Short-range Endemic Invertebrate Fauna Survey

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EXECUTIVE SUMMARY

Phoenix Environmental Sciences Pty Ltd (Phoenix) was commissioned by FerrAus Ltd, to undertake a Level 1 short-range endemic (SRE) invertebrate fauna survey (habitat assessment and foraging) for the FerrAus Pilbara Project (‘the Project’). The study area for the survey encompassed:

- a 19 km services corridor between the Project’s main processing area and its King Brown deposit;
- a 358 ha area immediately west of M52/1034, known as the King Brown deposit infrastructure area; and
- an extension of the Project’s Python/Gwardar deposit proposed pit area (known previously as the ‘Davidson Creek’ proposed pit).

This current survey expands on the Level 2 SRE fauna survey (which encompassed wet pitfall trapping and foraging) undertaken within the central portion of the Python / Gwardar project area in 2008 (Phoenix 2009b). The current survey was required because of a resource upgrade and an associated upgrade to the impact footprint. This report documents the results of the expanded survey effort, undertaken in April 2010. This report does not consider the most recent resource upgrades, proposed airstrip and the newly defined Mirrin Mirrin, Tiger and Dugite pits and associated waste dumps and other infrastructure.

A review of previous reports, aerial photography, topographic maps, GIS data and fauna databases prior to mobilisation did not identify any obvious prospective SRE habitat within the study area. The results of this current survey indicate that no locally restricted SRE taxa were located in the expanded Gwardar / Python iron ore deposit area.

Seven taxa were recorded from groups known to contain SRE species. These were represented by six genera, five families, two orders, and a single class, Arachnida. Three scorpion and four Mygalomorphae trap-door spider species were able to be distinguished. Two potentially distinct forms of the Gaius specimens were also identified (northern and southern populations ~30 km apart). However, this determination is not certain as both the specimens collected were female, and as such they have been treated as one species. No land snails, millipedes, or pseudoscorpions were recorded.

With the exception of the specimens of Lychas ‘harveyi’ group, none of the taxa that were collected during the survey had been recorded previously within or near the study area by Phoenix (2009b), and a number of new species were recorded. This result again suggests that seasonal differences in survey timing can strongly influence the resultant biological inventory produced by SRE surveys (Phoenix 2010b; c; a).

Three of the species identified in the study from the impact area were considered to be ‘potential SRE’ taxa by taxonomists of the WA Museum, those being Aname MYG001, Aname MYG004 and Urodacus ‘Davidson Creek’. With respect to the two Aname species the delineation as potential SREs is based on preliminary unpublished genetic analyses of the genus. Both ‘species’ are widespread across the Pilbara, but the genetic information to date suggests that deep divergence is evident. Where the boundaries for each of these species groups are, remains undefined.

Urodacus ‘Davidson Creek’ is a species new to the WA scorpion faunal collection and has been accorded potential SRE status for this reason. However that potential would appear to be low given that it was recorded across the project area (~30km linear distribution) and from within broad, continuous habitat types and, in the absence of major dispersal barriers.

A fourth species, Missulena sp. was also considered to have the potential to be an SRE by the WA Museum taxonomists. This delineation was due to patchy records for the genus, evident in the WA Museum database. However this genus is atypical of Mygalomorphae trap-door spiders in that it has...
a relatively high rate of fecundity (see Plate 3) and members of this genus are known to disperse by ‘ballooning’ (Framenau and Harvey 2010). These two biological traits effectively dismiss two of the major SRE selection criteria. Therefore its potential as an SRE species would appear to be extremely low.

In the absence of adequate distributional data for invertebrate taxa, both assessment of habitat extent and consideration of known distribution patterns of related species are appropriate surrogates for determining whether a species is likely to be an SRE species (EPA 2009b). Six broad habitat categories were identified in the study area, which include eight different habitat types. Of the three potential SRE taxa recorded, all appear to have no clear habitat preference, and were recorded broadly across the study area.

The study area contains broadly distributed and locally abundant habitat units (Phoenix 2009b; G&G Environmental 2010a; b), with no distinct or obvious barriers to the dispersal of the invertebrate taxa.
1.0 INTRODUCTION

Phoenix Environmental Sciences Pty Ltd (Phoenix) was commissioned by FerrAus Ltd (FerrAus), to undertake a Level 1 short-range endemic (SRE) invertebrate fauna survey for the FerrAus Pilbara Project (the Project). The study area for the survey encompassed:

- a 19 km services corridor between the Project’s main processing area and its King Brown deposit in M52/1034 (the services corridor)
- a 358 ha area immediately west of M52/1034, known as the King Brown deposit infrastructure area (the infrastructure area)
- an extension of the Project’s Python/Gwardar deposit proposed pit area (previously referred to as the ‘Davidson Creek’ proposed pit area).

This current survey expands on the Level 2 SRE fauna survey (which encompassed wet pitfall trapping and foraging) undertaken within the central portion of the Python / Gwardar project area in 2008 (Phoenix 2009b). The current survey was required because of a resource upgrade and an associated upgrade to the impact footprint. This report documents the results of the expanded survey effort, undertaken in April 2010. This report documents the results of the survey, which was undertaken in April 2010. This report does not consider the most recent resource upgrades, proposed airstrip and the newly defined Mirrin Mirrin, Tiger and Dugite pits and associated waste dumps and other infrastructure.

1.1 BACKGROUND

The study area is located approximately 80 km southeast of Newman, and lies on the boundary of the Gascoyne and Pilbara bioregions (Figure 1-1). Both the Pilbara and Gascoyne bioregions are classed as “Group 2” areas by the EPA. Within these groups, any disturbance to an area greater than 50 ha requires a “Level 2” biological survey (EPA 2009a).

While the nature of the Project is such that it requires a “Level 2” biological survey, the Project area is fairly homogenous and does not contain any obviously restricted SRE habitat. However, in 2008 the Environmental Management Branch of the Department of Environment and Conservation (DEC) recommended that FerrAus carry out a small-scale SRE trapping programme for the Project’s Python / Gwardar deposits as the invertebrate fauna of the area was poorly documented and a more detailed study would enhance the level of knowledge at the local scale. Phoenix carried out this SRE survey on behalf of FerrAus in October-November 2008 (Phoenix 2009b).

The results of the 2008 SRE survey indicated that the surveyed area had very low potential to contain SRE taxa. Each habitat type was well represented in the local area, and the broader study area contained no obvious dispersal barriers or clearly restricted / mesic habitats which might give rise to short-range endemism (Phoenix 2009a). The current Level 1 habitat assessment and foraging survey was undertaken for previously unsurveyed Project areas to supplement the results of the previous survey.

