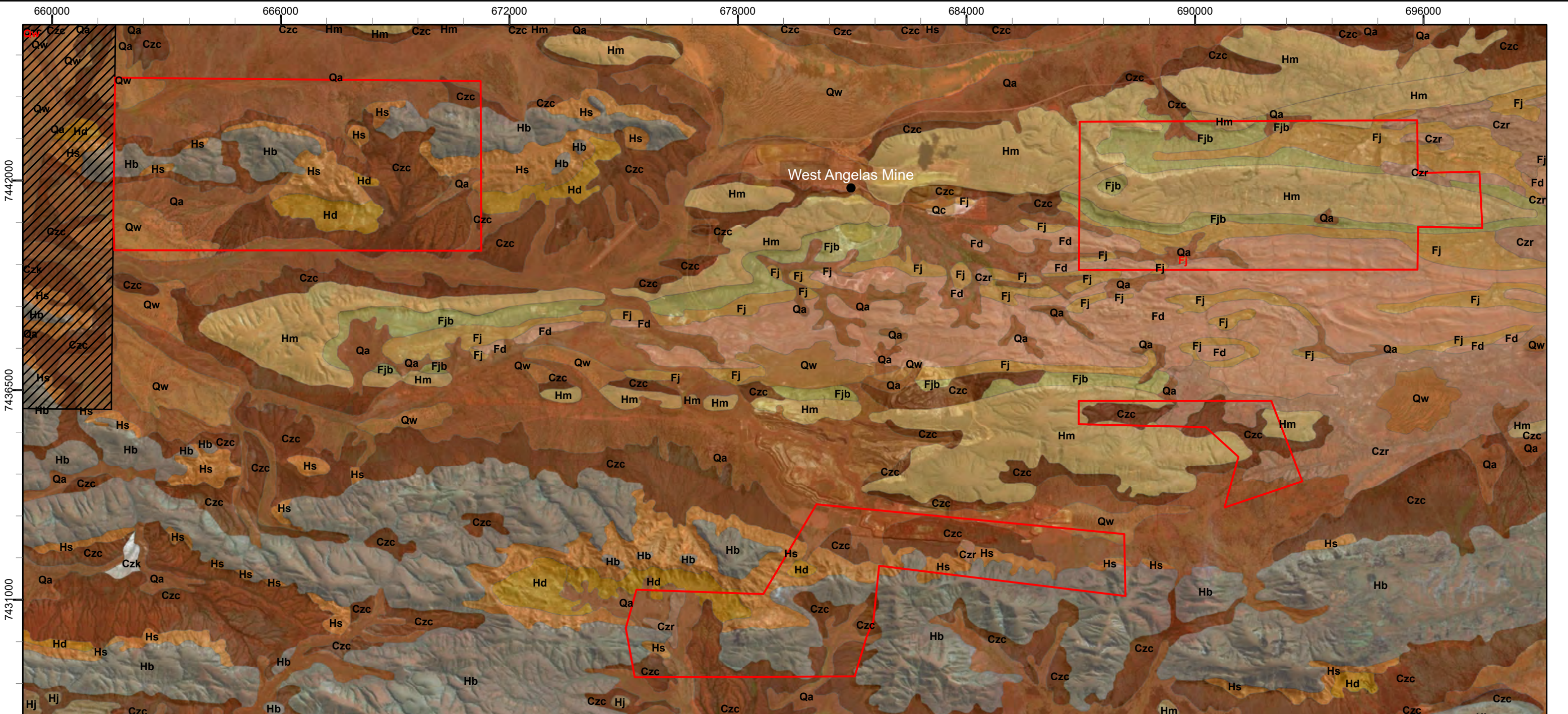
The West Angelas deposits are formed in Marra Mamba Iron Formation as well as the West Angelas Member of the overlying Wittenoom Formation (Rio Tinto 2018). The lower Marra Mamba Iron Formation Members contain significant proportions of shale, chert and dolomites, while the upper Member contains more Brockman Iron Formation. Weathering of the Marra Mamba formation has also produced a significant hydrated/mineralised zone (goethite-martite hardcap) over the bedrock. Tertiary and quaternary detritals (colluvium/ alluvium) cover the lower slopes and valley floors, occasionally featuring secondary deposits such as pisolite/channel iron deposit (CID) and calcrete deposited in areas near the historic (and in some cases present) water table (Table 2.2).

The Brockman Iron and Marra Mamba Formations are particularly significant for fauna as they support the formation of caves, which offer stable microclimates, shelter and protection (Medellin, Wiederholt & Lopez-Hoffman, 2017). A number of species of conservation significance rely on caves for roost and den sites, including the Northern Quoll, Pilbara Leaf-nosed Bat, Ghost Bat and Pilbara Olive Python. Caves utilised by these species have been previously recorded at West Angelas within Marra Mamba Formations (Biologic, 2018).

Areas of the Brockman Formation occur in the three western deposits (Western Hill and Deposit J and Mt Ella East), while Marra Mamba Formation is a feature of the two eastern deposits (Deposit F North and Deposit H). Notably, these cave-forming upland areas are separated from each by lower-lying slopes and plains associated with the Boolgeeda and Rocklea land systems. Terrestrial fauna which are supported by upland areas containing caves therefore have a limited ability to disperse across the Study Area. A certain level of connectivity between the upland areas of Deposit F North and Deposit J and Mt Ella East is afforded by a narrow valley containing stony lower slopes of the Boolgeeda land system. Similarly, a stretch of hills, slopes and plains associated with the Rocklea land systems connects the upland areas of Deposit F North with those of Deposit J. Although upland areas of the Study Area are not continuous between the deposits, it is important to note that they are well-connected to similar landforms extending outside the Study Area, with the surrounding area generally consisting of network of rocky ranges and stony slopes and plains.

**Table 2.2: Geology units within the Study Area**

Geological Unit	Description	Code	Extent in Study Area	
			ha	%
<b>Alluvium</b>	Unconsolidated silt, sand and gravel	Qa	2,424	20.9
<b>Colluvium</b>	Partly consolidated valley-fill deposits	Czc	2,323	20.1
<b>Marra Mamba Iron Formation</b>	Chert, ferruginous chert and banded iron-formation with minor shale	Hm	1,512	13.1
<b>Brockman Iron Formation</b>	Banded iron-formation, chert and minor shale (2490+-20 Ma, U-Pb)	Hb	1,366	11.8
<b>Laterite</b>	Surficial hematite-goethite deposits on banded iron-formation; forms Hamersley Surface	Czr	350	3.0
<b>Mount McRae Shale &amp; Mount Sylvia Formation</b>	Interbedded shale, chert and banded iron-formation	Hs	908	7.9
<b>Metabasalt</b>	Pillows locally well developed	Fjb	751	6.5
<b>Jeerinah Formation</b>	Interbedded mudstone, siltstone and chert with minor felsic tuff, dolomite and sandstone	Fj	715	6.2
<b>Metadolerite sills intruded into Fortescue Group</b>	Medium- to coarse-grained, massive grey-green rock, usually foliated	Fd	573	4.9
<b>Alluvium and colluvium</b>	Red-brown sandy and clayey soil	Qw	332	2.9
<b>Wittenoom Dolomite</b>	Dolomite; interbedded thin chert, shale and dolomite in upper part	Hd	316	2.7
<b>Total</b>			11,570	100



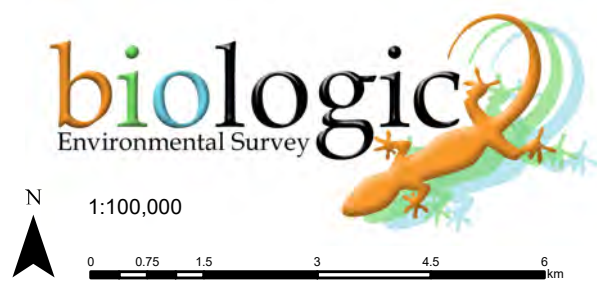
**Geological Units (1:250,000)**

- Czc Colluvium - partly consolidated valley-fill deposits
- Czk - Calcrete - sheet carbonate usually formed in major drainage lines
- Czr - Laterite, includes surficial hematite-goethite deposits on banded iron-formation; forms Hamersley Surface
- Fd - Metadolerite sills intruded into Fortescue Group; medium- to coarse-grained, massive grey-green rock, usually foliated

- Fj - Jeerinah Formation: interbedded mudstone, siltstone and chert with minor felsic tuff, dolomite and sandstone
- Fjb - Metabasalt; pillows locally well developed
- Hb- Brockman Iron Formation: banded iron-formation, chert and minor shale (2490+-20 Ma, U-Pb)
- Hd - Wittenoom Dolomite: dolomite; interbedded thin chert, shale and dolomite in upper part
- Hj - Weeli Wolli Formation: interlayered banded iron-formation and metadoleritic sills, minor shale

- Hm - Marra Mamba Iron Formation: chert, ferruginous chert and banded iron-formation with minor shale
- Hs - Mount McRae Shale and Mount Sylvia Formation: interbedded shale, chert and banded iron-formation
- Qa - Alluvium - unconsolidated silt, sand and gravel
- Qc - Colluvium - unconsolidated quartz and rock fragments in soil
- Qw - Alluvium and colluvium - red-brown sandy and clayey soil

- Legend**
- Study Area
  - Karijini National Park



**RTIO – West Angelas Beyond 2020**  
**Terrestrial Fauna Assessment**  
**Figure 2.4: Geology of the Study Area**

Coordinate System: GDA 1994 MGA Zone 50  
Projection: Transverse Mercator  
Datum: GDA 1994  
Size A3. Created 25/01/2019

## 2.6. Threatened and Priority Ecological Communities

An ecological community is a group of flora, fauna and other organisms that interact in a unique environment and thereby form a distinct community within a defined area. Conservation efforts often focus on protecting whole ecological communities so that both important species and their habitats are protected. The BC Act and EPBC Act provide protection of ecological communities listed as being threatened i.e. Threatened Ecological Communities (TECs). In WA, ecological communities that are not listed as TECs, but are considered to possibly be threatened, or which are rare but not currently threatened, have been listed by the DBCA as Priority Ecological Communities (PECs).

No TECs or PECs occur within the Study Area; however, three PECs are located close by (Table 2.3; Figure 2.5). These are the 'West Angelas Cracking-Clays', Brockman Iron cracking clay communities of the Hamersley and the 'Coolibah-lignum flats: *Eucalyptus victrix* over *Muehlenbeckia*' (Table 2.3; Figure 2.5).

The 'West Angelas Cracking-Clays' PEC occurs as close as 1.5 km to the Study Area and is located on tenure held by RTIO (Figure 2.5). It covers approximately 440 ha in the West Angelas region but is relatively uncommon in the wider surrounds. This PEC represents important habitat for the Short-tailed Mouse (*Leggadina lakedownensis*) (van Dyck & Strahan, 2008). Key threats to the PEC include mine development and introduction of weeds (DBCA, 2017). RTIO manages this PEC in accordance with the requirements of West Angelas Iron Ore Project State Ministerial Statement 1113.

The Brockman Iron cracking clay communities of the Hamersley occurs approximately ~1km northwest of the Western Hill Study Area. This community is classified by rare tussock grassland dominated by *Astrebla lappacea* (not every site has presence of *Astrebla*) in the Hamersley Range, on the Brockman land system. Tussock grassland on cracking clays- derived in valley floors, depositional floors. This is a rare community and the landform is rare. Known from near West Angeles, Newman, Tom Price and boundary of Hamersley and Brockman Station

The 'Coolibah-lignum flats: *Eucalyptus victrix* over *Muehlenbeckia* community' PEC occurs approximately 9 km north of the Study Area and is located on tenure held by a third party. This area is likely to attract species of conservation significance that prefer woodlands, which provide opportunities for roosting, nesting and denning within hollows. Such species may include the Northern Brushtail Possum (*Trichosurus vulpecula arnhemensis*) and Grey Falcon (*Falco hypoleucos*). The PEC is also believed to contain important foraging habitat for the Ghost Bat (Biologic, 2016a).

## 2.1. Significant areas





Karijini National Park covers 627,422 ha located just north of the Tropic of Cancer in the Hamersley Range and is Western Australia's second largest National Park. The West Angelas Study Area, specifically Western Hill Deposit borders the Karijini National Park to the west of the deposit. Karijini is located ~12 km west of the existing West Angela's Project Mine (Figure 1.1). Conservation significant species such as Northern Quoll, Ghost Bat, Pilbara Leaf-nosed Bat and Pilbara Olive Python have all been recorded within the Karijini National Park.

**Table 2.3: Priority Ecological Communities located near the Study Area**


PEC	Proximity to Study Area	Description	WA Priority Status	Threats
West Angelas Cracking-Clays	~1.5 km east of Deposit H ~2.5 km south of Deposit Western Hill ~3.5 km north of Deposit J & Mt Ella ~4 km south east of Deposit F	Open tussock grasslands of <i>Astrebla pectinata</i> , <i>Astrebla elymoides</i> , <i>Aristida latifolia</i> in combination with <i>Astrebla squarrosa</i> and low scattered shrubs of <i>Sida fibulifera</i> , on basalt derived cracking clay loam depressions and flowlines	Priority 1	Disturbance footprints increasing from mine, future infrastructure development, possible weed invasion and changes in fire regime.
Brockman Iron Cracking Clay communities of the Hamersley Range	~1km Northwest of Deposit Western Hill	Rare tussock grassland dominated by <i>Astrebla lappacea</i> (not every site has presence of <i>Astrebla</i> ) in the Hamersley Range, on the Brockman land system. Tussock grassland on cracking clays- derived in valley floors, depositional floors. This is a rare community and the landform is rare. Known from near West Angeles, Newman, Tom Price and boundary of Hamersley and Brockman Station	Priority 1	Heavily grazed, mining and infrastructure developments
Coolibah-lignum flats: <i>Eucalyptus victrix</i> over <i>Muehlenbeckia</i>	~9km north of the Study Area	Woodland or forest of <i>Eucalyptus victrix</i> (coolabah) over thicket of <i>Duma florulenta</i> (lignum) on red clays in run-on zones. Associated species include <i>Eriachne benthamii</i> , <i>Themeda triandra</i> , <i>Aristida latifolia</i> , <i>Eulalia aurea</i> and <i>Acacia aneura</i> . Sub types include:		Dewatering and grazing, altered hydrological regimes, clearing associated with infrastructure corridors.
		• Coolibah and mulga ( <i>Acacia aneura</i> ) woodland over lignum and tussock grasses on clay plains (Coondewanna Flats and Wanna Munna Flats)	Priority 3i	
		• Coolibah woodlands over lignum ( <i>Duma florulenta</i> ) over swamp wandiree (Lake Robinson is the only known occurrence)	Priority 1	

Source: DBCA (2017)



- Legend**
-  Study Area
  -  Brockman Iron cracking clay communities
  -  Coolibah - Lignum Flats, sub type 2
  -  West Angelas West Angelas Cracking-Clays

**biologic**  
Environmental Survey



N  
1:150,000  
0 1 2 4 6 8 km

**RTIO – West Angelas Beyond 2020**  
**Terrestrial Fauna Assessment**  
**Figure 2.5: Priority Ecological Communities located near the Study Area**

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

Size A3. Created 28/01/2019

### 3. DESKTOP ASSESSMENT

A desktop assessment comprising database searches and a literature review was undertaken prior to the field survey. The purpose of the desktop assessment was to identify fauna potentially occurring in the Study Area, particularly species of vertebrate fauna of conservation significance and SRE invertebrate fauna.

#### 3.1. Database Searches

A total of eight databases were searched, including four targeting vertebrate fauna species and four targeting SRE invertebrate species (Table 3.1).

**Table 3.1: Details of database searches conducted**

Database	Source	Information	Date of search	Search parameters
Threatened Fauna Database	Department of Biodiversity, Conservation and Attractions (DBCA, 2019a)	Previous records of vertebrate fauna species of conservation significance	13/08/2018	Circle of radius 100 km centred on the coordinates: -23.15917 118.76743
NatureMap	Department of Biodiversity, Conservation and Attractions (DPaW, 2018)	Previous records of vertebrate fauna species	13/08/2018	Circle of radius 40 km centred on the coordinates: -23.15917 118.76743
Birddata Custom Bird Atlas	BirdLife Australia (BirdLife Australia, 2018)	Previous records of bird species	13/08/2018	
Protected Matters Database Search Tool	Department of Environment and Energy (DoEE, 2018)	Vertebrate fauna species of conservation significance known or likely to occur	13/08/2018	
SRE Species Occurrence Search	Atlas of Living Australia (ALA, 2019)	Previous records of SRE invertebrate fauna species	13/08/2018	
Arachnid/Myriapod Database	Western Australian Museum (WAM, 2019a)		17/08/2018	
Mollusc Database	Western Australian Museum (WAM, 2019c)		20/08/2018	
Crustacean Database	Western Australian Museum (WAM, 2019d)		17/08/2018	

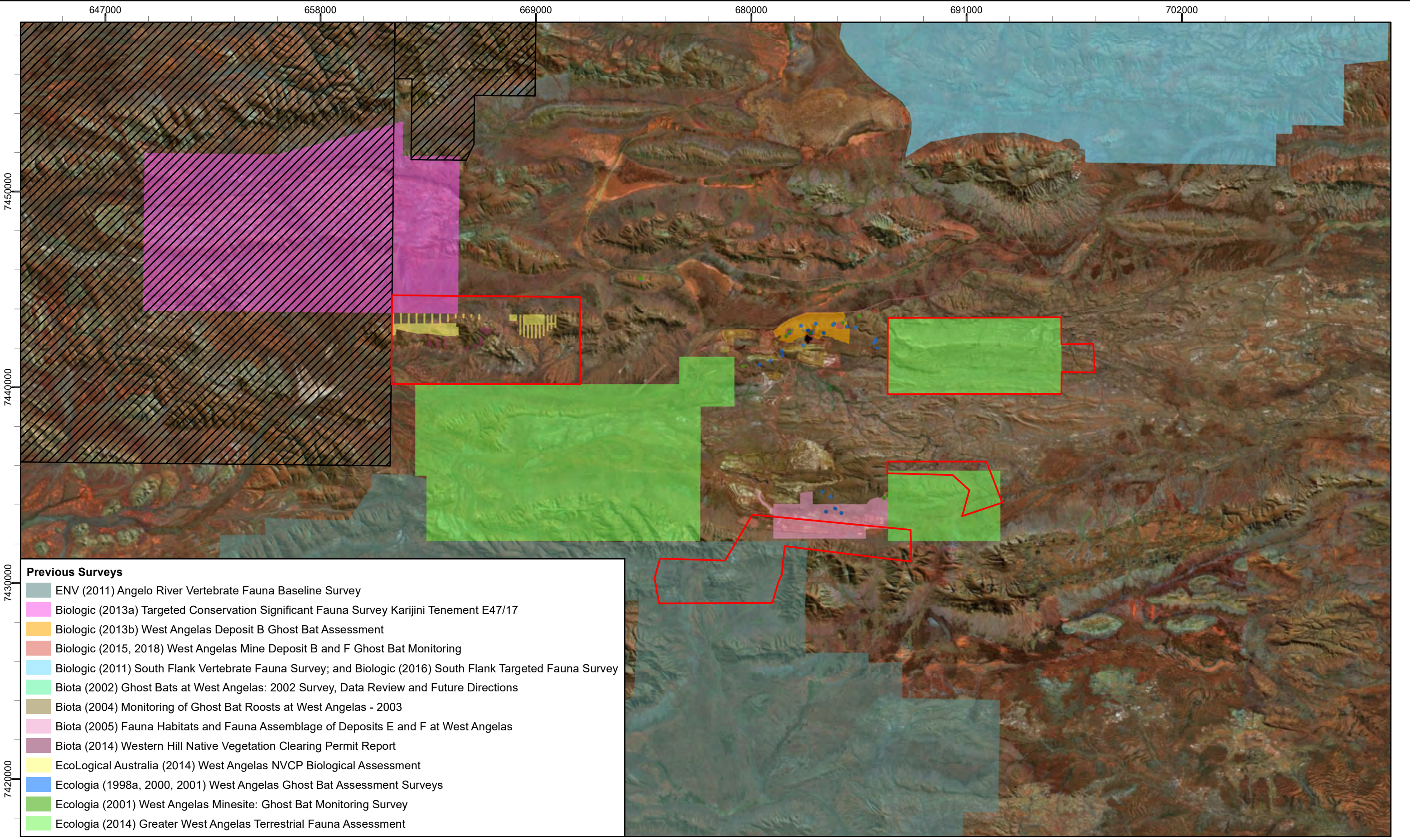
### 3.2. Literature Review

The literature review identified 18 relevant previous surveys conducted in the vicinity of the Study Area, comprising six Level 2, four Level 1 and eight targeted assessments (Table 3.2; Figure 3.1). A detailed review of these studies, including description of survey effort, is provided in Appendix B.

**Table 3.2: Previous surveys considered in the literature review**


Survey	Reference	Type	Location
An ecological appreciation of the West Angelas environment, Western Australia 1979 (Integrated Environmental Services, 1979)	A	Level 2	Greater West Angelas area <sup>1</sup>
West Angelas Ghost Bat ( <i>Macroderma gigas</i> ) assessment survey, September 1998 (Ecologia, 1998a)	B	Targeted Ghost Bat	Within Deposit F
West Angelas Project vertebrate fauna assessment survey (Ecologia, 1998b)	C	Level 2	Greater West Angelas area <sup>1</sup>
West Angelas mine site Ghost Bat assessment survey, September 2000 (Ecologia, 2000)	D	Targeted Ghost Bat	Within Deposit F
West Angelas mine site Ghost Bat assessment survey, September 2001 (Ecologia, 2001)	E	Targeted Ghost Bat	Within Deposit F
Ghost Bats at West Angelas: 2002 survey data review and future directions (Biota, 2002)	F	Targeted Ghost Bat	West Angelas mine area, immediately west of Deposit H
Monitoring of Ghost Bat roosts at West Angelas 2003 (Biota, 2004)	G	Targeted Ghost Bat	West Angelas mine area, immediately west of Deposit H
Fauna habitats and fauna assemblages of Deposits E and F at West Angelas (Biota, 2005)	H	Level 2 (single phase)	Covers part of Deposit F & Deposit J
South Flank Vertebrate Fauna Survey (Biologic, 2011)	I	Level 2	8 km north of Deposit H
Angelo River Vertebrate Fauna Baseline Survey (ENV, 2011)	J	Level 2	Covers part of Deposit J
Targeted Conservation Significant Fauna Survey Karijini Tenement E47 17 (Biologic, 2013a)	K	Level 1 (targeted significant fauna)	80 km north of Western Hill
West Angelas – Deposit B Ghost Bat assessment (Biologic, 2013b)	L	Targeted Ghost Bat	West Angelas mine area, immediately west of Deposit H
Greater West Angelas terrestrial fauna assessment (Ecologia, 2014)	M	Level 2	Covers portions of Deposit F and Deposit H
West Angelas NVCP Biological Assessment (EcoLogical Australia, 2014)	N	Level 1 (NVCP assessment)	Covers part of Western Hill
Western Hill NVCP Report (Biota, 2014)	O	Level 1 (NVCP assessment)	Covers part of Deposit F
West Angelas Iron Ore Mine – Deposit B and F Ghost Bat Assessment, December 2014 (Biologic, 2015)	P	Targeted Ghost Bat	West Angelas mine area, immediately west of Deposit H
South Flank Targeted Fauna Survey (Biologic, 2016c)	Q	Level 1 (targeted significant fauna)	8 km north of Deposit H
2017 West Angelas Iron Ore Mine – Deposit B and F Ghost Bat Monitoring 2017 (Biologic, 2018)	R	Targeted Ghost Bat	West Angelas mine area, immediately west of Deposit H

<sup>1</sup>Not included in Figure 3.1 as spatial data were unavailable



- Previous Surveys**
- ENV (2011) Angelo River Vertebrate Fauna Baseline Survey
  - Biologic (2013a) Targeted Conservation Significant Fauna Survey Karijini Tenement E47/17
  - Biologic (2013b) West Angelas Deposit B Ghost Bat Assessment
  - Biologic (2015, 2018) West Angelas Mine Deposit B and F Ghost Bat Monitoring
  - Biologic (2011) South Flank Vertebrate Fauna Survey; and Biologic (2016) South Flank Targeted Fauna Survey
  - Biota (2002) Ghost Bats at West Angelas: 2002 Survey, Data Review and Future Directions
  - Biota (2004) Monitoring of Ghost Bat Roosts at West Angelas - 2003
  - Biota (2005) Fauna Habitats and Fauna Assemblage of Deposits E and F at West Angelas
  - Biota (2014) Western Hill Native Vegetation Clearing Permit Report
  - EcoLogical Australia (2014) West Angelas NVCP Biological Assessment
  - Ecologia (1998a, 2000, 2001) West Angelas Ghost Bat Assessment Surveys
  - Ecologia (2001) West Angelas Minesite: Ghost Bat Monitoring Survey
  - Ecologia (2014) Greater West Angelas Terrestrial Fauna Assessment

- Legend**
- Study Area
  - Karijini National Park



1:175,000

0 1.25 2.5 5 7.5 10 km

**RTIO – West Angelas Beyond 2020**

**Terrestrial Fauna Assessment**

**Figure 3.1: Previous surveys conducted in the vicinity of the Study Area**

Coordinate System: GDA 1994 MGA Zone 50

Projection: Transverse Mercator

Datum: GDA 1994

Size A3. Created 28/01/2019

### 3.3. Vertebrate Fauna Likelihood of Occurrence

Fauna species of conservation significance identified during the desktop assessment were assessed for their likelihood to occur within the Study Area based on the distance of records from the Study Area and the suitability of habitat present in the Study Area (Table 3.3).

**Table 3.3: Species likelihood of occurrence decision matrix**

Range categories:	Habitat Categories				
	Core habitat known to occur	Foraging habitat known to occur	Dispersal habitat known to occur	Potential dispersal habitat	No known habitat occurs
Species recorded <5 km	Highly Likely	Likely	Likely	Possible	Possible
Species recorded 5-10 km	Likely	Likely	Possible	Possible	Rarely
Species recorded 10-40 km	Likely	Possible	Possible	Rarely	Unlikely
Species recorded >40 km	Possible	Possible	Rarely	Rarely	Unlikely
Species rarely recorded in region	Possible	Rarely	Unlikely	Unlikely	Highly Unlikely

This decision matrix is an indicative guide only and was applied with the following considerations:

- The range categories are subject to interpretation based on the known range of each species and its natural dispersal capabilities (for example, >50 km range may be a significant distance for a fossorial skink, but not a migratory bird);
- Both the range categories and the habitat categories can vary markedly for different types of fauna such as birds, reptiles, mammals, and amphibians, and fauna with different ecological niches within each of these groups;
- The degree of habitat specificity for each species is a major determining factor for each of the habitat categories, and this in turn is dependent on the current state of ecological knowledge of the species;
- The applicability of range categories is also influenced by the location and amount of previous sampling effort that has been conducted in the area, which is in turn affected by the accessibility of study areas;
- The current state of taxonomy can influence interpretation of available information; for example, species that are poorly known taxonomically can be difficult to identify accurately, and changes in classification and/or conservation category can affect the reliability of previous records within fauna databases, the conservation status of the newly defined species/populations, and the assumptions regarding species' ranges and habitat preferences; and
- The language used in each of the habitat and range categories may be useful for some taxa and not for others; for example, 'rarely' occurrences may be useful for describing birds or other fauna which can traverse large distances, but in the case of fauna with more limited dispersal capabilities, such as reptiles, there is no basis for 'rarely' occurrences and any records such fauna are more likely to represent range extensions.

## 4. FIELD SURVEY METHODS

The purpose of the field survey was to verify the data collated during the desktop assessment, describe assemblages of vertebrate fauna and SRE invertebrate fauna occurring in the Study Area, and define and map the fauna habitats present within the Study Area and their significance to vertebrate and SRE invertebrate fauna.

### 4.1. Timing and Weather

Seasonal activity for vertebrate fauna is strongly influenced by temperature and rainfall during the survey. Additionally, weather conditions experienced prior to a survey can influence vertebrate and SRE invertebrate fauna activity, which is why it is recommended that field surveys are conducted across multiple seasons (EPA, 2016a, 2016b). The current field survey was conducted over two phases in two unique seasons. Phase 1 was undertaken in spring following the typical winter dry season, between the 10<sup>th</sup> and 22<sup>nd</sup> October 2018. Phase 2 was undertaken in autumn following the typical wet season, between the 11<sup>th</sup> and 22<sup>nd</sup> March 2019.

The average minimum overnight temperatures recorded at Newman during the Phase 1 and Phase 2 surveys were 16.7°C and 25.5°C, respectively; while the average maximum daytime temperatures were 36.4°C and 38.0°C, respectively (Table 4.1). These temperatures are comparable with the long-term average minimum and maximum temperatures recorded at Newman during the same months, which are 17.7°C and 35.2°C, respectively, for October, and 22.1°C and 35.4°C, respectively, for March.

A total of 58 mm of rainfall was recorded at West Angelas in the six months prior to the Phase 1 survey (Figure 4.1). The majority (53 mm) of this rain fell during five days in June. While this represents a significant rainfall event, it occurred four months prior to the field survey and only 1 mm of rainfall was recorded at West Angelas between this rainfall event and the field survey. At the time of the Phase 1 field survey, no rain had been recorded at West Angelas for 103 days, and no rain occurred during the survey (Table 4.1).

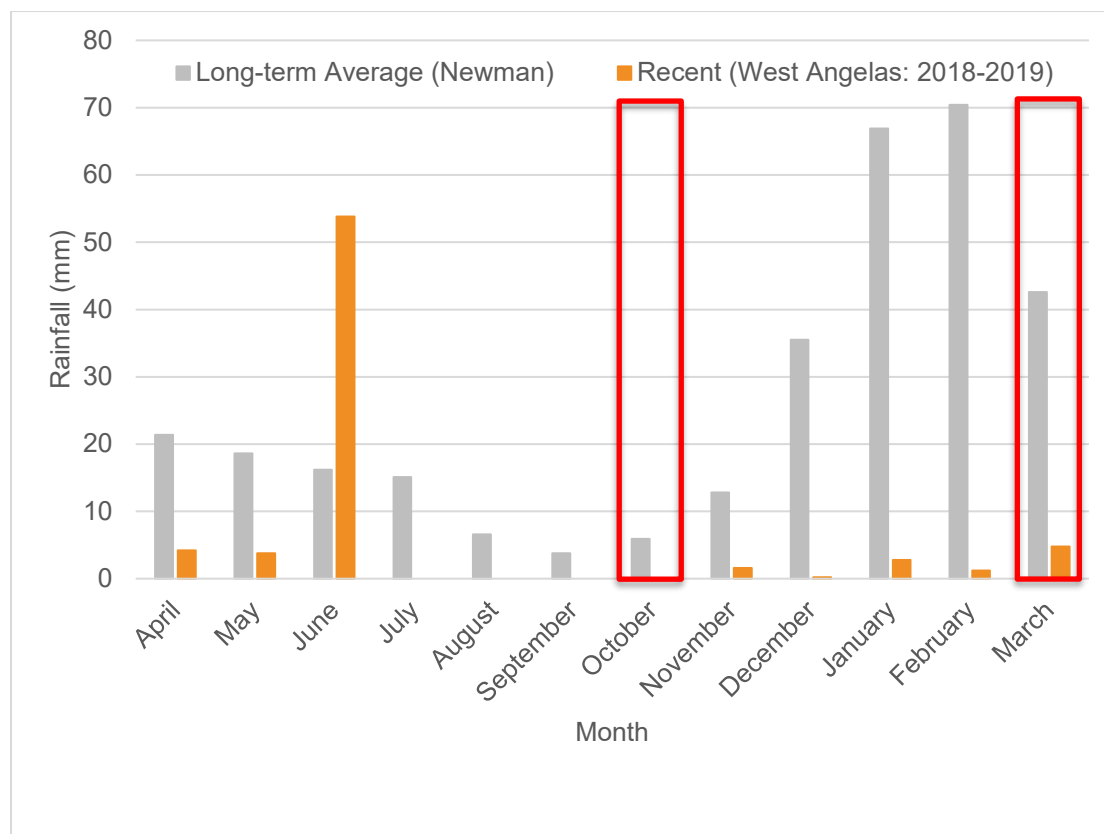
There was much less rain recorded at West Angelas in the six months prior to the Phase 2 survey (6.2 mm), compared with Phase 1; however, the rain was more recent (Figure 4.1). A total of 4.4 mm was recorded at West Angelas in the two months prior to the Phase 2 survey, with 0.4 mm recorded a week prior. During the survey, a total of 2.2 mm of rain was recorded at West Angelas across six days (Table 4.1). While this rain was responsible for wetter conditions during the Phase 2 survey compared with Phase 1, conditions leading up to the Phase 2 survey were still relatively dry compared with long-term averages.

Overall, conditions leading up to both surveys were relatively dry, compared with long term averages, and this is likely to have resulted in lower than average levels of fauna activity and abundance in the Study Area during the field surveys (Greenville, Wardle & Dickman, 2012). Notably, the June 2018 rainfall event was responsible for the formation of water pools that persisted in the landscape until the Phase 1 survey (see Section 5.2.3) and rainfall in between January and March 2019 is likely to have encouraged more amphibians to be active during the Phase 2 survey compared with Phase 1 (see Section 5.3.2).

**Table 4.1: Weather conditions recorded during the surveys**

Date	Rainfall recorded at West Angelas (mm)	Temperature recorded at Newman (°C) <sup>1</sup>	
		Minimum	Maximum
Phase 1			
10/10/2018	0	21.1	36.9
11/10/2018	0	15.8	37.1
12/10/2018	0	17.0	37.1
13/10/2018	0	19.5	36.2
14/10/2018	0	19.9	31.9
15/10/2018	0	16.3	30.9
16/10/2018	0	13.1	32.9
17/10/2018	0	13.7	35.5
18/10/2018	0	15.8	37.8
19/10/2018	0	16.7	30.9
20/10/2018	0	12.8	35.4
21/10/2018	0	18.9	39.2
22/10/2018	0	17.0	36.4
Total rainfall and average temperature	0	16.7	35.2
Phase 2			
11/03/2019	0	25.8	31.5
12/03/2019	0.2	29.2	33.1
13/03/2019	0.2	25.6	37.2
14/03/2019	1.2	25.6	38.1
15/03/2019	0	23.5	39.1
16/03/2019	0	25.4	40.4
17/03/2019	0.2	25.4	40.3
18/03/2019	0.2	21.4	38.9
19/03/2019	0.2	24.9	38.8
20/03/2019	0	24.7	39.3
21/03/2019	0	24.9	39.4
22/03/2019	0	29.4	39.7
Total rainfall and average temperature	2.2	25.5	38.0

<sup>1</sup>Source: BoM (2019)



**Figure 4.1: Rainfall recorded at Newman prior to the field survey**

Note: red highlight indicated survey timing

## 4.2. Habitat Mapping

### 4.2.1. Vertebrate Fauna Habitat Assessments

Habitat assessments were undertaken in the field to characterise and define habitats and their value to vertebrate fauna. Habitat assessments were undertaken at 91 locations across the Study Area, including at every systematic sampling site, and at every motion camera, acoustic recording and ultrasonic bat recording location (Appendix C).

Habitat assessments were conducted using methodology and terminology modified from the *Australian Soil and Land Survey Field Handbook* (National Committee on Soil and Terrain, 2009). Information recorded during the habitat assessments were:

- general site information e.g. location and representative photo;
- landform features e.g. landform type and the aspect and inclination of slopes;
- vegetation features e.g. floristic structure and composition and the presence of leaf litter, logs or other habitat structures;
- substrate features e.g. soil texture and colour, amount of bare ground, size and abundance of rocks, extent of erosion, presence of outcropping or water bodies;
- level of disturbance e.g. time since last fire, presence of weeds, grazing impacts or other human-induced disturbances.

#### 4.2.2.SRE Invertebrate Fauna Habitat Assessments

A total of 82 habitat assessments were undertaken to characterise and define microhabitat features available for SRE invertebrate fauna (Appendix D). SRE habitat assessments were aimed at determining whether a site could be classified as Potential SRE habitat, and hence the likelihood that each site may contain SRE fauna. The assessments were based on three major factors influencing the significance of habitats for SRE species: isolation, protection and complexity (see Section 4.2.5).

#### 4.2.3.Broad Fauna Habitat Mapping

Mapping of broad fauna habitats was completed using the habitat assessments conducted for vertebrate and SRE invertebrate fauna during the field surveys, in conjunction with high-resolution aerial imagery and previous mapping of vegetation, topography, land systems and drainage. Habitats were delineated and mapped across the Study Area at a scale of ~1:20,000. Where possible, habitat delineation and categorisation followed that of previous assessments conducted within the area, primarily that conducted by Ecologia (2014).

#### 4.2.4.Significance to Vertebrate Fauna

Broad fauna habitat types identified within the Study Area were assessed for their ability to support vertebrate fauna species of conservation significance and scored as being of High, Moderate or Low significance to vertebrate fauna according to set criteria (Table 4.2).

**Table 4.2: Fauna habitat significance assessment criteria**

Score	Possible criteria (score results from any possible criterion being met)
High	Fauna listed as threatened under the EPBC Act or BC Act have been recorded from this habitat type within the Study Area.
	Habitat known to be suitable core habitat <sup>1</sup> for EPBC Act and/or BC Act listed threatened fauna, and there are records of this species within 40 km <sup>2</sup> .
	Habitat is regionally uncommon and known to support species listed as: <ul style="list-style-type: none"> <li>Threatened fauna under the EPBC Act and/or BC Act, but it is not their core habitat (e.g. may be used periodically/ seasonally or for dispersal).</li> <li>Other Specially Protected Species under the BC Act.</li> <li>DBCA listed Priority fauna, which are known to be solely reliant on this habitat.</li> </ul>
Moderate	Habitat known to support EPBC Act and/or BC Act listed Migratory fauna.
	Habitat that is regionally uncommon (e.g., occurs in small and isolated areas) and supports a particularly diverse and uncommon faunal assemblage.
	Habitat is widespread and known to support species listed as: <ul style="list-style-type: none"> <li>Threatened fauna under the EPBC Act and/or BC Act, but it is not their core habitat (e.g., may be used periodically/ seasonally or for dispersal).</li> <li>Other Specially Protected Species under the BC Act.</li> <li>DBCA listed Priority fauna, which are known to be solely reliant on this habitat.</li> </ul>
Low	Habitat that may meet the definition of core habitat <sup>1</sup> for EPBC Act and/or BC Act listed threatened fauna, however there are no records of this species within 40 kms.
	Habitat is widespread/common and does not solely support any DBCA listed Priority fauna.

1. Core habitat is defined as containing the critical habitat elements for survival and reproduction of a species (Bingham & Noon, 1997) or as otherwise defined within relevant species recovery plans and guidelines.

2. Note in instances where survey work over this area has been limited, then a precautionary approach is generally applied, and the species will be considered likely to be present.

#### 4.2.5. Significance to SRE Invertebrates

The significance of each fauna habitat was assessed for likelihood to provide suitable habitat for SRE invertebrates, based on a five-tier system ranging from Highly Unlikely to Highly Likely (Figure 4.2). The assessment was based on three major factors influencing the significance of habitats for SRE species: isolation, protection and complexity (Figure 4.2).

**Isolation:** based on the level of connectivity between sites, which share similar habitat characteristics.

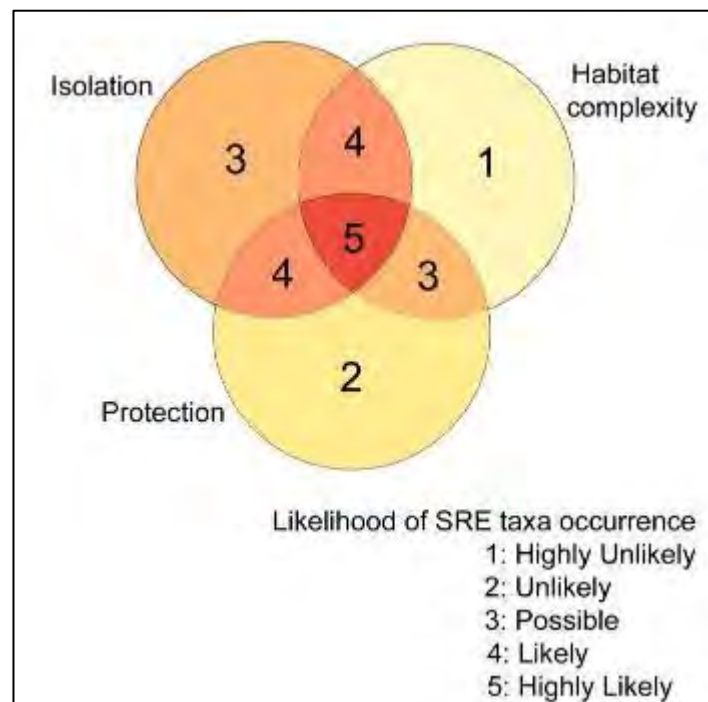
Isolation is the most important factor when it comes to the level of risk, as any fauna with limited dispersal characteristics, regardless of the habitat preference, will likely be, at least, an isolated population. Examples include islands and mountaintops.

**Protection:** this primarily covers protection from exposure. With respect to the arid-zone region however, protection from disturbance is also very important for the long-term viability of SRE habitats and communities, i.e. protection from fire, flood and invasive species. Protection is provided at two levels; the site level where the structural composition of the site (aspect, slope etc.) can provide protection from exposure and disturbance by providing physical barriers (e.g. gorges and gullies); and the habitat level where certain microhabitat characteristics, associated with habitat complexity, provide more direct protection, particularly from exposure (i.e. leaf litter, rocky substrates, canopy cover and soil depth).

**Complexity:** this factor drives species richness and often abundance at a site, i.e. the more complex a site is, the more species and individuals it is likely to contain. This is particularly important, as a number of SRE groups are predators; therefore, the richness and abundance of prey species are critical to their survival. Complexity, with respect to SREs, is based around a number of microhabitat types:

- Leaf litter: both depth and structural variation;
- Rocky substrates: loose rocks and crevices;
- Vegetation variation: flora richness and structural variation; and
- Soil: depth and structural variation.

Likewise, the complexity of the habitat is important to detritivore SRE taxa, such as isopods, millipedes and some snails, which rely upon decaying leaf litter, woody debris and organic matter for survival.



**Figure 4.2: Factors influencing the suitability of habitats for SRE invertebrate fauna**

### 4.3. Vertebrate Fauna Sampling

#### 4.3.1. Systematic Sampling

Systematic sampling was conducted to identify any vertebrate fauna species occurring within the Study Area. A total of ten systematic sampling sites were established during Phase 1. During Phase 2, eight of these ten sites were resurveyed, and an additional two sites were established. Thus, a total of 12 systematic sampling sites were established in the Study Area across both phases (Figure 4.3, Table 4.3, [Appendix E](#)).

The location of sites for systematic sampling considered the diversity and distribution of fauna habitats present in the Study Area and the location and timing of previous surveys undertaken within the Study Area. The aim was to ensure sites were located within major or significant fauna habitats, and that there was adequate geographic coverage across the Study Area during different seasons. It was in an effort to fulfil these aims that two new sites (VWAH-11 and VWAH-12) were established in Deposit H during the Phase 2 survey. Deposit H has been previously sampled during the dry season, thus the establishment of two sites here during Phase 2 ensured this deposit has been sampled during both the dry and wet season. The two sites that were surveyed during Phase 1 only (VRT-WA09 and VRT-WA10) were located in Deposit F, which has been subject to greater sampling effort during previous surveys.

Systematic sampling at these sites consisted of trapping and avifauna census.

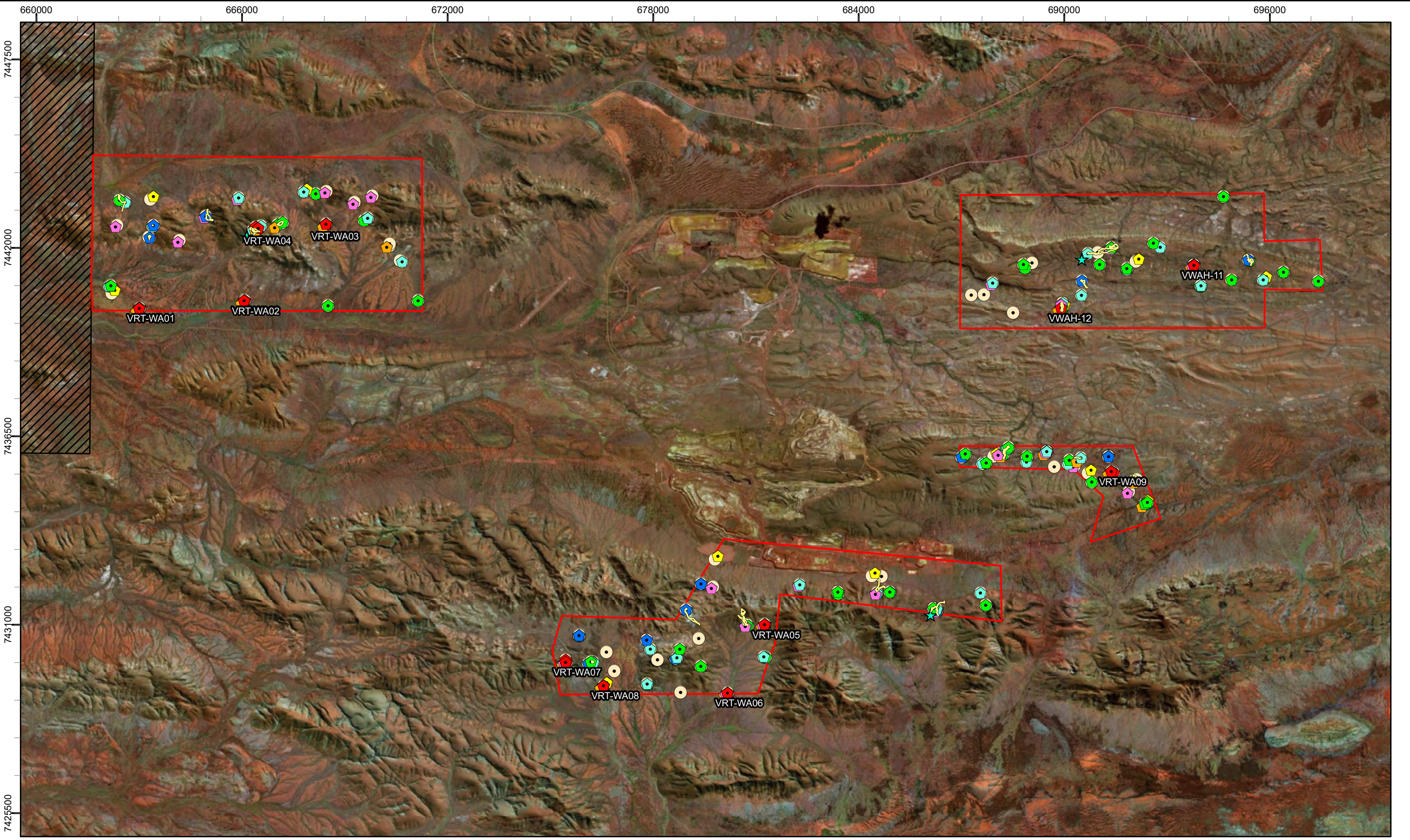
#### Systematic Trapping

At each systematic sampling site, a combination of pit traps, funnel traps, Elliott traps and cage traps were installed to capture terrestrial mammals, reptiles and amphibians (Figure 4.4).

At each site, ten pit traps were installed, comprising five 20 litre buckets and five PVC pipes (dimensions of 50 centimetres (cm) deep and 16 cm wide). To direct animals into the pit traps, a 5 metre (m) by 0.3 m aluminium fence was installed bisecting each pit trap. Pit traps were placed along two parallel transects (or a single transect, dependant on habitat), approximately 10–20 m apart. A funnel trap measuring 75 cm x 18 cm x 18 cm was installed at each end of every fence (20 funnel traps per site) and a Sheffield cage trap was installed at the start and end of the pit trap line (two cage traps per site). A series of medium Elliott box traps were installed on both sides of each pit trap line (20 Elliott traps per site).

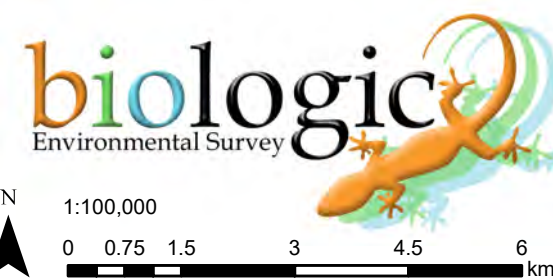
Traps were placed in locations deemed most likely to catch fauna; for example, areas providing cover to fauna in the form of dense ground cover, leaf litter and rocks. Styrofoam trays were placed within all pit traps to provide captured fauna with refuge from heat, cold and rain. Shade cloth was placed over the funnel traps to provide protection from direct sunlight. Elliott and cage traps were baited with universal bait - a mixture of oats, peanut butter and sardines. Traps were opened overnight and checked early (within three hours of sunrise, in accordance with DBCA, 2018a) the following morning, over seven consecutive nights.

The total numbers of trapping nights during the Phase 1 and Phase 2 surveys were 3,570 and 3,518, respectively (Table 4.3).



**Legend**

- |                        |                        |                            |
|------------------------|------------------------|----------------------------|
| StudyArea              | <b>Sampling method</b> | Systematic Trapping        |
| Karijini National Park | Acoustic Recording     | Ultrasonic Bat Recording   |
| Targeted searches      | Active Foraging        | Targeted Searches          |
|                        | Avifauna Census        | Motion Camera (Short Term) |
|                        |                        | Motion Camera (Long Term)  |
|                        |                        | Habitat Assessment         |



**RTIO – West Angelas Beyond 2020**  
**Terrestrial Fauna Assessment**  
**Figure 4.3: Vertebrate Fauna Sampling Sites**

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

Size A3. Created 28/01/2019

**Table 4.3: Survey effort per vertebrate trapping site**

Site	Location	Habitat type	Number of trap nights									
			Pit traps		Funnel traps		Elliott traps		Cage traps		Total	
			Phase 1	Phase 2	Phase 1	Phase 2	Phase 1	Phase 2	Phase 1	Phase 2	Phase 1	Phase 2
VRT-WA01	Western Hill	Footslope and Plain	70	70	140	140	140	140	14	14	364	364
VRT-WA02		Mixed Acacia Woodland	70	70	140	140	140	140	14	14	364	364
VRT-WA03		Minor Drainage	70	70	140	140	140	140	14	14	364	364
VRT-WA04		Gorge or Gully	70	70	140	140	140	140	14	14	364	364
VRT-WA05	Deposit J+ MT Ella	Hilltop, Hillslope, Ridge or Cliff	70	70	140	140	140	140	14	14	364	364
VRT-WA06		Drainage Area	70	70	140	140	140	140	14	14	364	364
VRT-WA07		Hilltop, Hillslope, Ridge or Cliff	0 <sup>1</sup>	0 <sup>1</sup>	140	140	140	140	14	14	294	294
VRT-WA08		Drainage Area	70	70	140	140	140	140	14	14	364	364
VRT-WA09	Deposit F	Footslope and Plain	70	-	140	-	140	-	14	-	364	-
VRT-WA10		Gorge or Gully	70	-	140	-	140	-	14	-	364	-
VWAH-11	Deposit H	Gorge or Gully	-	60	-	120	-	120	-	12	-	312
VWAH-12		Footslope and Plain	-	70	-	140	-	140	-	14	-	364
Total (each phase)			630	620	1,400	1,380	1,400	1,380	140	138	3,570	3,518
Total (both phases)			1,250		2,780		2,780		278		7,088	

<sup>1</sup> An impenetrable layer of rock prevented pit traps from being installed at VRT-WA07

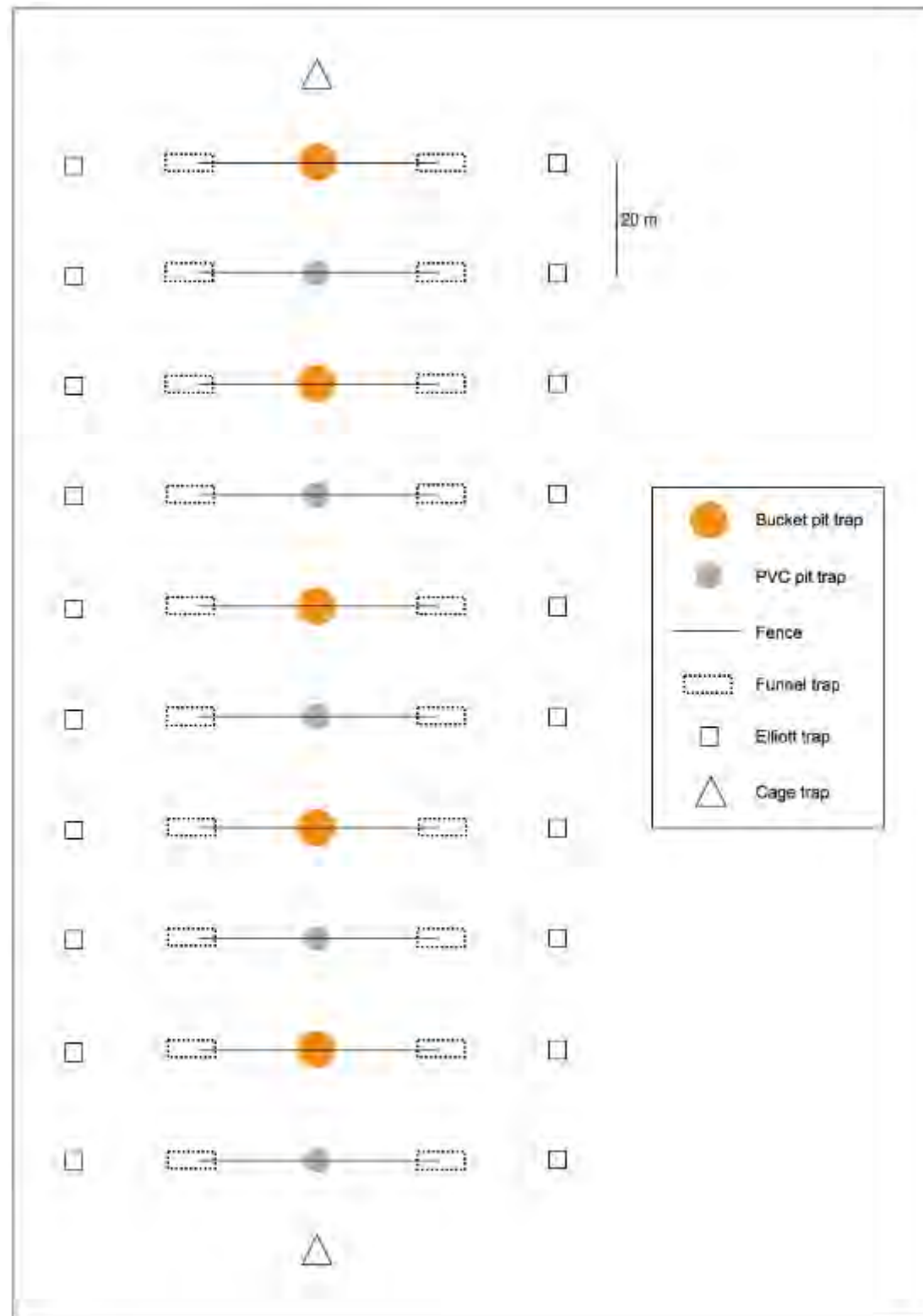


Figure 4.4: Layout of traps at a systematic sampling site

### *Avifauna Surveys*

During Phase 1, a single 20-minute avifauna census was conducted at each of the ten systematic sampling sites. During Phase 2, a 20-minute avifauna census was conducted at each of the ten systematic sampling sites each morning over seven consecutive days.

Each avifauna census was conducted between 6:30 am and 11:00 am, when bird activity is typically at its greatest. All signs of avifauna presence were recorded, including observations of individuals, calls or other evidence. The order in which the sites were visited changed during the survey so that an avifauna census was conducted at each site as close to dawn as possible, and personnel were rotated between sites to reduce any bias associated with the observer (Lindenmayer, Wood & MacGregor, 2009).

In addition to those avifauna surveys conducted at systematic sampling sites, six avifauna censuses were conducted at other locations within the Study Area (Figure 4.3).

#### **4.3.2. Targeted Sampling**

Targeted sampling was conducted within fauna habitats considered likely to support species of conservation significance. Targeted sampling methods included targeted searches and the deployment of ultrasonic bat recorders, acoustic recorders and motion-sensor cameras.

### *Targeted Searches*

A total of eleven targeted searches comprising 16.5 person hours of searching were conducted within the Study Area (Figure 4.3). Landforms targeted included gorges and gullies, sandy plains, caves and areas containing sources of water. Targeted searches included:

- searches of caves, crevices and rocky habitats for evidence of the Northern Quoll, Pilbara Leaf-nosed Bat, Ghost Bat and Northern Brushtail Possum;
- searches of large crevices and water pools for evidence of the Pilbara Olive Python; and
- searches of sandy plains and areas containing old-growth spinifex for evidence of the Greater Bilby (*Macrotis lagotis*) and Brush-tailed Mulgara (*Dasycercus blythi*).

During the targeted searches the team recorded all vertebrate fauna species encountered by either direct observation of individuals, or via the discovery of secondary evidence such as scats, burrows, diggings, bones and carcasses.

### *Ultrasonic Bat Recording*

Song Meter (SM2 and SM4; Wildlife Acoustics Inc.) ultrasonic bat recorders were used to investigate the presence of bat species, particularly those of conservation significance, the Pilbara Leaf-nosed Bat and Ghost Bat. Recorders were deployed at 25 locations for between two and six nights, for a total of 68 sampling nights (Figure 4.3, Appendix E). Deployments targeted prospective roost sites (i.e. caves) and foraging habitat (e.g. gullies and areas with sources of water). Recorder settings followed the manufacturer's recommendations (Wildlife Acoustics, 2011, 2017). Bat echolocation recordings were analysed by Mr Robert Bullen, a bat specialist from Bat Call WA.

### *Acoustic Recording*

Song Meter (SM4; Wildlife Acoustics Inc.) acoustic recorders were used to investigate the presence of the Night Parrot (*Pezoporus occidentalis*). Recorders were deployed for between and six nights at 13 locations within the Study Area, for a total of 30 sampling nights (Figure 4.3, Appendix E). In accordance with the *Interim Guideline for Preliminary Surveys of Night Parrot (Pezoporus occidentalis) in Western Australia*, deployments targeted locations considered likely to support the Night Parrot i.e. “stands of large, old clumps of spinifex (*Triodia*)... especially so if the identified area is part of a paleo-drainage system or contains healthy stands of samphire” (DPaW, 2017). Acoustic recordings were analysed by ornithologist, and Night Parrot specialist, Nigel Jackett.

### *Motion Cameras*

Motion cameras (Acorn Ltl5210A) were used to target larger mammals such as macropods and introduced predators, as well as cryptic fauna that are not often detected during via trapping. Cameras were baited with universal bait and the resulting footage was analysed visually by Biologic.

Single motion cameras were deployed for between two and nine nights at 40 locations within the Study Area, for a total of 139 sampling nights (Figure 4.3, Appendix E). Deployments targeted habitat most likely to support species of conservation significance, such as rocky outcrops and locations containing sources of water.

Three additional sites were selected for longer-term camera deployments. One of these was a cave (CWAN-04) at which scats of the Northern Quoll were recorded – two cameras were deployed here (VRT-WA62) for 141 nights between the Phase 1 (October 2018) and Phase 2 (March 2019) surveys, resulting in a total of 282 sampling nights. The other two sites (VRT-WA63 and VRT-WA64) comprised rocky habitat considered likely to support the Northern Quoll. Each of these two sites consisted of ten motion cameras spaced 100 m apart (as recommended by DoE, 2016). These cameras were in place for 145 nights between the Phase 1 (October 2018) and Phase 2 (March 2019) surveys, resulting in 2,900 sampling nights.

### *Scat Collection Sheets*

Scat collection sheets, consisting of mats measuring approximately 10 square metres, were installed in selected caves, recorded during Phase 1, to collect scats from the Ghost Bat. A total of six sheets were deployed in three caves during the Phase 1 field survey and revisited during the Phase 2 field survey.

The use of scat collection sheets makes it possible to identify scats which are deposited during a given period of time and thus a rate of scat accumulation in a cave. This information can be compared with data from other caves to understand the relative importance of caves to particular bat species.

#### **4.3.3. Opportunistic Records**

When not undertaking systematic or targeted sampling (e.g. when travelling between sites), any evidence pertaining to species not previously recorded during the survey, rare species and species of conservation significance was recorded. These records include the direct observation of individuals, as well as observations of secondary evidence such as scats, burrows, diggings, bones and carcasses. Track logs recorded efforts made to search any unique microhabitats encountered, such as by turning rocks and logs. No nocturnal work was conducted during the Level 2 survey due to safety concerns across the site.

#### **4.3.4. Data Analysis- Survey Adequacy**

Species accumulation curves can be used to estimate the sampling adequacy of systematic observation techniques for a survey (EPA, 2016a). When a curve approaches an asymptote, it suggests that sampling effort has been sufficient to adequately collect the majority of species comprising the faunal assemblage at the locations sampled (Thompson & Withers, 2003). The value at which the curve asymptotes can also be used as an approximate measure of the total size of the species complement at that location (Thompson, Withers, Pianka & Thompson, 2003).

Species accumulation curves for this survey were calculated using avifauna census data for birds, and systematic trapping data for mammals and herpetofauna (reptiles and amphibians combined). All species accumulation curves and estimators were run using EstimateS v8.2 (Colorado, USA). Species accumulation curves include Sobs (Mao Tao), to reflect the number of species observed (based on a given total of species recorded), and richness estimators Chao 1, Chao 2, Jackknife 1 and Michaelis-Menten to predict the total number of species that could potentially be recorded using these techniques.

Note that species accumulation curves were created using systematic trapping and avifauna census data and that additional species were detected via alternate techniques. In addition, many species may not have been detectable at the time of survey due to various reasons such as:

- temporal habitat variation – variables such as fire are known to influence the occurrence of some species, with some species preferring open landscapes more recently affected by fire, and others preferring landscapes that have not experienced fire for some time;
- weather patterns – species such as burrowing frogs may occur within the Study Area year-round but are not detectable in the absence of specific climatic events that trigger emergence;
- variation in detectability – some species are readily trapped, seen and/or hear, but other species are more cryptic and require concerted, highly targeted survey to detect them; and
- species rarity – species with restricted distributions or population sizes may not be detectable without a major, resource-intensive targeted survey.

#### **4.3.5. Taxonomy and Nomenclature**

The latest checklist of mammal, reptile and amphibian names published by WAM (2019b) was used as a guide to the current taxonomy and nomenclature of these groups. For birds, the current checklist of

Australian birds maintained by Birdlife Australia (based on Christidis & Boles, 2008) was used in conjunction with the WAM (2019b) species list. While compiling a list of fauna potentially occurring in the Study Area, all records were checked to ensure the latest taxonomy, using recent papers and lists, was used.

#### 4.4. SRE Invertebrate Sampling

Invertebrates were sampled via dry-pitfall trapping, active foraging and leaf/soil sieving. Trapping sites consisted of those pitfall traps which were installed as part of vertebrate fauna sampling (see Section 4.3.1). Sites for active foraging and leaf/soil sieving were selected in accordance with EPA (2016b) recommendations. Habitats considered most suitable for SRE invertebrates were targeted; however, to provide adequate geographical coverage of the Study Area and local context, several reference sites in less suitable habitat types were also assessed.

##### 4.4.1. Dry Pit-fall Trapping

Invertebrates captured in pitfall traps installed as part of vertebrate fauna trapping were collected. During the Phase 1 survey, a total of 90 pitfall traps were installed across nine sites and sampled over seven consecutive days for a total of 630 trap nights ( see Table 4.3). During the Phase 2 survey, a total of 90 pitfall traps were installed across nine sites (including seven that were previously sampled in Phase 1 and two new sites) and sampled between six (in the case of one site) and seven consecutive days for a total of 620 trap nights.

**Table 4.4: Pitfall trapping effort**

Site	Location	Habitat	Number of trap nights	
			Phase 1	Phase 2
VRT-WA01	Western Hill	Footslope and Plain	70	70
VRT-WA02		Mixed Acacia Woodland	70	70
VRT-WA03		Minor Drainage	70	70
VRT-WA04		Gorge or Gully	70	70
VRT-WA05	Deposit J+ MT Ella	Hilltop, Hillslope, Ridge or Cliff	70	70
VRT-WA06		Drainage Area	70	70
VRT-WA08		Hilltop, Hillslope, Ridge or Cliff	70	70
VRT-WA09	Deposit F	Drainage Area	70	-
VRT-WA10		Footslope and Plain	70	-
VWAH-11	Deposit H	Gorge or Gully	-	60
VWAH-12		Gorge or Gully	-	70
Total (each phase)			630	620
Total (both phases)			1,250	

##### 4.4.2. Active Foraging

Active searches were undertaken at 28 sampling sites during the Phase 1 field survey and 34 sites during the Phase 2 field survey (Figure 4.5). Each active search was for a duration of 1.5 person hours and involved:

- searching under rocks and in cracks and crevices for rock-dwelling species;
- searching under logs and within woody debris for detritivores;
- searching for invertebrates on shrubs and trees (e.g. Mulga), including under sheets of bark; and
- searching any burrows which may contain mygalomorph spiders or scorpions.

#### **4.4.3. Leaf/Soil Sieving**

Leaf/soil sieving was undertaken at 22 sites during the Phase 1 survey and 26 sites during the Phase 2 survey (Figure 4.5). Leaf litter, humus and topsoil (to approximately 5 cm below surface) was placed in a sieve at the site and agitated to divide the sample into four grades (>7 mm, 3-7 mm, 1.4-3 mm, <1.4 mm). Each grade was thoroughly searched for target SRE species such as pseudoscorpions, millipedes, snails, and small scorpions. The maximum volume of litter in the sieve was approximately 4808 cm<sup>3</sup>, and up to two sifts were conducted at each site, providing enough leaf litter and other material was available.

#### **4.4.4. Specimen Preservation and Identification**

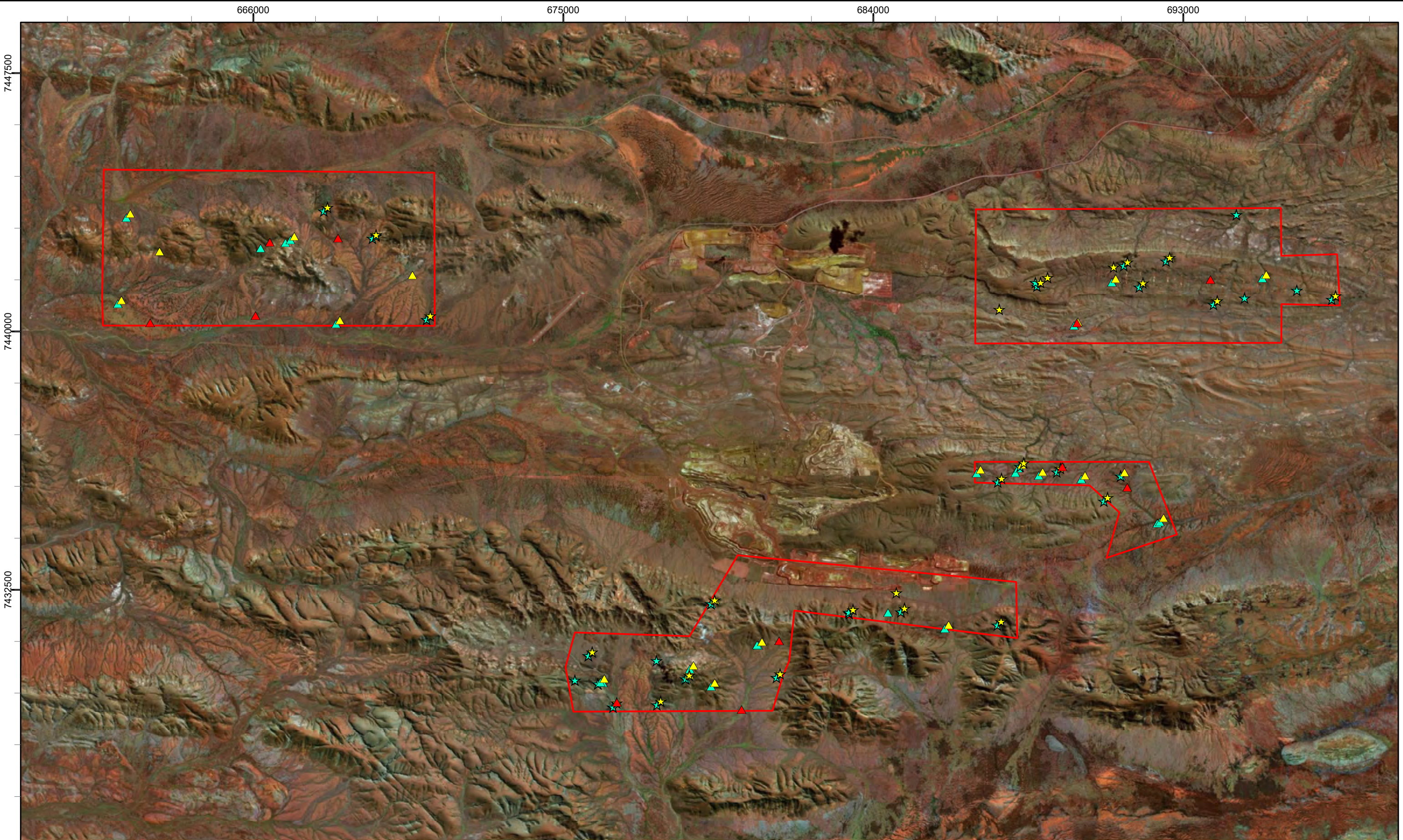
All invertebrate specimens collected were euthanised in 100% ethanol to preserve DNA for sequencing. Isopods were identified by isopod specialist Dr Simon Judd. Spiders, scorpions and myriapods were identified by Dr Erich Volschenk. Where indicated by morphological taxonomy, further identification was undertaken using molecular analysis. Tissue preparation was carried out by removing a leg from the specimen, briefly drying off the ethanol, and placing the tissue directly into ATL buffer at Biologic's laboratories. In all instances, greatest care was taken to decontaminate all tools and equipment between samples, using bleach and repeated rinsing in deionised water. Tissues were then amplified using Folmer PCR primers (LCO1490, HCO2198; Folmer et al. 1994) to assess the variability of COI region by Xytogen. Amplified PCR product was sequenced by the Australian Genomic Research Facility (AGRF) Perth node. The resulting sequences were then sent to the WA Museum Molecular Systematics Unit (WAM MSU) for BLASTing against their molecular library.

#### 4.5. Survey Team and Licensing

The field surveys were conducted under a DBCA Regulation 17 "Licence to Take Fauna for Scientific Purposes" issued to B. Downing (licence number 08-002839-1). Each survey was completed by four zoologists (Table 4.5).

**Table 4.5: Field personnel involved in the surveys**

Personnel	Position	Survey	Qualification	Experience
Ms Talitha Moyle	Senior Zoologist	Phase 1 and 2	B.Sc. (Hons) Natural Resources Management, Zoology	18 years' fauna and consulting experience
Mr Tom Rasmussen	Senior Zoologist	Phase 1 and 2	B.Sc. (in process)	12 years' fauna consulting
Mr Arnold Slabber	Senior Zoologist	Phase 1	B.Sc. (Hons) Aquatic Science	7 years' fauna consulting
Mr Ray Lloyd	Senior Zoologist	Phase 2	B.Sc. (Hons) Zoology	10 years' fauna experience, 4 years' consulting experience
Ms Brighton Downing	Zoologist	Phase 1 and 2	B.Sc. (Hons) Zoology, Conservation Biology	3 years' fauna experience, 1 year consulting experience



### Legend

 StudyArea

### Sampling Method

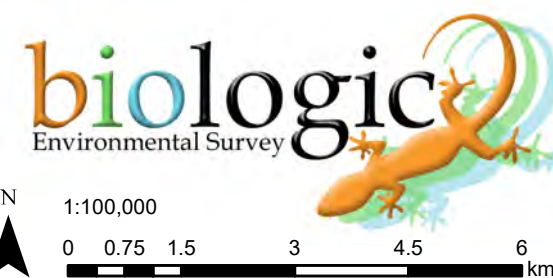
 Active Foraging - Phase 1

 Active Foraging - Phase 2

 Leaf/Soil Sieving - Phase 1

 Leaf/Soil Sieving - Phase 2

 Pit-fall Trapping



**RTIO – West Angulas Beyond 2020**

**Level 2 Terrestrial Fauna Survey**

**Figure 4.5: SRE Invertebrate sampling in the Study Area**

Coordinate System: GDA 1994 MGA Zone 50

Projection: Transverse Mercator

Datum: GDA 1994

Size A3. Created 28/01/2019

## 5. RESULTS AND DISCUSSION

### 5.1. Desktop Assessment

#### 5.1.1. Vertebrate Fauna

The desktop assessment identified a total of 298 vertebrate fauna species that have either been previously recorded within the Study Area, or have the potential to occur in the Study Area based on nearby records (Table 5.1, Appendix G). This total comprises 41 native mammal species, eight introduced mammal species, 135 bird species, 107 reptile species, and seven amphibian species.

Note that the number of species identified during the desktop assessment is likely to have overestimated the number of species potentially occurring in the Study Area. This is because database searches and previous studies were often conducted outside the Study Area and therefore are likely to have contained habitats that are not represented in the current Study Area.

Of the 298 species identified by the desktop assessment, 24 are of conservation significance, comprising seven mammals, 13 birds and four reptiles (Table 5.2; Figure 5.1).

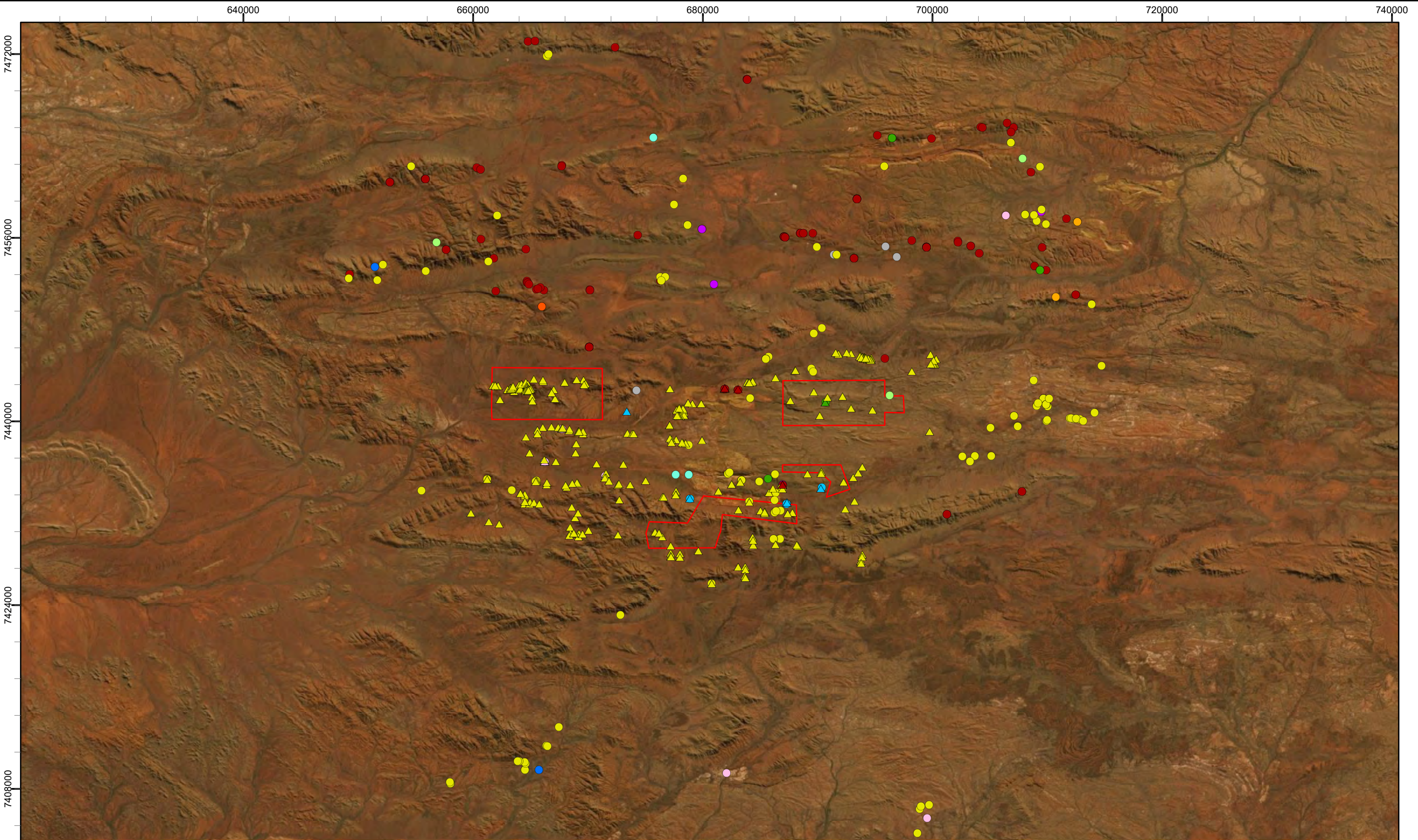
**Table 5.1: Species richness recorded by previous surveys and database searches**

Source	Reference	Mammals (native)	Mammals (introduced)	Birds	Reptiles	Amphibians	Total
<b>Literature Sources</b>							
An ecological appreciation of the West Angelas environment, Western Australia 1979 (Integrated Environmental Services, 1979)	A	17	1	61	39	3	121
West Angelas Ghost Bat ( <i>Macroderma gigas</i> ) assessment survey (Ecologia, 1998a)	B	3	0	0	0	0	3
West Angelas Project vertebrate fauna assessment survey (Ecologia, 1998b)	C	21	3	106	59	4	194
West Angelas mine site Ghost Bat assessment survey, September 2000 (Ecologia, 2000)	D	1	0	0	0	0	1
West Angelas mine site Ghost Bat assessment survey, September 2001 (ecologia Environmental Consultants, 2001)	E	3	0	0	0	0	3
Ghost Bats at West Angelas: 2002 survey data review and future directions (Biota, 2002)	F	3	0	1	0	0	4
Monitoring of Ghost Bat roosts at West Angelas 2003 (Biota 2004 (Biota, 2004))	G	2	0	0	0	0	2
Fauna habitats and fauna assemblages of Deposits E and F at West Angelas (Biota, 2005)	H	10	2	47	36	0	95
South Flank Vertebrate Fauna Survey (Biologic, 2011)	I	26	4	66	63	2	161
Angelo River Vertebrate Fauna Baseline Survey (ENV, 2011)	J	21	4	43	30	2	100
Targeted Conservation Significant Fauna Survey Karijini Tenement E47 17 (Biologic, 2013a)	K	6	0	13	4	0	23
West Angelas – Deposit B Ghost Bat assessment (Biologic, 2013b)	L	8	0	0	0	0	8

Source	Reference	Mammals (native)	Mammals (introduced)	Birds	Reptiles	Amphibians	Total
Greater West Angelas terrestrial fauna assessment (Ecologia, 2014)	M	23	2	80	62	0	167
West Angelas NVCP Biological Assessment (EcoLogical Australia, 2014)	N	4	0	20	3	0	27
Western Hill NVCP Report (Biota, 2014)	O	1	0	0	0	0	1
West Angelas – Deposit B and F Ghost Bat assessment (Biologic, 2015)	P	3	0	0	0	0	3
South Flank Targeted Fauna Survey (Biologic, 2016c)	Q	0	0	0	0	0	0
2017 West Angelas Ghost Bat Monitoring (Biologic, 2018)	R	1	0	0	0	0	1
Database Searches							
NatureMap (DPaW, 2018)	34	7	106	92	5	50	
Threatened Fauna (DBCA, 2019a)	6	0	3	3	0	20	
Protected Matters (DoEE, 2018)	5	7	15	1	0	12	
Birddata (BirdLife Australia, 2018)	-	-	63	-	-	171	
Total number of species	41	8	135	107	7	298	
Total number of species of conservation significance	7	-	13	4	0	24	

**Table 5.2: Species of conservation significance identified by the desktop assessment**

Common Name	Species	Conservation Status	
		BC Act	EPBC Act
Mammals			
Northern Quoll	<i>Dasyurus hallucatus</i>	EN	EN
Greater Bilby	<i>Macrotis lagotis</i>	VU	VU
Ghost Bat	<i>Macroderma gigas</i>	VU	VU
Pilbara Leaf-nosed Bat	<i>Rhinonicteris aurantia</i>	VU	VU
Short-tailed Mouse	<i>Leggadina lakedownensis</i>	P4	
Western Pebble-mound Mouse	<i>Pseudomys chapmani</i>	P4	
Brush-tailed Mulgara	<i>Dasycercus blythi</i>	P4	
Birds			
Curlew Sandpiper	<i>Calidris ferruginea</i>	CR/MI	CR/MI
Night Parrot	<i>Pezoporus occidentalis</i>	CR	EN
Australian Painted Snipe	<i>Rostratula australis</i>	EN	EN
Grey Falcon	<i>Falco hypoleucos</i>	VU	-
Common Sandpiper	<i>Actitis hypoleucos</i>	MI	MI
Fork-tailed Swift	<i>Apus pacificus</i>	MI	MI
Grey Wagtail	<i>Motacilla cinerea</i>	MI	MI
Yellow Wagtail	<i>Motacilla flava</i>	MI	MI
Oriental Plover	<i>Charadrius veredus</i>	MI	MI
Pectoral Sandpiper	<i>Calidris melanotos</i>	MI	MI
Sharp-tailed Sandpiper	<i>Calidris acuminata</i>	MI	MI
Barn Swallow	<i>Hirundo rustica</i>	MI	MI
Peregrine Falcon	<i>Falco peregrinus</i>	OS	-
Reptiles			
Pilbara Olive Python	<i>Liasis olivaceus barroni</i>	VU	VU
Pilbara Flat-headed Blind-snake	<i>Anilius ganei</i>	P1	
Pilbara Barking Gecko	<i>Underwoodisaurus seorsus</i>	P2	
Lined Soil-crevice Skink	<i>Notoscincus butleri</i>	P4	



**Legend**

Study Area

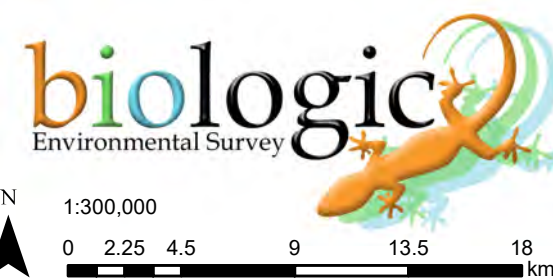
**DBCA Records**

- Pilbara Flat-headed Blind-snake
- Pilbara Barking Gecko
- Pilbara Leaf-nosed Bat
- Pilbara Olive Python
- Short-tailed Mouse

- Greater Bilby
- Fork-tailed Swift
- Ghost Bat
- Grey Falcon
- Northern Quoll
- Peregrine Falcon
- Western Pebble-mound Mouse

**RTIO Records**

- Fork-tailed Swift
- Ghost Bat
- Pilbara Barking Gecko
- Pilbara Leaf-nosed Bat
- Western Pebble-mound Mouse



**RTIO – West Angelas Beyond 2020**

**Terrestrial Fauna Assessment**

**Figure 5.1: Vertebrate fauna of conservation significance identified in the desktop assessment**

Coordinate System: GDA 1994 MGA Zone 50

Projection: Transverse Mercator

Datum: GDA 1994

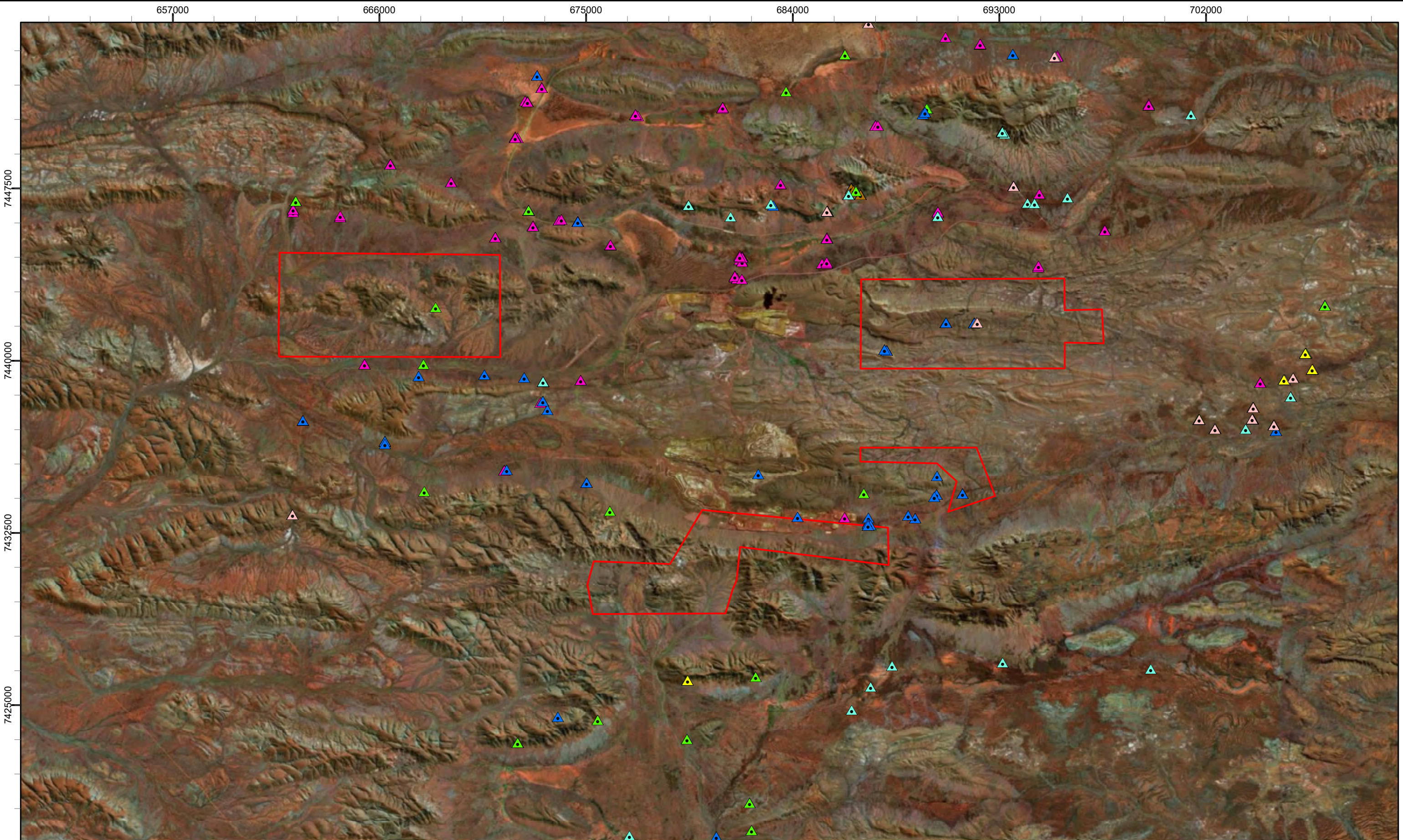
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### 5.1.2.SRE Invertebrate Fauna

The database searches identified 504 records belonging to taxonomic groups prone to short-range endemism. These records comprise 230 mygalomorph spiders, 27 selenopid spiders, 117 pseudoscorpions, 41 myriapods, 61 scorpions, 24 gastropods and four isopods (Figure 5.2; Appendix H). While no SRE invertebrate taxa have been previously recorded in the Study Area, fifteen taxa recorded within 10 km of the Study Area are regarded as Confirmed SRE (Table 5.3). While the SRE status for many of the remaining taxa is unknown, previous records provide some context into the sampling effort that has been applied in the local area and the availability of specimens in the wider region for comparison (Appendix H).

