LEVEL 2 SHORT RANGE ENDEMIC SURVEY OF THE MARDA TENEMENT

AND

LEVEL 1 SHORT RANGE ENDEMIC SURVEYS OF THE GOLDEN ORB AND KING BROWN TENEMENTS

FOR

SOUTHERN CROSS GOLDFIELDS LTD

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EXECUTIVE SUMMARY

Southern Cross Goldfields Ltd proposes to develop the Marda Gold project, approximately 114 kilometres north of Southern Cross. The project involves mining operations and ore processing facilities in the Marda tenement, as well as two satellite mine sites in the Golden Orb and King Brown tenements.

Rapallo Environmental completed a Level 2 Short Range Endemic invertebrate (SRE) survey of the Marda tenement, and Level 1 SRE surveys of the Golden Orb and King Brown tenements. The survey aims were to:

- identify SRE invertebrates occurring or likely to occur in the project area;
- describe SRE habitat in the project area;
- understand survey findings in a regional context to evaluate potential risks to SRE populations.

Methods

The SRE survey included a desktop search to establish a regional context, and a field survey of the project area from 14 to 23 September 2011. The field survey methods included dry pitfall trapping in the Marda tenement (10 sites), and hand foraging in the Marda tenement (13 sites), Golden Orb tenement (8 sites) and King Brown tenement (7 sites). Leaf litter samples were collected from all trapping and foraging sites, and run through Tullgren funnels or Winkler traps to extract invertebrate specimens at the Rapallo Environmental laboratory.

All invertebrate specimens collected from pitfall trapping, hand foraging and leaf litter samples were sorted in the Rapallo Environmental laboratory. A total of 325 specimens were submitted for identification and assessment of SRE status with taxonomists at the Western Australian Museum, Phoenix Environmental, and ScorpionID.

SRE taxa recorded

The taxonomists identified 28 different taxa from the specimens, four of which were potential SREs. These were:

- The mygalomorph spider *Aname* sp. 'MYG243' – A single adult male was collected from a single trapping site, located on a BIF ridge in the centre of the Marda tenement. The BIF ridge comprises a restricted and isolated habitat, and this increases the likelihood of *Aname* sp. 'MYG243' being an SRE. The BIF ridge is currently outside of the proposed impact areas and the potential impact of project on this taxon is therefore low.
- The mygalomorph spider *Aname* sp. indet. (juv) - A single juvenile specimen was collected from a single trapping site on an isolated BIF outcrop in the south of the Marda tenement. The specimen may be a juvenile of *Aname* sp. 'MYG243' but it could also represent a different and SRE taxon as the BIF outcrop is not connected to the central BIF ridge where *Aname* sp. 'MYG243' was collected. The BIF outcrop is currently outside of proposed impact areas, and the potential impact of project on this taxon is therefore low.
- The pseudoscorpion *Beierolpium* sp. '8/4 lge' – Several specimens were collected in leaf litter samples from three sites in the Marda tenement, and two sites in the Golden Orb tenement. At present this taxon is not known from anywhere other than the project area, and is therefore likely to be an SRE. Its distribution, however, is unlikely to be linked to vegetation type as it was collected from a wide variety of habitats within the project area including creek lines, plains and BIF hills. Of the five sites where this taxon was collected, only one is within a proposed impact area. The potential impact of the project on this taxon is therefore low.
- The land snail *Bothriembryon* sp. – A single juvenile specimen was collected from a trapping site in Marda, located in a creek line adjacent to proposed impact areas. As this location is likely to be

impacted by the project, and the taxon has not been recorded elsewhere, it is recommended that further collecting for *Bothriembryon* sp. be undertaken.

Desktop search results

The desktop search identified an additional 15 taxa of SRE, and one taxon listed by the DEC as Priority 4 (but not SRE), that have the potential to occur in the project area: these were two mygalomorph spiders, four millipedes and ten land snails. None of these taxa were recorded in the project area during the field survey.

The millipedes were collected from Mt Jackson, located between 5 and 10 km from the project area; due to the close proximity, they could potentially occur in the project area.

The trapdoor spider *Aganippe castellum*, listed by the DEC as Priority 4, has the potential to occur along a section of the proposed haul road into the Golden Orb tenement, but the majority of the project area does not appear to contain suitable habitat for this species.

SRE habitat in the project area

Habitat assessments were completed of the Marda, Golden Orb and King Brown tenements to assess presence of potential SRE habitat.

The Marda tenement included the greatest variety of habitats. The SRE survey targeted five habitats; these were plain / floodplain, creek line, hillside, banded ironstone formation (BIF) hill and plateau. The BIF hill and the creek line habitat have high potential to support SRE.

- BIF Hill – This habitat occurs as a complex BIF ridge running east-west through the centre of the Marda tenement, and as an isolated weathered BIF hill in the south-east of the tenement. The BIF hills have high potential to support SRE because of their high vegetation diversity, increased capacity for moisture retention, and isolation from other areas of similar habitat. Three potential SRE taxa were collected from this habitat; these were the mygalomorph spiders Aname sp. 'MYG243' and *Aname* sp. indet. (juv), and the pseudoscorpion *Beierolpium* sp. '8/4 lge'. No development is currently proposed in any of the BIF hill areas and the SRE habitat will therefore not be affected by the project.
- Creek line – Several ephemeral creek lines run through the Marda tenement, ranging in size from shallow creeks bordered by *Acacia* shrubland or mixed grasses, to more defined creek lines with emergent eucalypts and dense leaf litter. The creek lines have high potential to support SRE because of their capacity for moisture capture and retention, and presence of old, dense leaf litter along the larger creek lines. Two taxa of potential SRE were collected from this habitat; these were the pseudoscorpion *Beierolpium* sp. '8/4 lge' and the land snail *Bothriembryon* sp. The creek line where the land snail was collected borders on the proposed impact zone of the project, and further surveys are recommended to establish whether it also occurs further away from impact areas.