1.2 SCOPE OF WORK AND SURVEY OBJECTIVES

The aim of the survey was to provide baseline information on the presence and/or likelihood of presence of SRE species occurring in the study area.

The scope of the works was to:

1. Conduct field surveys and desktop assessments in the vicinity of the study area, including database searches and literature reviews of existing information for the study area;
2. Conduct a detailed SRE field survey consistent with EPA Guidance Statement No. 20 (EPA 2009) within the study area; and
3. Undertake data analysis and prepare a technical report using results from the 2008 SRE survey (Phoenix 2009b) and current survey.

1.3 SHORT RANGE ENDEMIC FAUNA

SRE fauna are defined as arthropods that display restricted geographic distributions that may be disjunct and highly localised (nominally defined as <10,000 km² in Harvey 2002). The most appropriate analogy is that of an island, where the movement of fauna is restricted by the surrounding marine waters, thus isolating the fauna from other terrestrial island populations. The restricted ranges of SRE species (often due to highly restricted habitats or geological dispersal barriers) makes them more vulnerable to adverse impacts and local extinction (Harvey 2002).

The study area has few landscape features with the potential to drive short-range endemism in the invertebrate fauna. The study area is dominated by an extensive floodplain, orientated in a north-south direction, which is flanked to the South-West by a low ridge line that is further dissected by a number of moderate ephemeral creek lines.

There are a number of existing or potential threatening processes that may impact SRE habitats within the study area:

- Land clearing
- Grazing
  - much of the study area is impacted from stock grazing
- Weeds
  - infestations of Buffel Grass (*Cenchrus ciliaris*) occur along most drainage courses
- Changed fire regimes
  - an altered fire regime may act to promote the premature ‘drying’ of mesic refuge habitats for SREs
- Changed hydrology, such as altered flow regimes affecting riparian vegetation, due to positioning of infrastructure, proposed pit development and haul road access routes.
Figure 1-1 Location of Project study area.
2.0 EXISTING ENVIRONMENT

2.1 INTERIM BIogeOGRAPHIC REGIONALISATION OF AUSTRALIA (IBRA)

Bioregions are defined as large land areas characterised by broad, landscape-scale natural features, and environmental processes that influence the functions of entire ecosystems. Their purpose is to capture the large-scale geophysical patterns that occur across the Australian continent. The identified patterns in the landscape are linked to fauna and flora assemblages and processes at the ecosystem scale. Land systems are therefore a useful means for simplifying and reporting on more complex patterns of biodiversity (Thackway and Cresswell 1995).

Western Australia contains 26 IBRA bioregions and 53 subregions. Each bioregion is afforded differing levels of protection through the state reserve system and differing effects by a range of threatening processes and displays varying levels of sensitivity to impacts.

The Project Area is situated in the Augustus subregion (GAS3) of the Gascoyne biogeographic region. However, it also lies close to the junction of the Little Sandy Desert and Pilbara biogeographic regions (Thackway and Cresswell 1995) and thus contains elements of each region. For example, the Fortescue plains (PIL2) subregion of the Pilbara bioregion is located just 15 km to the North of the study area, while the Rudall subregion (LSD1) of the Little Sandy Desert bioregion is located just 10 km to the west.

That being said, the majority of the study area most closely resembles the Pilbara in terms of the fauna and flora assemblages, but there are also numerous invertebrate elements that are more representative of the Gascoyne or Murchison regions, for example the trap–door spiders genus *Gaius* (Idiopidae), two species of which were recorded in the study area during the current survey. The Augustus subregion is characterised by rugged, low, Proterozoic sedimentary and granite ranges, divided by broad flat valleys, and contains the headwaters of the Ashburton and Fortescue Rivers (Thackway and Cresswell 1995). There are extensive areas of alluvial valley-fill deposits (as in the study area). Mulga woodland over Spinifex occur predominantly on shallow stony loams on rises, while the shallow earthy loams over hardpan on the plains are covered by Mulga parkland (Desmond et al 2001).

The Pilbara bioregion has four main geological components (subregions): the Hamersley Range, a mountainous area of Proterozoic sedimentary ranges and plateaux; the Fortescue Plains, consisting of alluvial plains and river frontages; the Chichester range comprising Archaean granite and basalt plains; and Roebourne consisting of Quaternary alluvial plains (DEWHA 2009a).

The Little Sandy Desert Bioregion totals 101,000km² and includes several lakes, the largest of which is Lake Disappointment. The median annual rainfall is 150-200mm. Average annual evaporation values range from 3600-4000mm. The summer average temperatures range from 22°C to 38.3°C. The average temperatures for winter range from 5.4°C to 21.3°C.

The bioregion is characterised by Quaternary dunefields and Proterozoic ranges of the Bangemall Basin. Drainage in the bioregion is internal. Savoy Creek is the main waterway, which flows into Lake Disappointment, in the north of the bioregion. Several small lakes occur in the south nearer the study area.

The soils consist of red sands associated with dunefields (the closest of which are situated approximately 20km to the east of the study area) and plains (common in the study area). Skeletal soils cover the majority of hills and ranges and alluvial deposits associated with ranges (such as Robertson Range in the study area).
The sandy soils support shrub steppe of *Acacia*, *Thryptomene* and *Grevillea* over feather-top spinifex (*Triodia schinzii*). Sparse shrub-steppe over hard spinifex (*Triodia basedowii*) grows on the stony hills. Alluvial plains support river gum communities and bunch grassland (Thackway 1995), of which two major examples are present within the study area.

### 2.2 Geology and Land Systems

The study area is located on the eastern margin of the Hamersley Province of the Pilbara Craton. The Hamersley province consists predominantly of late-Archaean and Lower Proterozoic (2800-230Ma) sedimentary rocks situated between the large Yilgarn and Pilbara Cratons.

Within the study area, the Marra Mamba Iron Formation outcrops as a low ridge. The Formation is divided into the Nammuldi, McLeod, and Mount Newman Members. The Mt Newman Member is the primary host unit for the iron ore mineralization within the study area. It consists of a thick succession of BIF, shale, and carbonate rocks. Typically, the Mount Newman Member is poorly exposed at surface; most of the orebody is below Cainozoic colluvial and alluvial material. Overlying the Mount Newman Member, also below Cainozoic cover, is stratigraphy of the Wittenoom Formation.

The Department of Agriculture and Food WA has mapped the Land Systems of the region from aerial photography, providing the largest scale interpretation of vegetation units for the project area.