**Table 5.3: SRE taxa known to occur within 10 km of the Study Area**




Taxonomic Group	Family	Taxa
Diplopoda	Paradoxosomatidae	<i>Antichiropus</i> `DIP007`
Diplopoda	Paradoxosomatidae	<i>Antichiropus</i> `DNA06`
Diplopoda	Paradoxosomatidae	<i>Antichiropus</i> `Wonmunna`
Gastropoda	Camaenidae	Gen. nov. `Mount Robinson` n.sp.
Gastropoda	Camaenidae	Gen. nov. `Z` n.sp.
Mygalomorphae	Barychelidae	<i>Aurecocrypta</i> `MYG315`
Mygalomorphae	Barychelidae	<i>Aurecocrypta</i> `MYG315-DNA`
Mygalomorphae	Barychelidae	<i>Synothele</i> `MYG309`
Mygalomorphae	Barychelidae	<i>Synothele</i> `MYG309-DNA`
Mygalomorphae	Ctenizidae	<i>Conothele</i> `MYG280`
Mygalomorphae	Halonoproctidae	<i>Conothele</i> `MYG281-DNA`
Mygalomorphae	Idiopidae	<i>Anidiops</i> `Wonmunna large`
Mygalomorphae	Nemesiidae	<i>Kwonkan</i> `MYG339-DNA`
Mygalomorphae	Nemesiidae	<i>Yilgarnia</i> `MYG197`
Pseudoscorpiones	Garypidae	<i>Synsphyronus gracilis</i>







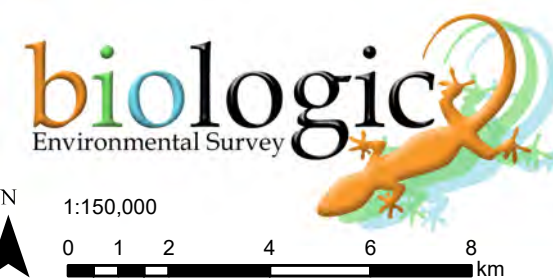
### Legend

 StudyArea

### Invertebrate Taxa

-  Gastropoda
-  Isopoda
-  Mygalomorphae

-  Myriapoda
-  Pseudoscorpiones
-  Scorpiones
-  Selenopidae



**RTIO – West Angas Beyond 2020**  
**Terrestrial Fauna Assessment**  
**Figure 5.2: SRE Invertebrate WA database results**

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

Size A3. Created 28/01/2019

## 5.2. Fauna Habitats

### 5.2.1. Broad Fauna Habitats

A total of seven broad fauna habitat types were identified within the Study Area (Figure 5.3). These were, in decreasing order of extent: Hilltop, Hillslope, Ridge or Cliff; Foothslope and Plain; Mulga Spinifex Woodland; Minor Drainage; Gorge or Gully; Drainage Area; and Mixed Acacia Woodland (Table 5.4). A portion of the Study Area comprising land that has been cleared of vegetation or otherwise developed was mapped as Cleared. Habitat assessments which informed the mapping are detailed in Appendix C for vertebrate fauna and Appendix D for SRE invertebrate fauna.

The majority (83.8%) of the Study Area is comprised of two habitat types, Hilltop, Hillslope, Ridge or Cliff habitat (42.5% of the Study Area) and Foothslope and Plain (41.3% of the Study Area). These habitats are characterised by open areas with a rocky substrate and scattered trees and shrubs over a low hummock grasslands. Important habitat features include old-growth spinifex, fallen boulders and outcropping ironstone containing overhangs and crevices. While Gorge or Gully habitat covers a relatively small portion of the Study Area, it comprises many habitat features and microhabitats that are rare or non-existent in other habitat types, such as caves, deep litter piles, rocky overhangs and crevices, and water pools.

Important microhabitats within the Drainage Area, Minor Drainage, Mulga Spinifex Woodlands, Mixed Acacia Woodlands habitats were those which are typical of open woodland areas, such as leaf litter accumulations, woody debris, small hollows, peeling bark, and a thick upper canopy. The Mulga Spinifex Woodlands and Mixed Acacia Woodlands habitats differed from one another in the composition and density of vegetation present, and in the availability of suitable burrowing substrate. The Drainage Area and Minor Drainage habitats are distinguished further as important fauna habitat by the fact they hold water for periods of time following rainfall and are linear features within the landscape, often providing connectivity across large areas.

#### 5.2.1. Significance for Vertebrate Fauna

Of the seven broad fauna habitat types identified within the Study Area, two, Gorge or Gully and Drainage Area habitat, were deemed to be of high significance for vertebrate fauna as they are limited in extent within the surrounding region and provide core habitat for species of conservation significance (Table 5.5). Three were deemed to be of moderate significance, Mulga Spinifex Woodland, Hilltop, Hillslope, Ridge or Cliff, and Mixed Acacia Woodland, as they support species of conservation significance for foraging but do not represent core habitat for these species. The two remaining habitats, Foothslope and Plain and Minor Drainage, were deemed to be of low significance as they are relatively common and widespread in the surrounding region, do not provide core habitat for species of conservation significance and do not solely support any DBCA listed Priority fauna.

### 5.2.2. Significance for SRE Invertebrate Fauna



The broad habitat regarded as most suitable for SRE invertebrate fauna within the Study Area is the Gorge or Gully habitat (high suitability) due to the steep rocky landforms which provide consistent shade and complex microhabitats. The high level of shelter and complexity of these habitats also offers some protection from fire, and areas where water can be retained long after rainfall resulting in dense pockets of vegetation with stable detrital microhabitats. Where these landform and vegetation factors combine, particularly when highly fragmented or isolated, they often provide the most suitable habitats for SRE invertebrate fauna.



The Mixed Acacia Woodland habitat is regarded as being of moderate/ high suitability for SRE invertebrate fauna based on the availability of dense patches of vegetation that are structurally distinct from the surrounding landscape and provide a high degree of shelter and detrital microhabitats (such as leaf litter and woody debris), as well as deep clay-loam soils.



Three other broad habitats are regarded as being of moderate suitability; Mulga Spinifex Woodland, Drainage Area and Hilltop, Hillslope, Ridge or Cliff. The former is distinguished from the surrounding low suitability open Plains habitat by the greater availability of shade, leaf litter and detrital habitats, and deep clay-loam soils; however, the more open nature of the vegetation and lower vegetation complexity makes this habitat less suitable than the Mixed Acacia Woodland. The Drainage Area, although similar in structure and complexity to the Mixed Acacia Woodland, these habitats tend to be less isolated due to their connection with other drainage habitats, such as floodplains and drainage lines which facilitate dispersal of many SRE invertebrate groups. Likewise, these drainage habitats tend to be seasonally disturbed by rain events and therefore any detrital microhabitats and surface soil structure tend to be less stable in the long term reducing the likelihood that any long-lived SRE invertebrates, such as trapdoor spiders, will favour this type of habitat.


The Hilltop, Hillslope, Ridge or Cliff habitat is a complex habitat as it largely comprises slopes and crests of skeletal soils and open vegetation (often *Triodia* hummock grassland with scattered *Corymbia*/*Eucalyptus* spp.), normally regarded as being of low suitability, interspersed with more suitable rocky habitats such as outcropping, ridges and gullies. Recent targeted SRE invertebrate work 10 km to the north of the Study Area has shown that Hilltop, Hillslope, Ridge or Cliff habitats can contain highly suitable microhabitats considered essential to some SRE invertebrate taxa, in this case the confirmed SRE and DBCA Priority 1 species *Antichiropus* 'DIP007' and A. 'DIP006' which use pockets of soil at the base of *Corymbia hamersleyana* (usually mallee form) on hillcrests and upper slopes (Biologic, 2016b). The remaining two habitats, Foothill and Plains and Minor Drainage, as well as the areas mapped as cleared were considered to be of low suitability for SRE invertebrate fauna.

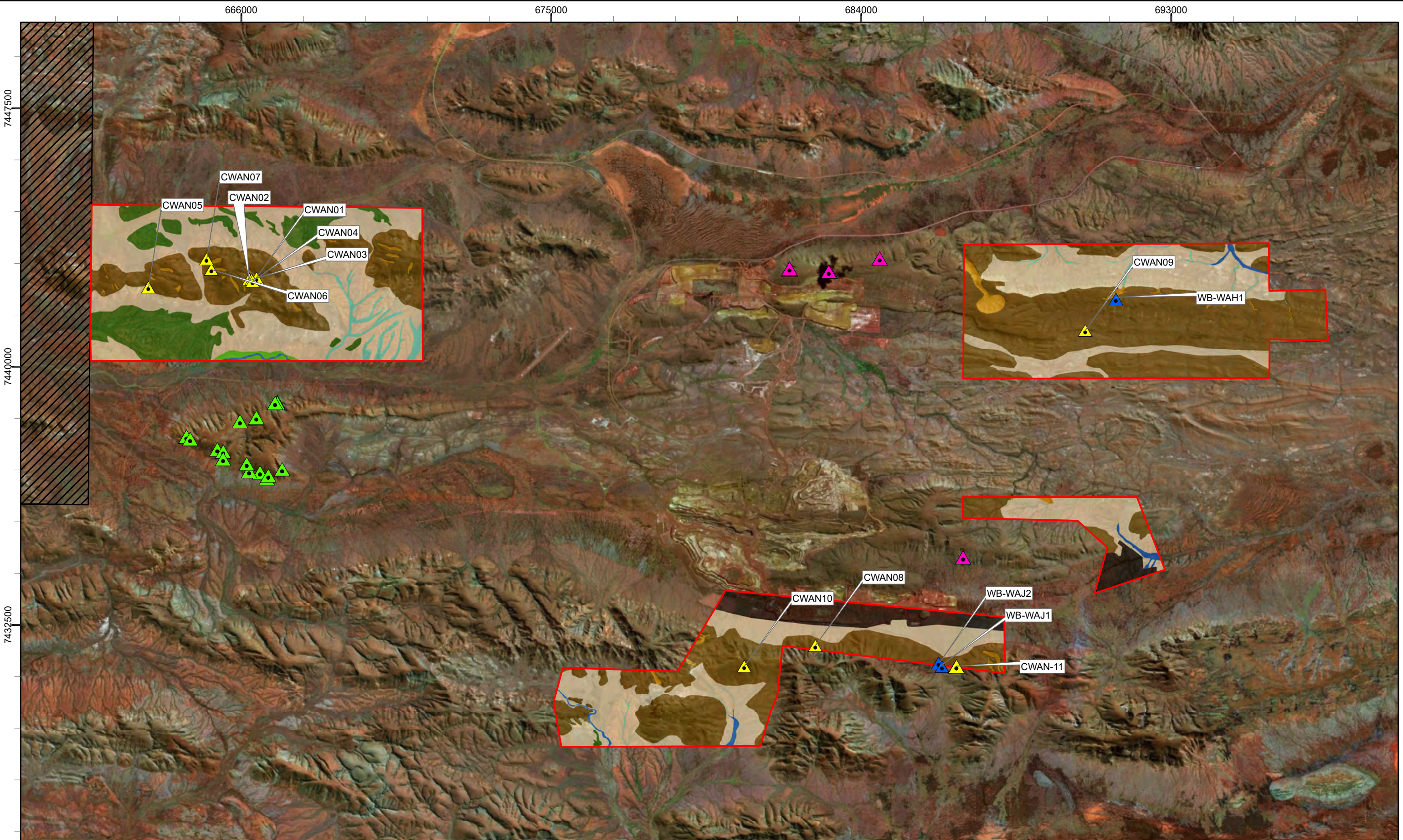
**Table 5.4: Fauna habitat descriptions**

Habitat Type	Description	Extent	Representative Photo
<p><b>Hilltop, Hillslope, Ridge or Cliff</b></p> <p><b>Extent in Study Area:</b> 4,920 ha (42.5%)</p> <p><b>Vertebrate Fauna Significance:</b> Moderate VRT-WA09 VRT-WA10</p> <p><b>SRE Invertebrate Fauna Suitability:</b> Moderate</p>	<p>Hilltop, Hillslope, Ridge or Cliff habitat tends to be more open and structurally simple than other fauna habitats. A common feature of this habitat is a rocky substrate, often with exposed bedrock, and skeletal red soils. These can contain cracks and crevices, but not to the same extent as within rocky upland areas of Gorge or Gully habitat. This habitat is usually dominated by open <i>Eucalyptus</i> woodlands, <i>Acacia</i> and <i>Grevillea</i> scrublands and <i>Triodia</i> low hummock grasslands.</p>	<p>Hilltop, Hillslope, Ridge or Cliff makes up most of the higher ground within the Study Area and is distributed across each of the deposits. This habitat is a very common habitat in the Hamersley subregion.</p>	
<p><b>Footslope and Plain</b></p> <p><b>Extent in Study Area:</b> 4778 ha; (41.3%)</p> <p><b>Vertebrate Fauna Significance:</b> Low VRT-WA01 VRT-WA04 VRT-WA05</p> <p><b>SRE Invertebrate Fauna Suitability:</b> Low</p>	<p>Footslope and Plain comprise low-lying open plains and the rolling hills below upland areas. Vegetation within this habitat varied in composition, but was generally dominated by scattered Mulga and <i>Acacia pruinocarpa</i> forming an over-storey, with a mid-storey comprising <i>Eremophila</i> and <i>Ptilotus</i> spp., over low hummock grasslands of <i>Triodia wiseana</i>, <i>T. basedowii</i>, <i>T. longifolia</i> and <i>T. pungens</i>. Scattered <i>Corymbia hamersleyana</i>, <i>Eucalyptus leucophloia</i>, <i>E. gamophylla</i> were also present.</p>	<p>Footslope and Plain habitat exists in the low-lying areas of all deposits within the Study Area. It represents a transition zone between Hillcrest, Hillslope, Ridge or Cliff habitat and the lower lying habitats of Drainage Area, Minor Drainage, Mixed Acacia Woodland and Mulga Spinifex Woodlands. Footslope and Plain habitat is common and widespread both within the Study Area and in the surrounding region.</p>	

Habitat Type	Description	Extent	Representative Photo
<b>Mulga Spinifex Woodland</b>  <b>Extent in Study Area:</b> 814 ha; (7.0%)  <b>Vertebrate Fauna Significance:</b> Moderate  <b>SRE Invertebrate Fauna Suitability:</b> Moderate	<p>Mulga Spinifex Woodland habitat comprises of areas where vegetation is dominated by an overstorey of Mulga with various scattered shrubs and a tussock grassland dominated by <i>Eragrostis eriopoda</i> and <i>Aristida</i> or spinifex (<i>Triodia</i>) grasslands. Leaf litter and woody debris are common components of this habitat.</p>	<p>Mulga Spinifex Woodland habitat is mainly located within the Western Hill Deposit and is typically surrounded by Drainage Area and Foothills and Plain habitat.</p> <p>Mulga Spinifex Woodland is common and widespread across the Pilbara, occurring extensively in the southern portions of the bioregion, particularly within the Hamersley subregion, which represents its northern extent (Cowan, 2001).</p>	
<b>Minor Drainage</b>  <b>Extent in Study Area:</b> 168 ha; (1.45%)  <b>Vertebrate Fauna Significance:</b> Low VWAH-11  <b>SRE Invertebrate Fauna Suitability:</b> Low	<p>Minor Drainage habitat comprises drainage systems that are dominated by dense stands of Mulga and other <i>Acacia</i> spp. over sandy creek beds. Vegetation adjacent to the main channel or channels is denser, taller and more diverse than adjacent terrain.</p>	<p>Minor Drainage habitat occurs within the lower lying areas across the Study Area. Minor Drainage habitat is common throughout the region but comprises a small proportion of the land area.</p>	

Habitat Type	Description	Extent	Representative Photo
<p><b>Gorge or Gully</b></p> <p><b>Extent in Study Area:</b> 157 ha; (1.4%)</p> <p><b>Vertebrate Fauna Significance:</b> High VRT-WA06 VRT-WA07 VRT-WA08</p> <p><b>SRE Invertebrate Fauna Suitability:</b> High</p>	<p>Gorges and gullies are rugged, steep-sided valleys incised into the surrounding landscape. Gorges tend to be deeply incised, with vertical cliff faces, while gullies are more open (but not as open as Drainage Area habitat or valleys). Caves and deep, rocky crevices are most often encountered in this habitat type, as are water pools. Vegetation can be dense and complex in areas of soil deposition or sparse and simple where erosion has occurred.</p>	<p>Gorge or Gully habitat type occurs in small areas across all deposits but is most extensive in the Western Hill Deposit.</p> <p>This habitat is widespread across the Pilbara, but covers a relatively small area, compared with other habitat types.</p>	
<p><b>Drainage Area</b></p> <p><b>Extent in Study Area:</b> 72.1 ha; (0.6%)</p> <p><b>Vertebrate Fauna Significance:</b> High VRT-WA02 VRT-WA03</p> <p><b>SRE Invertebrate Fauna Suitability:</b> Moderate</p>	<p>Drainage Area habitat comprises densely vegetated plains occurring on low-lying alluvial plains, with a moderate-high amount of leaf litter and woody debris. The vegetation differed from that of Mulga Spinifex Woodlands by the scattered Eucalypts and the dominance of other <i>Acacia</i> spp., such as <i>A. tetragonophylla</i>, and by the abundance of small ephemerals grasses and herbs.</p>	<p>Drainage Area habitat occurs throughout the Study Area, often in association with Mulga Spinifex Woodland habitat and Minor Drainage habitat. Drainage Area habitat is widespread in the surrounding region, but covers a relatively small area, compared with other habitat types.</p>	

Habitat Type	Description	Extent	Representative Photo
<p><b>Mixed Acacia Woodland</b></p> <p><b>Extent in Study Area:</b> 44 ha; (0.4%)</p> <p><b>Vertebrate Fauna Significance:</b> Moderate VRT-WA12</p> <p><b>SRE Invertebrate Fauna Suitability:</b> Moderate/High</p>	<p>Mixed Acacia Woodland habitat comprises areas where vegetation is a dense mix of <i>Acacia</i>, with a mixture of Mulga (<i>Acacia aneura</i>), <i>Acacia maitlandii</i> and <i>Acacia pruinocarpa</i> over a mixture of sparse small shrubs and grasses, such a <i>Triodia</i> and <i>Senna</i> species and <i>Ptilotus</i> sp. Dense leaf litter, and woody debris is a common feature of this habitat type. This habitat is very similar to Mulga Spinifex Woodland habitat.</p>	<p>The Mixed Acacia Woodland occurs within a small area within the Western Hill Deposit, but is considered common and widespread in the surrounding region.</p>	



**Legend**

- |                              |                                       |                             |                                    |
|------------------------------|---------------------------------------|-----------------------------|------------------------------------|
| StudyArea                    | <b>Previous Studies</b> Biologic 2018 | <b>Habitat Type</b> Cleared | Hilltop, Hillslope, Ridge or Cliff |
| Karijini National Park       | Biologic CDG caves                    | Drainage Area               | Minor Drainage                     |
| <b>Habitat Features</b> Cave |                                       | Footslope and Plain         | Mixed Acacia Woodland              |
| Water feature                |                                       | Gorge or Gully              | Mulga Spinifex Woodland            |

N  
1:100,000  
0 0.75 1.5 3 4.5 6 km

**RTIO – West Angelas Beyond 2020**  
**Terrestrial Fauna Assessment**  
**Figure 5.3: Fauna habitats of the Study Area**

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

Size A3. Created 28/01/2019

**Table 5.5: Habitat significance for vertebrate fauna**

Fauna habitat	Significance rating	Rationale
Gorge or Gully	High	Gorge or Gully habitat is widespread across the Pilbara, but covers a relatively small area. It is regionally significant as it supports unique faunal assemblages and represents core habitat for species of conservation significance. The habitat represents important denning (within caves and deep crevices) and foraging habitat for the Northern Quoll and Pilbara Olive Python. It also contains a concentration of caves and overhangs, which provide roosting opportunities the Ghost Bat and Pilbara Leaf-nosed Bat. These bat species also rely on this habitat for foraging. Gorge or Gully habitat may also support the Pilbara Flat-headed Blind-snake, which is known from moist soil within gorges and gullies, and the Pilbara Barking Gecko, which is known from gorges dominated by sparse tree cover and spinifex.
Drainage Area	High	Drainage Area habitat provides potentially suitable dispersal and foraging habitat for the Northern Quoll, Ghost Bat, Pilbara Leaf-nosed Bat, Pilbara Olive Python and Pilbara Flat-headed Blind-snake. The habitat also provides foraging habitat for the Grey Falcon and Peregrine Falcon. The Grey Falcon may also roost in the tall trees that are often present. Tall eucalypts may also contain hollows which may be used by the Northern Quoll as den sites. Drainage Area habitat may support the Short-tailed Mouse, which can also occur in a variety of other habitats. This habitat type may also provide temporary habitat for Migratory water birds in the form of water pools which persist following rainfall.
Hilltop, Hillslope, Ridge or Cliff	Moderate	Hilltop, Hillslope, Ridge or Cliff habitat provides potential foraging habitat for the Northern Quoll and Pilbara Olive Python. It also provides some limited denning habitat for these species in the form of rocky crevices. Cliff areas may provide potential breeding sites for the Peregrine Falcon. The Western Pebble-mound Mouse and Pilbara Barking Gecko may also occur on the rocky slopes present.
Mulga Spinifex Woodland	Moderate	Mulga Spinifex Woodland habitat provides potential foraging habitat for the Ghost Bat, Grey Falcon, Peregrine Falcon and Short-tailed Mouse; however, this habitat type does not form their core habitat and these species will forage in other habitat types.
Mixed Acacia Woodland	Moderate	Mixed Acacia Woodland provides potential foraging habitat for the Ghost Bat, Pilbara Leaf-nosed Bat, Grey Falcon, Peregrine Falcon and Short-tailed Mouse; however, this habitat type does not form core habitat for these species, and they will forage in other habitat types.
Footslope and Plain	Low	Footslope and Plain habitat supports the Western Pebble-mound Mouse and provides potential foraging habitat for raptors such as the Grey Falcon and Peregrine Falcon; however, these species do not rely exclusively on this habitat type. Footslope and Plain habitat may also support the Lined Soil-crevice Skink, which is known from stony areas dominated by spinifex; the Brush-tailed Mulgara, which inhabits spinifex grasslands; and the Short-tailed Mouse, which can occur within hummock grasslands among other habitat types.
Minor Drainage	Low	Minor Drainage habitat is utilised by several Priority species but does not support a significant population of these species and these species are not restricted to this habitat type.

### 5.2.3. Important Habitat Features

#### Caves

Caves are important habitat features within a landscape, particularly arid zone systems, as they offer fauna stable microclimates, shelter and protection (Medellin, Wiederholt & Lopez-Hoffman, 2017). A total of 11 caves were recorded within the Study Area (Table 5.6; Appendix I). Additional caves are likely to be present within Study Area within Gorge or Gully and the Hilltop, Hillslope, Ridge or Cliff habitats as not all areas likely to contain caves were systematically searched.

Of the 11 caves recorded, seven contained evidence of occupation by the Ghost Bat (Table 5.6). Three caves (CWAN-08, CWAN-09 and CWAN-11) were identified as being suitable as night roosts for the species (i.e. visited during foraging or dispersal activities); four caves (CWAN-01, CWAN-02, CWAN-03 and CWAN-10) were considered to be potential diurnal roosts for the species, as their structure (e.g. large size, limited light penetration) is consistent with other confirmed diurnal roosts within the region (Biologic, 2019c) and/ or there was evidence to suggest periods of high activity (e.g. large amounts of scat material) (Table 5.6).

Three caves (CWAN-04, CWAN-06, CWAN-07), all located within the Western Hill Deposit, were assessed as potentially supporting Ghost Bat females and pups during the reproductive cycle. Cave CWAN-04 was identified as a Ghost Bat maternity roost, owing to the abundance of scats and the discovery of a Ghost Bat pup carcass (Plate 5.1); and caves CWAN-06 and CWAN-07 were identified as potential Ghost Bat maternity roosts as their structure (e.g. large size, stable climate, limited light penetration) is consistent with other confirmed maternity roosts within the region (Biologic, 2019c), and they contained more than 5,000 scats of the species. A single Ghost Bat was observed in one of these (CWAN-06) during both the Phase 1 and Phase 2 surveys, confirming its use as a diurnal roost.

Ghost Bat scat collection sheets were installed at caves CWAN-04 (two sheets), CWAN-06 (one sheet) and CWAN-07 (three sheets) during the Phase 1 survey and assessed during the Phase 2 survey. The sheets installed at CWAN-07 collected approximately 500 Ghost Bat scats, indicating the cave had been used by a substantial number of individuals. Other sheets did not collect any scats.

Scats of the Northern Quoll and Pilbara Olive Python were also recorded from cave CWAN-04. The number of Northern Quoll scats at this location suggests the cave has been used as a permanent den by the species. A number of unknown scats were also recorded from caves CWAN-04, CWAN-06 and CWAN-07. Further work to identify the scats was inconclusive – refer to Section 5.3.3 for further details.

**Table 5.6: Caves recorded within the Study Area**

Name	Deposit	Cave category	Initial Assessment	Follow up monitoring
CWAN-01	Western Hill	• Potential diurnal roost	• 10 Ghost Bat scats	• N/A
CWAN-02	Western Hill	• Potential diurnal roost	• no Ghost Bat scats	• N/A
CWAN-03	Western Hill	• Potential diurnal roost	• no Ghost Bat scats	• N/A
CWAN-04	Western Hill	• Confirmed maternity roost	<ul style="list-style-type: none"> <li>• ~1,500 Ghost Bat scats recorded during Phase 1, sheeted</li> <li>• Dead Ghost Bat pup (Skeleton) found –</li> <li>• ~200 Northern Quoll scats (possible den)</li> <li>• Large midden of unidentified scats</li> <li>• Pilbara Olive Python scats recorded</li> </ul>	• Zero Ghost Bats scats deposited on sheets between Phase 1 and Phase 2
CWAN-05	Western Hill	• Potential night roost	• no Ghost Bat scats	• N/A
CWAN-06	Western Hill	• Potential maternity roost	<ul style="list-style-type: none"> <li>• ~1,500 Ghost Bat scats</li> <li>• 1 Ghost Bat individual present</li> <li>• Large midden of unidentified scats</li> </ul>	<ul style="list-style-type: none"> <li>• Zero scats on sheets</li> <li>• One Ghost Bat individual present</li> </ul>
CWAN-07	Western Hill	• Potential maternity roost	<ul style="list-style-type: none"> <li>• ~5,000 Ghost Bat scats</li> <li>• Large midden of unidentified scats</li> </ul>	<ul style="list-style-type: none"> <li>• ~500 Ghost Bats scats deposited on sheets between Phase 1 and Phase 2</li> <li>• 20 collected</li> </ul>
CWAN-08	Deposit J & Mt Ella East	• Night roost	• 30 Ghost Bat scats	• N/A
CWAN-09	Deposit H	• Night roost	• 7 Ghost Bat scats	• N/A
CWAN-10	Deposit J & Mt Ella East	• Potential diurnal roost	• No Ghost Bat scats	• N/A
CWAN-11	Deposit J & Mt Ella East	• Night roost	• 1 Ghost Bat scat	• N/A



**Plate 5.1: Ghost Bat pup carcass from CWAN-04**

#### *Water Features*



Water is a limiting factor for many ecosystems (James, Landsberg & Morton, 1995), particularly within arid and semi-arid zones such as in the Pilbara (Burbidge, Johnstone & Pearson, 2010; Doughty, Rolfe, Burbidge, Pearson & Kendrick, 2011), and water features often represent areas of comparatively high productivity (Murray, Zeppel, Hose & Eamus, 2003). Mammals and birds have endothermic metabolisms and thus require relatively continuous sources of food and moisture, while water for amphibians provides opportunities to forage (i.e. suitably wet periods) and breed (i.e. when water pools for long enough for them to complete the life cycle) (James, Landsberg & Morton, 1995). Therefore, any natural water features present in the Study Area represents critical habitat because of the important role they play in supporting fauna, particularly species of conservation significance.


Three water pools were recorded within the Study Area during the Phase 1 survey (Table 5.7), which was conducted in October following the typical dry season (Figure 5.3). It is likely that the water in these pools came from the high rainfall in June 2018, three months prior (see Section 4.1). Following the lack of rainfall between June and the survey, the pools were drying up, indicating that they provide only temporary sources of water following periods of rain.

Water feature WB-WAH1 (Table 5.7) was initially documented by RTIO staff in August 2018 and by the time of the Phase 1 survey, it had dried up substantially (Rio Tinto, 2018). As part of targeted sampling efforts (see Section 4.3.2) a motion camera and ultrasonic bat recorder were installed at the site for four nights; however, no species of conservation significance were recorded here during this time.

Water features WB-WAJ1 and WB-WAJ2 were located in the same rocky gully. Ten motion cameras were deployed at these sites between Phase 1 and Phase 2. No species of conservation significance were recorded on these cameras. When the cameras were retrieved during the Phase 2 survey, recent rain had created a series of small, interconnected pools within the gully.

**Table 5.7: Water Features recorded in the Study Area**

Name	Location	Latitude	Longitude	Comment	Photo
WB-WAJ2	Deposit J and Mt Ella East	-23.216	118.820	Small rock pool in Gorge or Gully habitat	
WB-WAJ1	Deposit J and Mt Ella East	-23.217	118.821	Small rock pool in Gorge or Gully habitat	

Name	Location	Latitude	Longitude	Comment	Photo
WB-WAH1	Deposit H	-23.120	118.869	Rock pool in Gorge or Gully habitat; within the upper catchment of Pebble Mouse Creek	

### 5.3. Vertebrate Fauna Sampling Results

#### 5.3.1. Species Richness within the Study Area

A total of 158 vertebrate fauna species comprising 26 native mammal species, four introduced mammal species, 67 bird species, 59 reptile species, and two amphibian species, were recorded during the field surveys (Appendix J). This comprises 53% of the total number of species identified by the desktop assessment ( $n = 298$ ) as potentially occurring in the Study Area (see Section 5.1.1). For example, a two-phase Level 2 survey conducted in the West Angeles area in 2014 recorded 167 vertebrate fauna species, and Level 2 surveys conducted in the South Flank and Angelo River areas in 2011 recorded 161 and 100 species, respectively (Biologic, 2011; Ecologia, 2014; ENV, 2011). The number of species recorded is comparable to other surveys of similar size and scope conducted in the vicinity of the Study Area.

One species recorded during the field surveys had not been identified by the desktop assessment; this was the Pink-eared Duck (*Malacorhynchus membranaceus*), which was recorded by acoustic recording during the Phase 2 survey. The Pink-eared Duck occurs throughout Australia and is usually observed around standing water. It is likely that the species has not been previously recorded in the area because of the lack of large waterbodies. The individual recorded is likely to have been a temporary visitor to the Study Area attracted by the recent rain (see Section 4.1).

A greater diversity of species was recorded during the Phase 2 survey (137 species) when compared to the Phase 1 survey (111 species). A total of 90 species were recorded during both Phases, while 21 species were recorded during Phase 1 only and 47 species were recorded during Phase 2 only (records from long-term deployments of motion-sensor cameras were allocated to Phase 2 results).

### 5.3.2. Species Assemblages

#### Mammals

A total of 26 native mammal species from 11 families were recorded in the Study Area (Appendix J). Four of these are of conservation significance, the Northern Quoll, Pilbara Leaf-nosed Bat, Ghost Bat and Western Pebble-mound Mouse (see Section 5.3.3).

An equal number of native mammal species (23 species) was recorded during each of the Phase 1 and Phase 2 surveys, and each phase recorded three unique native mammal species (i.e. species not recorded in the other phase).

A total of 11 mammal species were trapped during the field surveys. These belonged to two families, Dasyuridae (seven species) and Muridae (four species, of which three were native). The most commonly trapped species was the Kaluta (*Dasykaluta rosamondae*), of which there were 20 captures. Three species were only trapped once, the Western Pebble-mouse Mouse (*Pseudomys chapmani*), Rory's Pseudantechinus (*Pseudantechinus roryi*) and Pilbara Planigale (*Planigale* 'species 1'). The most commonly recorded species across all survey techniques was the Common Rock Rat (*Zyzomys argurus*), of which there were seven captures and 160 records from motion cameras.

The greatest diversity of mammals was trapped at VRT-WA02 within Mixed Acacia Woodland habitat (seven species, of which six are native) and VRT-WA08 within Drainage Area habitat (seven species). The greatest number of capture events occurred at VRT-WA01 (Western Hill Deposit) within Foothill and Plain habitat (where there were 14 captures of three species) and VRT-WA08 (Deposit J & Mt Ella East) (where there were 14 captures of seven species). No mammal species were trapped at VRT-WA05 (Deposit J & Mt Ella East) or VRT-WA07 (Deposit J & Mt Ella East) (both within Hilltop, Hillslope, Ridge or Cliff habitat), or at VW-AH11 (Deposit H) (within Gorge or Gully habitat).

Of the 14 bat species potentially occurring in the Study Area, the field surveys recorded 11 species, from five families. Five of the 11 species recorded (including the Ghost Bat and Pilbara Leaf-nosed Bat) are dependent on caves and rocky crevices for roosting, whereas the remaining six species will typically nest in tree hollows.

The assemblage of mammals recorded in the Study Area is typical for the Pilbara, with no unusual or unexpected species being recorded and all species having been recorded in the area by at least two previous surveys considered in the literature review (Appendix G). The species assemblage of small ground dwelling mammals reflects the rocky nature of the majority of the Study Area, aligning more closely with assemblages known to occur on rocky substrates, as opposed to sandy or clayey substrates (Gibson & McKenzie, 2009). This study recorded 26 native mammal species which the same as South Flank (Biologic, 2011) and similar to (Ecologia, 2014) with 23 species recorded (refer to section 3.2).

## Reptiles

A total of 59 reptile species from ten families were recorded in the Study Area (Appendix J). Two of these species are of conservation significance, the Pilbara Olive Python and the Pilbara Flat-headed Blind-snake (see Section 5.3.3).

More reptile species were recorded during the Phase 2 survey (49 species) than the Phase 1 survey (36 species). The Phase 1 survey identified ten reptile species that were not recorded during the Phase 2 survey, and the Phase 2 survey identified 23 species that were not recorded during the Phase 1 survey.

The most commonly recorded group of reptiles was the Scincidae (skinks), with 57.2% of all reptile records being of species belonging to this family. The Scincidae was also the most diverse group of reptiles recorded, with 16 species identified. The next most diverse group recorded was the Elapidae (venomous snakes), of which nine species were recorded. The most commonly recorded species was the Plain Ctenotus (*Ctenotus inornatus*), of which there were 149 capture events at systematic sampling sites. A total of 12 reptile species were represented by single records only.

The greatest diversity of reptiles was trapped at VRT-WA02 (Western Hill Deposit) within Mixed Acacia Woodland habitat, where 20 reptile species were captured. A relatively high diversity of reptile species was also trapped at VRT-WA03 (Western Hill Deposit) within Minor Drainage habitat (19 species), VRT-WA05 (Deposit J & Mt Ella) within Hilltop, Hillslope, Ridge or Cliff habitat (16 species) and VRT-WA06 (Deposit J & Mt Ella) within Drainage Area habitat (15 species). The lowest number of reptile species trapped at a systematic sampling site was seven, which was recorded at VRT-WA10 (Deposit F) within Gorge or Gully habitat.

The assemblage of reptiles recorded in the Study Area is generally typical for the Pilbara, aligning with assemblages known to occur in the region, particularly those within habitats dominated by a rocky substrate (Doughty, Rolfe, Burbidge, Pearson & Kendrick, 2011). As this survey recorded 59 species it is similar to (Ecologia, 2014) with 62 species recorded and South Flank (Biologic, 2011) with 63 species recorded (refer to section 3.2). Two species recorded in the Study Area are relatively uncommon in the area, each having only been recorded by one other survey considered in the literature review and each being represented by relatively few records in the wider region (DBCA, 2019b). These are the Southern Pilbara Rock Goanna (*Varanus hamersleyensis*) and the Pale-headed Blind Snake (*Anilius hamatus*). Rather than indicating rarity, the low number of previous records of the Southern Pilbara Rock Goanna more likely reflects the fact that the species has been recently split from the Pilbara Rock Monitor (*Varanus pilbarensis*) and previous records of the Pilbara Rock Monitor in the Hamersley Range, which are more abundant, are also likely attributable to the species. The low number of records of the Pale-headed Blind Snake in the vicinity of the Study Area may be due to the Study Area being located at the northern limits of its distribution (Wilson & Swan, 2014). The species is distributed through arid and semi-arid regions south of the Study Area through the midwest of Western Australia where it is usually found in mallee/spinifex associations, samphire flats, and mulga woodlands and shrublands (Wilson & Swan, 2014).

## Birds

A total of 67 bird species from 35 families were recorded in the Study Area (Appendix J). One of these is of conservation significance, the Fork-tailed Swift, which is listed as Migratory under the BC Act and EPBC Act (see Section 5.3.3 for more details).

More bird species were recorded during the Phase 2 survey (60 species) than the Phase 1 survey (48 species). The Phase 1 survey identified seven bird species that were not recorded during the Phase 2 survey, and the Phase 2 survey identified 19 species that were not recorded during the Phase 1 survey.

The most commonly recorded group of birds was the Meliphagidae (honeyeaters), with 39.7% of all records being of species belonging to this family. Meliphagidae (honeyeaters) was also the most diverse group of birds recorded, with 12 species identified. The next most diverse groups recorded were the Columbidae (pigeons and doves), Acanthizidae (warblers) and Campephagidae (cuckooshrikes), of which four species were recorded from each.

The most commonly observed bird species were the Zebra Finch (*Taeniopygia guttata*) and Singing Honeyeater (*Gavicalis virescens*), of which there were 139 and 99 records, respectively. Four bird species were represented by single individuals: Collared Sparrowhawk (*Accipiter cirrocephalus*), Pink-eared Duck, Pheasant Coucal (*Centropus phasianinus*) and Tawny Frogmouth (*Podargus strigoides*).

The greatest diversity of birds was observed at VRT-WA03 (Western Hill Deposit) within Minor Drainage habitat, where 26 bird species were recorded. A relatively high diversity of birds was also observed at VRT-WA02 (Western Hill Deposit) within Mixed Acacia Woodland habitat (22 species) and VRT-WA08 (Deposit J & Mt Ella) within Drainage Area habitat (21 species). Only two species were recorded at VRT-WA09 (Deposit F) within Foothills and Plain habitat, which was surveyed with a single avifauna census during Phase 1.

The assemblage of birds recorded in the Study Area is typical for the Pilbara, especially an area that does not appear to contain permanent waterbodies, which would attract a greater diversity of waterbirds. The most commonly recorded bird groups (i.e. honeyeaters, pigeons and doves, warblers and cuckoo shrikes) were those which typically inhabit woodlands where vegetation structure and composition is relatively diverse compared with other habitats such as open grasslands. These groups will be dependent on the relatively well-vegetated habitats of the Study Area, such as the Drainage Area, Minor Drainage, Mixed Acacia Woodland and Mulga Spinifex Woodland habitats. It is these habitats that support the highest diversity of bird species within the Study Area. Greater numbers of bird species are likely to be present in the Study Area during wet periods, when waterbirds are more likely to temporarily visit the Study Area. A total of 67 bird species was recorded for the Study Area during this survey which is lower than (Ecologia, 2014) which recorded 80 species in the nearby area, Angelo River survey recorded 43 species (ENV, 2011) (refer to section 3.2).

### Amphibians

Two amphibian species were recorded in the Study Area, neither of which are of conservation significance (Appendix J). One individual of the Little Red Tree Frog (*Litoria rubella*) was opportunistically sighted at the water pool WB-WAH1 during the Phase 1 survey. During the Phase 2 survey, a total of 20 individuals of the Sheep Frog (*Cyclorana maini*) were captured at four systematic sampling sites (all within Western Hill Deposit); 16 individuals were captured at VRT-WA02, two individuals at VRT-WA04, and one individual at each of VRT-WA01 and VRT-WA03. These species are common and widespread within a variety of habitats across much of Western Australia. There are likely to be more amphibian species present in the Study Area; however, the ability to detect them was likely limited by the relatively dry conditions leading up to the surveys (see section 4.1), which would have discouraged amphibians from being active. Previous surveys in the nearby areas only recorded between 2-4 species of amphibians in the literature review (refer to section 3.2) and Nature Map recorded five species in the area (Appendix B).

### Introduced Fauna

Four introduced mammal species were recorded in the Study Area, the Cat (*Felis catus*), Dingo/Dog (*Canis familiaris*), Dromedary Camel (*Camelus dromedarius*) and House Mouse (*Mus musculus*) (Appendix J). One cat was sighted, and the species was also captured on motion camera, with scats and tracks of the species also being observed. Dingoes/Dogs were captured on motion camera, one individual was sighted, and tracks were observed. In addition to scats and tracks of the Dromedary Camel, a total of 27 individuals were observed. Two individuals of the House Mouse were captured.

### Unidentified Scats

Scats collected from three caves within the Study Area (CWAN-04, CWAN-06, CWAN-07) were unable to be identified. The scats, which ranged in size from 8 mm to 35 mm, were yellow-brown and consisted of plant material (Plate 5.2).

The scats were initially thought to possibly belong to the Brushtail Possum (*Trichosurus vulpecula* subspecies unknown), which is listed as Vulnerable under the BC Act; however, when compared with known Brushtail Possum scats, they appear smaller in size and more elongated in shape. Additionally, the Brushtail Possum was not identified by the desktop assessment.

The scats were sent for morphological analysis to two experts in the field of scat identification, Georgeanna Story and Barbara Triggs. A small number of scats were also subject to genetic analysis (Appendix K).

All identifications were inconclusive in their findings; however, the two morphological identifications suggested that the scats belonged to a rodent species. The most likely candidate, based on distribution alone, is the Common Rock Rat (*Zyromys argurus*), which was recorded in the Study Area on multiple occasions during the current survey. Several hair fragments found in the scats most likely belong to the genus *Zyromys*; however, it was not possible to identify the hair to species level (B. Triggs, pers. comm.). In both instances the scats



**Plate 5.2: Unidentified scats collected from caves within the Study Area**

were noted as being substantially larger than known scats of the Common Rock Rat (G. Story, pers. comm.; B. Triggs, pers. comm.). The scats were described as being more similar in size to those of larger rodents, such as the native Pale Field-rat (*Rattus tunneyi*) or introduced Black Rat (*R. rattus*) (G. Story, pers. comm.); however, there are no previous records of these species in the vicinity of the Study Area and both are highly unlikely to occur. The Pale Field-rat is only known in the Pilbara from a number of islands, and the closest record of the Black Rat is approximately 230 km northwest of the Study Area (DBCA, 2019b).

The genetic analysis comprised two tests, a general assay to determine the most similar genetic material and another assay specifically testing for a Brushtail Possum species. No genetic material was traced in the Brushtail Possum assay. The general assay indicated that a portion of the genetic material recorded was most similar to a *Zyzomys* sp. (Appendix K). Given the occurrence of the Common Rock Rat in the Study Area, it is possible that the genetic material detected from this test was derived from a Common Rock Rat coming into contact with the scats rather than the scats belonging to this species.

Without further genetic testing it is not possible to confidently assign the scats to a particular species. Given that the scats were recorded from deep caves where they are protected from weathering, it is possible that they are remnant scats from species that are now considered locally extinct from the region, such as the Central Rock-rat (*Z. pedunculatus*) or Lesser Stick-nest Rat (*Leporillus apicalis*) (Gibson & McKenzie, 2009). Evidence of the latter species was found in the Study Area in the form of amberat (crystallised urine); however, the scats were reported to be smaller than known scats of this species (G. Story, pers. comm.)

### **5.3.3. Vertebrate Fauna of Conservation Significance**

#### Vertebrate Fauna of Conservation Significance Potentially Occurring in the Study Area

The desktop assessment identified 24 species of conservation significance as potentially occurring in the Study Area. Of these:

- seven species were recorded during the current field surveys (Northern Quoll, Ghost Bat, Pilbara Leaf-nosed Bat, Western Pebble-mound Mouse, Pilbara Olive Python, Pilbara Flat-headed Blind-snake and Fork-tailed Swift)
- one species has been previously recorded in the Study Area (but was not recorded during the current field surveys (Pilbara Barking Gecko);
- two species were considered Likely to occur (Peregrine Falcon and Grey Falcon);
- three species were considered to Possibly occur (Night Parrot, Short-tailed Mouse and Brush-tailed Mulgara);
- two species were considered Unlikely to occur (Greater Bilby and Lined Soil-crevice Skink); and
- nine species were considered Highly Unlikely to occur (Australian Painted Snipe, Curlew Sandpiper, and seven other Migratory bird species).

Justification for likelihood of occurrence is outlined in Table 5.8. An account of each species recorded in the Study Area, or considered Likely to occur, or to Possible occur, or Unlikely to occur in the Study Area, is provided below.

**Table 5.8: Likelihood of occurrence for fauna of conservation significance**

Species	Conservation Status		Preferred habitat	Does Suitable Habitat Occur Within the Study Area?	Is the Study Area within the Species' Current Known Distribution ?	Previous Records Near the Study Area	Likelihood of Occurring Within the Study Area
	EPBC Act	BC Act					
Mammals							
Northern Quoll ( <i>Dasyurus hallucatus</i> )	EN	EN	The species tends to inhabit rocky habitats which offer protection from predators and are generally more productive in terms of availability of resources (Braithwaite & Griffiths, 1994b; Oakwood, 2000). Caves and rocky crevices provide important den sites, especially when occurring near sources of water (Woinarski, Oakwood, Winter, Burnett, Milne, Foster, Myles & Holmes, 2008).	Yes – suitable denning habitat occurs within the Gorge or Gully habitat, and suitable foraging and dispersal habitat occurs within the Gorge or Gully, Hilltop, Hillslope, Ridge or Cliff and Drainage Area habitats.	Yes	17 km northeast of Deposit H (2017); three additional records on Hope Downs Mine (2010) (DPaW, 2018)	Confirmed (Western Hill Deposit)
Greater Bilby ( <i>Macrotis lagotis</i> )	VU	VU	Variety of habitats including spinifex hummock grassland and Acacia shrubland, on soft soils (Burrows, Dunlop & Burrows, 2012). In the Pilbara often associated with major drainage line sandy terraces (How, Dell & Cooper, 1991).	Marginally suitable sandy spinifex areas exist within Footslope and Plain habitat	Yes	5 km north of Deposit H (1983); 78 km north of Study Area (2013); 99 km Northwest of Study Area (2013) (DPaW, 2018)	Unlikely – only small patches of marginally suitable habitat are present
Ghost Bat ( <i>Macroderma gigas</i> )	VU	VU	Ghost Bats roost in deep, complex caves beneath bluffs of low, rounded hills, granite rock piles and abandoned mines (Armstrong & Anstee, 2000). These features often occur within habitats including gorge/gully, hill crest/hill slope and low hills (Armstrong & Anstee, 2000).	Yes – suitable roosting habitat (caves) occurs within Gorge or Gully habitat, and suitable foraging habitat exists in the Gorge or Gully, Drainage Area, Mixed Acacia Woodland and Mulga Spinifex Woodland habitats	Yes	Recorded in multiple caves nearby (<5 km) the Study Area (Biologic, 2018, 2019b)	Confirmed (Western Hill Deposit, Deposit J & Mt Ella East, Deposit H)

Species	Conservation Status		Preferred habitat	Does Suitable Habitat Occur Within the Study Area?	Is the Study Area within the Species' Current Known Distribution ?	Previous Records Near the Study Area	Likelihood of Occurring Within the Study Area
	EPBC Act	BC Act					
Pilbara Leaf-nosed Bat ( <i>Rhinonicters aurantia</i> )	VU	VU	Pilbara Leaf-nosed Bats roost within caves and abandoned mines with high humidity (95%) and temperature (32°C) (Armstrong, 2001). The species forages along waterbodies with fringing vegetation (TSSC, 2016).	Yes – suitable roosting habitat (caves) occurs within Gorge or Gully habitat, and suitable foraging habitat exists in the Gorge or Gully, Drainage Area and, Mixed Acacia Woodland habitats.	Yes	800 m south of Western Hill (2014) (Ecologia, 2014)	Confirmed (Western Hill Deposit)
Short-tailed Mouse ( <i>Leggadina lakedownensis</i> )	-	P4	The species occupies a diverse range of habitats from the monsoon tropical coast to semiarid climates, including spinifex and tussock grasslands, samphire and sedgeland, <i>Acacia</i> shrublands, tropical eucalypt and Melaleuca woodlands and stony ranges; however, the species is usually found in seasonally inundated habitats on red or white sandy-clay soils (Moro & Kutt, 2008)	Marginally suitable habitat occurs within the Foothills and Plain habitat, Mulga Spinifex Woodland and Mixed Acacia Woodland habitats.	Yes	5 km from Study Area within West Angelas main pit area (1997) (DPaW, 2018)	Possible
Western Pebble-mound Mouse ( <i>Pseudomys chapmani</i> )	-	P4	This species occurs on the gentler slopes of rocky ranges where the ground is covered with a stony mantle and vegetated by hard spinifex, often with a sparse overstorey of eucalypts and scattered shrubs (Anstee, 1996; Start, Anstee & Endersby, 2000).	Yes – suitable habitat occurs within stony slopes of Foothills and Plain and Hilltop, Hillslope, Ridge or Cliff habitats, and the species may also utilise stony areas within other habitats	Yes	Numerous records in the immediate surrounds (DPaW, 2018)	Confirmed (All Deposits)
Brush-tailed Mulgara ( <i>Dasycercus blythi</i> )	-	P4	Prefers spinifex <i>Triodia</i> spp. grasslands on sand plains and the swales between low dunes (Pavey, Nano, Cooper, Cole & McDonald, 2012; Woolley, 2006). Mature spinifex hummocks appear to be important for protection from introduced predators (Körtner, Pavey & Geiser, 2007).	Marginally suitable habitat occurs in the form of sandy plains within the Foothills and Plain habitat types	Yes	12 records within 35 km of the Study Area to the south (2014) (DBCA, 2019a)	Possible

Species	Conservation Status		Preferred habitat	Does Suitable Habitat Occur Within the Study Area?	Is the Study Area within the Species' Current Known Distribution ?	Previous Records Near the Study Area	Likelihood of Occurring Within the Study Area
	EPBC Act	BC Act					
Birds							
Curlew Sandpiper ( <i>Calidris ferruginea</i> )	CR	CR/MI	Inhabits intertidal mudflats in sheltered coastal areas (i.e. estuaries, bays, inlets and lagoons) (Geering, Agnew & Harding, 2007). This rare species generally roosts on bare dry shingle, shell or sand beaches, sandspits and islets in or around coastal or near-coastal lagoons and other wetlands (Geering, Agnew & Harding, 2007).	No	Yes	95 km east of Study Area (2005) (DPaW, 2018)	Highly Unlikely – the Study Area is outside the species' distribution and does not contain suitable habitat; any occurrences are likely to represent temporary visitation
Night Parrot ( <i>Pezoporus occidentalis</i> )	CR	EN	Sandy/stony plain habitat with old-growth spinifex ( <i>Triodia</i> ) for roosting and nesting in conjunction with native grasses and herbs for foraging (DPaW, 2017).	Marginally suitable habitat occurs in the sandy and stony flats within Drainage Area and Foothills and Plain habitat types	Yes	100 km north of Study Area (2005) (DPaW, 2018)	Possible
Australian Painted Snipe ( <i>Rostratula australis</i> )	EN	EN	Well-vegetated margins of wetlands and other water bodies (Pizzey & Knight, 2007)	No	No	100 km east of Study Area (DPaW, 2018)	Highly Unlikely – the Study Area is outside the species' distribution; any occurrences are likely to represent temporary visitation
Grey Falcon ( <i>Falco hypoleucos</i> )	-	VU	Timbered lowlands, particularly Acacia shrubland and along inland drainage systems. Also frequent spinifex and tussock grassland (Burbidge, Johnstone & Pearson, 2010; Olsen & Olsen, 1986)	Yes – the species may forage within Drainage Area, Mulga Spinifex Woodland, Mixed Acacia Woodland and Foothills and Plain habitats, and may utilise nests constructed by other birds in any large trees or other structures across the Study Area.	Yes	3 km east of Western Hill (1997); 3 records from 10 km north of Deposit H (2008) (DBCA, 2019a)	Likely

Species	Conservation Status		Preferred habitat	Does Suitable Habitat Occur Within the Study Area?	Is the Study Area within the Species' Current Known Distribution ?	Previous Records Near the Study Area	Likelihood of Occurring Within the Study Area
	EPBC Act	BC Act					
Fork-tailed Swift ( <i>Apus pacificus</i> )	Mi	MI	Inhabits dry/open habitats, inclusive of riparian woodlands and tea-tree swamps, low scrub, heathland or saltmarsh, as well as treeless grassland and sandplains covered with spinifex, open farmland and inland and coastal sand-dunes (Johnstone & Storr, 1998).	The species can potentially be observed within all habitat types	Yes	~300 m northwest of Deposit J and 900m west of Deposit J (DBCA, 2019a)	Confirmed (Western Hill Deposit)
Grey Wagtail ( <i>Motacilla cinerea</i> )	MI	MI	A rare vagrant to Western Australia where it has been recorded within various habitats with open waterbodies (Johnstone & Storr, 2004).	No	No	85 km north of Study Area (2012) (DPaW, 2018)	Highly Unlikely – the Study Area is outside the species' distribution and the species is only occasionally present in Australia as a vagrant
Yellow Wagtail ( <i>Motacilla flava</i> )	MI	MI	An uncommon but regular visitor to the Pilbara region (Johnstone, Burbidge & Darnell, 2013). Occupies a range of damp or wet habitats with low vegetation although favours edges of fresh water, especially sewage ponds (Oakwood, 2000)	No	No	312 km northwest of Study Area (1982) (DPaW, 2018)	Highly Unlikely – the Study Area is outside the species' distribution and the species has not been recorded nearby
Oriental Plover ( <i>Charadrius veredus</i> )	MI	MI	A variety of habitats, including coastal habitats, such as estuarine mudflats and sandbanks, on sandy or rocky ocean beaches as well as open inland environments such as, semi-arid or arid grasslands, where the grass is short and sparse (Johnstone & Storr, 2004).	No	Yes	90 km southeast of Study Area (1981) (DPaW, 2018)	Highly Unlikely – the Study Area does not contain suitable habitat; any occurrences are likely to represent temporary visitation
Pectoral Sandpiper ( <i>Calidris melanotos</i> )	MI	MI	Coastal lagoons, estuaries, bays, swamps, lakes, inundated grasslands, saltmarshes, river pools, creeks, floodplains and artificial wetlands (Johnstone & Storr, 2004; Johnstone, Burbidge & Darnell, 2013). It prefers wetlands with open fringing mudflats and low, emergent or fringing vegetation (Geering, Agnew & Harding, 2007).	No	No	85 km southwest of Study Area (1981) (DPaW, 2018)	Highly Unlikely – the Study Area is outside the species' distribution and does not contain suitable habitat; any occurrences are likely to represent temporary visitation

Species	Conservation Status		Preferred habitat	Does Suitable Habitat Occur Within the Study Area?	Is the Study Area within the Species' Current Known Distribution ?	Previous Records Near the Study Area	Likelihood of Occurring Within the Study Area
	EPBC Act	BC Act					
Barn Swallow ( <i>Hirundo rustica</i> )		MI	The Barn Swallow is recorded in open country in coastal lowlands, often near water, towns and cities. Found near freshwater wetlands, paperbark <i>Melaleuca</i> woodland, mesophyll shrub thickets and tussock grassland (Schodde & Mason, 1999). The Barn Swallow is a non-breeding summer visitor to the Pilbara. It favours areas near water (Johnstone, Kirkby & Sarti, 2013).	Yes – suitable habitat occurs within Drainage Area habitat	No	306 km north of Study Area (2005) (DPaW, 2018)	Highly Unlikely – any occurrences are likely to represent temporary visitation
Sharp-tailed Sandpiper ( <i>Calidris acuminata</i> )	Mi	MI	Favours flooded samphire flats and grasslands, mangrove creeks mudflats, beaches, river pools, saltwork ponds, sewage ponds and freshwater soaks (Johnstone, Burbidge & Darnell, 2013).	No	Yes	85 km west of Study Area (1981); 95 km west of Study Area (2001) (DPaW, 2018)	Highly Unlikely – any occurrences are likely to represent temporary visitation
Common Sandpiper ( <i>Tringa hypoleucos</i> )	MI	MI	Estuaries and deltas of streams, as well as banks farther upstream; around lakes, pools, billabongs, reservoirs, dams and claypans (Johnstone & Storr, 1998).	No	No	70 km southeast of Study Area (2012) (DPaW, 2018)	Highly Unlikely – the Study Area is outside the species' distribution and does not contain suitable habitat
Peregrine Falcon ( <i>Falco peregrinus</i> )	-	OS	In arid areas, it is most often encountered along cliffs above rivers, ranges and wooded watercourses where it hunts birds (Johnstone & Storr, 1998). It typically nests on rocky ledges occurring on tall, vertical cliff faces between 25 m and 50 m high (Olsen, Debus, Rodse & Hayes, 2004; Olsen & Olsen, 1989).	Yes – suitable nesting and foraging habitat occurs in the Gorge or Gully and Hilltop, Hillslope, Ridge or Cliff habitats, and suitable foraging habitat occurs within Drainage Area, Mulga Spinifex Woodland, Mixed Acacia Woodland and Foothills and Plain habitats	Yes	13 km northwest of Western Hill (DBCA, 2019a)	Likely

Species	Conservation Status		Preferred habitat	Does Suitable Habitat Occur Within the Study Area?	Is the Study Area within the Species' Current Known Distribution ?	Previous Records Near the Study Area	Likelihood of Occurring Within the Study Area
	EPBC Act	BC Act					
Reptiles							
Pilbara Olive Python ( <i>Liasis olivaceus barroni</i> )	VU	VU	Associated with drainage systems, including areas with localised drainage and watercourses (Pearson, 1993). In the inland Pilbara the species is most often encountered near permanent waterholes in rocky ranges or among riverine vegetation (Pearson, 1993).	Yes – suitable denning and foraging habitat occurs in Gorge or Gully habitat and suitable foraging and dispersal habitat occurs in Drainage Area and Hillslope, Hillslope, Ridge or Cliff habitats.	Yes	On the edge of Deposit H (1900); 11 km northwest of Western Hill (2013) (DPaW, 2018)	Confirmed (Western Hill Deposit and Deposit H)
Pilbara Flat-headed Blind-snake ( <i>Anilius ganei</i> )	-	P1	Little is known about the ecology of the Pilbara Flat-headed Blind-snake, but the species is possibly associated with moist soils and leaf litter within gorges and gullies, and potentially within a wide range of other stony habitats (Wilson & Swan, 2014). The species has been recorded from numerous habitats but is most likely to be present in rocky terrain and along drainage lines (DBCA, 2018b).	Yes – suitable habitat burrowing habitat occurs in Gorge or Gully habitat (where moist soil is present) and in rocky terrain within with Drainage Area habitat	Yes	19 km northeast of Deposit H (2006) (DPaW, 2018)	Confirmed (Deposit J and Mt Ella East)
Pilbara Barking Gecko ( <i>Underwoodi saurus seorsus</i> )		P2	Little is known about the ecology of the Pilbara Barking Gecko, but the species is thought to prefer rocky areas with spinifex and low tree cover habitats (Wilson & Swan, 2014).	Yes – suitable habitat occurs within Gorge or Gully and Hilltop, Hillslope, Ridge or Cliff habitats	Yes	Within Deposit H and 2 km from main West Angelas pit (2014) (Ecologia, 2014)	Confirmed (recorded in Study Area during previous survey)
Lined Soil-crevice Skink ( <i>Notoscincus butleri</i> )		P4	Recorded in areas dominated by spinifex and near water courses (Wilson & Swan, 2014). Records are restricted to a coastal area within the Lower Fortescue Hedland region.	Marginally suitable habitat occurs within Foothslope and Plain habitat.	No	165 km northwest of Study Area (2011) (DBCA, 2019a)	Unlikely – the Study Area is outside the species' distribution and there are no nearby records

### Vertebrate Fauna of Conservation Significance Recorded within the Study Area

A total of seven vertebrate fauna species of conservation significance were recorded in the Study Area during the field surveys (Figure 5.4). Records included direct observations of individuals through capture or sighting, as well the discovery of secondary evidence such as scats, echolocation recordings, and burrows (Table 5.9). An eighth species (the Pilbara Barking Gecko, *Underwoodisaurus seorsus*; Priority 2 – DBCA), is known to occur in the Study Area, having been recorded within Deposit H in 2014 (Ecologia, 2014); however, this species was not recorded during the current field surveys. An account of all eight species is provided below.

#### Northern Quoll (*Dasyurus hallucatus*)

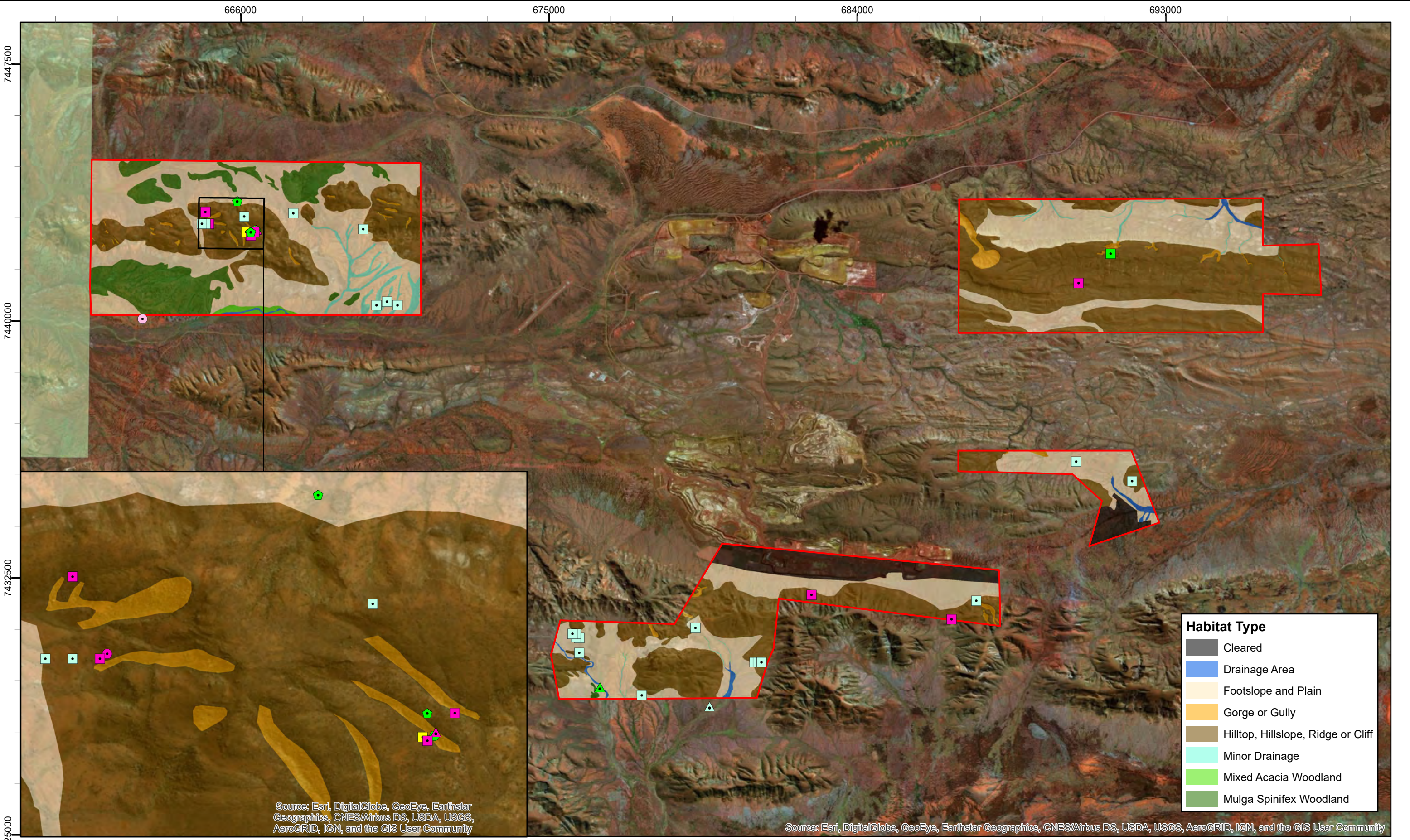
The Northern Quoll is listed as Endangered under both the EPBC Act and BC Act. The species was once widely distributed across northern Australia, although is now restricted to three disjunct populations in the Pilbara, the Kimberley and Northern Territory, and Queensland, as well as on a number of islands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

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

The Northern Quoll has been recorded within Karijini National Park, which lies immediately to the west of the Study Area (DPaW, 2018). The species has also been recorded approximately 17 km northeast of the Study Area at Hope Downs Mine, where the species was captured on camera in 2017 and sighted in 2010 (DBCA, 2019a).

Evidence of the Northern Quoll in the Study Area was restricted to scats found at one location, cave CWAN-04, within the Western Hill Deposit. The scats, of which there were approximately 200, were located towards the back of the cave within a smaller cavity, these scats were considered old, not fresh or recent (+6mths). The cavity was lined with grass, suggesting it may have been a den. Two cameras were installed at the site, one inside the cave and one at its entrance; however, these did not record Northern Quoll over a five-month period between Phase1 and Phase 2 (29/10/2018-19/03/2019).

Suitable denning and foraging habitat for the Northern Quoll is present in the Study Area within the Gorge or Gully habitat type. This habitat type represents core habitat for the species, which consists of rocky breakaways and major gorges and gullies (DoE, 2016). Caves and rock crevices are particularly important for the species as potential den sites. Small pockets of potential denning habitat are also found in Hilltop, Hillslope, Ridge or Cliff habitat. Drainage Area and Hilltop, Hillslope, Ridge or Cliff habitats provide foraging habitat for the species, while Drainage Area habitat also represents important dispersal habitat.



**Habitat Type**

- Cleared
- Drainage Area
- Footslope and Plain
- Gorge or Gully
- Hilltop, Hillslope, Ridge or Cliff
- Minor Drainage
- Mixed Acacia Woodland
- Mulga Spinifex Woodland

**Legend**

Study Area

Karijini National Park

**Fauna Record**

- Fork-tailed Swift (sighted)
- Ghost Bat (remains)
- Ghost Bat (scat)
- Ghost Bat (sighted)
- Northern Quoll (scat)
- Pilbara Flat-headed Blind-snake (captured)
- Pilbara Leaf nosed Bat (ultrasonic call)
- Pilbara Olive Python (motion-sensor camera)
- Pilbara Olive Python (scat)
- Western Pebble-mound Mouse (captured)
- Western Pebble-mound Mouse (mound)

**biologic**  
Environmental Survey

1:100,000

0 0.75 1.5 3 4.5 6 km

**RTIO – West Angelas Beyond 2020**

**Level 2 Terrestrial Fauna Survey**

**Figure 5.4: Fauna of conservation significance recorded in the Study Area**

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

Size A3. Created 12/12/2019

**Table 5.9: Fauna of conservation significance recorded in the Study Area**

Common Name (Scientific name)	Conservation Status		Site	Location		Deposit	Broad Fauna Habitat Type	Evidence
	WA	EPBC Act		Latitude	Longitude			
Mammals								
Northern Quoll ( <i>Dasyurus hallucatus</i> )	EN	EN	CWAN-04	-23.118	118.624	Western Hill	Gorge or Gully	Scats observed in cave
Pilbara Olive Python ( <i>Liasis olivaceus barroni</i> )	VU	VU	CWAN-04	-23.118	118.624	Western Hill	Gorge or Gully	Scats observed in cave
			VRT-WA16	-23.120	118.869	Deposit H	Gorge or Gully	Individual recorded on motion-sensor camera
Ghost Bat ( <i>Macroderma gigas</i> )	VU	VU	CWAN-04	-23.118	118.624	Western Hill	Gorge or Gully	Ghost Bat pup remains found in cave
			CWAN-06	-23.115	118.612	Western Hill	Gorge or Gully	Individual sighted in cave during both Phase 1 and Phase 2
			CWAN-04	-23.118	118.624	Western Hill	Gorge or Gully	Scats observed in cave
			CWAN-06	-23.115	118.612	Western Hill	Gorge or Gully	Scats observed in cave
			CWAN-07	-23.112	118.611	Western Hill	Gorge or Gully	Scats observed in cave
			CWAN-08	-23.212	118.785	Deposit J and Mt Ella East	Gorge or Gully	Scats observed in cave
			CWAN-09	-23.150	118.631	Deposit H	Gorge or Gully	Scats observed in cave
			CWAN-01	-23.117	118.625	Western Hill	Gorge or Gully	Scats observed in cave
			CWAN-11	-23.217	118.825	Deposit J and Mt Ella East	Gorge or Gully	Scats observed in cave
CWAN-07	-23.112	118.611	Western Hill	Gorge or Gully	Scats observed in cave			
Pilbara Leaf-nosed Bat ( <i>Rhinonictis aurantia</i> )	VU	VU	CWAN-04	-23.117	118.624	Western Hill	Gorge or Gully	Echolocation calls recorded
			VVAW-87	-23.109	118.620	Western Hill	Footslope and Plain	Echolocation calls recorded
Western Pebble-mound Mouse ( <i>Pseudomys chapmani</i> )	P4		VRT-WA06	-23.238	118.761	Deposit J and Mt Ella East	Drainage Area	Individual captured in Elliot trap
			VRT-WA38	-23.180	118.876	Deposit F	Hilltop, Hillslope, Ridge or Cliff	Mound observed
			VVAJ-76	-23.223	118.719	Deposit J and Mt Ella East	Footslope and Plain	Mound observed

Common Name (Scientific name)	Conservation Status		Site	Location		Deposit	Broad Fauna Habitat Type	Evidence
	WA	EPBC Act		Latitude	Longitude			
			VWAJ-76	-23.223	118.718	Deposit J and Mt Ella East	Footslope and Plain	Mound observed
			VWAJ-76	-23.222	118.718	Deposit J and Mt Ella East	Footslope and Plain	Mound observed
			VWAJ-76	-23.222	118.717	Deposit J and Mt Ella East	Footslope and Plain	Mound observed
			OPP	-23.115	118.611	Western Hill	Hilltop, Hillslope, Ridge or Cliff	Mound observed
			OPP	-23.112	118.636	Western Hill	Footslope and Plain	Mound observed
			OPP	-23.220	118.752	Deposit J and Mt Ella East	Footslope and Plain	Mound observed
			OPP	-23.175	118.860	Deposit F North	Footslope and Plain	Mound observed
			OPP	-23.113	118.622	Western Hill	Hilltop, Hillslope, Ridge or Cliff	Mound observed (active mound)
			OPP	-23.136	118.666	Western Hill	Minor Drainage	Mound observed
			OPP	-23.136	118.660	Western Hill	Minor Drainage	Mound observed
			OPP	-23.135	118.663	Western Hill	Minor Drainage	Mound observed
			OPP	-23.115	118.610	Western Hill	Hilltop, Hillslope, Ridge or Cliff	Mound observed (active mound)
			OPP	-23.212	118.832	Deposit J and Mt Ella East	Hilltop, Hillslope, Ridge or Cliff	Mound observed (active mound)
			OPP	-23.227	118.719	Deposit J and Mt Ella East	Hilltop, Hillslope, Ridge or Cliff	Mound observed (active mound)
			OPP	-23.238	118.737	Deposit J and Mt Ella East	Footslope and Plain	Mound observed (active mound)
			OPP	-23.229	118.769	Deposit J and Mt Ella East	Hilltop, Hillslope, Ridge or Cliff	Mound observed
			OPP	-23.229	118.770	Deposit J and Mt Ella East	Hilltop, Hillslope, Ridge or Cliff	Mound observed
			OPP	-23.229	118.770	Deposit J and Mt Ella East	Hilltop, Hillslope, Ridge or Cliff	Mound observed
			OPP	-23.229	118.771	Deposit J and Mt Ella East	Hilltop, Hillslope, Ridge or Cliff	Mound observed
			OPP	-23.229	118.771	Deposit J and Mt Ella East	Hilltop, Hillslope, Ridge or Cliff	Mound observed

Common Name (Scientific name)	Conservation Status		Site	Location		Deposit	Broad Fauna Habitat Type	Evidence
	WA	EPBC Act		Latitude	Longitude			
			OPP	-23.116	118.656	Western Hill	Footslope and Plain	Mound observed
<b>Reptiles</b>								
Pilbara Flat-headed Blind-snake ( <i>Anilius ganei</i> )	P1		VRT-WA08	-23.236	118.725	Deposit J and Mt Ella East	Drainage Area	Individual captured in pit trap
<b>Birds</b>								
Fork-tailed Swift ( <i>Apus pacificus</i> )	MI	MI	VRT-WA01	-23.139	118.592	Western Hill	Footslope and Plain	Individuals sighted flying overhead during avifauna census

### Ghost Bat (*Macroderma gigas*)

The Ghost Bat is listed as Vulnerable under both the EPBC Act and BC Act. Ghost Bats roost in deep, complex caves beneath bluffs of low, rounded hills, granite rock piles and abandoned mines (Armstrong & Anstee, 2000). These features often occur within habitats including gorge/gully, hill crest/hill slope and low hills (Armstrong & Anstee, 2000). Ghost Bats are known to require a number of suitable caves throughout their home ranges; both due to temporal factors (i.e. night/ feeding roosts for feeding throughout the duration of the night, as well as day roosts for resting), and seasonal factors (use of certain caves as maternity roosts, depending on the right environmental conditions). The presence of day roosts and/ or maternity roosts in an area is the most important indicator of suitable habitat for Ghost Bats, and these caves are generally the primary focus of conservation and/or monitoring (DBCA, 2019a).

Ghost Bats have been known to occur within the West Angelas area since 1978 and have been recorded intermittently since this time (Biologic, 2018). Five caves used by the Ghost Bat in the West Angelas area (A1, A2, L2, L3, AA1) have been part of a monitoring program since 2012 (Biologic, 2018). Cave AA1, which represents a maternity roost, is located 1.2 km west of Deposit F North and 1.6 km north of Deposit J & Mt Ella East. The remaining four caves (A1, A2, L2 and L3) are located between 2.4 km and 5 km from Deposit F North and 10 km from both the Western Hill Deposit and Deposit J. A recent targeted fauna assessment of other deposits close to the Study Area (i.e. Deposits C, D and G) located 11 caves used by the Ghost Bat, of which three (CWAN-13, CWAN-21 and CWAN-23) may be maternity roosts, four are likely to be diurnal roosts and four are likely to be night roosts, these caves are located between 1.2 km and 3.4km south of the Western Hill Deposit in the Study Area (Biologic, 2019b).

While Ghost Bats utilising the Study Area may originate from these previously recorded caves, they are likely to also roost in caves within the Study Area itself. A total of 11 new caves were identified during the current surveys and seven of these contained evidence of occupation by the Ghost Bat (Section 5.2.3). A Ghost Bat was observed in cave CWAN-06 during both the Phase 1 and Phase 2 surveys, and the remains of a Ghost Bat pup were found in cave CWAN-04. Approximately 1,500 Ghost Bat scats were also observed in each of these two caves. Scats of the species were also recorded in five other caves in the Study Area, with the number of scats observed ranging from a single scat to up to 5,000 scat (in the case of CWAN-07). Based on these records and the structure of the caves, of the 11 caves recorded in the Study Area, one was identified as a maternity roost (CWAN-04), two as potential maternity roosts (CWAN-06, CWAN-07), four as potential diurnal roosts (CWAN-01, CWAN-02, CWAN-03, CWAN-10), three as suitable night roosts (CWAN-08, CWAN-09, CWAN-11) and one as potential night roost (CWAN-05). It is possible that more caves are present within the Gorge or Gully, Hilltop, Hillslope, Ridge or Cliff habitats in the Study Area but are yet to be recorded.

Gorge or Gully habitat represents the most important habitat or core habitat for the Ghost Bat within the Study Area, as it is generally within this habitat that caves are located, which can be utilised for roosting and foraging. Woodlands in the Study Area, such as those within Drainage Area, Mulga Spinifex Woodland and Mixed Acacia Woodland habitats, provide suitable foraging habitat for Ghost Bats.

### Pilbara Leaf-nosed Bat (*Rhinonictis aurantia* Pilbara Form)

The Pilbara Leaf-nosed Bat is listed as Vulnerable under both the EPBC Act and BC Act. The species is restricted to the Pilbara region and is thought to have been separated from populations of the Orange Leaf-nosed Bat in the Kimberley, Northern Territory and western Queensland for at least 30,000 years (van Dyck & Strahan, 2008). The Pilbara population is regarded as representing a single interbreeding biological population comprising multiple colonies (TSSC, 2016). Population subdivision may occur between western and eastern groups of the Pilbara Leaf-nosed Bat; however, the extent of genetic separation is not known (Armstrong, 2001).

Owing to a limited ability to conserve heat and water, Pilbara Leaf-nosed Bats requires warm (28-32°C) and very humid (85 – 100%) locations as roost sites, as it under these conditions that they can minimise water loss and energy expenditure (Armstrong, 2001; Churchill, 1991). As a result, the species typically roosts within warm and humid caves and abandoned mine shafts (van Dyck & Strahan, 2008). During the dry season, approximately March to August, Pilbara Leaf-nosed Bats aggregate in colonies within caves that provide a suitably warm, humid microclimate; however, the species disperses from these main colonies during the wet season, approximately September to February, when suitably humid caves are more widely available (TSSC, 2016). The level of dispersal in the wet season may also be influenced by the seasonal availability of food resources (Churchill, 1994).

Caves which offer a microclimate suitable for diurnal roosting by the Pilbara Leaf-nosed Bat are generally uncommon in the Pilbara. Ten day roosts of the species are known, in both caves and disused mineshafts, and more than 25 potential day roosts however, the number of confirmed roost sites is increasing as more biological surveys are conducted in the region (Cramer, Armstrong, Bullen, Ellis, Gibson, McKenzie, O'Connell, Spate & van Leeuwen, 2016).

Regional work conducted in the area has recorded the species at 12 locations, comprising 11 by RTIO (December 2016 = 2, April 2017 = 3, and November 2018 = 6) and one by Biologic (2019a). The most notable recording was from the south-east corner of Karijini National Park, where 181 calls were recorded at a breakaway above a dry gully. The earliest call from this location was recorded seven minutes after dusk civil twilight (CT; civil twilight representing the time when individuals of the species leave/enter their roost; Bullen, 2013), indicating a roost is in close proximity to this location. Given the sampling was undertaken in the late dry season, when bats are believed to congregate back to the most important and permanent roosts (Armstrong, 2000, 2001), it is likely that the newly discovered roost represents a Permanent Diurnal Roost (as defined by TSSC, 2016). Based on an indicative location, the Karijini roost is located within approximately 20 km to the west of the Western Hill Deposit, a distance that could possibly be covered by a foraging individual.

Within the Study Area, echolocation calls of the Pilbara Leaf-nosed Bat were recorded at two locations within the Western Hill Deposit: VWAW-87 within Foothills and Plain habitat, where a single call was recorded at 2am during the Phase 1 survey; and cave CWAN-04, within Gorge or Gully habitat where a single call was recording at 2.26am during the Phase 2 survey. The timing of calls at these locations is consistent with individuals flying to the Study Area from the Karijini roost; therefore, from a roost from

outside of the Study Area. However, the possible existence of other, as yet unidentified, diurnal roosts in the area should not be discounted.

Significant caves which may be utilised by the species are found within Gorge or Gully and Hilltop, Hillslope, Ridge or Cliff habitats. Cave CWAN-04 is likely to represent a Nocturnal Refuge (as defined by TSSC, 2016) for the species, given the size and structure of the cave and the fact that the species was recorded at its entrance. Other caves in the Study Area may similarly be used during nocturnal foraging by the species.

Suitable foraging habitat for the Pilbara Leaf-nosed Bat occurs within the Gorge or Gully, Drainage Area, and Mixed Acacia Woodland habitats. While the Pilbara Leaf-nosed Bat may be recorded in other habitats within the Study Area, as evidenced by the single call recorded within Footslope and Plain habitat, it is these habitats which the species is most likely to target during foraging. Gorge or Gully habitat has the potential to contain Priority 1 and Priority 2 foraging habitat (as defined by TSSC, 2016) for the species. These foraging habitats consist of gorges and gullies which can contain water pools that persist for weeks or months. Those locations where water features were recorded represent examples of Priority 2 foraging habitat within the Study Area (see Section 5.2.3). Drainage Area habitat contains important dispersal habitat for the Pilbara Leaf-nosed Bat and represents Priority 4 foraging habitat for the species, which includes sandy or gravelly channels of riverbeds and surrounding riparian vegetation. Mixed Acacia Woodland habitat represents Priority 5 foraging habitat for the species, which is characterised by open grassland and woodland.

#### Pilbara Olive Python (*Liasis olivaceus barroni*)

The Pilbara Olive Python is listed as Vulnerable under both the EPBC Act and BC Act. The species is often recorded with drainage systems, including areas with localised drainage and watercourses (Pearson, 1993). In the inland Pilbara the species is most often encountered near permanent waterholes in rocky ranges, or among riverine vegetation (Pearson, 1993).

The nearest recent record of the Pilbara Olive Python is from 2013 when the species was recorded 11 km north-west of the Western Hill Deposit (DPaW, 2018).

During the current field surveys, a Pilbara Olive Python was recorded on motion camera at VRT-WA16 in Deposit H, within Gorge or Gully habitat. The camera had been pointed to water pool WB-WAH1, from which the python emerged to investigate a macropod that had come to the water to drink. Scats of the Pilbara Olive Python were also found in cave CWAN04, which is located in Hilltop, Hillslope, Ridge or Cliff habitat within the Western Hill Deposit.

Gorge or Gully habitat is the most significant habitat or core habitat for the Pilbara Olive Python in the Study Area as it contains important denning and foraging habitat in the form of caves, crevices and water features. Also providing important foraging habitat for the species are the Drainage Area and Hilltop, Hillslope, Ridge or Cliff habitats. Any water features represent particularly important foraging locations as the species utilises water pools during hunting, as observed at VRT-WA16. Drainage Area habitat also represents suitable dispersal habitat for the species.

### Pilbara Flat-headed Blind-snake (*Anilius ganeĩ*)

The Pilbara Flat-headed Blind-snake is listed by the DBCA as a Priority 1 species. Given the Pilbara Flat-headed Blind-snake has a cryptic, fossorial habit, the species is rarely encountered. Little is known of this species' ecology, but, like most other blind snakes, it is insectivorous, feeding on termites and their eggs, as well as the larvae and pupae of ants (Cogger, 2014). The Pilbara Flat-headed Blind-snake is associated with moist gorges and gullies, and potentially within other stony habitats (Cogger, 2014).

The nearest recent record of the species to the Study Area is from 2006 and is located approximately 19 km northeast of Deposit H (DPaW, 2018). An additional five records are located within 80 km to the east of the Study Area, including a record from 2014 approximately 30 km south-southeast and a record from 2008 approximately 35 km east-northeast.

During the current field surveys, one individual of the Pilbara Flat-headed Blind-snake was captured in a pit trap at VRT-WA08 within Drainage Area habitat in Deposit J.

Within the Study Area, the Pilbara Flat-headed Blind-snake is most likely to occur in any moist soil within Gorge or Gully, and it may also occur within Drainage Area habitat.

### Pilbara Barking Gecko (*Underwoodisaurus seorsus*)

The Pilbara Barking Gecko is listed by the DBCA as a Priority 2 species. The species is only known from a small area of the Hamersley Range, from north of Tom Price to the West Angelas mine area, where it has been encountered in rocky areas, including within a rocky gorge (Doughty & Oliver, 2011).

While the Pilbara Barking Gecko was not recorded during the current field surveys, it has been previously recorded within Deposit H and about 2 km southwest of Deposit H (Ecologia, 2014).

Within the Study Area, the species is most likely to occur within Gorge or Gully and Hilltop, Hillslope, Ridge or Cliff habitats.

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

The Western Pebble-mound Mouse is listed by the DBCA as a Priority 4 species. The species has experienced a significant decline in their range through the Gascoyne and Murchison and is now considered endemic to the Pilbara (Start, Anstee & Endersby, 2000). The Western Pebble-mound Mouse almost exclusively occurs on the gentler slopes of rocky ranges where the ground is covered with a stony mantle and vegetated by hard spinifex, often with a sparse overstorey of eucalypts and scattered shrubs (Anstee & Armstrong, 2001). Records of the species often consist of stony mounds that have been constructed by the species. Many of these mounds are no longer used by the species and they can persist in a landscape for decades.

Previous surveys have also recorded the Western Pebble-mound Mouse in all four deposits that make up the Study Area, with 52 records coming from Western Hill, 17 from Deposit J, nine from Deposit H and two from Deposit F. This species predominantly occurs within Hilltop, Hillslope, Ridge or Cliff and Foothill and Plain habitats, which occur across all five deposits within the Study Area.

During the current field surveys, one Western Pebble-mound Mouse was captured at site VRT-WA06 within Drainage Area habitat in Deposit J. A total of 22 mounds constructed by the species were also observed, five of which were considered active (i.e. currently used by the species). Of these five, four were located on stony slopes of Hilltop, Hillslope, Ridge or Cliff habitat and one was located within Foothill and Plain habitat (Table 5.9).

Within the Study Area, the Western Pebble-mound Mouse most likely occurs within Foothill and Plain habitat and on the stony slopes of Hilltop, Hillslope, Ridge or Cliff habitat, which provide suitable material for the construction of mounds. The Western Pebble-mound Mouse is also likely to utilise habitats adjacent to these areas for foraging, as indicated by the capture of an individual at VRT-WA06, which is located within Drainage Area habitat immediately adjacent to Foothill and Plain habitat.

### Fork-tailed Swift (*Apus pacificus*)

The Fork-tailed Swift is listed as a Migratory listed species under the BC Act and EPBC Act. The species breeds in Asia and winters in Australia and southern New Guinea (Johnstone & Storr, 1998). Ecologia (2014) recorded approximately 550 individuals from various sites in the West Angelas area in 2014, including from sites located 300 m northwest and 900 m west of Deposit J and Mt Ella East.

During the current field surveys, 20 individuals were recorded flying during an avifauna census at VRT-WA01 (Western Hill Deposit). Fork-tailed Swifts spend much of their time in the air and are not dependent on any particular terrestrial habitat. All habitats within the Study Area provide suitable habitat for the species although individuals would not be restricted to or dependent on these.

### Vertebrate Fauna of Conservation Significance Considered Likely to Occur in the Study Area

Two species were considered Likely to occur in the Study Area, the Peregrine Falcon and Grey Falcon.

#### *Peregrine Falcon (Falco peregrinus)*

The Peregrine Falcon is listed as OS ('other specially protected fauna') under the BC Act, which means that special protection is required to ensure its conservation. In arid areas it is most often encountered along cliffs above rivers, ranges and wooded watercourses where it hunts birds (Johnstone & Storr, 1998). It typically nests on rocky ledges occurring on tall, vertical cliff faces and also occasionally within tall trees occurring along major drainage lines (Olsen & Olsen, 1989). The species is also known to nest on radio towers and other human-built structures.

The closest record of the Peregrine Falcon to the Study Area is from 2010 and is located approximately 8 km north of the Study Area (DPaW, 2018).

Hilltop, Hillslope, Ridge or Cliff habitat within the Study Area offers potential nesting sites for the Peregrine Falcon, while potential foraging habitat for the species can be found in the Drainage Area, Mulga Spinifex Woodland, Mixed Acacia Woodland and Foothills and Plain habitats.

#### *Grey Falcon (Falco hypoleucos)*

The Grey Falcon is listed as Vulnerable under the BC Act. The species favours treeless areas as well as timbered lowland plains for foraging, particularly *Acacia* shrublands in areas with tree-lined watercourses (Garnett, Szabo & Dutson, 2011). Grey Falcons are known to breed in the nests of other bird species that are located in tall trees along watercourses. They are thought to be threatened by pastoral activities, which may limit recruitment and provision of nest trees (Garnett, Szabo & Dutson, 2011).

The closest record of the Grey Falcon to the Study Area is from 1997 and is located approximately 3 km west of the Western Hill Deposit within Karijini National Park. A further three records from 2008 are located as close as 10 km north of Deposit H (DBCA, 2019a).

Tall trees within Drainage Line habitat represent potential breeding sites for the Peregrine Falcon, while potential foraging habitat for the species can be found in the Drainage Area, Mulga Spinifex Woodland, Mixed Acacia Woodland and Foothills and Plain habitats.

### Vertebrate Fauna of Conservation Significance Considered to Possibly Occur in the Study Area

Two species were considered to Possibly occur in the Study Area: the Short-tailed Mouse and Brush-tailed Mulgara.

#### Short-tailed Mouse (*Leggadina lakedownensis*)

The Short-tailed Mouse is listed by the DBCA as a Priority 4 species. The species is endemic to northern Australia, where it occurs from Cape York in the east to the Pilbara in Western Australia, although the distribution is discontinuous (Moro & Kutt, 2008). There are populations present on Thevenard Island and Serrurier Island in Western Australia, the latter being a translocated population, introduced for conservation purposes (Lee, 1995; Moro & Kutt, 2008). It is a nocturnal species found in a variety of habitats including open tussock and hummock grasslands, samphire and sedgelands, *Acacia* shrublands, *Eucalyptus* and *Melaleuca* woodlands and stony ranges (Lee, 1995; van Dyck & Strahan, 2008). Preferred habitat comprises seasonally inundated habitats on red or white sandy-clay soils (Moro & Kutt, 2008).

The Short-tailed Mouse has been previously been recorded within cracking clay habitat located approximately 5 km from the Study Area. Marginally suitable habitat for the species occurs in the Study Area within Drainage Area, Foothills and Plain, Mulga Spinifex Woodland and Mixed Acacia Woodland habitats.

#### Brush-tailed Mulgara (*Dasycercus blythi*)

The Brush-tailed Mulgara is listed by the DBCA as a Priority 4 species. The species is found in sandy habitats and gibber plain (Pavey, Nano, Cooper, Cole & McDonald, 2012). In Western Australia the species occurs in the Pilbara and Western Deserts, with few records in the Murchison region.

The nearest records of the species are from 2014 and are located approximately 35 km south of the Study Area (DBCA, 2019a). No burrows that could be attributed to the Brush-tailed Mulgara were located during the current field surveys. The species is considered to Possibly occur in the Study Area because of the proximity of recent records and the fact that marginally suitable habitat is present within Mulga Spinifex Woodland and Foothills and Plain habitats.

### Threatened Vertebrate Fauna Considered to Unlikely Occur in the Study Area

#### Night Parrot (*Pezoporus occidentalis*)

The Night Parrot is listed as Critically Endangered under the BC Act and Endangered under the EPBC Act. The species was thought to be extinct until it was rediscovered 2013 within Queensland's Pullen Pullen Reserve. Subsequently, the species has been found in Gineaway National Park and Diamantina National Park in Queensland (Palaszczuk & Miles, 2017) and at two locations in central Western Australia (Hamilton, Burbidge, Douglas & Gilbert, 2017; Jackett, Greatwich, Swann & Boyle, 2017; Mills, 2017).

The Night Parrot is a small, elusive and ground-dwelling parrot endemic to Australia (DoEE, 2018). The species is nocturnal and highly cryptic, inhabiting arid and semi-arid areas that contain dense, low vegetation. Based on confirmed records, the habitat of the Night Parrot consists of *Triodia* grasslands that are found in: stony or sandy environments; samphire and chenopod shrublands containing *Atriplex*, *Bassia* and *Maireana*; floodplains and claypans; and on the margins of saltlakes, creeks or other sources of water (McGilp, 1931; North, 1898; Whitlock, 1924; Wilson, 1937). Night Parrots have also been observed entering dense *Duma* growth when flushed from a more typical habitat (Boles, Longmore & Thompson, 1994; Forshaw, 1981) and one record of the species is from *Acacia* woodland (North, 1898). A carcass of the species was found near Boulia in Queensland, recovered from the side of a road in an area containing low, sparse *Astrebla*, *Calotis* and species of chenopods, with some patches of exposed gibber (Boles, Longmore & Thompson, 1994). Another carcass has recently been recovered from near a waterhole surrounded by sparse vegetation within Diamantina National Park (Anstis & Altig, 2007).

Based on accepted records, the habitat of the Night Parrot consists of *Triodia* grasslands in stony or sandy environments (McGilp, 1931; North, 1898; Whitlock, 1924; Wilson, 1937), and of samphire and chenopod shrublands, including genera such as *Atriplex*, *Bassia* and *Maireana*, on floodplains and claypans, and on the margins of salt lakes, creeks or other sources of water (McGilp, 1931; Wilson, 1937). The current interim guidelines for preliminary surveys of Night Parrot in Western Australia suggest this species requires old-growth spinifex (*Triodia* that has not been burned for at least 50 years) for roosting and nesting, as well as habitats containing various grasses and herbs for foraging, old-growth (often more than 50 years unburnt) spinifex (*Triodia*) for roosting and nesting (DPaW, 2017). Foraging habitat is likely to be more important if it is adjacent to or within about 10 km of patches of *Triodia* deemed suitable as roosting habitat (DPaW, 2017); however, foraging habitat is not necessarily within or adjacent to roosting habitat, as individuals are known to fly up to 40 km in a single night to forage. *Triodia* is likely to provide a good food resource at times of mass flowering and seeding. The succulent *Sclerolaena* provides the Night Parrot with a source of food and moisture and other succulent chenopods are likely to be similarly important.

The distribution of the Night Parrot is very poorly understood. The small number of confirmed or verifiable records prevents the population size from being assessed with any accuracy. The distribution of the species is likely to be highly fragmented and continuing to decline in area. It is thought that there are about 50 breeding birds across five subpopulations, with the largest subpopulation consisting of about 20 breeding birds (Crowley, 2000).

There are few records of the Night Parrot in Western Australia. The species had not been sighted since 1912 when three individuals were observed in April 2005 at Minga Well, approximately 100 km north of the Study Area on the northern side of the Fortescue Marsh (Davis & Metcalf, 2008). The Night Parrot has since been recorded in the East Murchison at Matuwa and Millrose pastoral station ~530 km south east of the Study Area (Hamilton, Burbidge, Douglas & Gilbert, 2017; Jackett, Greatwich, Swann & Boyle, 2017; Mills, 2017).

Calls of the same frequency as known Night Parrot calls (Leseberg, Murphy, Jackett, Greatwich, Brown, Hamilton, Joseph & Watson, 2019) were recorded in the Western Hill Deposit within Mulga Spinifex Woodland habitat at site VWAW-85 which were recorded in close proximity to large spinifex hummocks nearby sumps containing water during the Level 2 survey. The calls were always faint and recorded all on the same night (i.e. not during any subsequent nights at the same locations). Despite these sounds/calls resembling those of Night Parrot, there was insufficient information to conclude these were attributable to Night Parrot. Significantly, the sounds were associated with periods of wind gusts. Further targeted sampling in May – July 2019 (Biologic, in prep.) was conducted to verify the source of these noises. This additional sampling provided sufficient detail to confirm that these calls were produced by the movement of nearby tree branches, and/or the subtle movement of the Song Meters or their attachment, when fixed to an object (e.g. a tree) (Jackett, 2019b) during heavy wind gusts. Based on the significant amount of targeted sampling effort undertaken within the Study Area for this species (Biologic, 2019), and the lack of records within the region, it is regarded as Unlikely that the species resides in the Study Area.

The Study Area contains marginally suitable habitat for the species in the form of sandy and stony flats containing patches of large spinifex hummocks, such as those observed within the Mulga Spinifex Woodland habitat, as well as the Drainage Area, and Foothills and Plain habitats in areas that remain long unburnt from fire. As only marginal habitat exists on site, and the cryptic nature of the species, it is still considered Unlikely for the species to occur in the Study Area.

#### 5.4. SRE Invertebrate Fauna Sampling Results

A total of 330 invertebrate specimens were collected during the field surveys, including 36 mygalomorph spiders, one selenopid spider, 102 pseudoscorpions, 29 scorpions, 60 myriapods, 15 gastropods and 87 isopods (Appendix L). More specimens were collected during the Phase 2 survey (267 specimens) than the Phase 1 survey (63 specimens).

The specimens collected belonged to 36 unique taxa. While none of these taxa are Confirmed SRE, 17 were considered to be Potential SRE. The remaining 19 taxa were considered to be Widespread. Of the 17 morphospecies that were considered as Potential SRE, a subset number of specimens of each of the morphospecies was submitted to the WAM MSU for a BLAST against their database. Only Arachnida and Diplopoda sequences were submitted to WAM MSU as an appropriate Isopoda sequence library is not currently available. The results from WAM MSU BLAST analysis can be found in Appendix M.

The results of the molecular analysis revealed that there are 23 molecular species (operational taxonomic units or OTU) that represent Potential SRE. Of these 23 OTUs the majority do not appear to be restricted to the Study Area. Many have been collected in close proximity to the Study Area. Six OTUs, however lack adequate data to ascertain their distribution beyond the Study Area. These are highlighted in bold through the results section.

### Mygalomorphae: Idiopidae

#### *Anidiops sp. MYG286*

One specimen of this taxon was trapped within Stony habitat (Figure 5.5). The specimen was unable to be identified to species level morphologically and was sent for sequencing. Molecular analysis undertaken by WAM MSU indicated that this specimen is the same as other specimens from the region classified as *Anidiops sp. MYG286* (Appendix M). It was 100% similar to another *Anidiops sp. MYG286* collected less than 20 km from the Study Area (WAMT116766). It was also in a clade that included specimens from Hope Downs, Area C, and South Parmelia, all between 50 to 100km of Newman. These specimens were recorded as *Gaius 'tealei'* in the WAM database search conducted in the desktop assessment for this report.

There are 84 previous records of this family from 46 locations within 10 km of the Study Area (Figure 5.6; Appendix G). The family Idiopidae includes Widespread, Potential SRE and Confirmed SRE species; however, many species are being regarded as Confirmed SRE based on recent molecular and morphological revisions (Rix et al., 2018). Until further work is carried out on the distribution of this molecular species it will be considered Potential SRE.

### Mygalomorphae: Nemesiidae

#### *Nemesiidae sp.*

Four specimens of this taxon were collected from three sites (Figure 5.5). Three of the four specimens were mature males collected in pitfall traps within Gorge/Gully (two specimens) and Eucalypt Woodland habitat (one specimen); they were likely active on the surface in search of a mate. The fourth specimen was a female or juvenile collected from a burrow in Mulga Woodland habitat. (Table 5.10).

The mature male specimens were compared to other species known from the local area within the WA Museum collection, but no morphological match was found despite the species being very distinctive (E. Volschenk pers. comm.). The sequences of these specimens were sent to WAM MSU for molecular analysis. When compared to regional sequences of Nemesiidae these four specimens were clustered together on the tree (100% related), however, they were at least 15% divergent from their closest relatives in the region (Appendix M). WAM has deemed it to be a previously unrecorded taxon and hence Potential SRE.

**Table 5.10: Specimens of Arachnida that represent Potential SRE collected during the survey.**

No. is the number of specimens; Dep is Deposit and Mt Ella E is Mt Ella East.

Class	Family	Lowest/Molecular ID	Site	Deposit	Method	Habitat Type	Habitat Zone	No.
Araneae	Idiopidae	<i>Anidiops</i> MYG286	SRE-WA04	Western Hill	Pitfall Trap (Dry)	Stony Plain	Stony Plain	1
	Nemesiidae	<b>Nemesiidae n. sp.</b>	SRE-WA14	Dep F North	Hand collected	Mulga Woodland	Sandy/ Stony Plain	1
		<b>Nemesiidae n. sp.</b>	SRE-WA20	Dep F North	Pitfall Trap (Dry)	Gorge/ Gully	Gully	2
		<b>Nemesiidae n. sp.</b>	SRE-WA21	Dep F North	Pitfall Trap (Dry)	Eucalypt Woodland	Stony Plain	1
		<i>Aname</i> MYG004	SRE-WA14	Dep F North	Pitfall Trap (Dry)	Mulga Woodland	Sandy/ Stony Plain	1
		<i>Kwonkan</i> MYG380	SRE-WA14	Western Hill	Hand collected	Mulga Woodland	Sandy/ Stony Plain	1
	Selenopidae	<i>Karaops nyangumarta</i>	SRE-WA01	Mt Ella E & Dep J	Hand collected	Gorge/ Gully	Gully	1
Pseudoscorpiones	Chthoniidae	<b><i>Tyrannochthonius</i> sp. indet.</b>	SRE-WA63	Dep H	Leaf/soil sieving	Gorge/ Gully	Hillslope	3
		<b><i>Tyrannochthonius</i> sp. indet.</b>	SRE-WA79	Dep H	Leaf/soil sieving	Gorge/ Gully	Gully	2
		<b><i>Tyrannochthonius</i> sp. indet.</b>	SRE-WA83	Dep H	Leaf/soil sieving	Gorge/ Gully	Gully	3
	Olpiidae	<b><i>Austrohorus</i> sp. indet.</b>	SRE-WA77	Dep H	Leaf/soil sieving	Gorge/ Gully	Gully	1
		<b><i>Austrohorus</i> sp. indet.</b>	SRE-WA95	Mt Ella E & Dep J	Leaf/soil sieving	Hillcrest/ Hillslope	Hillcrest/ Upper Hillslope	1
		<i>Euryolpium</i> sp. indet.	SRE-WA14	Dep F North	Leaf/soil sieving	Mulga Woodland	Sandy/ Stony Plain	1
		Genus 7/4 sp. indet.	SRE-WA71	Dep F North	Leaf/soil sieving	Ironstone Outcrops	Undulating Low Hills	1
		Genus 7/4 sp. indet.	SRE-WA90	Mt Ella E & Dep J	Leaf/soil sieving	Gorge/ Gully	Hillslope	1
		<b><i>Indolpium</i> sp. indet.</b>	SRE-WA14	Dep F North	Leaf/soil sieving	Mulga Woodland	Sandy/ Stony Plain	1
		<b><i>Indolpium</i> sp. indet.</b>	SRE-WA33	Dep H	Leaf/soil sieving	Medium Drainage Line	Medium Drainage Line	1
		<b><i>Indolpium</i> sp. indet.</b>	SRE-WA40	Mt Ella E & Dep J	Leaf/soil sieving	Hillcrest/ Hillslope	Hillcrest/ Upper Hillslope	1

Class	Family	Lowest/Molecular ID	Site	Deposit	Method	Habitat Type	Habitat Zone	No.
		<i>Indolpium</i> sp. indet.	SRE-WA57	Mt Ella E & Dep J	Leaf/soil sieving	Ironstone Outcrops	Gully	2
		<i>Indolpium</i> sp. indet.	SRE-WA63	Mt Ella E & Dep J	Leaf/soil sieving	Gorge/ Gully	Hillslope	4
		<i>Indolpium</i> sp. indet.	SRE-WA83	Dep H	Leaf/soil sieving	Gorge/ Gully	Gully	1
		<i>Xenolpium</i> sp. indet.	SRE-WA09	Dep F North	Hand collected	Gorge/ Gully	Gully	1
		Olpidae sp. indet.	SRE-WA90	Dep F North	Leaf/soil sieving	Gorge/ Gully	Hillslope	1
<b>Scorpiones</b>	Buthidae	<i>Lychas</i> sp. indet 1	SRE-WA85	Western Hill	Leaf/soil sieving	Mulga Woodland	Stony Plain	1
		<i>Lychas</i> sp. indet 2	RC17WAW 0183	Mt Ella E & Dep J	Subfauna scrape	(blank)	(blank)	1
		<i>Lychas</i> sp. indet 2	SRE-WA13	Western Hill	Pitfall Trap (Dry)	Stony Plain	Footslope	1
		<i>Lychas</i> sp. indet 2	SRE-WA23	Western Hill	Pitfall Trap (Dry)	Gorge/ Gully	Gully	2
		<i>Lychas</i> sp. indet 2	SRE-WA40	(blank)	Leaf/soil sieving	Hillcrest/ Hillslope	Hillcrest/ Upper Hillslope	1

*Aname* sp. MYG004

One specimen was collected from a burrow at the same site (SRE-WA14) within Mulga Woodland habitat that a specimen of *Nemesiidae* sp. indet. was found in a burrow (described above) (Figure 5.5). The specimen could not be identified to species morphologically and was sent for molecular analysis. It was identified as being 99% similar to *Aname* sp. MYG004 (WAMT116863) collected less than 5 km outside of the Study Area. This molecular species is well-supported and is represented by a number of other specimens from the area (50-130 km west and northwest of Newman). However, until further taxonomic work is undertaken on this molecular species it is considered Potential SRE.

*Kwonkan* sp. MYG380

A single male specimen of this taxon was trapped within Stony Plain habitat (Figure 5.5). The specimen was unable to be identified to species level morphologically. It was 97% similar to one record of *Kwonkan* 'MYG380-DNA' found less than 10 km from the Study Area (WAMT116744). There are six previous records of *Kwonkan* sp. within 10 km of the Study Area (Appendix H) including the one *Kwonkan* 'MYG380-DNA' specimen. The other five specimens represent *Kwonkan* 'MYG339-DNA', which is a Confirmed SRE species. While *Kwonkan* 'MYG380-DNA' has not been designated an SRE status, being a *Kwonkan* sp., it is likely to be a Potential SRE species.

Araneomorphae: Selenopidae*Karaops nyangumarta*

One specimen of this taxon was collected from Gorge/Gully habitat (Figure 5.3). The specimen was unable to be identified to species level morphologically. Molecular analysis revealed it to be 99.5% similar to a specimen identified as *Karaops nyangumarta* (WAMT116567) collected less than 20 km from the Study Area. There are 127 previous records of *Karaops* spp. from the database search, including five records of the Potential SRE *Karaops nyangumarta*. All five were recorded 100 km northwest of the Study Area (Figure 1.1; Appendix H).

Pseudoscorpiones: Chthoniidae*Tyrannochthonius* sp. indet.

Eight specimens of this taxon were collected during leaf/soil sieving at three sites within Gorge/Gully habitat (Figure 5.6). These specimens were unable to be identified to species level morphologically. One Widespread taxon belonging to the genus *Tyrannochthonius* (*T. aridus*) is known throughout the region, although recent molecular studies have indicated this might be a species complex of Potential SRE species. There are three previous records of *Tyrannochthonius* sp. from three locations within 10 km of the Study Area (Figure 5.6; Appendix H).

Eight specimens were sent for molecular analysis. At the time of the provision of sequences to WAM MSU, only one specimen yielded a viable sequence for BLAST analysis. This sequence was not of high quality and the resulting analysis did not place the specimen within the pseudoscorpions and most likely

represents contamination. Of the remaining seven specimens, six yielded viable sequence during a second round of amplification; however, these sequences could not be provided to WAM MSU in time for the report production. Further analysis of the remaining sequences would provide clarity in determining where these specimens sit within the genus. The species is still treated as representing a Potential SRE.

#### Pseudoscorpiones: Olpiidae

##### *Austrohorus sp. indet.*

Two specimens of this taxon were collected during leaf/soil sieving at two sites within Hillcrest/Hillslope and Gorge/Gully habitats (Figure 5.6). These specimens were unable to be identified to species level morphologically. There are six previous records of *Austrohorus* sp. from four locations within 10 km of the Study Area (Figure 5.6; Appendix H). Although one Widespread taxon belonging to this genus is known throughout the region, recent molecular studies have indicated this taxon might be a species complex of Potential SRE species. It is therefore possible that the specimens represent a Potential SRE species.

Neither sequences yielded viable sequences during the first round of amplification and hence were not provided to WAM for analysis. The second round of amplification, however, did yield viable sequences so further analysis of the remaining sequences would provide clarity in determining where these specimens sit within the genus. The species is still treated as representing a Potential SRE.

##### *Euryolpium sp. indet.*

One specimen of this species was collected from within Mulga Woodland (Figure 5.6). As it was a damaged, juvenile specimen it could only be morphologically identified as Olpiidae sp. indet.; however, it was recognised as possibly being a previously unseen species (E. Volschenk pers. comm.). Molecular analysis has placed this specimen as being 97% similar to another specimen (WAMT127762), a currently undescribed species of *Euryolpium* (Appendix X). The WAM specimen was not recorded in the WAM database query and so is assumed to occur outside of the 40 km<sup>2</sup> radius of the Study Area.

*Euryolpium* as a genus is generally regarded as primarily containing widespread species and hence the other *Euryolpium* specimens were not sequenced. Further sequencing could provide some clarification regarding the likelihood that the specimens recorded in the Study Area are widespread.

##### *Genus 7/4 sp. indet.*

Three specimens of this taxon were recorded from three sites within Gorge/Gully (two specimens) and Ironstone Outcrops (one specimen) habitats (Figure 5.6). One was hand-collected from vegetation while the other two were collected during leaf/soil sieving. Initially identified morphologically as *Xenolpium* sp. indet., molecular analysis placed two of the three specimens squarely within the clade of undescribed Genus 7/4 sp. indet. (one specimen from Gorge/Gully site SRE-WA79 failed to provide viable sequences). This species is a known but as yet undescribed species. The WAM database search for Genus 7/4 yielded 34 entries for the area, two of which appeared within the molecular clade of Genus

7/4 sp. indet in the current analysis. Both these specimens were from 65 km northwest of Newman. Until further taxonomic work is carried out on the species, the specimens represent a Potential SRE.

***Indolpium* sp. indet.**

Ten specimens of this taxon were collected during leaf-soil sieving at six sites within Mulga Woodland (one specimen), Medium Drainage Line (one specimen), Hillcrest/Hillslope (one specimen), Ironstone Outcrops (two specimens) and Gorge/Gully (five specimens) habitats (Figure 5.6). The genus *Indolpium* is found throughout the Pilbara and is poorly known taxonomically; however, recent DNA work has identified many cryptic species which are considered to be Potential SRE. There are 27 previous records of *Indolpium* sp. from 21 locations within 10km of the Study Area, including one previous record from within the Study Area (Figure 5.6; Appendix H).

Only two specimens revealed viable sequences during the first round of amplification and were provided to WAM for analysis. Both sequences were 10 % divergent (only 90% similar) from each other and ranged between 9-15% different from their nearest neighbours in the key (Appendix X). Both specimens were from two different Gorge/Gully sites (SRE-WA63 in Mt Ella East and Deposit J and SRE-WA83 in Deposit H). It is possible the two specimens represent two new and different taxa. The second round of amplification, however, did yield a further five viable sequences so further analysis of the remaining sequences would be useful in determining where these specimens sit within the tree. The specimens are treated as representing one or more Potential SRE species.

*Xenolpium* sp. indet.

One specimen of this species was collected from within Gorge/Gully habitat (Figure 5.6). This specimen was unable to be identified to species level morphologically; however, it was recognised as possibly being a previously unseen species (E. Volschenk *pers. comm.*). Molecular analysis did not yield a viable sequence for WAM MSU even through two rounds of amplification and so cannot be resolved using molecular techniques at the moment. Further legs could be removed from the specimen to re-attempt amplification. Currently the specimen represents a Potential SRE.

*Olpiidae* sp. indet.

One specimen of this species was also collected from within Gorge/Gully habitat (Figure 5.6). This specimen was unable to be identified to species level; however, it was recognised as possibly being a previously unseen species (E. Volschenk *pers. comm.*). Molecular analysis did not yield a viable sequence for WAM MSU even through two rounds of amplification and so cannot be resolved using molecular techniques at the moment. Further legs could be removed from the specimen to re-attempt amplification. Currently the specimen represents a Potential SRE.

Scorpiones: Buthidae

*Lychas bituberculatus* / 'hairy tail complex

Six specimens of this species complex were collected from the Study Area. They were morphologically identified as either *L. bituberculatus* complex or *L. 'hairy tail'* complex by Dr Erich Volschenk. The

species complex is known from throughout the Pilbara and has been recorded previously at Paraburdoo (Figure 5.6; Appendix H). The specimens may be representatives of multiple Potential SRE species (E. Volschenk pers. comm. 2018) as the whole species complex requires morphological and molecular review. All six specimens were sent for molecular analysis and were successfully sequenced with the following results.

*Lychas* sp. indet. 1 (*Lychas bituberculatus* / 'hairy tail complex')

Two specimens of this species were collected from two sites during leaf/soil sieving within Mulga and Eucalypt Woodland habitats (Figure 5.6). They sit well within a clade that contains species morphologically identified as *L. bituberculatus* and have been informally designated as *L. sp. indet. 1* (Appendix M). Currently the specimens represent a Potential SRE.

*Lychas* sp. indet. 2 (*Lychas bituberculatus* / 'hairy tail complex')

Four specimens of this species were recorded from three sites within Stony Plain (one specimen), Hillcrest/Hillslope (one specimen) and Gorge/Gully (two specimens) habitats (Figure 5.6). Three specimens were trapped while one specimen was collected during leaf-soil sieving. A fifth specimen was collected in borehole RC17WAW0183 during the West Angelas Subterranean Fauna Survey in 2019. This additional specimen was also sequenced. All five specimens fall well within a clade that contains specimens mainly identified as *L. 'hairy tail'* (Appendix M). This has been given the informal designation of *L. sp. indet. 2*. Currently the specimens represent a Potential SRE.

Isopoda: Armadillidae

*Buddelundia* '47'

Twelve specimens of this taxon were recorded from four sites Hillcrest/Hillslope (nine specimens), Gorge/Gully (two specimens) and Minor Drainage Line (one specimen) habitats (Figure 5.7). Two specimens were trapped while 10 specimens were collected during leaf/soil sieving. This taxon is a Potential SRE, as it is limited in distribution and may represent a complex of two more limited species (S. Judd pers. comm. 2018). The nearest record of this taxon to the Study Area is located approximately 35 km southwest of the Study Area (Appendix H).

***Buddelundia* '77'**

Six specimens of this taxon were collected during leaf/soil sieving at one site within Gorge/Gully habitat (Figure 5.7). This taxon has a highly limited distribution consisting of two disjunct populations that may represent two separate Potential SRE species (S. Judd pers. comm. 2018). There are no previous records of this taxon within 10 km of the Study Area.

*Buddelundia* sp. indet.

Six specimens of this taxon were trapped at two sites within Gorge/Gully (five specimens) and Medium Drainage Line (one specimen) habitats (Figure 5.7). These specimens were unable to be identified to species level. They may represent Widespread or Potential SRE species, both of which are known to

occur in the region. For example, they may represent additional specimens of the Potential SRE species *Buddelundia* '47' and *Buddelundia* '77' described above, or they may represent additional specimens *Buddelundia* '15' and *Buddelundia* '16', which were also recorded during the field surveys. Molecular analysis would be required to determine whether the specimens collected align with previous records of the genus and/or represent known SRE species. However, currently the sequence library for Pilbara Isopoda both in public and museum databases is poor and a large amount of comparison work would be required before molecular species delineation is attempted.

**Table 5.11: Specimens of Isopoda, Diplopoda and Gastropoda that represent Potential SRE collected during the survey.**

No. is the number of specimens; Dep is Deposit and Mt Ella E is Mt Ella East.

Class	Family	Lowest/Molecular ID	Site	Deposit	Method	Habitat Type	Habitat Zone	No.
Crustacea								
Isopoda	Armadillidae	<i>Buddelundia</i> sp. 47	SRE-WA23	Mt Ella E & Dep J	Pitfall Trap (Dry)	Gorge/ Gully	Gully	2
		<i>Buddelundia</i> sp. 47	SRE-WA40	Mt Ella E & Dep J	Leaf/soil sieving	Hillcrest/ Hillslope	Hillcrest/ Upper Hillslope	6
		<i>Buddelundia</i> sp. 47	SRE-WA40	Mt Ella E & Dep J	Leaf/soil sieving	Hillcrest/ Hillslope	Hillcrest/ Upper Hillslope	2
		<i>Buddelundia</i> sp. 47	SRE-WA36	Mt Ella E & Dep J	Leaf/soil sieving	Hillcrest/ Hillslope	Hillslope	1
		<i>Buddelundia</i> sp. 47	SRE-WA61	Western Hill	Leaf/soil sieving	Minor Drainage Line	Undulating Low Hills	1
		<b><i>Buddelundia</i> sp. 77</b>	SRE-WA83	Dep H	Leaf/soil sieving	Gorge/ Gully	Gully	6
		<i>Buddelundia</i> sp. indet.	SRE-WA50	Dep H	Pitfall Trap (Dry)	Gorge/ Gully	Gully	5
		Buddelundiinae sp. indet.	SRE-WA36	Mt Ella E & Dep J	Pitfall Trap (Dry)	Medium Drainage Line	Medium Drainage Line	1
Diplopoda								
Spirobolida	Trigoniulidae	<i>Austrostrophus</i> Clade A	SRE-WA20	Dep F North	Active foraging	Gorge/ Gully	Gully	8
		<i>Austrostrophus</i> Clade A	SRE-WA50	Dep H	Pitfall Trap (Dry)	Gorge/ Gully	Gully	1
		<i>Austrostrophus</i> Clade A	SRE-WA64	Dep H	Leaf/soil sieving	Gorge/ Gully	Gully	1
		<i>Austrostrophus</i> Clade A	SRE-WA74	Dep H	Active foraging	Minor Drainage Line	Minor Drainage Line	6
		<i>Austrostrophus</i> Clade A	SRE-WA84	Dep H	Active foraging	Gorge/ Gully	Gorge	3
		<i>Austrostrophus</i> Clade E	SRE-WA23	Western Hill	Pitfall Trap (Dry)	Gorge/ Gully	Gully	1
		<i>Austrostrophus</i> Clade F	SRE-WA36	Mt Ella E & Dep J	Pitfall Trap (Dry)	Hillcrest/ Hillslope	Hillslope	3
		<i>Austrostrophus</i> Clade unknown 1	SRE-WA20	Dep F North	Pitfall Trap (Dry)	Gorge/ Gully	Gully	1

		<i>Austrostrongylus</i> Clade unknown 1	SRE-WA32	Dep F North	Leaf/soil sieving	Gorge/ Gully	Gorge	11
		<i>Austrostrongylus</i> Clade unknown 1	SRE-WA32	Dep F North	Leaf/soil sieving	Gorge/ Gully	Gorge	2
		<i>Austrostrongylus</i> Clade unknown 2	SRE-WA40	Mt Ella E & Dep J	Leaf/soil sieving	Hillcrest/ Hillslope	Hillcrest/ Upper Hillslope	1
		<i>Austrostrongylus</i> Clade unknown 2	SRE-WA36	Mt Ella E & Dep J	Pitfall Trap (Dry)	Hillcrest/ Hillslope	Hillslope	2
		<i>Austrostrongylus</i> Clade unknown 2	SRE-WA71	Mt Ella E & Dep J	Leaf/soil sieving	Ironstone Outcrops	Undulating Low Hills	9
		<i>Austrostrongylus</i> sp. indet.	SRE-WA20	Dep F North	Leaf/soil sieving	Gorge/ Gully	Gully	2
		<i>Austrostrongylus</i> sp. indet.	SRE-WA23	Dep H	Pitfall Trap (Dry)	Gorge/ Gully	Gully	1
		<i>Austrostrongylus</i> sp. indet.	SRE-WA57	Dep H	Leaf/soil sieving	Ironstone Outcrops	Gully	1
		<i>Austrostrongylus</i> sp. indet.	SRE-WA70	Dep H	Active foraging	Hillcrest/ Hillslope	Hillcrest/ Upper Hillslope	1
		<i>Austrostrongylus</i> sp. indet.	SRE-WA72	Dep H	Leaf/soil sieving	Gorge/ Gully	Gully	3
		<i>Austrostrongylus</i> sp. indet.		Dep H	Pitfall Trap (Dry)	Stony Plain	Stony Plain	1
		<i>Austrostrongylus</i> sp. indet.	SRE-WA83	Dep H	Leaf/soil sieving	Gorge/ Gully	Gully	1
Gastropoda								
Eupulmonata	Camaenidae	Sinumeloninae sp. indet.	SRE-WA01	Mt Ella E & Dep J	(blank)	Gorge/ Gully	Gully	1

### Myriapoda: Trigonulidae

#### *Austrostephanus* sp. indet.

A total of 59 specimens of this taxon were recorded within from 15 sites within Gorge/Gully (35 specimens), Ironstone Outcrops (ten specimens), Hillcrest/Hillslope (seven specimens), Minor Drainage Line (six specimens) and Stony Plain (one specimen) habitats (Figure 5.6). Ten specimens were trapped, ten specimens were detected during active foraging and 39 specimens were collected during leaf-soil sieving. These specimens were unable to be identified to species level morphologically. Recent molecular studies have indicated that *Austrostephanus* sp. may represent a complex of Potential SRE species. There are 25 previous records of *Austrostephanus* sp. from 19 locations within 10 km of the Study Area, including three records from one location within the Study Area (Figure 5.7; Appendix H).

Sixteen specimens representing the spread of sites and habitat types were sent to WAM MSU for analysis. All 16 provided viable sequences and fell into three known clades and two new clades for *Austrostephanus* in the region.

- *Austrostephanus* Clade A

Five specimens are >99% similar to each other and to another Clade A specimen WAMT131157. The WAM specimen was collected 18 km east of West Angelas Aerodrome within the Study Area (Appendix G, Appendix Meroor). This specimen and the specimens from the current study sit within a couplet that contains specimens from Area C and South Flank, both approximately 100 km northwest of Newman. This couplet sits within a larger group of clades that contains numerous specimens from the region, including *Austrostephanus* Clade Unknown 2 (see below). Until the genus is phylogenetically analysed and species clades defined, it is difficult to say whether this particular clade will be SRE or not, hence it is classified as Potential SRE.

- *Austrostephanus* Clade E

Only one sequence was identified as 99% similar to WAMT107389 and WAMT100768 (Clade E) (Appendix G, Appendix M), these occurred between 20 – 40 km from the Study Area. This Clade sits quite separately from the other Clades in the genus however, WAMT107389 was collected from Hope Downs, 74 km northwest of Newman and WAMT100768 was collected from Area C, 92 km northwest of Newman. This indicates that the specimen in this Clade from the current study is found in the local area outside of the Study Area. However, it still may represent a Potential SRE species.

- *Austrostephanus* Clade F

Three specimens are >99% similar to each other and to WAMT128924 (Clade F). The WAM specimen was also collected within 5 km of the Study Area (Appendix G, Appendix M). This clade sat closely with another specimen from WAM(T114705) which was collected in Angelo River, 118 km west of Newman. This couplet was also arranged in the same branch as *Austrostephanus* Clade Unknown 1 (see below). Until further taxonomic and molecular clarity is provided for this group, this clade is designated as representing Potential SRE.

- *Austrostrophus Clade Unknown 1*

Three specimens are 99% similar to each other, and 95% similar to WAMT114705 (Clade F). This specimen was collected at Angelo River, less than 20 km from the Study Area. WAM MSU reports that these specimens represent a previously unrecorded taxon and hence a Potential SRE species.

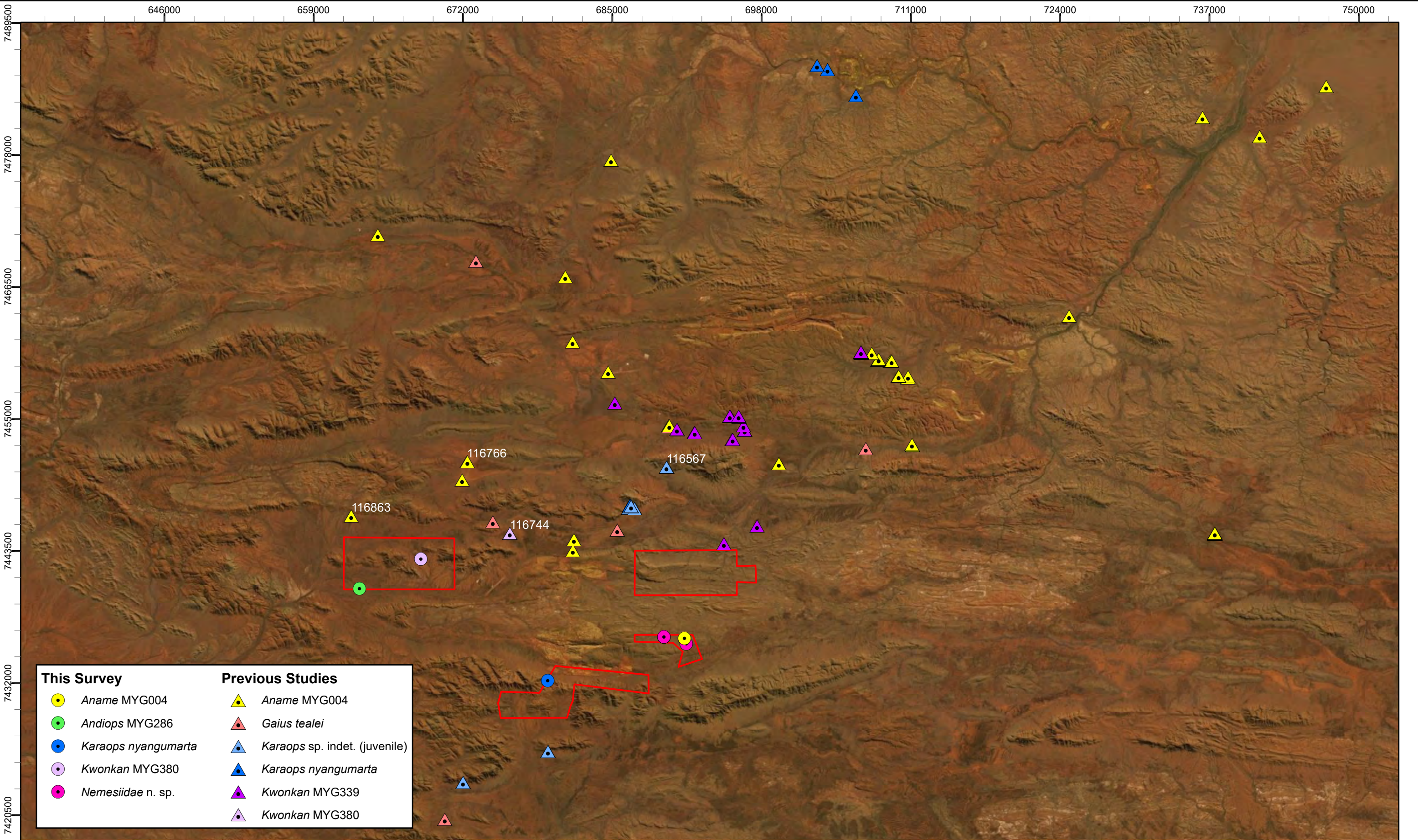
- *Austrostrophus Clade Unknown 2*

Four specimens are 1% or less divergent from each other, and 5% divergent from the nearest other specimen (WAMT130968). The WAM database search from the desktop assessment did not include this specimen so its locality is outside of the 40 km<sup>2</sup> of the database query. The WAM report states that these specimens represent a previously unrecorded taxon for the genus and hence, a Potential SRE species.

#### Gastropoda: Camaenidae

##### **Camaenidae (Sinumeloninae) sp. indet.**

One specimen of this taxon was hand-collected from leaf litter within Gorge/Gully habitat (Figure 5.6). This specimen is very unusual and likely represents a new genus of Camaenidae (E. Volschenk, pers. comm). The specimen is morphologically similar to the Confirmed SRE species, Gen. nov. 'Mount Robinson' sp., which has been previously recorded at one location 6 km north of the Study Area (Figure 5.7; Appendix H). Another Confirmed SRE species belonging to Camaenidae, Gen. nov. 'Z' sp., is also known from three locations within 4 km of the Study Area to the north. Additional specimens of the same species would be required to further define this specimen morphologically and molecular analysis completed on these and the specimens of the other two WAM species mentioned.



This Survey	Previous Studies
<i>Aname</i> MYG004	<i>Aname</i> MYG004
<i>Andiops</i> MYG286	<i>Gaius tealei</i>
<i>Karaops nyangumarta</i>	<i>Karaops</i> sp. indet. (juvenile)
<i>Kwonkan</i> MYG380	<i>Karaops nyangumarta</i>
<i>Nemesiidae</i> n. sp.	<i>Kwonkan</i> MYG339
	<i>Kwonkan</i> MYG380

**Legend**  
 Study Area

N

1:300,000

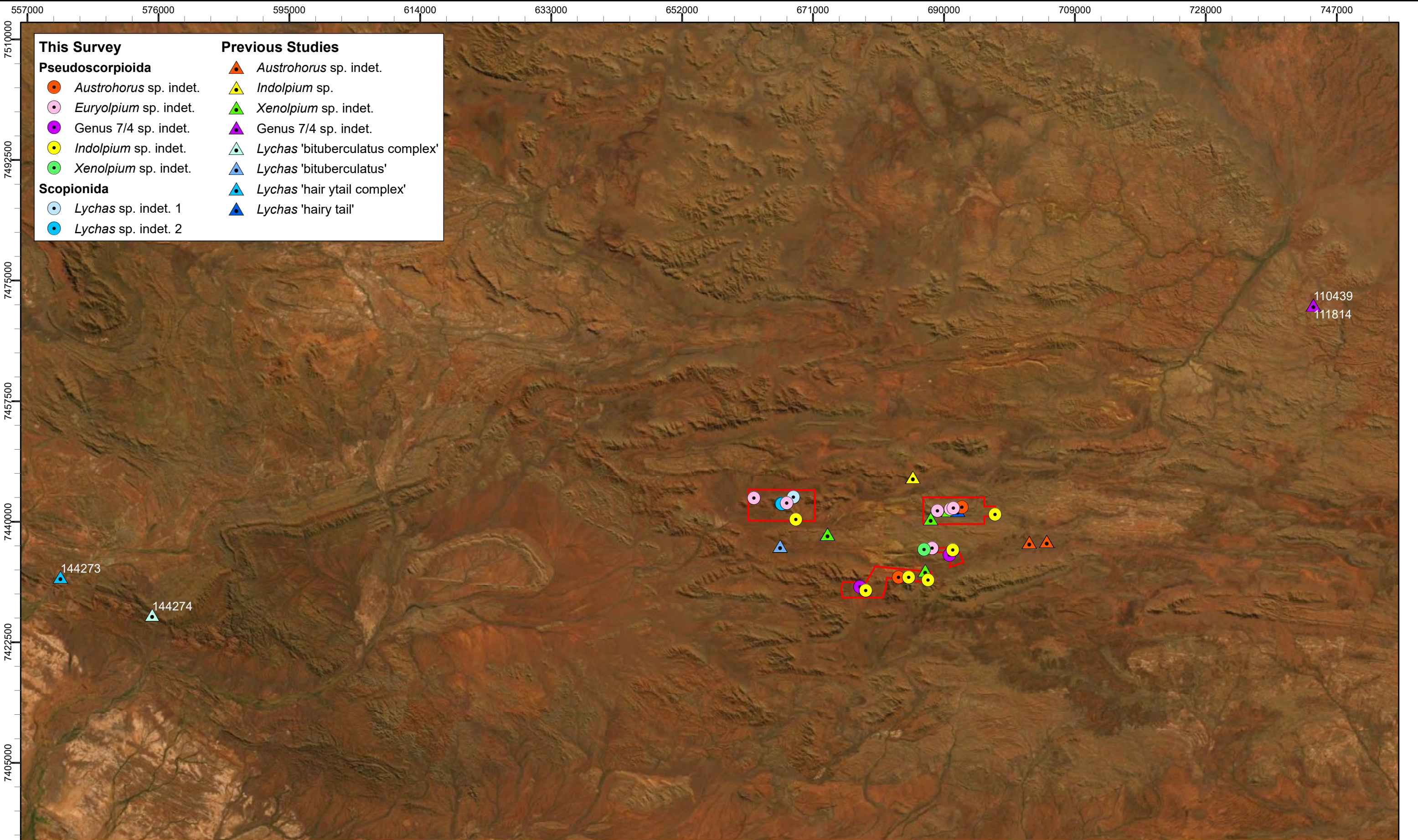
0 2.25 4.5 9 13.5 18 km

**RTIO – West Angelas Beyond 2020**  
**Terrestrial Fauna Assessment**  
**Figure 5.5: SRE Invertebrate Records (Araneae)**

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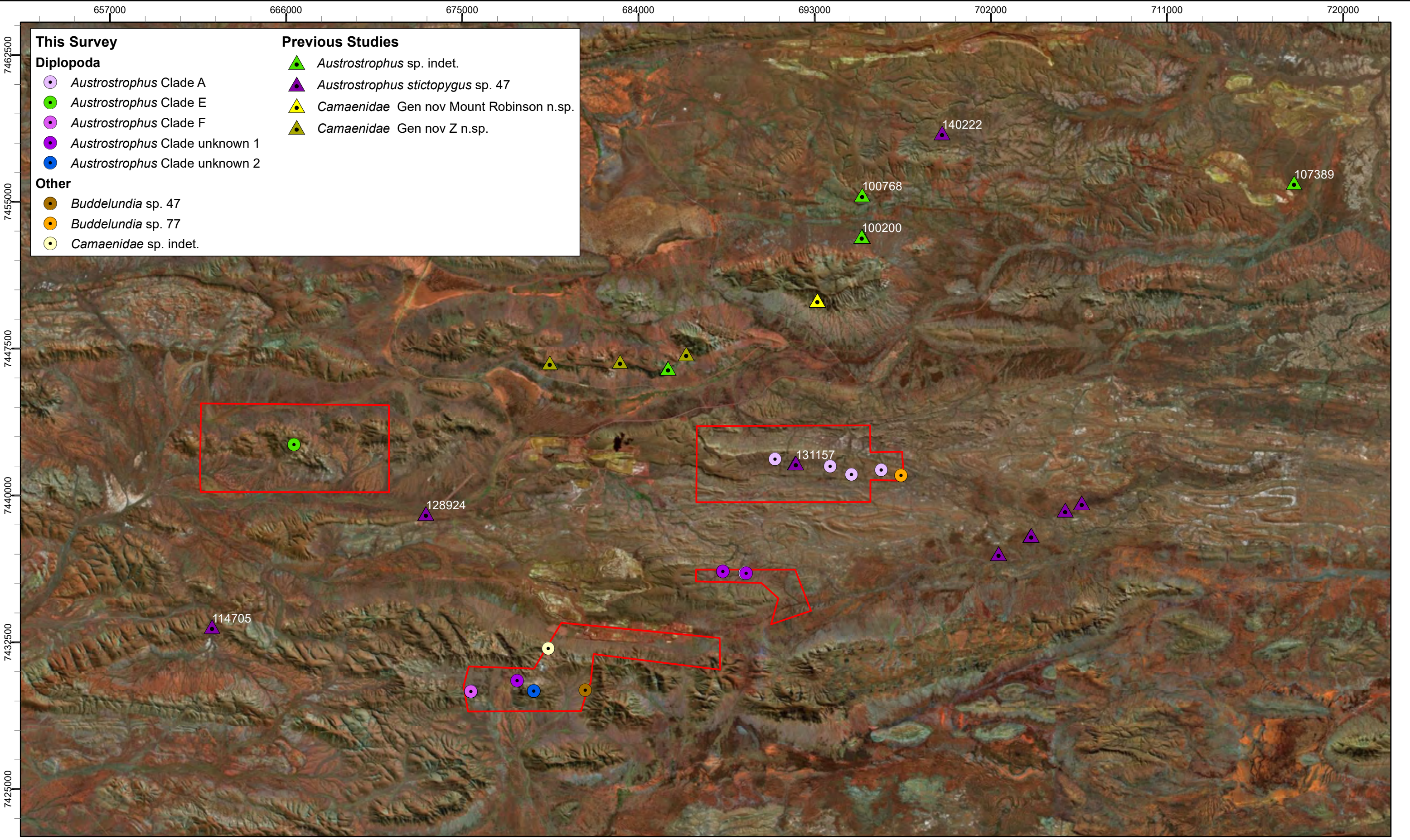
Coordinate System: GDA 1994 MGA Zone 50  
Projection: Transverse Mercator  
Datum: GDA 1994


Size A3. Created 25/11/2019




**This Survey**  
**Pseudoscorpionida**  
● *Austrohorus* sp. indet.  
● *Euryolpium* sp. indet.  
● Genus 7/4 sp. indet.  
● *Indolpium* sp. indet.  
● *Xenolpium* sp. indet.  
**Scorpionida**  
● *Lychas* sp. indet. 1  
● *Lychas* sp. indet. 2

**Previous Studies**  
▲ *Austrohorus* sp. indet.  
▲ *Indolpium* sp.  
▲ *Xenolpium* sp. indet.  
▲ Genus 7/4 sp. indet.  
▲ *Lychas* 'bituberculatus complex'  
▲ *Lychas* 'bituberculatus'  
▲ *Lychas* 'hair ytail complex'  
▲ *Lychas* 'hairy tail'



**Legend**  
 StudyArea



1:175,000

0 1.25 2.5 5 7.5 10 km

N

**RTIO – West Angas Beyond 2020**  
**Terrestrial Fauna Assessment**  
**Figure 5.7: SRE Invertebrate Records (Diplopoda, Isopoda and Gastropoda)**

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

Size A3. Created 25/11/2019

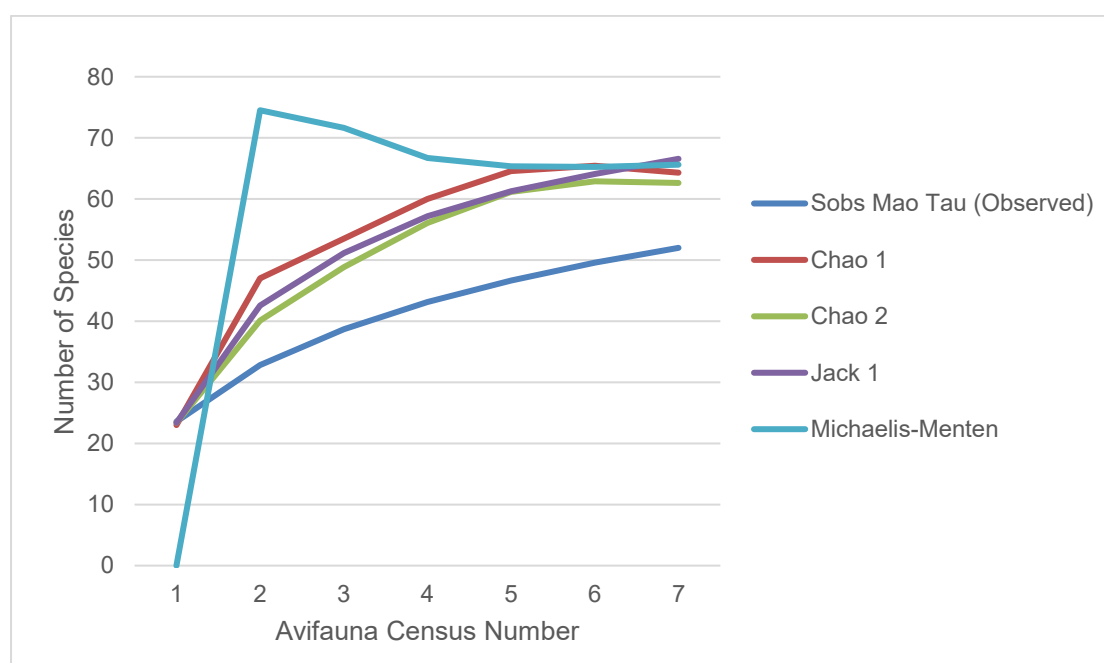
## 5.5. Survey Adequacy

### 5.5.1. Vertebrate Fauna Species Accumulation Curves

The results below represent this survey accumulation curves for each taxa, due to differences in survey methods and statistical analysis between previous surveys we are unable to make statistical comparisons between previous surveys. The results below are based on systematic results only and doesn't not include opportunistic sightings. Some taxa such as amphibians have low numbers of species recorded, due to captures being dependant on rainfall and rainfall being variable. Therefore, captures are not consistent and not enough data available to statistically compare. Contextual comparisons between previous surveys have been made in section 3.2.

#### Avifauna

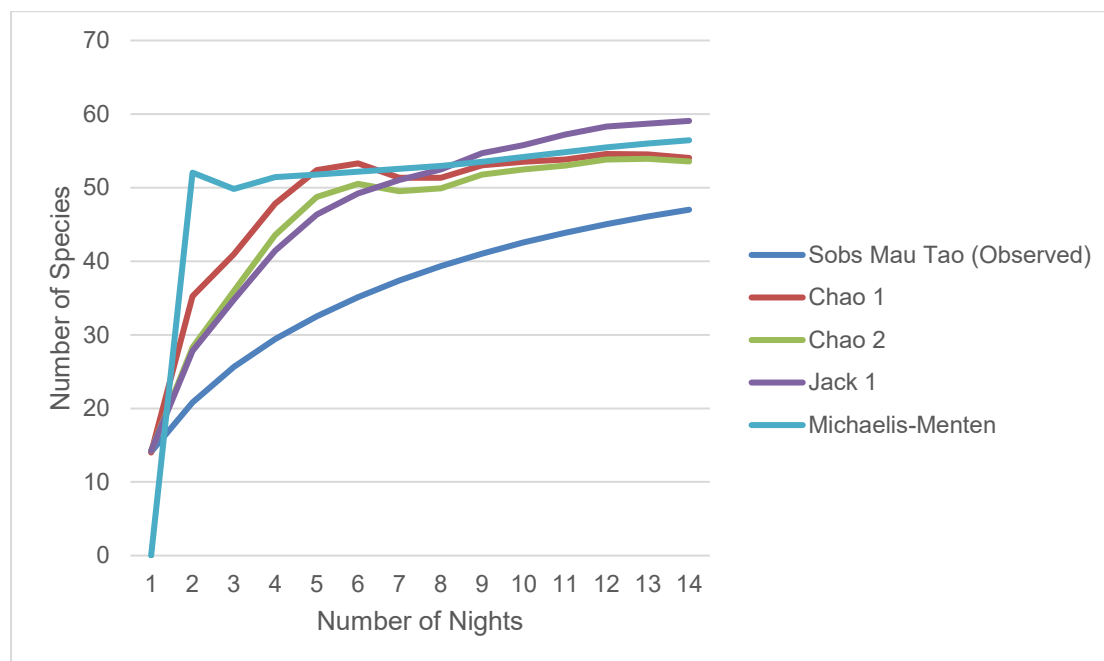
Analysis of the avifauna dataset from the dual phase survey produced a smooth curve, increasing steadily over the 7-day sampling period (Figure 5.8). Visually, the Sobs curve appears to be steadily increasing falling short of reaching an asymptote. Richness estimators indicated that the Survey was 81% (Chao 1), 83% (Chao 2), 78% (Jackknife 1) and 79% (Michaelis-Menten) adequate. A total of 52 species were recorded and it was indicated that 62 to 65 would be expected based on the results obtained. These results indicate that additional survey effort may increase the species richness, although the avifauna censuses were effective in identifying and recording the majority of the bird assemblage present at these sites. Note that a further six standardised avifauna censuses were completed across the Study Area but not included in the analysis. Contextual avifauna comparisons between previous surveys have been made in desktop assessment section 3.2 and also discussed 5.3.



**Figure 5.8: Species accumulation curve for birds recorded at systematic sampling sites**

## Herpetofauna

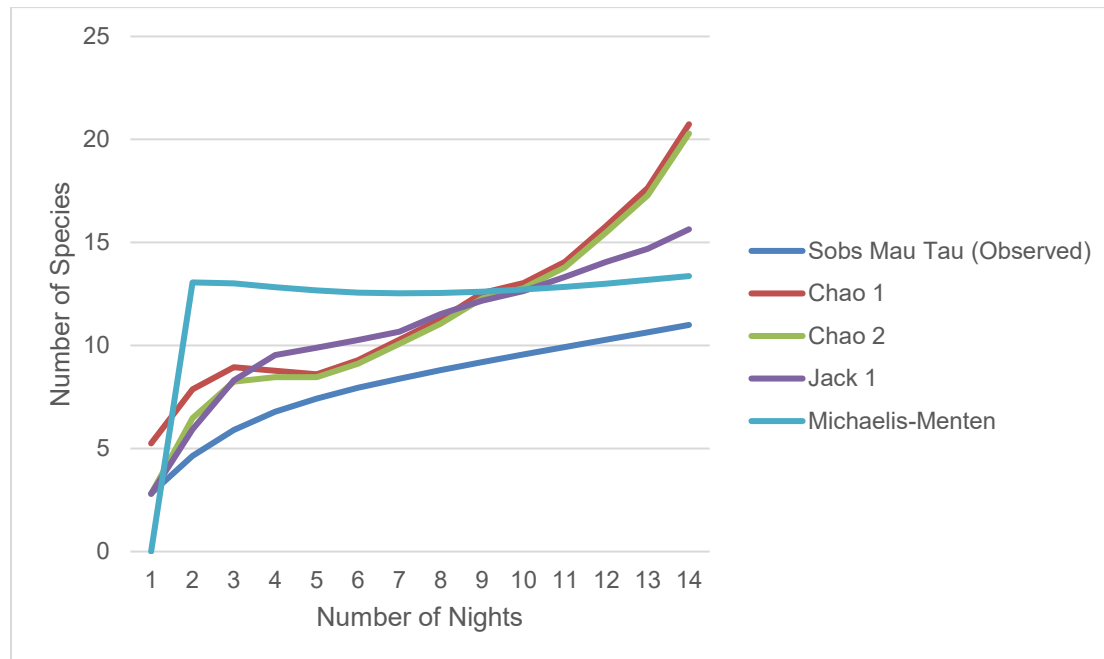
Analysis of the herpetofauna data set from the dual phase survey produced a smooth curve, increasing steadily over the 14-day sampling period (Figure 5.9). Visually, the Sobs curve appears to be steadily increasing falling short of reaching an asymptote. Richness estimators indicated that the Survey was 80% (Jack 1) to 88% (Chao 2) adequate. A total of 47 species were recorded and it was indicated that 53 to 60 would be expected based on the results obtained. These results indicate that while additional survey effort may increase the species richness, the systematic trapping effort applied was effective in identifying and recording the majority of the herpetofauna assemblage present. Contextual herpetofauna comparisons between previous surveys have been made in desktop assessment section 3.2 and also discussed 5.3.



**Figure 5.9: Species accumulation curve for herpetofauna trapped at systematic sampling sites**

## Mammals

The Sobs curve for mammals produced a steadily increasing line, indicating that an asymptote had not been reached (Figure 5.10). Richness estimated that between 53% (Chao 2) and 72% (Michaelis-Menten) of species had been recorded. While low, these results are likely to reflect the fact that species richness for mammals is typically lower than that for birds and herpetofauna, thus the capture of a single new species on any given day makes a proportionately large change to the overall dataset. Contextual mammal comparisons between previous surveys have been made in desktop assessment section 3.2 and also discussed 5.3.



**Figure 5.10: Species accumulation curve for mammals trapped at systematic sampling sites**

### 5.5.2. Vertebrate Fauna Survey Limitations and Constraints

The EPA Technical Guidance on terrestrial fauna surveys outlines a number of factors that can affect the adequacy of fauna surveys (EPA, 2016c). These were assessed in relation to the current assessment (Table 5.12). The amount of relevant data collected during the field surveys was potentially limited by the fact that they were conducted after a long period dry weather, which is likely to have reduced fauna activity, particularly among amphibians. Additional survey effort is likely to increase the number of reptile species known to occur in the Study Area, and further survey after periods of wet weather is likely to increase the number of amphibian species recorded. Spotlighting, which is a practical way of identifying nocturnal and crepuscular species that are unlikely to be trapped, was not conducted due to safety concerns.

**Table 5.12: Survey limitations and constraints**

Potential limitation or constraint	Applicability to current assessment	Limitation to survey
Experience of personnel	The field personnel involved in the survey collectively had over 35 years of fauna survey experience in Western Australia's arid-zone.	No
Scope (faunal groups sampled and whether any constraints affect this)	The scope was a Level 2 survey and the assessment was conducted within that framework. All terrestrial vertebrate fauna groups were surveyed using standardised and well-established techniques, and previous survey work in the vicinity of the Study Area was reviewed. No spotlighting was conducted during the surveys due to safety concerns. As many Australian species are nocturnal or crepuscular, spotlighting is a useful way to detect species that are not often trapped, and it is possible that spotlighting would increase the number of species known to occur in the Study Area.	Partial
Proportion of fauna identified or collected	The majority of fauna recorded in the Study Area were identified at the point of capture or observation. Bat calls were identified after they were recorded by Mr Robert Bullen, a bat specialist from Bat Call WA. Acoustic recordings were similarly analysed following the survey by Nigel Jackett, an ornithologist and Night Parrot specialist. A number of records could not be attributed to particular fauna species with certainty. These included a collection of scats, which were sent to scat identification experts for morphological and genetic analysis, with inconclusive results, but the possibility of it being an extinct rodent species. Unidentifiable bird calls were also recorded in the Study Area. While these calls were of the same frequency as known Night Parrot calls, they could not be attributed to the species, or any other species, with certainty. Follow up work during the targeted survey provided sufficient detail to confirm that these calls were a result of wind gusts and therefore considered Unlikely to occur within the Study Area (Biologic, in prep.).	No
Sources of information (recent or historic) and availability of contextual information	All contextual resources required to complete the assessment were available (previous surveys, database searches, environmental information, climate data). This included information from 18 biological surveys previously conducted in the vicinity of the Study Area, comprising a reasonable amount of previous survey effort. Also available were regional biodiversity surveys describing known assemblages of vertebrate fauna occurring in the Pilbara.	No
Proportion of the task achieved and further work which might be needed	A two-phase level 2 survey of the Study Area was carried out according to scope. The conservation value of the Study Area for vertebrate fauna has been described. This report provides sufficient baseline information to inform subsequent surveys targeting species of conservation significance.	No

Potential limitation or constraint	Applicability to current assessment	Limitation to survey
Timing / weather / season / cycle	Conditions leading up to the field surveys were relatively dry compared with long-term averages. This may have influenced the abundance and activity of fauna at the time of the surveys. Lightning storms during the Phase 2 survey reduced field time and may also have reduced fauna activity.	No
Disturbances	Lightning storms during the Phase 2 survey reduced field time and may also have reduced fauna activity. However, fauna assemblages were nonetheless accurately identified and defined, and this posed no constraint on the outcomes of the survey.	No
Intensity of survey	The Study Area was surveyed using a variety of recommended techniques across multiple seasons. The total number of trap nights across the field surveys was 7,088. A total of 96 avifauna censuses and 11 targeted searches were conducted. Acoustic recording devices and ultrasonic recording devices were deployed for a total of 30 and 68 recording nights, respectively. Motion cameras were deployed in the short term for 139 recording nights, while cameras deployed in the longer term were in place for 3,182 recording nights.	No
Completeness of survey	A two-phase level 2 survey of the Study Area was completed. Habitats most likely to support species of conservation significance were targeted for systematic sampling and targeted searches were conducted to ensure adequate coverage of the Study Area. No systematic sampling sites were established in Mulga Spinifex Woodland habitat. This habitat is common and widespread across the region and is not considered to support species that are not also found in other habitat types containing similar habitat features, such as Mixed Acacia Woodland habitat (where one systematic sampling site was located) and Drainage Area habitat (where two systematic sampling sites were located). The desktop assessment identified 298 species of vertebrate fauna as potentially occurring in the Study Area, and the current field surveys recorded 158 (53%) of these. The number of species recorded during the current field surveys is comparable to other surveys of similar size and scope conducted in the vicinity of the Study Area. Species accumulation curves suggest further sampling effort may increase the number of species known to occur within the Study Area, but that the majority of fauna present were detected.	Partial
Resources (e.g. degree of expertise available)	All resources required to complete the assessment were available. Field personnel consisted of qualified zoologists with extensive experience in conducting biological surveys in the Pilbara. Where required, assistance was sought from experts in their respective fields, including bat specialist Mr Robert Bullen of Bat Call WA, Night Parrot specialist Nigel Jakkett, scat identification specialists Barbara Trigg and Georgeanna Story.	No
Remoteness or access issues	The Study Area was accessible either by vehicle or on foot, thus the survey effort applied during the field surveys was unconstrained by accessibility or remoteness.	No

### **5.5.3.SRE Invertebrate Survey Limitations and Constraints**

There are several general limitations regarding the completeness of SRE fauna surveys, particularly with regard to the target fauna living in cryptic habitats, occurring in low numbers, and being difficult to detect. Despite this, it is not considered that the survey detailed herein suffered from any specific constraints in relation to the number of samples, the coverage of SRE habitat types or the sampling and preservation methods used to detect the target fauna.

The identification of SRE species, the interpretation of species' distributions and the resulting categorisation of their respective SRE status is dependent on the current state of taxonomic and ecological knowledge of the target groups at the time of survey. Owing to ongoing developments in regional sampling coverage and taxonomic information, the SRE status, distributions and habitat preferences of the taxa described herein may be subject to change over time.

## 6. CONCLUSION

### 6.1. Vertebrate Fauna

A total of 158 vertebrate fauna species comprising 26 native mammal species, four introduced mammal species, 67 bird species, 59 reptile species, and two amphibian species, was recorded during the field surveys. The number of species recorded in the Study Area is comparable to that recorded in the area during previous surveys of a similar size and scope to the current assessment. It is likely that additional survey effort, including spotlighting and sampling after a period of rainfall that is more reflective of long-term patterns, might increase the number of species known to occur in the Study Area, particularly among reptiles and amphibians. Even so, additional survey effort would be unlikely to alter conclusions regarding the likelihood of occurrence of species of conservation significance, or the level of significance attributed to fauna habitats identified in the Study Area.

A total of seven broad fauna habitat types were recorded and mapped across the Study Area. These habitats are typical of the Pilbara region and thus the vertebrate fauna contained within the Study Area are generally known from similar habitat in the surrounding region. Within the Study Area, the Gorge or Gully and Drainage Area habitat types were considered to be of high significance as they either were found to support species of conservation significance or contain core habitat for such species. Mulga Spinifex Woodlands, Hilltop, Hillslope, Ridge or Cliff and Mixed Acacia Woodlands were considered to be of moderate significance as they provide habitat for species of conservation significance, but do not represent core habitat for these species. The two remaining habitats, Footslope and Plain and Minor Drainage, were deemed to be of low significance as they are relatively widespread in the surrounding region and they are not exclusively depended upon by species of conservation significance.

Of the 298 species recorded during the desktop assessment, 24 species are of conservation significance, comprising seven mammals, 13 birds and four reptiles. Seven of these were recorded in the Study Area during the current field surveys, and an eighth species has been recorded in the Study Area during a previous survey. The eight species of conservation significance known to occur in the Study Area are the:

- Northern Quoll, which is listed as Endangered under the BC Act and EPBC Act;
- Pilbara Olive Python, Ghost Bat and Pilbara Leaf-nosed Bat, which are listed as Vulnerable under the BC Act and EPBC Act;
- Pilbara Flat-headed Blind-snake, which is listed by the DBCA as a Priority 1 species;
- Pilbara Barking Gecko, which is listed by the DBCA as a Priority 2 species;
- Western Pebble-mound Mouse, which is listed by the DBCA as a Priority 4 species; and
- Fork-tailed Swift, which is listed under the BC Act and EPBC Act as a Migratory species.

Of these species, the most relevant to the development of the project are the: Northern Quoll, scats of which were recorded at one site in the Study Area; the Ghost Bat, of which a number of important roost sites, including at least one maternity roost, were found in caves within the Study Area; the Pilbara Leaf-nosed Bat, which was recorded during the night in the Study Area, possibly during foraging flights; and the Pilbara Olive Python, an individual of which was recorded on motion-sensor camera. These species all rely on Gorge or Gully habitat for denning, roosting and foraging. Any caves and locations prone to forming water pools after periods of rainfall are particularly significant for these species. The majority of the records of these species was associated with caves within the Western Hill Deposit. Those caves which have been identified as maternity roosts (CWAN-04) or potential maternity (CWAN-06, CWAN-07) or potential diurnal (CWAN-01, CWAN-02, CWAN-03, CWAN-10) roosts of the Ghost Bat should be considered to be regionally significant.