The study area is located across seven Land Systems (Figure 2-1):

- **Cadgie** – Hardpan plains with thin sand cover and sandy banks supporting mulga shrublands with soft and hard spinifex.
- **Divide** – Sandplains and occasional dunes supporting shrubby hard spinifex grasslands.
- **Fortescue** – Alluvial plains and flood plains supporting patchy grassy woodlands and shrublands and tussock grasslands.
- **Newman** – Rugged jaspilite plateaux, ridges and mountains supporting hard spinifex grasslands.
- **Robertson** - Hills and ranges of sedimentary rocks supporting hard spinifex grasslands.
- **Sylvania** – Gritty surfaced plains and low rises on granite supporting acacia-eremophila-cassia shrublands.
- **Washplain** – Hardpan plains supporting groved mulga shrublands.

The services corridor falls predominantly within the Divide Land System, but briefly passes through the Cadgie and River and Sylvania Land Systems. The infrastructure area falls almost entirely within the Divide Land System.

The Python / Gwardar deposits are primarily hosted within the east-west trending Newman Land System, with the associated process and rail load out infrastructure area being primarily situated within the Sylvania Land System.
Figure 2-1 The Land Systems of the FPP study area.
2.3 CLIMATE

The Pilbara region has a semi-desert to tropical climate with highly variable, mostly summer rainfall. The average rainfall over the broader Pilbara area ranges from about 200 mm to 350 mm, although rainfall may vary widely from the average from year to year (DEWHA 2009b).

The nearest Bureau of Meteorology (BOM) weather station is located at Newman airport, located approximately 75 km west of the study area. Newman has the highest maximum mean monthly temperature (39°C) in January, the lowest maximum mean annual temperature (22.3°C) in July and an average annual rainfall of 310 mm (BOM 2009) (Figure 2-2).

![Figure 2-2 Historic climate data for Newman airport (BOM, 2009).](image)

2.4 PREVIOUS BIOLOGICAL SURVEYS

A significant number of biological surveys have been carried out previously for the Project e.g. Ecologia (Ecologia 2007c; a; b; 2008; 2009b; a; Phoenix 2009b; c). However, the one previous SRE survey in the study area (Phoenix 2009b) did not identify any SRE taxa. A lack of barriers to dispersal was noted at the time and pitfall trapping confirmed that assumption.

2.5 LAND USE

Land use in the study area comprises pastoral grazing and exploration activities. The study area has been impacted by cattle grazing, exploration activities and recent fires.
3.0 METHODS

3.1 HABITAT ASSESSMENT AND SITE SELECTION

A review of aerial photography identified a number of habitat types within the study area that were considered to have minor potential to facilitate short-range endemism among the resident invertebrate fauna:

- Major and Minor drainage lines;
- Spinifex Sandplains - Floodplains;
- Rocky outcrops on low stony slopes;
- South-facing minor slopes on low stony hills;
- Acacia woodland; and
- Acacia in drainage lines.

Final site selection was determined on commencement of the field survey, following site verification. Ten SRE sites were hand surveyed and nine pitfall sites were surveyed across the study area, for a total of 19 sites (Figure 3-1).

3.2 TARGET TAXA

The survey targeted all taxonomic groups known to include SRE species in the Pilbara region:

- Trap-door spiders (Arachnida);
- Scorpions (Arachnida);
- Pseudoscorpions (Arachnida);
- Non-marine snails (Gastropoda);
- Millipedes (Diplopoda);
- Isopods (Malacostraca);

3.3 SURVEY TIMING AND WEATHER

The SRE foraging survey component was carried out in the period 6-9 April 2010. The dry pitfall trapping that contributed a number of specimens was carried out in the period 6-16 of April 2010.

The nearest Bureau of Meteorology (BOM) weather station is located at Newman airport, approximately 75 km west of the study area. Newman has the highest maximum mean monthly temperature (39°C) in January, the lowest maximum mean annual temperature (22.3°C) in July and an average annual rainfall of 310mm (BOM 2009). A total of 66 mm of rain was received at Newman airport during March and April 2010 (Figure 3-2).
Figure 3-1 Locations of the L1 SRE survey sites and supplementary vertebrate dry pitfall trapping sites.
3.4 SAMPLING METHODOLOGY

The field survey consisted of industry-recognised sampling techniques that target SRE taxa; active searches (foraging) and dry pitfall trapping.

The habitats with the greatest potential to facilitate short-range endemism were sampled across the study area. Targeted SRE foraging was undertaken at ten SRE sites throughout the study area. Exploration activities have long occurred in the study area, however, the activities were largely occurring in non-prospective SRE habitats and are therefore unlikely to have affected capture rates.

A total of nine dry (vertebrate) pitfall sites were established at the same time as the commencement of the targeted SRE survey. Daytime and nocturnal foraging activities were also undertaken by the three vertebrate field team members. While the vertebrate traps sites targeted the most representative of the habitat types locally, the SRE survey specifically targeted any restricted habitats such as dense woodlands, therefore the full complement of habitat types was sampled.

Foraging incorporated the systematic inspection of logs, larger plant debris, under the bark of larger trees and the underside of larger rocks (outcrops). Methodical searches were also conducted amongst the leaf litter of shade-bearing tall shrubs and trees. Rocks and rock crevices were also inspected, particularly for pseudoscorpions. A temporally and spatially standardised approach was undertaken, whereby each of the ten sites was sampled for 60 - 90 minutes within a 50m x 50m area (30 - 45 mins x 2 people; 75 mins average). This equated to 750 minutes (12.5 hours) of hand searching, and a total search area of 2.5 hectare (Table 3-1).

Dry pitfall trapping was also conducted at the nine vertebrate fauna sites that were being assessed in a concurrent survey. Each pitfall trap consisted of the standard vertebrate fauna trapping assembly. This comprised a trap line of 6m long, 300mm high aluminium drift fence bisecting a PVC pipe.
with a collection diameter of 150mm x 500mm depth at each end of the fence line or a 20L bucket in the centre. Each site contained 10 trap lines at each site, totalling 90 trapping locations.

Mygalomorphae trap door spider burrows identified during the searches were excavated if they were considered to be inhabited. Excavation involved removing soil from around the burrow to expose the burrow chamber and remove the spider. Multiple species were excavated from creekline habitats and quartz-loam rises. Some burrows revealed huntsman spiders upon excavation, which may have predated upon or displaced the trap door spiders.

Site descriptions, vegetation, and sampling activity were recorded at each site (Appendix 1). The coordinates of each site were recorded by a hand held GPS device (Appendix 2).

Table 3-1  Sampling effort for the survey.

<table>
<thead>
<tr>
<th>Techniques</th>
<th>No. Sites</th>
<th># traps (per site) / area (m²)</th>
<th>Trap nights / Time (mins)</th>
<th>Total Sample Size (n)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dry pitfall trapping</td>
<td>9</td>
<td>10</td>
<td>540</td>
<td>4860 nights</td>
</tr>
<tr>
<td>Foraging</td>
<td>10</td>
<td>50m x 50m</td>
<td>75 mins (average)</td>
<td>750 minutes</td>
</tr>
<tr>
<td>Night Foraging</td>
<td>8</td>
<td>n/a</td>
<td>n/a</td>
<td>8</td>
</tr>
</tbody>
</table>

3.5 Sample Handling

All specimens collected were transported to Perth for sorting and identification. Specimens collected were placed in a glass vial preserved in 100% ethanol and labelled accordingly.

3.6 Taxonomy and Nomenclature

Specimens of Mygalomorphae spiders, scorpions, and centipedes were identified by Phoenix scientists to at least the level of Genus. Species level identification of Mygalomorphae spiders and scorpion specimens were identified by taxonomists at the Western Australian Museum. All groups were submitted for identification in early May 2010.

3.7 Environmental Protection Authority Guidance

The methods employed in this survey were based on Phoenix’s previous experience in undertaking SRE surveys throughout many regions of Western Australia.

Where practicable, the survey design, methodology and report-writing aspects scope of the work adhered to appropriate principles and guidelines, including:

- Environmental Protection Authority (EPA) Position Statement No. 3: Terrestrial Biological Surveys as an Element of Biodiversity Protection (EPA 2002); and
- EPA Guidance Statement No. 20: Sampling of Short Range Endemic Invertebrate Fauna for Environmental Impact Assessment in Western Australia (EPA 2009b).

The survey presented here adheres to Guidance Statement 20. The limitations to the study with respect to Guidance Statements number 20 and 56 (EPA 2004; 2009b) are discussed in Section 4.0.
4.0 RESULTS

A total of seven (potentially eight) taxa from two groups known (or suspected) to contain SRE species were recorded during the survey (Table 4-1, Table 4-2, Table 4-3 and Table 4-4). These were represented by six genera, five families, two orders, and a single class, Arachnids. Of those, five mygalomorph species and four scorpion species were recorded. No land snails, millipedes, or other classes were recorded.

The structure and aspect of each habitat unit was largely homogenous and well represented regionally. There were no obvious significant geographical barriers to drive endemism, and therefore the intensity of sampling was considered adequate for the study area.

The sites selected for the survey were representative of the eight broad habitat types across the study area (Table 4-1 and Table 4-2). The individual species recorded per site and the habitat type of each site is also presented in Table 4-3 and Table 4-4 respectively. Although each habitat was broadly represented in the study area, the largest collections of specimens were obtained from Major and Minor drainage lines. For example, 45% of all Mygalomorphae specimens were obtained from drainage lines.

Similarly, over 65% of scorpions recorded in this survey were collected from drainage line habitat. The burrows of the large Urodacidae species, for example, were abundant and obvious at sites Site 4 (intersecting three different land systems, Sylvania, Divide and River) and Site 7.

While many of the taxa identified in the survey were recorded from multiple sites and habitat types, three of the eighteen specimens have not previously been recorded in Western Australia. They are therefore, for the moment, considered SRE species.

The classification of the three SRE species was due in part to the revision of the genetic and morphologically knowledge of the *Aname* and *Missulena* genera (Nemesiidae) of spiders. Each taxa is discussed further below.

### Table 4-1 Number of sites in each habitat type that recorded mygalomorphae spider species.

<table>
<thead>
<tr>
<th>Family / Genus</th>
<th>Species</th>
<th>Rocky Outcrop</th>
<th>South-facing Slope</th>
<th>Major Drainage Line/ Floodplain</th>
<th>Minor Drainage Line/ Acacia Woodland</th>
<th>Open Grassland</th>
<th>Low Shrubland Open Woodland</th>
<th>Total Number of Habitats</th>
</tr>
</thead>
<tbody>
<tr>
<td>Actinopodidae</td>
<td>Missulena sp.</td>
<td></td>
<td></td>
<td>√</td>
<td></td>
<td></td>
<td></td>
<td>1</td>
</tr>
<tr>
<td>Idiopidae</td>
<td><em>Anidiops (Gaius)</em> sp.</td>
<td></td>
<td></td>
<td>√</td>
<td>√</td>
<td></td>
<td></td>
<td>2</td>
</tr>
<tr>
<td>Nemesiidae</td>
<td><em>Aname</em> ‘MYG001’</td>
<td>√</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>3</td>
</tr>
<tr>
<td></td>
<td><em>Aname</em> ‘MYG004’</td>
<td>√</td>
<td></td>
<td></td>
<td>√</td>
<td>√</td>
<td></td>
<td>4</td>
</tr>
</tbody>
</table>

### Table 4-2 Number of sites in each habitat type that recorded scorpion species.

<table>
<thead>
<tr>
<th>Family / Genus</th>
<th>Species</th>
<th>Rocky Outcrop</th>
<th>South-facing Slope</th>
<th>Major Drainage Line/ Floodplain</th>
<th>Minor Drainage Line/ Acacia Woodland</th>
<th>Open Grassland</th>
<th>Low Shrubland Open Woodland</th>
<th>Total Number of Habitats</th>
</tr>
</thead>
<tbody>
<tr>
<td>Buthidae</td>
<td><em>Lychas</em> ‘harvey’ gp</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>2</td>
</tr>
<tr>
<td></td>
<td><em>Isometroides</em> sp.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1</td>
</tr>
<tr>
<td>Urodacidae</td>
<td><em>Urodacus</em> ‘Davidson Creek’</td>
<td>√</td>
<td></td>
<td></td>
<td>√</td>
<td></td>
<td></td>
<td>3</td>
</tr>
</tbody>
</table>
4.1 **MYGALOMORPHAE**

4.1.1 **Actinopodidae**

In Australia, this family is represented by only one genus, *Missulena*. Spiders of the family Actinopodidae are largely endemic to Australia, with habitats which range from open-forest to semi-arid shrubland. Spiders within this family are medium to large spiders with trap-door lidded burrows, typically with two doors, hinged together (Plate 1).

*Missulena* sp.