## 6.2. SRE Invertebrate Fauna

Of the seven broad habitats recorded in the Study Area, one is regarded to be of high suitability (Gorge or Gully), one of moderate/high suitability (Mixed Acacia Woodland) and three of moderate suitability (Mulga Spinifex Woodland, Drainage Area and Hilltop, Hillslope, Ridge or Cliff). The remaining habitats are not considered suitable for SRE invertebrate fauna as they lack protection, complexity and/or are widespread, common and continuous.

The Gorge or Gully habitats are the most restricted in the Study Area and the most likely to contain SRE taxa due to the high level of protection and restricted nature. Wet season sampling in these habitats will likely yield further Potential SRE taxa and extend the range of those currently known.

The Mixed Acacia Woodland habitat also appears to be a restricted habitat in the local area but does extend beyond the Study Area. The connection of this habitat with the Drainage Area habitat, which can be regarded as a similar type of habitat with respect to SRE invertebrate suitability, will reduce the chance of any SRE fauna being restricted to the local area; however, further sampling would be required to confirm this.

The Mulga Spinifex Woodland habitat is patchy in the west of the Study Area and largely absent from the eastern parts of the Study Area. While it is likely that this habitat will contain SRE invertebrate fauna, it is unlikely that any SRE fauna would be restricted to any individual patch of this habitat as dispersal between adjacent patches (through the Footslopes and Plain habitat) would be unhindered during the cooler times of the year.

The Hilltop, Hillslope, Ridge or Cliff habitat appears largely unsuitable for SRE invertebrate fauna as a result of their generally exposed positions and lower degrees of isolation; however, two DBCA listed Priority 1 millipede species (*Antichiropus* 'DIP006' and *A.* 'DIP007') were collected in this habitat type in the central Pilbara in recent surveys highlighting the fact that this habitat type may have a higher potential for supporting Potential SRE species than previously assumed.

Of the 23 Potential SRE taxa recorded in the Study Area, six are currently regarded as having a higher likelihood of being restricted to the Study Area or the local area. These were *Nemesiidae* sp. indet., *Tyrranochthonius* sp. indet., *Austrohorus* sp. indet., *Euryolpium* sp. indet., *Indolpium* sp. indet.,

*Buddelundia* '77', and *Sinumeloninae* sp. indet. The remaining Potential SRE species have distributions ranging well beyond the Study Area.

*Nemesiidae* sp. indet. is a morphologically distinctive species and does not appear to have been previously collected based on comparisons with WA Museum specimens. Given the number of *Nemesiidae* records within 10 km of the Study Area this may illustrate that this species is locally restricted, although there has been less invertebrate sampling to the south of Study Area. Establishing burrow morphology and sampling of Mulga *Spinifex* Woodland habitats within the local area will give a clearer indication of the likely distribution of this species.

The four pseudoscorpion OTUs (*Tyrranochthonius* sp. indet., *Austrohorus* sp. indet., *Euryolpium* sp. indet., *Indolpium* sp. indet.) could be further resolved if the remaining second round sequences and additional specimens were sent to WAM for further analysis. However, as pseudoscorpions of the Pilbara require a lot of taxonomic resolution, it is possible that analysis of these specimens may not yield any further information on their regional distribution.

*Buddelundia* '77', requires molecular resolution to understand the relatedness of the two disjunct populations of this taxon. Until this is carried out, it would not be possible to speculate the distribution of the species. Further molecular work on the juvenile *Buddelundia* sp. indet. collected may show are a greater distribution within the Study Area. Further targeted sampling for this species in the local area may give a clearer indication of the likely distribution of this species as well.

*Camaenidae* (*Sinumeloninae*) sp. indet. could represent either Gen. nov. 'Mount Robinson' n.sp. and Gen. nov. 'Z' n.sp, both of which are Confirmed SRE species in the local area; both these species are currently only known from very small distributions and may be highly restricted; however, it may represent something new altogether. *Camaenid* snails are not recorded regularly so there is likely a level of sampling bias associated with the lack of records in the local area. Further targeted sampling for this species in the local area may give a clearer indication of the likely distribution of this species and may provide further evidence of taxonomic relationships with the other species in the area.

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## 8. APPENDICES

## Appendix A: Conservation Status Codes

### *International Union for Conservation of Nature*

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

**Environment Protection and Biodiversity Conservation Act 1999**

Category	Definition
<b>Threatened</b>	
<b>Extinct (EX)</b>	Presumed extinct i.e., there is no reasonable doubt that the last member of the species has died.
<b>Extinct in the Wild (EW)</b>	Presumed extinct in the wild, only surviving in cultivation, captivity or as a naturalised population well outside its past range.
<b>Critically Endangered (CE)</b>	Taxa facing an extremely high risk of extinction in the wild in the immediate future (i.e., 50% chance of extinction in the immediate future).
<b>Endangered (EN)</b>	Taxa facing a very high risk of extinction in the wild in the near future i.e., 20% chance of extinction in the near future.
<b>Vulnerable (VU)</b>	Taxa facing a high risk of extinction in the wild in the medium-term future i.e., 10% chance of extinction in the medium-term future.
<b>Conservation Dependent (CD)</b>	Taxa which will become Vulnerable, Endangered or Critically Endangered if specific conservation efforts cease.
<b>Other</b>	
<b>Migratory (MI)</b>	Birds listed under international agreements relating to the protection of migratory birds i.e., Convention on the Conservation of Migratory Species of Wild Animals (Bonn Convention), China-Australia Migratory Bird Agreement (CAMBA), Japan-Australia Migratory Bird Agreement (JAMBA) or Republic of Korea-Australia Migratory Bird Agreement (ROKAMBA).

**Biodiversity Conservation Act 2016**

Category	Definition
<b>Extinct</b>	
<b>Extinct (EX)</b>	Presumed extinct i.e., there is no reasonable doubt that the last member of the species has died.
<b>Extinct in the Wild (EW)</b>	Presumed extinct in the wild i.e., species which have been adequately searched for and there is no reasonable doubt that the last wild individual has died.
<b>Threatened</b>	
<b>Critically Endangered (CE)</b>	Taxa facing an extremely high risk of extinction in the wild.
<b>Endangered (EN)</b>	Taxa facing a very high risk of extinction in the wild.
<b>Vulnerable (VU)</b>	Taxa facing a high risk of extinction in the wild.
<b>Specially Protected</b>	
<b>Migratory (MI)</b>	Birds listed under international agreements relating to the protection of migratory birds i.e., Convention on the Conservation of Migratory Species of Wild Animals (Bonn Convention), China-Australia Migratory Bird Agreement (CAMBA), Japan-Australia Migratory Bird Agreement (JAMBA) or Republic of Korea-Australia Migratory Bird Agreement (ROKAMBA).
<b>Conservation Dependent (CD)</b>	Species dependent on ongoing conservation intervention to prevent them becoming eligible for listing as threatened.
<b>Other specially protected fauna (OS)</b>	Species otherwise in need of special protection to ensure their conservation.

**Department of Biodiversity, Conservation and Attractions Priority codes**

Category	Definition
<b>Poorly known</b>	
<b>Priority 1 (P1)</b>	Species that are known from one or a few locations which are potentially at risk. Species whose occurrences are either small, on lands not managed for conservation or otherwise threatened with habitat destruction or degradation. Species that are well known from one or more locations but are under immediate threat from threatening processes. In urgent need of further survey.
<b>Priority 2 (P2)</b>	Species that are known from one or a few locations, some of which are on lands managed for conservation. Species that are well known from one or more locations but are under threat from threatening processes. In urgent need of further survey. In need of further survey.
<b>Priority 3 (P3)</b>	Species that are well known from several locations and are not are under imminent threat. Species known from few but widespread locations with either a large population size or with large areas of suitable habitat remaining, much of which is not under imminent threat. Species that are well known from one or more locations and threatening processes exist that could affect them.
<b><i>Rare, Near Threatened and other species in need of monitoring</i></b>	
<b>Priority 4 (P4)</b>	<p><i>Rare</i> – Species that are considered to have been adequately surveyed, or for which sufficient knowledge is available, and which are considered not currently threatened or in need of special protection but could be if present circumstances change.</p> <p><i>Near Threatened</i> – Species that are considered to have been adequately surveyed and that are close to qualifying for Vulnerable but are not listed as Conservation Dependent.</p> <p><i>In need of monitoring</i> - Species that have been removed from the list of threatened species during the past five years for reasons other than taxonomy</p>

## **Appendix B: Summary of previous reports considered in the literature review**

Survey	An Ecological Appreciation of the West Angelas Environment Western Australia	West Angelas Iron Ore Project Vertebrate Fauna Assessment Survey	West Angelas Project Ghost Bat Macroderma Gigas Survey Assessment	Robe Development Plan West Angelas Minesite Ghost Bat Assessment Survey	Robe Development Plan West Angelas Minesite Ghost Bat Monitoring Survey	Ghost Bats at West Angelas: 2002 Survey, Data Review and Future Directions	Monitoring of Ghost Bat roosts at West Angelas 2003	Fauna Habitats and Fauna Assemblages of Deposit E and F at West Angelas	Southern Flank Vertebrate Fauna Survey	Rio Tinto- Angelo River Vertebrate Fauna Baseline Survey	West Angelas – Deposit B Ghost Bat Assessment	Rio Tinto Iron Ore Greater West Angelas Terrestrial Fauna Assessment	Western Hill Native Vegetation Clearing Permit Report	2017 West Angelas Ghost Bat Monitoring	West Angelas 2 (AR-14-12516) Biological Assessment Native Vegetation Clearing Permit Supporting Report	South Flank Target Fauna Survey	Targeted Conservation Significant Fauna Survey – Karlijini tenement E47/117	West Angelas Iron Ore Mine – Deposit B and F Ghost Bat Assessment: December 2014
Consultant	Integrated Environmental Services	Ecologia	Ecologia	Ecologia	Ecologia	Biota	Biota	Biota	Biologic	ENV	Biologic	Ecologia	Biota	Biologic	Ecological	Biologic	Biologic	Biologic
Year	1979	1998	1998	2000	2001	2002	2004	2005	2011	2011	2013	2014	2014	2018	2014	2016	2013	2015
Type	Extensive vertebrate fauna assessment	Level 2	Targeted Survey	Monitoring Survey	Monitoring Survey	Targeted Survey	Monitoring Survey	Level 2	Level 2	Level 2	Targeted Survey	Level 2	Level 1	Monitoring Survey	Level 1	Targeted Survey	Targeted Survey	Monitoring Survey
Duration	1978 & 1979	10 June - 10 July & 18 September - 3 October 1997	31 August - 4 September 1998	29 August 2000	4-6 September 2000	27-28 November 2002	2-3 December 2003	4-12 May 2004	7 April – 19 April & 23 August – 4 September 2010.	20 June - 1 July 2011	10 October 2012 & 19-22 November 2012	26 September - 6 October 2012 & 19-27 March 2013	25-26 March 2014	17 - 19 October 2017	31 August - 7 September 2014	19 - 22 November 2015 & 15 – 17 December 2015.	17 and 25 June 2013	1-4 December 2014
Approximate Distance from Study Area	Old report with GIS data	Within Greater West Angelas Mine Area	Western Hill: ~3km NE; Deposit H: within; Deposit J: 0.5km N; Deposit F: 1km S	Western Hill: ~11km E; Deposit H: ~2km W; Deposit J: ~2km N; Deposit F: 1km S	Western Hill: ~3km NE; Deposit H: ~2km W; Deposit J: ~2km N; Deposit F: 1km S	Western Hill: ~3km NE; Deposit H: ~1km W; Deposit J: ~1km N; Deposit F: 1km S	Western Hill: ~3km NE; Deposit H: ~1km W; Deposit J: ~1km N; Deposit F: 1km S	Western Hill: ~11km SE; Deposit H: ~5km S; Deposit J: within; Deposit F: within	~8 km N of Deposit H	Western Hill: ~5km S; Deposit H: ~9km SSW; Deposit J: within; Deposit F: ~5km SW	Western Hill: ~3km NE; Deposit H: ~1km W; Deposit J: ~1km N; Deposit F: 1km S	Western Hill: Borders; Deposit H, Deposit J and Deposit F: within	Within Western Hill	Western Hill: ~3km NE; Deposit H: ~1km W; Deposit J: ~1km N; Deposit F: 1km S	Within Western Hill	~8 km N of Deposit H	~7km NW Western Hill	Western Hill: ~3km NE; Deposit H: ~1km W; Deposit J: ~1km N; Deposit F: 1km S
Site Type	8 Systematic sites (pitfalls spaced at 5m intervals), 3 Elliot trapping sites (Type A and E baited traps laid out in parallel rows to form a grid), 3 break-back trapping sites (baited and set up where Elliot's were ineffective), spotlighting and intensive searching.	CALM Pilbara grid, Corridor site, Helicopter survey site	Targeted Searches, Harp Trapping (1) location, mist-netting (1) location, Bat detector (1) location	Targeted Searches	Targeted Searches	Targeted Searches	Targeted Searches	Five grids: row of 10 pitfall traps at 9m intervals. Sixth grid also comprised 12 funnel traps. Seventh grid comprised 12 funnel traps and 25 Elliot traps. Final site comprised 17 Elliot traps at 10m intervals.	Linear transect. 5 Bucket, 5 PVC, 20 Funnel, 20 Elliott, 2 Cage	Systematic trapping (10 locations) of 100 m x 100 m quadrat comprising 2 lines of 5 pitfall traps, 16 funnel trap, 6 cage traps and 10 Elliot traps.	Targeted Searches	Systematic (10 pitfall traps, 10 Elliot traps, 20 funnel traps, 2 cage traps) and Opportunistic	Targeted searches and Opportunistic	Targeted Searches	Opportunistic	Targeted Searches and camera sites	Targeted Searches SM2 sites and camera sites	Targeted Searches
No. Trapping Sites	15	60	60 caves in 27 gullies	5 caves	5 caves and cave searching in 6 <sup>th</sup> location	7 caves	8 caves	9	10	10	5 caves	12	N/A	5 caves	N/A	N/A	N/A	5 caves
Elliot trap nights	2297	4230	N/A	N/A	N/A	N/A	N/A	168	2800	760	N/A	1680	N/A	N/A	N/A	N/A	N/A	N/A
Pitfall trap nights	3313	1265	N/A	N/A	N/A	N/A	N/A	270	1400	700	N/A	1680	N/A	N/A	N/A	N/A	N/A	N/A
Funnel trap nights	N/A	N/A	N/A	N/A	N/A	N/A	N/A	108	2800	1120	N/A	3360	N/A	N/A	N/A	N/A	N/A	N/A
Cage trap nights	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	280	420	N/A	336	N/A	N/A	N/A	N/A	N/A	N/A
Diurnal search (hrs)	Unknown	102.5hrs	N/A	N/A	N/A	N/A	N/A	Unknown	152	26	N/A	51.6	Unknown	Unknown	N/A	40	Unknown	Unknown
Nocturnal search (hrs)	Unknown	Unknown	N/A	N/A	N/A	N/A	N/A	Unknown	48	22	1 (nocturnal count for Ghost Bats)	25	N/A	N/A	N/A	13	N/A	N/A

Survey	An Ecological Appreciation of the West Angelas Environment Western Australia	West Angelas Iron Ore Project Vertebrate Fauna Assessment Survey	West Angelas Project Ghost Bat Macroderma Gigas Survey Assessment	Robe Development Plan West Angelas Minesite Ghost Bat Assessment Survey	Robe Development Plan West Angelas Minesite Ghost Bat Monitoring Survey	Ghost Bats at West Angelas: 2002 Survey, Data Review and Future Directions	Monitoring of Ghost Bat roosts at West Angelas 2003	Fauna Habitats and Fauna Assemblages of Deposit E and F at West Angelas	Southern Flank Vertebrate Fauna Survey	Rio Tinto- Angelo River Vertebrate Fauna Baseline Survey	West Angelas – Deposit B Ghost Bat Assessment	Rio Tinto Iron Ore Greater West Angelas Terrestrial Fauna Assessment	Western Hill Native Vegetation Clearing Permit Report	2017 West Angelas Ghost Bat Monitoring	West Angelas 2 (AR-14-12516) Biological Assessment Native Vegetation Clearing Permit Supporting Report	South Flank Target Fauna Survey	Targeted Conservation Significant Fauna Survey – Karlijini tenement E47/117	West Angelas Iron Ore Mine – Deposit B and F Ghost Bat Assessment: December 2014
Consultant	Integrated Environmental Services	Ecologia	Ecologia	Ecologia	Ecologia	Biota	Biota	Biota	Biologic	ENV	Biologic	Ecologia	Biota	Biologic	Ecological	Biologic	Biologic	Biologic
Year	1979	1998	1998	2000	2001	2002	2004	2005	2011	2011	2013	2014	2014	2018	2014	2016	2013	2015
Bird Survey method	Unknown/ Opportunistic	Systematic censuses and opportunistic sightings	N/A	N/A	N/A	N/A	N/A	Opportunistic observations and Systematic searches	20 min set time period	Systematic (10 sites) diurnal and nocturnal	N/A	Opportunistic observations and Systematic sites within 3hrs of dawn	Opportunistic	N/A	N/A	N/A	N/A	N/A
Bird surveys (hrs)	Unknown	Unknown	N/A	N/A	N/A	N/A	N/A	840	24	35	N/A	53.83	N/A	N/A	N/A	N/A	N/A	N/A
Bat survey method	Mist nets	Mist nets	Harp Trap (Austbat), U30 bat detector, Mist nets	Targeted searches for Ghost Bat	Targeted searches for Ghost Bat	Targeted searches for Ghost Bat	Targeted searches for Ghost Bat	Anabat II	ANABATTM II and ANABATTM SD-1, gully searches	Anabat SD1 and Song Meter 2	Nocturnal counts, infra-red (IR)-lit high-speed video, SM2 Song Meter	SM2BAT+	Opportunistic	Targeted searches for Ghost Bat & SM2BAT+ and SM4BAT FS	N/A	N/A	SM2BAT	SM2
Bat survey effort	Unknown	Unknown	2 recording hrs	N/A	N/A	N/A	N/A	2 recording nights	22 recording nights	6 recording nights	4 recording nights	340 recording hrs	N/A	7 recording nights	N/A	N/A	4 recording nights	5 recording nights
Camera nights	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	24	Unknown	4	576	N/A	N/A	N/A	1120	4	5
Seasonal Conditions	Survey conducted over a two-year period and in all seasons	Bimodal distribution of rainfall - typical Pilbara pattern	Unknown	Unknown	Unknown	Unknown	Unknown	No rainfall occurred during the survey, max temperatures slightly above average, min temperatures below average	Temperatures slightly higher than LTA. Range of temperatures greater than LTA range. Rainfall leading up to both surveys was below average	Average annual rainfall preceding survey - above average, but 3 months preceding survey - slightly below average. Min temperatures below average and max temperatures slightly above average	Temperatures typical for November. Year preceding survey was slightly wetter than average, due to heavy and prolonged rainfall in January 2012. However, the year was by no means exceptional.	Phase 1 - typical early spring conditions and no rainfall was received during the survey. Phase 2 - warmer conditions, above average rainfall for the region experienced leading up to Phase 2.	Rainfall received during the 2013-2014 wet season was above average (most recorded during January). February and March 2014 were both below average	Typical for the time of year. Rainfall recorded in the twelve months prior to the survey was well above the average annual rainfall	The rainfall preceding the survey was above average with many species flowering.	Maximum temperatures during the survey were consistent with average temperatures for the region	Rain fell on five days during the survey period and was significantly higher than LTA for June. Average temperature - significantly lower LTA.	Temperatures were typical for December. Rainfall received during the 12 months preceding the survey were higher than the LTA.

Survey	An Ecological Appreciation of the West Angelas Environment Western Australia	West Angelas Iron Ore Project Vertebrate Fauna Assessment Survey	West Angelas Project Ghost Bat Macroderma Gigas Survey Assessment	Robe Development Plan West Angelas Minesite Ghost Bat Assessment Survey	Robe Development Plan West Angelas Minesite Ghost Bat Monitoring Survey	Ghost Bats at West Angelas: 2002 Survey, Data Review and Future Directions	Monitoring of Ghost Bat roosts at West Angelas 2003	Fauna Habitats and Fauna Assemblages of Deposit E and F at West Angelas	Southern Flank Vertebrate Fauna Survey	Rio Tinto- Angelo River Vertebrate Fauna Baseline Survey	West Angelas – Deposit B Ghost Bat Assessment	Rio Tinto Iron Ore Greater West Angelas Terrestrial Fauna Assessment	Western Hill Native Vegetation Clearing Permit Report	2017 West Angelas Ghost Bat Monitoring	West Angelas 2 (AR-14-12516) Biological Assessment Native Vegetation Clearing Permit Supporting Report	South Flank Target Fauna Survey	Targeted Conservation Significant Fauna Survey – Karlijini tenement E47/17	West Angelas Iron Ore Mine – Deposit B and F Ghost Bat Assessment: December 2014
Consultant	Integrated Environmental Services	Ecologia	Ecologia	Ecologia	Ecologia	Biota	Biota	Biota	Biologic	ENV	Biologic	Ecologia	Biota	Biologic	Ecological	Biologic	Biologic	Biologic
Year	1979	1998	1998	2000	2001	2002	2004	2005	2011	2011	2013	2014	2014	2018	2014	2016	2013	2015
Experience Level of Consultant	Unknown	Unknown	Conducted by a Project Manager, Senior Zoologist and Zoologist	Unknown	Unknown	Unknown	Unknown	Adequate	Each field member had 5+ years' experience undertaking Pilbara fauna surveys, were involved in several surveys surrounding the Study Area. Specialist experience available.	Included practitioners that are regarded as suitably qualified in their respective fields:	The assessment was undertaken by ecologists with extensive experience with the target bat species in the Pilbara.	All members of the survey team were experienced in Pilbara fauna identification and fauna surveys.	No zoologists were present during the field survey; however, personnel have experience in fauna habitat assessment and detecting species of conservation significance	The assessment was undertaken by ecologists with extensive experience with the target bat species in the Pilbara	Extensive experience undertaking flora and fauna surveys across WA, including the Pilbara and other arid areas	The field personnel involved in the survey each have 10+ years' experience undertaking fauna surveys in the Pilbara and have specific experience surveying for the target species.	The assessment was undertaken by senior zoologists with extensive experience with the targeted fauna.	The assessment was undertaken by ecologists with extensive experience with the target bat species in the Pilbara.
Threatened and Priority Ecological Communities	Not mentioned	Cracking Clay habitat, Millstream-Chichester NP, Karlijini NP	Not mentioned	Not mentioned	Not mentioned	Not mentioned	Not mentioned	No TEC's - Coondewann a Addition proposed.  Ecosystems at risk: Grove/intergr ove mulga of the eastern, Valley floor mulga, Lower slope mulga, West Angelas cracking-clays.	Coolibah-Lignum, Coondewann a Flats	Not mentioned	Not mentioned	Not mentioned	Within 50km Brockman Iron Cracking Clay communities of the Hamersley Range, West Angelas Cracking-Clays, Coolibah – Lignum flats. Ecosystems at risk that may be relevant; Lower slope mulga, Valley floor mulga, All major ephemeral water courses	Not mentioned	Within 50km: Brockman Iron Cracking Clay communities of the Hamersley Range, West Angelas Cracking-Clays, Coolibah – Lignum flats.	Not mentioned	Not mentioned	Not mentioned

Survey	An Ecological Appreciation of the West Angelas Environment Western Australia	West Angelas Iron Ore Project Vertebrate Fauna Assessment Survey	West Angelas Project Ghost Bat Macroderma Gigas Survey Assessment	Robe Development Plan West Angelas Minesite Ghost Bat Assessment Survey	Robe Development Plan West Angelas Minesite Ghost Bat Monitoring Survey	Ghost Bats at West Angelas: 2002 Survey, Data Review and Future Directions	Monitoring of Ghost Bat roosts at West Angelas 2003	Fauna Habitats and Fauna Assemblages of Deposit E and F at West Angelas	Southern Flank Vertebrate Fauna Survey	Rio Tinto- Angelo River Vertebrate Fauna Baseline Survey	West Angelas – Deposit B Ghost Bat Assessment	Rio Tinto Iron Ore Greater West Angelas Terrestrial Fauna Assessment	Western Hill Native Vegetation Clearing Permit Report	2017 West Angelas Ghost Bat Monitoring	West Angelas 2 (AR-14-12516) Biological Assessment Native Vegetation Clearing Permit Supporting Report	South Flank Target Fauna Survey	Targeted Conservation Significant Fauna Survey – Karlijini tenement E47/117	West Angelas Iron Ore Mine – Deposit B and F Ghost Bat Assessment: December 2014
Consultant	Integrated Environmental Services	Ecologia	Ecologia	Ecologia	Ecologia	Biota	Biota	Biota	Biologic	ENV	Biologic	Ecologia	Biota	Biologic	Ecological	Biologic	Biologic	Biologic
Year	1979	1998	1998	2000	2001	2002	2004	2005	2011	2011	2013	2014	2014	2018	2014	2016	2013	2015
Survey Limitations	Not specified	Timing in winter meant fewer reptile species were active and few bat species encountered	Determining age of scats is difficult and based on apparent freshness	Determining age of scats is difficult and based on apparent freshness. Adit could not be accessed due to presence of a locked gate	Determining age of scats is difficult and based on apparent freshness. Adit could not be accessed due to presence of a locked gate.	Determining age of scats is difficult and based on apparent freshness. Adit could not be accessed due to presence of a locked gate.	Determining age of scats is difficult and based on apparent freshness. Recommended to conduct monitoring in August to correspond with periods when pregnant females may be overwintering	Single phase survey only. Museum vouchers were not provided for all vertebrate species collected. Some bat species may not have been recorded if they were not readily detectable by the Anabat system or do not frequent watercourses and caves.	Prevailing dry conditions may have reduced capture rates, but diversity was high. Some amphibians emerged following rain during both phases of the survey. Nocturnal work was limited due to safety consideration; reduced the ability for opportunistic detection of nocturnally active animals.	The cooler temperatures experienced during winter when the survey was conducted effect reptile activity.	Experience of the survey team was adequate. Intensity was adequate in that all caves potentially supporting Ghost Bats and likely to be impacted by the Deposit B development were assessed. The survey was conducted during the appropriate season to record breeding.	Not specified	Some areas of very steep slopes and sheer drops at the eastern end of the Study Area could not be traversed for safety reasons.	The lack of survey in 2016 may have reduced the success rate of genotyping in the 2017 samples, although to a much lesser extent as indicated by the overall high rate of genotyping for these samples.	No systematic trapping for vertebrate fauna was conducted. However, survey was consistent with expectations for a Level 1 survey. One small portion in the eastern section was inaccessible due to safety concerns. There was evidence of recent fires across the western half of the Study Area.	Extensive fires occurred across the region between October and December, with approximately one third of the Assessment Area burnt while the camera traps were in place.	No nocturnal work was undertaken; reduced the ability for detection of nocturnally active species. No trapping was undertaken. Unfavourable weather conditions - large portion of the interest areas were not surveyed by helicopter and only 3.5 days of surveying were undertaken	Assessing the type of use and importance of caves to Ghost Bats is difficult, even for experienced zoologists - bats are shy and cryptic, and generally roost in inaccessible areas of the cave. Additional survey techniques could be used to improve the outcomes of the monitoring.

## **Appendix C: Vertebrate fauna habitat assessments**

Site ID	Latitude	Longitude	Date	Habitat Type	Landform	Aspect	Slope	Soil Type	Outcropping	Outcropping Type	Vegetation Litter	Dominant Vegetation Type	Rocky Cracks/ Crvices	Suitability for Burrowing	Hollows <10cm	Hollows >10cm	Water Presence	Habitat Condition	Time Since Last Fire	Disturbances	Notes
Phase 1																					
VRT-WA01	-23.1386	118.5920	11/10/18	Spinifex Stony Plain	Stony Plain	Flat	Flat	Clay Loam	Negligible		Many Small Patches	Acacia Shrubland, Mulga Woodland, Spinifex Hummock Grassland	Nil	Low	None	None	None	1	Old (6+ yr.)	Old tracks	
VRT-WA02	-23.1363	118.6220	11/10/18	Drainage Area/ Floodplain	Drainage Area/ Floodplain	Flat	Flat	Silty Clay Loam	Negligible		Many Small Patches	Acacia Shrubland, Scattered Eucalypts, Spinifex Hummock Grassland	Nil	Moderate	None	None	Prone to Flooding	1	Old (6+ yr.)	None Discernible	
VRT-WA03	-23.1159	118.6450	12/10/18	Spinifex Stony Plain	Footslope	Flat	Low	Clay Loam	Negligible		Few Small Patches	Acacia Shrubland, Spinifex Hummock Grassland	Nil	Nil	None	None	None	0.8	Moderate (3 to 5 yr.)	Mining Exploration	
VRT-WA04	-23.1180	118.6261	12/10/18	Gorge/ Gully	Gully	South	Moderate	Clay Loam	Major Outcropping	BIF	Many Small Patches	Scattered Eucalypts, Spinifex Hummock Grassland	High	Moderate	Scarce	Scarce	Scarce	0.8	Moderate (3 to 5 yr.)	Frequent Fire, Weed Invasion	
VRT-WA05	-23.2201	118.7714	13/10/18	Gorge/ Gully	Gully	East	Moderate	Silty Loam	Moderate Outcropping	BIF	Few Small Patches	Acacia Shrubland, Scattered Eucalypts, Spinifex Hummock Grassland, Tussock Grassland	Low	Nil	None	None	None	0.6	Moderate (3 to 5 yr.)	None Discernible	
VRT-WA06	-23.2381	118.7611	13/10/18	Medium Drainage Line	Medium Drainage Line	Flat	Flat	Sandy Clay Loam	Negligible		Many Small Patches	Acacia Shrubland, Scattered Eucalypts, Spinifex Hummock Grassland, Tussock Grassland	Nil	Low	Scarce	Scarce	None	0.8	Moderate (3 to 5 yr.)	None Discernible	
VRT-WA07	-23.2306	118.7147	14/10/18	Hillcrest/ Hillslope	Hillslope	East	Moderate	Silty Loam	Moderate Outcropping	BIF	Many Small Patches	Scattered Eucalypts, Spinifex Hummock Grassland	Moderate	Nil	None	None	None	1	Old (6+ yr.)	Mining Exploration, Road/ Access Track	
VRT-WA08	-23.2367	118.7256	14/10/18	Stony Plain	Stony Plain	Flat	Flat	Silty Clay Loam	Negligible		Few Small Patches	Acacia Shrubland, Spinifex Hummock Grassland	Nil	Nil	None	None	None	1	Old (6+ yr.)	None Discernible	
VRT-WA09	-23.1786	118.8696	15/10/18	Stony Plain	Stony Plain	Flat	Flat	Silty Clay Loam	Negligible		Many Large Patches	Mulga Woodland, Spinifex Hummock Grassland, Tussock Grassland	Nil	Nil	None	None	None	0.8	Old (6+ yr.)	Mining Exploration, Road/ Access Track	
VRT-WA10	-23.1736	118.8511	15/10/18	Gorge/ Gully	Gully	Flat	Flat	Silty Loam	Minor Outcropping	BIF	Many Large Patches	Acacia Shrubland, Mulga Woodland, Scattered Eucalypts, Tussock Grassland	Low	High	None	None	None	1	Old (6+ yr.)	None Discernible	
VRT-WA11	-23.1206	118.6033	12/10/18	Gorge/ Gully	Gully	South	Steep	Silty Clay Loam	Major Outcropping	BIF	Few Small Patches	Acacia Shrubland, Scattered Eucalypts, Spinifex Hummock Grassland	High	Nil	None	None	Prone to Pooling	0.8	Old (6+ yr.)	Mining Exploration, Road/ Access Track	
VRT-WA12	-23.1166	118.6264	12/10/18	Breakaway/ Cliff	Footslope	South	Steep	Silty Clay Loam	Major Outcropping	BIF	Many Small Patches	Mulga Woodland, Spinifex Hummock Grassland	Very High	Low	None	None	None	0.8	Old (6+ yr.)	Mining Exploration	
VRT-WA13	-23.2202	118.7663	13/10/18	Gorge/ Gully	Gully	North	Steep	Silty Loam	Major Outcropping	BIF	Few Small Patches	Spinifex Hummock Grassland	High	Nil	None	None	None	0.8	Moderate (3 to 5 yr.)	Mining Exploration	
VRT-WA14	-23.2114	118.8032	16/10/18	Breakaway/ Cliff	Cliff	North/ West	Very Steep	Silty Loam	Extensive Outcropping	BIF	Few Small Patches	Spinifex Hummock Grassland, Tussock Grassland	High	Nil	None	None	None	0.8	Old (6+ yr.)	None Discernible	
VRT-WA15	-23.2069	118.8018	16/10/18	Spinifex Stony Plain	Footslope	North/ East	Flat	Clay Loam	Negligible		Few Small Patches	Scattered Eucalypts (Eucalypts mallee form), Spinifex Hummock Grassland	Nil	Nil	None	None	None	0.6	Old (6+ yr.)	Mining Exploration, Road/ Access Track	
VRT-WA16	-23.1196	118.8689	17/10/18	Waterhole	Gorge	North	Cliff	Silty Loam	Extensive Outcropping	BIF	Many Large Patches	Acacia Shrubland, Scattered Eucalypts	Very High	Nil	None	None	Ephemeral rock pool	1	Old (6+ yr.)	None Discernible	
VRT-WA17	-23.1344	118.8551	17/10/18	Boulders/ Rockpiles	Boulders/ Rockpiles	South	Steep	Silty Loam	Extensive Outcropping	BIF	Few Small Patches	Scattered Eucalypts, Spinifex Hummock Grassland, Tussock Grassland	Very High	Nil	None	None	None	0.8	Old (6+ yr.)	None Discernible	
VRT-WA18	-23.1329	118.5834	18/10/18	Stony Plain	Stony Plain	Flat	Flat	Clay Loam	Negligible		Many Small Patches	Acacia Shrubland, Mulga Woodland, Spinifex Hummock Grassland	Nil	Moderate	None	None	None	0.8	Old (6+ yr.)	None Discernible	
VRT-WA19	-23.2163	118.7489	19/10/18	Gorge/ Gully	Gully	East	Very Steep	Silty Loam	Major Outcropping	BIF	Few Large Patches	Scattered Eucalypts, Callitris pines	High	Low	Scarce	None	Prone to Pooling	1	Old (6+ yr.)	None Discernible	
VRT-WA20	-23.1753	118.8269	18/10/18	Gorge/ Gully	Gully	South	Steep	Sandy Loam	Moderate Outcropping	BIF	Few Small Patches	Acacia Shrubland, Eucalypt Woodland, Spinifex Hummock Grassland, Tussock Grassland	Moderate	Nil	None	None	None	0.8	Old (6+ yr.)	None Discernible	
VRT-WA21	-23.1107	118.5877	18/10/18	Stony Plain	Sand Plain	Flat	Low	Clay Loam	Negligible		Many Small Patches	Acacia Shrubland, Mulga Woodland, Spinifex Hummock Grassland	Nil	Moderate	None	None	None	0.8	Recent (0 to 2 yr.)	None Discernible	Fire 0-2 nearby
VRT-WA22	-23.1172	118.6252	18/10/18	Gorge/ Gully	Gully	South	Moderate	Clay Loam	Major Outcropping	BIF	Many Small Patches	Scattered Eucalypts, Spinifex Hummock Grassland	High	Moderate	Scarce	Scarce	Scarce	0.8	Moderate (3 to 5 yr.)	Frequent Fire, Weed Invasion	
VRT-WA23	-23.2102	118.7565	19/10/18	Minor Drainage Line	Gully	East	Moderate	Silty Loam	Moderate Outcropping	BIF	Few Small Patches	Acacia Shrubland, Scattered Eucalypts, Spinifex Hummock Grassland, Tussock Grassland	Low	Nil	Scarce	None	Prone to Flooding	0.6	Moderate (3 to 5 yr.)	Road/ Access Track	
VRT-WA24	-23.2158	118.8205	18/10/18	Gorge/ Gully	Gully	North	Steep	Silty Clay Loam	Extensive Outcropping	BIF	Many Large Patches	Scattered Eucalypts, Spinifex Hummock Grassland, Tussock Grassland	Very High	Nil	None	None	Ephemeral rock pool	1	Old (6+ yr.)	None Discernible	
VRT-WA25	-23.1200	118.5947	19/10/18	Hillcrest/ Hillslope	Gully	South/ East	Moderate	Clay Loam	Major Outcropping	BIF	Few Small Patches	Scattered Eucalypts, Spinifex Hummock Grassland	High	Nil	Scarce	Scarce	None	0.8	Old (6+ yr.)	Mining Exploration, Road/ Access Track	
VRT-WA26	-23.2031	118.7569	18/10/18	Stony Plain	Stony Plain	Flat	Flat	Silty Loam	Negligible		Few Small Patches	Acacia Shrubland, Spinifex Hummock Grassland	Nil	Nil	None	None	None	0.8	Moderate (3 to 5 yr.)	None Discernible	
VRT-WA27	-23.1751	118.8609	20/10/18	Minor Drainage Line	Minor Drainage Line	Flat	Flat	Clay Loam Sandy	Negligible		Few Small Patches	Acacia Shrubland, Scattered Eucalypts, Spinifex Hummock Grassland, Tussock Grassland	Low	Low	Scarce	None	Prone to Pooling	0.6	Moderate (3 to 5 yr.)	Mining Exploration	
VRT-WA28	-23.2305	118.7227	19/10/18	Gorge/ Gully	Gully	North/ West	Moderate	Silty Loam	Major Outcropping	BIF	Few Small Patches	Acacia Shrubland, Scattered Eucalypts, Spinifex Hummock Grassland, Tussock Grassland	High	Low	None	None	None	0.6	Moderate (3 to 5 yr.)	Mining Exploration, Road/ Access Track	
VRT-WA29	-23.1347	118.5841	21/10/18	Stony Plain	Stony Plain	Flat	Flat	Clay Loam	Negligible		Scarce	Spinifex Hummock Grassland, Open Mulga	Nil	Moderate	None	None	None	0.8	Old (6+ yr.)	Road/ Access Track	
VRT-WA30	-23.1232	118.8759	20/10/18	Spinifex Stony Plain	Hillslope	South	Low	Silty Loam	Moderate Outcropping	BIF	Few Small Patches	Eucalypt Woodland, Spinifex Hummock Grassland	Moderate	Low	Moderate	None	None	0.8	Old (6+ yr.)	Mining Exploration, Road/ Access Track	
VRT-WA31	-23.1754	118.8606	20/10/18	Hardpan Plain	Stony Plain	Flat	Flat	Clay Loam	Negligible		Few Small Patches	Scattered Eucalypts, Spinifex Hummock Grassland	Nil	Low	Moderate	Scarce	None	0.8	Recent (0 to 2 yr.)	Frequent Fire	
VRT-WA32	-23.1743	118.8389	20/10/18	Gorge/ Gully	Gorge	North/ East	Moderate	Clay Loam	Major Outcropping	BIF	Many Small Patches	Scattered Eucalypts, Tussock Grassland	High	Nil	Scarce	None	Prone to Pooling	0.8	Moderate (3 to 5 yr.)	None Discernible	Better drainage down stream
VRT-WA33	-23.1168	118.5854	12/10/18	Gorge/ Gully	Ironstone Outcrops	North/ East	Steep	Silty Loam	Major Outcropping	BIF	Scarce	Spinifex Hummock Grassland	High	Nil	None	None	None	0.8	Moderate (3 to 5 yr.)	Mining Exploration	
VRT-WA34	-23.1162	118.6312	21/10/18	Mulga Woodland	Hillslope	South/ East	Steep	Clay Loam	Moderate Outcropping	BIF	Many Small Patches	Mulga Woodland, Eremophila	Moderate	Nil	None	None	None	0.8	Old (6+ yr.)	None Discernible	
VRT-WA35	-23.1082	118.6581	12/10/18	Gorge/ Gully	Gully	East	Moderate	Silty Loam	Extensive Outcropping	BIF	Scarce	Spinifex Hummock Grassland	High	Nil	None	None	None	0.8	Moderate (3 to 5 yr.)	Road/ Access Track	
VRT-WA36	-23.1214	118.6632	21/10/18	Hillcrest/ Hillslope	Hillcrest/ Upper Hillslope	North/ West	Moderate	Silty Loam	Major Outcropping	Conglomerate	Scarce	Scattered Eucalypts, Spinifex Hummock Grassland	Low	Low	Scarce	None	Prone to Flooding	0.8	Old (6+ yr.)	Road/ Access Track	Minor drainage line at base of hill
VRT-WA37	-23.1209	118.6632	21/10/18	Minor Drainage Line	Minor Drainage Line	South/ West	Low	Clay Loam	Minor Outcropping	BIF	Few Small Patches	Scattered Eucalypts, Spinifex Hummock Grassland	Low	Low	Scarce	Scarce	Prone to Pooling	0.8	Old (6+ yr.)	None Discernible	
VRT-WA38	-23.1806	118.8769	20/10/18	Hillcrest/ Hillslope	Hillcrest/ Upper Hillslope	South	Moderate	Clay Loam	Limited Outcropping	None Discernible	Few Small Patches	Acacia Shrubland, Eucalypt Woodland, Spinifex Hummock Grassland	Nil	Low	Moderate	Scarce	None	0.8	Recent (0 to 2 yr.)	None Discernible	
VRT-WA39	-23.1742	118.8377	21/10/18	Medium Drainage Line	Stony Plain	Flat	Flat	Clayey Sand	Negligible		Scarce	Acacia Shrubland, Eucalypt Woodland, Spinifex Hummock Grassland, Tussock Grassland	Low	Low	Scarce	None	Prone to Pooling	0.6	Moderate (3 to 5 yr.)	Mining Exploration	
VRT-WA40	-23.1870	118.8793	18/10/18	Minor Drainage Line	Footslope	Flat	Low	Silty Loam	Negligible		Many Small Patches	Acacia Shrubland, Mulga Woodland, Scattered Eucalypts, Spinifex Hummock Grassland, Tussock Grassland	Nil	Low	None	None	None	0.6	Old (6+ yr.)	Mining Exploration, Road/ Access Track	

Site ID	Latitude	Longitude	Date	Habitat Type	Landform	Aspect	Slope	Soil Type	Outcropping	Outcropping Type	Vegetation Litter	Dominant Vegetation Type	Rocky Cracks/ Crevices	Suitability for Burrowing	Hollows <10cm	Hollows >10cm	Water Presence	Habitat Condition	Time Since Last Fire	Disturbances	Notes
VRT-WA41	-23.1256	118.6668	18/10/18	Minor Drainage Line	Minor Drainage Line	South/ West	Low	Clay Loam	Negligible		Many Small Patches	Eucalypt Woodland, Spinifex Hummock Grassland	Nil	Low	Scarce	Scarce	Prone to Pooling	0.6	Recent (0 to 2 yr.)	Road/ Access Track	
VRT-WA42	-23.1178	118.6242	19/10/18	Gorge/ Gully	Gorge	West	Moderate	Clay Loam	Major Outcropping	BIF	Many Large Patches	Eucalypt Woodland, Mulga Woodland, Tussock Grassland	High	Low	Scarce	Scarce	Prone to Pooling	1	Old (6+ yr.)	None Discernible	Multiple bat caves
VRT-WA43	-23.1099	118.5949	20/10/18	Stony Plain	Stony Plain	North	Low	Silty Loam	Negligible		Few Small Patches	Acacia Shrubland, Mulga Woodland, Spinifex Hummock Grassland	Nil	Low	None	None	None	0.8	Old (6+ yr.)	None Discernible	
VRT-WA44	-23.1141	118.6107	20/10/18	Hillcrest/ Hillslope	Hillslope	West	Moderate	Silty Loam	Moderate Outcropping	BIF	Few Small Patches	Scattered Eucalypts, Spinifex Hummock Grassland	Moderate	Nil	None	None	None	0.6	Moderate (3 to 5 yr.)	Mining Exploration, Road/ Access Track	
VRT-WA45	-23.1870	118.8794	20/10/18	Minor Drainage Line	Minor Drainage Line	South/ East	Low	Clay Loam	Negligible		Many Small Patches	Acacia Shrubland, Eucalypt Woodland, Mulga Woodland, Spinifex Hummock Grassland	Nil	Moderate	Scarce	Scarce	Prone to Pooling	0.6	Old (6+ yr.)	Mining Exploration, Road/ Access Track	
VRT-WA46	-23.1791	118.8630	21/10/18	Stony Plain	Drainage Area/ Floodplain	Flat	Flat	Loamy Sand	Negligible		Many Small Patches	Acacia Shrubland, Eucalypt Woodland, Spinifex Hummock Grassland	Nil	Low	Scarce	Scarce	Prone to Flooding	0.6	Old (6+ yr.)	Mining Exploration	
VRT-WA47	-23.2269	118.7468	16/10/18	Gorge/ Gully	Gully	North	Moderate	Silty Loam	Moderate Outcropping	BIF	Many Small Patches	Eucalypt Woodland	Moderate	Low	Scarce	Scarce	Prone to Pooling	0.8	Moderate (3 to 5 yr.)	Frequent Fire	
VRT-WA62	-23.1178	118.6242	29/10/18	Gorge/ Gully	Gorge	West	Moderate	Clay Loam	Major Outcropping	BIF	Many Large Patches	Eucalypt Woodland, Mulga Woodland, Tussock Grassland	High	Low	Scarce	Scarce	Prone to Pooling	1	Old (6+ yr.)	None Discernible	Multiple bat caves
VRT-WA63	-23.2155	118.8204	21/10/18									Acacia Shrubland, Mulga Woodland, Spinifex Hummock Grassland									
VRT-WA64	-23.1212	118.8622	21/10/18									Acacia Shrubland, Scattered Eucalypts, Spinifex Hummock Grassland									
Phase 2																					
VRT-WA01	-23.1386	118.5920	13/03/19	Spinifex Stony Plain	Stony Plain	Flat	Flat	Clay Loam	Negligible		Many Small Patches	Acacia Shrubland, Mulga Woodland, Spinifex Hummock Grassland	Nil	Low	None	None	None	1	Old (6+ yr.)	Old tracks	
VRT-WA02	-23.1363	118.6220	13/03/19	Drainage Area/ Floodplain	Drainage Area/ Floodplain	Flat	Flat	Silty Clay Loam	Negligible		Many Small Patches	Acacia Shrubland, Scattered Eucalypts, Spinifex Hummock Grassland	Nil	Moderate	None	None	Prone to Flooding	1	Old (6+ yr.)	None Discernible	
VRT-WA03	-23.1159	118.6450	13/03/19	Spinifex Stony Plain	Footslope	Flat	Low	Clay Loam	Negligible		Few Small Patches	Acacia Shrubland, Spinifex Hummock Grassland	Nil	Nil	None	None	None	0.8	Moderate (3 to 5 yr.)	Mining Exploration	
VRT-WA04	-23.1180	118.6261	13/03/19	Gorge/ Gully	Gully	South	Moderate	Clay Loam	Major Outcropping	BIF	Many Small Patches	Scattered Eucalypts, Spinifex Hummock Grassland	High	Moderate	Scarce	Scarce	Scarce	0.8	Moderate (3 to 5 yr.)	Frequent Fire, Weed Invasion	
VRT-WA05	-23.2201	118.7714	14/03/19	Gorge/ Gully	Gully	East	Moderate	Silty Loam	Moderate Outcropping	BIF	Few Small Patches	Acacia Shrubland, Scattered Eucalypts, Spinifex Hummock Grassland, Tussock Grassland	Low	Nil	None	None	None	0.6	Moderate (3 to 5 yr.)	None Discernible	
VWAF-01	-23.1838	118.8747	17/03/19	Drainage Area/ Floodplain	Drainage Area/ Floodplain	Flat	Flat	Clay Loam	Negligible		Few Small Patches	Scattered Eucalypts, Spinifex Hummock Grassland	Nil	Nil	Scarce	None	Prone to Flooding	0.6	Old (6+ yr.)	Mining Exploration, Road/ Access Track	
VWAF-02	-23.1771	118.8592	17/03/19	Minor Drainage Line	Minor Drainage Line	South/ West	Flat	Clay Loam	Negligible		Many Small Patches	Acacia Shrubland, Scattered Eucalypts, Spinifex Hummock Grassland	Nil	Low	Scarce	None	Prone to Flooding	0.6	Moderate (3 to 5 yr.)	Mining Exploration, Road/ Access Track	
VWAF-03	-23.1767	118.8573	18/03/19	Minor Drainage Line	Minor Drainage Line	South/ West	Low	Clay Loam	Negligible		Few Small Patches	Scattered Eucalypts, Spinifex Hummock Grassland, Tussock Grassland	Nil	Nil	None	None	Prone to Flooding	0.8	Recent (0 to 2 yr.)	Mining Exploration, Road/ Access Track	
VWAF-04	-23.1764	118.8454	18/03/19	Stony Plain	Undulating Low Hills	Flat	Low	Clay Loam	Negligible		Scarce	Scattered Eucalypts, Spinifex Hummock Grassland	Nil	Nil	None	None	None	0.6	Recent (0 to 2 yr.)	Mining Exploration, Road/ Access Track	
VWAF-05	-23.1769	118.8329	18/03/19	Stony Plain	Undulating Low Hills	Flat	Low	Clay Loam	Negligible		Scarce	Scattered Eucalypts, Spinifex Hummock Grassland	Nil	Low	Scarce	Scarce	None	0.6	Recent (0 to 2 yr.)	Road/ Access Track	
VWAF-07	-23.1729	118.8398	18/03/19	Gorge/ Gully	Gorge	South/ West	Moderate	Clay Loam	Extensive Outcropping	BIF	Few Large Patches	Scattered Eucalypts, Tussock Grassland	High	Nil	Scarce	None	Prone to Pooling	1	Old (6+ yr.)	None Discernible	
VWAF-10	-23.1736	118.8511	18/03/19	Gorge/ Gully	Gully	Flat	Flat	Silty Loam	Minor Outcropping	BIF	Many Large Patches	Acacia Shrubland, Mulga Woodland, Scattered Eucalypts, Tussock Grassland	Low	High	None	None	None	1	Old (6+ yr.)	None Discernible	
VWAF-67	-23.1750	118.8360	17/03/19	Hillcrest/ Hillslope	Hillcrest/ Upper Hillslope	Flat	Flat	Silty Loam	Limited Outcropping	BIF	Scarce	Scattered Eucalypts, Spinifex Hummock Grassland	Nil	Nil	Scarce	None	None	0.6	Recent (0 to 2 yr.)	Mining Exploration	
VWAH-11a	-23.1239	118.8924	13/03/19	Gorge/ Gully	Gully	South/ West	Low	Clay Loam	Major Outcropping	BIF	Many Small Patches	Acacia Shrubland, Scattered Eucalypts, Tussock Grassland	High	Nil	Scarce	Moderate	Prone to Flooding	0.8	Moderate (3 to 5 yr.)	Mining Exploration	
VWAH-11b	-23.1233	118.8921	20/03/19	Gorge/ Gully	Gully	North	Low	Clay Loam	Major Outcropping	BIF	Many Small Patches	Acacia Shrubland, Scattered Eucalypts, Tussock Grassland	High	Nil	Scarce	Moderate	Prone to Flooding	0.8	Moderate (3 to 5 yr.)	Mining Exploration	
VWAH-12	-23.1357	118.8548	13/03/19	Spinifex Stony Plain	Stony Plain	Flat	Flat	Clay Loam	Negligible		Few Small Patches	Acacia Shrubland, Spinifex Hummock Grassland, Tussock Grassland	Nil	Moderate	Scarce	None	Prone to Flooding	0.6	Old (6+ yr.)	Road/ Access Track	Large spinifex hummocks, 10-20 unburned
VWAH-13	-23.1276	118.9122	20/03/19	Hillcrest/ Hillslope	Hillcrest/ Upper Hillslope	Flat	Moderate	Clay Loam	Negligible		Scarce	Scattered Eucalypts, Spinifex Hummock Grassland	Nil	Nil	None	Scarce	None	0.6	Recent (0 to 2 yr.)	Mining Exploration, Road/ Access Track	
VWAH-14	-23.1254	118.9180	20/03/19	Gorge/ Gully	Gorge	South	Moderate	Silty Loam	Extensive Outcropping	BIF	Few Large Patches	Acacia Shrubland, Scattered Eucalypts, Tussock Grassland	High	Nil	Scarce	None	None	1	Old (6+ yr.)	None Discernible	
VWAH-63	-23.1294	118.8351	16/03/19	Gorge/ Gully	Gully	South	Steep	Silty Loam	Major Outcropping	BIF	Many Small Patches	Acacia Shrubland, Tussock Grassland	Very High	Nil	Scarce	None	None	0.6	Old (6+ yr.)	None Discernible	
VWAH-66	-23.1192	118.8828	18/03/19	Hillcrest/ Hillslope	Hillcrest/ Upper Hillslope	North	Moderate	Silty Loam	Major Outcropping	BIF	Scarce	Spinifex Hummock Grassland	High	Nil	None	None	None	0.6	Recent (0 to 2 yr.)	Mining Exploration	
VWAH-67	-23.1293	118.8945	17/03/19	Breakaway/ Cliff	Breakaway	South	Moderate	Silty Loam	Major Outcropping	BIF	Many Small Patches	Mulga Woodland, Scattered Eucalypts	High	Nil	Scarce	None	None	0.6	Old (6+ yr.)	None Discernible	
VWAH-77	-23.1252	118.8734	18/03/19	Gorge/ Gully	Hillslope	North	Moderate	Clay Loam	Major Outcropping	BIF	Few Large Patches	Mulga Woodland, Scattered Eucalypts, Tussock Grassland	Moderate	Moderate	Scarce	None	None	0.8	Old (6+ yr.)	Mining Exploration	
VWAH-78	-23.1322	118.8605	18/03/19	Boulders/ Rockpiles	Boulders/ Rockpiles	North	Steep	Silty Loam	Extensive Outcropping	BIF	Few Small Patches	Scattered Eucalypts, Tussock Grassland, Spinifex Hummock Grassland	High	Low	None	None	None	0.6	Moderate (3 to 5 yr.)	None Discernible	
VWAH-92	-23.1058	118.9006	20/03/19	Drainage Area/ Floodplain	Drainage Area/ Floodplain	North	Flat	Loamy Sand	Limited Outcropping	None Discernible	Few Large Patches	Scattered Eucalypts, Tussock Grassland	Nil	Moderate	Common	Very Common	Prone to Flooding	0.8	Recent (0 to 2 yr.)	None Discernible	
VWAJ-06	-23.2425	118.7554	14/03/19	Medium Drainage Line	Medium Drainage Line	Flat	Flat	Sandy Clay Loam	Negligible		Many Small Patches	Acacia Shrubland, Scattered Eucalypts, Spinifex Hummock Grassland, Tussock Grassland	Nil	Low	Scarce	Scarce	None	0.8	Moderate (3 to 5 yr.)	None Discernible	
VWAJ-62	-23.2113	118.7921	15/03/19	Hillcrest/ Hillslope	Hillcrest/ Upper Hillslope	North	Moderate	Silty Loam	Moderate Outcropping	BIF	Scarce	Spinifex Hummock Grassland	Moderate	Nil	None	None	None	0.6	Moderate (3 to 5 yr.)	Road/ Access Track, Mining Exploration	
VWAJ-70	-23.2362	118.7380	16/03/19	Breakaway/ Cliff	Footslope	South	Moderate	Clay Loam	Major Outcropping	BIF	Few Large Patches	Scattered Eucalypts, Tussock Grassland	Moderate	Low	Scarce	None	None	0.6	Moderate (3 to 5 yr.)	None Discernible	
VWAJ-71	-23.2286	118.7712	16/03/19	Minor Drainage Line	Minor Drainage Line	West	Low	Clay Loam	Limited Outcropping	BIF	Few Large Patches	Scattered Eucalypts, Spinifex Hummock Grassland, Tussock Grassland	Nil	Low	Scarce	None	None	0.8	Old (6+ yr.)	None Discernible	

Site ID	Latitude	Longitude	Date	Habitat Type	Landform	Aspect	Slope	Soil Type	Outcropping	Outcropping Type	Vegetation Litter	Dominant Vegetation Type	Rocky Cracks/ Crevices	Suitability for Burrowing	Hollows <10cm	Hollows >10cm	Water Presence	Habitat Condition	Time Since Last Fire	Disturbances	Notes
VWAJ-72	-23.2110	118.8328	16/03/19	Ironstone Outcrops	Undulating Low Hills	North	Low	Clay Loam	Moderate Outcropping	BIF	Scarce	Spinifex Hummock Grassland, Tussock Grassland	Moderate	Nil	Scarce	None	None	0.8	Moderate (3 to 5 yr.)	Road/ Access Track	
VWAJ-73	-23.2111	118.8071	16/03/19	Gorge/ Gully	Hillslope	North	Steep	Clay Loam	Extensive Outcropping	BIF	Many Large Patches	Scattered Eucalypts, Spinifex Hummock Grassland, Tussock Grassland	High	Low	Scarce	None	None	0.8	Old (6+ yr.)	None Discernible	
VWAJ-75a	-23.2093	118.7815	16/03/19	Ironstone Outcrops	Footslope	South/ East	Moderate	Clay Loam	Moderate Outcropping	BIF	Scarce	Scattered Eucalypts, Spinifex Hummock Grassland, Tussock Grassland	Moderate	Nil	Scarce	Scarce	None	1	Old (6+ yr.)	None Discernible	
VWAJ-75b	-23.2094	118.7812	16/03/19	Ironstone Outcrops	Footslope	South/ East	Moderate	Clay Loam	Moderate Outcropping	BIF	Scarce	Scattered Eucalypts, Spinifex Hummock Grassland, Tussock Grassland	Moderate	Nil	Scarce	Scarce	None	1	Old (6+ yr.)	None Discernible	
VWAJ-75c	-23.2268	118.7389	17/03/19	Breakaway/ Cliff	Footslope	North/ West	Moderate	Clay Loam	Minor Outcropping	BIF	Few Small Patches	Scattered Eucalypts, Tussock Grassland	Moderate	Low	Scarce	None	None	0.6	Moderate (3 to 5 yr.)	Road/ Access Track	
VWAJ-76	-23.2236	118.7185	17/03/19	Stony Plain	Undulating Low Hills	Flat	Low	Clay Loam	Negligible		Few Small Patches	Eucalypt Woodland, Spinifex Hummock Grassland	Nil	Nil	None	None	None	1	Moderate (3 to 5 yr.)	None Discernible	
VWAJ-77	-23.2291	118.7465	18/03/19	Hillcrest/ Hillslope	Hillcrest/ Upper Hillslope	North	Steep	Clay Loam	Major Outcropping	BIF	Few Large Patches	Spinifex Hummock Grassland, Tussock Grassland	Moderate	Nil	Scarce	None	None	0.6	Old (6+ yr.)	Road/ Access Track	
VWAW-68	-23.1142	118.6569	17/03/19	Hillcrest/ Hillslope	Hillslope	West	Moderate	Silty Loam	Moderate Outcropping	BIF	Few Small Patches	Eucalypt Woodland	Moderate	Low	Scarce	Moderate	None	0.6	Moderate (3 to 5 yr.)	None Discernible	
VWAW-81	-23.1100	118.6530	19/03/19	Hillcrest/ Hillslope	Hillslope	East	Moderate	Silty Loam	Moderate Outcropping	BIF	Scarce	Spinifex Hummock Grassland, Acacia Shrubland	Moderate	Nil	None	None	None	0.6	Moderate (3 to 5 yr.)	Road/ Access Track	
VWAW-83	-23.1072	118.6450	19/03/19	Gorge/ Gully	Gully	West	Moderate	Silty Loam	Moderate Outcropping	BIF	Scarce	Spinifex Hummock Grassland, Scattered Eucalypts	Moderate	Nil	None	None	None	0.6	Moderate (3 to 5 yr.)	Mining Exploration	
VWAW-85	-23.1075	118.6386	19/03/19	Stony Plain	Stony Plain	Flat	Flat	Silty Clay Loam	Minor Outcropping	None Discernible	Few Large Patches	Spinifex Hummock Grassland, Acacia Shrubland, Mulga Woodland	Nil	Low	None	None	None	0.8	Old (6+ yr.)	None Discernible	
VWAW-87	-23.1092	118.6200	19/03/19	Gorge/ Gully	Gully	North	Moderate	Silty Loam	Major Outcropping	None Discernible	Scarce	Spinifex Hummock Grassland, Scattered Eucalypts	Moderate	Nil	None	None	None	0.6	Moderate (3 to 5 yr.)	None Discernible	
VWAW-89	-23.1169	118.5955	19/03/19	Ironstone Outcrops	Ironstone Outcrops	North/ West	Moderate	Silty Loam	Major Outcropping	None Discernible	Scarce	Spinifex Hummock Grassland	High	Nil	None	None	None	0.6	Moderate (3 to 5 yr.)	Mining Exploration	

## **Appendix D: SRE invertebrate fauna habitat assessments**

Site	Latitude	Longitude	Date	Habitat Type	Drainage	Landform	Slope	Aspect	Outcropping Extent	Outcropping Type	Rock Size	Vegetation Type	Leaf Litter	Shade	Soil Type	Soil Availability	Burrows	Fire Age	Condition	Disturbances	SRE Suitability	Comments
Phase 1																						
SRE-WA01	-23.2095	118.7530	16/10/2018	Gorge/ Gully	Gully	Gully	Steep	East	Moderate Outcropping	Other	Large Rocks (21-60cm)		Many Small Patches	Low to Med 20- 40%	Silty Loam	Many Small Patches	Other	Old (6+ yr.)	0.8	None Discernible	Moderate/High	Mix of rocks 20- 60 and boulders
SRE-WA02	-23.2239	118.7526	16/10/2018	Medium Drainage Line	Creek	Medium Drainage Line	Low	North/ East	Minor Outcropping	BIF	Pebbles (5- 10cm)	Other Acacia Open Shrubland, Open Eucalyptus/ Corymbia, Triodia Grassland	Few Small Patches	Low to Med 20- 40%	Sandy Clay Loam	Scarce	None	Old (6+ yr.)	0.6	None Discernible	Moderate/Low	
SRE-WA03a	-23.6673	118.7256	16/10/2018	Stony Plain	Creek	Stony Plain	Flat	Flat	Negligible	None Discernible	Gravel (1- 4cm)	Other Acacia Open Shrubland, Triodia Grassland	Few Small Patches	Low 5- 20%	Sandy Clay Loam	Scarce	Mygalomorph Spider	Old (6+ yr.)	1	None Discernible	Moderate	
SRE-WA05	-23.2312	118.7533	16/10/2018	Breakaway/ Cliff	Negligible	Cliff	Very Steep	South	Major Outcropping	BIF	Small Rocks (11-20cm)	Other Shrub, Other Tree, Triodia Grassland, Soft/ Tussock Grassland	Many Small Patches	Med to High 60- 80%	Silty Loam	Many Small Patches	None	Moderate (3 to 5 yr.)	0.8	None Discernible	Moderate	
SRE-WA06	-23.2267	118.7473	16/10/2018	Ironstone Outcrops	Gully	Ironstone Outcrops	Moderate	North	Major Outcropping	BIF	Boulders (>61cm)	Open Mulga Shrubland, Other Acacia Open Shrubland, Open Eucalyptus/ Corymbia, Triodia Grassland	Few Small Patches	Low 5- 20%	Sandy Clay Loam	Scarce	None	Old (6+ yr.)	0.6	None Discernible	Moderate/Low	
SRE-WA07	-23.1748	118.8456	17/10/2018	Eucalypt Woodland	Sheet Flow	Footslope	Low	North	Negligible	None Discernible	Gravel (1- 4cm)	Open Eucalyptus/ Corymbia, Soft/ Tussock Grassland	Few Small Patches	Low 5- 20%	Silty Loam	Few Small Patches	None	Moderate (3 to 5 yr.)	0.6	Mining Exploration, Road/ Access Track	Moderate/Low	
SRE-WA08	-23.2279	118.7263	16/10/2018	Stony Plain	Creek	Stony Plain	Flat	Flat	Negligible	None Discernible	Gravel (1- 4cm)	Other Acacia Open Shrubland, Open Eucalyptus/ Corymbia, Triodia Grassland	Few Small Patches	Low 5- 20%	Sandy Clay Loam	Few Small Patches	None	Moderate (3 to 5 yr.)	0.6	Mining Exploration	Low	
SRE-WA09	-23.1744	118.8280	17/10/2018	Gorge/ Gully	Gully	Gully	Moderate	South	Major Outcropping	BIF	Large Rocks (21-60cm)	Open Eucalyptus/ Corymbia, Soft/ Tussock Grassland	Few Small Patches	Low 5- 20%	Silty Loam	Few Small Patches	None	Old (6+ yr.)	0.8	Road/ Access Track	Moderate	
SRE-WA10	-23.2328	118.7286	16/10/2018	Stony Plain	Creek	Stony Plain	Low	Flat	Negligible	None Discernible	Gravel (1- 4cm)	Other Acacia Open Shrubland, Open Eucalyptus/ Corymbia, Triodia Grassland	Scarce	Negligible <5%	Clayey Sand	Scarce	None	Moderate (3 to 5 yr.)	0.6	Mining Exploration	Low	
SRE-WA11	-23.1240	118.8656	17/10/2018	Mulga Woodland	Negligible	Hillslope	Flat	Flat	Negligible	None Discernible	Negligible	Mulga Woodland	Evenly Spread	Low to Med 20- 40%	Silty Loam	Evenly Spread	None	Old (6+ yr.)	0.4	Mining Exploration, Road/ Access Track	Low	
SRE-WA12	-23.2297	118.7410	16/10/2018	Hillcrest/ Hillslope	Gully	Hillcrest/ Upper Hillslope	Steep	West	Moderate Outcropping	BIF	Small Rocks (11-20cm)	Other Acacia Open Shrubland, Open Eucalyptus/ Corymbia, Triodia Grassland	Few Small Patches	Low 5- 20%	Clay Loam	Few Small Patches	None	Moderate (3 to 5 yr.)	0.6	Mining Exploration	Low	
SRE-WA13	-23.1172	118.6257	18/10/2018	Stony Plain	Creek	Footslope	Low	West	Minor Outcropping	BIF	Pebbles (5- 10cm)	Open Mulga Shrubland, Open Eucalyptus/ Corymbia, Triodia Grassland	Scarce	Negligible <5%	Clay Loam	None Discernible	None	Old (6+ yr.)	1	Road/ Access Track	Moderate	
SRE-WA14	-23.1747	118.8688	17/10/2018	Mulga Woodland	Sheet Flow	Sandy/ Stony Plain	Flat	Flat	Negligible	None Discernible	Gravel (1- 4cm)	Mulga Woodland, Open Mulga Shrubland, Other Acacia Open Shrubland, Triodia Grassland, Soft/ Tussock Grassland	Many Small Patches	Low 5- 20%	Clayey Sand	Many Large Patches	Mygalomorph Spider	Old (6+ yr.)	0.6	Mining Exploration, Road/ Access Track	Moderate/Low	
SRE-WA15	-23.1362	118.6221	18/10/2018	Drainage Area/ Floodplain		Drainage Area/ Floodplain	Flat	Flat	Negligible	None Discernible	Pebbles (5- 10cm)	Open Eucalyptus/ Corymbia, Other Shrub, Triodia Grassland, Soft/ Tussock Grassland	Many Small Patches	Low 5- 20%	Silty Clay Loam	Evenly Spread	None	Old (6+ yr.)	1	Road/ Access Track, None Discernible	Low	
SRE-WA16	-23.1757	118.8576	17/10/2018	Minor Drainage Line	Creek	Minor Drainage Line	Low	Flat	Negligible	None Discernible	Gravel (1- 4cm)	Other Acacia Open Shrubland, Open Eucalyptus/ Corymbia, Triodia Grassland, Soft/ Tussock Grassland	Few Small Patches	Low 5- 20%	Sandy Clay Loam	Many Small Patches	None	Moderate (3 to 5 yr.)	0.4	Road/ Access Track	Low	No SRE specimens found
SRE-WA17	-23.1101	118.5860	18/10/2018	Stony Plain	Negligible	Stony Plain	Flat	Flat	Negligible	None Discernible	Gravel (1- 4cm)	Open Mulga Shrubland, Triodia Grassland	Few Small Patches	Negligible <5%	Clay Loam	None Discernible	None	Old (6+ yr.)	1	None Discernible	Low	
SRE-WA18	-23.1354	118.8550	17/10/2018	Drainage Area/ Floodplain	Creek	Medium Drainage Line	Flat	Flat	Negligible	None Discernible	Gravel (1- 4cm)	Other Acacia Open Shrubland, Open Eucalyptus/ Corymbia, Triodia Grassland, Soft/ Tussock Grassland	Many Small Patches	Low 5- 20%	Sandy Clay Loam	Many Large Patches	None	Old (6+ yr.)	0.6	Road/ Access Track	Moderate/Low	
SRE-WA19	-23.1253	118.6662	18/10/2018	Mulga Woodland	Creek	Hardpan Plain	Flat	South/ West	Negligible	None Discernible	Pebbles (5- 10cm)	Open Mulga Shrubland	Few Large Patches	Low to Med 20- 40%	Clay Loam	Many Large Patches	None	Old (6+ yr.)	0.8	None Discernible	Moderate/Low	

Site	Latitude	Longitude	Date	Habitat Type	Drainage	Landform	Slope	Aspect	Outcropping Extent	Outcropping Type	Rock Size	Vegetation Type	Leaf Litter	Shade	Soil Type	Soil Availability	Burrows	Fire Age	Condition	Disturbances	SRE Suitability	Comments
SRE-WA20	-23.1739	118.8513	18/10/2018	Gorge/ Gully	Creek	Gully	Flat	Flat	Moderate Outcropping	BIF	Pebbles (5-10cm)	Open Mulga Shrubland, Other Acacia Thicket, Other Acacia Open Shrubland, Open Eucalyptus/ Corymbia, Soft/ Tussock Grassland	Many Small Patches	Med to High 60-80%	Sandy Clay Loam	Few Large Patches	None	Old (6+ yr.)	0.8	None Discernible	Moderate/High	found in Vert Pitfall trap
SRE-WA21	-23.1789	118.8703	19/10/2018	Eucalypt Woodland	Sheet Flow	Stony Plain	Flat	Flat	Negligible	None Discernible	Gravel (1-4cm)	Other Tree, Triodia Grassland, Soft/ Tussock Grassland	Many Large Patches	Low to Med 20-40%	Clayey Sand	Many Large Patches	None	Old (6+ yr.)	0.8	Mining Exploration, Road/ Access Track	Moderate	
SRE-WA22	-23.1866	118.8800	18/10/2018	Drainage Area/ Floodplain	Creek	Drainage Area/ Floodplain	Low	Flat	Negligible	None Discernible	Gravel (1-4cm)	Open Mulga Shrubland, Other Acacia Open Shrubland, Open Eucalyptus/ Corymbia, Triodia Grassland	Few Small Patches	Low 5-20%	Clay Loam	Few Large Patches	None	Old (6+ yr.)	0.6	Mining Exploration, Road/ Access Track	Moderate/Low	
SRE-WA23	-23.1169	118.6250	19/10/2018	Gorge/ Gully	Gully	Gully	Steep	North/ East	Major Outcropping	BIF	Large Rocks (21-60cm)	Open Mulga Shrubland, Triodia Grassland	Few Small Patches	Low 5-20%	Clay Loam	Few Small Patches	None	Moderate (3 to 5 yr.)	1	None Discernible	Moderate/High	
SRE-WA24	-23.2153	118.8194	18/10/2018	Gorge/ Gully	Gully	Gorge	Flat	North	Extensive Outcropping	BIF	Boulders (>61cm)	Mulga Woodland, Open Eucalyptus/ Corymbia, Ficus Tree/ Shrub, Soft/ Tussock Grassland	Many Large Patches	Med to High 60-80%	Clay Loam	Few Small Patches	None	Old (6+ yr.)	1	None Discernible	High	
SRE-WA25	-23.1198	118.5945	19/10/2018	Gorge/ Gully	Gully	Gully	Low	South/ West	Moderate Outcropping	BIF	Pebbles (5-10cm)	Open Eucalyptus/ Corymbia, Triodia Grassland	Few Large Patches	Negligible <5%	Clay Loam	Few Large Patches	None	Recent (0 to 2 yr.)	0.8	Frequent Fire	Moderate	
SRE-WA26	-23.2203	118.7666	19/10/2019	Gorge/ Gully	Gully	Gully	Moderate	West	Major Outcropping	BIF	Boulders (>61cm)	Other Acacia Open Shrubland, Open Eucalyptus/ Corymbia, Ficus Tree/ Shrub, Soft/ Tussock Grassland	Few Large Patches	Low 5-20%	Clay Loam	Scarce	None	Old (6+ yr.)	0.6	None Discernible	Moderate	No SRE invertebrates found
SRE-WA27	-23.2206	118.7713	20/10/2018	Stony Plain	Creek	Gully	Moderate	East	Moderate Outcropping	BIF	Small Rocks (11-20cm)	Other Acacia Open Shrubland, Open Eucalyptus/ Corymbia, Triodia Grassland, Soft/ Tussock Grassland	Few Small Patches	Negligible <5%	Silty Loam	Scarce	None	Moderate (3 to 5 yr.)	0.8	Mining Exploration, Road/ Access Track	Moderate	
SRE-WA28	-23.2163	118.7490	19/10/2018	Gorge/ Gully	Gully	Gully	Flat	East	Major Outcropping	BIF	Boulders (>61cm)	Open Eucalyptus/ Corymbia, Other Tree, Soft/ Tussock Grassland	Few Large Patches	Low to Med 20-40%	Sandy Loam	Few Small Patches	None	Old (6+ yr.)	0.6	None Discernible	Moderate	
SRE-WA29	-23.1155	118.6326	21/10/2018	Mulga Woodland	Negligible	Hillslope	Steep	South	Major Outcropping	BIF	Large Rocks (21-60cm)	Mulga Woodland, Triodia Grassland	Few Small Patches	Low 5-20%	Silty Loam	Scarce	None	Old (6+ yr.)	0.8	Road/ Access Track	Moderate/High	
SRE-WA31	-23.1327	118.5838	21/10/2018	Stony Plain	Negligible	Stony Plain	Flat	Flat	Negligible	None Discernible	Gravel (1-4cm)	Open Mulga Shrubland, Other Acacia Open Shrubland, Triodia Grassland	Few Large Patches	Negligible <5%	Clay Loam	Scarce	Mygalomorph Spider	Old (6+ yr.)	0.8	Road/ Access Track	Low	
SRE-WA32	-23.1730	118.8396	20/10/2018	Gorge/ Gully	Gully	Gorge	Moderate	Flat	Major Outcropping	BIF	Boulders (>61cm)	Ficus Tree/ Shrub	Few Large Patches	Low to Med 20-40%	Loamy Sand	Few Small Patches	None	Old (6+ yr.)	0.8	None Discernible	Moderate/High	Pseudoscorpion found in leaf litter under large Ficus grove
SRE-WA33	-23.1374	118.6458	21/10/2018	Medium Drainage Line	Creek	Medium Drainage Line	Flat	South	Negligible	None Discernible	Negligible	Open Eucalyptus/ Corymbia	Many Small Patches	Low 5-20%	Clay Loam	Few Large Patches	None	Recent (0 to 2 yr.)	0.8	Frequent Fire	Low	
SRE-WA34	-23.1224249	118.9082	20/10/2018	Gorge/ Gully	Gully	Gully	Moderate	North/ East	Major Outcropping	BIF	Boulders (>61cm)	Open Mulga Shrubland, Open Eucalyptus/ Corymbia, Triodia Grassland, Soft/ Tussock Grassland	Few Small Patches	Low 5-20%	Silty Loam	Scarce	None	Moderate (3 to 5 yr.)	0.6	None Discernible	Moderate	
SRE-WA38	-23.2305	118.7220	21/10/2018	Medium Drainage Line	Creek	Medium Drainage Line	Flat	Flat	Moderate Outcropping	BIF	Large Rocks (21-60cm)	Other Acacia Open Shrubland, Open Eucalyptus/ Corymbia, Ficus Tree/ Shrub, Triodia Grassland, Soft/ Tussock Grassland	Few Small Patches	Low 5-20%	Clay Loam	Few Small Patches	None	Old (6+ yr.)	0.6	Mining Exploration	Moderate/Low	No SRE invertebrates were found
SRE-WA40	-23.2293	118.7461	21/10/2018	Hillcrest/ Hillslope	Negligible	Hillcrest/ Upper Hillslope	Steep	North	Major Outcropping	BIF	Boulders (>61cm)	Ficus Tree/ Shrub, Triodia Grassland, Soft/ Tussock Grassland	Few Large Patches	Low to Med 20-40%	Clay Loam	Scarce	None	Old (6+ yr.)	0.6	None Discernible	Moderate/High	
Phase 2																						
SRE-WA01	-23.2095	118.7530	15/03/2019	Gorge/ Gully	Gully	Gully	Steep	East	Moderate Outcropping	Other	Large Rocks (21-60cm)		Many Small Patches	Low to Med 20-40%	Silty Loam	Many Small Patches	Other	Old (6+ yr.)	0.8	None Discernible	Moderate/High	Mix of rocks 20-60 and boulders
SRE-WA03a	-23.2367	118.7256	15/03/2019	Stony Plain	Negligible	Stony Plain	Flat	Flat	Negligible	None Discernible	Pebbles (5-10cm)	Other Acacia Open Shrubland, Triodia Grassland	Few Small Patches	Low 5-20%	Silty Clay Loam	Scarce	None	Old (6+ yr.)	1	None Discernible	Low	
SRE-WA03b	-23.2255	118.7470	17/03/2019	Stony Plain	Negligible	Stony Plain	Flat	Flat	Negligible	None Discernible	Pebbles (5-10cm)	Other Acacia Open Shrubland, Triodia Grassland	Few Small Patches	Low 5-20%	Silty Clay Loam	Scarce	None	Old (6+ yr.)	1	None Discernible	Low	



Site	Latitude	Longitude	Date	Habitat Type	Drainage	Landform	Slope	Aspect	Outcropping Extent	Outcropping Type	Rock Size	Vegetation Type	Leaf Litter	Shade	Soil Type	Soil Availability	Burrows	Fire Age	Condition	Disturbances	SRE Suitability	Comments
SRE-WA04	-23.1385	118.5921	14/03/2019	Stony Plain	Negligible	Stony Plain	Low	Flat	Negligible	None Discernible	Pebbles (5-10cm)	Mulga Woodland, Other Acacia Open Shrubland, Triodia Grassland	Many Small Patches	Low 5-20%	Clay Loam	Few Small Patches	None	Old (6+ yr.)	1	Old tracks	Low	
SRE-WA13	-23.1172	118.6257	14/03/2019	Stony Plain	Creek	Footslope	Low	West	Minor Outcropping	BIF	Pebbles (5-10cm)	Open Mulga Shrubland, Open Eucalyptus/ Corymbia, Triodia Grassland	Scarce	Negligible <5%	Clay Loam	None Discernible	None	Old (6+ yr.)	1	Road/ Access Track	Moderate	
SRE-WA14	-23.1747	118.8688	21/03/2019	Mulga Woodland	Sheet Flow	Sandy/ Stony Plain	Flat	Flat	Negligible	None Discernible	Gravel (1-4cm)	Mulga Woodland, Open Mulga Shrubland, Other Acacia Open Shrubland, Triodia Grassland, Soft/ Tussock Grassland	Many Small Patches	Negligible <5%	Clayey Sand	Many Large Patches	Mygalomorph Spider	Old (6+ yr.)	0.6	Mining Exploration, Road/ Access Track	Moderate/Low	
SRE-WA15	-23.1362	118.6221	13/03/2019	Drainage Area/ Floodplain	Sheet Flow	Drainage Area/ Floodplain	Flat	Flat	Negligible	None Discernible	Pebbles (5-10cm)	Other Acacia Open Shrubland, Open Eucalyptus/ Corymbia, Triodia Grassland, Soft/ Tussock Grassland	Many Small Patches	Negligible <5%	Silty Clay Loam	Many Large Patches	None	Old (6+ yr.)	1	None Discernible	Moderate/Low	Move coordinates to vertebrate site 2 (western hill)
SRE-WA20	-23.1738	118.8506	18/03/2019	Gorge/ Gully	Creek	Gully	Flat	Flat	Moderate Outcropping	BIF	Pebbles (5-10cm)	Open Mulga Shrubland, Other Acacia Thicket, Other Acacia Open Shrubland, Open Eucalyptus/ Corymbia, Soft/ Tussock Grassland	Many Small Patches	Med to High 60-80%	Sandy Clay Loam	Few Large Patches	None	Old (6+ yr.)	0.8	None Discernible	Moderate/High	
SRE-WA23	-23.1169	118.6250	19/03/2019	Gorge/ Gully	Gully	Gully	Steep	North/ East	Major Outcropping	BIF	Large Rocks (21-60cm)	Open Mulga Shrubland, Triodia Grassland	Few Small Patches	Low 5-20%	Clay Loam	Few Small Patches	None	Moderate (3 to 5 yr.)	1	None Discernible	Moderate/High	
SRE-WA30	-23.1149	118.6439	14/03/2019	Stony Plain	Creek	Footslope	Flat	Flat	Major Outcropping	BIF	Gravel (1-4cm)	Other Acacia Open Shrubland, Soft/ Tussock Grassland	Few Small Patches	High 80-100%	Clay Loam	Scarce	None	Moderate (3 to 5 yr.)	0.8	Mining Exploration	Moderate	VWAW-03
SRE-WA32	-23.1726	118.8402	21/03/2019	Gorge/ Gully	Gully	Gorge	Moderate	West	Extensive Outcropping	BIF	Boulders (>61cm)	Open Eucalyptus/ Corymbia, Ficus Tree/ Shrub, Soft/ Tussock Grassland	Many Large Patches	Low to Med 20-40%	Silty Loam	Few Small Patches	None	Old (6+ yr.)	1	None Discernible	Moderate/High	
SRE-WA36	-23.2300	118.7147	15/03/2019	Hillcrest/ Hillslope		Hillslope	Moderate	East	Moderate Outcropping	BIF	Pebbles (5-10cm)	Open Eucalyptus/ Corymbia, Triodia Grassland	Many Small Patches	Low to Med 20-40%	Silty Loam	Scarce	None	Old (6+ yr.)	1	Mining Exploration, Road/ Access Track	Moderate/High	
SRE-WA40	-23.2293	118.7461	18/03/2019	Hillcrest/ Hillslope	Negligible	Hillcrest/ Upper Hillslope	Steep	North	Major Outcropping	BIF	Boulders (>61cm)	Ficus Tree/ Shrub, Triodia Grassland, Soft/ Tussock Grassland	Few Large Patches	Low to Med 20-40%	Clay Loam	Scarce	None	Old (6+ yr.)	0.6	None Discernible	Moderate/High	
SRE-WA50	-23.1239	118.8924	13/03/2019	Gorge/ Gully	Gully	Gully	Low	South/ West	Major Outcropping	BIF	Boulders (>61cm)	Other Acacia Open Shrubland, Open Eucalyptus/ Corymbia, Soft/ Tussock Grassland	Few Small Patches	High 80-100%	Clay Loam	Scarce	Other	Moderate (3 to 5 yr.)	0.8	Mining Exploration	Moderate	
SRE-WA51	-23.1357	118.8550	13/03/2019	Stony Plain	Sheet Flow	Undulating Low Hills	Low	Flat	Negligible	None Discernible	Pebbles (5-10cm)	Other Acacia Open Shrubland, Triodia Grassland, Soft/ Tussock Grassland	Few Small Patches	Negligible <5%	Clay Loam	Many Small Patches	None	Old (6+ yr.)	0.8	Road/ Access Track	Moderate/Low	
SRE-WA57	-23.2142	118.8343	15/03/2019	Ironstone Outcrops	Gully	Gully	Steep	North	Extensive Outcropping	BIF	Boulders (>61cm)	Open Eucalyptus/ Corymbia, Triodia Grassland, Soft/ Tussock Grassland	Few Large Patches	Low 5-20%	Silty Loam	Scarce	None	Moderate (3 to 5 yr.)	1	None Discernible	Moderate/High	
SRE-WA58	-23.2362	118.7380	16/03/2019	Breakaway/ Cliff	Negligible	Footslope	Moderate	South	Major Outcropping	BIF	Large Rocks (21-60cm)	Open Eucalyptus/ Corymbia, Soft/ Tussock Grassland	Few Large Patches	Low to Med 20-40%	Silty Loam	Scarce	None	Moderate (3 to 5 yr.)	0.8	Road/ Access Track	Moderate	
SRE-WA59	-23.2383	118.7477	16/03/2019	Minor Drainage Line	Creek	Undulating Low Hills	Low	South	Negligible	None Discernible	Small Rocks (11-20cm)	Open Eucalyptus/ Corymbia, Triodia Grassland, Soft/ Tussock Grassland	Few Small Patches	Negligible <5%	Silty Clay Loam	Scarce	Other	Old (6+ yr.)	1	Road/ Access Track	Low	
SRE-WA60	-23.1326	118.8291	15/03/2019	Stony Plain	Negligible	Stony Plain	Flat	Flat	Limited Outcropping	None Discernible	Gravel (1-4cm)	Other Acacia Open Shrubland	None Discernible	Negligible <5%	Clay Loam	Many Large Patches	None	Recent (0 to 2 yr.)	0.8	None Discernible	Low	
SRE-WA61	-23.2287	118.7718	16/03/2019	Minor Drainage Line	Creek	Undulating Low Hills	Low	West	Negligible	None Discernible	Small Rocks (11-20cm)	Open Eucalyptus/ Corymbia, Soft/ Tussock Grassland	Few Large Patches	Low 5-20%	Silty Loam	Scarce	None	Old (6+ yr.)	1	Road/ Access Track	Low	
SRE-WA62	-23.1372	118.8411	15/03/2019	Minor Drainage Line	Creek	Minor Drainage Line	Low	South	Limited Outcropping	None Discernible	Pebbles (5-10cm)	Open Eucalyptus/ Corymbia, Soft/ Tussock Grassland	Few Small Patches	Low 5-20%	Clay Loam	Few Small Patches	None	Recent (0 to 2 yr.)	0.8	None Discernible	Moderate	
SRE-WA63	-23.2110	118.8069	16/03/2019	Gorge/ Gully	Gully	Hillslope	Cliff	North	Extensive Outcropping	BIF	Boulders (>61cm)	Other Acacia Thicket, Eucalyptus/ Corymbia Grove, Triodia Grassland, Soft/ Tussock Grassland	Many Large Patches	Low to Med 20-40%	Clay Loam	Scarce	None	Old (6+ yr.)	0.8	None Discernible	Moderate/High	



Site	Latitude	Longitude	Date	Habitat Type	Drainage	Landform	Slope	Aspect	Outcropping Extent	Outcropping Type	Rock Size	Vegetation Type	Leaf Litter	Shade	Soil Type	Soil Availability	Burrows	Fire Age	Condition	Disturbances	SRE Suitability	Comments
SRE-WA64	-23.1210	118.8650	16/03/2019	Gorge/ Gully	Gully	Gully	Steep	North/ East	Moderate Outcropping	BIF	Small Rocks (11-20cm)	Open Eucalyptus/ Corymbia	Few Small Patches	Low 5-20%	Silty Loam	Many Small Patches	None	Moderate (3 to 5 yr.)	0.6	Road/ Access Track, Mining Exploration	Moderate	
SRE-WA65	-23.2420	118.7555	17/03/2019	Medium Drainage Line	Creek	Medium Drainage Line	Flat	Flat	Negligible	None Discernible	Negligible	Other Acacia Open Shrubland, Open Eucalyptus/ Corymbia, Triodia Grassland, Soft/ Tussock Grassland	Many Small Patches	Low 5-20%	Sandy Clay Loam	Many Large Patches	None	Moderate (3 to 5 yr.)	1	Road/ Access Track	Low	
SRE-WA66	-23.1239	118.8463	16/03/2019	Gorge/ Gully	Gully	Gully	Moderate	East	Moderate Outcropping	BIF	Small Rocks (11-20cm)	Open Eucalyptus/ Corymbia	Few Small Patches	Low 5-20%	Silty Loam	Scarce	None	Recent (0 to 2 yr.)	0.6	None Discernible	Moderate	
SRE-WA67	-23.2070	118.8045	16/03/2019	Stony Plain	Negligible	Undulating Low Hills	Low	North	Limited Outcropping	BIF	Small Rocks (11-20cm)	Open Eucalyptus/ Corymbia, Triodia Grassland	Few Small Patches	Low 5-20%	Clay Loam	Scarce	None	Old (6+ yr.)	0.6	Mining Exploration, Road/ Access Track	Moderate/Low	
SRE-WA68	-23.1252	118.8444	16/03/2019	Gorge/ Gully	Gully	Gully	Moderate	North	Moderate Outcropping	BIF	Large Rocks (21-60cm)	Ficus Tree/ Shrub, Open Eucalyptus/ Corymbia, Soft/ Tussock Grassland	Many Small Patches	Med to High 60-80%	Silty Loam	Many Small Patches	None	Moderate (3 to 5 yr.)	0.8	None Discernible	Moderate/High	
SRE-WA69	-23.2236	118.7184	17/03/2019	Stony Plain	Creek	Undulating Low Hills	Low	Flat	Negligible	None Discernible	Pebbles (5-10cm)	Open Eucalyptus/ Corymbia, Triodia Grassland	Few Small Patches	Negligible <5%	Clay Loam	Scarce	None	Moderate (3 to 5 yr.)	1	None Discernible	Low	
SRE-WA70	-23.1243	118.8439	16/03/2019	Hillcrest/ Hillslope	Negligible	Hillcrest/ Upper Hillslope	Low	North	Negligible	None Discernible	Gravel (1-4cm)	Open Eucalyptus/ Corymbia, Triodia Grassland, Soft/ Tussock Grassland	Few Small Patches	Negligible <5%	Silty Loam	Few Small Patches	None	Recent (0 to 2 yr.)	0.8	None Discernible	Moderate	Millipede and slater under Corymbia
SRE-WA71	-23.2246	118.7378	17/03/2019	Ironstone Outcrops	Negligible	Undulating Low Hills	Moderate	North	Moderate Outcropping	CID	Boulders (>61cm)	Open Eucalyptus/ Corymbia, Triodia Grassland, Soft/ Tussock Grassland	Few Small Patches	Low 5-20%	Silty Loam	Scarce	None	Old (6+ yr.)	1	None Discernible	Moderate	
SRE-WA73	-23.2309	118.7212	18/03/2019	Medium Drainage Line	Creek	Medium Drainage Line	Low	South	Major Outcropping	BIF	Small Rocks (11-20cm)	Open Eucalyptus/ Corymbia, Triodia Grassland, Soft/ Tussock Grassland	Many Small Patches	Low 5-20%	Sandy Clay Loam	Few Small Patches	None	Old (6+ yr.)	1	Road/ Access Track	Moderate/Low	
SRE-WA74	-23.1276	118.9032	17/03/2019	Minor Drainage Line	Creek	Minor Drainage Line	Low	East	Minor Outcropping	BIF	Small Rocks (11-20cm)	Open Eucalyptus/ Corymbia, Other Acacia Open Shrubland, Soft/ Tussock Grassland	Many Small Patches	Low 5-20%	Silty Loam	Many Small Patches	None	Moderate (3 to 5 yr.)	0.8	None Discernible	Moderate	
SRE-WA75	-23.1196	118.8689	18/03/2019	Gorge/ Gully	Gully	Gorge	Moderate	North	Extensive Outcropping	BIF	Large Rocks (21-60cm)	Open Eucalyptus/ Corymbia, Other Acacia Open Shrubland, Soft/ Tussock Grassland	Many Small Patches	Low to Med 20-40%	Silty Loam	Many Small Patches	None	Old (6+ yr.)	0.6	None Discernible	Moderate	
SRE-WA76	-23.1294	118.8944	17/03/2019	Mulga Woodland	Negligible	Hillslope	Moderate	South	Minor Outcropping	BIF	Pebbles (5-10cm)	Mulga Grove	Few Large Patches	Med to High 60-80%	Clay Loam	Many Small Patches	None	Moderate (3 to 5 yr.)	0.8	None Discernible	Moderate/High	
SRE-WA77	-23.1182	118.8808	18/03/2019	Gorge/ Gully	Gully	Gully	Moderate	South	Major Outcropping	BIF	Large Rocks (21-60cm)	Open Eucalyptus/ Corymbia, Soft/ Tussock Grassland	Few Small Patches	Low 5-20%	Silty Loam	Few Small Patches	None	Moderate (3 to 5 yr.)	0.6	None Discernible	Moderate	
SRE-WA78	-23.1148	118.6558	17/03/2019	Minor Drainage Line	Creek	Minor Drainage Line	Low	South	Moderate Outcropping	BIF	Large Rocks (21-60cm)	Open Eucalyptus/ Corymbia, Triodia Grassland	Few Small Patches	Low 5-20%	Clay Loam	Few Small Patches	None	Recent (0 to 2 yr.)	0.8	None Discernible	Low	
SRE-WA79	-23.1251	118.8734	18/03/2019	Gorge/ Gully	Gully	Gully	Moderate	North	Moderate Outcropping	BIF	Small Rocks (11-20cm)	Mulga Grove, Triodia Grassland	Few Small Patches	Low to Med 20-40%	Silty Loam	Few Small Patches	None	Old (6+ yr.)	0.6	Mining Exploration	Moderate	
SRE-WA81	-23.1321	118.8603	19/03/2019	Stony Plain	Creek	Stony Plain	Flat	Flat	Negligible	None Discernible	Pebbles (5-10cm)	Other Acacia Open Shrubland, Triodia Grassland, Soft/ Tussock Grassland	Few Small Patches	Negligible <5%	Clay Loam	Many Small Patches	None	Old (6+ yr.)	0.6	None Discernible	Low	
SRE-WA82	-23.1358	118.6714	20/03/2019	Mulga Woodland	Sheet Flow	Stony Plain	Flat	Flat	Negligible	None Discernible	Gravel (1-4cm)	Mulga Grove	Scarce	Low 5-20%	Silty Clay Loam	Scarce	None	Moderate (3 to 5 yr.)	0.6	None Discernible	Moderate/Low	
SRE-WA83	-23.1277	118.9279	20/03/2019	Gorge/ Gully	Gully	Gully	Steep	North/ East	Major Outcropping	BIF	Small Rocks (11-20cm)	Ficus Tree/ Shrub, Triodia Grassland, Soft/ Tussock Grassland	Few Large Patches	Low 5-20%	Silty Loam	Few Small Patches	None	Old (6+ yr.)	0.8	Mining Exploration, Road/ Access Track	Moderate/High	
SRE-WA84	-23.1254	118.9180	20/03/2019	Gorge/ Gully	Gully	Gorge	Moderate	South	Extensive Outcropping	BIF	Pebbles (5-10cm)	Other Acacia Open Shrubland, Triodia Grassland, Soft/ Tussock Grassland	Few Small Patches	Low 5-20%	Silty Loam	Scarce	None	Old (6+ yr.)	1	None Discernible	Moderate/High	
SRE-WA85	-23.1078	118.6420	20/03/2019	Mulga Woodland	Negligible	Stony Plain	Flat	North	Limited Outcropping	BIF	Pebbles (5-10cm)	Mulga Woodland, Triodia Grassland	Many Large Patches	Low 5-20%	Silty Loam	Many Small Patches	None	Old (6+ yr.)	0.6	Road/ Access Track	Moderate	
SRE-WA86	-23.1058	118.9006	20/03/2019	Major Drainage Line	Creek	Drainage Area/ Floodplain	Low	South	Negligible	None Discernible	Gravel (1-4cm)	Open Eucalyptus/ Corymbia, Triodia Grassland, Soft/ Tussock Grassland	Few Large Patches	Low 5-20%	Sandy Loam	Evenly Spread	None	Recent (0 to 2 yr.)	0.8	None Discernible	Low	
SRE-WA87	-23.1767	118.8339	21/03/2019	Minor Drainage Line	Creek	Minor Drainage Line	Low	West	Negligible	None Discernible	Large Rocks (21-60cm)	Open Eucalyptus/ Corymbia, Soft/ Tussock Grassland	Few Small Patches	Low 5-20%	Sandy Clay Loam	Scarce	None	Moderate (3 to 5 yr.)	0.8	Road/ Access Track	Low	
SRE-WA88	-23.1776	118.8534	21/03/2019	Stony Plain	Negligible	Undulating Low Hills	Low	Flat	Negligible	None Discernible	Small Rocks (11-20cm)	Open Eucalyptus/ Corymbia, Triodia Grassland	None Discernible	Negligible <5%	Clay Loam	Scarce	None	Recent (0 to 2 yr.)	0.6	Mining Exploration,	Low	







Site	Latitude	Longitude	Date	Habitat Type	Drainage	Landform	Slope	Aspect	Outcropping Extent	Outcropping Type	Rock Size	Vegetation Type	Leaf Litter	Shade	Soil Type	Soil Availability	Burrows	Fire Age	Condition	Disturbances	SRE Suitability	Comments
																				Road/ Access Track		
SRE-WA90	-23.1814	118.8641	21/03/2019	Gorge/ Gully	Gully	Hillslope	Moderate	North/ West	Moderate Outcropping	BIF	Large Rocks (21-60cm)	Open Eucalyptus/ Corymbia, Triodia Grassland, Soft/ Tussock Grassland	Few Small Patches	Low 5-20%	Silty Loam	Scarce	None	Recent (0 to 2 yr.)	0.8	None Discernible	Moderate/Low	Mining exploration near base
SRE-WA95	-23.2117	118.7922	21/03/2019	Hillcrest/ Hillslope	Gully	Hillcrest/ Upper Hillslope	Steep	South/ East	Extensive Outcropping	BIF	Large Rocks (21-60cm)	Open Eucalyptus/ Corymbia, Triodia Grassland, Soft/ Tussock Grassland	Few Small Patches	Negligible <5%	Silty Loam	Scarce	None	Old (6+ yr.)	0.8	Mining Exploration, Road/ Access Track	Moderate/Low	Was SREWAXX
SRE-WAH72	-23.1324	118.8327	16/03/2019	Gorge/ Gully	Gully	Gully	Steep	South	Moderate Outcropping	BIF	Large Rocks (21-60cm)	Soft/ Tussock Grassland, Open Eucalyptus/ Corymbia	Many Small Patches	Low to Med 20-40%	Silty Loam	Many Small Patches	None	Old (6+ yr.)	0.8	None Discernible	Moderate	



## **Appendix E: Vertebrate Trapping Site Descriptions**



Vegetation and Fauna Habitat Description	Site Photo
<p><b>VRT-WA01</b></p> <p><b>Habitat Type: Foothlope and Plain</b></p> <p>Hummock spinifex grassland plain with open scattered Mulga woodland.</p> <p>Clay loam soil with an almost continuous layer of small surface pebbles (5-10cm).</p>	
<p><b>VRT-WA02</b></p> <p><b>Habitat Type: Mixed Acacia Woodland</b></p> <p>Mixed Acacia shrubs with scattered Eucalyptus trees on a Drainage Area/ Floodplain. Ground cover comprised tussock grassland in low to medium density.</p> <p>Evenly spread soil with texture consisting of silt clay loam.</p>	

Vegetation and Fauna Habitat Description	Site Photo
<p><b>VRT-WA03</b></p> <p><b>Habitat Type: Minor Drainage</b></p> <p>Mixed Acacia shrubs and Hummock spinifex grassland plain extending from footslopes of a nearby rocky hills to the north-west.</p> <p>Clay loam soil with an almost continuous layer of small surface gravel (1-4cm).</p>	
<p><b>VRT-WA04</b></p> <p><b>Habitat Type: Gorge or Gully</b></p> <p>Scattered Eucalyptus trees over Hummock spinifex grassland located within mouth of gorge and southward extending drainage line on footslopes.</p> <p>Clay loam soil with an almost continuous layer of small surface pebbles (5-10cm) to large rocks (21-60cm).</p>	

Vegetation and Fauna Habitat Description	Site Photo
<p><b>VRT-WA05</b></p> <p><b>Habitat Type: Hilltop, Hillslope, Ridge or Cliff</b></p> <p>Scattered Eucalyptus trees with an open mixed Acacia shrubland. Grasses are dominated by <i>Triodia</i> sp. with scattered <i>Tussock</i> sp.</p> <p>Soil texture comprises silty loam with an almost continuous layer of small surface pebbles (5-10cm).</p>	
<p><b>VRT-WA06</b></p> <p><b>Habitat Type: Drainage Area</b></p> <p>Trapping site ran along a medium drainage line on a Drainage Area/ Floodplain.</p> <p>Scattered Eucalyptus trees with an open mixed Acacia shrubland. Grasses are dominated by <i>Tussock</i> sp. with scattered <i>Triodia</i> sp.</p> <p>Evenly spread soil with texture consisting of sandy clay loam.</p>	

Vegetation and Fauna Habitat Description	Site Photo
<p><b>VRT-WA07</b></p> <p><b>Habitat Type: Hilltop, Hillslope, Ridge or Cliff</b></p> <p>Trapping site ran eastward along a moderately sloped Hillslope.</p> <p>Scattered Eucalyptus trees over a Hummock spinifex grassland of medium to high density.</p> <p>Soil texture comprises silty loam with an almost continuous layer of small surface pebbles (5-10cm).</p>	
<p><b>VRT-WA08</b></p> <p><b>Habitat Type: Drainage Area</b></p> <p>Hummock spinifex grassland on a stony plain with an open Mulga woodland.</p> <p>Soil texture comprises silty clay loam with an almost continuous layer of small surface pebbles (5-10cm).</p>	

Vegetation and Fauna Habitat Description	Site Photo
<p><b>VRT-WA09</b></p> <p><b>Habitat Type: Foothlope and Plain</b></p> <p>Mallee form <i>Eucalyptus</i> sp. over a Hummock spinifex grassland of medium to high density on a Stony Plain.</p> <p>Soil texture comprises silty clay loam with an almost continuous layer of small surface gravel (1-4cm).</p>	
<p><b>VRT-WA10</b></p> <p><b>Habitat Type: Gorge or Gully</b></p> <p>Scattered Eucalyptus trees over Mulga woodland and mixed Acacia shrubland over Hummock spinifex grassland located within mouth of gully and extending drainage line.</p> <p>Soil, comprising silty loam, was continuous throughout the trapping site.</p>	

Vegetation and Fauna Habitat Description	Site Photo
<p><b>VWAH-11</b></p> <p><b>Habitat Type: Gorge or Gully</b></p> <p>Scattered Eucalyptus trees over Mulga woodland over tussock grassland located within a drainage line extending north east toward the mouth of a gully.</p> <p>Clay loam soil with an almost continuous layer of small surface pebbles (5-10cm) to boulders (&gt;60cm).</p>	
<p><b>VWAH-12</b></p> <p><b>Habitat Type: Foothlope and Plain</b></p> <p>Hummock spinifex grassland with open mixed acacia woodland on a Stony Plain.</p> <p>Clay loam soil with an almost continuous layer of small surface pebbles (5-10cm).</p>	

## **Appendix F: Locations of vertebrate fauna sampling sites**

Site ID	Deposit	Start Date	End Date	Method	Habitat	Latitude	Longitude
<b>Phase 1</b>							
VRT-WA09	Deposit F	15/10/2018		Avifauna census	Footslope and Plain	-23.178626	118.869618
VRT-WA09	Deposit F	15/10/2018	22/10/2018	Cage trap	Footslope and Plain	-23.178626	118.869618
VRT-WA09	Deposit F	15/10/2018	22/10/2018	Elliott trap	Footslope and Plain	-23.178626	118.869618
VRT-WA09	Deposit F	15/10/2018	22/10/2018	Funnel trap	Footslope and Plain	-23.178626	118.869618
VRT-WA09	Deposit F	15/10/2018	22/10/2018	Pitfall trap (dry)	Footslope and Plain	-23.178626	118.869618
VRT-WA10	Deposit F	15/10/2018		Avifauna census	Gorge or Gully	-23.173558	118.851105
VRT-WA10	Deposit F	15/10/2018	22/10/2018	Cage trap	Gorge or Gully	-23.173558	118.851105
VRT-WA10	Deposit F	15/10/2018	22/10/2018	Elliott trap	Gorge or Gully	-23.173558	118.851105
VRT-WA10	Deposit F	15/10/2018	22/10/2018	Funnel trap	Gorge or Gully	-23.173558	118.851105
VRT-WA10	Deposit F	15/10/2018	22/10/2018	Pitfall trap (dry)	Gorge or Gully	-23.173558	118.851105
VRT-WA10	Deposit F	21/10/2018	22/10/2018	Echolocation recording	Gorge or Gully	-23.173558	118.851105
VRT-WA20	Deposit F	18/10/2018	22/10/2018	Camera (active)	Hilltop, Hillslope, Ridge or Cliff	-23.17533	118.826885
VRT-WA20	Deposit F	18/10/2018		Targeted searches	Hilltop, Hillslope, Ridge or Cliff	-23.17533	118.826885
VRT-WA27	Deposit F	20/10/2018	22/10/2018	Camera (active)	Footslope and Plain	-23.175091	118.860875
VRT-WA31	Deposit F	20/10/2018		Avifauna census	Footslope and Plain	-23.175352	118.860575
VRT-WA32	Deposit F	20/10/2018		Active foraging	Footslope and Plain	-23.174291	118.83889
VRT-WA32	Deposit F	20/10/2018		Avifauna census	Footslope and Plain	-23.174291	118.83889
VRT-WA38	Deposit F	20/10/2018		Avifauna census	Hilltop, Hillslope, Ridge or Cliff	-23.180623	118.87689
VRT-WA39	Deposit F	21/10/2018	22/10/2018	Echolocation recording	Hilltop, Hillslope, Ridge or Cliff	-23.174238	118.83772
VRT-WA40	Deposit F	18/10/2018	20/10/2018	Acoustic recording	Drainage Area	-23.186976	118.879295
VRT-WA40	Deposit F	18/10/2018		Active foraging	Drainage Area	-23.186976	118.879295
VRT-WA45	Deposit F	20/10/2018		Active foraging	Drainage Area	-23.187026	118.87937
VRT-WA45	Deposit F	20/10/2018		Avifauna census	Drainage Area	-23.187026	118.87937
VRT-WA45	Deposit F	20/10/2018	22/10/2018	Camera (active)	Drainage Area	-23.187026	118.87937
VRT-WA46	Deposit F	21/10/2018	22/10/2018	Acoustic recording	Footslope and Plain	-23.179058	118.863011

Site ID	Deposit	Start Date	End Date	Method	Habitat	Latitude	Longitude
VRT-WA16 (WB-WAH1)	Deposit H	17/10/2018	21/10/2018	Camera (active)	Gorge or Gully	-23.119591	118.868886
VRT-WA16 (WB-WAH1)	Deposit H	17/10/2018	21/10/2018	Echolocation recording	Gorge or Gully	-23.119591	118.868886
VRT-WA16 (WB-WAH1)	Deposit H	17/10/2018		Targeted searches	Gorge or Gully	-23.119591	118.868886
VRT-WA17	Deposit H	17/10/2018	21/10/2018	Camera (active)	Hilltop, Hillslope, Ridge or Cliff	-23.134364	118.855119
VRT-WA17	Deposit H	17/10/2018	21/10/2018	Echolocation recording	Hilltop, Hillslope, Ridge or Cliff	-23.134364	118.855119
VRT-WA30	Deposit H	20/10/2018	21/10/2018	Acoustic recording	Hilltop, Hillslope, Ridge or Cliff	-23.123214	118.875883
VRT-WA49	Deposit H	20/10/2018		Targeted searches	Hilltop, Hillslope, Ridge or Cliff	-23.1224	118.908
VRT-WA50	Deposit H	20/10/2018		Targeted searches	Hilltop, Hillslope, Ridge or Cliff	-23.12841	118.860554
VRT-WA64	Deposit H	21/10/2018		Camera (active)	Hilltop, Hillslope, Ridge or Cliff	-23.12125	118.862211
VRT-WA05	Deposit J and Mt Ella East	13/10/2018		Avifauna census	Hilltop, Hillslope, Ridge or Cliff	-23.220085	118.771375
VRT-WA05	Deposit J and Mt Ella East	13/10/2018	20/10/2018	Cage trap	Hilltop, Hillslope, Ridge or Cliff	-23.220085	118.771375
VRT-WA05	Deposit J and Mt Ella East	13/10/2018	20/10/2018	Elliott trap	Hilltop, Hillslope, Ridge or Cliff	-23.220085	118.771375
VRT-WA05	Deposit J and Mt Ella East	13/10/2018	20/10/2018	Funnel trap	Hilltop, Hillslope, Ridge or Cliff	-23.220085	118.771375
VRT-WA05	Deposit J and Mt Ella East	13/10/2018	20/10/2018	Pitfall trap (dry)	Hilltop, Hillslope, Ridge or Cliff	-23.220085	118.771375
VRT-WA06	Deposit J and Mt Ella East	13/10/2018	20/10/2018	Cage trap	Drainage Area	-23.238186	118.761052
VRT-WA06	Deposit J and Mt Ella East	13/10/2018	20/10/2018	Elliott trap	Drainage Area	-23.238186	118.761052
VRT-WA06	Deposit J and Mt Ella East	13/10/2018	20/10/2018	Funnel trap	Drainage Area	-23.238186	118.761052
VRT-WA06	Deposit J and Mt Ella East	13/10/2018	20/10/2018	Pitfall trap (dry)	Drainage Area	-23.238186	118.761052
VRT-WA06	Deposit J and Mt Ella East	13/10/2018		Avifauna census	Drainage Area	-23.238186	118.761052
VRT-WA07	Deposit J and Mt Ella East	14/10/2018		Avifauna census	Hilltop, Hillslope, Ridge or Cliff	-23.23062	118.714686
VRT-WA07	Deposit J and Mt Ella East	14/10/2018	21/10/2018	Cage trap	Hilltop, Hillslope, Ridge or Cliff	-23.23062	118.714686
VRT-WA07	Deposit J and Mt Ella East	14/10/2018	21/10/2018	Elliott trap	Hilltop, Hillslope, Ridge or Cliff	-23.23062	118.714686
VRT-WA07	Deposit J and Mt Ella East	14/10/2018	21/10/2018	Funnel trap	Hilltop, Hillslope, Ridge or Cliff	-23.23062	118.714686
VRT-WA07	Deposit J and Mt Ella East	14/10/2018	21/10/2018	Pitfall trap (dry)	Hilltop, Hillslope, Ridge or Cliff	-23.23062	118.714686
VRT-WA08	Deposit J and Mt Ella East	14/10/2018	18/10/2018	Acoustic recording	Drainage Area	-23.236673	118.725646
VRT-WA08	Deposit J and Mt Ella East	14/10/2018		Avifauna census	Drainage Area	-23.236673	118.725646

Site ID	Deposit	Start Date	End Date	Method	Habitat	Latitude	Longitude
VRT-WA08	Deposit J and Mt Ella East	14/10/2018	21/10/2018	Cage trap	Drainage Area	-23.236673	118.725646
VRT-WA08	Deposit J and Mt Ella East	14/10/2018	21/10/2018	Elliott trap	Drainage Area	-23.236673	118.725646
VRT-WA08	Deposit J and Mt Ella East	14/10/2018	21/10/2018	Funnel trap	Drainage Area	-23.236673	118.725646
VRT-WA08	Deposit J and Mt Ella East	14/10/2018	21/10/2018	Pitfall trap (dry)	Drainage Area	-23.236673	118.725646
VRT-WA13	Deposit J and Mt Ella East	13/10/2018		Active foraging	Hilltop, Hillslope, Ridge or Cliff	-23.220184	118.766268
VRT-WA13	Deposit J and Mt Ella East	13/10/2018	19/10/2018	Echolocation recording	Hilltop, Hillslope, Ridge or Cliff	-23.220184	118.766268
VRT-WA14	Deposit J and Mt Ella East	16/10/2018		Active foraging	Hilltop, Hillslope, Ridge or Cliff	-23.211359	118.803226
VRT-WA14	Deposit J and Mt Ella East	16/10/2018	18/10/2018	Camera (active)	Hilltop, Hillslope, Ridge or Cliff	-23.211359	118.803226
VRT-WA14	Deposit J and Mt Ella East	16/10/2018	18/10/2018	Echolocation recording	Hilltop, Hillslope, Ridge or Cliff	-23.211359	118.803226
VRT-WA15	Deposit J and Mt Ella East	16/10/2018	18/10/2018	Acoustic recording	Footslope and Plain	-23.206919	118.80178
VRT-WA19	Deposit J and Mt Ella East	19/10/2018		Targeted searches	Gorge Gully	-23.216335	118.74893
VRT-WA23	Deposit J and Mt Ella East	19/10/2018	20/10/2018	Echolocation recording	Hilltop, Hillslope, Ridge or Cliff	-23.210236	118.756454
VRT-WA24	Deposit J and Mt Ella East	18/10/2018	20/10/2018	Camera (active)	Hilltop, Hillslope, Ridge or Cliff	-23.215795	118.820456
VRT-WA24	Deposit J and Mt Ella East	18/10/2018	20/10/2018	Echolocation recording	Hilltop, Hillslope, Ridge or Cliff	-23.215795	118.820456
VRT-WA24	Deposit J and Mt Ella East	18/10/2018		Targeted searches	Hilltop, Hillslope, Ridge or Cliff	-23.215795	118.820456
VRT-WA26	Deposit J and Mt Ella East	18/10/2018	20/10/2018	Acoustic recording	Footslope and Plain	-23.203068	118.756915
VRT-WA28	Deposit J and Mt Ella East	19/10/2018		Active foraging	Drainage Area	-23.230533	118.722667
VRT-WA28	Deposit J and Mt Ella East	19/10/2018	21/10/2018	Camera (active)	Drainage Area	-23.230533	118.722667
VRT-WA63	Deposit J and Mt Ella East	21/10/2018		Camera (active)	Hilltop, Hillslope, Ridge or Cliff	-23.215468	118.820361
VRT-WA01	Western Hill	11/10/2018		Avifauna census	Footslope and Plain	-23.138647	118.592016
VRT-WA01	Western Hill	11/10/2018	18/10/2018	Cage trap	Footslope and Plain	-23.138647	118.592016
VRT-WA01	Western Hill	11/10/2018	18/10/2018	Elliott trap	Footslope and Plain	-23.138647	118.592016
VRT-WA01	Western Hill	11/10/2018	18/10/2018	Funnel trap	Footslope and Plain	-23.138647	118.592016
VRT-WA01	Western Hill	11/10/2018	18/10/2018	Pitfall trap (dry)	Footslope and Plain	-23.138647	118.592016
VRT-WA02	Western Hill	11/10/2018		Avifauna census	Mixed Acacia Woodland	-23.1363218	118.6219
VRT-WA02	Western Hill	11/10/2018	18/10/2018	Cage trap	Mixed Acacia Woodland	-23.1363218	118.6219

Site ID	Deposit	Start Date	End Date	Method	Habitat	Latitude	Longitude
VRT-WA02	Western Hill	11/10/2018	18/10/2018	Elliott trap	Mixed Acacia Woodland	-23.1363218	118.6219
VRT-WA02	Western Hill	11/10/2018	18/10/2018	Funnel trap	Mixed Acacia Woodland	-23.1363218	118.6219
VRT-WA02	Western Hill	11/10/2018	18/10/2018	Pitfall trap (dry)	Mixed Acacia Woodland	-23.1363218	118.6219
VRT-WA03	Western Hill	12/10/2018		Avifauna census	Minor Drainage	-23.115853	118.644996
VRT-WA03	Western Hill	12/10/2018	19/10/2018	Cage trap	Minor Drainage	-23.115853	118.644996
VRT-WA03	Western Hill	12/10/2018	19/10/2018	Elliott trap	Minor Drainage	-23.115853	118.644996
VRT-WA03	Western Hill	12/10/2018	19/10/2018	Funnel trap	Minor Drainage	-23.115853	118.644996
VRT-WA03	Western Hill	12/10/2018	19/10/2018	Pitfall trap (dry)	Minor Drainage	-23.115853	118.644996
VRT-WA04	Western Hill	12/10/2018		Avifauna census	Gorge or Gully	-23.117952	118.626143
VRT-WA04	Western Hill	12/10/2018	19/10/2018	Cage trap	Gorge or Gully	-23.117952	118.626143
VRT-WA04	Western Hill	12/10/2018	19/10/2018	Elliott trap	Gorge or Gully	-23.117952	118.626143
VRT-WA04	Western Hill	12/10/2018	19/10/2018	Funnel trap	Gorge or Gully	-23.117952	118.626143
VRT-WA04	Western Hill	12/10/2018	19/10/2018	Pitfall trap (dry)	Gorge or Gully	-23.117952	118.626143
VRT-WA11	Western Hill	12/10/2018	18/10/2018	Echolocation recording	Gorge or Gully	-23.120605	118.603284
VRT-WA12	Western Hill	12/10/2018	21/10/2018	Camera (active)	Hilltop, Hillslope, Ridge or Cliff	-23.116558	118.626446
VRT-WA18	Western Hill	18/10/2018	21/10/2018	Camera (active)	Mulga Spinifex Woodland	-23.13289	118.583384
VRT-WA21	Western Hill	18/10/2018	21/10/2018	Camera (active)	Footslope and Plain	-23.110722	118.587654
VRT-WA21	Western Hill	18/10/2018		Targeted searches	Footslope and Plain	-23.110722	118.587654
VRT-WA22	Western Hill	18/10/2018	20/10/2018	Echolocation recording	Hilltop, Hillslope, Ridge or Cliff	-23.11724	118.625218
VRT-WA25	Western Hill	19/10/2018		Targeted searches	Hilltop, Hillslope, Ridge or Cliff	-23.120018	118.594711
VRT-WA29	Western Hill	21/10/2018	22/10/2018	Acoustic recording	Footslope and Plain	-23.134731	118.584129
VRT-WA33	Western Hill	12/10/2018	17/10/2018	Echolocation recording	Hilltop, Hillslope, Ridge or Cliff	-23.116839	118.585421
VRT-WA34	Western Hill	21/10/2018		Active foraging	Hilltop, Hillslope, Ridge or Cliff	-23.116168	118.631218
VRT-WA34	Western Hill	21/10/2018		Avifauna census	Hilltop, Hillslope, Ridge or Cliff	-23.116168	118.631218
VRT-WA35	Western Hill	12/10/2018	17/10/2018	Echolocation recording	Footslope and Plain	-23.10822	118.658091
VRT-WA36	Western Hill	21/10/2018		Habitat Assessment	Footslope and Plain	-23.121371	118.663197

Site ID	Deposit	Start Date	End Date	Method	Habitat	Latitude	Longitude
VRT-WA37	Western Hill	21/10/2018		Avifauna census	Footslope and Plain	-23.120908	118.663192
VRT-WA41	Western Hill	18/10/2018	21/10/2018	Camera (active)	Minor Drainage	-23.125608	118.666811
VRT-WA42	Western Hill	19/10/2018	22/10/2018	Camera (active)	Gorge or Gully	-23.117762	118.624152
VRT-WA42	Western Hill	19/10/2018		Targeted searches	Gorge or Gully	-23.117762	118.624152
VRT-WA42	Western Hill	20/10/2018	22/10/2018	Echolocation recording	Gorge or Gully	-23.117762	118.624152
VRT-WA43	Western Hill	20/10/2018	21/10/2018	Acoustic recording	Mulga Spinifex Woodland	-23.109932	118.594865
VRT-WA44	Western Hill	20/10/2018	22/10/2018	Camera (active)	Hilltop, Hillslope, Ridge or Cliff	-23.114108	118.610713
VRT-WA44	Western Hill	20/10/2018	22/10/2018	Echolocation recording	Hilltop, Hillslope, Ridge or Cliff	-23.114108	118.610713
VRT-WA44	Western Hill	20/10/2018		Targeted searches	Hilltop, Hillslope, Ridge or Cliff	-23.114108	118.610713
VRT-WA48	Western Hill	20/10/2018		Targeted searches	Gorge or Gully	-23.116664	118.595827
<b>Phase 2</b>							
VRT-WA10	Deposit F	18/03/2019	21/03/2019	Motion camera (active)	Gorge or Gully	-23.1735583	118.851105
VWAF-01	Deposit F	17/03/2019	19/03/2019	Echolocation recording	Footslope and Plain	-23.1837996	118.874733
VWAF-02	Deposit F	17/03/2019	19/03/2019	Echolocation recording	Footslope and Plain	-23.1770552	118.859198
VWAF-03	Deposit F	18/03/2019	21/03/2019	Motion camera (active)	Footslope and Plain	-23.1767473	118.857333
VWAF-04	Deposit F	18/03/2019	21/03/2019	Motion camera (active)	Footslope and Plain	-23.1763514	118.845391
VWAF-05	Deposit F	18/03/2019	21/03/2019	Motion camera (active)	Hilltop, Hillslope, Ridge or Cliff	-23.1769311	118.832909
VWAF-07	Deposit F	18/03/2019	21/03/2019	Motion camera (active)	Gorge or Gully	-23.1728993	118.839831
VWAF-10	Deposit F	18/03/2019	21/03/2019	Motion camera (active)	Gorge or Gully	-23.1735583	118.851105
VWAF-67	Deposit F	17/03/2019	19/03/2019	Acoustic recording	Hilltop, Hillslope, Ridge or Cliff	-23.1749607	118.836048
VWAH-11	Deposit H	13/03/2019	19/03/2019	Avifauna census	Gorge or Gully	-23.1239043	118.892431
VWAH-11	Deposit H	13/03/2019	19/03/2019	Cage trap	Gorge or Gully	-23.1239043	118.892431
VWAH-11	Deposit H	20/03/2019	22/03/2019	Echolocation recording	Gorge or Gully	-23.1239043	118.892431
VWAH-11	Deposit H	13/03/2019	19/03/2019	Elliott trap	Gorge or Gully	-23.1239043	118.892431
VWAH-11	Deposit H	13/03/2019	19/03/2019	Funnel trap	Gorge or Gully	-23.1239043	118.892431
VWAH-11	Deposit H	13/03/2019	19/03/2019	Pitfall trap	Gorge or Gully	-23.1239043	118.892431

Site ID	Deposit	Start Date	End Date	Method	Habitat	Latitude	Longitude
VWAH-12	Deposit H	13/03/2019	17/03/2019	Acoustic recording	Footslope and Plain	-23.135678	118.854777
VWAH-12	Deposit H	13/03/2019	20/03/2019	Avifauna census	Footslope and Plain	-23.135678	118.854777
VWAH-12	Deposit H	13/03/2019	20/03/2019	Cage trap	Footslope and Plain	-23.135678	118.854777
VWAH-12	Deposit H	13/03/2019	20/03/2019	Elliott trap	Footslope and Plain	-23.135678	118.854777
VWAH-12	Deposit H	13/03/2019	20/03/2019	Funnel trap	Footslope and Plain	-23.135678	118.854777
VWAH-12	Deposit H	13/03/2019	20/03/2019	Pitfall trap	Footslope and Plain	-23.135678	118.854777
VWAH-13	Deposit H	20/03/2019	22/03/2019	Acoustic recording	Hilltop, Hillslope, Ridge or Cliff	-23.1275726	118.912195
VWAH-13	Deposit H	20/03/2019	22/03/2019	Motion camera (active)	Hilltop, Hillslope, Ridge or Cliff	-23.1275726	118.912195
VWAH-14	Deposit H	20/03/2019	22/03/2019	Motion camera (active)	Hilltop, Hillslope, Ridge or Cliff	-23.1254481	118.917972
VWAH-63	Deposit H	16/03/2019	19/03/2019	Echolocation recording	Hilltop, Hillslope, Ridge or Cliff	-23.1293697	118.835142
VWAH-63	Deposit H	16/03/2019	19/03/2019	Motion camera (active)	Hilltop, Hillslope, Ridge or Cliff	-23.1293697	118.835142
VWAH-66	Deposit H	18/03/2019	22/03/2019	Motion camera (active)	Hilltop, Hillslope, Ridge or Cliff	-23.1192408	118.882785
VWAH-67	Deposit H	17/03/2019	22/03/2019	Motion camera (active)	Hilltop, Hillslope, Ridge or Cliff	-23.1292679	118.894498
VWAH-77	Deposit H	18/03/2019	22/03/2019	Motion camera (active)	Hilltop, Hillslope, Ridge or Cliff	-23.125195	118.873362
VWAH-78	Deposit H	18/03/2019	22/03/2019	Motion camera (active)	Hilltop, Hillslope, Ridge or Cliff	-23.1322314	118.860499
VWAH-92	Deposit H	20/03/2019		Habitat assessment	Drainage Area	-23.1058059	118.900614
VRT-WA05	Deposit J and Mt Ella East	14/03/2019	21/03/2019	Avifauna census	Hilltop, Hillslope, Ridge or Cliff	-23.2200849	118.771375
VRT-WA05	Deposit J and Mt Ella East	14/03/2019	21/03/2019	Cage trap	Hilltop, Hillslope, Ridge or Cliff	-23.2200849	118.771375
VRT-WA05	Deposit J and Mt Ella East	14/03/2019	17/03/2019	Echolocation recording	Hilltop, Hillslope, Ridge or Cliff	-23.2200849	118.771375
VRT-WA05	Deposit J and Mt Ella East	14/03/2019	21/03/2019	Elliott trap	Hilltop, Hillslope, Ridge or Cliff	-23.2200849	118.771375
VRT-WA05	Deposit J and Mt Ella East	14/03/2019	21/03/2019	Funnel trap	Hilltop, Hillslope, Ridge or Cliff	-23.2200849	118.771375
VRT-WA05	Deposit J and Mt Ella East	14/03/2019	21/03/2019	Pitfall trap	Hilltop, Hillslope, Ridge or Cliff	-23.2200849	118.771375
VRT-WA06	Deposit J and Mt Ella East	14/03/2019	21/03/2019	Avifauna census	Minor Drainage	-23.238186	118.761052
VRT-WA06	Deposit J and Mt Ella East	14/03/2019	21/03/2019	Cage trap	Minor Drainage	-23.238186	118.761052
VRT-WA06	Deposit J and Mt Ella East	14/03/2019	17/03/2019	Echolocation recording	Minor Drainage	-23.238186	118.761052
VRT-WA06	Deposit J and Mt Ella East	14/03/2019	21/03/2019	Elliott trap	Minor Drainage	-23.238186	118.761052
VRT-WA06	Deposit J and Mt Ella East	14/03/2019	21/03/2019	Funnel trap	Minor Drainage	-23.238186	118.761052

Site ID	Deposit	Start Date	End Date	Method	Habitat	Latitude	Longitude
VRT-WA06	Deposit J and Mt Ella East	14/03/2019	21/03/2019	Pitfall trap	Minor Drainage	-23.238186	118.761052
VRT-WA07	Deposit J and Mt Ella East	14/03/2019	21/03/2019	Avifauna census	Hilltop, Hillslope, Ridge or Cliff	-23.2306197	118.714686
VRT-WA07	Deposit J and Mt Ella East	14/03/2019	21/03/2019	Cage trap	Hilltop, Hillslope, Ridge or Cliff	-23.2306197	118.714686
VRT-WA07	Deposit J and Mt Ella East	14/03/2019	16/03/2019	Echolocation recording	Hilltop, Hillslope, Ridge or Cliff	-23.2306197	118.714686
VRT-WA07	Deposit J and Mt Ella East	14/03/2019	21/03/2019	Elliott trap	Hilltop, Hillslope, Ridge or Cliff	-23.2306197	118.714686
VRT-WA07	Deposit J and Mt Ella East	14/03/2019	21/03/2019	Funnel trap	Hilltop, Hillslope, Ridge or Cliff	-23.2306197	118.714686
VRT-WA07	Deposit J and Mt Ella East	14/03/2019	21/03/2019	Pitfall trap	Hilltop, Hillslope, Ridge or Cliff	-23.2306197	118.714686
VRT-WA08	Deposit J and Mt Ella East	14/03/2019	20/03/2019	Acoustic recording	Drainage Area	-23.2366726	118.725646
VRT-WA08	Deposit J and Mt Ella East	14/03/2019	21/03/2019	Avifauna census	Drainage Area	-23.2366726	118.725646
VRT-WA08	Deposit J and Mt Ella East	14/03/2019	21/03/2019	Cage trap	Drainage Area	-23.2366726	118.725646
VRT-WA08	Deposit J and Mt Ella East	14/03/2019	21/03/2019	Elliott trap	Drainage Area	-23.2366726	118.725646
VRT-WA08	Deposit J and Mt Ella East	14/03/2019	21/03/2019	Funnel trap	Drainage Area	-23.2366726	118.725646
VRT-WA08	Deposit J and Mt Ella East	14/03/2019	21/03/2019	Pitfall trap	Drainage Area	-23.2366726	118.725646
VWAJ-62	Deposit J and Mt Ella East	15/03/2019		Active foraging	Hilltop, Hillslope, Ridge or Cliff	-23.2112781	118.792066
VWAJ-70	Deposit J and Mt Ella East	16/03/2019	21/03/2019	Motion camera (active)	Hilltop, Hillslope, Ridge or Cliff	-23.2361538	118.738031
VWAJ-71	Deposit J and Mt Ella East	16/03/2019	21/03/2019	Motion camera (active)	Hilltop, Hillslope, Ridge or Cliff	-23.2286155	118.771242
VWAJ-72	Deposit J and Mt Ella East	16/03/2019	21/03/2019	Motion camera (active)	Hilltop, Hillslope, Ridge or Cliff	-23.2110297	118.832758
VWAJ-73	Deposit J and Mt Ella East	16/03/2019	21/03/2019	Motion camera (active)	Hilltop, Hillslope, Ridge or Cliff	-23.2111251	118.807073
VWAJ-74	Deposit J and Mt Ella East	17/03/2019	21/03/2019	Motion camera (active)	Hilltop, Hillslope, Ridge or Cliff	-23.2268283	118.738893
VWAJ-75b	Deposit J and Mt Ella East	16/03/2019	18/03/2019	Echolocation recording	Hilltop, Hillslope, Ridge or Cliff	-23.2094362	118.781213
VWAJ-75c	Deposit J and Mt Ella East	16/03/2019	21/03/2019	Motion camera (active)	Hilltop, Hillslope, Ridge or Cliff	-23.2094362	118.781213
VWAJ-75a	Deposit J and Mt Ella East	16/03/2019	18/03/2019	Motion camera (active)	Hilltop, Hillslope, Ridge or Cliff	-23.2094362	118.781213
VWAJ-76	Deposit J and Mt Ella East	17/03/2019	21/03/2019	Motion camera (active)	Footslope and Plain	-23.2236019	118.718475
VWAJ-77	Deposit J and Mt Ella East	18/03/2019	21/03/2019	Motion camera (active)	Hilltop, Hillslope, Ridge or Cliff	-23.2290902	118.746461
VRT-WA01	Western Hill	13/03/2019	20/03/2019	Avifauna census	Footslope and Plain	-23.1386466	118.592016
VRT-WA01	Western Hill	13/03/2019	20/03/2019	Cage trap	Footslope and Plain	-23.1386466	118.592016
VRT-WA01	Western Hill	13/03/2019	20/03/2019	Elliott trap	Footslope and Plain	-23.1386466	118.592016

Site ID	Deposit	Start Date	End Date	Method	Habitat	Latitude	Longitude
VRT-WA01	Western Hill	13/03/2019	20/03/2019	Funnel trap	Footslope and Plain	-23.1386466	118.592016
VRT-WA01	Western Hill	13/03/2019	20/03/2019	Pitfall trap	Footslope and Plain	-23.1386466	118.592016
VRT-WA02	Western Hill	13/03/2019	20/03/2019	Avifauna census	Mixed Acacia Woodland	-23.1363218	118.6219
VRT-WA02	Western Hill	13/03/2019	20/03/2019	Cage trap	Mixed Acacia Woodland	-23.1363218	118.6219
VRT-WA02	Western Hill	13/03/2019	20/03/2019	Elliott trap	Mixed Acacia Woodland	-23.1363218	118.6219
VRT-WA02	Western Hill	13/03/2019	20/03/2019	Funnel trap	Mixed Acacia Woodland	-23.1363218	118.6219
VRT-WA02	Western Hill	13/03/2019	20/03/2019	Pitfall trap	Mixed Acacia Woodland	-23.1363218	118.6219
VRT-WA03	Western Hill	13/03/2019	20/03/2019	Avifauna census	Minor Drainage	-23.1158532	118.644996
VRT-WA03	Western Hill	13/03/2019	20/03/2019	Cage trap	Minor Drainage	-23.1158532	118.644996
VRT-WA03	Western Hill	13/03/2019	20/03/2019	Elliott trap	Minor Drainage	-23.1158532	118.644996
VRT-WA03	Western Hill	13/03/2019	20/03/2019	Funnel trap	Minor Drainage	-23.1158532	118.644996
VRT-WA03	Western Hill	13/03/2019	20/03/2019	Pitfall trap	Minor Drainage	-23.1158532	118.644996
VRT-WA04	Western Hill	13/03/2019	20/03/2019	Avifauna census	Gorge or Gully	-23.1179524	118.626143
VRT-WA04	Western Hill	13/03/2019	20/03/2019	Cage trap	Gorge or Gully	-23.1179524	118.626143
VRT-WA04	Western Hill	13/03/2019	20/03/2019	Elliott trap	Gorge or Gully	-23.1179524	118.626143
VRT-WA04	Western Hill	13/03/2019	20/03/2019	Funnel trap	Gorge or Gully	-23.1179524	118.626143
VRT-WA04	Western Hill	13/03/2019	20/03/2019	Pitfall trap	Gorge or Gully	-23.1179524	118.626143
VWAW-68	Western Hill	17/03/2019		Active foraging	Hilltop, Hillslope, Ridge or Cliff	-23.1141638	118.656868
VWAW-68	Western Hill	17/03/2019	21/03/2019	Motion camera (active)	Hilltop, Hillslope, Ridge or Cliff	-23.1141638	118.656868
VWAW-81	Western Hill	19/03/2019	21/03/2019	Echolocation recording	Hilltop, Hillslope, Ridge or Cliff	-23.1100473	118.653015
VWAW-83	Western Hill	19/03/2019	21/03/2019	Echolocation recording	Hilltop, Hillslope, Ridge or Cliff	-23.1072195	118.645003
VWAW-85	Western Hill	19/03/2019	21/03/2019	Acoustic recording	Mulga Spinifex Woodland	-23.1074919	118.638571
VWAW-85	Western Hill	19/03/2019	21/03/2019	Motion camera (active)	Mulga Spinifex Woodland	-23.1074919	118.638571
VWAW-87	Western Hill	19/03/2019	21/03/2019	Echolocation recording	Footslope and Plain	-23.1092395	118.620015
VWAW-87	Western Hill	19/03/2019	21/03/2019	Motion camera (active)	Footslope and Plain	-23.1092395	118.620015
VWAW-89	Western Hill	19/03/2019	21/03/2019	Motion camera (active)	Hilltop, Hillslope, Ridge or Cliff	-23.1169465	118.595544

Site ID	Deposit	Start Date	End Date	Method	Habitat	Latitude	Longitude
VRT-WA62	Western Hill	29/10/2018	19/03/2019	Camera (active) – long-term deployment	Gorge Gully	-23.117762	118.624152
VRT-WA63	Western Hill	21/10/2018	15/03/2019	Camera (active) – long-term deployment	Gorge Gully	-23.2154684	118.820361
VRT-WA64	Western Hill	21/10/2018	15/03/2019	Camera (active) – long-term deployment	Gorge Gully	-23.1212498	118.862211

## **Appendix G: Vertebrate fauna identified by the desktop assessment and field surveys**

**List of databases searched:**

Database	Source
Threatened Fauna Database	Department of Biodiversity, Conservation and Attractions (DBCA, 2019a)
NatureMap	Department of Biodiversity, Conservation and Attractions (DPaW, 2018)
Birddata Custom Bird Atlas	BirdLife Australia (BirdLife Australia, 2018)
Protected Matters Database Search Tool	Department of Environment and Energy (DoEE, 2018)

**List of surveys considered in the literature review:**

Survey	Reference
An ecological appreciation of the West Angelas environment, Western Australia 1979 (Integrated Environmental Services, 1979)	A
West Angelas Ghost Bat ( <i>Macroderma gigas</i> ) assessment survey (Ecologia, 1998a)	B
West Angelas Project vertebrate fauna assessment survey (ecologia Environmental Consultants, 1998)	C
West Angelas mine site Ghost Bat assessment survey, September 2000 (Ecologia, 2000)	D
West Angelas mine site Ghost Bat assessment survey, September 2001 (ecologia Environmental Consultants, 2001)	E
Ghost Bats at West Angelas: 2002 survey data review and future directions (Biota, 2002)	F
Monitoring of Ghost Bat roosts at West Angelas 2003 (Biota, 2004)	G
Fauna habitats and fauna assemblages of Deposits E and F at West Angelas (Biota, 2005)	H
South Flank Vertebrate Fauna Survey (Biologic, 2011)	I
Angelo River Vertebrate Fauna Baseline Survey (ENV, 2011)	J
Targeted Conservation Significant Fauna Survey Karijini Tenement E47 17 (Biologic, 2013 (Biologic, 2013a)	K
West Angelas – Deposit B Ghost Bat assessment (Biologic, 2013b)	L
Greater West Angelas terrestrial fauna assessment (Ecologia, 2014)	M
West Angelas NVCP Biological Assessment (EcoLogical Australia, 2014)	N
Western Hill NVCP Report (Biota, 2014)	O
West Angelas – Deposit B and F Ghost Bat assessment (Biologic, 2015)	P
South Flank Targeted Fauna Survey (Biologic, 2016c)	Q
2017 West Angelas Ghost Bat Monitoring (Biologic, 2018)	R

## Mammals

Scientific Name	Common Name	Conservation Status				Database searches			Survey																		
		EPBC	BC	DBCA	IUCN	DoEE 2018	Nature Map	DBCA 2019a	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	Current
BOVIDAE																											
<i>Bos taurus</i>	*European Cattle						•				•						•										
CAMELIDAE																											
<i>Camelus dromedarius</i>	*Camel					•	•										•	•									•
CANIDAE																											
<i>Canis dingo</i>	Dingo					•	•		•		•					•	•	•			•	•					•
<i>Vulpes vulpes</i>	*Red Fox					•																					
DASYURIDAE																											
<i>Dasykaluta rosamondae</i>	Little Red Kaluta						•		•		•						•	•			•						•
<i>Dasymercus blythi</i>	Brush-tailed Mulgara						•																				
<i>Dasyurus hallucatus</i>	Northern Quoll	E N	E N		E N	•	•	•			•						•										•
<i>Ningau ridei</i>	Wongai Ningau						•																				
<i>Ningau timealeyi</i>	Pilbara Ningau								•		•					•	•	•			•						•
<i>Planigale ingrami</i>	Long-tailed Planigale						•				•																
<i>Planigale</i> 'species 1'	Pilbara Planigale								•		•						•	•			•						•
<i>Pseudantechinus roryi</i>	Rory's Pseudantechinus						•																				•
<i>Pseudantechinus woolleyae</i>	Woolley's Pseudantechinus						•										•	•									
<i>Sminthopsis macroura</i>	Stripe-faced Dunnart						•		•		•					•	•	•			•						•
<i>Sminthopsis ooldea</i>	Ooldea Dunnart								•		•							•			•						•

Scientific Name	Common Name	Conservation Status				Database searches			Survey																		
		EPBC	BC	DBCA	IUCN	DoEE 2018	Nature Map	DBCA 2019a	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	Current
<i>Sminthopsis youngsoni</i>	Lesser Hairy-footed Dunnart						•										•										
EMBALLONURIDAE																											
<i>Saccolaimus flaviventris</i>	Yellow-bellied Sheathtail-bat						•										•	•		•	•						•
<i>Taphozous georgianus</i>	Common Sheathtail-bat						•						•	•			•	•	•	•	•			•			•
<i>Taphozous hilli</i>	Hill's Sheathtail-bat						•		•	•	•		•				•										•
EQUIDAE																											
<i>Equus asinus</i>	*Donkey					•	•										•	•									
<i>Equus caballus</i>	*Horse					•	•				•							•									
FELIDAE																											
<i>Felis catus</i>	*Cat					•	•									•	•	•									•
LEPORIDAE																											
<i>Oryctolagus cuniculus</i>	*Rabbit					•	•				•						•			•							•
MACROPODIDAE																											
<i>Osphranter robustus</i>	Euro						•		•		•					•	•	•	•		•	•					•
<i>Osphranter rufus</i>	Red Kangaroo						•		•		•						•			•	•						
<i>Petrogale rothschildi</i>	Rothschild's Rock-wallaby						•				•					•	•		•								•
MEGADERMATIDAE																											
<i>Macroderma gigas</i>	Ghost Bat	V U	V U		V U	•	•	•	•	•		•	•	•	•		•		•	•							•
MOLOSSIDAE																											
<i>Austronomus australis</i>	White-striped Freetail-bat																•	•									

Scientific Name	Common Name	Conservation Status				Database searches			Survey																		
		EPBC	BC	DBCA	IUCN	DoEE 2018	Nature Map	DBCA 2019a	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	Current
<i>Chaerephon jobensis</i>	Greater Northern Freetail-bat						•										•	•		•	•			•			•
<i>Ozimops lumsdenae</i>	Northern Free-tailed Bat								•		•						•	•			•						•
MURIDAE																											
<i>Leggadina lakedownensis</i>	Short-tailed Mouse			P4			•	•			•																
<i>Mus musculus</i>	*House Mouse					•	•		•		•					•				•							•
<i>Notomys alexis</i>	Spinifex Hopping-mouse						•								•												
<i>Pseudomys chapmani</i>	Western Pebble-mound Mouse			P4			•	•			•				•	•	•	•		•	•	•					•
<i>Pseudomys delicatulus</i>	Delicate Mouse						•				•									•							
<i>Pseudomys desertor</i>	Desert Mouse						•									•	•			•							•
<i>Pseudomys hermannsburgensis</i>	Sandy Inland Mouse						•		•		•				•		•			•							•
<i>Pseudomys nanus</i>	Western Chestnut Mouse						•																				
<i>Zyzomys argurus</i>	Common Rock-rat						•		•		•					•				•							•
RHINOYCTERIDAE																											
<i>Rhinonicteris aurantius Pilbara form'</i>	Pilbara Leaf-nosed Bat	V U	V U			•	•	•									•	•		•							•
TACHYGLOSSIDAE																											
<i>Tachyglossus aculeatus</i>	Short-beaked Echidna						•		•								•										
THYLACOMYIDAE																											
<i>Macrotis lagotis</i>	Greater Bilby	V U	V U		V U	•	•	•	•																		

Scientific Name	Common Name	Conservation Status				Database searches			Survey																		
		EPBC	BC	DBCA	IUCN	DoEE 2018	Nature Map	DBCA 2019a	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	Current
VESPERTILIONIDAE																											
<i>Chalinolobus gouldii</i>	Gould's Wattled Bat						•		•		•							•		•	•						•
<i>Nyctophilus daedalus</i>	North western Long-eared Bat						•																				
<i>Nyctophilus geoffroyi</i>	Lesser Long-eared Bat						•			•							•		•	•							•
<i>Nyctophilus gouldi</i>	Gould's Long-eared Bat																	•									
<i>Scotorepens greyii</i>	Little Broad-nosed Bat						•										•	•		•	•						•
<i>Vespadelus finlaysoni</i>	Finlayson's Cave Bat						•		•	•		•	•		•	•	•	•	•	•			•				•

\* = introduced species

## Birds

Scientific Name	Common name	Conservation Status				Database searches				Surveys																			
		EPBC	BC	DBCA	IUCN	DoEE 2018	NatureMap	Birdlife Report	DBCA 2019a	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	Current	
ACANTHIZIDAE																													
<i>Acanthiza apicalis</i>	Inland Thornbill						•	•				•					•				•							•	
<i>Acanthiza chrysorrhoa</i>	Yellow-rumped Thornbill						•									•	•												
<i>Acanthiza robustirostris</i>	Slaty-backed Thornbill						•	•								•	•												
<i>Acanthiza uropygialis</i>	Chestnut-rumped Thornbill						•	•		•		•				•	•				•						•		
<i>Gerygone fusca</i>	Western Gerygone						•	•		•		•				•	•	•			•						•		
<i>Pyrrholaemus brunneus</i>	Redthroat						•	•		•		•				•													
<i>Smicronis brevirostris</i>	Weebill						•	•		•		•				•	•	•	•		•	•					•		
ACCIPITRIDAE																													
<i>Accipiter cirrocephalus</i>	Collared Sparrowhawk						•					•				•	•				•						•		
<i>Accipiter fasciatus</i>	Brown Goshawk						•					•					•				•								
<i>Aquila audax</i>	Wedge-tailed Eagle						•	•				•					•				•						•		
<i>Circus assimilis</i>	Spotted Harrier						•	•				•					•				•						•		
<i>Elanus axillaris</i>	Black-shouldered Kite						•					•									•								
<i>Haliastur sphenurus</i>	Whistling Kite						•	•				•					•				•								
<i>Hamirostra melanosternon</i>	Black-breasted Buzzard						•			•																			
<i>Hieraaetus morphnoides</i>	Little Eagle						•					•									•								
<i>Milvus migrans</i>	Black Kite						•					•																	
ACROCEPALIDAE																													
<i>Acrocephalus stentoreus</i>	Australian Reed-warbler											•																	

Scientific Name	Common name	Conservation Status				Database searches				Surveys																		
		EPBC	BC	DBCA	IUCN	DoEE 2018	NatureMap	Birdlife Report	DBCA 2019a	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	Current
AEGOTHELIDAE																												
<i>Aegotheles cristatus</i>	Australian Owlet-nightjar						•					•					•				•							•
ALAUDIDAE																												
<i>Mirafra javanica</i>	Horsfield's Bushlark						•					•									•							
ALCEDINIDAE																												
<i>Dacelo leachii</i>	Blue-winged Kookaburra						•					•																
<i>Todiramphus pyrrhopygius</i>	Red-backed Kingfisher						•	•		•		•					•				•							•
<i>Todiramphus sanctus</i>	Sacred Kingfisher						•					•																
ANATIDAE																												
<i>Anas superciliosa</i>	Pacific Black Duck						•					•																
<i>Cygnus atratus</i>	Black Swan											•																
<i>Dendrocygna eytoni</i>	Plumed Whistling Duck						•																					
<i>Malacorhynchus membranaceus</i>	Pink-eared Duck				LC																							•
ANHINGIDAE																												
<i>Anhinga novaehollandiae</i>	Australasian Darter						•																					
APODIDAE																												
<i>Apus pacificus</i>	Fork-tailed Swift	MI	MI			•	•		•												•							•
ARDEIDAE																												
<i>Ardea ibis</i>	Cattle Egret					•																						
<i>Ardea modesta</i>	Eastern Great Egret					•																						
<i>Ardea novaehollandiae</i>	White-faced Heron											•																

Scientific Name	Common name	Conservation Status				Database searches				Surveys																	
		EPBC	BC	DBCA	IUCN	DoEE 2018	NatureMap	Birdlife Report	DBCA 2019a	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R
<i>Ardea pacifica</i>	White-necked Heron						•					•															
<i>Nycticorax nycticorax</i>	Nankeen Night Heron											•															
ARTAMIDAE																											
<i>Artamus cinereus</i>	Black-faced Woodswallow						•	•		•		•					•	•	•			•					•
<i>Artamus minor</i>	Little Woodswallow						•	•		•		•						•		•		•	•				•
<i>Artamus personatus</i>	Masked Woodswallow						•			•											•	•					
BURHINIDAE																											
<i>Burhinus grallarius</i>	Bush Stone-curlew						•					•									•						
CACATUIDAE																											
<i>Cacatua roseicapilla</i>	Galah						•	•		•		•					•	•	•			•	•				•
<i>Cacatua sanguinea</i>	Little Corella						•	•		•		•															
<i>Nymphicus hollandicus</i>	Cockatiel											•					•	•	•			•					•
CAMPEPHAGIDAE																											
<i>Coracina maxima</i>	Ground Cuckoo-shrike						•					•						•									•
<i>Coracina novaehollandiae</i>	Black-faced Cuckoo-shrike						•	•		•		•					•	•	•			•					•
<i>Lalage tricolor</i>	White-winged Triller						•	•		•		•						•	•	•		•					•
CAPRIMULGIDAE																											
<i>Eurostopodus argus</i>	Spotted Nightjar						•			•		•									•						•
CHARADRIIDAE																											
<i>Charadrius melanops</i>	Black-fronted Dotterel						•					•															
<i>Charadrius veredus</i>	Oriental Plover	MI	MI			•																					
<i>Vanellus tricolor</i>	Banded Lapwing											•															

Scientific Name	Common name	Conservation Status				Database searches				Surveys																		
		EPBC	BC	DBCA	IUCN	DoEE 2018	NatureMap	Birdlife Report	DBCA 2019a	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	Current
CLIMACTERIDAE																												
<i>Climacteris melanura</i>	Black-tailed Treecreeper											•																
COLUMBIDAE																												
<i>Geopelia cuneata</i>	Diamond Dove						•	•		•		•					•		•			•					•	
<i>Geopelia striata</i>	Peaceful Dove						•					•																
<i>Geophaps plumifera</i>	Spinifex Pigeon						•					•						•	•			•	•				•	
<i>Ocyphaps lophotes</i>	Crested Pigeon						•	•		•		•					•	•	•			•	•				•	
<i>Phaps chalcoptera</i>	Common Bronzewing						•	•		•		•						•	•			•					•	
CORVIDAE																												
<i>Corvus bennetti</i>	Little Crow						•	•														•						
<i>Corvus orru</i>	Torresian Crow						•	•		•		•					•	•	•			•					•	
CRACTICIDAE																												
<i>Cracticus nigrogularis</i>	Pied Butcherbird						•	•		•		•					•	•	•	•		•	•				•	
<i>Cracticus tibicen</i>	Australian Magpie						•	•		•		•						•				•	•				•	
<i>Cracticus torquatus</i>	Grey Butcherbird						•	•		•		•					•	•	•			•					•	
CUCULIDAE																												
<i>Cacomantis pallidus</i>	Pallid Cuckoo						•	•		•		•					•		•								•	
<i>Centropus phasianinus</i>	Pheasant Coucal						•					•															•	
<i>Chrysococcyx basalus</i>	Horsfield's Bronze Cuckoo						•	•				•					•	•				•					•	
<i>Chrysococcyx osculans</i>	Black-eared Cuckoo					•		•																			•	
DICAEIDAE																												
<i>Dicaeum hirundinaceum</i>	Mistletoebird						•	•		•		•						•	•	•		•						

Scientific Name	Common name	Conservation Status				Database searches				Surveys																		
		EPBC	BC	DBCA	IUCN	DoEE 2018	NatureMap	Birdlife Report	DBCA 2019a	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	Current
DROMAIIDAE																												
Dromaius novaehollandiae	Emu						•			•		•																
ESTRILDIDAE																												
Emblema pictum	Painted Finch						•	•		•		•					•	•	•			•	•					•
Neochmia ruficauda	Star Finch						•					•																
Taeniopygia guttata	Zebra Finch						•	•		•		•					•	•	•			•	•					•
FALCONIDAE																												
Falco berigora	Brown Falcon						•	•		•		•					•	•	•			•						•
Falco cenchroides	Australian Kestrel						•	•		•		•					•	•	•			•						
Falco hypoleucos	Grey Falcon		VU		VU		•		•	•		•																
Falco longipennis	Australian Hobby						•			•											•							
Falco peregrinus	Peregrine Falcon		OS				•		•									•		•								
HIRUNDINIDAE																												
Hirundo rustica	Barn Swallow	MI	MI			•																						
Petrochelidon ariel	Fairy Martin						•	•				•																
Petrochelidon nigricans	Tree Martin						•			•		•																
LOCUSTELLIDAE																												
Eremiornis carteri	Spinifex-bird						•	•		•		•					•	•	•	•		•						•
Megalurus cruralis	Brown Songlark											•									•							
Megalurus mathewsi	Rufous Songlark						•	•		•		•							•		•	•						•
MALURIDAE																												
Amytornis striatus	Striated Grasswren						•	•				•						•										

Scientific Name	Common name	Conservation Status				Database searches				Surveys																		
		EPBC	BC	DBCA	IUCN	DoEE 2018	NatureMap	Birdlife Report	DBCA 2019a	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	Current
<i>Malurus lamberti</i>	Variegated Fairy-wren						•	•		•		•					•	•		•		•	•					•
<i>Malurus leucopterus</i>	White-winged Fairy-wren						•	•				•					•	•	•			•						•
<i>Malurus splendens</i>	Splendid Fairy-wren						•	•				•					•					•						
<i>Stipiturus ruficeps</i>	Rufous-crowned Emu-wren						•	•		•		•					•	•				•						
<b>MELIPHAGIDAE</b>																												
<i>Acanthagenys rufogularis</i>	Spiny-cheeked Honeyeater						•	•		•		•					•	•	•			•						•
<i>Certhionyx variegatus</i>	Pied Honeyeater						•																					
<i>Epthianura tricolor</i>	Crimson Chat						•	•		•		•							•			•						•
<i>Gavicalis virescens</i>	Singing Honeyeater						•	•		•		•					•	•	•			•	•					•
<i>Lacustroica whitei</i>	Grey Honeyeater						•			•		•						•				•						•
<i>Lichmera indistincta</i>	Brown Honeyeater						•	•				•						•	•			•						•
<i>Manorina flavigula</i>	Yellow-throated Miner						•	•				•					•	•	•	•		•						•
<i>Melithreptus gularis</i>	Black-chinned Honeyeater						•	•				•						•				•						
<i>Ptilotula keartlandi</i>	Grey-headed Honeyeater						•	•		•		•						•	•	•		•						•
<i>Ptilotula penicillatus</i>	White-plumed Honeyeater									•		•						•										•
<i>Ptilotula plumulus</i>	Grey-fronted Honeyeater									•																		•
<i>Purnella albifrons</i>	White-fronted Honeyeater						•					•										•						
<i>Sugomel niger</i>	Black Honeyeater																•											
<b>MEROPIIDAE</b>																												
<i>Merops ornatus</i>	Rainbow Bee-eater					•	•			•		•					•	•										•

Scientific Name	Common name	Conservation Status				Database searches				Surveys																		
		EPBC	BC	DBCA	IUCN	DoEE 2018	NatureMap	Birdlife Report	DBCA 2019a	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	Current
MONARCHIDAE																												
Grallina cyanoleuca	Magpie-lark						•					•						•	•			•						•
MOTACILLIDAE																												
Anthus australis	Australian Pipit						•			•		•						•	•			•						•
Motacilla cinerea	Grey Wagtail	MI	MI			•																						
Motacilla flava	Yellow Wagtail	MI	MI			•																						
NEOSITTIDAE																												
Daphoenositta chrysoptera	Varied Sittella						•	•		•		•																
OTIDIDAE																												
Ardeotis australis	Australian Bustard						•			•		•			•		•	•	•			•						•
OREOICIDAE																												
Oreoica gutturalis	Crested Bellbird						•	•		•		•					•	•	•			•	•					•
PACHYCEPHALIDAE																												
Colluricincla harmonica	Grey Shrike-thrush						•	•		•		•					•	•	•	•		•						•
Pachycephala rufiventris	Rufous Whistler						•	•		•		•					•	•	•			•	•					•
PARDALOTIDAE																												
Pardalotus rubricatus	Red-browed Pardalote						•					•						•	•			•						•
Pardalotus striatus	Striated Pardalote						•	•		•		•					•	•			•							
PELECANIDAE																												
Pelecanus conspicillatus	Australian Pelican											•																
PETROICIDAE																												
Melanodryas cucullata	Hooded Robin						•	•		•		•					•	•			•							•

Scientific Name	Common name	Conservation Status				Database searches				Surveys																		
		EPBC	BC	DBCA	IUCN	DoEE 2018	NatureMap	Birdlife Report	DBCA 2019a	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	Current
<i>Petroica goodenovii</i>	Red-capped Robin						•	•				•					•	•				•						
PHAETHONTIDAE																												
<i>Phalacrocorax melanoleucos</i>	Little Pied Cormorant											•																
<i>Phalacrocorax sulcirostris</i>	Little Black Cormorant						•					•																
PHASIANIDAE																												
<i>Coturnix ypsilophora</i>	Brown Quail						•														•							
PODARGIDAE																												
<i>Podargus strigoides</i>	Tawny Frogmouth						•	•		•		•						•	•		•						•	
POMATOSTOMIDAE																												
<i>Pomatostomus superciliosus</i>	White-browed Babbler						•	•		•		•					•	•			•						•	
<i>Pomatostomus temporalis</i>	Grey-crowned Babbler						•	•				•					•	•	•		•	•					•	
PSITTACIDAE																												
<i>Melopsittacus undulatus</i>	Budgerigar						•	•		•		•					•		•		•						•	
<i>Neophema bourkii</i>	Bourke's Parrot						•					•						•										
<i>Pezoporus occidentalis</i>	Night Parrot	EN	CR		EN	•																						
<i>Platycercus varius</i>	Mulga Parrot						•			•											•						•	
<i>Platycercus zonarius</i>	Australian Ringneck						•	•		•		•					•	•	•		•	•					•	
PSOPHODIDAE																												
<i>Psophodes occidentalis</i>	Western Wedgebill											•																
PTILINORHYNCHIDAE																												
<i>Ptilonorhynchus maculatus guttatus</i>	Western Bowerbird						•	•		•		•					•	•			•	•					•	
RECURVIROSTRIDAE																												

Scientific Name	Common name	Conservation Status				Database searches				Surveys																	
		EPBC	BC	DBCA	IUCN	DoEE 2018	NatureMap	Birdlife Report	DBCA 2019a	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R
<i>Himantopus himantopus</i>	Black-winged Stilt						•																				
RHIPIDURIDAE																											
<i>Rhipidura albiscapa</i>	Grey Fantail						•	•		•		•					•	•	•			•					
<i>Rhipidura leucophrys</i>	Willie Wagtail						•	•		•		•					•	•	•	•		•	•				•
ROSTRATULIDAE																											
<i>Rostratula australis</i>	Australian Painted Snipe	EN	EN		EN	•																					
SCOLOPACIDAE																											
<i>Calidris acuminata</i>	Sharp-tailed Sandpiper	MI	MI			•																					
<i>Calidris ferruginea</i>	Curlew Sandpiper	CR/MI	CR/MI		NT	•																					
<i>Calidris melanotos</i>	Pectoral Sandpiper	MI	MI			•																					
<i>Tringa hypoleucos</i>	Common Sandpiper	MI	MI			•																					
STRIGIDAE																											
<i>Ninox boobook</i>	Boobook Owl									•		•						•		•		•					•
THRESKIORNITHIDAE																											
<i>Threskiornis spinicollis</i>	Straw-necked Ibis											•									•						
TURNICIDAE																											
<i>Turnix velox</i>	Little Button-quail						•	•				•						•			•	•					•
TYTONIDAE																											
<i>Tyto alba</i>	Barn Owl						•			•		•									•						•

## Reptiles

Scientific Name	Common Name	Conservation Status				Database searches			Survey																		
		EPBC	BC	DBCA	IUCN	DoEE 2018	Nature Map	DBCA 2019a	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	Current
AGAMIDAE																											
<i>Ctenophorus caudicinctus</i>	Ring-tailed Dragon						•				•					•	•	•			•	•					•
<i>Ctenophorus isolepis</i>	Military Dragon						•				•					•	•										•
<i>Ctenophorus reticulatus</i>	Western Netted Dragon						•				•					•	•										
<i>Diporiphora amphiboluroides</i>	Mulga Dragon										•					•	•										
<i>Diporiphora valens</i>	Southern Pilbara Tree Dragon						•				•					•	•			•							•
<i>Gowidon longirostris</i>	Long-nosed Dragon						•		•		•					•	•	•		•							•
<i>Pogona minor</i>							•				•						•			•							•
<i>Tympanocryptis cephalus</i>	Coastal Pebble-mimic dragons						•		•		•									•							
<i>Diporiphora winneckei</i>	Blue-lined Dragon										•																
CARPHODACTYLIDAE																											
<i>Nephrurus wheeleri</i>											•						•			•							•
<i>Underwoodisaurus seorsus</i>	Pilbara Barking Gecko			P2			•	•									•			•							
CHELUIDAE																											
<i>Chelodina steindachneri</i>	Flat-shelled Turtle						•		•																		
DIPLODACTYLIDAE																											
<i>Crenadactylus ocellatus</i>	Clawless Gecko						•																				
<i>Diplodactylus bilybara</i>	Western Fat-tailed Gecko						•																				
<i>Diplodactylus granariensis</i>							•																				

Scientific Name	Common Name	Conservation Status				Database searches			Survey																		
		EPBC	BC	DBCA	IUCN	DoEE 2018	Nature Map	DBCA 2019a	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	Current
<i>Diplodactylus pulcher</i>							•		•							•	•				•						•
<i>Diplodactylus savagei</i>	Southern Pilbara Beak-faced Gecko						•														•						•
<i>Lucasium stenodactylum</i>							•										•				•						•
<i>Lucasium wombeyi</i>							•										•	•			•						•
<i>Oedura fimbria</i>	Western Marbled Velvet Gecko						•									•	•	•	•		•						•
<i>Rhynchoedura ornata</i>	Western Beaked Gecko						•										•				•						•
<i>Strophurus ciliaris</i>									•									•									
<i>Strophurus elderi</i>							•									•					•						•
<i>Strophurus wellingtonae</i>							•				•					•	•				•						•
<b>ELAPIDAE</b>																											
<i>Acanthophis pyrrhus</i>	Desert Death Adder								•		•																
<i>Acanthophis wellsi</i>	Pilbara Death Adder						•										•				•						•
<i>Brachyuropsis approximans</i>							•										•				•						•
<i>Demansia psammophis</i>	Yellow-faced Whipsnake						•		•								•				•						•
<i>Demansia rufescens</i>	Rufous Whipsnake						•									•	•	•			•						•
<i>Furina ornata</i>	Moon Snake						•										•	•			•						•
<i>Parasuta monachus</i>							•		•		•						•				•						•
<i>Pseudechis australis</i>	Mulga Snake						•		•		•					•	•		•		•						•
<i>Pseudonaja mengdeni</i>	Western Brown Snake						•		•		•										•						•
<i>Pseudonaja modesta</i>	Ringed Brown Snake						•		•		•					•	•				•						