Commonly known as a mouse spider, it was originally thought that they resided in burrows which resemble the burrow of a mouse. However, the members of this group reside in burrows covered with a trapdoor. The lid is often oval in shape, with two doors joined at a hinge (Plate 1). The burrow commonly extend to 30cm, but can sometimes be up to one meter in depth (Framenau and Harvey 2010). This genus is known to include eight species in Australia. *Missulena* display sexual dimorphism, in that while the females are typically all black or all brown in colour, the males can be quite distinctive in colouration. In addition, the eyes of this genus are located across at least a third of the width of the anterior carapace (unlike other primitive spiders whose eyes are compactly grouped in the centre of the head region) (Brunet 2008).

Western Australian Museum arachnologists recently conducted a review of the taxonomy and distribution of the genus and concluded that there is a diverse fauna with limited distribution in many cases.

This is the first record of the species, and therefore it is accounted the term of SRE by default. Despite this determination, this species has been assigned a low likelihood of being an SRE because members of this genus contain two biologically attributes that reduce its predisposition toward short range endemism.

Firstly, juvenile spiders of this genera are known to disperse via ‘ballooning’ (using a particularly light silk and the right wind conditions, common in modern spiders), affording potential dispersal of several kilometres (Bell et al 2005). Secondly, species’ of the genus are also known to breed in significant numbers. The female specimen collected in this survey for example, was brooding over at least 200 spiderlings (Plate 2). This degree of breeding is much greater than in other endemic Mygalomorphae genera (e.g. Idiopidae and Nemesiidae) and is more akin to the breeding strategies employed by insects.

Plate 1 A typical *Missulena* burrow entrance.
4.1.2 Idiopidae

In Australia, this family currently consists of eight genera and 66 species commonly known as ‘Typical Trapdoor’ spiders or twig-lining trap-doors. The name ‘trapdoor’ spider has caused some confusion as many species do not build lids or doors to their burrow entrance. Their burrows can be lidded, or non-lidded, inclined or vertical, some are curved, and some branch out into multiple burrows. Burrows can be up to a metre deep and the majority end in a retreat chamber to avoid predation and maintain moisture within the burrow.

Most Idiopidae are generally considered medium to large spiders and their body is often compared to that of a tarantula (Brunet 2008). Like the Barychelids, females are sedentary and remain in a single burrow throughout life, foraging within the general locality of their burrow. Adult males abandon their burrows to ‘wander’ in search of a mate.

Anidiops sp. (Gaius sp.)

The genus Gaius is currently listed as a junior synonym (different scientific names used for a single taxon) of the genus Anidiops. While commonly found throughout Western Australia, only two species have been formally described. As males are required for accurate species level identification, and the specimens collected during the survey were females, species identification, and hence, assessment of distribution and conservation status, could not be determined.

Two female specimens of differing morphology were collected from the study area (Plate 3). This could indicate the presence of two distinct species; however males are required for accurate species identification. Anidiops burrows can have a very distinct twig lining (Plate 5), and due to the size of the spiders in the case of Gaius sp. (which are often quite large), their burrow doors are relatively visible. In the study area, burrows lids were thick (>5mm) and were surrounded by a radial twig lining. The burrows were lined with a particularly thick (tissue paper like) silken burrow wall that blocked the burrow as it was being excavated. This created a temporary, false, burrow bottom, presumably to fool interlopes and predators.

Similar to other species of Idiopids found throughout the Murchison and Gascoyne Regions, the Gaius sp. was observed in family clusters underneath Acacia trees (Plate 4). The northern population were found within a creekline habitat, close to the Python/Gwardar deposits, but outside of the infrastructure area and the southern population was located close to the exploration camp.
This species is considered to be a potential SRE species, however irrespective of their potential SRE status, the *Gaius* specimens were located outside of the Project footprint and will therefore not be impacted and thus considered further within this report.

**Plate 3** Female *Gaius* collected in the Northern population.

**Plate 5** The *Gaius* burrow entrance.

**Plate 4** *Gaius* meta-populations and individual burrow from the southern population.

### 4.1.3 Nemesiidae

Nemesiidae are burrowing trapdoor spiders, commonly called Wishbone spiders. The family reaches its highest diversity in Australia, with different genera occurring in different habitats. Species of genera found in rainforests in eastern Australia tend to have highly localised distributions, being restricted to one or two adjacent mountaintops. Species belonging to genera that dominate in drier forest to desert (e.g. *Aname*) have generally wider distributions, but depending on the biogeographical events that have occurred, they may still have disjunct distributions. Their burrows often have no lid (Brunet 2008).

Members of this family are represented by several genera including *Aname*, *Chenistonia*, *Yilgarnia*, *Stanwellia*, *Teyl*, *Swolnpes* and *Kwonkan* (Main and Framenau 2009).

Two species of Nemesiid were recorded in the survey.

**Aname MYG001 group**

According to the Descriptive Language for Taxonomy (DELTA) database, the genus *Aname* and its relatives (e.g. *Kwonkan*) have diversified strongly in Western Australia and show higher degrees of endemism than those genera in eastern Australia.

Until recently, *Aname* ‘MYG001’ was believed to be widespread across the Pilbara region of the state and to consist of only a single species. However, recent studies have confirmed genetic
divergence within the group and indicate that there may be at least four separate species present (Framenau 2010). Based on the current level of knowledge of this group, it is possible that these spiders may represent an SRE species. The specimen recorded from the FPP study area is presented in Plate 6.

**Plate 6 Anane MGY001**

*Anane ‘MYG004’*

Similar to the MYG001 group, knowledge of this species requires further taxonomic work to understand and assess its status and distribution. The collection from the survey included multiple specimens of *Anane ‘MYG004’*. This species was previously known from a single male collected at a mine site ca. 40km west of the Python/Gwardar deposits (‘Jimblebar’, 23°23’40”S 120°09’13”E). The species was not collected during the recent DEC Pilbara survey. Based on current genetic knowledge, this species is considered to be a short-range endemic.

### 4.2 Scorpiones

Current classification of the Scorpiones usually recognise five superfamilies, of which two, Buthoidea and Scorpionoidea, are represented in the Australian fauna. Three species of scorpion representing both superfamilies were recorded. The number of records in relation to habitat type is provided in (Table 4-2).

#### 4.2.1 Buthidae

The family Buthidae is diverse with some 50 genera and over 500 species currently recognised (Sissom 1990). The Australian buthid fauna currently contains five genera and 11 extant species (Koch 1983) but unpublished research indicates that the fauna is actually much more diverse, with substantial changes at the genetic level, and numerous new species yet to be described (Voschenk pers.comm.; DEWHA 2009a).

*Isometroides sp.*

A single *Isometroides* specimen was recorded at Site 4 whilst conducting nocturnal searches (Plate 7). Members of this genus are known to actively hunt Mygalomorphae trap-door spiders in their own burrows. They are the only group known to display this behaviour. There are no known SRE species within the genus. However, Site 4 is outside of the Project footprint and therefore will not be impacted.
**Lychas ‘harveyi’ group**

Specimens belonging to the *Lychas ‘harveyi’*-group were at Site 4 and Vertebrate Site 2 (Plate 8). This genus is abundant and increasingly diverse (due to taxonomic work) across all of mainland Australia (Framenau and Harvey 2009). All *Lychas* species are generally quite small with slender pedipalps and mottled colouration. This group is widespread throughout the Pilbara region and is considered unlikely to contain any SRE taxa.

**4.2.2 Urodacidae**

The family Urodacidae consists of two genera, *Urodacus* and *Aops*, a genus with only a single extant member; a troglobitic species (*A.oncodactylus*) known only from Barrow Island. One undescribed species also exists. *Urodacus*, while abundant, is confined to mainland Australia. The Western Australian Urodacidae fauna is extremely diverse with high numbers of new species remaining to be formally described. Numerous SRE species are known, but many species are more widespread.

**Urodacus ‘Davidson Creek’**

A single female and three juvenile specimens of the genus *Urodacus* was recorded from Site 4, Site 6, Site 7 and Vertebrate Site 7, which include habitats within Major and Minor drainage lines and in open grassland (Site 7) (Table 4-4). This collection represents an unusually morphologically adapted species, unlike any collected previously from the Pilbara Region. It is unique to the area and has not yet been collected anywhere else. As such, it is potentially an SRE species (Plate 9).
Table 4-3  Invertebrate taxa recorded during the survey.

| Family               | Genus      | Species       | S1 | S2 | S3 | S4 | S5 | S6 | S7 | S8 | S9 | S10 | V1 | V2 | V3 | V4 | V5 | V6 | V7 | V8 | V9 | Total # Sites | % presence |
|----------------------|------------|---------------|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----------------|------------|
| Araneae - Mygalomorphae | Nemesiidae | *Aname*       |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    | 3              | 15         |
|                      |            | ‘MYG001’ gp   | √  |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |               |            |
|                      |            | ‘MYG004’ sp.  |    | √  |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |               |            |
|                      |            | ‘MYG004’ sp.  |    |    | √  |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |               |            |
|                      |            | sp. juv       |    |    |    | √  |    |    |    |    |    |    |    |    |    |    |    |    |    |    |               |            |
|                      | Idiopidae  | *Anidiops*    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    | 2              | 10         |
|                      |            | sp. (Gaius sp.) |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |               |            |
|                      | Actinopodidae | *Missulena* |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    | 1              | 5          |
|                      |            | sp.           |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |               |            |

1 – denotes presence;
‘S’ refers to an SRE Level 1 foraging site;
‘V’ refers to a vertebrate fauna trapping site.

Table 4-4  Habitat Site Matrix.

| Habitat Type                   | S1 | S2 | S3 | S4 | S5 | S6 | S7 | S8 | S9 | S10 | V1 | V2 | V3 | V4 | V5 | V6 | V7 | V8 | V9 | Total # Sites |
|--------------------------------|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----------------|
| Major Drainage Lines           | √  |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |                | 2          |
| Minor Drainage Lines – Acacia woodland |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |                |            |
| Spinifex Sand plain - Floodplain |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |                | 2          |
| Rocky outcrop on stony hillslopes |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |                | 2          |
| Minor south facing slope       |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |                | 1          |
| Open grasslands                |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |                | 4          |
| Open Woodland                  |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |                | 2          |
| Low Shrublands                 |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |                | 1          |

‘S’ refers to an SRE Level 1 foraging site;
‘V’ refers to a vertebrate fauna trapping site.
Figure 4-1 Locations of taxa recorded during the survey.
4.3 LIMITATIONS

Limitations of the survey are outlined in Table 4-5, as per EPA Guidance Statement No. 56 (EPA 2004).

Table 4-5 Limitations of the survey.

<table>
<thead>
<tr>
<th>Limitations</th>
<th>Relevant?</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Competency / experience of the consultant carrying out the survey.</td>
<td>No</td>
<td>Jarrad Clark has extensive experience in undertaking SRE surveys throughout the Pilbara, Midwest, Southwest, Kimberley and Goldfields regions of WA.</td>
</tr>
<tr>
<td>Scope (what faunal groups were sampled and were some sampling methods not able to be employed because of constraints such as weather conditions, e.g. pitfall trapping in waterlogged soils or inability to use pitfall traps.)</td>
<td>No</td>
<td>The survey targeted all groups known to include SREs. Extensive foraging effort supplemented the trapping program undertaken in 2009 (Phoenix, 2009b).</td>
</tr>
<tr>
<td>Proportion of fauna identified, recorded and/or collected.</td>
<td>Yes</td>
<td>Due to the paucity of knowledge concerning SREs and invertebrates in general, it is almost impossible to assess whether all SRE species have been recorded. Species area curves may be used to determine the likelihood that species are adequately represented, but only if multiple survey data is generated from wet pitfall trapping is it meaningful.</td>
</tr>
<tr>
<td>Sources of information e.g. previously available information (whether historic or recent) as distinct from new data</td>
<td>Yes</td>
<td>There is little historic data concerning invertebrates in the Little Sandy Desert and Gascoyne biogeographic regions. Phoenix (2009b) has the most comprehensive data for the area.</td>
</tr>
<tr>
<td>Timing/weather/season/cycle.</td>
<td>No</td>
<td>The survey was undertaken in April. Temperatures were similar to other years during the period of survey. Moderate to negligible rainfall was experienced in December and January. Rainfall was experienced on two of the four surveys, making the conditions perfect for dry trapping and foraging.</td>
</tr>
<tr>
<td>The proportion of the task achieved and further work which might be needed</td>
<td>No</td>
<td>The program was implemented as planned. A total of nine dry pitfall sites were established and foraging was undertaken at these and at ten specific SRE sites throughout the study area. Nocturnal searches using high powered torches and black-lights were also undertaken.</td>
</tr>
<tr>
<td>Disturbances (e.g. fire, flood, accidental human intervention etc.) which affected results of survey.</td>
<td>No</td>
<td>Exploration activities had commenced within the study area, however, the activities were largely occurring in non-prospective SRE habitats and are therefore unlikely to have affected capture rates</td>
</tr>
<tr>
<td>Intensity (in retrospect, was the intensity adequate?)</td>
<td>No</td>
<td>The study area was fairly homogenous and is well represented regionally. As there were no obvious isolated habitats or geographical barriers present, the intensity of sampling was considered adequate for the site.</td>
</tr>
<tr>
<td>Completeness (was relevant area fully surveyed?)</td>
<td>No</td>
<td>Habitats with the greatest potential to facilitate short-range endemism were sampled across the study area.</td>
</tr>
<tr>
<td>Remoteness and/or access problems.</td>
<td>No</td>
<td>As the site is relatively flat, no access issues were experienced.</td>
</tr>
<tr>
<td>Availability of contextual (e.g. biogeographic) information on the region.</td>
<td>Yes</td>
<td>The study area lies on the western edge of the Little Sandy Desert at the junction of the Gascoyne and Pilbara bioregions. Little information exists on the invertebrate fauna of these systems.</td>
</tr>
</tbody>
</table>
5.0 DISCUSSION