Scientific Name	Common Name	Conservation Status				Database searches			Survey																		
		EPBC	BC	DBCA	IUCN	DoEE 2018	Nature Map	DBCA 2019a	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	Current
<i>Simoselaps bertholdi</i>	Jan's Banded Snake						•																				
<i>Suta fasciata</i>	Rosen's Snake						•				•					•	•				•						•
<i>Suta punctata</i>	Spotted Snake						•																				
<i>Vermicella snelli</i>							•										•				•						
GEKKONIDAE																											
<i>Gehyra australis</i>											•																
<i>Gehyra pilbara</i>							•				•																•
<i>Gehyra punctata</i>							•				•					•	•	•		•							•
<i>Gehyra variegata</i>							•		•		•					•	•	•		•							•
<i>Heteronotia binoei</i>	Bynoe's Gecko						•		•		•						•			•							•
<i>Heteronotia spelea</i>	Desert Cave Gecko						•		•							•	•	•		•							•
PYGOPODIDAE																											
<i>Delma butleri</i>											•																
<i>Delma elegans</i>							•		•											•							
<i>Delma haroldi</i>	Neck-barred Delma						•																				
<i>Delma nasuta</i>							•		•		•					•	•			•							
<i>Delma pax</i>							•				•							•		•							
<i>Delma tincta</i>							•		•		•					•	•	•									•
<i>Lialis burtonis</i>							•		•		•						•			•							•
<i>Pygopus nigriceps</i>							•									•				•							
PYTHONIDAE																											

Scientific Name	Common Name	Conservation Status				Database searches			Survey																		
		EPBC	BC	DBCA	IUCN	DoEE 2018	Nature Map	DBCA 2019a	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	Current
<i>Antaresia perthensis</i>	Pygmy Python						•				•						•	•	•		•						•
<i>Antaresia stimsoni</i>	Stimson's Python						•		•		•																
<i>Aspidites melanocephalus</i>	Black-headed Python						•		•		•					•											
<i>Liasis olivaceus barroni</i>	Pilbara Olive Python	V U	V U			•	•	•											•								•
<b>SCINCIDAE</b>																											
<i>Carlia munda</i>							•		•		•					•	•	•			•						•
<i>Carlia triacantha</i>							•										•			•							
<i>Cryptoblepharus buehnerii</i>							•										•	•			•						
<i>Cryptoblepharus plagiocephalus</i>							•		•		•					•											
<i>Cryptoblepharus ustulatus</i>							•										•	•			•						•
<i>Ctenotus ariadnae</i>							•																				
<i>Ctenotus duricola</i>							•				•					•		•			•						•
<i>Ctenotus grandis</i>											•																
<i>Ctenotus inornatus</i>							•		•		•					•	•	•			•						•
<i>Ctenotus leonhardii</i>							•				•																
<i>Ctenotus pantherinus</i>	Leopard Ctenotus						•		•		•					•	•	•			•						•
<i>Ctenotus piangkai</i>									•		•																
<i>Ctenotus robustus</i>							•														•						
<i>Ctenotus rubicundus</i>							•				•																
<i>Ctenotus rutilans</i>							•									•	•	•			•						•
<i>Ctenotus schomburgkii</i>							•		•							•	•	•			•						•

Scientific Name	Common Name	Conservation Status				Database searches			Survey																		
		EPBC	BC	DBCA	IUCN	DoEE 2018	Nature Map	DBCA 2019a	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	Current
<i>Ctenotus serventyi</i>							•																				
<i>Cyclodomorphus melanops</i>	Slender Blue-tongue						•			•						•	•				•						•
<i>Egernia cygnitos</i>	Western Pilbara Spiny-tailed Skink						•										•									•	
<i>Egernia depressa</i>	Southern Pygmy Spiny-tailed Skink						•		•	•							•										
<i>Egernia formosa</i>							•			•						•	•	•			•					•	
<i>Eremiascincus isolepis</i>										•																	
<i>Eremiascincus pallidus</i>	Western Narrow-banded Skink						•																				
<i>Eremiascincus richardsonii</i>	Broad-banded Sand Swimmer						•			•																	
<i>Lerista flammicauda</i>							•			•																	
<i>Lerista jacksoni</i>							•											•									
<i>Lerista muelleri</i>							•		•	•						•	•	•			•					•	
<i>Lerista neander</i>							•		•							•		•			•					•	
<i>Lerista timida</i>							•														•						
<i>Lerista verhmens</i>							•														•						
<i>Lerista zietzi</i>							•										•				•					•	
<i>Menetia greyii</i>							•									•	•	•			•					•	
<i>Menetia surda</i>							•			•																	
<i>Morethia ruficauda</i>							•		•	•						•	•	•			•					•	
<i>Notoscincus butleri</i>				P4						•																	
<i>Tiliqua multifasciata</i>	Central Blue-tongue						•			•											•	•				•	

Scientific Name	Common Name	Conservation Status				Database searches			Survey																		
		EPBC	BC	DBCA	IUCN	DoEE 2018	Nature Map	DBCA 2019a	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	Current
TYPHLOPIDAE																											
Anilios australis									•																		
Anilios ganei				P1			•	•									•										•
Anilios grypus									•		•					•	•										•
Anilios hamatus											•																•
VARANIDAE																											
Varanus acanthurus	Spiny-tailed Monitor						•		•		•					•	•	•			•						•
Varanus brevicauda	Short-tailed Pygmy Monitor						•		•								•			•							•
Varanus bushi	Pilbara Mulga Monitor						•										•			•							
Varanus caudolineatus							•										•										
Varanus eremius	Pygmy Desert Monitor										•						•										
Varanus giganteus	Perentie						•		•		•						•			•							•
Varanus gilleni	Pygmy Mulga Monitor										•						•										•
Varanus gouldii	Sand Monitor						•		•								•										•
Varanus hamersleyensis	Southern Pilbara Rock Goanna						•										•										•
Varanus panoptes	Yellow-spotted Monitor						•				•						•			•							•
Varanus tristis	Racehorse Monitor						•				•						•	•		•							•

## Amphibians

Scientific Name	Common Name	Conservation Status				Database searches			Surveys																			
		EPBC	BC	DBCA	IUCN	DoEE 2018	Nature Map	DBCA 2019a	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	Current
PELODRYADIDAE																												
<i>Cyclorana maini</i>	Sheep Frog						•		•									•										•
<i>Litoria rubella</i>	Little Red Tree Frog						•		•		•							•	•									•
LIMNODYNASTIDAE																												
<i>Neobatrachus aquilonius</i>	Northern Burrowing Frog						•																					
<i>Neobatrachus sutor</i>	Shoemaker Frog						•																					
<i>Platyplectrum spenceri</i>	Centralian Burrowing Frog										•																	
MYOBATRACHIDAE																												
<i>Pseudophryne douglasi</i>	Gorge Toadlet						•				•								•									
<i>Uperoleia russelli</i>	Northwest Toadlet								•		•																	

## **Appendix H: SRE invertebrate fauna identified in the database searches**

Phylum	Class	Order	Infraorder	Family	Species	Latitude	Longitude
Arthropoda	Arachnida	Araneae	Araneomorphae	Selenopidae	Karaops `sp. indet. (juvenile)`	-23.29012	118.6822
Arthropoda	Arachnida	Araneae	Araneomorphae	Selenopidae	Karaops `sp. indet. (juvenile)`	-23.26478	118.7539
Arthropoda	Arachnida	Araneae	Araneomorphae	Selenopidae	Karaops `sp. indet. (juvenile)`	-23.07306	118.82
Arthropoda	Arachnida	Araneae	Araneomorphae	Selenopidae	Karaops `sp. indet. (juvenile)`	-23.07306	118.825
Arthropoda	Arachnida	Araneae	Araneomorphae	Selenopidae	Karaops `sp. indet. (juvenile)`	-23.07172	118.8221
Arthropoda	Arachnida	Araneae	Araneomorphae	Selenopidae	Karaops `sp. indet. (juvenile)`	-23.07136	118.8221
Arthropoda	Arachnida	Araneae	Araneomorphae	Selenopidae	Karaops `sp. indet. (juvenile)`	-23.07055	118.8211
Arthropoda	Arachnida	Araneae	Araneomorphae	Selenopidae	Karaops `sp. indet. (juvenile)`	-23.04028	118.8517
Arthropoda	Arachnida	Araneae	Araneomorphae	Selenopidae	Karaops `sp. indet. (juvenile)`	-23.2901	118.682
Arthropoda	Arachnida	Araneae	Araneomorphae	Selenopidae	Karaops `sp. indet. (juvenile)`	-23.2648	118.754
Arthropoda	Arachnida	Araneae	Araneomorphae	Selenopidae	Karaops `sp. indet. (juvenile)`	-23.0403	118.852
Arthropoda	Arachnida	Araneae	Araneomorphae	Selenopidae	Karaops `sp. indet. (juvenile)`	-23.0731	118.82
Arthropoda	Arachnida	Araneae	Araneomorphae	Selenopidae	Karaops `sp. indet. (juvenile)`	-23.0731	118.82
Arthropoda	Arachnida	Araneae	Araneomorphae	Selenopidae	Karaops `sp. indet. (juvenile)`	-23.0731	118.82
Arthropoda	Arachnida	Araneae	Araneomorphae	Selenopidae	Karaops `sp. indet. (juvenile)`	-23.0731	118.82
Arthropoda	Arachnida	Araneae	Araneomorphae	Selenopidae	Karaops `sp. indet. (juvenile)`	-23.0731	118.825
Arthropoda	Arachnida	Araneae	Araneomorphae	Selenopidae	Karaops `sp. indet. (juvenile)`	-23.0731	118.825
Arthropoda	Arachnida	Araneae	Araneomorphae	Selenopidae	Karaops `sp. indet. (juvenile)`	-23.0731	118.825
Arthropoda	Arachnida	Araneae	Araneomorphae	Selenopidae	Karaops `sp. indet. (juvenile)`	-23.0731	118.825
Arthropoda	Arachnida	Araneae	Araneomorphae	Selenopidae	Karaops `sp. indet. (juvenile)`	-23.0706	118.821
Arthropoda	Arachnida	Araneae	Araneomorphae	Selenopidae	Karaops `sp. indet. (juvenile)`	-23.0706	118.821
Arthropoda	Arachnida	Araneae	Araneomorphae	Selenopidae	Karaops `sp. indet. (juvenile)`	-23.0706	118.821
Arthropoda	Arachnida	Araneae	Araneomorphae	Selenopidae	Karaops nyangumarta	-23.0706	118.821
Arthropoda	Arachnida	Araneae	Araneomorphae	Selenopidae	Karaops nyangumarta	-23.0706	118.821
Arthropoda	Arachnida	Araneae	Araneomorphae	Selenopidae	Karops `sp. Juv`	-23.0717	118.822
Arthropoda	Arachnida	Araneae	Araneomorphae	Selenopidae	Karops `sp. Juv`	-23.0714	118.822
Arthropoda	Arachnida	Araneae	Mygalomorphae	`F. indet.`	`G. indet.` `sp. indet.`	-23.1448	118.996
Arthropoda	Arachnida	Araneae	Mygalomorphae	`F. indet.`	`G. indet.` `sp. indet.`	-23.1448	118.996
Arthropoda	Arachnida	Araneae	Mygalomorphae	`F. indet.`	`G. indet.` `sp. indet.`	-23.1448	118.996

Phylum	Class	Order	Infraorder	Family	Species	Latitude	Longitude
Arthropoda	Arachnida	Araneae	Mygalomorphae	`F. indet.`	`G. indet.` `sp. indet.`	-23.1448	118.996
Arthropoda	Arachnida	Araneae	Mygalomorphae	Actinopodidae	Missulena `MYG045`	-23.0939	118.719
Arthropoda	Arachnida	Araneae	Mygalomorphae	Actinopodidae	Missulena `MYG045`	-23.0381	118.683
Arthropoda	Arachnida	Araneae	Mygalomorphae	Actinopodidae	Missulena `MYG045`	-23.0844	118.697
Arthropoda	Arachnida	Araneae	Mygalomorphae	Actinopodidae	Missulena `MYG045`	-23.09	118.811
Arthropoda	Arachnida	Araneae	Mygalomorphae	Actinopodidae	Missulena `MYG045`	-23.0797	118.858
Arthropoda	Arachnida	Araneae	Mygalomorphae	Actinopodidae	Missulena `MYG045`	-23.0794	118.858
Arthropoda	Arachnida	Araneae	Mygalomorphae	Actinopodidae	Missulena `MYG253-DNA`	-23.0867	118.686
Arthropoda	Arachnida	Araneae	Mygalomorphae	Actinopodidae	Missulena `MYG253-DNA`	-23.0869	118.686
Arthropoda	Arachnida	Araneae	Mygalomorphae	Actinopodidae	Missulena `sp. indet. (juvenile)`	-23.0817	118.584
Arthropoda	Arachnida	Araneae	Mygalomorphae	Actinopodidae	Missulena `sp. indet.`	-23.1428	119.01
Arthropoda	Arachnida	Araneae	Mygalomorphae	Barychelidae	`G. indet.` `sp. indet.`	-23.1448	118.996
Arthropoda	Arachnida	Araneae	Mygalomorphae	Barychelidae	Aureocrypta `MYG315`	-23.14194	118.615
Arthropoda	Arachnida	Araneae	Mygalomorphae	Barychelidae	Aureocrypta `MYG315`	-23.0425	118.7289
Arthropoda	Arachnida	Araneae	Mygalomorphae	Barychelidae	Aureocrypta `MYG315`	-23.03972	118.7658
Arthropoda	Arachnida	Araneae	Mygalomorphae	Barychelidae	Aureocrypta `MYG315`	-23.01056	118.8603
Arthropoda	Arachnida	Araneae	Mygalomorphae	Barychelidae	Aureocrypta `MYG315-DNA`	-23.0425	118.729
Arthropoda	Arachnida	Araneae	Mygalomorphae	Barychelidae	Aureocrypta `MYG315-DNA`	-23.0397	118.766
Arthropoda	Arachnida	Araneae	Mygalomorphae	Barychelidae	Aureocrypta `MYG315-DNA`	-23.1419	118.615
Arthropoda	Arachnida	Araneae	Mygalomorphae	Barychelidae	Aureocrypta `sp. indet. (juvenile)`	-23.1563	118.69
Arthropoda	Arachnida	Araneae	Mygalomorphae	Barychelidae	Synothele `MYG127`	-23.1228	118.875
Arthropoda	Arachnida	Araneae	Mygalomorphae	Barychelidae	Synothele `MYG127`	-23.1597	118.97
Arthropoda	Arachnida	Araneae	Mygalomorphae	Barychelidae	Synothele `MYG127`	-23.1428	119.01
Arthropoda	Arachnida	Araneae	Mygalomorphae	Barychelidae	Synothele `MYG127`	-23.1593	118.993
Arthropoda	Arachnida	Araneae	Mygalomorphae	Barychelidae	Synothele `MYG127`	-23.1633	118.977
Arthropoda	Arachnida	Araneae	Mygalomorphae	Barychelidae	Synothele `MYG127`	-23.1547	118.993
Arthropoda	Arachnida	Araneae	Mygalomorphae	Barychelidae	Synothele `MYG127`	-23.1615	119.002
Arthropoda	Arachnida	Araneae	Mygalomorphae	Barychelidae	Synothele `MYG309`	-23.07944	118.8581
Arthropoda	Arachnida	Araneae	Mygalomorphae	Barychelidae	Synothele `MYG309-DNA`	-23.0794	118.858
Arthropoda	Arachnida	Araneae	Mygalomorphae	Barychelidae	Synothele `MYG311-DNA`	-23.0808	118.684
Arthropoda	Arachnida	Araneae	Mygalomorphae	Barychelidae	Synothele `MYG311-DNA`	-23.0825	118.584

Phylum	Class	Order	Infraorder	Family	Species	Latitude	Longitude
Arthropoda	Arachnida	Araneae	Mygalomorphae	Barychelidae	Synothele `sp. indet. (female)`	-23.0325	118.689
Arthropoda	Arachnida	Araneae	Mygalomorphae	Barychelidae	Synothele `sp. indet. (female)`	-23.0428	118.729
Arthropoda	Arachnida	Araneae	Mygalomorphae	Barychelidae	Synothele `sp. indet. (female)`	-23.0425	118.729
Arthropoda	Arachnida	Araneae	Mygalomorphae	Barychelidae	Synothele `sp. indet. (female)`	-23.0858	118.929
Arthropoda	Arachnida	Araneae	Mygalomorphae	Barychelidae	Synothele `sp. indet. (female)`	-23.0456	118.831
Arthropoda	Arachnida	Araneae	Mygalomorphae	Barychelidae	Synothele `sp. indet. (female)`	-23.0814	118.584
Arthropoda	Arachnida	Araneae	Mygalomorphae	Barychelidae	Synothele `sp. indet. (juvenile)`	-23.0856	118.929
Arthropoda	Arachnida	Araneae	Mygalomorphae	Barychelidae	Synothele `sp. indet. (juvenile)`	-23.0458	118.831
Arthropoda	Arachnida	Araneae	Mygalomorphae	Barychelidae	Synothele `sp. indet. (juvenile)`	-23.0814	118.584
Arthropoda	Arachnida	Araneae	Mygalomorphae	Barychelidae	Synothele `sp. indet. (juvenile)`	-23.1419	118.615
Arthropoda	Arachnida	Araneae	Mygalomorphae	Ctenizidae	Conothele `MYG280`	-23.0325	118.689
Arthropoda	Arachnida	Araneae	Mygalomorphae	Ctenizidae	Conothele `MYG280`	-23.0325	118.689
Arthropoda	Arachnida	Araneae	Mygalomorphae	Ctenizidae	Conothele `MYG280`	-23.0522	118.679
Arthropoda	Arachnida	Araneae	Mygalomorphae	Ctenizidae	Conothele `MYG280`	-23.0522	118.678
Arthropoda	Arachnida	Araneae	Mygalomorphae	Ctenizidae	Conothele `MYG280`	-23.0522	118.678
Arthropoda	Arachnida	Araneae	Mygalomorphae	Ctenizidae	Conothele `MYG280`	-23.0425	118.729
Arthropoda	Arachnida	Araneae	Mygalomorphae	Ctenizidae	Conothele `MYG280`	-23.0431	118.73
Arthropoda	Arachnida	Araneae	Mygalomorphae	Ctenizidae	Conothele `MYG280`	-23.0394	118.766
Arthropoda	Arachnida	Araneae	Mygalomorphae	Ctenizidae	Conothele `MYG280`	-23.0394	118.766
Arthropoda	Arachnida	Araneae	Mygalomorphae	Ctenizidae	Conothele `MYG280`	-23.098	118.775
Arthropoda	Arachnida	Araneae	Mygalomorphae	Ctenizidae	Conothele `MYG280`	-23.0978	118.775
Arthropoda	Arachnida	Araneae	Mygalomorphae	Ctenizidae	Conothele `MYG280`	-23.0992	118.774
Arthropoda	Arachnida	Araneae	Mygalomorphae	Ctenizidae	Conothele `MYG280`	-23.0997	118.775
Arthropoda	Arachnida	Araneae	Mygalomorphae	Ctenizidae	Conothele `MYG280`	-23.1058	118.772
Arthropoda	Arachnida	Araneae	Mygalomorphae	Ctenizidae	Conothele `MYG280`	-23.1061	118.772
Arthropoda	Arachnida	Araneae	Mygalomorphae	Ctenizidae	Conothele `MYG280`	-23.1	118.775
Arthropoda	Arachnida	Araneae	Mygalomorphae	Ctenizidae	Conothele `MYG280`	-23.09	118.811
Arthropoda	Arachnida	Araneae	Mygalomorphae	Ctenizidae	Conothele `MYG280`	-23.0903	118.811
Arthropoda	Arachnida	Araneae	Mygalomorphae	Ctenizidae	Conothele `MYG280`	-23.0364	118.947
Arthropoda	Arachnida	Araneae	Mygalomorphae	Ctenizidae	Conothele `MYG280`	-23.085	118.705
Arthropoda	Arachnida	Araneae	Mygalomorphae	Ctenizidae	Conothele `MYG280`	-23.1644	118.589

Phylum	Class	Order	Infraorder	Family	Species	Latitude	Longitude
Arthropoda	Arachnida	Araneae	Mygalomorphae	Ctenizidae	Conothele `MYG280`	-23.1644	118.589
Arthropoda	Arachnida	Araneae	Mygalomorphae	Ctenizidae	Conothele `MYG280`	-23.1419	118.615
Arthropoda	Arachnida	Araneae	Mygalomorphae	Ctenizidae	Conothele `MYG280`	-23.1472	118.707
Arthropoda	Arachnida	Araneae	Mygalomorphae	Ctenizidae	Conothele `MYG280`	-23.1472	118.707
Arthropoda	Arachnida	Araneae	Mygalomorphae	Ctenizidae	Conothele `MYG280`	-23.1472	118.707
Arthropoda	Arachnida	Araneae	Mygalomorphae	Ctenizidae	Conothele `MYG280`	-23.1472	118.707
Arthropoda	Arachnida	Araneae	Mygalomorphae	Ctenizidae	Conothele `MYG280`	-23.1472	118.707
Arthropoda	Arachnida	Araneae	Mygalomorphae	Ctenizidae	Conothele `MYG281-DNA`	-23.0478	118.885
Arthropoda	Arachnida	Araneae	Mygalomorphae	Ctenizidae	Conothele `MYG281-DNA`	-23.0478	118.885
Arthropoda	Arachnida	Araneae	Mygalomorphae	Ctenizidae	Conothele `MYG281-DNA`	-23.0478	118.885
Arthropoda	Arachnida	Araneae	Mygalomorphae	Ctenizidae	Conothele `sp. indet.`	-23.0688	118.89
Arthropoda	Arachnida	Araneae	Mygalomorphae	Ctenizidae	Conothele `sp. indet.`	-23.1593	118.993
Arthropoda	Arachnida	Araneae	Mygalomorphae	Ctenizidae	Conothele `sp. indet.`	-23.1332	119.015
Arthropoda	Arachnida	Araneae	Mygalomorphae	Halonoproctidae	Conothele `MYG281-DNA`	-23.04781	118.8849
Arthropoda	Arachnida	Araneae	Mygalomorphae	Halonoproctidae	Conothele `MYG281-DNA`	-23.04781	118.885
Arthropoda	Arachnida	Araneae	Mygalomorphae	Idiopidae	`Aganippe?` `sp. indet. (female)`	-23.0133	118.875
Arthropoda	Arachnida	Araneae	Mygalomorphae	Idiopidae	`G. indet.` `sp. indet.`	-23.0325	118.689
Arthropoda	Arachnida	Araneae	Mygalomorphae	Idiopidae	`Gaius?` `sp. indet.`	-23.1002	118.809
Arthropoda	Arachnida	Araneae	Mygalomorphae	Idiopidae	`Gaius?` `sp. indet.`	-23.085	118.705
Arthropoda	Arachnida	Araneae	Mygalomorphae	Idiopidae	`Gaius?` `sp. indet.`	-23.085	118.705
Arthropoda	Arachnida	Araneae	Mygalomorphae	Idiopidae	Aganippe `MYG306-DNA`	-23.0381	118.683
Arthropoda	Arachnida	Araneae	Mygalomorphae	Idiopidae	Aganippe `MYG384-DNA`	-23.0811	118.858
Arthropoda	Arachnida	Araneae	Mygalomorphae	Idiopidae	Aganippe `sp. (female); sigillate`	-23.0131	118.875
Arthropoda	Arachnida	Araneae	Mygalomorphae	Idiopidae	Aganippe `sp. indet. (female)`	-23.0394	118.766
Arthropoda	Arachnida	Araneae	Mygalomorphae	Idiopidae	Aganippe `sp. indet.`	-23.0381	118.683
Arthropoda	Arachnida	Araneae	Mygalomorphae	Idiopidae	Aganippe `sp. indet.`	-23.0688	118.89
Arthropoda	Arachnida	Araneae	Mygalomorphae	Idiopidae	Aganippe `sp. indet.`	-23.1002	118.811
Arthropoda	Arachnida	Araneae	Mygalomorphae	Idiopidae	Aganippe `sp. indet.`	-23.1002	118.811
Arthropoda	Arachnida	Araneae	Mygalomorphae	Idiopidae	Aganippe `sp. indet.`	-23.085	118.705
Arthropoda	Arachnida	Araneae	Mygalomorphae	Idiopidae	Aganippe `sp. indet.`	-23.085	118.705
Arthropoda	Arachnida	Araneae	Mygalomorphae	Idiopidae	Aganippe `sp. indet.`	-23.085	118.705

Phylum	Class	Order	Infraorder	Family	Species	Latitude	Longitude
Arthropoda	Arachnida	Araneae	Mygalomorphae	Idiopidae	Aganippe `sp. indet.`	-23.085	118.705
Arthropoda	Arachnida	Araneae	Mygalomorphae	Idiopidae	Aganippe `sp. indet.`	-23.0688	118.89
Arthropoda	Arachnida	Araneae	Mygalomorphae	Idiopidae	Aganippe `sp. indet.`	-23.0688	118.89
Arthropoda	Arachnida	Araneae	Mygalomorphae	Idiopidae	Aganippe `sp. indet.`	-23.0688	118.89
Arthropoda	Arachnida	Araneae	Mygalomorphae	Idiopidae	Aganippe `sp. indet.`	-23.085	118.705
Arthropoda	Arachnida	Araneae	Mygalomorphae	Idiopidae	Aganippe `sp. indet.`	-23.0688	118.89
Arthropoda	Arachnida	Araneae	Mygalomorphae	Idiopidae	Anidiops `MYG083`	-23.1394	119.018
Arthropoda	Arachnida	Araneae	Mygalomorphae	Idiopidae	Anidiops `MYG083`	-23.1142	119.023
Arthropoda	Arachnida	Araneae	Mygalomorphae	Idiopidae	Anidiops `MYG083`	-23.1633	118.977
Arthropoda	Arachnida	Araneae	Mygalomorphae	Idiopidae	Anidiops `MYG083`	-23.1593	118.993
Arthropoda	Arachnida	Araneae	Mygalomorphae	Idiopidae	Anidiops `MYG083`	-23.1394	119.018
Arthropoda	Arachnida	Araneae	Mygalomorphae	Idiopidae	Anidiops `MYG083`	-23.1633	118.977
Arthropoda	Arachnida	Araneae	Mygalomorphae	Idiopidae	Anidiops `MYG083`	-23.1592	118.993
Arthropoda	Arachnida	Araneae	Mygalomorphae	Idiopidae	Anidiops `MYG083`	-23.1593	118.993
Arthropoda	Arachnida	Araneae	Mygalomorphae	Idiopidae	Anidiops `MYG083`	-23.1593	118.993
Arthropoda	Arachnida	Araneae	Mygalomorphae	Idiopidae	Anidiops `MYG286-DNA`	-23.0378	118.682
Arthropoda	Arachnida	Araneae	Mygalomorphae	Idiopidae	Anidiops `MYG286-DNA`	-23.0381	118.683
Arthropoda	Arachnida	Araneae	Mygalomorphae	Idiopidae	Anidiops `MYG286-DNA`	-23.0425	118.729
Arthropoda	Arachnida	Araneae	Mygalomorphae	Idiopidae	Anidiops `MYG286-DNA`	-23.0903	118.811
Arthropoda	Arachnida	Araneae	Mygalomorphae	Idiopidae	Anidiops `MYG286-DNA`	-23.085	118.705
Arthropoda	Arachnida	Araneae	Mygalomorphae	Idiopidae	Anidiops `MYG286-DNA`	-23.085	118.705
Arthropoda	Arachnida	Araneae	Mygalomorphae	Idiopidae	Anidiops `MYG286-DNA`	-23.0688	118.89
Arthropoda	Arachnida	Araneae	Mygalomorphae	Idiopidae	Anidiops `MYG286-DNA`	-23.1002	118.811
Arthropoda	Arachnida	Araneae	Mygalomorphae	Idiopidae	Anidiops `MYG286-DNA`	-23.1002	118.811
Arthropoda	Arachnida	Araneae	Mygalomorphae	Idiopidae	Anidiops `MYG286-DNA`	-23.085	118.705
Arthropoda	Arachnida	Araneae	Mygalomorphae	Idiopidae	Anidiops `MYG286-DNA`	-23.0688	118.89
Arthropoda	Arachnida	Araneae	Mygalomorphae	Idiopidae	Anidiops `MYG286-DNA`	-23.0688	118.89
Arthropoda	Arachnida	Araneae	Mygalomorphae	Idiopidae	Anidiops `sp. indet. (female)`	-23.0942	118.719
Arthropoda	Arachnida	Araneae	Mygalomorphae	Idiopidae	Anidiops `sp. Indet. (female)`	-23.0914	118.67
Arthropoda	Arachnida	Araneae	Mygalomorphae	Idiopidae	Anidiops `sp. Indet. (female)`	-23.0914	118.67
Arthropoda	Arachnida	Araneae	Mygalomorphae	Idiopidae	Anidiops `sp. indet. (female)`	-23.0867	118.686

Phylum	Class	Order	Infraorder	Family	Species	Latitude	Longitude
Arthropoda	Arachnida	Araneae	Mygalomorphae	Idiopidae	Anidiops `sp. indet. (female)`	-23.0869	118.686
Arthropoda	Arachnida	Araneae	Mygalomorphae	Idiopidae	Anidiops `sp. indet. (female)`	-23.0519	118.678
Arthropoda	Arachnida	Araneae	Mygalomorphae	Idiopidae	Anidiops `sp. indet. (female)`	-23.0519	118.678
Arthropoda	Arachnida	Araneae	Mygalomorphae	Idiopidae	Anidiops `sp. indet. (female)`	-23.0394	118.766
Arthropoda	Arachnida	Araneae	Mygalomorphae	Idiopidae	Anidiops `sp. indet. (female)`	-23.0394	118.766
Arthropoda	Arachnida	Araneae	Mygalomorphae	Idiopidae	Anidiops `sp. indet. (female)`	-23.098	118.775
Arthropoda	Arachnida	Araneae	Mygalomorphae	Idiopidae	Anidiops `sp. indet. (female)`	-23.0797	118.858
Arthropoda	Arachnida	Araneae	Mygalomorphae	Idiopidae	Anidiops `sp. indet. (juvenile)`	-23.0856	118.929
Arthropoda	Arachnida	Araneae	Mygalomorphae	Idiopidae	Anidiops `sp. indet.`	-23.0428	118.729
Arthropoda	Arachnida	Araneae	Mygalomorphae	Idiopidae	Anidiops `sp. indet.`	-23.0975	118.774
Arthropoda	Arachnida	Araneae	Mygalomorphae	Idiopidae	Anidiops `sp. indet.`	-23.1056	118.772
Arthropoda	Arachnida	Araneae	Mygalomorphae	Idiopidae	Anidiops `sp. indet.`	-23.0358	118.947
Arthropoda	Arachnida	Araneae	Mygalomorphae	Idiopidae	Anidiops `sp. indet.`	-23.0858	118.929
Arthropoda	Arachnida	Araneae	Mygalomorphae	Idiopidae	Anidiops `sp. nov.`	-23.0277	118.687
Arthropoda	Arachnida	Araneae	Mygalomorphae	Idiopidae	Anidiops `Wonmunna large`	-23.1597	118.97
Arthropoda	Arachnida	Araneae	Mygalomorphae	Idiopidae	Anidiops `Wonmunna large`	-23.1502	119.009
Arthropoda	Arachnida	Araneae	Mygalomorphae	Idiopidae	Eucyrtops `sp. Indet. (female)`	-23.0939	118.719
Arthropoda	Arachnida	Araneae	Mygalomorphae	Idiopidae	Eucyrtops `sp. indet. (female)`	-23.0633	118.625
Arthropoda	Arachnida	Araneae	Mygalomorphae	Idiopidae	Eucyrtops `sp. indet. (female)`	-23.0381	118.683
Arthropoda	Arachnida	Araneae	Mygalomorphae	Idiopidae	Eucyrtops `sp. indet. (female)`	-23.0178	118.907
Arthropoda	Arachnida	Araneae	Mygalomorphae	Idiopidae	Eucyrtops `sp. indet. (female)`	-23.0425	118.729
Arthropoda	Arachnida	Araneae	Mygalomorphae	Idiopidae	Eucyrtops `sp. indet. (female)`	-23.0808	118.684
Arthropoda	Arachnida	Araneae	Mygalomorphae	Idiopidae	Eucyrtops `sp. indet. (female)`	-23.0808	118.684
Arthropoda	Arachnida	Araneae	Mygalomorphae	Idiopidae	Eucyrtops `sp. indet. (female)`	-23.0844	118.697
Arthropoda	Arachnida	Araneae	Mygalomorphae	Idiopidae	Eucyrtops `sp. indet. (female)`	-23.098	118.775
Arthropoda	Arachnida	Araneae	Mygalomorphae	Idiopidae	Eucyrtops `sp. indet. (female)`	-23.098	118.775
Arthropoda	Arachnida	Araneae	Mygalomorphae	Idiopidae	Eucyrtops `sp. indet. (female)`	-23.1056	118.772
Arthropoda	Arachnida	Araneae	Mygalomorphae	Idiopidae	Eucyrtops `sp. indet. (female)`	-23.0794	118.858
Arthropoda	Arachnida	Araneae	Mygalomorphae	Idiopidae	Eucyrtops `sp. indet. (juvenile)`	-23.0844	118.697
Arthropoda	Arachnida	Araneae	Mygalomorphae	Idiopidae	Eucyrtops `sp. indet. (juvenile)`	-23.0844	118.697
Arthropoda	Arachnida	Araneae	Mygalomorphae	Idiopidae	Eucyrtops `sp. indet. (juvenile)`	-23.1061	118.772

Phylum	Class	Order	Infraorder	Family	Species	Latitude	Longitude
Arthropoda	Arachnida	Araneae	Mygalomorphae	Idiopidae	Eucyrtops `sp. indet.`	-23.0694	118.791
Arthropoda	Arachnida	Araneae	Mygalomorphae	Idiopidae	Eucyrtops `sp. indet.`	-23.1058	118.772
Arthropoda	Arachnida	Araneae	Mygalomorphae	Idiopidae	Eucyrtops `sp. indet.`	-23.1061	118.772
Arthropoda	Arachnida	Araneae	Mygalomorphae	Idiopidae	Eucyrtops `sp. indet.`	-23.1064	118.773
Arthropoda	Arachnida	Araneae	Mygalomorphae	Idiopidae	Eucyrtops `sp. indet.`	-23.1067	118.773
Arthropoda	Arachnida	Araneae	Mygalomorphae	Idiopidae	Eucyrtops `sp. indet.`	-23.1006	118.901
Arthropoda	Arachnida	Araneae	Mygalomorphae	Nemesiidae	`G. indet.` `sp. indet.`	-23.085	118.705
Arthropoda	Arachnida	Araneae	Mygalomorphae	Nemesiidae	`G. indet.` `sp. indet.`	-23.2	118.82
Arthropoda	Arachnida	Araneae	Mygalomorphae	Nemesiidae	Aname `MYG004`	-23.0381	118.683
Arthropoda	Arachnida	Araneae	Mygalomorphae	Nemesiidae	Aname `MYG004`	-23.0522	118.678
Arthropoda	Arachnida	Araneae	Mygalomorphae	Nemesiidae	Aname `MYG004`	-23.098	118.774
Arthropoda	Arachnida	Araneae	Mygalomorphae	Nemesiidae	Aname `MYG004`	-23.1067	118.773
Arthropoda	Arachnida	Araneae	Mygalomorphae	Nemesiidae	Aname `MYG004`	-23.0364	118.947
Arthropoda	Arachnida	Araneae	Mygalomorphae	Nemesiidae	Aname `MYG004`	-23.0364	118.947
Arthropoda	Arachnida	Araneae	Mygalomorphae	Nemesiidae	Aname `MYG004`	-23.0814	118.584
Arthropoda	Arachnida	Araneae	Mygalomorphae	Nemesiidae	Aname `sp. indet. (female)`	-23.098	118.775
Arthropoda	Arachnida	Araneae	Mygalomorphae	Nemesiidae	Aname `sp. indet. (juvenile)`	-23.0842	118.604
Arthropoda	Arachnida	Araneae	Mygalomorphae	Nemesiidae	Aname `sp. indet. (juvenile)`	-23.0842	118.604
Arthropoda	Arachnida	Araneae	Mygalomorphae	Nemesiidae	Aname `sp. indet. (juvenile)`	-23.0939	118.719
Arthropoda	Arachnida	Araneae	Mygalomorphae	Nemesiidae	Aname `sp. indet. (juvenile)`	-23.0914	118.67
Arthropoda	Arachnida	Araneae	Mygalomorphae	Nemesiidae	Aname `sp. indet. (juvenile)`	-23.0633	118.625
Arthropoda	Arachnida	Araneae	Mygalomorphae	Nemesiidae	Aname `sp. indet. (juvenile)`	-23.0633	118.625
Arthropoda	Arachnida	Araneae	Mygalomorphae	Nemesiidae	Aname `sp. indet. (juvenile)`	-23.07	118.651
Arthropoda	Arachnida	Araneae	Mygalomorphae	Nemesiidae	Aname `sp. indet. (juvenile)`	-23.07	118.651
Arthropoda	Arachnida	Araneae	Mygalomorphae	Nemesiidae	Aname `sp. indet. (juvenile)`	-23.0381	118.683
Arthropoda	Arachnida	Araneae	Mygalomorphae	Nemesiidae	Aname `sp. indet. (juvenile)`	-23.0381	118.683
Arthropoda	Arachnida	Araneae	Mygalomorphae	Nemesiidae	Aname `sp. indet. (juvenile)`	-23.0381	118.683
Arthropoda	Arachnida	Araneae	Mygalomorphae	Nemesiidae	Aname `sp. indet. (juvenile)`	-23.0808	118.684
Arthropoda	Arachnida	Araneae	Mygalomorphae	Nemesiidae	Aname `sp. indet. (juvenile)`	-23.0842	118.698
Arthropoda	Arachnida	Araneae	Mygalomorphae	Nemesiidae	Aname `sp. indet. (juvenile)`	-23.0983	118.775
Arthropoda	Arachnida	Araneae	Mygalomorphae	Nemesiidae	Aname `sp. indet. (juvenile)`	-23.1056	118.772

Phylum	Class	Order	Infraorder	Family	Species	Latitude	Longitude
Arthropoda	Arachnida	Araneae	Mygalomorphae	Nemesiidae	Aname `sp. indet. (juvenile)`	-23.1067	118.775
Arthropoda	Arachnida	Araneae	Mygalomorphae	Nemesiidae	Aname `sp. indet. (juvenile)`	-23.0903	118.811
Arthropoda	Arachnida	Araneae	Mygalomorphae	Nemesiidae	Aname `sp. indet. (juvenile)`	-23.1	118.901
Arthropoda	Arachnida	Araneae	Mygalomorphae	Nemesiidae	Aname `sp. indet. (juvenile)`	-23.0131	118.875
Arthropoda	Arachnida	Araneae	Mygalomorphae	Nemesiidae	Aname `sp. indet. (juvenile)`	-23.0131	118.875
Arthropoda	Arachnida	Araneae	Mygalomorphae	Nemesiidae	Aname `sp. indet. (juvenile)`	-23.1633	118.977
Arthropoda	Arachnida	Araneae	Mygalomorphae	Nemesiidae	Aname `sp. indet.`	-23.0867	118.686
Arthropoda	Arachnida	Araneae	Mygalomorphae	Nemesiidae	Aname `sp. indet.`	-23.0381	118.683
Arthropoda	Arachnida	Araneae	Mygalomorphae	Nemesiidae	Aname `sp. indet.`	-23.0381	118.683
Arthropoda	Arachnida	Araneae	Mygalomorphae	Nemesiidae	Aname `sp. indet.`	-23.098	118.774
Arthropoda	Arachnida	Araneae	Mygalomorphae	Nemesiidae	Aname `sp. indet.`	-23.0856	118.929
Arthropoda	Arachnida	Araneae	Mygalomorphae	Nemesiidae	Aname `sp. indet.`	-23.0717	118.901
Arthropoda	Arachnida	Araneae	Mygalomorphae	Nemesiidae	Aname `sp. indet.`	-23.0717	118.901
Arthropoda	Arachnida	Araneae	Mygalomorphae	Nemesiidae	Aname `sp. indet.`	-23.0688	118.89
Arthropoda	Arachnida	Araneae	Mygalomorphae	Nemesiidae	Aname `sp. indet.`	-23.0688	118.89
Arthropoda	Arachnida	Araneae	Mygalomorphae	Nemesiidae	Aname `sp. indet.`	-23.085	118.705
Arthropoda	Arachnida	Araneae	Mygalomorphae	Nemesiidae	Aname `sp. indet.`	-23.0997	118.811
Arthropoda	Arachnida	Araneae	Mygalomorphae	Nemesiidae	Aname mellosa	-23.0836	118.604
Arthropoda	Arachnida	Araneae	Mygalomorphae	Nemesiidae	Aname mellosa	-23.0178	118.907
Arthropoda	Arachnida	Araneae	Mygalomorphae	Nemesiidae	Aname mellosa	-23.0522	118.678
Arthropoda	Arachnida	Araneae	Mygalomorphae	Nemesiidae	Aname mellosa	-23.0522	118.678
Arthropoda	Arachnida	Araneae	Mygalomorphae	Nemesiidae	Aname mellosa	-23.0808	118.684
Arthropoda	Arachnida	Araneae	Mygalomorphae	Nemesiidae	Aname mellosa	-23.1831	118.675
Arthropoda	Arachnida	Araneae	Mygalomorphae	Nemesiidae	Aname mellosa	-23.1831	118.675
Arthropoda	Arachnida	Araneae	Mygalomorphae	Nemesiidae	Aname mellosa	-23.0458	118.832
Arthropoda	Arachnida	Araneae	Mygalomorphae	Nemesiidae	Aname mellosa	-23.0133	118.875
Arthropoda	Arachnida	Araneae	Mygalomorphae	Nemesiidae	Aname mellosa	-23.018	118.907
Arthropoda	Arachnida	Araneae	Mygalomorphae	Nemesiidae	Aname mellosa	-23.0172	118.908
Arthropoda	Arachnida	Araneae	Mygalomorphae	Nemesiidae	Kwonkan `MYG339-DNA`	-23.0131	118.875
Arthropoda	Arachnida	Araneae	Mygalomorphae	Nemesiidae	Kwonkan `MYG339-DNA`	-23.0131	118.875
Arthropoda	Arachnida	Araneae	Mygalomorphae	Nemesiidae	Kwonkan `MYG339-DNA`	-23.0131	118.875

Phylum	Class	Order	Infraorder	Family	Species	Latitude	Longitude
Arthropoda	Arachnida	Araneae	Mygalomorphae	Nemesiidae	Kwonkan `MYG339-DNA`	-23.0178	118.908
Arthropoda	Arachnida	Araneae	Mygalomorphae	Nemesiidae	Kwonkan `MYG339-DNA`	-23.0178	118.907
Arthropoda	Arachnida	Araneae	Mygalomorphae	Nemesiidae	Kwonkan `MYG380-DNA`	-23.0939	118.719
Arthropoda	Arachnida	Araneae	Mygalomorphae	Nemesiidae	Teyl `sp. indet. (juvenile)`	-23.0869	118.686
Arthropoda	Arachnida	Araneae	Mygalomorphae	Nemesiidae	Teyl `sp. indet. (juvenile)`	-23.0692	118.791
Arthropoda	Arachnida	Araneae	Mygalomorphae	Nemesiidae	Teyl `sp. indet. (juvenile)`	-23.1	118.901
Arthropoda	Arachnida	Araneae	Mygalomorphae	Nemesiidae	Teyl `sp. indet. (juvenile)`	-23.0858	118.929
Arthropoda	Arachnida	Araneae	Mygalomorphae	Nemesiidae	Teyl `sp. indet. (juvenile)`	-23.1547	118.993
Arthropoda	Arachnida	Araneae	Mygalomorphae	Nemesiidae	Yilgarnia `MYG197`	-23.17235	118.6239
Arthropoda	Arachnida	Araneae	Mygalomorphae	Nemesiidae	Yilgarnia `MYG197`	-23.1723	118.624
Arthropoda	Arachnida	Pseudoscorpiones	Panctenata	Atemnidae	Oratemnus `sp. indet. (juvenile)`	-23.15466	118.9932
Arthropoda	Arachnida	Pseudoscorpiones	Panctenata	Atemnidae	Oratemnus `sp. indet. (juvenile)`	-23.14284	119.0099
Arthropoda	Arachnida	Pseudoscorpiones	Panctenata	Atemnidae	Oratemnus `sp. indet. (juvenile)`	-23.00556	118.8275
Arthropoda	Arachnida	Pseudoscorpiones	Panctenata	Atemnidae	Oratemnus `sp. indet.`	-23.1597	118.97
Arthropoda	Arachnida	Pseudoscorpiones	Panctenata	Atemnidae	Oratemnus `sp. indet.`	-23.1428	119.01
Arthropoda	Arachnida	Pseudoscorpiones	Panctenata	Atemnidae	Oratemnus `sp. indet.`	-23.1597	118.97
Arthropoda	Arachnida	Pseudoscorpiones	Panctenata	Atemnidae	Oratemnus `sp. indet.`	-23.1547	118.993
Arthropoda	Arachnida	Pseudoscorpiones	Panctenata	Atemnidae	Oratemnus `sp. indet.`	-23.1547	118.993
Arthropoda	Arachnida	Pseudoscorpiones	Panctenata	Atemnidae	Oratemnus `sp. indet.`	-23.1428	119.01
Arthropoda	Arachnida	Pseudoscorpiones	Panctenata	Atemnidae	Oratemnus `sp. indet.`	-23.1547	118.993
Arthropoda	Arachnida	Pseudoscorpiones	Panctenata	Atemnidae	Oratemnus `sp. indet.`	-23.1547	118.993
Arthropoda	Arachnida	Pseudoscorpiones	Panctenata	Atemnidae	Oratemnus `sp. indet.`	-23.1597	118.97
Arthropoda	Arachnida	Pseudoscorpiones	Panctenata	Atemnidae	Oratemnus `sp. indet.`	-23.288	118.754
Arthropoda	Arachnida	Pseudoscorpiones	Panctenata	Atemnidae	Oratemnus `sp. indet.`	-23.3128	118.781
Arthropoda	Arachnida	Pseudoscorpiones	Panctenata	Atemnidae	Oratemnus `sp. indet.`	-23.15965	118.9703
Arthropoda	Arachnida	Pseudoscorpiones	Panctenata	Atemnidae	Oratemnus `sp. indet.`	-23.15466	118.9932
Arthropoda	Arachnida	Pseudoscorpiones	Panctenata	Atemnidae	Oratemnus `sp. indet.`	-23.14284	119.0099
Arthropoda	Arachnida	Pseudoscorpiones	Panctenata	Atemnidae	Oratemnus `sp. indet.`	-23.03278	118.7928
Arthropoda	Arachnida	Pseudoscorpiones	Panctenata	Atemnidae	Oratemnus `sp. indet.`	-23.01808	118.8176
Arthropoda	Arachnida	Pseudoscorpiones	Panctenata	Atemnidae	Oratemnus `sp. indet.`	-23.00556	118.8275
Arthropoda	Arachnida	Pseudoscorpiones	Panctenata	Garypidae	Synsphyronus `PSE085`	-23.0798	118.811

Phylum	Class	Order	Infraorder	Family	Species	Latitude	Longitude
Arthropoda	Arachnida	Pseudoscorpiones	Panctenata	Garypidae	Synsphyronus `PSE085`	-23.0798	118.811
Arthropoda	Arachnida	Pseudoscorpiones	Panctenata	Garypidae	Synsphyronus `PSE085`	-23.0798	118.811
Arthropoda	Arachnida	Pseudoscorpiones	Panctenata	Garypidae	Synsphyronus `PSE085`	-23.0798	118.811
Arthropoda	Arachnida	Pseudoscorpiones	Panctenata	Garypidae	Synsphyronus `PSE085`	-23.0798	118.811
Arthropoda	Arachnida	Pseudoscorpiones	Panctenata	Garypidae	Synsphyronus `PSE085`	-23.0798	118.811
Arthropoda	Arachnida	Pseudoscorpiones	Panctenata	Garypidae	Synsphyronus `PSE085`	-23.0798	118.811
Arthropoda	Arachnida	Pseudoscorpiones	Panctenata	Garypidae	Synsphyronus `sp. indet. (juvenile)`	-23.0476	118.885
Arthropoda	Arachnida	Pseudoscorpiones	Panctenata	Garypidae	Synsphyronus `sp. indet. (juvenile)`	-23.0474	118.885
Arthropoda	Arachnida	Pseudoscorpiones	Panctenata	Garypidae	Synsphyronus `sp. nov. 8/1 Pilbara`	-23.0808	118.684
Arthropoda	Arachnida	Pseudoscorpiones	Panctenata	Garypidae	Synsphyronus gracilis	-23.0474	118.885
Arthropoda	Arachnida	Pseudoscorpiones	Panctenata	Garypidae	Synsphyronus gracilis	-23.0388	118.853
Arthropoda	Arachnida	Pseudoscorpiones	Panctenata	Garypidae	Synsphyronus gracilis	-23.0474	118.885
Arthropoda	Arachnida	Pseudoscorpiones	Panctenata	Garypidae	Synsphyronus gracilis	-23.0474	118.885
Arthropoda	Arachnida	Pseudoscorpiones	Panctenata	Garypidae	Synsphyronus gracilis	-23.0474	118.885
Arthropoda	Arachnida	Pseudoscorpiones	Panctenata	Garypidae	Synsphyronus gracilis	-23.0476	118.885
Arthropoda	Arachnida	Pseudoscorpiones	Panctenata	Garypidae	Synsphyronus gracilis	-23.0797	118.811
Arthropoda	Arachnida	Pseudoscorpiones	Panctenata	Garypidae	Synsphyronus gracilis	-23.07972	118.81083
Arthropoda	Arachnida	Pseudoscorpiones	Panctenata	Garypidae	Synsphyronus gracilis	-23.04756	118.885
Arthropoda	Arachnida	Pseudoscorpiones	Panctenata	Garypidae	Synsphyronus gracilis	-23.04739	118.8852
Arthropoda	Arachnida	Pseudoscorpiones	Panctenata	Garypidae	Synsphyronus gracilis	-23.03883	118.8527
Arthropoda	Arachnida	Pseudoscorpiones	Panctenata	Olpiidae	`G. indet.` `sp. indet. (juvenile)`	-23.0781	118.585
Arthropoda	Arachnida	Pseudoscorpiones	Panctenata	Olpiidae	`G. indet.` `sp. indet. (juvenile)`	-23.1229	118.862
Arthropoda	Arachnida	Pseudoscorpiones	Panctenata	Olpiidae	`G. indet.` `sp. indet. (juvenile)`	-23.0781	118.585
Arthropoda	Arachnida	Pseudoscorpiones	Panctenata	Olpiidae	`G. indet.` `sp. indet.`	-23.1332	119.015
Arthropoda	Arachnida	Pseudoscorpiones	Panctenata	Olpiidae	`G. indet.` `sp. indet.`	-23.1394	119.018
Arthropoda	Arachnida	Pseudoscorpiones	Panctenata	Olpiidae	`G. indet.` `sp. indet.`	-23.1547	118.993
Arthropoda	Arachnida	Pseudoscorpiones	Panctenata	Olpiidae	`Genus 7/4` `sp. indet.`	-23.0478	118.885
Arthropoda	Arachnida	Pseudoscorpiones	Panctenata	Olpiidae	`Genus 7/4` `sp. indet.`	-23.0717	118.823
Arthropoda	Arachnida	Pseudoscorpiones	Panctenata	Olpiidae	`Genus indet. (juvenile)` `sp. indet. (juvenile)`	-23.1904	118.828
Arthropoda	Arachnida	Pseudoscorpiones	Panctenata	Olpiidae	`Genus indet. (juvenile)` `sp. indet. (juvenile)`	-23.1917	118.641
Arthropoda	Arachnida	Pseudoscorpiones	Panctenata	Olpiidae	`PSEAAA` `sp. indet.`	-23.2809	118.716

Phylum	Class	Order	Infraorder	Family	Species	Latitude	Longitude
Arthropoda	Arachnida	Pseudoscorpiones	Panctenata	Olpidae	Austrohorus `sp. indet.`	-23.1615	119.002
Arthropoda	Arachnida	Pseudoscorpiones	Panctenata	Olpidae	Austrohorus `sp. indet.`	-23.1615	119.002
Arthropoda	Arachnida	Pseudoscorpiones	Panctenata	Olpidae	Austrohorus `sp. indet.`	-23.1632	118.977
Arthropoda	Arachnida	Pseudoscorpiones	Panctenata	Olpidae	Austrohorus `sp. indet.`	-23.16325	118.97698
Arthropoda	Arachnida	Pseudoscorpiones	Panctenata	Olpidae	Austrohorus `sp. indet.`	-23.16154	119.00198
Arthropoda	Arachnida	Pseudoscorpiones	Panctenata	Olpidae	Austrohorus `sp. indet.`	-23.1615	119.002
Arthropoda	Arachnida	Pseudoscorpiones	Panctenata	Olpidae	Beierolpium `8/4`	-23.1437	119.006
Arthropoda	Arachnida	Pseudoscorpiones	Panctenata	Olpidae	Beierolpium `8/4`	-23.1592	118.993
Arthropoda	Arachnida	Pseudoscorpiones	Panctenata	Olpidae	Beierolpium `8/4`	-23.1332	119.015
Arthropoda	Arachnida	Pseudoscorpiones	Panctenata	Olpidae	Beierolpium `8/4`	-23.1332	119.015
Arthropoda	Arachnida	Pseudoscorpiones	Panctenata	Olpidae	Beierolpium `sp. 8/4 lge`	-23.0781	118.585
Arthropoda	Arachnida	Pseudoscorpiones	Panctenata	Olpidae	Beierolpium `sp. 8/4 small`	-23.2631	118.783
Arthropoda	Arachnida	Pseudoscorpiones	Panctenata	Olpidae	Beierolpium `sp. 8/4 small`	-23.3235	118.782
Arthropoda	Arachnida	Pseudoscorpiones	Panctenata	Olpidae	Beierolpium `sp. 8/4 small`	-23.3128	118.781
Arthropoda	Arachnida	Pseudoscorpiones	Panctenata	Olpidae	Beierolpium `sp. indet. (juvenile)`	-23.0779	118.752
Arthropoda	Arachnida	Pseudoscorpiones	Panctenata	Olpidae	Beierolpium `sp. indet. (juvenile)`	-23.1875	118.71
Arthropoda	Arachnida	Pseudoscorpiones	Panctenata	Olpidae	Euryolpium `sp. indet. (juvenile)`	-23.1481	118.691
Arthropoda	Arachnida	Pseudoscorpiones	Panctenata	Olpidae	Euryolpium `sp. indet.`	-23.1332	119.015
Arthropoda	Arachnida	Pseudoscorpiones	Panctenata	Olpidae	Euryolpium `sp. indet.`	-23.1615	119.002
Arthropoda	Arachnida	Pseudoscorpiones	Panctenata	Olpidae	Euryolpium `sp. indet.`	-23.1332	119.015
Arthropoda	Arachnida	Pseudoscorpiones	Panctenata	Olpidae	Euryolpium `sp. indet.`	-23.1597	118.97
Arthropoda	Arachnida	Pseudoscorpiones	Panctenata	Olpidae	Euryolpium `sp. indet.`	-23.2648	118.754
Arthropoda	Arachnida	Pseudoscorpiones	Panctenata	Olpidae	Indolpium `sp. indet. (juvenile)`	-23.16326	118.977
Arthropoda	Arachnida	Pseudoscorpiones	Panctenata	Olpidae	Indolpium `sp. indet. (juvenile)`	-23.15466	118.9932
Arthropoda	Arachnida	Pseudoscorpiones	Panctenata	Olpidae	Indolpium `sp. indet. (juvenile)`	-23.14368	119.0064
Arthropoda	Arachnida	Pseudoscorpiones	Panctenata	Olpidae	Indolpium `sp. indet.`	-23.0172	118.889
Arthropoda	Arachnida	Pseudoscorpiones	Panctenata	Olpidae	Indolpium `sp. indet.`	-23.1986	118.72
Arthropoda	Arachnida	Pseudoscorpiones	Panctenata	Olpidae	Indolpium `sp. indet.`	-23.1192	118.645
Arthropoda	Arachnida	Pseudoscorpiones	Panctenata	Olpidae	Indolpium `sp. indet.`	-23.0172	118.889
Arthropoda	Arachnida	Pseudoscorpiones	Panctenata	Olpidae	Indolpium `sp. indet.`	-23.1417	118.64
Arthropoda	Arachnida	Pseudoscorpiones	Panctenata	Olpidae	Indolpium `sp. indet.`	-23.1142	119.023

Phylum	Class	Order	Infraorder	Family	Species	Latitude	Longitude
Arthropoda	Arachnida	Pseudoscorpiones	Panctenata	Olpidae	Indolpium `sp. indet.`	-23.1597	118.97
Arthropoda	Arachnida	Pseudoscorpiones	Panctenata	Olpidae	Indolpium `sp. indet.`	-23.1547	118.993
Arthropoda	Arachnida	Pseudoscorpiones	Panctenata	Olpidae	Indolpium `sp. indet.`	-23.1437	119.006
Arthropoda	Arachnida	Pseudoscorpiones	Panctenata	Olpidae	Indolpium `sp. indet.`	-23.1332	119.015
Arthropoda	Arachnida	Pseudoscorpiones	Panctenata	Olpidae	Indolpium `sp. indet.`	-23.1633	118.977
Arthropoda	Arachnida	Pseudoscorpiones	Panctenata	Olpidae	Indolpium `sp. indet.`	-23.1142	119.023
Arthropoda	Arachnida	Pseudoscorpiones	Panctenata	Olpidae	Indolpium `sp. indet.`	-23.1142	119.023
Arthropoda	Arachnida	Pseudoscorpiones	Panctenata	Olpidae	Indolpium `sp. indet.`	-23.2901	118.682
Arthropoda	Arachnida	Pseudoscorpiones	Panctenata	Olpidae	Indolpium `sp. indet.`	-23.0781	118.585
Arthropoda	Arachnida	Pseudoscorpiones	Panctenata	Olpidae	Indolpium `sp. indet.`	-23.1481	118.691
Arthropoda	Arachnida	Pseudoscorpiones	Panctenata	Olpidae	Indolpium `sp. indet.`	-23.0781	118.585
Arthropoda	Arachnida	Pseudoscorpiones	Panctenata	Olpidae	Indolpium `sp. indet.`	-23.0781	118.585
Arthropoda	Arachnida	Pseudoscorpiones	Panctenata	Olpidae	Indolpium `sp. indet.`	-23.0798	118.811
Arthropoda	Arachnida	Pseudoscorpiones	Panctenata	Olpidae	Indolpium `sp. indet.`	-23.15965	118.9703
Arthropoda	Arachnida	Pseudoscorpiones	Panctenata	Olpidae	Indolpium `sp. indet.`	-23.13317	119.0154
Arthropoda	Arachnida	Pseudoscorpiones	Panctenata	Olpidae	Indolpium `sp.`	-23.0797	118.811
Arthropoda	Arachnida	Pseudoscorpiones	Panctenata	Olpidae	Indolpium `sp.`	-23.0797	118.811
Arthropoda	Arachnida	Pseudoscorpiones	Panctenata	Olpidae	Indolpium `sp.`	-23.07972	118.81083
Arthropoda	Arachnida	Pseudoscorpiones	Panctenata	Olpidae	Xenolpium `sp. indet. (juvenile)`	-23.1229	118.862
Arthropoda	Arachnida	Pseudoscorpiones	Panctenata	Olpidae	Xenolpium `sp. indet. (juvenile)`	-23.12293	118.8618
Arthropoda	Arachnida	Pseudoscorpiones	Panctenata	Olpidae	Xenolpium `sp. indet.`	-23.1557	118.691
Arthropoda	Arachnida	Pseudoscorpiones	Panctenata	Olpidae	Xenolpium `sp. indet.`	-23.2022	118.83
Arthropoda	Arachnida	Pseudoscorpiones	Panctenata	Olpidae	Xenolpium `sp. indet.`	-23.1557	118.691
Arthropoda	Arachnida	Pseudoscorpiones	Panctenata	Olpidae	Xenolpium `sp. indet.`	-23.1723	118.624
Arthropoda	Arachnida	Pseudoscorpiones	Panctenata	Olpidae	Xenolpium `sp. indet.`	-23.1342	118.837
Arthropoda	Arachnida	Pseudoscorpiones	Panctenata	Olpidae	Xenolpium `sp. indet.`	-23.1229	118.862
Arthropoda	Arachnida	Pseudoscorpiones	Panctenata	Olpidae	Xenolpium `sp. indet.`	-23.1557	118.691
Arthropoda	Arachnida	Pseudoscorpiones	Panctenata	Olpidae	Xenolpium `sp. indet.`	-23.123	118.874
Arthropoda	Arachnida	Pseudoscorpiones	Panctenata	Olpidae	Xenolpium `sp. indet.`	-23.1229	118.862
Arthropoda	Arachnida	Pseudoscorpiones		`F. indet.`	`G. indet.` `sp. indet.`	-23.0797	118.811
Arthropoda	Arachnida	Pseudoscorpiones		Chthoniidae	Austrochthonius `sp. indet.`	-23.1593	118.993

Phylum	Class	Order	Infraorder	Family	Species	Latitude	Longitude
Arthropoda	Arachnida	Pseudoscorpiones		Chthoniidae	Tyrannochthonius `sp. indet.`	-23.0474	118.885
Arthropoda	Arachnida	Pseudoscorpiones		Chthoniidae	Tyrannochthonius aridus	-23.1332	119.015
Arthropoda	Arachnida	Pseudoscorpiones		Chthoniidae	Tyrannochthonius aridus	-23.1437	119.006
Arthropoda	Arachnida	Scorpiones		`F. indet.`	`G. indet.` `sp. indet.`	-23.0411	118.851
Arthropoda	Arachnida	Scorpiones		`F. indet.`	`G. indet.` `sp. indet.`	-23.1644	118.589
Arthropoda	Arachnida	Scorpiones		Buthidae	Isometroides `pilbara1`	-23.1592	118.693
Arthropoda	Arachnida	Scorpiones		Buthidae	Isometroides `sp. indet.`	-23.1592	118.993
Arthropoda	Arachnida	Scorpiones		Buthidae	Isometroides `sp.`	-23.0689	118.89
Arthropoda	Arachnida	Scorpiones		Buthidae	Lychas `harveyi`	-23.1833	118.859
Arthropoda	Arachnida	Scorpiones		Buthidae	Lychas `harveyi`	-23.2022	118.83
Arthropoda	Arachnida	Scorpiones		Buthidae	Lychas `harveyi`	-23.2022	118.83
Arthropoda	Arachnida	Scorpiones		Buthidae	Lychas `harveyi`	-23.1829	118.676
Arthropoda	Arachnida	Scorpiones		Buthidae	Lychas `harveyi`	-23.1464	118.638
Arthropoda	Arachnida	Scorpiones		Buthidae	Lychas `harveyi`	-23.1875	118.71
Arthropoda	Arachnida	Scorpiones		Buthidae	Lychas `harveyi`	-23.1907	118.859
Arthropoda	Arachnida	Scorpiones		Buthidae	Lychas `harveyi`	-23.1557	118.691
Arthropoda	Arachnida	Scorpiones		Buthidae	Lychas `pilbara1`	-23.123	118.874
Arthropoda	Arachnida	Scorpiones		Buthidae	Lychas `pilbara1`	-23.1229	118.862
Arthropoda	Arachnida	Scorpiones		Buthidae	Lychas `pilbara1`	-23.1229	118.862
Arthropoda	Arachnida	Scorpiones		Buthidae	Lychas `pilbara1`	-23.1229	118.862
Arthropoda	Arachnida	Scorpiones		Buthidae	Lychas `pilbara1`	-23.1342	118.837
Arthropoda	Arachnida	Scorpiones		Buthidae	Lychas `pilbara1`	-23.1342	118.837
Arthropoda	Arachnida	Scorpiones		Buthidae	Lychas `pilbara1`	-23.1342	118.837
Arthropoda	Arachnida	Scorpiones		Buthidae	Lychas `pilbara1`	-23.1907	118.859
Arthropoda	Arachnida	Scorpiones		Buthidae	Lychas `pilbara1`	-23.1875	118.71
Arthropoda	Arachnida	Scorpiones		Buthidae	Lychas `pilbara1`	-23.123	118.874
Arthropoda	Arachnida	Scorpiones		Buthidae	Lychas `bituberculatus`	-23.1723	118.624
Arthropoda	Arachnida	Scorpiones		Buthidae	Lychas `hairy tail`	-23.1228	118.875
Arthropoda	Arachnida	Scorpiones		Buthidae	Lychas `harveyi`	-23.3262	118.767
Arthropoda	Arachnida	Scorpiones		Buthidae	Lychas `multipunctatus`	-23.1637	119.003
Arthropoda	Arachnida	Scorpiones		Buthidae	Lychas `pilbara1`	-23.1339	118.836





Phylum	Class	Order	Infraorder	Family	Species	Latitude	Longitude
Arthropoda	Arachnida	Scorpiones		Buthidae	Lychas `pilbara1`	-23.1914	118.858
Arthropoda	Arachnida	Scorpiones		Buthidae	Lychas `pilbara1`	-23.123	118.874
Arthropoda	Arachnida	Scorpiones		Buthidae	Lychas `pilbara1`	-23.1342	118.837
Arthropoda	Arachnida	Scorpiones		Buthidae	Lychas `pilbara1`	-23.1339	118.836
Arthropoda	Arachnida	Scorpiones		Buthidae	Lychas `sp. 3`	-23.2797	118.699
Arthropoda	Arachnida	Scorpiones		Buthidae	Lychas `sp. indet.`	-23.0403	118.852
Arthropoda	Arachnida	Scorpiones		Buthidae	Lychas `sp. indet.`	-23.0403	118.852
Arthropoda	Arachnida	Scorpiones		Buthidae	Lychas `sp. indet.`	-23.0731	118.82
Arthropoda	Arachnida	Scorpiones		Buthidae	Lychas `sp. indet.`	-23.2	118.83
Arthropoda	Arachnida	Scorpiones		Buthidae	Lychas `sp. indet.`	-23.2	118.8
Arthropoda	Arachnida	Scorpiones		Buthidae	Lychas `sp. indet.`	-23.2	118.85
Arthropoda	Arachnida	Scorpiones		Buthidae	Lychas `sp. indet.`	-23.2	118.85
Arthropoda	Arachnida	Scorpiones		Buthidae	Lychas `sp. indet.`	-23.19	118.87
Arthropoda	Arachnida	Scorpiones		Buthidae	Lychas `sp. indet.`	-23.19	118.87
Arthropoda	Arachnida	Scorpiones		Buthidae	Lychas bituberculatus	-23.0169	118.889
Arthropoda	Arachnida	Scorpiones		Buthidae	Lychas jonesae	-23.1833	118.783
Arthropoda	Arachnida	Scorpiones		Urodacidae	Aops `sp. indet.`	-23.0476	118.885
Arthropoda	Arachnida	Scorpiones		Urodacidae	Aops `sp. indet.`	-23.0477	118.885
Arthropoda	Arachnida	Scorpiones		Urodacidae	Urodacus `firetail`	-23.1637	119.003
Arthropoda	Arachnida	Scorpiones		Urodacidae	Urodacus `novaehollandiae`?	-23.0277	118.687
Arthropoda	Arachnida	Scorpiones		Urodacidae	Urodacus `sp. indet.`	-23.0777	118.788
Arthropoda	Arachnida	Scorpiones		Urodacidae	Urodacus `sp. indet.`	-23.1465	118.683
Arthropoda	Arachnida	Scorpiones		Urodacidae	Urodacus `sp. indet.`	-23.203	118.83
Arthropoda	Arachnida	Scorpiones		Urodacidae	Urodacus `sp. indet.`	-23.1732	118.624
Arthropoda	Arachnida	Scorpiones		Urodacidae	Urodacus `sp. indet.`	-23.203	118.83
Arthropoda	Arachnida	Scorpiones		Urodacidae	Urodacus `sp. indet.`	-23.203	118.83
Arthropoda	Arachnida	Scorpiones		Urodacidae	Urodacus `sp. indet.`	-23.2023	118.83
Arthropoda	Arachnida	Scorpiones		Urodacidae	Urodacus `sp. indet.`	-23.2029	118.831
Arthropoda	Arachnida	Scorpiones		Urodacidae	Urodacus `sp. indet.`	-23.203	118.83
Arthropoda	Arachnida	Scorpiones		Urodacidae	Urodacus `sp. indet.`	-23.1988	118.847
Arthropoda	Arachnida	Scorpiones		Urodacidae	Urodacus `sp. indet.`	-23.1455	118.666





Phylum	Class	Order	Infraorder	Family	Species	Latitude	Longitude
Arthropoda	Arachnida	Scorpiones		Urodacidae	Urodacus `sp. indet.`	-23.19	118.87
Arthropoda	Arachnida	Scorpiones		Urodacidae	Urodacus `sp.`	-23.085	118.705
Arthropoda	Chilopoda	Geophilomorpha		Chilenophilidae	Sepedonophilus `sp. indet.`	-23.16326	118.977
Arthropoda	Chilopoda	Geophilomorpha		Chilenophilidae	Sepedonophilus `sp. indet.`	-23.1615	119.002
Arthropoda	Chilopoda	Geophilomorpha		Chilenophilidae	Sepedonophilus `sp. indet.`	-23.15965	118.9703
Arthropoda	Chilopoda	Geophilomorpha		Chilenophilidae	Sepedonophilus `sp. indet.`	-23.14368	119.0064
Arthropoda	Diplopoda	Polydesmida		Paradoxosomatidae	`Genus indet.` `sp. indet. (juvenile)`	-23.06889	118.89
Arthropoda	Diplopoda	Polydesmida		Paradoxosomatidae	Antichiropus `DIP007`	-23.00556	118.8275
Arthropoda	Diplopoda	Polydesmida		Paradoxosomatidae	Antichiropus `DNA06`	-23.1615	119.002
Arthropoda	Diplopoda	Polydesmida		Paradoxosomatidae	Antichiropus `Wonmunna`	-23.1615	119.002
Arthropoda	Diplopoda	Polydesmida		Paradoxosomatidae	Antichiropus `Wonmunna`	-23.1592	118.993
Arthropoda	Diplopoda	Polydesmida		Paradoxosomatidae	Antichiropus `Wonmunna`	-23.1615	119.002
Arthropoda	Diplopoda	Polydesmida		Paradoxosomatidae	Antichiropus `Wonmunna`	-23.1592	118.993
Arthropoda	Diplopoda	Polydesmida		Paradoxosomatidae	Antichiropus `Wonmunna`	-23.1633	118.977
Arthropoda	Diplopoda	Polydesmida		Paradoxosomatidae	Antichiropus `wonmunna`	-23.16154	119.00199
Arthropoda	Diplopoda	Polydesmida		Paradoxosomatidae	Antichiropus `wonmunna`	-23.15921	118.99281
Arthropoda	Diplopoda	Polydesmida		Paradoxosomatidae	Antichiropus `wonmunna`	-23.1592	118.9928
Arthropoda	Diplopoda	Spirobolida		Trigoniulidae	`Austrostrophus?` `indet. (fragments)`	-23.15466	118.9932
Arthropoda	Diplopoda	Spirobolida		Trigoniulidae	`Genus indet.` `sp.`	-23.16326	118.977
Arthropoda	Diplopoda	Spirobolida		Trigoniulidae	Austrostrophus `sp. indet. (female)`	-23.0178	118.907
Arthropoda	Diplopoda	Spirobolida		Trigoniulidae	Austrostrophus `sp. indet. (female)`	-23.0178	118.907
Arthropoda	Diplopoda	Spirobolida		Trigoniulidae	Austrostrophus `sp. indet. (female)`	-23.01778	118.9067
Arthropoda	Diplopoda	Spirobolida		Trigoniulidae	Austrostrophus `sp. indet.`	-23.0797	118.811
Arthropoda	Diplopoda	Spirobolida		Trigoniulidae	Austrostrophus `sp. indet.`	-23.0797	118.8108
Arthropoda	Diplopoda	Spirobolida		Trigoniulidae	Austrostrophus stictopygus	-23.2014	118.585
Arthropoda	Diplopoda	Spirobolida		Trigoniulidae	Austrostrophus stictopygus	-23.0477	118.885
Arthropoda	Diplopoda	Spirobolida		Trigoniulidae	Austrostrophus stictopygus	-23.0477	118.885
Arthropoda	Diplopoda	Spirobolida		Trigoniulidae	Austrostrophus stictopygus	-23.1394	119.018
Arthropoda	Diplopoda	Spirobolida		Trigoniulidae	Austrostrophus stictopygus	-23.1633	118.977
Arthropoda	Diplopoda	Spirobolida		Trigoniulidae	Austrostrophus stictopygus	-23.1428	119.01
Arthropoda	Diplopoda	Spirobolida		Trigoniulidae	Austrostrophus stictopygus	-23.1547	118.993




Phylum	Class	Order	Infraorder	Family	Species	Latitude	Longitude
Arthropoda	Diplopoda	Spirobolida		Trigoniulidae	Austrostrophus stictopygus	-23.1547	118.993
Arthropoda	Diplopoda	Spirobolida		Trigoniulidae	Austrostrophus stictopygus	-23.1633	118.977
Arthropoda	Diplopoda	Spirobolida		Trigoniulidae	Austrostrophus stictopygus	-23.1228	118.875
Arthropoda	Diplopoda	Spirobolida		Trigoniulidae	Austrostrophus stictopygus	-23.1228	118.875
Arthropoda	Diplopoda	Spirobolida		Trigoniulidae	Austrostrophus stictopygus	-23.1481	118.691
Arthropoda	Diplopoda	Spirobolida		Trigoniulidae	Austrostrophus stictopygus	-23.20142	118.5851
Arthropoda	Diplopoda	Spirobolida		Trigoniulidae	Austrostrophus stictopygus	-23.15466	118.9932
Arthropoda	Diplopoda	Spirobolida		Trigoniulidae	Austrostrophus stictopygus	-23.14808	118.6912
Arthropoda	Diplopoda	Spirobolida		Trigoniulidae	Austrostrophus stictopygus	-23.14284	119.0099
Arthropoda	Diplopoda	Spirobolida		Trigoniulidae	Austrostrophus stictopygus	-23.13937	119.0182
Arthropoda	Diplopoda	Spirobolida		Trigoniulidae	Austrostrophus stictopygus	-23.12279	118.8753
Arthropoda	Diplopoda	Spirobolida		Trigoniulidae	Austrostrophus stictopygus	-23.04772	118.885
Arthropoda	Malacostraca	Isopoda	Ligiamorpha	Armadiillidae	Buddelundia sp. 19	-23.1331	119.015
Arthropoda	Malacostraca	Isopoda	Ligiamorpha	Armadiillidae	Buddelundia sp. 48	-23.2647	118.754
Arthropoda	Malacostraca	Isopoda	Ligiamorpha	Philosciidae	Laevophiloscia 'Wonmunna A'	-23.1436	119.006
Arthropoda	Malacostraca	Isopoda	Ligiamorpha	Philosciidae	Laevophiloscia 'Wonmunna B'	-23.1393	119.018
Mollusca	Gastropoda	Stylommatophora		Camaenidae	Gen. nov. 'Mount Robinson' n.sp.	-23.0477	118.885
Mollusca	Gastropoda	Stylommatophora		Camaenidae	Gen. nov. 'Mount Robinson' n.sp.	-23.0476	118.885
Mollusca	Gastropoda	Stylommatophora		Camaenidae	Gen. nov. 'Mount Robinson' n.sp.	-23.0475	118.885
Mollusca	Gastropoda	Stylommatophora		Camaenidae	Gen. nov. 'Z' n.sp.	-23.0779	118.752
Mollusca	Gastropoda	Stylommatophora		Camaenidae	Gen. nov. 'Z' n.sp.	-23.077	118.787
Mollusca	Gastropoda	Stylommatophora		Camaenidae	Gen. nov. 'Z' n.sp.	-23.073	118.82
Mollusca	Gastropoda			Bothriembryonidae	Bothriembryon 'Pilbara' n.sp.	-23.3261	118.73
Mollusca	Gastropoda			Bothriembryonidae	Bothriembryon 'Pilbara' n.sp.	-23.2756	118.824
Mollusca	Gastropoda			Bothriembryonidae	Bothriembryon 'Pilbara' n.sp.	-23.2665	118.832
Mollusca	Gastropoda			Bothriembryonidae	Bothriembryon 'Pilbara' n.sp.	-23.2581	118.841
Mollusca	Gastropoda			Bothriembryonidae	Bothriembryon 'Pilbara' n.sp.	-23.2579	118.951
Mollusca	Gastropoda			Bothriembryonidae	Bothriembryon 'Pilbara' n.sp.	-23.2562	118.888
Mollusca	Gastropoda			Bothriembryonidae	Bothriembryon 'Pilbara' n.sp.	-23.1632	118.99
Mollusca	Gastropoda			Bothriembryonidae	Bothriembryon 'Pilbara' n.sp.	-23.1502	119.009
Mollusca	Gastropoda			Bothriembryonidae	Bothriembryon 'Pilbara' n.sp.	-23.148	118.691

Phylum	Class	Order	Infraorder	Family	Species	Latitude	Longitude
Mollusca	Gastropoda			Bothriembryonidae	Bothriembryon `Pilbara` n.sp.	-23.0822	118.77
Mollusca	Gastropoda			Bothriembryonidae	Bothriembryon `Pilbara` n.sp.	-23.0811	118.858
Mollusca	Gastropoda			Bothriembryonidae	Bothriembryon `Pilbara` n.sp.	-23.0755	118.896
Mollusca	Gastropoda			Bothriembryonidae	Bothriembryon `Pilbara` n.sp.	-23.0755	118.899
Mollusca	Gastropoda			Bothriembryonidae	Bothriembryon `Pilbara` n.sp.	-23.0731	118.913
Mollusca	Gastropoda			Bothriembryonidae	Bothriembryon `Pilbara` n.sp.	-23.0483	118.886
Mollusca	Gastropoda			Bothriembryonidae	Bothriembryon `Pilbara` n.sp.	-23.0477	118.885
Mollusca	Gastropoda			Bothriembryonidae	Bothriembryon `Pilbara` n.sp.	-23.0476	118.885
Mollusca	Gastropoda			Bothriembryonidae	Bothriembryon `Pilbara` n.sp.	-23.0398	118.965

## **Appendix I: Cave descriptions**

Cave ID	Coordinates	Date Assessed	Roost Type	Cave Position	Floor Slope	Aspect	Cave Exposure	Entrance Type	Entrance Shape	Entrance Width (m)	Entrance Height (m)	Cave Depth (m)	No Cham	Cham Height (m)	Water Present	Number of Ghost Bat Scats	Scat Count or Scat Estimate	Scat Age	Bats in cave	Entrance Photo
CWAN-01	-23.11719067 118.6252856	18/10/2018	Potential Ghost Bat diurnal roost	Upper Slope	Incline	North	Semi Exposed	Overhang	Round/ Oval	3	2	10	2	2.5	None	10	Count	Recent (1 to 6mths)	Nil	
CWAN-02	-23.1175515 118.623311	2018-10-19	Potential Ghost Bat diurnal roost	Upper Slope	Flat	North/ West	Exposed	Cavern	Round /Oval	6	2	10	2	2.5	None				Nil	
CWAN-03	-23.1176952 118.6240202	2018-10-19	Ghost Bat diurnal roost	Lower Slope	Incline	South/ West	Sheltered	Overhang	Horizontal	6.5	1.5	25	2	4	None				<i>Taphozous georgianus</i>	
CWAN-04	-23.1181643 118.6242662	2018-10-19	Ghost Bat maternity roost	Mid Slope	Incline	North/ East	Semi Exposed	Overhang	Round/ Oval	2	1.5	15	2	3.5	None	1500	Estimate	Fresh (<1mth)	<i>Taphozous georgianus</i>	