A review of previous reports, aerial photography, topographic maps, GIS data and fauna databases prior to mobilisation did not identify any obvious prospective SRE habitat within the study area.

A total of seven taxa were recorded from groups known to contain SRE species. These were represented by six genera, five families, two orders, and a single class, Arachnida. Three scorpion and four Mygalomorphae trap-door spider species were able to be distinguished. Two potentially distinct forms of the *Gaius* specimens were also identified (northern and southern populations ~30 km apart). However, this determination is not certain as both the specimens collected were female, and, as such, they have been treated as one species. No land snails, millipedes, or pseudoscorpions were recorded.

With the exception of the specimens of *Lychas ‘harveyi’* group, none of the taxa that were collected during the survey had been recorded previously within or near the study area by Phoenix (2009b), and a number of new species were recorded.

Three of the species identified in the study were considered to be ‘potential SRE’ taxa by taxonomists of the WA Museum - *Aname MYG001*, *Aname MYG004* and *Urodacus ‘Davidson Creek’*. A fourth species, *Missulena* sp. was also considered to have the potential to be an SRE. However this potential would appear to be extremely low given that the species clearly has relatively high fecundity (see Plate 3) and members of this genus are known to disperse by ‘ballooning’ (Framenau and Harvey 2010), effectively dismissing two of the major SRE selection criteria.

In the absence of adequate distributional data for invertebrate taxa, both assessment of habitat extent and consideration of known distribution patterns of related species are appropriate surrogates for determining whether a species is likely to be an SRE species (EPA 2009b). Six broad habitat categories were identified in the study area, which include eight different habitat types. Of the three potential SRE taxa recorded, all appear to have no clear habitat preference, and were recorded broadly across the study area. *Aname* sp. ‘MYG001’ was recorded from three distinct habitat types, all of which are well represented locally and regionally. Thus despite the apparent deep genetic divergence shown by recent molecular analysis of the ‘group’, locally, the FPP proposal would appear to represent limited risk to the species as a whole and, to the local genetic variant of the group (if indeed a local genetic variant was shown to exist).

The same is true of *Aname* ‘MYG004’, which is previously known from Jimblebar, approximately 40km to the west. Within the study area this species was recorded from four sites and four habitat types. Clearly the species shows no habitat preferences therefore it would not be expected to be restricted in any way. Further, the species was recorded 40km to the west and in the absence of additional, significant development proposals between the two areas and the small, linear scale of the FPP proposal, the risk to the species therefore would also appear to be very limited.

The final potential SRE taxon recorded was *Urodacus ‘Davidson Creek’*. Again this species was found to be broadly distributed locally, but showed a minor habitat preference. It was recorded from a major and a minor drainage line and an open woodland, therefore it would appear to prefer habitats with a greater degree of canopy cover, leaf litter and associated transported or finer clay soils (as opposed to the deeper aeolian sands of the spinifex plains, or skeletal soils of the rock ridges).

While the two populations of *Gaius n. sp. (Anidiops)* are potentially SRE taxa, these were not identified in the proposed disturbance footprint for the Project, and will therefore not be impacted by the Project.
Extensive foraging efforts, in combination with dry pitfall trapping and seasonal rains, resulted in Phoenix identifying several new invertebrate fauna species in the study area, and species with sparse records or apparent genetic divergence. The study area contains broadly distributed and locally abundant habitat units (Phoenix 2009b; G&G Environmental 2010a; b), with no distinct or obvious barriers to the dispersal of these taxa. All species recorded were from a range of distinct habitat types, showing no habitat preferences.

Given the results of the 2008 and 2010 SRE surveys of the study area, the Project is very unlikely to have a significant impact on invertebrate faunal assemblages.
6.0 SURVEY PERSONNEL

A summary of the personnel involved in the survey is provided in Table 6-1. Phoenix also gratefully acknowledges the taxonomists who assisted with the species identifications.

Table 6-1 Survey personnel.

<table>
<thead>
<tr>
<th>Name</th>
<th>Title</th>
<th>Qualifications</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mr Jarrad Clark</td>
<td>Senior Invertebrate Zoologist, Project Manager</td>
<td>BSc Environmental Management</td>
</tr>
<tr>
<td>Ms Andrea Bending</td>
<td>Biologist</td>
<td>BSc. Marine Biology, Post Grad Dip. Conservation Biology</td>
</tr>
<tr>
<td>Ms Karen Crews</td>
<td>Senior Environmental Advisor</td>
<td>BSc (Hons) Environmental Biology</td>
</tr>
</tbody>
</table>
7.0 REFERENCES


EPA (2002). Position Statement No. 3 *Terrestrial Biological Surveys as an element of Biodiversity Protection.* Perth, Environmental Protection Authority.