Cave ID	Coordinates	Date Assessed	Roost Type	Cave Position	Floor Slope	Aspect	Cave Exposure	Entrance Type	Entrance Shape	Entrance Width (m)	Entrance Height (m)	Cave Depth (m)	No Cham	Cham Height (m)	Water Present	Number of Ghost Bat Scats	Scat Count or Scat Estimate	Scat Age	Bats in cave	Entrance Photo
CWAN-05	-23.1199321 118.5947551	2018-10-19	Potential Ghost Bat night roost	Mid Slope	Incline	East	Exposed	Overhang	Round/Oval	12	4	10	1	4	None				<i>Vespadelus finlaysoni</i> , <i>Taphozous georgianus</i>	
CWAN-06	-23.11517803 118.6125083	2018-10-20	Potential Ghost Bat maternity roost	Mid Slope	Incline	West	Exposed	Cavity	Horizontal	4	1	30	1	4	None	1500	Estimate	Fresh (<1mth)	<i>Vespadelus finlaysoni</i> , <i>Taphozous georgianus</i> , <i>Macroderma gigas</i>	
CWAN-07	-23.1123807 118.6111788	2018-10-20	Potential Ghost Bat maternity roost	Mid Slope	Incline	South/East	Semi Exposed	Overhang	Round/Oval	3	2	35	3	3	None	5000	Estimate	Fresh (<1mth)	<i>Vespadelus finlaysoni</i> , <i>Taphozous georgianus</i>	
CWAN-08	-23.2118291 118.7850553	2018-10-20	Ghost Bat night roost	Mid Slope	Incline	North/East	Exposed	Overhang	Horizontal	11	2.5	30	1	4	None	30	Count	Recent (1 to 6mths)	<i>Vespadelus finlaysoni</i> , <i>Taphozous georgianus</i>	

Cave ID	Coordinates	Date Assessed	Roost Type	Cave Position	Floor Slope	Aspect	Cave Exposure	Entrance Type	Entrance Shape	Entrance Width (m)	Entrance Height (m)	Cave Depth (m)	No Cham	Cham Height (m)	Water Present	Number of Ghost Bat Scats	Scat Count or Scat Estimate	Scat Age	Bats in cave	Entrance Photo
CWAN-09	-23.149707 118.63129	2018-10-20	Ghost Bat night roost	Upper Slope	Incline	South	Semi Exposed	Overhang	Round/ Oval	6	3	30	1	3	None	7	Count	Recent (1 to 6mths)	<i>Vespadelus finlaysoni</i>	
CWAN-10	-23.2175484 118.7649055	2018-10-19	Potential Ghost Bat diurnal roost	Upper Slope	Incline	South/ East	Semi Exposed	Cavity	Horizontal	3	1	20	2	3	None	None	-	-	<i>Tapozous georgianus</i>	
CWAN-11	-23.2168183 118.8250839	2019-03-15	Ghost Bat night roost	Upper Slope	Flat	North/ West	Exposed	Cavity	Round/ Oval	3	1.5	15	1	2	None	1	Count	Old (6mths to 3yrs)	Nil	

## **Appendix J: Vertebrate fauna records from the current field surveys**

## Mammals

Species name	Common name	Western Hill			Deposit J			Deposit F			Deposit H			Other records	Total
		VRT-WA01	VRT-WA02	VRT-WA03	VRT-WA04	VRT-WA05	VRT-WA06	VRT-WA07	VRT-WA08	VRT-WA09	VRT-WA10	VWAH-11	VWAH-12		
Camelidae															
Camelus dromedarius*	Dromedary, Camel								1		1			27	29
Canidae															
Canis familiaris*	Dingo, Dog		1							1				6	8
Dasyuridae															
Dasykaluta rosamondae	Kaluta	9	2						4	3			2	0	20
Dasyurus hallucatus	Northern Quoll													1	1
Ningauai timealeyi	Pilbara Ningauai	3		1										0	4
Planigale 'species 1'	Pilbara Planigale			1										0	1
Pseudantechinus roryi					1									0	1
Sminthopsis macroura	Stripe-faced Dunnart		1	1										0	2
Sminthopsis ooldea	Ooldea Dunnart		2	2			6		2	2	1			0	15
Emballonuridae															
Saccolaimus flaviventris	Yellow-bellied Sheath-tailed Bat													10	10
Taphozous georgianus	Common Sheath-tailed Bat					3	3					2		31	39
Taphozous hilli	Hill's Sheath-tailed Bat					3	3					2		16	24
Felidae															
Felis catus*	Cat									1				7	8
Macropodidae															
Osphranter robustus	Euro, Biggada								1	1	1			24	27
Osphranter rufus	Red Kangaroo, Marlu													2	2
Petrogale rothschildi	Rothschild's Rock-wallaby													116	116
Megadermatidae															
Macroderma gigas	Ghost Bat													2 (1204 8)**	2 (1204 8)**
Molossidae															
Chaerephon jobensis	Greater Northern Free-tailed Bat					3	3					2		13	21

<i>Ozimops lumsdenae</i>	Northern freetail bat													2	2
<b>Muridae</b>															
<i>Mus musculus</i> *	House Mouse		2											0	2
<i>Pseudomys chapmani</i>	Western Pebble-mound Mouse						1							23	24
<i>Pseudomys desertor</i>	Desert Mouse		1	1			2			3				0	7
<i>Pseudomys hermannsburgensis</i>	Sandy Inland Mouse	2	4	2						4			2	0	14
<i>Zyzomys argurus</i>	Common Rock-rat				6					1				160	167
<b>Rhinonycteridae</b>															
<i>Rhinonictis aurantia</i>	Pilbara Leaf-nosed Bat													2	2
<b>Vespertilionidae</b>															
<i>Chalinolobus gouldii</i>	Gould's Wattled Bat					3	3					1		22	29
<i>Nyctophilus geoffroyi</i>	Lesser Long-eared Bat													1	1
<i>Scotorepens greyii</i>	Little Broad-nosed Bat					3	3					1	2	21	30
<i>Vespadelus finlaysoni</i>	Finlayson's Cave-bat					3	3					1	2	38	47
<b>Total</b>		<b>14</b>	<b>13</b>	<b>8</b>	<b>6</b>	<b>18</b>	<b>27</b>	<b>0</b>	<b>16</b>	<b>8</b>	<b>7</b>	<b>10</b>	<b>4</b>	<b>534 (1204 8)**</b>	<b>666 (1271 4)**</b>

\* introduced species; \*\*number inside brackets indicates additional records which are Ghost Bat scats

## Reptiles

Species name	Common name	Western Hill				Deposit J				Deposit F		Deposit H		Other records	Total
		VRT-WA01	VRT-WA02	VRT-WA03	VRT-WA04	VRT-WA05	VRT-WA06	VRT-WA07	VRT-WA08	VRT-WA09	VRT-WA10	VWAH-11	VWAH-12		
Agamidae															
<i>Ctenophorus caudicinctus</i>	Western Ring-tailed Dragon	2	1	2	2				3		1		1	5	17
<i>Ctenophorus isolepis</i>	Military Dragon			1										0	1
<i>Diporiphora valens</i>	Southern Pilbara Tree Dragon												1	0	1
<i>Gowidon longirostris</i>	Long-nosed Dragon		2	2								1		6	11
<i>Pogona minor</i>	Western Bearded Dragon		2											1	3
Carphodactylidae															
<i>Nephurus wheeleri</i>				1										0	1
Diplodactylidae															
<i>Diplodactylus pulcher</i>		1	1	1										0	3
<i>Diplodactylus savagei</i>	Southern Pilbara Beak-faced Gecko					5		5				1		0	11
<i>Lucasium stenodactylum</i>		3	14	8		1	5		11	1				0	43
<i>Lucasium wombeyi</i>		2	4	2		3			2					0	13
<i>Oedura fimbria</i>	Western Marble Gecko					1								2	3
<i>Rhynchoedura ornata</i>	Western Beaked Gecko	1	1	6			12		1					0	21
<i>Strophurus elderi</i>				1										0	1
<i>Strophurus wellingtonae</i>			1	1			1			1				0	4
Elapidae															
<i>Acanthophis wellsii</i>	Pilbara Death Adder	1												0	1
<i>Brachyuropsis approximans</i>			1			1	2					1		0	5
<i>Demansia psammophis</i>			2											0	2
<i>Demansia rufescens</i>	Rufous Whipsnake								1					0	1
<i>Furina ornata</i>	Moon Snake					1								0	1
<i>Parasuta monachus</i>										1				0	1
<i>Pseudechis australis</i>	Mulga Snake			2										1	3
<i>Pseudonaja mengdeni</i>	Western Brown Snake		1				1		1					0	3
<i>Suta fasciata</i>	Rosen's Snake													1	1
Gekkonidae															

Species name	Common name	Western Hill				Deposit J				Deposit F		Deposit H		Other records	Total
		VRT-WA01	VRT-WA02	VRT-WA03	VRT-WA04	VRT-WA05	VRT-WA06	VRT-WA07	VRT-WA08	VRT-WA09	VRT-WA10	VWAH-11	VWAH-12		
<i>Gehyra pilbara</i>								1			1			0	2
<i>Gehyra punctata</i>					1			1						0	2
<i>Gehyra variegata</i>		1	2		1				1					0	5
<i>Heteronotia binoei</i>	Bynoe's Gecko				1	8	1	4			2	1		0	17
<i>Heteronotia spelea</i>	Pilbara Cave Gecko				6	1								0	7
<b>Pygopodidae</b>															
<i>Delma tinctoria</i>			1						2					0	3
<i>Lialis burtonis</i>				1					1					0	2
<b>Pythonidae</b>															
<i>Antaresia perthensis</i>	Pygmy Python								1					0	1
<i>Liasis olivaceus subsp. barroni</i>	Pilbara Olive Python													2	2
<b>Scincidae</b>															
<i>Carlia munda</i>		4	8	3	1	3	13	3	8	4	7			0	54
<i>Cryptoblepharus ustulatus</i>														5	5
<i>Ctenotus duricola</i>	Eastern Pilbara Lined Ctenotus			1	1									0	2
<i>Ctenotus inornatus</i>		15	10	9	12	14	14	26	22	3	2	8	14	0	149
<i>Ctenotus pantherinus</i>		9	4	7			9		4	1			10	0	44
<i>Ctenotus rutilans</i>		4												0	4
<i>Ctenotus schomburgkii</i>			3								1			0	4
<i>Cyclodomorphus melanops</i>										1			1	0	2
<i>Egernia cygnitos</i>	Western Pilbara Spiny-tailed Skink													1	1
<i>Egernia formosa</i>													1	6	7
<i>Lerista muelleri</i>			2	1	11	7	1				2			0	24
<i>Lerista neander</i>				1	1		2							0	4
<i>Lerista zietzi</i>												3		0	3
<i>Menetia greyii</i>						1								0	1
<i>Morethia ruficauda</i>					5	1		2						0	8
<i>Tiliqua multifasciata</i>	Central Blue-tongue	3		3									2	0	8
<b>Typhlopidae</b>															
<i>Anilius ganei</i>									1					0	1

Species name	Common name	Western Hill				Deposit J				Deposit F		Deposit H		Other records	Total
		VRT-WA01	VRT-WA02	VRT-WA03	VRT-WA04	VRT-WA05	VRT-WA06	VRT-WA07	VRT-WA08	VRT-WA09	VRT-WA10	VWAH-11	VWAH-12		
<i>Anilius grypus</i>						1	5		4			1		0	11
<i>Anilius hamatus</i>		1	1				2		1					0	5
<b>Varanidae</b>															
<i>Varanus acanthurus</i>	Spiny-tailed Goanna				1		1					1	1	2	6
<i>Varanus brevicauda</i>	Short-tailed Pygmy Goanna						1							0	1
<i>Varanus giganteus</i>	Perentie													8	8
<i>Varanus gilleni</i>	Pygmy Mulga Goanna					1								0	1
<i>Varanus gouldii</i>	Bungarra or Sand Goanna													1	1
<i>Varanus hamersleyensis</i>	Southern Pilbara Rock Goanna													6	6
<i>Varanus panoptes</i>			2											2	4
<i>Varanus tristis</i>					1	2								1	4
<b>Total</b>		<b>47</b>	<b>63</b>	<b>53</b>	<b>44</b>	<b>52</b>	<b>70</b>	<b>42</b>	<b>64</b>	<b>12</b>	<b>16</b>	<b>17</b>	<b>31</b>	<b>49</b>	<b>560</b>

## Birds

Species name	Common name	Western Hill				Deposit J				Deposit F		Deposit H		Other records	Total
		VRT-WA01	VRT-WA02	VRT-WA03	VRT-WA04	VRT-WA05	VRT-WA06	VRT-WA07	VRT-WA08	VRT-WA09	VRT-WA10	VWAH-11	VWAH-12		
Acanthizidae															
<i>Acanthiza apicalis</i>	Inland Thornbill		4	4										1	9
<i>Acanthiza uropygialis</i>	Chestnut-rumped Thornbill		3		1									0	4
<i>Gerygone fusca</i>	Western Gerygone													4	4
<i>Smicromis brevirostris</i>	Weebill		8	10	3	5	15	9	11			4	12	4	81
Accipitridae															
<i>Accipiter cirrocephalus</i>	Collared Sparrowhawk													1	1
<i>Aquila audax</i>	Wedge-tailed Eagle												2	0	2
<i>Circus assimilis</i>	Spotted Harrier								1					1	2
Aegothelidae															
<i>Aegotheles cristatus</i>	Australian Owlet-nightjar								1				1	3	5
Alcedinidae															
<i>Todiramphus pyrrhopygius</i>	Red-backed Kingfisher								1				1	1	3
Anatidae															
<i>Malacorhynchus membranaceus</i>	Pink-eared Duck													1	1
Apodidae															
<i>Apus pacificus</i>	Fork-tailed Swift	20												0	20
Artamidae															
<i>Artamus cinereus</i>	Black-faced Woodswallow			10		4							1	3	18
<i>Artamus minor</i>	Little Woodswallow					2							4	0	6
Cacatuidae															
<i>Cacatua roseicapilla</i>	Galah	1	2										1	0	4
<i>Nymphicus hollandicus</i>	Cockatiel			10										0	10
Campephagidae															
<i>Coracina maxima</i>	Ground Cuckoo-shrike													3	3
<i>Coracina novaehollandiae</i>	Black-faced Cuckoo-shrike			5		3			1					3	12
<i>Lalage tricolor</i>	White-winged Triller		1	1										0	2
Caprimulgidae															

Species name	Common name	Western Hill				Deposit J				Deposit F		Deposit H		Other records	Total
		VRT-WA01	VRT-WA02	VRT-WA03	VRT-WA04	VRT-WA05	VRT-WA06	VRT-WA07	VRT-WA08	VRT-WA09	VRT-WA10	VWAH-11	VWAH-12		
<i>Eurostopodus argus</i>	Spotted Nightjar												1	1	2
<b>Columbidae</b>															
<i>Geopelia cuneata</i>	Diamond Dove													5	5
<i>Geophaps plumifera</i>	Spinifex Pigeon													19	19
<i>Ocyphaps lophotes</i>	Crested Pigeon		2	3			1							27	33
<i>Phaps chalcoptera</i>	Common Bronzewing							2						17	19
<b>Corvidae</b>															
<i>Corvus orru</i>	Torresian Crow	3	2		1	1		5	4				6	13	35
<b>Cracticidae</b>															
<i>Cracticus nigrogularis</i>	Pied Butcherbird	4	5	3	1	2	4	4	4				1	10	38
<i>Cracticus tibicen</i>	Australian Magpie						3					1	1	3	8
<i>Cracticus torquatus</i>	Grey Butcherbird								1					6	7
<b>Cuculidae</b>															
<i>Cacomantis pallidus</i>	Pallid Cuckoo								1		2			2	5
<i>Centropus phasianinus</i>	Pheasant Coucal		1											0	1
<i>Chrysococcyx basalis</i>	Horsfield's Bronze Cuckoo			1		1	3		3				1	4	13
<i>Chrysococcyx osculans</i>	Black-eared Cuckoo								1					2	3
<b>Estrildidae</b>															
<i>Emblema pictum</i>	Painted Finch			2										1	3
<i>Taeniopygia guttata</i>	Zebra Finch		41	13	8				12				20	45	139
<b>Falconidae</b>															
<i>Falco berigora</i>	Brown Falcon						1	1					2	4	8
<b>Locustellidae</b>															
<i>Eremiornis carteri</i>	Spinifexbird	1		6					2				1	4	14
<i>Megalurus mathewsi</i>	Rufous Songlark		1						1				1	0	3
<b>Maluridae</b>															
<i>Malurus lamberti</i>	Variegated Fairy-wren	10	8	4	5				7		5	4	4	6	53
<i>Malurus leucopterus</i>	White-winged Fairy-wren	2	6	1										8	17
<b>Meliphagidae</b>															
<i>Acanthagenys rufogularis</i>	Spiny-cheeked Honeyeater	1			1			2	4				1	16	25

Species name	Common name	Western Hill				Deposit J				Deposit F		Deposit H		Other records	Total
		VRT-WA01	VRT-WA02	VRT-WA03	VRT-WA04	VRT-WA05	VRT-WA06	VRT-WA07	VRT-WA08	VRT-WA09	VRT-WA10	VWAH-11	VWAH-12		
<i>Epthianura tricolor</i>	Crimson Chat			5									1	2	8
<i>Gavicalis virescens</i>	Singing Honeyeater		2	4			4		12				1	76	99
<i>Lacustroica whitei</i>	Grey Honeyeater	1												1	2
<i>Lichmera indistincta</i>	Brown Honeyeater	2	1											0	3
<i>Manorina flavigula</i>	Yellow-throated Miner		1	1	19									8	29
<i>Ptilotula keartlandi</i>	Grey-headed Honeyeater	4	3	5	1	12			3		1		1	40	70
<i>Ptilotula penicillata</i>	White-plumed Honeyeater								5					0	5
<i>Ptilotula plumula</i>	Grey-fronted Honeyeater					3								1	4
<i>Ptilotula plumulus</i>	Grey-fronted Honeyeater			1	1	4								0	6
<b>Meropidae</b>															
<i>Merops ornatus</i>	Rainbow Bee-eater			1		2			5		2			4	14
<b>Monarchidae</b>															
<i>Grallina cyanoleuca</i>	Magpie-lark											1		1	2
<b>Motacillidae</b>															
<i>Anthus australis</i>	Australian Pipit													1	1
<b>Oreoicidae</b>															
<i>Oreoica gutturalis</i>	Crested Bellbird	5	6	1			1		1					2	16
<b>Otididae</b>															
<i>Ardeotis australis</i>	Australian Bustard													3	3
<b>Pachycephalidae</b>															
<i>Colluricincla harmonica</i>	Grey Shrike-thrush	1		3	7	3					1		1	35	51
<i>Pachycephala rufiventris</i>	Rufous Whistler	2	2	2					8	2	1	1		6	24
<b>Pardalotidae</b>															
<i>Pardalotus rubricatus</i>	Red-browed Pardalote				1	1					1			0	3
<b>Petroicidae</b>															
<i>Melanodryas cucullata</i>	Hooded Robin													2	2
<b>Podargidae</b>															
<i>Podargus strigoides</i>	Tawny Frogmouth													1	1
<b>Pomatostomidae</b>															
<i>Pomatostomus superciliosus</i>	White-browed Babbler													3	3

Species name	Common name	Western Hill				Deposit J				Deposit F		Deposit H		Other records	Total
		VRT-WA01	VRT-WA02	VRT-WA03	VRT-WA04	VRT-WA05	VRT-WA06	VRT-WA07	VRT-WA08	VRT-WA09	VRT-WA10	VWAH-11	VWAH-12		
<i>Pomatostomus temporalis</i>	Grey-crowned Babbler	3		9	4		3		2					41	62
<b>Psittacidae</b>															
<i>Melopsittacus undulatus</i>	Budgerigar	1		6									2	0	9
<i>Platycercus varius</i>	Mulga Parrot													3	3
<i>Platycercus zonarius</i>	Australian Ringneck		5	2	2		3		2			2		4	20
<b>Ptilonorhynchidae</b>															
<i>Ptilonorhynchus maculatus</i> subsp. <i>guttatus</i>	Western Bowerbird					1			1					28	30
<b>Rhipiduridae</b>															
<i>Rhipidura leucophrys</i>	Willie Wagtail	3		2	7	4	1	2		1	1			34	55
<b>Strigidae</b>															
<i>Ninox boobook</i>	Boobook Owl													3	3
<b>Turnicidae</b>															
<i>Turnix velox</i>	Little Button-quail		2				1							0	3
<b>Tytonidae</b>															
<i>Tyto alba</i>	Barn Owl												1	2	3
<b>Total</b>		<b>64</b>	<b>106</b>	<b>115</b>	<b>62</b>	<b>48</b>	<b>40</b>	<b>25</b>	<b>94</b>	<b>3</b>	<b>14</b>	<b>13</b>	<b>68</b>	<b>519</b>	<b>1171</b>

## Amphibians

Species name	Common name	Western Hill				Deposit J				Deposit F		Deposit H		Other records	Total
		VRT-WA01	VRT-WA02	VRT-WA03	VRT-WA04	VRT-WA05	VRT-WA06	VRT-WA07	VRT-WA08	VRT-WA09	VRT-WA10	VWAH-11	VWAH-12		
Pelodryadidae															
Cyclorana maini	Sheep Frog	1	16	1	2										20
Litoria rubella	Little Red Tree Frog													1	1

## **Appendix K: Potential Northern Brushtail Possum Scat Analysis Results**



## Species Identification Results Report

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07/05/2019

Attention: Chris Knuckey  
 Senior Zoologist | Manager Vertebrate Zoology  
 Biologic Environmental

## Results Report

## Species Identification from faecal samples

Background

Faecal samples were submitted for species identification. Biologic environmental is interested to determine whether the samples may have originated from a northern brush tail possum (*Trichosurus arnhemensis*) or any other mammal. Faecal samples consisted of multiple elongated droppings, about 1cm long. Supplied samples are listed in table 1.

Table 1. List of samples supplied for species identification.

ID	Type of sample	Species	Comments
Sample 1	Scats	Unknown	Western Hill (WA07), Hamersley Ranges. WA07.20181028
Sample 2	Scats	Unknown	Western Hill (WA07), Hamersley Ranges. Cave WA07 28/10/2018
Sample 3	Scats	Unknown	Hamersley Ranges.

### **Methodology**

The above three samples were divided into seven DNA extractions based on the number of individual droppings per sample. Therefore, sample 1 and sample 3 were divided into two and four extractions respectively. Due to the limited number and the brittle condition of sample 2, it was represented by a single sample.

Total genomic DNA was extracted using commercially available kits and following the manufacturer's instructions. Species identification was attempted by the amplification of a 390 base pair (bp) segment of the mitochondrial gene Cytochrome b (cytb) by polymerase chain reaction using previously published primers<sup>1</sup>. Subsequent amplification attempts also involved the amplification of a larger segment of the same region 460 (bp) using an alternative forward primer<sup>2</sup>. Since samples were suspected to belong to northern brush tail possum, amplification of a small cytb region were also carried out, using two independent sets of possum specific primers<sup>2</sup>. Efforts to obtain a positive result also involved performing the above reactions with a variety of template concentrations.

Resulting sequences were checked manually, trimmed in Geneious v.10.2.6 (Biomatters) and compared to publicly available sequences available in Genbank.

### **Results**

Positive PCR products were obtained from most extractions except from sample 2. A total of 18 PCR products were sequenced and 14 sequences resulted in the detection of a single target. A query against publicly available sequences in Genbank showed that of these 14 sequences, 11 were highly similar to human with a nucleotide identity ranging from 99.7% to 100%. The remaining three high quality sequences were amplified from sample 3 and were most similar to *Zyomys argurus* (common rock rat) with a nucleotide identity of 97%. Further analyses were carried out to determine the nucleotide identity among species of *Zyomys* along the amplified region. The alignment included sequences representing *Z. argurus*, *Z. maini*, *Z. palatalis* and *Z. woodwardi*. The nucleotide identity between species of this group ranged between 88.7% and 98%.

Of the four low quality sequences, two were discarded from analysis and the remaining two appeared to represent the amplification of mixed templates. Manual analysis suggested that both samples contained DNA from *Zyomys sp* and the second contributing template in one of the samples is likely human and results were inconclusive for the second sample.

All extractions showed a negative result for the possum specific assays.



## Species Identification Results Report

**Interpretation of results**

Amplification of human DNA from the scats indicates the likely cross contamination of the samples together with a low number of cells of the target species or poor binding between the primer set and target DNA. The employed primers bind to a large variety of vertebrates and therefore in cases of low number of cells from the target species, the primers may preferentially amplify the available human DNA, even if it is present in very low quantities. Development of group specific primers (e.g. marsupials, rodents, etc.) can increase the specificity of species identification from environmental samples as they would be designed to avoid binding to human DNA, and if present, amplify DNA from the targeted group.

Nucleotide identity to available sequences and the levels of identity within *Zyromys*, suggest the presence of *Zyromys*-like DNA in the scats, particularly in sample 3. These results must be used in conjunction with additional evidence to reach an overall conclusion that can explain the presence of this species' DNA in the scats. Even though, the possum specific assays showed negative results, this is not enough evidence to discard that the scats may be of possum origin.

**References**

1. Kocher, T. D. *et al.* Dynamics of mitochondrial DNA evolution in animals: amplification and sequencing with conserved primers. *Proc. Natl. Acad. Sci. U. S. A.* **86**, 6196–200 (1989).
2. Ramón-Laca, A., Linacre, A. M. T., Gleeson, D. M. & Tobe, S. S. Identification multiplex assay of 19 terrestrial mammal species present in New Zealand. *Electrophoresis* **34**, 3370–3376 (2013).

Prepared by



Diana Prada BSc (Hons) PhD Candidate  
Managing Director

## **Appendix L: Potential Night Parrot Call Analysis Results**



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30 November 2018

Morgan O'Connell  
Director / Principal Zoologist  
Biologic Environmental Survey

Dear Morgan,

The Broome Bird Observatory conducted an analysis of bioacoustic recordings targeting the Night Parrot (*Pezoporus occidentalis*) at 'West Angelas' during a survey in October 2018.

Song Meter 4 devices were positioned at eight sites and recorded for approximately 12 hr/night each, for a total of 14 nights (Table 1).

**Table 1. Night Parrot survey effort during the October 2018 targeted survey.**

Site Name	Recording start date	Recording end date	Total nights
VRT-WA08	14/10/2018	18/10/2018	4
VRT-WA40	18/10/2018	20/10/2018	2
VRT-WA30	20/10/2018	21/10/2018	1
VRT-WA35	21/10/2018	22/10/2018	1
VRT-WA15	16/10/2018	18/10/2018	2
VRT-WA26	18/10/2018	20/10/2018	2
VRT-WA43	20/10/2018	21/10/2018	1
VRT-WA29	21/10/2018	22/10/2018	1

### Results

No definitive calls attributable to Night Parrots were detected during the analysis.

Six calls (Appendix 1) were detected that could not be confidently assigned to an alternative species, and show characteristics similar to known Night Parrots calls, being in the 2-3 kHz frequency range, and comprising two or three simple, whistled notes. However, these calls are relatively faint, which may result in some detail within each call not being visible in the spectrogram. These calls were recorded all on the same night, but not detected in the three subsequent nights at this site.

### General remarks

The recordings were generally of good quality, except for at sites where there was a regular passage of heavy machinery. Sites VRT-WA40, VRT-WA30 and VRT-WA26 were affected by such interference. Non-target bird calls were

detected at these sites, but much of the 2-3 kHz band was disrupted by machinery noise at various times throughout the night. Some noises generated by the machinery produced good imitations of plausible Night Parrot calls, particularly when viewed on a spectrogram.

Unless there are reasonable explanations not considered here as to what may have produced the six calls shown in Appendix 1, it is recommended that further surveys be conducted in the area of site VRT-WA08.

If you have any further questions regarding the analysis, don't hesitate to contact the Broome Bird Observatory.

Sincerely,



Nigel Jackett

Broome Bird Observatory – Warden

Nigel Jackett

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27<sup>th</sup> May 2019

Talitha Moyle  
Senior Zoologist  
Biologic Environmental Survey

Dear Talitha,

Please find below the results of Biologic's bioacoustic survey targeting the Night Parrot in March 2019.

#### Survey summary

Biologic Environmental Survey conducted sampling for the Night Parrot (*Pezoporus occidentalis*) in an area surrounding Rio Tinto Iron Ore's West Angelas mine in March 2019. Wildlife Acoustic Song Meter 4 bioacoustic recording units were installed at five sites, and recorded over a total of 16 nights (Table 1).

Table 1. Bioacoustic recordings analysed from the March 2019 targeted survey.

Site name	Recording start date	Recording end date	Total nights
VWAH-12	13/03/2019	17/03/2019	4
VWAJ-08	14/03/2019	20/03/2019	6
VWAH-13	20/03/2019	22/03/2019	2
VWAW-85	19/03/2019	21/03/2018	2
VWAF-67	17/03/2019	19/03/2018	2

#### Results

A series of 33 simple (i.e. one to three note) unknown calls/sounds were detected at site VWAW-85 between 7:15 pm and 7:26 pm on the 19/05/19. It was difficult to ascertain the source of the series, as some detections had a mechanical quality, while others were bell-like. All the detections within the series were within the known calling frequency range of the Night Parrot.

A two-note constant frequency call (Figure 1) was the best example of a call resembling a confirmed Night Parrot call, the *dink-dink* call from Pullen Pullen in south-west Queensland (Murphy *et al.* 2017, Leseberg *et al.* in press). The Queensland *dink-dink* call has a total duration of 0.4 secs and shows a frequency range of 2.2-3.1 kHz (typically 2.5 kHz). The two-note constant frequency call recorded at West Angelas measured 0.4 secs in total duration and 2.9 kHz in frequency, and was therefore within the known range of the *dink-dink* call, albeit at the higher end of the frequency spectrum.

All unknown calls/sounds detected at site VWAW-85 are listed in Table 2. No potential Night Parrot calls were detected at other sites.

A total of 20 non-target bird species were detected during the analysis and are listed in Appendix 1.

Table 2. Detections from site WVAW within the known frequency range of the Night Parrot.

Call description	Detections	Frequency range (Hz)
Short, constant frequency, single whistle	23	1906 – 2949
Short, constant frequency, two-note whistle	3	2166 – 2928
Three-note, constant frequency whistle	1	2144
Two-note rising whistle	2	1966 – 2013
Two-note, constant frequency whistle	4	2150 – 2940

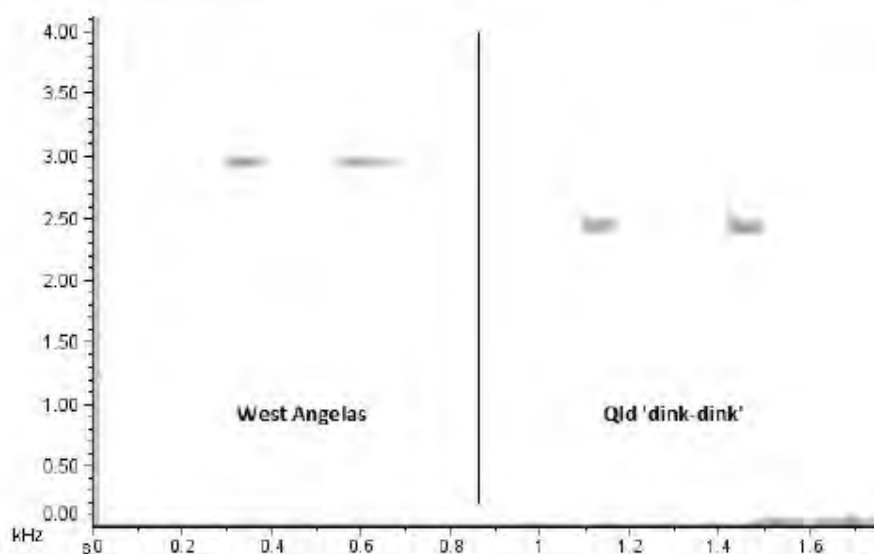


Figure 1. Comparison of two-note, constant frequency call recorded at West Angelas with confirmed Night Parrot call from Queensland.

**Analysis remarks**

The survey coincided with a tropical disturbance (Tropical Cyclone Veronica) in the north-west region, which increased noise disturbances from wind and rain within some recordings. However, discernible vocalisations from [non-target] birds were detected for all nights sampled, which indicates the weather wouldn't have significantly reduced the likelihood of detecting Night Parrots.

Although several potential calls of Night Parrots were recorded, these detections are best treated as *unconfirmed* at this stage. Calls were only detected during a single night, were somewhat faint, and occurred during mildly adverse weather conditions (i.e. constant wind gusts). The proximity of the site to mining activities is also of strong consideration, as distant machinery and infrastructure may produce faint sounds that resemble Night Parrot vocalisations during analyses. Confirmation of Night Parrot presence at the site (through bioacoustic recordings) will require further calls without background interference.

Sincerely,



Nigel Jackett

Selected references

- Jackett, N.A., Greatwich, B.R., Swann, G., and Boyle, A. (2017) A nesting record and vocalisations of the Night Parrot *Pezoporus occidentalis* from the East Murchison, Western Australia. *Australian Field Ornithology*, 34, 144-150.
- Leseberg, N.P., Murphy, S.A., Jackett, N.A., Greatwich, B.R., Brown, J., Hamilton, N., Joseph, L. & Watson, J. (in press) Descriptions of known vocalisations of the Night Parrot *Pezoporus occidentalis*. *Australian Field Ornithology*.
- Murphy, S.A., Austin, J.A., Murphy, R.K., Silcock, J., Joseph, L., Garnett, S.T., Leseberg, N.P., Watson, J.E.M. & Burbidge, A.H. (2017a) Observations on breeding Night Parrots (*Pezoporus occidentalis*) in western Queensland. *Emu* 117, 107-113.

**Appendix 1 – Species detected during the analysis**

Species	VWAH-12	VWAF-67	VWAW-85	VWAJ-08	VWAH-13
Pink-eared Duck			*		
Horsfield's Bronze-Cuckoo	*		*	*	*
Black-eared Cuckoo			*	*	*
Pallid Cuckoo			*	*	*
Australian Owlet-nightjar	*	*	*	*	
Eastern Barn Owl	*		*		
Galah	*				
Spiny-cheeked Honeyeater			*		
Singing Honeyeater	*		*	*	*
White-plumed Honeyeater				*	
Grey-headed Honeyeater	*	*			
Weebill	*				*
Grey Butcherbird			*	*	
Pied Butcherbird		*			*
Black-faced Cuckoo-shrike		*			
Grey Shrike-thrush	*				*
Rufous Whistler			*		
Crested Bellbird			*		
Torresian Crow	*			*	
Spinifexbird	*		*	*	*

## **Appendix M: Invertebrate fauna collected from the survey**

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Site	Date	Latitude	Longitude	Deposit	Habitat Type	Sampling Method	Class	Order	Family	Genus	Species	Infra Rank	Infra Name	Specimens	Status
SRE-WA21	19/10/2018	-23.1789158	118.8702866	Dep F North	Eucalypt Woodland	Pitfall Trap (Dry)	Arachnida	Araneae	Nemesiidae			n. sp.	indet.	1	Potential SRE
SRE-WA21	19/10/2018	-23.1789158	118.8702866	Dep F North	Eucalypt Woodland	Leaf/soil sieving	Arachnida	Scorpiones	Buthidae	<i>Lychas</i>		sp.	indet 1	1	Widespread
SRE-WA23	19/10/2018	-23.1168533	118.6249896	Western Hill	Gorge/ Gully	Leaf/soil sieving	Crustacea	Isopoda	Armadillidae	<i>Buddelundia</i>		sp.	16	1	Widespread
SRE-WA23	19/10/2018	-23.1168533	118.6249896	Western Hill	Gorge/ Gully	Leaf/soil sieving	Crustacea	Isopoda	Armadillidae	<i>Buddelundia</i>		sp.	47	2	Potential SRE
SRE-WA29	21/10/2018	-23.1155365	118.6326167	Western Hill	Mulga Woodland	Targeted searches	Arachnida	Pseudoscorpiones	Olpiidae	<i>Euryolpium</i>		sp.	indet.	1	Widespread
SRE-WA31	21/10/2018	-23.1326899	118.5838233	Western Hill	Stony Plain	Leaf/soil sieving	Arachnida	Pseudoscorpiones	Olpiidae	<i>Beierolpium</i>		sp.	'8/4'	1	Widespread
SRE-WA32	20/10/2018	-23.1730202	118.8396182	Dep F North	Gorge/ Gully	Targeted searches	Arachnida	Pseudoscorpiones	Olpiidae	<i>Euryolpium</i>		sp.	indet.	1	Widespread
SRE-WA33	21/10/2018	-23.1373675	118.6457958	Western Hill	Medium Drainage Line	Hand collected	Arachnida	Pseudoscorpiones	Olpiidae	<i>Indolpium</i>		sp.	indet.	1	Potential SRE
SRE-WA34	20/10/2018	-23.1224249	118.9082345	Dep H	Gorge/ Gully	Leaf/soil sieving	Arachnida	Pseudoscorpiones	Olpiidae	<i>Beierolpium</i>		sp.	'8/3'	1	Widespread
SRE-WA34	20/10/2018	-23.1224249	118.9082345	Dep H	Gorge/ Gully	Leaf/soil sieving	Arachnida	Pseudoscorpiones	Olpiidae	<i>Beierolpium</i>		sp.	'8/4 small'	1	Widespread
SRE-WA40	21/10/2018	-23.2293248	118.7460923	Mt Ella E and Dep J	Hillcrest/ Hillslope	Leaf/soil sieving	Arachnida	Pseudoscorpiones	Olpiidae	<i>Indolpium</i>		sp.	indet.	1	Potential SRE
<b>Phase 2</b>															
RC17WAW0183	16/03/2019					Hand collected	Arachnida	Scorpiones	Buthidae	<i>Lychas</i>		sp.	indet 2	1	Potential SRE
SRE-WA03a	15/03/2019	-23.2366726	118.7256462	Mt Ella E and Dep J	Stony Plain	Pitfall Trap (Dry)	Arachnida	Araneae	Nemesiidae	<i>Aname</i>	<i>mellosa</i>			1	Widespread
SRE-WA03a	15/03/2019	-23.2366726	118.7256462	Mt Ella E and Dep J	Stony Plain	Pitfall Trap (Dry)	Arachnida	Araneae	Nemesiidae	<i>Aname</i>	<i>mellosa</i>			1	Widespread
SRE-WA03a	15/03/2019	-23.2366726	118.7256462	Mt Ella E and Dep J	Stony Plain	Pitfall Trap (Dry)	Arachnida	Araneae	Nemesiidae	<i>Aname</i>	<i>mellosa</i>			1	Widespread
SRE-WA03a	15/03/2019	-23.2366726	118.7256462	Mt Ella E and Dep J	Stony Plain	Pitfall Trap (Dry)	Arachnida	Araneae	Nemesiidae	<i>Aname</i>	<i>mellosa</i>			1	Widespread
SRE-WA03a	15/03/2019	-23.2366726	118.7256462	Mt Ella E and Dep J	Stony Plain	Pitfall Trap (Dry)	Arachnida	Scorpiones	Buthidae	<i>Lychas</i>		sp.	'pilbara 1'	1	Widespread
SRE-WA03a	15/03/2019	-23.2366726	118.7256462	Mt Ella E and Dep J	Stony Plain	Pitfall Trap (Dry)	Arachnida	Scorpiones	Buthidae	<i>Lychas</i>		sp.	'pilbara 1'	1	Widespread
SRE-WA03a	15/03/2019	-23.2366726	118.7256462	Mt Ella E and Dep J	Stony Plain	Active foraging	Crustacea	Isopoda	Armadillidae	<i>Buddelundia</i>		sp.	15	1	Widespread
SRE-WA04	14/03/2019	-23.1385268	118.5921124	Western Hill	Stony Plain	Leaf/soil sieving	Arachnida	Araneae	Idiopidae	<i>Anidiops</i>		sp.	MYG286	1	Potential SRE
SRE-WA04	14/03/2019	-23.1385268	118.5921124	Western Hill	Stony Plain	Pitfall Trap (Dry)	Arachnida	Araneae	Nemesiidae	<i>Aname</i>	<i>mellosa</i>			1	Widespread
SRE-WA04	14/03/2019	-23.1385268	118.5921124	Western Hill	Stony Plain	Pitfall Trap (Dry)	Arachnida	Araneae	Nemesiidae	<i>Aname</i>	<i>mellosa</i>			1	Widespread
SRE-WA04	14/03/2019	-23.1385268	118.5921124	Western Hill	Stony Plain	Pitfall Trap (Dry)	Arachnida	Scorpiones	Buthidae	<i>Isometroides</i>		sp.	'pilbara 1'	1	Widespread
SRE-WA04	14/03/2019	-23.1385268	118.5921124	Western Hill	Stony Plain	Pitfall Trap (Dry)	Arachnida	Scorpiones	Buthidae	<i>Isometroides</i>		sp.	'pilbara 1'	1	Widespread
SRE-WA04	14/03/2019	-23.1385268	118.5921124	Western Hill	Stony Plain	Pitfall Trap (Dry)	Arachnida	Scorpiones	Buthidae	<i>Lychas</i>		sp.	'harveyi complex'	1	Widespread
SRE-WA04	14/03/2019	-23.1385268	118.5921124	Western Hill	Stony Plain	Pitfall Trap (Dry)	Arachnida	Scorpiones	Buthidae	<i>Lychas</i>		sp.	'harveyi complex'	1	Widespread
SRE-WA04	14/03/2019	-23.1385268	118.5921124	Western Hill	Stony Plain	Pitfall Trap (Dry)	Arachnida	Scorpiones	Buthidae	<i>Lychas</i>		sp.	'harveyi complex'	1	Widespread
SRE-WA04	14/03/2019	-23.1385268	118.5921124	Western Hill	Stony Plain	Pitfall Trap (Dry)	Arachnida	Scorpiones	Buthidae	<i>Lychas</i>		sp.	'harveyi complex'	1	Widespread
SRE-WA13	14/03/2019	-23.1171701	118.6256976	Western Hill	Stony Plain	Pitfall Trap (Dry)	Arachnida	Araneae	Nemesiidae	<i>Aname</i>	<i>mellosa</i>			1	Widespread
SRE-WA13	14/03/2019	-23.1171701	118.6256976	Western Hill	Stony Plain	Pitfall Trap (Dry)	Arachnida	Araneae	Nemesiidae	<i>Aname</i>	<i>mellosa</i>			1	Widespread
SRE-WA13	14/03/2019	-23.1171701	118.6256976	Western Hill	Stony Plain	Pitfall Trap (Dry)	Arachnida	Araneae	Nemesiidae	<i>Aname</i>	<i>mellosa</i>			1	Widespread
SRE-WA13	14/03/2019	-23.1171701	118.6256976	Western Hill	Stony Plain	Pitfall Trap (Dry)	Arachnida	Araneae	Nemesiidae	<i>Aname</i>	<i>mellosa</i>			1	Widespread
SRE-WA13	14/03/2019	-23.1171701	118.6256976	Western Hill	Stony Plain	Pitfall Trap (Dry)	Arachnida	Araneae	Nemesiidae	<i>Aname</i>	<i>mellosa</i>			1	Widespread
SRE-WA13	14/03/2019	-23.1171701	118.6256976	Western Hill	Stony Plain	Pitfall Trap (Dry)	Arachnida	Araneae	Nemesiidae	<i>Aname</i>	<i>mellosa</i>			1	Widespread
SRE-WA13	14/03/2019	-23.1171701	118.6256976	Western Hill	Stony Plain	Pitfall Trap (Dry)	Arachnida	Araneae	Nemesiidae	<i>Aname</i>	<i>mellosa</i>			1	Widespread
SRE-WA13	14/03/2019	-23.1171701	118.6256976	Western Hill	Stony Plain	Pitfall Trap (Dry)	Arachnida	Araneae	Nemesiidae	<i>Aname</i>	<i>mellosa</i>			1	Widespread
SRE-WA13	14/03/2019	-23.1171701	118.6256976	Western Hill	Stony Plain	Pitfall Trap (Dry)	Arachnida	Araneae	Nemesiidae	<i>Aname</i>	<i>mellosa</i>			1	Widespread
SRE-WA14	21/03/2019	-23.1746721	118.8687566	Dep F North	Mulga Woodland	Leaf/soil sieving	Arachnida	Araneae	Idiopidae	<i>Gaius</i>	<i>tealei</i>			1	Widespread
SRE-WA15	19/03/2019	-23.1362434	118.6221099	Western Hill	Drainage Area/ Floodplain	Targeted searches	Arachnida	Araneae	Nemesiidae	<i>Aname</i>	<i>mellosa</i>			1	Widespread
SRE-WA15	19/03/2019	-23.3624348	118.6221099	Western Hill	Drainage Area/ Floodplain	Pitfall Trap (Dry)	Arachnida	Scorpiones	Buthidae	<i>Lychas</i>		sp.	'harveyi complex'	1	Widespread
SRE-WA15	19/03/2019	-23.1363547	118.6221622	Western Hill	Drainage Area/ Floodplain	Leaf/soil sieving	Arachnida	Scorpiones	Buthidae	<i>Lychas</i>		sp.	'harveyi complex'	1	Widespread
SRE-WA15	19/03/2019	-23.1363547	118.6221622	Western Hill	Drainage Area/ Floodplain	Subfauna Survey Scrape	Arachnida	Scorpiones	Buthidae	<i>Lychas</i>		sp.	'harveyi complex'	1	Widespread
SRE-WA15	19/03/2019	-23.1363547	118.6221622	Western Hill	Drainage Area/ Floodplain	Pitfall Trap (Dry)	Arachnida	Scorpiones	Buthidae	<i>Lychas</i>		sp.	'harveyi complex'	1	Widespread
SRE-WA20	18/03/2019	-23.1738351	118.850617	Dep F North	Gorge/ Gully	Leaf/soil sieving	Crustacea	Isopoda	Armadillidae	<i>Buddelundia</i>		sp.	16	2	Widespread

Site	Date	Latitude	Longitude	Deposit	Habitat Type	Sampling Method	Class	Order	Family	Genus	Species	Infra Rank	Infra Name	Specimens	Status
SRE-WA20	18/03/2019	-23.1738351	118.850617	Dep F North	Gorge/ Gully	Pitfall Trap (Dry)	Diplopoda	Spirobolida	Trigoniulidae	<i>Austrostrophus</i>		sp.	Clade A	8	Potential SRE
SRE-WA20	18/03/2019	-23.1738351	118.850617	Dep F North	Gorge/ Gully	Active foraging	Diplopoda	Spirobolida	Trigoniulidae	<i>Austrostrophus</i>		sp.	indet.	2	Potential SRE
SRE-WA21	21/03/2019	-23.1789158	118.8702866	Dep F North	Eucalypt Woodland	Leaf/soil sieving	Arachnida	Araneae	Idiopidae	<i>Gaius</i>	<i>tealei</i>			1	Widespread
SRE-WA21	21/03/2019	-23.1789158	118.8702866	Dep F North	Eucalypt Woodland	Leaf/soil sieving	Arachnida	Araneae	Idiopidae	<i>Gaius</i>	<i>tealei</i>			1	Widespread
SRE-WA23	19/03/2019	-23.1168533	118.6249896	Western Hill	Gorge/ Gully	Pitfall Trap (Dry)	Arachnida	Scorpiones	Buthidae	<i>Lychas</i>		sp.	indet 2	1	Potential SRE
SRE-WA23	19/03/2019	-23.1168533	118.6249896	Western Hill	Gorge/ Gully	Pitfall Trap (Dry)	Arachnida	Scorpiones	Buthidae	<i>Lychas</i>		sp.	indet 2	1	Potential SRE
SRE-WA23	19/03/2019	-23.1168533	118.6249896	Western Hill	Gorge/ Gully	Pitfall Trap (Dry)	Diplopoda	Spirobolida	Trigoniulidae	<i>Austrostrophus</i>		sp.	Clade E	1	Potential SRE
SRE-WA23	19/03/2019	-23.1168533	118.6249896	Western Hill	Gorge/ Gully	Leaf/soil sieving	Diplopoda	Spirobolida	Trigoniulidae	<i>Austrostrophus</i>		sp.	indet.	1	Potential SRE
SRE-WA27	17/03/2019	-23.2206463	118.7713319	Mt Ella E and Dep J	Stony Plain	Pitfall Trap (Dry)	Arachnida	Pseudoscorpiones	Olpiidae	<i>Beierolpium</i>		sp.	'8/3'	2	Widespread
SRE-WA27	20/03/2019	-23.2206463	118.7713319	Mt Ella E and Dep J	Stony Plain	Pitfall Trap (Dry)	Arachnida	Scorpiones	Buthidae	<i>Lychas</i>		sp.	'harveyi complex'	1	Widespread
SRE-WA27	17/03/2019	-23.2206463	118.7713319	Mt Ella E and Dep J	Stony Plain	Pitfall Trap (Dry)	Arachnida	Scorpiones	Buthidae	<i>Lychas</i>		sp.	'pilbara 1'	1	Widespread
SRE-WA27	20/03/2019	-23.2206463	118.7713319	Mt Ella E and Dep J	Stony Plain	Pitfall Trap (Dry)	Arachnida	Scorpiones	Buthidae	<i>Lychas</i>		sp.	'pilbara 1'	1	Widespread
SRE-WA27	20/03/2019	-23.2206463	118.7713319	Mt Ella E and Dep J	Stony Plain	Pitfall Trap (Dry)	Arachnida	Scorpiones	Buthidae	<i>Lychas</i>		sp.	'pilbara 1'	1	Widespread
SRE-WA27	20/03/2019	-23.2206463	118.7713319	Mt Ella E and Dep J	Stony Plain	Pitfall Trap (Dry)	Arachnida	Scorpiones	Buthidae	<i>Lychas</i>		sp.	'pilbara 1'	1	Widespread
SRE-WA27	20/03/2019	-23.2206463	118.7713319	Mt Ella E and Dep J	Stony Plain	Pitfall Trap (Dry)	Arachnida	Scorpiones	Buthidae	<i>Lychas</i>		sp.	'pilbara 1'	1	Widespread
SRE-WA27	20/03/2019	-23.2206463	118.7713319	Mt Ella E and Dep J	Stony Plain	Pitfall Trap (Dry)	Arachnida	Scorpiones	Buthidae	<i>Lychas</i>		sp.	'pilbara 1'	1	Widespread
SRE-WA30	14/03/2019	-23.114875	118.6438891	Western Hill	Stony Plain	Pitfall Trap (Dry)	Arachnida	Araneae	Nemesiidae	<i>Aname</i>	<i>mellosa</i>			1	Widespread
SRE-WA30	14/03/2019	-23.114875	118.6438891	Western Hill	Stony Plain	Pitfall Trap (Dry)	Arachnida	Araneae	Nemesiidae	<i>Aname</i>	<i>mellosa</i>			1	Widespread
SRE-WA30	14/03/2019	-23.114875	118.6438891	Western Hill	Stony Plain	Pitfall Trap (Dry)	Arachnida	Araneae	Nemesiidae	<i>Aname</i>	<i>mellosa</i>			1	Widespread
SRE-WA30	14/03/2019	-23.114875	118.6438891	Western Hill	Stony Plain	Pitfall Trap (Dry)	Arachnida	Araneae	Nemesiidae	<i>Kwonkan</i>		sp.	MYG380	1	Potential SRE
SRE-WA30	14/03/2019	-23.114875	118.6438891	Western Hill	Stony Plain	Pitfall Trap (Dry)	Arachnida	Scorpiones	Buthidae	<i>Isometroides</i>		sp.	'pilbara 1'	1	Widespread
SRE-WA30	14/03/2019	-23.114875	118.6438891	Western Hill	Stony Plain	Leaf/soil sieving	Arachnida	Scorpiones	Buthidae	<i>Lychas</i>		sp.	'harveyi complex'	1	Widespread
SRE-WA30	14/03/2019	-23.114875	118.6438891	Western Hill	Stony Plain	Pitfall Trap (Dry)	Arachnida	Scorpiones	Buthidae	<i>Lychas</i>		sp.	'harveyi complex'	1	Widespread
SRE-WA32	21/03/2019	-23.1730202	118.8396182	Dep F North	Gorge/ Gully	Leaf/soil sieving	Arachnida	Pseudoscorpiones	Olpiidae	<i>Euryolpium</i>		sp.	indet.	1	Widespread
SRE-WA32	21/03/2019	-23.1730202	118.8396182	Dep F North	Gorge/ Gully	Leaf/soil sieving	Crustacea	Isopoda	Armadiillidae	<i>Buddelundia</i>		sp.	16	7	Widespread
SRE-WA32	21/03/2019	-23.1730202	118.8396182	Dep F North	Gorge/ Gully	Pitfall Trap (Dry)	Diplopoda	Spirobolida	Trigoniulidae	<i>Austrostrophus</i>		sp.	Clade unknown 1		Potential SRE
SRE-WA32	21/03/2019	-23.1730202	118.8396182	Dep F North	Gorge/ Gully	Pitfall Trap (Dry)	Diplopoda	Spirobolida	Trigoniulidae	<i>Austrostrophus</i>		sp.	Clade unknown 1		Potential SRE
SRE-WA36	15/03/2019	-23.2299667	118.7147102	Mt Ella E and Dep J	Hillcrest/ Hillslope	Pitfall Trap (Dry)	Crustacea	Isopoda	Armadiillidae	<i>Buddelundia</i>		sp.	16	1	Widespread
SRE-WA36	15/03/2019	-23.2299667	118.7147102	Mt Ella E and Dep J	Hillcrest/ Hillslope	Leaf/soil sieving	Crustacea	Isopoda	Armadiillidae	<i>Buddelundia</i>		sp.	47	1	Potential SRE
SRE-WA36	15/03/2019	-23.2299667	118.7147102	Mt Ella E and Dep J	Hillcrest/ Hillslope	Active foraging	Diplopoda	Spirobolida	Trigoniulidae	<i>Austrostrophus</i>		sp.	Clade F	1	Potential SRE
SRE-WA36	15/03/2019	-23.2299667	118.7147102	Mt Ella E and Dep J	Hillcrest/ Hillslope	Active foraging	Diplopoda	Spirobolida	Trigoniulidae	<i>Austrostrophus</i>		sp.	Clade F	1	Potential SRE
SRE-WA36	15/03/2019	-23.2299667	118.7147102	Mt Ella E and Dep J	Hillcrest/ Hillslope	Active foraging	Diplopoda	Spirobolida	Trigoniulidae	<i>Austrostrophus</i>		sp.	Clade F	1	Potential SRE
SRE-WA36	15/03/2019	-23.2299667	118.7147102	Mt Ella E and Dep J	Hillcrest/ Hillslope	Leaf/soil sieving	Diplopoda	Spirobolida	Trigoniulidae	<i>Austrostrophus</i>		sp.	Clade unknown 2		Potential SRE
SRE-WA36	15/03/2019	-23.2299667	118.7147102	Mt Ella E and Dep J	Hillcrest/ Hillslope	Leaf/soil sieving	Diplopoda	Spirobolida	Trigoniulidae	<i>Austrostrophus</i>		sp.	Clade unknown 2		Potential SRE
SRE-WA40	18/03/2019	-23.2293248	118.7460923	Mt Ella E and Dep J	Hillcrest/ Hillslope	Leaf/soil sieving	Arachnida	Pseudoscorpiones	Olpiidae	<i>Beierolpium</i>		sp.	'8/4'	2	Widespread
SRE-WA40	18/03/2019	-23.2293248	118.7460923	Mt Ella E and Dep J	Hillcrest/ Hillslope	Leaf/soil sieving	Arachnida	Pseudoscorpiones	Olpiidae	<i>Beierolpium</i>		sp.	'8/4'	1	Widespread
SRE-WA40	18/03/2019	-23.2293248	118.7460923	Mt Ella E and Dep J	Hillcrest/ Hillslope	Pitfall Trap (Dry)	Arachnida	Scorpiones	Buthidae	<i>Lychas</i>		sp.	indet 2	1	Potential SRE
SRE-WA40	18/03/2019	-23.2293248	118.7460923	Mt Ella E and Dep J	Hillcrest/ Hillslope	Active foraging	Crustacea	Isopoda	Armadiillidae	<i>Buddelundia</i>		sp.	16	4	Widespread
SRE-WA40	18/03/2019	-23.2293248	118.7460923	Mt Ella E and Dep J	Hillcrest/ Hillslope	Leaf/soil sieving	Crustacea	Isopoda	Armadiillidae	<i>Buddelundia</i>		sp.	47	6	Potential SRE
SRE-WA40	18/03/2019	-23.2293248	118.7460923	Mt Ella E and Dep J	Hillcrest/ Hillslope		Crustacea	Isopoda	Armadiillidae	<i>Buddelundia</i>		sp.	47	1	Potential SRE
SRE-WA40	18/03/2019	-23.2293248	118.7460923	Mt Ella E and Dep J	Hillcrest/ Hillslope	Pitfall Trap (Dry)	Crustacea	Isopoda	Armadiillidae	<i>Buddelundia</i>		sp.	47	1	Potential SRE
SRE-WA40	18/03/2019	-23.2293248	118.7460923	Mt Ella E and Dep J	Hillcrest/ Hillslope	Leaf/soil sieving	Diplopoda	Spirobolida	Trigoniulidae	<i>Austrostrophus</i>		sp.	Clade unknown 2		Potential SRE
SRE-WA50	13/03/2019	-23.1239134	118.8924317	Dep H	Gorge/ Gully	Pitfall Trap (Dry)	Arachnida	Araneae	Nemesiidae	<i>Aname</i>	<i>mellosa</i>			1	Widespread
SRE-WA50	13/03/2019	-23.1239134	118.8924317	Dep H	Gorge/ Gully	Pitfall Trap (Dry)	Arachnida	Araneae	Nemesiidae	<i>Aname</i>	<i>mellosa</i>			1	Widespread
SRE-WA50	13/03/2019	-23.1239134	118.8924317	Dep H	Gorge/ Gully	Pitfall Trap (Dry)	Arachnida	Araneae	Nemesiidae	<i>Aname</i>	<i>mellosa</i>			1	Widespread
SRE-WA50	13/03/2019	-23.1239134	118.8924317	Dep H	Gorge/ Gully	Pitfall Trap (Dry)	Crustacea	Isopoda	Armadiillidae	<i>Buddelundia</i>		sp.	indet.	5	Potential SRE

Site	Date	Latitude	Longitude	Deposit	Habitat Type	Sampling Method	Class	Order	Family	Genus	Species	Infra Rank	Infra Name	Specimens	Status
SRE-WA50	13/03/2019	-23.1239134	118.8924317	Dep H	Gorge/ Gully	Leaf/soil sieving	Diplopoda	Spirobolida	Trigoniulidae	<i>Austrostrophus</i>		sp.	Clade A	1	Potential SRE
SRE-WA53	13/03/2019	-23.1363547	118.6221622	Western Hill	Drainage Area/ Floodplain	OPP.	Gastropoda	Eupulmonata	Bothriembryontidae	<i>Bothriembryon</i>		sp.	indet.	6	Widespread
SRE-WA57	15/03/2019	-23.2142231	118.8343072	Mt Ella E and Dep J	Ironstone Outcrops	Pitfall Trap (Dry)	Arachnida	Pseudoscorpiones	Olpiidae	<i>Indolpium</i>		sp.	indet.	2	Potential SRE
SRE-WA57	15/03/2019	-23.2142231	118.8343072	Mt Ella E and Dep J	Ironstone Outcrops	Leaf/soil sieving	Diplopoda	Spirobolida	Trigoniulidae	<i>Austrostrophus</i>		sp.	indet.	1	Potential SRE
SRE-WA58	16/03/2019	-23.2362277	118.7380264	Mt Ella E and Dep J	Breakaway/ Cliff	Pitfall Trap (Dry)	Crustacea	Isopoda	Armadillidae	<i>Buddelundia</i>		sp.	16	2	Widespread
SRE-WA61	16/03/2019	-23.2286504	118.7718037	Mt Ella E and Dep J	Minor Drainage Line		Crustacea	Isopoda	Armadillidae	<i>Buddelundia</i>		sp.	47	1	Potential SRE
SRE-WA63	16/03/2019	-23.2110296	118.8069134	Mt Ella E and Dep J	Gorge/ Gully		Arachnida	Pseudoscorpiones	Chthoniidae	<i>Tyrannochthonius</i>		sp.	indet.	3	Potential SRE
SRE-WA63	16/03/2019	-23.2110296	118.8069134	Mt Ella E and Dep J	Gorge/ Gully	Active foraging	Arachnida	Pseudoscorpiones	Olpiidae	<i>Euryolpium</i>		sp.	indet.	1	Widespread
SRE-WA63	16/03/2019	-23.2110296	118.8069134	Mt Ella E and Dep J	Gorge/ Gully	Leaf/soil sieving	Arachnida	Pseudoscorpiones	Olpiidae	<i>Indolpium</i>		sp.	indet.	3	Potential SRE
SRE-WA63	16/03/2019	-23.2110296	118.8069134	Mt Ella E and Dep J	Gorge/ Gully	Pitfall Trap (Dry)	Arachnida	Pseudoscorpiones	Olpiidae	<i>Indolpium</i>		sp.	indet.	1	Potential SRE
SRE-WA64	16/03/2019	-23.1209830	118.8649733	Dep H	Gorge/ Gully	Leaf/soil sieving	Arachnida	Pseudoscorpiones	Olpiidae	<i>Beierolpium</i>		sp.	indet.	1	Widespread
SRE-WA64	16/03/2019	-23.1209830	118.8649733	Dep H	Gorge/ Gully	Leaf/soil sieving	Arachnida	Pseudoscorpiones	Olpiidae	<i>Euryolpium</i>		sp.	indet.	10	Widespread
SRE-WA64	16/03/2019	-23.1209830	118.8649733	Dep H	Gorge/ Gully		Diplopoda	Spirobolida	Trigoniulidae	<i>Austrostrophus</i>		sp.	Clade A	1	Potential SRE
SRE-WA65	17/03/2019	-23.2420144	118.7554558	Mt Ella E and Dep J	Medium Drainage Line	Pitfall Trap (Dry)	Arachnida	Araneae	Nemesiidae	<i>Aname</i>	<i>melloso</i>			1	Widespread
SRE-WA65	17/03/2019	-23.2420144	118.7554558	Mt Ella E and Dep J	Medium Drainage Line	Leaf/soil sieving	Crustacea	Isopoda	Armadillidae	Buddelundiinae		sp.	indet.	1	Potential SRE
SRE-WA66	16/03/2019	-23.1239379	118.8462724	Dep H	Gorge/ Gully		Arachnida	Pseudoscorpiones	Olpiidae	<i>Beierolpium</i>		sp.	'8/4'		Widespread
SRE-WA66	16/03/2019	-23.1239379	118.8462724	Dep H	Gorge/ Gully	Targeted searches	Arachnida	Pseudoscorpiones	Olpiidae	<i>Euryolpium</i>				6	Widespread
SRE-WA68	16/03/2019	-23.1252018	118.8443542	Dep H	Gorge/ Gully	Leaf/soil sieving	Crustacea	Isopoda	Armadillidae	<i>Buddelundia</i>		sp.	16	2	Widespread
SRE-WA69	17/03/2019	-23.2235603	118.7184393	Mt Ella E and Dep J	Stony Plain	Leaf/soil sieving	Arachnida	Pseudoscorpiones	Olpiidae	<i>Beierolpium</i>		sp.	'8/4'	3	Widespread
SRE-WA70	16/03/2019	-23.1243169	118.8439058	Dep H	Hillcrest/ Hillslope	Leaf/soil sieving	Crustacea	Isopoda	Armadillidae	<i>Buddelundia</i>		sp.	16	4	Widespread
SRE-WA70	16/03/2019	-23.1243169	118.8439058	Dep H	Hillcrest/ Hillslope	Pitfall Trap (Dry)	Diplopoda	Spirobolida	Trigoniulidae	<i>Austrostrophus</i>		sp.	indet.	1	Potential SRE
SRE-WA71	17/03/2019	-23.2245619	118.7377646	Mt Ella E and Dep J	Ironstone Outcrops		Arachnida	Pseudoscorpiones	Olpiidae	<i>Beierolpium</i>		sp.	'8/4'		Widespread
SRE-WA71	17/03/2019	-23.2245619	118.7377646	Mt Ella E and Dep J	Ironstone Outcrops	Leaf/soil sieving	Arachnida	Pseudoscorpiones	Olpiidae	Genus 7/4		sp.	indet.	1	Potential SRE
SRE-WA71	17/03/2019	-23.2245619	118.7377646	Mt Ella E and Dep J	Ironstone Outcrops	Pitfall Trap (Dry)	Diplopoda	Spirobolida	Trigoniulidae	<i>Austrostrophus</i>		sp.	Clade unknown 2		Potential SRE
SRE-WA72	16/03/2019	-23.1323957	118.8326924	Dep H	Gorge/ Gully	Active foraging	Crustacea	Isopoda	Armadillidae	<i>Buddelundia</i>		sp.	16	4	Widespread
SRE-WA72	16/03/2019	-23.1323957	118.8326924	Dep H	Gorge/ Gully	Leaf/soil sieving	Diplopoda	Spirobolida	Trigoniulidae	<i>Austrostrophus</i>		sp.	indet.	3	Potential SRE
SRE-WA72	16/03/2019	-23.1323957	118.8326924	Dep H	Gorge/ Gully	Active foraging	Gastropoda	Eupulmonata	Bothriembryontidae	<i>Bothriembryon</i>		sp.	indet.	5	Widespread
SRE-WA73	18/03/2019	-23.2308738	118.7212101	Mt Ella E and Dep J	Medium Drainage Line	Leaf/soil sieving	Crustacea	Isopoda	Armadillidae	<i>Buddelundia</i>		sp.	15	1	Widespread
SRE-WA74	17/03/2019	-23.1276411	118.9031898	Dep H	Minor Drainage Line		Arachnida	Pseudoscorpiones	Garypidae	<i>Synsphyronus</i>		sp.	'8/1 pilbara'	1	Widespread
SRE-WA74	17/03/2019	-23.1276411	118.9031898	Dep H	Minor Drainage Line	Pitfall Trap (Dry)	Diplopoda	Spirobolida	Trigoniulidae	<i>Austrostrophus</i>		sp.	Clade A	6	Potential SRE
SRE-WA75	18/03/2019	-23.1195603	118.8688528	Dep H	Gorge/ Gully	Leaf/soil sieving	Arachnida	Pseudoscorpiones	Olpiidae	<i>Euryolpium</i>		sp.	indet.	2	Widespread
SRE-WA75	18/03/2019	-23.1195603	118.8688528	Dep H	Gorge/ Gully	Active foraging	Crustacea	Isopoda	Armadillidae	<i>Buddelundia</i>		sp.	16	8	Widespread
SRE-WA76	17/03/2019	-23.1294191	118.8944228	Dep H	Mulga Woodland	Active foraging	Crustacea	Isopoda	Armadillidae	<i>Buddelundia</i>		sp.	16	1	Widespread
SRE-WA77	18/03/2019	-23.1182264	118.880826	Dep H	Gorge/ Gully	Leaf/soil sieving	Arachnida	Pseudoscorpiones	Olpiidae	<i>Austrohorus</i>		sp.	indet.	1	Potential SRE
SRE-WA77	18/03/2019	-23.1182264	118.880826	Dep H	Gorge/ Gully	Pitfall Trap (Dry)	Crustacea	Isopoda	Armadillidae	<i>Buddelundia</i>		sp.	16	9	Widespread
SRE-WA78	17/03/2019	-23.1147927	118.6558178	Western Hill	Minor Drainage Line	Active foraging	Crustacea	Isopoda	Armadillidae	<i>Buddelundia</i>		sp.	16	2	Widespread
SRE-WA79	18/03/2019	-23.1250504	118.8733604	Dep H	Gorge/ Gully		Arachnida	Pseudoscorpiones	Chthoniidae	<i>Tyrannochthonius</i>		sp.	indet.	2	Potential SRE
SRE-WA81	13/03/2019	-23.1320552	118.8602807	Dep H	Stony Plain	Pitfall Trap (Dry)	Arachnida	Araneae	Nemesiidae	<i>Aname</i>	<i>melloso</i>			1	Widespread
SRE-WA81	19/03/2019	-23.1320552	118.8602807	Dep H	Stony Plain		Diplopoda	Spirobolida	Trigoniulidae	<i>Austrostrophus</i>		sp.	indet.	1	Potential SRE
SRE-WA83	20/03/2019	-23.1276864	118.927938	Dep H	Gorge/ Gully	Leaf/soil sieving	Arachnida	Pseudoscorpiones	Chthoniidae	<i>Austrochthonius</i>		sp.	pilbara'	7	Widespread
SRE-WA83	20/03/2019	-23.1276864	118.927938	Dep H	Gorge/ Gully		Arachnida	Pseudoscorpiones	Chthoniidae	<i>Tyrannochthonius</i>		sp.	indet.	3	Potential SRE
SRE-WA83	20/03/2019	-23.1276864	118.927938	Dep H	Gorge/ Gully	Hand collected	Arachnida	Pseudoscorpiones	Garypidae	<i>Synsphyronus</i>		sp.	'8/1 pilbara'	2	Widespread
SRE-WA83	20/03/2019	-23.1276864	118.927938	Dep H	Gorge/ Gully	Leaf/soil sieving	Arachnida	Pseudoscorpiones	Olpiidae	<i>Beierolpium</i>		sp.	indet.	3	Widespread
SRE-WA83	20/03/2019	-23.1276864	118.927938	Dep H	Gorge/ Gully	Pitfall Trap (Dry)	Arachnida	Pseudoscorpiones	Olpiidae	<i>Indolpium</i>		sp.	indet.	1	Potential SRE
SRE-WA83	20/03/2019	-23.1276864	118.927938	Dep H	Gorge/ Gully	Active foraging	Crustacea	Isopoda	Armadillidae	<i>Buddelundia</i>		sp.	16	9	Widespread

Site	Date	Latitude	Longitude	Deposit	Habitat Type	Sampling Method	Class	Order	Family	Genus	Species	Infra Rank	Infra Name	Specimens	Status
SRE-WA83	20/03/2019	-23.1276864	118.927938	Dep H	Gorge/ Gully	Pitfall Trap (Dry)	Crustacea	Isopoda	Armadillidae	<i>Buddelundia</i>		sp.	77	6	Potential SRE
SRE-WA83	20/03/2019	-23.1276864	118.927938	Dep H	Gorge/ Gully	Pitfall Trap (Dry)	Diplopoda	Spirobolida	Trigoniulidae	<i>Austrostrophus</i>		sp.	indet.	1	Potential SRE
SRE-WA84	20/03/2019	-23.1254148	118.9179767	Dep H	Gorge/ Gully	Pitfall Trap (Dry)	Diplopoda	Spirobolida	Trigoniulidae	<i>Austrostrophus</i>		sp.	Clade A	3	Potential SRE
SRE-WA85	20/03/2019	-23.1078186	118.6419706	Western Hill	Mulga Woodland	Pitfall Trap (Dry)	Arachnida	Scorpiones	Buthidae	<i>Lychas</i>		sp.	indet 1	1	Potential SRE
SRE-WA90	21/03/2019	-23.1813979	118.8640735	Dep F North	Gorge/ Gully	Leaf/soil sieving	Arachnida	Pseudoscorpiones	Olpiidae	Genus 7/4		sp.	indet	1	Potential SRE
SRE-WA90	21/03/2019	-23.1813979	118.8640735	Dep F North	Gorge/ Gully	Hand collected	Arachnida	Pseudoscorpiones	Olpiidae			sp.	indet.	1	Potential SRE
SRE-WA95	15/03/2019	-23.211665	118.792246	Mt Ella E and Dep J	Hillcrest/ Hillslope	Leaf/soil sieving	Arachnida	Pseudoscorpiones	Olpiidae	<i>Austrohorus</i>		sp.	indet.	1	Potential SRE

## **E.8: West Angelas Revised Proposal Short-Range Endemic Invertebrate Fauna Environmental Impact Assessment**



West Angelas Revised Proposal  
Short-Range Endemic  
Invertebrate Fauna  
Environmental Impact  
Assessment

Biologic Environmental Survey  
Report to Rio Tinto Iron Ore  
February 2023

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

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## 1 INTRODUCTION

Rio Tinto Iron Ore Pty Ltd (Rio Tinto) owns and operates the West Angelas Iron Ore Project (The Project). Current and previous mining operations within the West Angelas Region comprise operations at Deposits A, B, C, D, E, F and G approved under Ministerial Statements 1113, 1015, 0970 and 0514. Rio Tinto is evaluating the potential to expand these existing mining operations under the West Angelas Revised Proposal (the Proposal, EPA Assessment 2290). The Proposal is located approximately 100 kilometres (km) north-west of Newman in the Pilbara region of Western Australia (Figure°1.1) Rio Tinto commissioned Biologic Environmental Survey (Biologic) to undertake an environmental impact assessment (EIA) for short-range endemic (SRE) invertebrate fauna identified from the West Angelas Revised Proposal Project area or Development Envelope (DE). These results will be used to inform the environmental review document (ERD) for the DE.

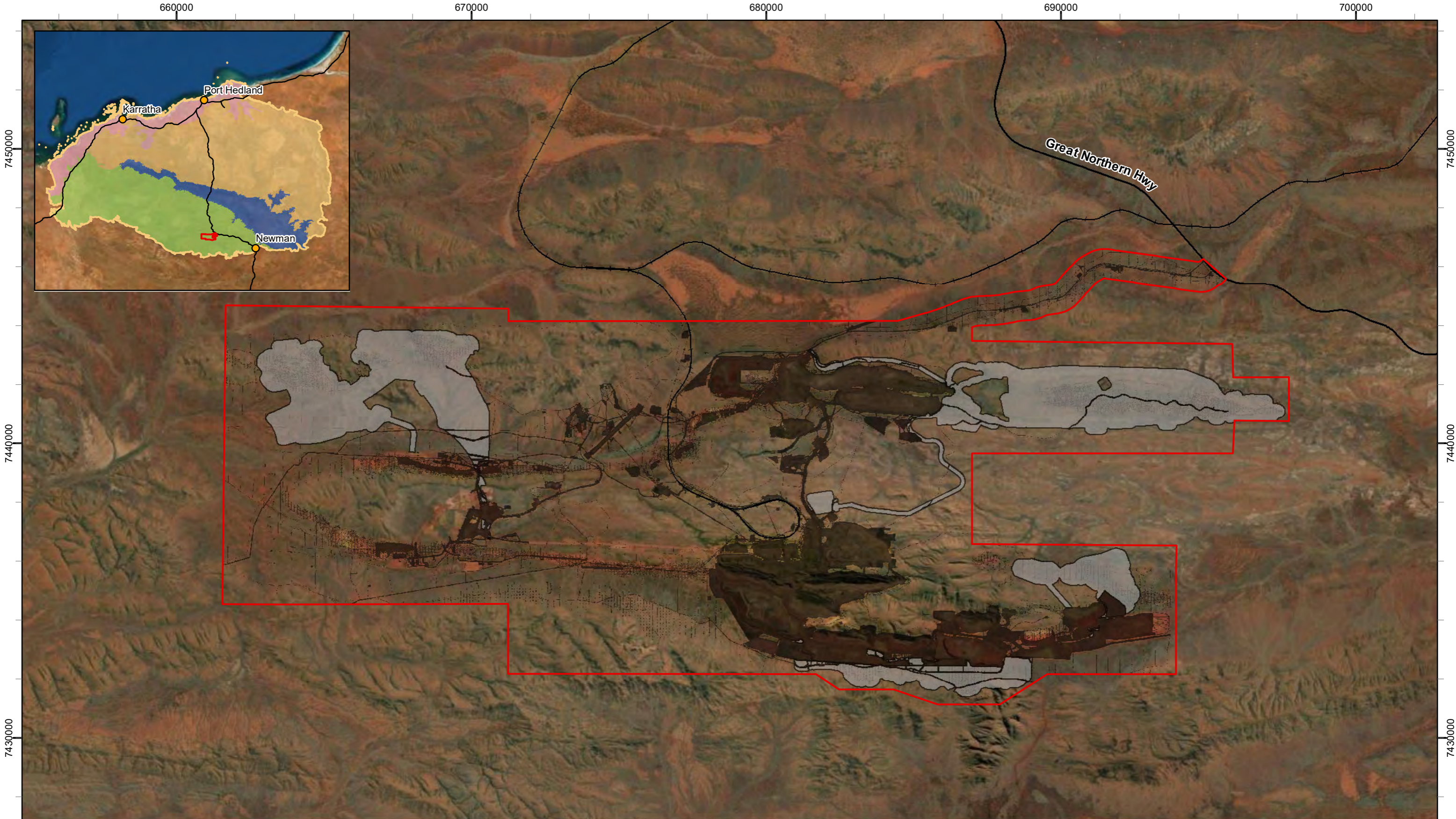
### 1.1 Sections of the Proposal

The West Angelas Revised Proposal ERD (EPA Assessment 2290) provides a detailed description of the Proposal, which involves clearing of an additional 5,350 hectares (ha) of native vegetation (in addition to the 12,205 ha currently authorised under Ministerial Statement 1113) within a Development Envelope of 36,779 ha.

### 1.2 Supporting documents and studies


The technical reports used to prepare this SRE invertebrate fauna EIA include:

- West Angelas Beyond 2020: Level 2 Vertebrate and SRE Invertebrate Fauna Assessment Phase 1 & 2 Report (Biologic, 2021) - report consolidating terrestrial fauna records and habitat for the West Angelas development as it stood in 2021;
- West Angelas Revised Proposal SRE Invertebrate Fauna Molecular Report (Biologic, 2023) – Report containing consolidation of sequence results for the West Angelas revised proposal area including additionally sequenced specimens from 2022; and
- West Angelas Revised Proposal SRE Invertebrate Fauna Risk Assessment (Biologic, 2022) – Report detailing an assessment of all invertebrate taxa, their distribution in relation to the DE, the habitats within which they were collected, sampling effort and an updated analysis of potential SRE species and the potential risk posed by the mining footprint .

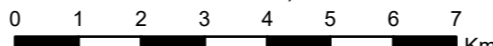


- LEGEND**
- Development Envelope
  - Proposed Additional Footprint
  - Current Footprint
  - State Road
  - Rail

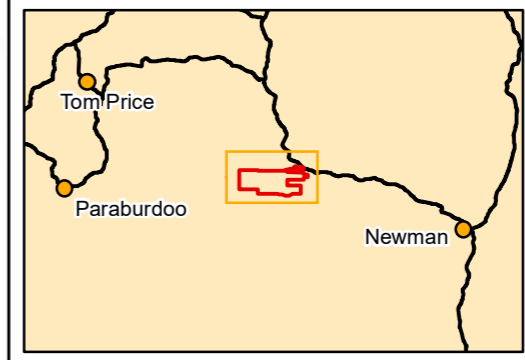
- |   |  |
|---|--|
| <b>IBRA Region</b>                            | <b>IBRA Subregion</b>  |
| <span style="color: orange;">—</span> Pilbara | <span style="background-color: yellow; display: inline-block; width: 15px; height: 10px; margin-right: 5px;"></span> Chichester    |
|   | <span style="background-color: blue; display: inline-block; width: 15px; height: 10px; margin-right: 5px;"></span> Fortescue       |
|   | <span style="background-color: lightgreen; display: inline-block; width: 15px; height: 10px; margin-right: 5px;"></span> Hamersley |
|   | <span style="background-color: pink; display: inline-block; width: 15px; height: 10px; margin-right: 5px;"></span> Roebourne       |



**Scale: 1:120,000**



Coordinate System: GDA2020 MGA Zone 50  
 Projection: Transverse Mercator  
 Datum: GDA2020      Created 31/10/2022



**RIO TINTO IRON ORE**  
**West Angeles: Short-Range**  
**Endemic Invertebrate Fauna**  
**Environmental Impact**  
**Assessment**  
 Figure 1.1: West Angeles  
 Study Area and regional  
 location

## 2 EIA FRAMEWORK

### 2.1 Potential impacts to SRE invertebrate fauna

The EPA's objective for the factor Terrestrial Fauna is: *"To protect terrestrial fauna so that biological diversity and ecological integrity are maintained"*. Ecological integrity is defined as the composition, structure, function and processes of ecosystems, and the natural range of variation of these elements (EPA, 2016). The objectives of the EPA in respect of SRE invertebrate fauna are to ensure that no SRE invertebrate species is placed under risk of extinction and that the conservation status of SRE invertebrate taxa are not adversely changed as a result of development proposals. This can be done by:

- ensuring the protection of key habitats for SRE species; and
- maintaining the distribution, abundance and productivity of populations of SRE taxa.

The assessment of potential impacts takes into account the following direct and indirect impacts. Both direct and indirect impacts may cumulatively affect SRE invertebrate fauna occurrence and persistence in the environment. Direct impacts include:

- Direct loss of SRE fauna individuals via mining activities, vegetation clearing, and land surface changes (e.g. construction of waste dumps, stockpiles and infrastructure); and
- Direct loss of SRE habitat resulting from mining activities, vegetation clearing, and land surface changes.

Indirect impacts include:

- changes to hydrological or hydrogeological processes increasing desiccation or flooding within SRE habitats;
- declining vegetation health within SRE habitats (e.g. disturbance from mining activities, altered hydrological processes, increased dust, altered fire regimes, weeds or pathogens); and
- changes to soil quality/ condition within SRE habitats (e.g. soil salinisation or contamination, or changes to erosion/ deposition processes from altered hydrology and land surface change).

The fragmentation of SRE habitats by direct impacts may cause populations to become isolated, potentially increasing genetic fragmentation and reducing the genetic variability of affected species. However, many SRE species inherently occur within isolated or fragmented pockets of suitable habitat throughout the landscape, and the ability of SRE fauna to disperse between habitat fragments is highly variable between taxa. Assessment of the indirect impacts of habitat fragmentation on SRE species can often be limited by knowledge gaps regarding the wider potential range/ distribution of a species beyond limited sampling records, its dispersal capabilities, and ecological characteristics including habitat requirements. Where this information does not exist at a species level (e.g. for new taxa), the assessment relies on assumptions and knowledge relevant at higher taxonomic levels (e.g. genus, family, or order level). Impacts to SRE fauna and habitats can be ranked Low, Medium or High as defined in Table 2.1 below.

**Table 2.1: Proposed impact categories for SRE invertebrate fauna and habitats**

Category	Description
<b>Low</b>	The proposed impacts are unlikely to significantly affect Potential or Confirmed SRE species or their habitats in the local area. The species or habitats in question are known to occur widely beyond the proposed impact areas, and their long-term viability or persistence in the region is unlikely to change as a result of the Proposal. The environmental objectives for SRE fauna are met in relation to the values in question, without any management/ mitigation.
<b>Medium</b>	The proposed impacts may temporarily or partially affect a Potential or Confirmed SRE species in the local area. Populations of the species, or important habitats may be impacted throughout part of their known range, but other significant parts are likely to remain unaffected, and the long-term persistence of the species in the region is not at risk. It is likely that the environmental objectives for SRE fauna will be able to be met by the Proposal due to moderate or low residual impacts.
<b>High</b>	The proposed impacts are likely to affect the persistence of a Potential or Confirmed SRE species in the local area. A significant proportion of the known or likely habitat may be permanently lost and the long-term persistence of the species in the region may be at risk. It is unlikely that the environmental objectives for SRE fauna will be able to be met where residual impacts are high.

### 3 ASSESSMENT OF IMPACTS TO SRE INVERTEBRATE FAUNA

#### 3.1 Direct impacts to SRE species

Although the Proposal may result in the direct loss of SRE individuals via mining activities, clearing, and land surface changes at sites within the impact footprint, these impacts are unlikely to cause the loss of any species. This is because the recorded occurrence of SRE species within the DE is unlikely to represent the total range or distribution of any of the taxa recorded, due to the sampling artefacts inherent in SRE surveys. Especially for the singletons and species recorded only from single sites herein, it is unlikely that a single sampling location could encapsulate the total distribution range of the species; rather, it indicates an association to a particular habitat type that can be assessed as a proxy where the sampling to date failed to detect a more complete distribution range.

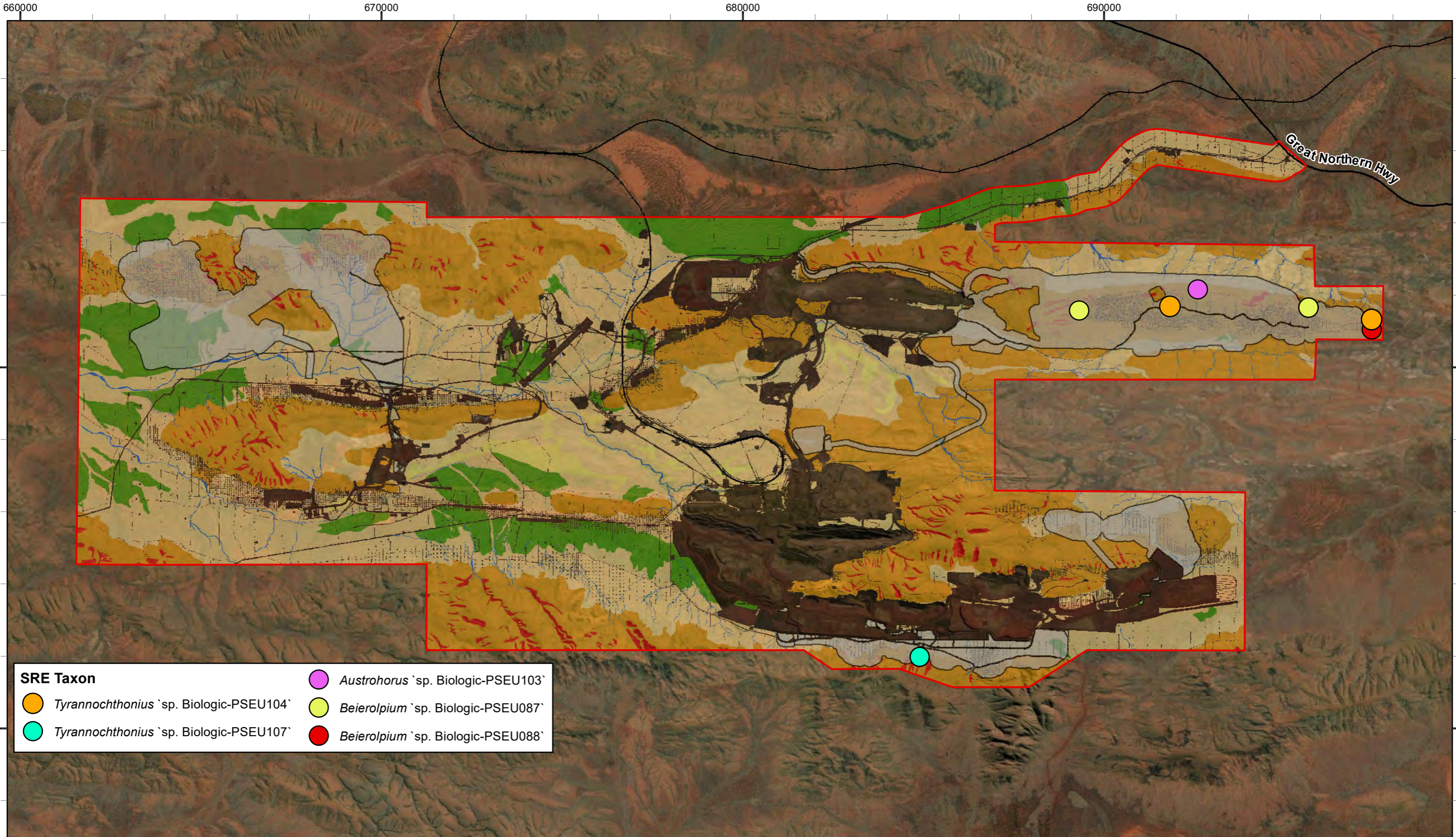
Seventy-five taxa were considered as occurring within the DE. Of these, 19 were indeterminate taxa, identified only to genus level or higher, the majority of which are likely to represent one of the other identified taxa. These indeterminate taxa are not considered further but are summarised in the West Angelas Revised Proposal SRE Invertebrate Fauna Risk Assessment (Biologic, 2022). Of the remaining 56 taxa, 38 are Potential SRE and 18 are Widespread taxa. No Confirmed SRE invertebrates have been recorded. Of the 38 Potential SRE taxa recorded in the DE, there are four mygalomorph spiders, 18 pseudoscorpions, three scorpions, two millipedes, ten terrestrial isopods and one snail.

Currently, 18 Potential SRE invertebrate taxa are known only from the DE while nine are known only from within the proposed footprint. Direct impacts from the Proposal are considered Low for all Potential SRE taxa that are known to occur beyond the impact footprint (comprising the areas of mining, clearing, infrastructure and land surface change).

#### Taxa restricted to the footprint


Of the nine Potential SRE taxa that have, to date, only been collected from within the impact footprint, five were considered to be of Medium risk from the Proposal with the remaining four considered to be Low risk. This assessment was made based on what was known of the taxon, if not at the species level then at the genus or family level and the habitat they were recorded in. All Medium risk taxa were pseudoscorpions collected from one or two sites within restricted habitat inside the footprint

*Tyrannochthonius* 'sp. Biologic-PSEU104' and *Tyrannochthonius* 'sp. Biologic-PSEU107' were both collected from one or two sites from within the footprint. Until recently, many *Tyrannochthonius* specimens were morphologically identified as the same widespread species *Tyrannochthonius aridus*. Molecular sequencing has demonstrated that there is a large amount of cryptic diversity in both genera but that also a large amount of regional sequencing is required before taxa are confidently labelled as an SRE (Figure°3.1).




SRE Taxon	
	<i>Tyrannochthonius</i> `sp. Biologic-PSEU104`
	<i>Tyrannochthonius</i> `sp. Biologic-PSEU107`
	<i>Austrohorus</i> `sp. Biologic-PSEU103`
	<i>Beierolpium</i> `sp. Biologic-PSEU088`
	<i>Beierolpium</i> `sp. Biologic-PSEU087`


LEGEND




Development Envelope



Proposed Additional Footprint




State Road




Rail


**Habitat**




Cracking Clay




Disturbed




Drainage Line




Footslopes and Plains



Gorge/Gully



Hillcrest and Hillslope

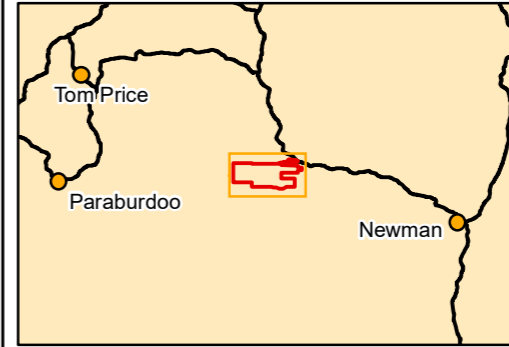


Mixed Acacia Woodland

Scale: 1:100,000

0 1 2 3 4 5 Km

Coordinate System: GDA2020 MGA Zone 50  
 Projection: Transverse Mercator  
 Datum: GDA2020 Created 31/10/2022



**RIO TINTO IRON ORE**  
 West Angeles: Short-Range  
 Endemic Invertebrate Fauna  
 Environmental Risk  
 Assessment

Figure 3.1: SRE fauna  
 designated as Medium  
 risk of impact

*Austrohorus* `sp. Biologic-PSEU103`, *Beierolpium* `sp. Biologic-PSEU087`, *Beierolpium* `sp. Biologic-PSEU088` were collected from one or two sites from within the footprint. Olpiidae taxonomy is poorly developed, with identification even to genus considered challenging by taxonomic experts. Molecular analyses of the family indicate significant cryptic diversity and many taxa that appear to have restricted ranges. Further regional work would be necessary to comment on whether these species will be restricted to the footprint or would be found in similar habitat beyond the DE.

It must be considered that these “species” are in fact operational taxonomic units (OTUs) defined in Biologic (2023) as species-equivalent taxonomic unit based on COI or 12S cluster similarity. This means that it is similar to “morphospecies” in that phylogenetic analysis is required for the group and formal species defined before their species delimitation can be confidently assigned.

### 3.2 Direct impacts to SRE habitats

Direct impacts to SRE habitats comprise the removal of suitable habitat by clearing and mining activities, and land surface changes such as construction of waste dumps, stockpiles, and infrastructure. Many SRE fauna have specific habitat requirements and a limited ability to disperse over wide distances, in some cases their habitats can be inherently fragmented and occur only in small patches throughout the landscape. Other similar taxa collected during SRE surveys may be able to disperse throughout a range of different habitat types and have more generalist habitat requirements.

The presence and absence of species and OTUs (and broader faunal groups) per habitat type is detailed in Biologic (2022). Consistent with what is known throughout the region, the consolidated SRE records suggested that the mountainous habitat types (comprising Hillslope and Hillcrest and Gorge/ Gully), were of Moderate to High significance for most SRE fauna groups. These contained the majority of the Potential SRE species (29 of the 52 Potential SRE taxa identified from the DE). Drainage Line and Mixed Acacia Woodland habitats were also considered Moderate value, while Footslopes and Plains, Cracking Clay and Disturbed habitats were of Low value for SRE fauna.

The differences in the numbers of taxa per habitat type may be influenced by inherent sampling biases, as targeted SRE surveys often focus collection efforts towards mountainous habitats that are known to be of high value for SRE fauna in the region. Nevertheless, in combination, the mountainous habitat types appeared to support most of the SRE fauna recorded from the DE to date (Biologic, in prep -b). These types of habitats occur in an interconnected network (or mosaic) from east to west throughout the DE, providing a network of complex, sheltered rocky microhabitats. While the Gorge/ Gully habitats are likely to be focal points for SRE values due to complex microhabitats, shelter from desiccation, and their inherent patchiness across the landscape, similar microhabitats occurring throughout the surrounding mosaic may provide opportunities for mountain-adapted SRE fauna to disperse between individual Gorge/ Gullies.

Biologic (2022) shows that the overall impact of the Proposal is to approximately 14.5% of the DE by area, and the proportional reduction of each habitat type within DE is no greater than 21%. Based on these calculations, the proportional impact to each SRE habitat type is considered low. Gorge/ Gully habitats naturally occur in smaller patches and fragments throughout rocky/ mountainous landscapes;

approximately 85% of the mapped extent of Gorge/Gully, and at least 80% of the mapped extent of all other habitat types throughout the DE are expected to remain intact; therefore the overall impact of the Proposal on SRE habitat values within the DE is considered Low.

Residual impacts from the Proposal to SRE habitat values include the removal of:

- High value SRE fauna habitat (approximately 126 ha Gorge/Gully);
- Medium value SRE fauna habitat (approximately 3,731 ha Hillcrest and Hillslope, 374 ha Mixed Acacia Woodland, 79ha Drainage Line habitat); and
- Low value SRE fauna habitat (approximately 1,789 ha Stony and Alluvial Plain).

These area figures are indicative only and may be subject to change with the inclusion of buffer zones around proposed infrastructure for operational flexibility. As buffer zones are universally applied, it is not expected that their inclusion would materially change the relative proportions of the various habitat types impacted.

### 3.3 Indirect impacts to SRE fauna/ habitats

Indirect impacts to SRE values are unable to be quantified due to ecological knowledge gaps and limitations to data/ information. Implementation of the Proposal may have some potential to result in indirect impacts to SRE habitats such as:

- increased habitat fragmentation;
- altered hydrological regimes;
- habitat degradation from introduced weeds, fauna species, or pathogens; and
- increased disturbance in the immediate vicinity of active mining and construction, from light, noise, vibration, or dust.

#### Habitat fragmentation

Most of the habitat types occurring throughout the DE are known to occur, or likely to occur, more widely beyond the DE within the immediate surrounding area (based on aerial photography and anecdotal observations). The wider occurrence of similar habitat types beyond the DE would be expected to mitigate the impact of habitat fragmentation within the DE for habitats such as Hillcrest and Hillslope and Gorge/ Gully (occurring in a mosaic of mountainous habitat), Drainage and Woodland habitats (linear habitats that extend well beyond the DE), and Alluvial and Stony Plains (widespread habitats that extend well beyond the DE).

Some habitat types such as Gorge/ Gully naturally occur in smaller patches and fragments throughout the landscape; therefore, SRE fauna occurring across these types of habitats are likely to make use of the surrounding mosaic of mountainous habitats (e.g. Hillcrest and Hillslopes, Gorge/ Gully) to disperse. There is a possibility that some SRE fauna cannot disperse beyond very limited spatial areas across habitats that are naturally fragmented. Nevertheless, a moderate to high proportion of all habitat types is expected to remain in-tact within the DE following the implementation of the Proposal, and it is likely that all of the habitat types are well represented in the surrounding area beyond the DE. As such, the potential indirect impacts of habitat fragmentation are likely to be low.

### **Alteration of hydrology**

None of the SRE fauna known to occur in the DE are known to be associated with groundwater or groundwater dependent ecosystems (GDEs). Additionally, the majority of high and medium value SRE habitat types were associated with mountainous habitat areas, which occur high in the landscape, far from the influence of groundwater. The risk of indirect impacts from alteration of groundwater hydrology to SRE values in these types of habitats is therefore low.

SRE values in drainage or woodland habitats (e.g. Drainage Line or Mixed Acacia Woodland) may be subject to impacts from alteration of groundwater or surface water hydrology. Implementation of the Proposal has the potential to alter riparian vegetation and water availability in these types of habitats via groundwater drawdown, riparian discharge, and changes to surface water flows.

It is likely that many of the SRE fauna species occurring in drainage or woodland habitats are adapted to cope with periodic flooding and drying due to the nature of ephemeral waterways in the Pilbara region. Impacts such as groundwater drawdown or riparian discharge may extend the immediate vicinity of the proposed direct impact areas, but these types of habitats extend in a linear fashion well beyond the DE. The risk of indirect impacts from altered hydrology to SRE values in these types of habitats is unlikely to be significant.

### **Other impacts**

Most environments in the Pilbara region have been subjected to introduced weeds and introduced fauna species from previous land uses. The proposed construction and mining activities may have the potential to increase transport of weeds or introduced fauna species to habitats in proximity to direct impact areas. However, best management procedures are expected to effectively manage the risk of major incursions of weeds, introduced fauna species, or pathogens.

Increased exposure to artificial light and to noise/ vibration from construction and mining activities may have an impact on invertebrate species in the immediate vicinity of active operational areas. None of the types of SRE fauna recorded from the DE are expected to be attracted to light, but some of their prey species may be (e.g. moths and flying invertebrates). There is insufficient information to assess the potential impact on SRE fauna species. Some burrowing spiders such as mygalomorph spiders are known to be attracted to some types of vibration (e.g. from diesel engines) and may leave their burrows to investigate. However, these types of vibrations dissipate with distances over a few metres and are unlikely to cause any impact beyond operational buffer zones.

While most environments in the Pilbara are naturally dusty, construction and mining activities have the potential to increase dust in the immediate vicinity of operational areas. Standard dust management practises are expected to effectively manage these risks.

**Table 3.1: Area of each habitat type and proportion of total area likely to be retained following implementation of the Proposal.**

Areas of each habitat type	Gorge/Gully	Hillcrest and Hillslope	Mixed Acacia Woodland	Drainage Line	Footslopes and Plains	Disturbed	Cracking Clay	Total
Area within DE (ha)	622	12356	3295	384	12702	6991	430	<b>36779</b>
Area within impact footprint (ha)	97	2535	374	79	1871	394	0	<b>5350*</b>
Estimated habitat remaining (%)	84.4	79.5	88.6	79.4	85.3	N/A	100	<b>85.5</b>
Indicative Occurrence outside DE (based on aerial photography)	Throughout mountainous areas, particularly south & east	Throughout mountainous areas, particularly south & east	Extensive/ widespread particularly centre & west	Extensive (linear) along major drainage lines	Extensive/ widespread particularly north, east & west	N/A	N/A	
Generalised, overall habitat value (for SRE taxa recorded to date)	High	Moderate	Moderate	Moderate	Low	Low	Low	

Note: \* 'Area within impact footprint and 'Estimated habitat remaining' does not include areas within existing disturbance areas. All habitat areas and %ages are indicative based on mapping, and may be subject to change with inclusion of buffer areas around proposed infrastructure.

### 3.4 Potential cumulative impacts to fauna/ habitats

Existing mining operations occur within DE and hence, quantification of cumulative impacts to SRE fauna and habitats is constrained by the commencement of these existing operations prior to consideration and assessment of SRE fauna in EIA. As such, there is no information available with which to assess pre-mining habitat extent for any of the mapped habitat types within the DE.

Nevertheless, existing disturbance accounts for 19% of the spatial area of the DE based on current mapping (Biologic, 2022), and the implementation of the Proposal would result in disturbance to a further 14.5% of the total area. The footprint will also cover a percentage of the already disturbed area of the DE therefore net footprint will impact 13.5% of all habitats within the DE. Although the cumulative impacts of the Proposal are unable to be fully assessed due to the lack of sampling and habitat assessment prior to the existing operations, the persistence of a considerable extent of each of the SRE habitat types provides confidence that SRE values will be maintained following the implementation of the Proposal.

Quantitative cumulative impact assessment of SRE habitats on a wider local or regional scale is constrained by the lack of data and a common framework for cumulative impact assessment. Nonetheless, given the known and likely occurrence of all of the SRE habitat types within DE throughout the wider local area, it is unlikely that the cumulative impacts of the Proposal are significant at the wider local or regional scale.

### 3.5 Mitigation/ management

An outline of the proposed avoidance or disturbance minimisation measures is detailed in the Environmental Review Document (ERD) for the proposal including application of the mitigation hierarchy to manage known residual impacts as far as practicable.

- mitigation strategies proposed to minimise impacts to significant environmental values;
- environmental targets that the Proponent will use to monitor performance of the mitigation strategies to ensure environmental objectives are met;
- management and contingency actions aligned with the overall management approach; and
- management actions that will be implemented in response to monitoring results.

Additional mitigation and management of potential impacts to SRE fauna and habitat values is not anticipated to be necessary due to:

- the relatively limited spatial area of the proposed impacts – i.e. approximately 14.5% of the total DE, and no greater than 31% for any SRE habitat type;
- the known or likely wider occurrence of all SRE habitat types in the local area beyond the DE; and
- the minor or likely minor effects of indirect impacts (to the extent that can be assessed based on current information), mostly limited to the immediate vicinity of the proposed mining and construction areas.

## 4 KEY FINDINGS AND OUTCOMES

The consolidation and alignment of SRE fauna records has revealed a total of 75 taxa recorded from the DE. The fauna from the DE comprised 38 Potential SRE, 18 Widespread taxa and 19 taxa of indeterminate status. Nine Potential SRE invertebrate taxa only been collected from within the impact footprint, of which five were considered to be of Medium risk from the Proposal with the remaining four considered to be Low risk. This assessment was made based on what was known of the taxon, if not at the species level then at the genus or family level and the habitat they were recorded in. All Medium risk taxa were pseudoscorpions collected from one or two sites within restricted habitat inside the footprint.

Five taxa (*Tyrannochthonius* `sp. Biologic-PSEU104` and *Tyrannochthonius* `sp. Biologic-PSEU107` *Austrohorus* `sp. Biologic-PSEU103`, *Beierolpium* `sp. Biologic-PSEU087`, *Beierolpium* `sp. Biologic-PSEU088`) representing new, unique OTUs recorded only from either a single site or two sites were recorded from inside proposed impact areas and have been designated as having a Medium risk of impact from the proposal. Based on current information, these taxa have not been detected outside the DE, although their habitats are well represented in the wider local area beyond the DE. These SRE habitats (Gorge/ Gully, Hillcrest and Hillslope habitats) form a mosaic of interconnected mountainous habitat that is extensive beyond impacts throughout the DE and the wider local area. The direct impacts to Gorge/ Gully and Hillcrest and Hillslope habitats from the Proposal are low (respectively, loss of 2535 ha or 20.5%, and 97 ha or 15.6%, of the mapped area within the DE).

The potential impacts of the Proposal are unlikely to cause a significant risk to the long-term persistence of these five taxa in the DE (*Tyrannochthonius* `sp. Biologic-PSEU104` and *Tyrannochthonius* `sp. Biologic-PSEU107` *Austrohorus* `sp. Biologic-PSEU103`, *Beierolpium* `sp. Biologic-PSEU087`, *Beierolpium* `sp. Biologic-PSEU088`). The mitigation hierarchy has been applied to the Proposal, to avoid and reduce as far as practicable, impacts to terrestrial fauna and SRE (amongst other environmental values). The residual impacts to these values are considered low; comprising habitat clearing at their recorded locations, and the loss of 2535 ha or 20.5% of Hillcrest and Hillslope habitat, and 97 ha or 15.6% Gorge/ Gully habitat within the DE

Based on a low residual impact to SRE fauna and habitat values, no additional mitigation or management measures are required. It is likely that the environmental objectives for SRE fauna will be able to be met in relation to the Proposal.

## 5 REFERENCES

- Biologic. (2021). *West Angelas Beyond 2020: Level 2 Vertebrate and SRE Invertebrate Fauna Assessment Phase 1 & 2*. Unpublished report prepared for Rio Tinto Iron Ore. Biologic Environmental Survey, East Perth, WA.
- Biologic. (2022). *West Angelas Revised Proposal Short-range Endemic Invertebrate Fauna Risk Assessment*. Unpublished report prepared for Rio Tinto Iron Ore. Biologic Environmental Survey, East Perth, WA.
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- EPA, Environmental Protection Authority. (2016). *Environmental factor guideline: Terrestrial fauna*. Perth, Western Australia: Environmental Protection Authority.

## **E.9: West Angelas: Short-Range Endemic Invertebrate Fauna Risk Assessment**



West Angelas Revised Proposal:  
Short-Range Endemic  
Invertebrate Fauna Risk  
Assessment

Biologic Environmental Survey  
Report to Rio Tinto Iron Ore  
January 2023

Document Status				
Revision No.	Author	Review / Approved for Issue	Approved for Issue to	
			Name	Date
1	Morgan Lythe	Nihara Gunawardene	Elizabeth Mason	08/06/2022
2	Morgan Lythe	N. Gunawardene	Elizabeth Mason	13/01/2023

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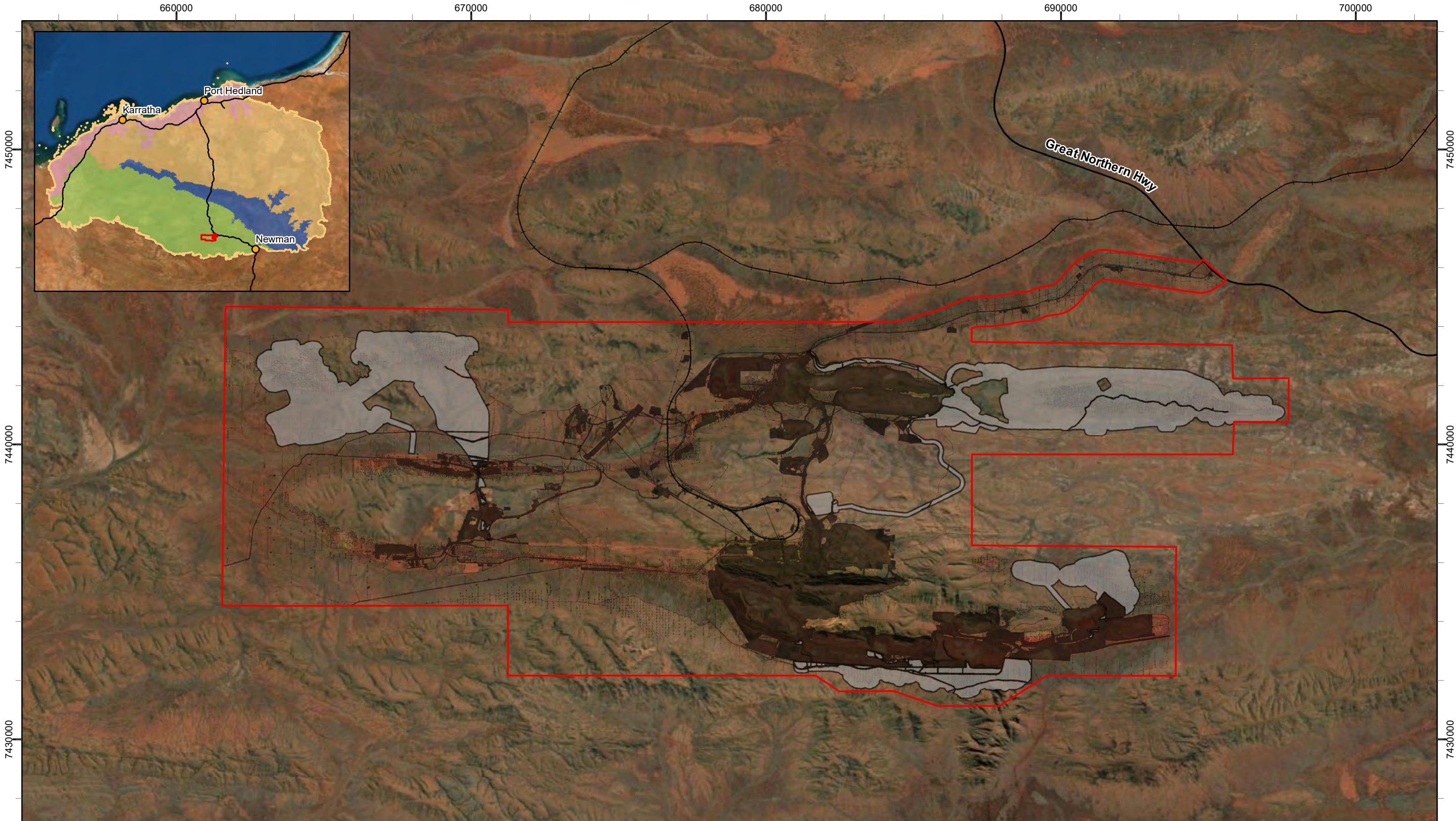
In this note, a reference to loss and damage includes past and prospective economic loss, loss of profits, damage to property, injury to any person (including death) costs and expenses incurred in taking measures to prevent, mitigate or rectify any harm, loss of opportunity, legal costs, compensation,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

## 1 INTRODUCTION

Rio Tinto Iron Ore (Rio Tinto) commissioned Biologic Environmental Survey (Biologic) to undertake a risk assessment for short-range endemic (SRE) invertebrate fauna identified from the West Angelas Project area (the Study Area/Development Envelope, Figure 1.1). These results will then be used to support the environmental impact assessment (EIA) for SRE invertebrate fauna which will in turn inform the environmental review document (ERD) for the development.



This memorandum report provides:

1. Consolidation of SRE species and habitat information from all surveys to date within the Development Envelope, including:
  - a. Alignment of SRE fauna identifications from all previous surveys (as much as practicable based on available specimens, taxonomic frameworks, and genetic sequences);
  - b. Updated taxonomic and ecological information relevant to assessment of species distributions relative to potential impact areas;
  - c. Indicative linear ranges in the local or wider regional area for all SRE taxa, based on the best available data;
  - d. Consolidation of fauna habitat mapping and occurrence of SRE taxa in habitat types mapped throughout the Development Envelope; and
  - e. Occurrence of SRE taxa in relation to proposed impact areas.
2. Risk Assessment of SRE species values and habitat values in relation to potential impacts of the project (within the footprint of disturbance), as much as practicable within the constraints of available data.

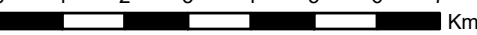


- LEGEND
- Development Envelope
  - Proposed Additional Footprint
  - Current Footprint
  - Sealed Road
  - Rail

IBRA Region	IBRA Subregion
Pilbara	Chichester
	Fortescue
	Hamersley
	Roebourne



Scale: 1:120,000



Coordinate System: GDA2020 MGA Zone 50  
Projection: Transverse Mercator  
Datum: GDA2020      Created 11/10/2022



**RIO TINTO IRON ORE**  
**West Angeles: Short-Range**  
**Endemic Invertebrate Fauna**  
**Risk Assessment**

Figure 1.1: West Angeles  
Study Area and regional  
location

## 2 DATA CONSOLIDATION AND ALIGNMENT

SRE species records and habitat information were sourced from Rio Tinto's internal terrestrial invertebrate database, Western Australian Museum (WAM) databases, and external reports of surveys within and nearby the Development Envelope. These were:

- Biota (2005) Fauna Habitats and Fauna Assemblage of Deposits E and F at West Angelas
- Biota (2006) Hope Downs Rail Corridor (Juna Downs Section) Fauna Survey
- Biota (2010) West Angelas Gas Pipeline Targeted Fauna Survey
- Ecologia (2014) Greater West Angelas Terrestrial Fauna Assessment
- Astron (2019) Hope Downs 2 Proposal Fauna Survey
- Biologic (2021a) West Angelas Beyond 2020: Level 2 Vertebrate and SRE Invertebrate Fauna Assessment Phase 1 & 2
- Biologic (2021b) West Angelas Development Envelope Consolidated Fauna Habitat Mapping and Extrapolated Regional Fauna Habitat Mapping
- WAM (2022a) Arachnida and Myriapoda Collection Database
- WAM (2022b) Crustacea Collection Database
- WAM (2022c) Mollusca Collection Database

Identifications at the species level were aligned as much as practicable based on the information available for morphological and molecular identification within existing taxonomic frameworks. Following alignment of taxonomic identifications between WAM database searches and external reports, the remaining indeterminate records were examined against potentially similar species from the same site or the same sampling event. The approach aimed to:

- Provide a single, consolidated list of SRE invertebrate species (morphological and molecular) occurring in the Development Envelope (DE);
- Inform the assessment of habitat associations and species occurrence relative to impact areas (proposed footprint) within the DE; and
- Facilitate the assessment of species distributions in the wider local and regional area beyond the DE.

### 2.1 Local and regional linear ranges

Preliminary linear ranges were calculated for all species based on collection records from the Development Envelope, WAM database records, and local and regional DNA databases, to the limit of available data.

### 3 SAMPLING ADEQUACY IN THE DEVELOPMENT ENVELOPE

#### 3.1 Sample effort

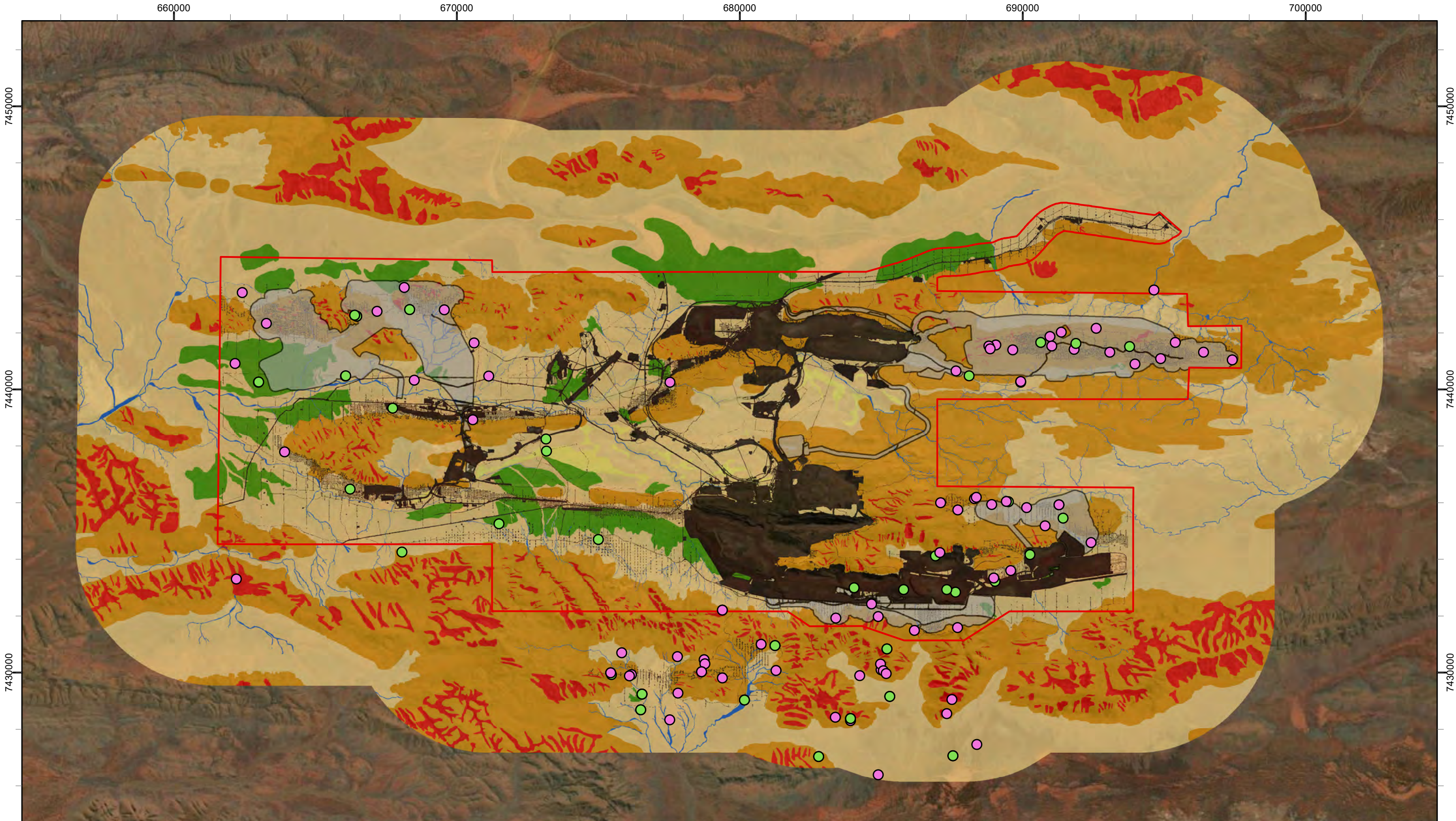
The habitat mapping conducted by Biologic (2021b) was detailed throughout the entire DE (Figure 3.1). Additionally, extrapolation of habitat beyond the DE to 20 km allowed for an understanding of the connection and distribution of habitat within the local area. The mapping was adequately detailed for the assessment of area and percentage cover of each habitat type within the entire DE, as well as inside and outside of proposed impacts (Table 3.1). SRE survey sampling effort could then be assessed for each habitat type (Table 3.2, Figure 3.1). In addition, due to the proximity of Angelo River Project Area, up to a 5 km buffer was placed around the DE where the sample effort could be considered as relevant to the West Angelas Study Area.

**Table 3.1: Habitat types within the DE**

HABITAT	SRE Suitability	DE (ha)	DE%	Footprint (ha)	Footprint %	Footprint /DE%
Cracking Clay	Low	430	1.2	0	0.0	0.0
Disturbed	Low	6991	19.0	394	7.4	5.6
Footslopes and Plains	Low	12702	34.5	1871	35.0	14.7
Drainage Line	Moderate	384	1.0	79	1.5	20.6
Mixed Acacia Woodland	Moderate	3295	9.0	374	7.0	11.4
Hillcrest and Hillslope	Moderate	12356	33.6	2535	47.4	20.5
Gorge/Gully	High	622	1.7	97	1.8	15.6
<b>Total</b>		<b>36779</b>	<b>100.0</b>	<b>5350</b>	<b>100.0</b>	<b>14.5</b>

**Table 3.2: Sample effort by habitat type within 5 km of the DE**

HABITAT	Total		Outside Footprint		Within Footprint	
	Pit trap sites	Foraging sites	Pit trap sites	Foraging sites	Pit trap sites	Foraging sites
Cracking Clay	1	0	1	0	0	0
Disturbed	15	7	14	5	1	2
Footslopes and Plains	15	22	10	14	5	8
Drainage Line	5	3	5	3	0	0
Mixed Acacia Woodland	2	1	2	1	0	0
Hillcrest and Hillslope	11	28	9	14	2	14
Gorge/Gully	4	17	4	14	0	3
<b>Total</b>	<b>53</b>	<b>78</b>	<b>45</b>	<b>51</b>	<b>8</b>	<b>27</b>



**LEGEND**  

Development Envelope

Proposed Additional Footprint

**Sample Site**  

Targeted SRE Survey Site

Pitfall Trap Site

**Habitat**  

Cracking Clay

Disturbed

Drainage Line

Footslopes and Plains

Gorge/Gully

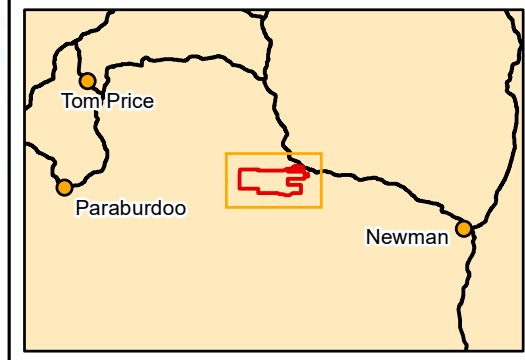
Hillcrest and Hillslope

Mixed Acacia Woodland

Scale: 1:125,000

Km

Coordinate System: GDA2020 MGA Zone 50  
Projection: Transverse Mercator  
Datum: GDA2020      Created 11/10/2022



**RIO TINTO IRON ORE**  
**West Angelen: Short-Range**  
**Endemic Invertebrate Fauna**  
**Risk Assessment**  
**Figure 3.1: Sample effort and**  
**habitat mapping within and**  
**nearby the West Angelen**  
**Development Envelope**

### 3.2 Sampling adequacy

#### Widespread habitat

Widespread habitat includes the generally low-lying landscape units with greater extent and connectivity throughout and beyond the DE. From the Biologic (2021b) habitat mapping, this comprises the Cracking Clay, Disturbed and Footslopes and Plains habitat units, all considered of Low suitability for SRE fauna. Drainage Line and Mixed Acacia Woodland, while considered of Moderate suitability for SRE fauna, are also widespread throughout and beyond the DE. Any SRE taxa recorded from these landscape units are likely to be at low risk from the Proposal and are considered adequately sampled.

#### Restricted habitat

Restricted habitat includes the largely elevated landscape units that are disconnected from other areas of similar habitat. From the Biologic (2021b) habitat mapping, this comprises the Hillcrest and Hillslope (of Moderate suitability for SRE fauna) and the Gorge/Gully habitat units (considered of High suitability for SRE fauna).

The restricted habitat types represent 35.3% of the DE and 20.3 % of the restricted habitat types will be directly impacted by the mining footprint (2,632 ha combined Hillcrest and Hillslope and Gorge/Gully habitat in footprint out of 12,978 ha in DE). The footprint covers 14.54% of the DE and though approximately half of the footprint is made up of restricted habitat types over 80% of the restricted habitat types remain within the DE.

In terms of sampling effort, 46% of sample effort (pitfall trapping and foraging sites) was expended in restricted habitat types in the DE (including up to 5 km outside the DE). Within the footprint itself, over half of the sample sites were located within the restricted habitat types. This is in line with the footprint itself being about 50% made up of restricted habitat types.

## 4 SRE INVERTEBRATE FAUNA IN THE DEVELOPMENT ENVELOPE

In total, 75 SRE invertebrate taxa have been collected from within the West Angelas Development Envelope (DE) (Table 4.1, Appendix A). Of these, 19 were indeterminate taxa, identified only to genus level or higher, the majority of which are likely to represent one of the other morphospecies or OTUs. These taxa are not considered further but are summarised in Appendix A. Of the remaining 56 taxa, 38 are Potential SRE and 18 are Widespread taxa (Table 4.1). No Confirmed SRE invertebrates have been recorded. Of the 38 Potential SRE taxa recorded in the DE, there are four mygalomorph spiders, 18 pseudoscorpions, three scorpions, two millipedes, ten terrestrial isopods and one snail (Table 4.1). Currently, 18 taxa are known only from the DE (Table 4.1, Figure 4.1, Figure 4.2), while nine are known only from within the proposed footprint. These taxa are detailed more below.

### 4.1 Pseudoscorpiones

Twenty-one pseudoscorpion taxa have been recorded from the DE, primarily identified by molecular analysis. Of these, ten (three chthoniids and seven olpiids) are known only from the DE. Seven are currently only known from within the proposed footprint. These taxa were collected from either two sites or one site in restricted habitats (Table 4.1, Figure 4.2).

#### Chthoniidae

*Austrochthonius* `sp. Biologic-PSEU101`, *Tyrannochthonius* `sp. Biologic-PSEU104` and *Tyrannochthonius* `sp. Biologic-PSEU107` were all collected from one or two sites and have only been collected from within the footprint. Until recently, many *Tyrannochthonius* specimens were morphologically identified as the same widespread species *Tyrannochthonius aridus*. *Austrochthonius* `pilbara` is also considered a widespread species. *Austrochthonius* `sp. Biologic-PSEU101` was collected from the same site as *Austrochthonius* `pilbara`. Molecular sequencing has demonstrated that there is a large amount of cryptic diversity in both genera but that also a large amount of regional sequencing is required before taxa are confidently labelled as short-range endemics.

#### Olpiidae

Olpiidae taxonomy is poorly developed, with identification even to genus considered challenging by taxonomic experts. Molecular analyses of the family indicate significant cryptic diversity and many taxa that appear to have restricted ranges. Many of those that have matches beyond the DE have ranges greater than 50 km, often over 100 km which may be reflect an inclination for olpiids to be generally wide-ranging or a reflection of the current state of molecular taxonomy. Currently, as more sequencing in the Newman region is being carried out, more matches are being made, even for those taxa that are found in restricted habitat types. Four of the 15 olpiids recorded from the DE are currently only known from the proposed footprint, three of which were collected from single sites. The restricted taxa are *Austrohorus* `sp. Biologic-PSEU103`, *Beierolpium* `sp. Biologic-PSEU087`, *Beierolpium* `sp. Biologic-PSEU088` and Olpiidae `sp. Biologic-PSEU085` (Table 4.1, Figure 4.2). *Euryolpium* `sp. Biologic-PSEU086`, *Euryolpium* `sp. Biologic-PSEU102` and Olpiidae `sp. Biologic-PSEU084` were also collected from one or two sites from within the DE only (Table 4.1, Figure 4.2). Further regional work

would be necessary to comment on whether these species will be restricted to the footprint or would be found in similar habitat beyond the DE.

## 4.2 Isopoda

*Buddelundia* `sp. 68WA`, Armadillidae Gen. nov. `sp. nov. 1`, *Buddelundia* `sp. 10 1458A`, *Buddelundia* `sp. 10 1458B`, *Buddelundia* `sp. Biologic-ISOP082`, *Buddelundia* `sp. 10 1458C` and *Buddelundia* `sp. 10 1458D` have been recorded from only within the DE with the last two being recorded only from within the footprint (Table 4.1, Figure 4.1). All, except *Buddelundia* `sp. Biologic-ISOP082`, were morphologically identified in 2014 (Ecologia, 2014). Ecologia (2014) states that “[*Buddelundia* `sp. 10`] is a species complex and is common and widespread in the Pilbara. There were at least four morphologically different forms found in this survey (*Buddelundia* sp. nov. 10 1458A – 1458D). Further work on this group of species is required to understand better their true SRE status. Morphological characteristics used in identification are subtle, with DNA analysis recommended for full resolution of species present.” Isopod taxonomy has progressed significantly since 2014 and these morphospecies would require a review by isopod taxonomist Simon Judd to identify whether these specimens represent separate morphospecies. The genus *Buddelundia* appears to contain both wide-ranging and range-restricted species. *Buddelundia* `sp. Biologic-ISOP082` was collected within the DE from restricted habitat however as there is a lack of molecular sequencing for the genus it is not surprising there are currently no molecular matches for the sequences. Dr Simon Judd is currently undertaking molecular sequencing for many of his morphospecies which will progress the understanding of *Buddelundia*, the most speciose genus of armadillid isopod in WA.

## 4.3 Gastropoda

### Camaenidae

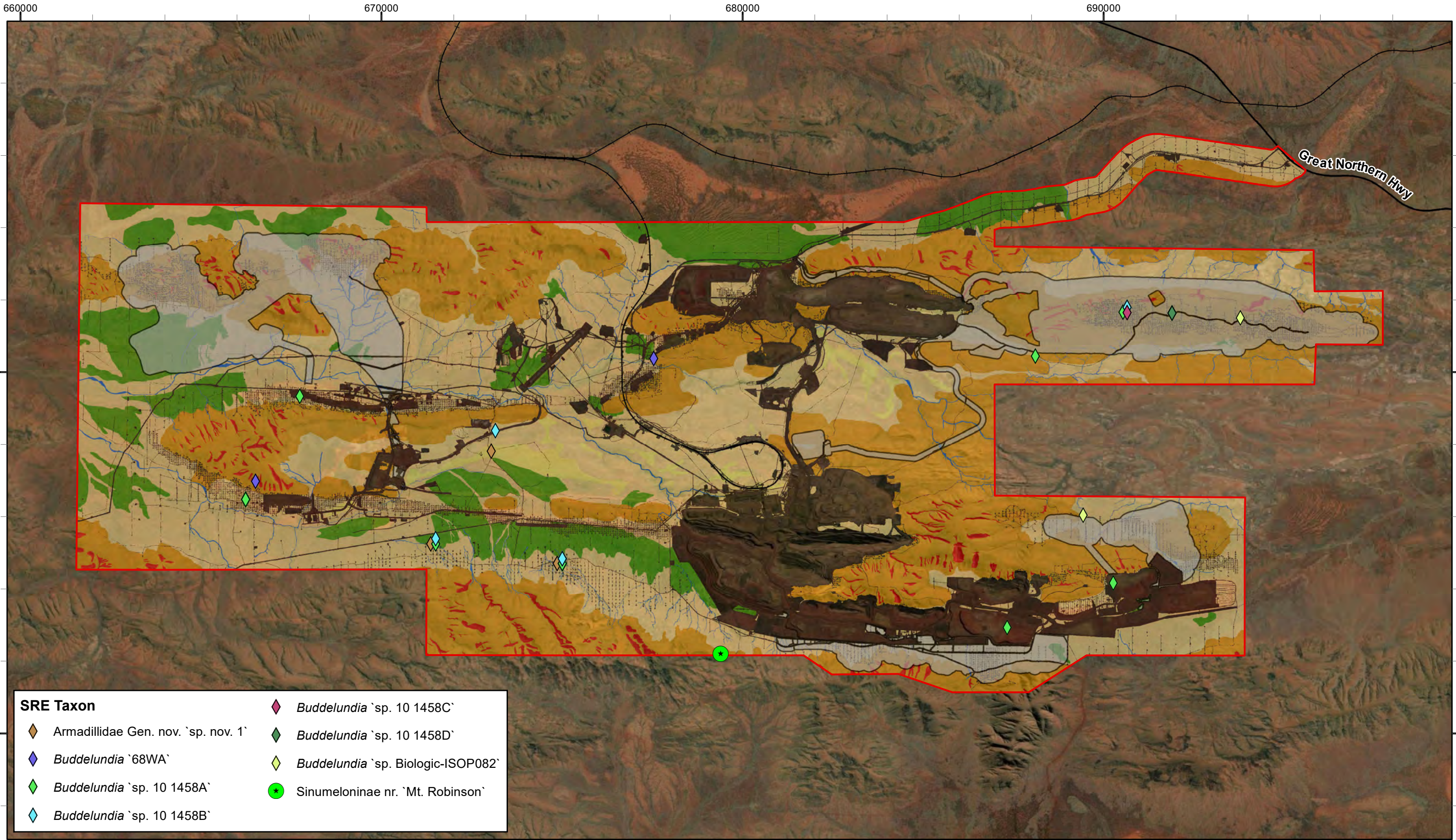
Camaenid snails have been well-sequenced in northern WA and have yielded species with tiny ranges to very large widespread ranges. Sinumeloninae nr. `Mt. Robinson` was collected from one site in restricted habitat within the DE (Table 4.1, Figure 4.1). This specimen did not yield any sequences despite multiple attempts at extraction. It was examined morphologically by Dr Erich Volschenk against WA Museum specimens with the aid of Dr Corey Whisson, and no further morphological identification could be made past subfamily. It was deemed as being similar to another specimen found in the region at Mt Robinson but comparisons between specimens did not yield any positive identification.

**Table 4.1: Consolidated list of SRE invertebrate fauna recorded within the West Angelas Development Envelope (DE).**

NB: Taxa in red are only known from within the proposed footprint, taxa in blue are known only from within the DE

Taxon	Source	ID level	SRE category	Recorded within footprint	Recorded outside footprint	Linear range	Identification and distribution comments
<b>ARACHNIDA: ARANEAE</b>							
<b>Anamidae</b>							
<i>Aname mellosa</i>	Biologic 2022	molecular	Widespread	yes	yes	>200 km	Molecular ID matched these specimens to this widespread species
<i>Aname whitei</i>	Biologic 2022	molecular	Widespread	yes	yes	>200 km	Molecular ID matched these specimens to this widespread species
<i>Aname</i> `sp. Biologic-ARAN050`	Biologic 2022	molecular	Potential SRE	yes	yes	~2 km	Molecular ID matched these specimens to others from Angelo River. Recorded from widespread habitat (Footslopes and Plains) and from beyond the DE.
<i>Kwonkan</i> `MYG197`	ecologia 2014, Astron 2019	molecular	Potential SRE	no	yes	~51 km	WAM morphospecies. Recorded from widespread habitat (Footslopes and Plains) and from beyond the DE.
<i>Kwonkan</i> `MYG380`	Biologic 2022	molecular	Potential SRE	yes	yes	~8 km	Molecular ID confirmed WAM morphospecies. Recorded from widespread habitat (Footslopes and Plains) and from beyond the DE.
<b>Barychelidae</b>							
<i>Aureocrypta</i> `MYG315`	WAM 2022a	molecular	Widespread	no	yes	~124 km	WAM morphospecies. Recorded from widespread habitat (Mixed Acacia Woodland) and from beyond the DE.
<b>Halonoproctidae</b>							
<i>Conothele</i> `MYG002`	WAM 2022a	molecular	Potential SRE	no	yes	~71 km	WAM morphospecies. Recorded from widespread habitat (Footslopes and Plains, Mixed Acacia Woodland) and from beyond the DE.
<b>Idiopidae</b>							
<i>Gaius tealei</i>	Biologic 2022	molecular	Widespread	yes	yes	>200 km	Molecular ID matched these specimens to this widespread species
<b>Selenopidae</b>							
<i>Karaops nyangumarta</i>	Biologic 2022	molecular	Widespread	no	yes	>200 km	Molecular ID matched these specimens to this widespread species
<b>ARACHNIDA: PSEUDOSCORPIONES</b>							
<b>Chthoniidae</b>							
<i>Austrochthonius</i> `sp. Biologic-PSEU101`	Biologic 2022	molecular	Potential SRE	yes	no	single site	Originally ID'd as <i>Austrochthonius</i> `pilbara`. Molecular ID could not match this specimen to any other known taxon. <i>Austrochthonius</i> `pilbara` is a WAM morphospecies considered to be widespread. Only recorded from within the proposed footprint in restricted habitat.
<i>Austrochthonius</i> `pilbara`	Biologic 2022	morphological	Widespread	yes	yes	>200 km	WAM morphospecies considered to be widespread. Recorded from restricted habitat (Hillcrest and Hillslope) within the proposed footprint.
<i>Tyrannochthonius</i> `sp. Biologic-PSEU104`	Biologic 2022	molecular	Potential SRE	yes	no	~6 km	Molecular ID could not match these specimens to any other known taxon. Only recorded within proposed footprint. Potentially restricted range based on collection in restricted habitat (Hillcrest and Hillslope).
<i>Tyrannochthonius</i> `sp. Biologic-PSEU107`	Biologic 2022	molecular	Potential SRE	yes	no	single site	Molecular ID could not match this specimen to any other known taxon. Only recorded within proposed footprint. Potentially restricted range based on collection in restricted habitat (Hillcrest and Hillslope).
<b>Garypidae</b>							
<i>Synsphyronus xynus</i>	Biologic 2022	molecular	Widespread	yes	yes	>200 km	Molecular ID matched these specimens to this widespread species
<b>Olpiidae</b>							
<i>Austrohorus</i> `sp. Biologic-PSEU103`	Biologic 2022	molecular	Potential SRE	yes	no	single site	Molecular ID could not match this specimen to any other known taxon. Only recorded within proposed footprint. Potentially restricted range based on collection in restricted habitat (Gorge/Gully).
<i>Beierolpium</i> `sp. 8/3`	Biologic 2021	morphological	Potential SRE	yes	yes	>200 km	WAM morphospecies considered widespread but molecular evidence increasingly showing that this and other Beierolpium morphospecies are likely inaccurate and represent a complex of potentially range restricted species. Recorded from restricted habitat (Hillcrest and Hillslope) and from beyond the DE.
<i>Beierolpium</i> `sp. 8/4`	Biologic 2021	morphological	Potential SRE	no	yes	>200 km	WAM morphospecies considered widespread but molecular evidence increasingly showing that this and other Beierolpium morphospecies are likely inaccurate and represent a complex of potentially range restricted species. Recorded from various habitat and from beyond the DE.
<i>Beierolpium</i> `sp. Biologic-PSEU087`	Biologic 2022	molecular	Potential SRE	yes	no	~6 km	Molecular ID could not match these specimens to any other known taxon. Only recorded within proposed footprint. Potentially restricted range based on collection in restricted habitat (Gorge/Gully, Hillcrest and Hillslope).
<i>Beierolpium</i> `sp. Biologic-PSEU088`	Biologic 2022	molecular	Potential SRE	yes	no	single site	Molecular ID could not match this specimen to any other known taxon. Only recorded within proposed footprint. Potentially restricted range based on collection in restricted habitat (Hillcrest and Hillslope).
<i>Beierolpium</i> `sp. Biologic-PSEU092`	Biologic 2022	molecular	Potential SRE	yes	yes	~82 km	Molecular ID matched to another specimen from beyond the DE near Western Ridge. Recorded from widespread habitat (Footslopes and Plains).
<i>Euryolpium</i> `sp. Biologic-PSEU086`	Biologic 2022	molecular	Potential SRE	yes	yes	~2 km	Molecular ID could not match these specimens to any other known taxon. Potentially restricted range based on collection in restricted habitat (Gorge/Gully, Hillcrest and Hillslope).
<i>Euryolpium</i> `sp. Biologic-PSEU093`	Biologic 2022	molecular	Potential SRE	no	yes	~100 km	Molecular ID matched to another specimen from beyond the DE. Recorded from widespread habitat (Footslopes and Plains).
<i>Euryolpium</i> `sp. Biologic-PSEU102`	Biologic 2022	molecular	Potential SRE	no	yes	single site	Molecular ID could not match this specimen to any other known taxon. Potentially restricted range based on collection in restricted habitat (Gorge/Gully).
<i>Indolpium</i> `sp. Biologic-PSEU017`	Biologic 2022	molecular	Potential SRE	yes	yes	~23 km	Molecular ID matched to other specimens from Angelo River. Recorded from various habitat and from beyond the DE..
<i>Indolpium</i> `sp. WAM-PSE118`	Biologic 2022	molecular	Potential SRE	yes	yes	~63 km	Molecular ID matched to others specimen from beyond the DE. Recorded from various habitat.
Olpiidae `sp. Biologic-PSEU072`	Biologic 2022	molecular	Potential SRE	yes	yes	~43 km	Molecular ID matched to another specimen from Angelo River. Potentially restricted range based on collection in restricted habitat (Hillcrest and Hillslope).
Olpiidae `sp. Biologic-PSEU084`	Biologic 2022	molecular	Potential SRE	no	yes	single site	Molecular ID could not match this specimen to any other known taxon. Only known from the DE but collected from widespread habitat (Footslopes and Plains).

Taxon	Source	ID level	SRE category	Recorded within footprint	Recorded outside footprint	Linear range	Identification and distribution comments
<i>Olpiidae</i> `sp. Biologic-PSEU085`	Biologic 2022	molecular	Potential SRE	yes	no	single site	Molecular ID could not match this specimen to any other known taxon. Only recorded within proposed footprint. Potentially restricted range based on collection in restricted habitat (Hillcrest and Hillslope).
<i>Xenolpium</i> `sp. Biologic-PSEU091`	Biologic 2022	molecular	Potential SRE	no	yes	~85 km	Molecular ID matched to others specimen from beyond the DE. Recorded from various habitats.
<b>Sternophoridae</b>							
<i>Afrosterophorus</i> `sp. Biologic-PSEU100`	Biologic 2022	molecular	Widespread	yes	no	single site	Molecular ID could not match this specimen to any other known taxon; however this genus is considered to only contain widespread species.
<b>ARACHNIDA: SCORPIONES</b>							
<b>Buthidae</b>							
<i>Isometroides</i> `sp. Biologic-SCOR010`	Biologic 2022	molecular	Widespread	yes	yes	~150 km	Molecular ID matched these specimens to this widespread taxon.
<i>Isometroides</i> `pilbara 1`	Biologic 2021a	morphological	Widespread	no	yes	>200 km	WAM morphospecies considered to be widespread.
<i>Lychas</i> `bituberculatus complex`	Astron 2019	morphological	Potential SRE	yes	yes	>200 km	Species complex. Recorded from widespread habitat (Footslopes and Plains) and from beyond the DE.
<i>Lychas</i> `hairy tail complex`	ecologia 2014, Astron 2019	morphological	Potential SRE	yes	yes	>200 km	Species complex. Recorded from various habitat and from beyond the DE.
<i>Lychas</i> `harveyi complex`	ecologia 2014, Astron 2019	morphological	Potential SRE	yes	yes	>200 km	Species complex. Recorded from various habitat and from beyond the DE.
<i>Lychas</i> `sp. Biologic-SCOR001`	Biologic 2022	molecular	Widespread	no	yes	~160 km	Molecular ID matched these specimens to this widespread taxon.
<i>Lychas</i> `sp. Biologic-SCOR003`	Biologic 2022	molecular	Widespread	yes	yes	>200 km	Molecular ID matched these specimens to this widespread taxon.
<i>Lychas</i> `sp. WAM-SCO039`	Biologic 2022	molecular	Widespread	yes	yes	~147 km	Molecular ID matched these specimens to this widespread taxon.
<b>DIPLOPODA: SPIROBOLIDA</b>							
<b>Trigoniulidae</b>							
<i>Austrostrophus</i> `sp. clade A`	Biologic 2022	molecular	Widespread	yes	yes	~177 km	Molecular ID matched these specimens to this widespread species
<i>Austrostrophus</i> `sp. clade E`	Biologic 2022	molecular	Potential SRE	no	yes	~53 km	Molecular ID matched to specimens from beyond the DE. Recorded from restricted habitat (Gorge/Gully) but outside the footprint
<i>Austrostrophus</i> `sp. clade F`	Biologic 2022	molecular	Potential SRE	no	yes	~27 km	Molecular ID matched to specimens from beyond the DE. Recorded from restricted habitat (Hillcrest and Hillslope) but outside the footprint.
<i>Austrostrophus</i> `stictopygus`	ecologia 2014, WAM 2022a	morphological	Widespread	yes	yes	>200 km	Species complex. Recorded from various habitat and from beyond the DE.
<b>MALACOSTRACA: ISOPODA</b>							
<b>Armadiillidae</b>							
Armadiillidae Gen. nov. `sp. nov. 1`	ecologia 2014	morphological	Potential SRE	no	yes	~4 km	Unknown morphospecies. Only known from within the DE but collected from various widespread habitat.
<i>Buddelundia</i> `sp. 10 1458A`	ecologia 2014	morphological	Potential SRE	yes	yes	~26 km	Specimens would need review by Dr Simon Judd. Sequencing will not likely yield results due to age of specimen.
<i>Buddelundia</i> `sp. 10 1458B`	ecologia 2014	morphological	Potential SRE	yes	yes	~20 km	Specimens would need review by Dr Simon Judd. Sequencing will not likely yield results due to age of specimen.
<i>Buddelundia</i> `sp. 10 1458C`	ecologia 2014	morphological	Potential SRE	yes	no	single site	Specimens would need review by Dr Simon Judd. Sequencing will not likely yield results due to age of specimen.
<i>Buddelundia</i> `sp. 10 1458D`	ecologia 2014	morphological	Potential SRE	yes	no	single site	Specimens would need review by Dr Simon Judd. Sequencing will not likely yield results due to age of specimen.
<i>Buddelundia</i> `sp. 15`	ecologia 2014, Biologic 2021	morphological	Widespread	yes	yes	>200 km	Known morphospecies thought to be widespread. Recorded from the DE in widespread habitat (Footslopes and Plains) and already cleared areas.
<i>Buddelundia</i> `sp. 16`	ecologia 2014, Biologic 2021	morphological	Widespread	yes	yes	>200 km	Known morphospecies thought to be widespread but likely a species complex. Recorded from the DE in various habitat.
<i>Buddelundia</i> `sp. 47`	Biologic 2021	morphological	Potential SRE	no	yes	~37 km	Known morphospecies with seemingly restricted range. Recorded from restricted habitat (Gorge/ Gully) but also from outside the DE.
<i>Buddelundia</i> `sp. 68WA`	ecologia 2014	morphological	Potential SRE	no	yes	~12 km	Known morphospecies with seemingly restricted range. Only known from the DE but recorded from various habitat outside the proposed footprint.
<i>Buddelundia</i> `sp. 77`	Biologic 2021	morphological	Potential SRE	yes	yes	~23 km	Known morphospecies with seemingly restricted range. Recorded from restricted habitat (Hillcrest and Hillslope) within the DE and from various habitat beyond the DE.
<i>Buddelundia</i> `sp. Biologic-ISOP081`	Biologic 2022	molecular	Potential SRE	yes	yes	~22 km	Molecular ID could not match these specimens to any other known taxon. Recorded from restricted habitat (Hillcrest and Hillslope) but also from outside the DE.
<i>Buddelundia</i> `sp. Biologic-ISOP082`	Biologic 2022	molecular	Potential SRE	yes	yes	~7 km	Molecular ID could not match these specimens to any other known taxon. Only known from the DE and recorded from restricted habitat (Hillcrest and Hillslope) both inside and outside the proposed footprint.
Buddelundiinae `PES999`	ecologia 2014	morphological	Widespread	yes	yes	~122 km	Known morphospecies thought to be widespread. Recorded from the DE in various habitat.
<b>GASTROPODA</b>							
<b>Camaenidae</b>							
<i>Sinumeloninae</i> nr. `Mt. Robinson`	Biologic 2021	morphological	Potential SRE	no	yes	single site	Unknown morphospecies only recorded from restricted habitat (Gorge/Gully) within the DE but outside the proposed footprint.



**LEGEND**

	Development Envelope	<b>Habitat</b>		Cracking Clay		Footslopes and Plains
	Proposed Additional Footprint		Disturbed		Gorge/Gully	
	State Road		Hillcrest and Hillslope		Mixed Acacia Woodland	
	Rail		Drainage Line			

Scale: 1:100,000

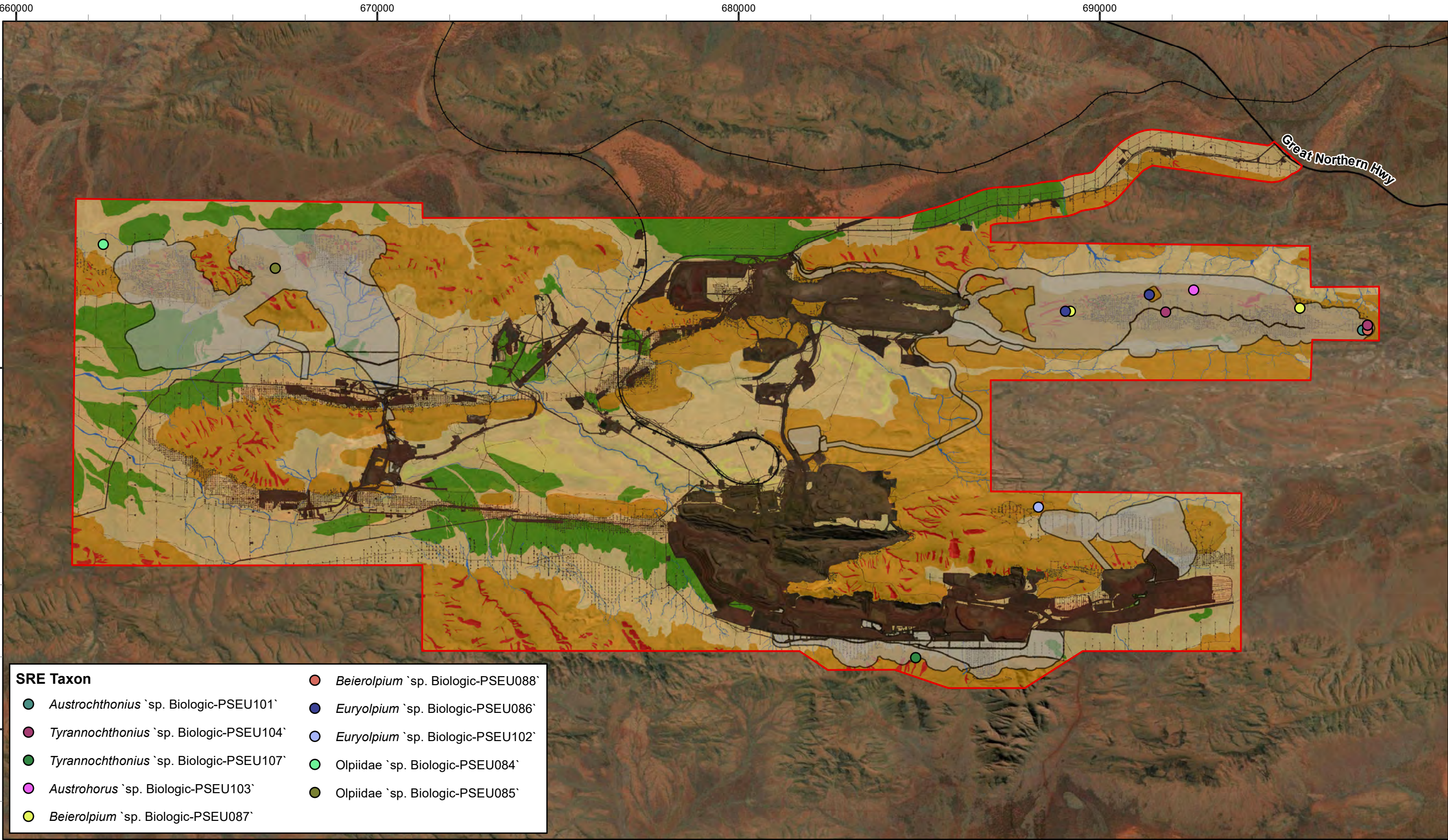
0 1 2 3 4 5 6 Km

Coordinate System: GDA2020 MGA Zone 50  
Projection: Transverse Mercator  
Datum: GDA2020 Created 13/01/2023

**RIO TINTO IRON ORE**

West Angeles: Short-Range  
Endemic Invertebrate Fauna  
Risk Assessment

Figure 4.1: SRE fauna known  
only from the DE (Isopoda,  
Gastropoda)



SRE Taxon	
<i>Austrochthonius</i> `sp. Biologic-PSEU101`	<i>Beierolpium</i> `sp. Biologic-PSEU088`
<i>Tyrannochthonius</i> `sp. Biologic-PSEU104`	<i>Euryolpium</i> `sp. Biologic-PSEU086`
<i>Tyrannochthonius</i> `sp. Biologic-PSEU107`	<i>Euryolpium</i> `sp. Biologic-PSEU102`
<i>Austrohorus</i> `sp. Biologic-PSEU103`	<i>Olpidae</i> `sp. Biologic-PSEU084`
<i>Beierolpium</i> `sp. Biologic-PSEU087`	<i>Olpidae</i> `sp. Biologic-PSEU085`

LEGEND

Development Envelope

Proposed Additional Footprint

State Road

Rail

Habitat

Cracking Clay

Disturbed

Drainage Line

Footslopes and Plains

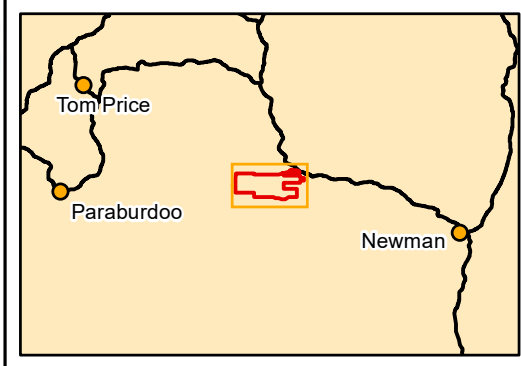
Gorge/Gully

Hillcrest and Hillslope

Mixed Acacia Woodland

Scale: 1:100,000

Coordinate System: GDA2020 MGA Zone 50  
Projection: Transverse Mercator  
Datum: GDA2020      Created 13/01/2023



RIO TINTO IRON ORE  
West Angeles: Short-Range  
Endemic Invertebrate Fauna  
Risk Assessment  
Figure 4.2: SRE fauna known  
only from the DE  
(Pseudoscorpiones)

## 5 RISK ASSESSMENT

The level of impact to significant habitat or populations of SRE taxa from mining activities in a particular area can be varied and difficult to assess adequately. However, the taxa recorded for an area and the level to which significant habitats have been surveyed can indicate whether or not a level of risk of impact can be estimated. Here, we provide a preliminary level of risk from impact based on what we know of a particular taxon's range, the habitat that it occurs in and the amount of that habitat that will be impacted by mining activities, i.e the proposed footprint (Table 5.1). This is of particular relevance to taxa that, to date, have been collected from single sites within the DE.

**Table 5.1: Definition of level of risk for SRE invertebrate fauna and habitats**

Category	Description
<b>High</b>	Taxonomic factors indicate that a species is <b>likely to be</b> restricted in range based on what is known of the genus or species, it has been collected from a <b>restricted</b> habitat type and a significant proportion of the known or likely habitat that it occurs in will be removed by mining activities (inside proposed footprint).
<b>Medium</b>	Taxonomic factors indicate that a species is <b>possibly</b> restricted in range based on what is known of the genus or species, it has been collected from a <b>restricted</b> habitat type and a significant proportion of the known or likely habitat that it occurs in will be removed by mining activities (inside proposed footprint).
<b>Low</b>	Taxonomic factors indicate that a species is <b>possibly</b> restricted in range based on what is known of the genus or species, it has been collected from a <b>widespread</b> habitat type.

Of the 75 taxa recorded within the DE, 66 were collected at least once from outside the proposed footprint, most in widespread or varied habitats, and many also from beyond the DE (see Table 4.1 and Appendix A). These 66 taxa are considered not at risk from the development as it is currently mapped. The nine taxa collected only from within the footprint have been assessed as having some level of risk from the development (Table 5.2).

**Table 5.2: SRE fauna considered at risk from the currently proposed footprint.**

\*indicates molecular identification

Taxon	Taxonomic factors affecting risk	Distribution and habitat factors affecting risk	Risk Level
ARACHNIDA: PSEUDOSCORPIONES			
Chthoniidae			
* <i>Austrochthonius</i> `sp. Biologic-PSEU101`	All three taxa could not be matched to any known sequences. Molecular work on Chthoniidae pseudoscorpions is indicating a high degree of cryptic species. Much taxonomic work is required for the family.	This taxon was recorded from within the proposed footprint in Gully habitat. It was collected at the same site as specimens identified as <i>Austrochthonius</i> `pilbara` a morphospecies considered widespread.	Low
* <i>Tyrannochthonius</i> `sp. Biologic-PSEU104`		Recorded from two Gorge/Gully sites within proposed footprint.	Medium
* <i>Tyrannochthonius</i> `sp. Biologic-PSEU107`		Recorded from a single Hillcrest and Hillslope site within proposed footprint.	Medium
Olpiidae			
* <i>Austrohorus</i> `sp. Biologic-PSEU103`	Olpiidae taxonomy is very limited and needs review. Molecular analysis seems to show many species with restricted ranges. Could not be matched to any other sequences.	Recorded from single Gorge/Gully site within proposed footprint.	Medium
* <i>Beierolpium</i> `sp. Biologic-PSEU087`		Recorded from two Gorge/Gully sites within proposed footprint.	Medium
* <i>Beierolpium</i> `sp. Biologic-PSEU088`		Recorded from single Gorge/Gully site within proposed footprint.	Medium
* <i>Euryolpium</i> `sp. Biologic-PSEU086`		Recorded from two Gorge/Gully sites within DE.	Low
* <i>Euryolpium</i> `sp. Biologic-PSEU102`		Recorded from single Gorge/Gully site within DE.	Low
*Olpiidae `sp. Biologic-PSEU084`		Recorded from single stony plain microhabitat site (widespread habitat) within DE.	Low
*Olpiidae `sp. Biologic-PSEU085`		Recorded from single mulga woodland site (widespread habitat) within proposed footprint.	Low
MALACOSTRACA: ISOPODA			
Armadiillidae			

Taxon	Taxonomic factors affecting risk	Distribution and habitat factors affecting risk	Risk Level
Armadillidae Gen. nov. `sp. nov. 1`	These are all morphologically identified taxa carried out in 2014. Dr Simon Judd has been reviewing the state of taxonomy of the armadillid isopods and would likely want to review or sequence these specimens as <i>Buddelundia</i> contains both widespread and short-ranging species. it is hard to comment on these species based on the taxonomic limitations of morphological identifications.	Unknown morphospecies. Only known from within the DE but collected from various widespread habitat.	Low
<i>Buddelundia</i> `sp. 10 1458A`		Collected from over 10 sites in a variety of habitats	Low
<i>Buddelundia</i> `sp. 10 1458B`		Collected from four sites in a variety of habitats	Low
<i>Buddelundia</i> `sp. 10 1458C`		Recorded from one site in a Hillslope and Hillcrest habitat type inside the footprint, but morphologically resembled <i>Buddelundia</i> `sp. 10 1458A`	Low
<i>Buddelundia</i> `sp. 10 1458D`		Recorded from one site in a Hillslope and Hillcrest habitat type inside the footprint, but morphologically resembled <i>Buddelundia</i> `sp. 10 1458A`	Low
<i>Buddelundia</i> `sp. 68WA`		Known morphospecies with seemingly restricted range. Only known from the DE but recorded from various habitats outside the proposed footprint.	Low
* <i>Buddelundia</i> `sp. Biologic-ISOP082`	Could not be matched to any known sequences.	Recorded from two sites in restricted habitat (Hillcrest and Hillslope) from the DE, both inside and outside the proposed footprint.	Low
<b>GASTROPODA</b>			
<b>Camaenidae</b>			
Sinumeloninae nr. `Mt. Robinson`	Could not be matched to any known sequences. Genus contains widespread and restricted taxa.	Recorded from single site in restricted habitat (Gorge/Gully) within the DE.	Low

## 6 CONCLUSION

Overall, sample effort and subsequent SRE invertebrate fauna diversity for the West Angelas DE and surrounds has been adequate to assess the likely risk to the fauna from activities in the footprint of the proposed project. Mygalomorph spiders, selenopid spiders, pseudoscorpions, scorpions, polydesmid millipedes, isopods and snails were all collected and identified to a high taxonomic level. Perhaps the only group that is missing are geophilomorph centipedes which at the time of these surveys were not considered to be an important group for collection. Some geophilomorph centipedes were collected in 2013 but were not taken past family level identification.

Of the 75 taxa recorded from the DE, five were considered to have Medium risk of impact from activities associated with the footprint and a further 14 were considered to have a Low level of risk from impacts associated with the footprint. The taxa designated as Medium risk of impact were predominantly collected from single sites in restricted habitats within the footprint. This was the main reason they were given a higher level of risk compared to the other taxa in Table 5.2. Given that about 80% of the restricted habitat types will remain unimpacted by the development within the DE and that it is likely that the Medium risk taxa are found in the other areas of restricted habitat type outside the footprint, the overall risk of impact to the SRE invertebrate fauna in the West Angelas DE as considered to be low.

## 7 REFERENCES

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## Appendix A: Indeterminate SRE taxa records from the West Angelas Development Envelope

Higher taxon	Taxon	Source	Identification and distribution comments
ARACHNIDA: Araneae			
Anamidae	<i>Aname</i> sp. indet.	Biota 2010	Recorded from widespread habitat outside the proposed footprint prior to 2014. These early records are unlikely to yield suitable DNA for extraction and comparison.
	Anamidae sp. indet.	Biota 2005	
Barychelidae	<i>Aureocrypta</i> sp. indet.	Ecologia 2014	
	<i>Synothele</i> sp. indet.	Biota 2010	
	<i>Eucyrtops</i> sp. indet.	Biota 2010	
Idiopidae	<i>Idiosoma</i> sp. indet.	Biota 2005, Biota 2010	
ARACHNIDA: Pseudoscorpiones			
Chthoniidae	<i>Tyrannochthonius</i> sp. indet.	Biologic 2021a	Recorded from within the proposed footprint but from the same site as <i>Tyrannochthonius</i> `sp. Biologic-PSEU104` and likely to represent this taxon.
	<i>Beierolpium</i> sp. indet.	Biologic 2021a	One specimen recorded from within the proposed footprint at the same site as <i>Beierolpium</i> `sp. Biologic-PSEU088` and likely to represent that OTU. One additional specimen collected within the proposed footprint likely to represent one of the nearby olpiid OTUs.
Olpiidae	<i>Euryolpium</i> sp. indet.	Biologic 2021a	Recorded from within the proposed footprint but from the same sites as other molecularly identified taxa, which they are likely to represent.
	<i>Indolpium</i> sp. indet.	Biota 2010	Specimens collected in 2010 from widespread habitat within the proposed footprint are likely to represent one of the other olpiid OTUs.
	Olpiidae sp. indet.	Ecologia 2014	Specimens collected in 2012 from restricted habitat within the proposed footprint but are likely to represent one of the other olpiid OTUs.
	<i>Xenolpium</i> sp. indet.	Ecologia 2014	
ARACHNIDA: Scorpiones			
Buthidae	<i>Lychas</i> sp. indet.	Biota 2005	Recorded from various habitat outside the proposed footprint.
Urodacidae	<i>Urodacus</i> sp. indet.	Ecologia 2014	Recorded from widespread habitat outside the proposed footprint.
CHILOPODA: Geophilomorpha			
Chilenophilidae	Chilenophilidae sp. indet.	Ecologia 2014	Recorded from within the proposed footprint in 2013. At the time geophilomorph centipedes were not considered in SRE survey and these specimens are likely too old for successful DNA extraction.
Geophilidae	Geophilidae sp. indet.	Ecologia 2014	
DIPLOPODA: Spirobolida			
Trigoniulidae	<i>Austrostrophus</i> sp. indet.	Biologic 2021a	Recorded from within the proposed footprint but from sites or close to sites where the widespread <i>Austrostrophus</i> `sp. Clade A` was recorded, these specimens are likely to represent this taxon.
GASTROPODA			
Bothriembryontidae	<i>Bothriembryon</i> sp. indet.	Biologic 2021a	Recorded from within the proposed footprint but as shells only so DNA analysis was not possible. These specimens were collected from widespread habitat and are unlikely to be restricted to the footprint or the DE.
MALACOSTRACA: Isopoda			
Armadillidae	<i>Buddelundia</i> sp. indet.	Biologic 2021a	Recorded from within the proposed footprint but from the same site as <i>Buddelundia</i> `sp. Biologic-ISOP081` and <i>Buddelundia</i> `sp. Biologic-ISOP082` and likely to represent one of these taxa.