APPENDIX 1: SITE DESCRIPTIONS

<table>
<thead>
<tr>
<th>Site</th>
<th>Date</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Site 1</td>
<td>01/10/2008</td>
<td>Major drainage line / floodplain. <em>Eucalyptus victrix</em> and <em>Acacia</em> sp. sparse low trees to 4m over <em>Cenchrus ciliaris</em> (Buffel grass). Red/brown sandy clay soil.</td>
</tr>
<tr>
<td>Site 2</td>
<td>01/10/2008</td>
<td><em>Triodia</em> hummock grassland. <em>Acacia</em> sp. very open small trees to 4m over sparse low shrubs, over mature hummocks. Red/brown sandy clay. Peeling clay at surface.</td>
</tr>
<tr>
<td>Site 3</td>
<td>01/10/2008</td>
<td>South slope (minor). <em>Acacia aneura</em> medium shrubs over mixed shrubs to 1.5m over <em>Triodia pungens</em>. Red sandy clay. Skeletal soils with large rocks and stones.</td>
</tr>
</tbody>
</table>

NO PHOTO AVAILABLE
<table>
<thead>
<tr>
<th>Site</th>
<th>Date</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Site 4</td>
<td>01/10/2008</td>
<td>Hilltop drainage line (minor) in low hills. Acacia aneura small trees to 4m over Eremophila forrestii. Stick debris plentiful. Red/brown sandy clay loam. Soils to 1m overlain by small stones.</td>
</tr>
<tr>
<td>Site 5</td>
<td>01/10/2008</td>
<td>Minor South-facing slope. Acacia aneura small trees to 4m over Eremophila forrestii over Triodia pungens hummock grass. Stick debris plentiful. Red/brown sandy clay. Hard soils with large rocks and stones at surface. Outcropping present.</td>
</tr>
<tr>
<td>Site 6</td>
<td>01/10/2008</td>
<td>Major drainage line in low hills. Acacia aneura low trees to 4m over sparse mixed shrubs to 1.5m over mixed low scattered shrubs to 60cm. Red/brown sandy clay. Shallow soils, broken rocks and stones</td>
</tr>
</tbody>
</table>
### Site Descriptions: SRE Level 1 Foraging Sites

**Site 7**  
01/10/2008  
Floodplain grassland.  
*Eucalyptus victrix* and dead *Acacia* sp. over *Cenchrus ciliaris*.  
Deep Red/brown sand.

**Site 8**  
01/10/2008  
Mulga woodland  
Open Mulga woodland to 4m over *Poaceae* sp. Heavy litter under Mulga, otherwise bare.  
**NO PHOTO AVAILABLE**

**Site 9**  
01/10/2008  
Low Shrubland  
Sparse low open shrubland. Mixed shrubs 2.0 - 0.5m over *Poaceae* sp. Burnt within the past five years.  
Red/brown sandy clay.
Site Descriptions: SRE Level 1 Foraging Sites

Site 10
01/10/2008

Open Mulga Woodland.

Open medium-tall Mulga shrubs and low trees over mixed Acacia sp. medium-tall shrubs (mostly Mulga), scattered low-medium Eremophila and Acacia spp. shrubs, over scattered bunch grasses, with large patches of bare earth. Significant wood litter, with scattered, patchy leaf litter.

Red clay loam with scattered quartz on the surface.

NO PHOTO AVAILABLE

Site Descriptions: Vertebrate Fauna Trapping Sites

Vert. Site 1
06/04/2010

Open Mulga Woodland.

Open medium-tall Mulga shrubs and low trees over mixed acacia spp. medium-tall shrubs (mostly Mulga), scattered low-medium Eremophila and Acacia spp. shrubs, over scattered bunch grasses, with large patches of bare earth. Significant wood litter, with scattered, patchy leaf litter.

Red clay loam with scattered quartz on the surface.

Vert. Site 2
06/04/2010

Spinifex Sandplain.

Moderately dense, mature but low (c. 40cm) spinifex forming almost continuous habitat with small open sand patches. Scattered Corymbia hamersleyana and Hakea sp. low trees break up the grassland. Scattered Grevillea sp. low shrubs.

Red/brown sandy loam.
### Vert. Site 3
06/04/2010

Stony Hillslope.

Gentle hillslope with minor drainage channels.

Open low-medium *Acacia* sp. (? *rhodonoides*) shrubs over low, open, mixed shrubs and dwarf shrubs (< 20 cm), predominantly *Eremophila* sp., grading to taller Acacias, shrubs and bunch grasses with spinifex clumps at the margin of the stony slope. Some dead trees and wood debris present. Scant leaf litter.

Shallow clay loam to deep red clay, large Quartz stone and pebbles.

### Vert. Site 4
06/04/2010

Mulga woodland

Flat Plain

Open to moderately dense medium *Acacia aneura* trees over low to medium mixed *Acacia* and *Eremophila* sp. shrubs over low-medium spinifex. Spinifex in bands, rings and patches with large areas of bare ground. Significant leaf litter below trees and shrubs and much wood litter.

Red/brown deep sandy clay.

### Vert. Site 5
06/04/2010

Mulga Valley

Shallow E-W drainage valley between two low ridgelines

Open mulga trees over mixed, scattered medium shrubs over open low *Eremophila* and *Acacia* shrubs, over low, moderately dense scattered spinifex patches.

Rocky, stony red clay loam and sandy clays with hard clayey base.
### Vert. Site 6
06/04/2010
Open spinifex grassland.
Sandplain.
Open spinifex grassland with mixed medium sparse shrubs (predominantly *Acacia* spp.) over low-medium dense patchy spinifex clumps. Wood litter present. Patchy leaf litter accumulations but little overall. Scattered low shrubs. Good condition with no evidence of grazing.
Red/brown sandy loam.

### Vert. Site 7
06/04/2010
Acacia Creekline.
Drainage channel.
Tall, moderately dense *Acacia aneura* woodland over mixed open low-medium shrubs. Groundcover absent in many areas. Significant wood litter. Heavily grazed. Low bunch grasses and annuals and scattered Buffel grass in patches.
Sand-based drainage channel cuts into harder red clayey loam.

### Vert. Site 8
06/04/2010
Creekline.
Major Creekline.
Creekline lined with open *Eucalyptus* and mulga over Buffel grass and open low shrubs. Significant wood litter. Degraded with evidence of heavy grazing.
Sandy bottomed creekline, c. 20 m wide, with embankments consisting of a firm, orangey sandy loam.
Vert. Site 9
06/04/2010
Grassland.
Drainage depression/clayey plain.
Open mulga and Corymbia sp. woodland over Hakea and Grevillea spp. scattered low trees and shrubs over low open Acacia and Eremophila shrubs over moderately dense, patchy Buffel grass. Many dead standing trees and scattered wood litter. Degraded; heavily grazed.
Complex of stony soils, predominantly shallow sandy loam on a clay base.
## APPENDIX 2: SRE SURVEY SITES GPS COORDINATES

<table>
<thead>
<tr>
<th>Name</th>
<th>Easting (UTM) WGS-84 (51K)</th>
<th>Northing (UTM)</th>
<th>Latitude</th>
<th>Longitude</th>
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