The Golden Orb tenement supported a diverse vegetation, including flora species and communities not present in the Marda tenement. The SRE survey focused on three habitats; these were plain / floodplain, rocky ridge and plateau. The heath formations in the plateau habitat have potential to support SRE, but the absence of BIF hills in the Golden Orb tenement make it less prospective for SRE compared to the Marda tenement.

- Plateau – A low plateau of orange lateritic clay occurs in the south-eastern part of the Golden Orb tenement. It supports a dense heath of Melaleuca, Acacia, Eremophila and peas. This habitat has potential to support SRE because its vegetation diversity and isolation from other areas of similar habitat.
- Plain / floodplain – The potential SRE taxon *Beierolpium* sp. '8/4 lge' was collected from two sites in the plain / floodplain habitat in the Golden Orb tenement. The floodplain habitats

therefore have some potential to support SRE; however *Beierolpium* sp. '8/4' lge was collected from a variety of habitats in both Marda and Golden Orb, and does not appear to be restricted to a particular habitat type.

The King Brown tenement was located where two low rocky ridges converge and almost borders on the northern end of a salt lake. The more uniform vegetation, greater aridity and saline nature of King Brown, combined with the east-west aspect of the hill-slopes make it overall less likely to support SRE than either Marda or Golden Orb. Four habitats were targeted in the survey; these were plain / floodplain, hill slope, hilltop and creek line. No SRE taxa were recorded.

Recommendations for management and further surveys

Further Surveys: While it is not considered critical to the advancement of the project, further surveys could assist in developing a better understanding of the distribution of the new, and potential SRE, invertebrate taxa recorded during this survey. Survey aims would include:

- Collecting mature specimens of *Bothriembryon* sp. and expand the range of localities from which it is currently known.
- Recording invertebrate species and potential SRE taxa with a different seasonal activity pattern from the ones collected during spring.

Native Vegetation Management Plan: A native vegetation management plan should be developed with the aim of:

- protecting creek line habitats and minimising of clearing near creek lines and drainage lines
- restrict access to creek lines not required for the Project Area
- limit the number of access tracks across creek lines and drainage lines where possible
- managing and excluding impacts from areas where potential SRE's have been found outside current proposed impact zones, especially the BIF ridges.
- progressively rehabilitate habitats that support SRE's such as creek lines.
- fire management to ensure long term viability of habitats that are recognised to support potential SRE's in the Project Area. This should include development and management of fire breaks especially at sites supporting potential SRE's.

Mine Planning: A few simple mine planning adjustments could result in effective benefits for potential SRE taxa. Ideas include:

- Design and position infrastructure in away from key SRE habitats such as creek lines and BIF habitats, and where possible ensure roads and structures do not cross or block off drainage lines and creeks;
- Equipment that causes vibrations (such as crushing plants) should be placed a distance away from key habitats as mygalomorph spiders appear to be attracted to vibration.

Collection and Observation: Future employees should be educated about SRE's and recognise groups which are potential SRE's. Future environmental officers should be licensed by DEC to be able to collect potential SRE specimens if they are found during the day to day running of the project.

Noise, Vibration and Light Management: Noise, vibration and altered light regimes can impact the behaviour of SRE taxa, especially mygalomorph spiders, often resulting in death. Equipment and infrastructure (i.e. processing plants) should be located in areas/habitats deemed as low risk for the potential SRE's found on the Project Area (i.e. not adjacent to creek lines/ drainage habitats)

1. INTRODUCTION

1.1. PROJECT BACKGROUND

Southern Cross Goldfields Ltd (SXG) proposes to develop the Marda Gold project (the project) in the Goldfields region of Western Australia. The project area is approximately 114 kilometres (km) north of Southern Cross, with Bullfinch as the nearest town, and is accessed via the Bullfinch-Evanston Road.

The project involves mining operations and ore processing facilities in the Marda tenement, as well as two satellite mine sites in the Golden Orb and King Brown tenements (Figure 1). The developments in each of the tenements are presented in Table 1 below. For the purpose of this report, the term project area will refer to all three areas combined.

Table 1 Tenements in which the project area is located

Area	Project Elements	Tenement Number
Marda	Mining pits (4), bunds (4), topsoil dumps (4), waste dumps (2), tailings dam, magazine, mill, offices, roads.	M77/394
King Brown	Mining pit, bund, topsoil dump, waste dump, roads.	M77/646, M77/931
Golden Orb	Mining pits (2), bunds (2), topsoil dump, waste dump, roads.	M77/962, E77/1320

1.2. SCOPE AND OBJECTIVES OF THE SURVEY

As part of the environmental approvals process for the project, Rapallo Environmental completed a Level 2 Short Range Endemic invertebrate (SRE) survey of the Marda tenement, as well as Level 1 SRE surveys of the Golden Orb and King Brown tenements.

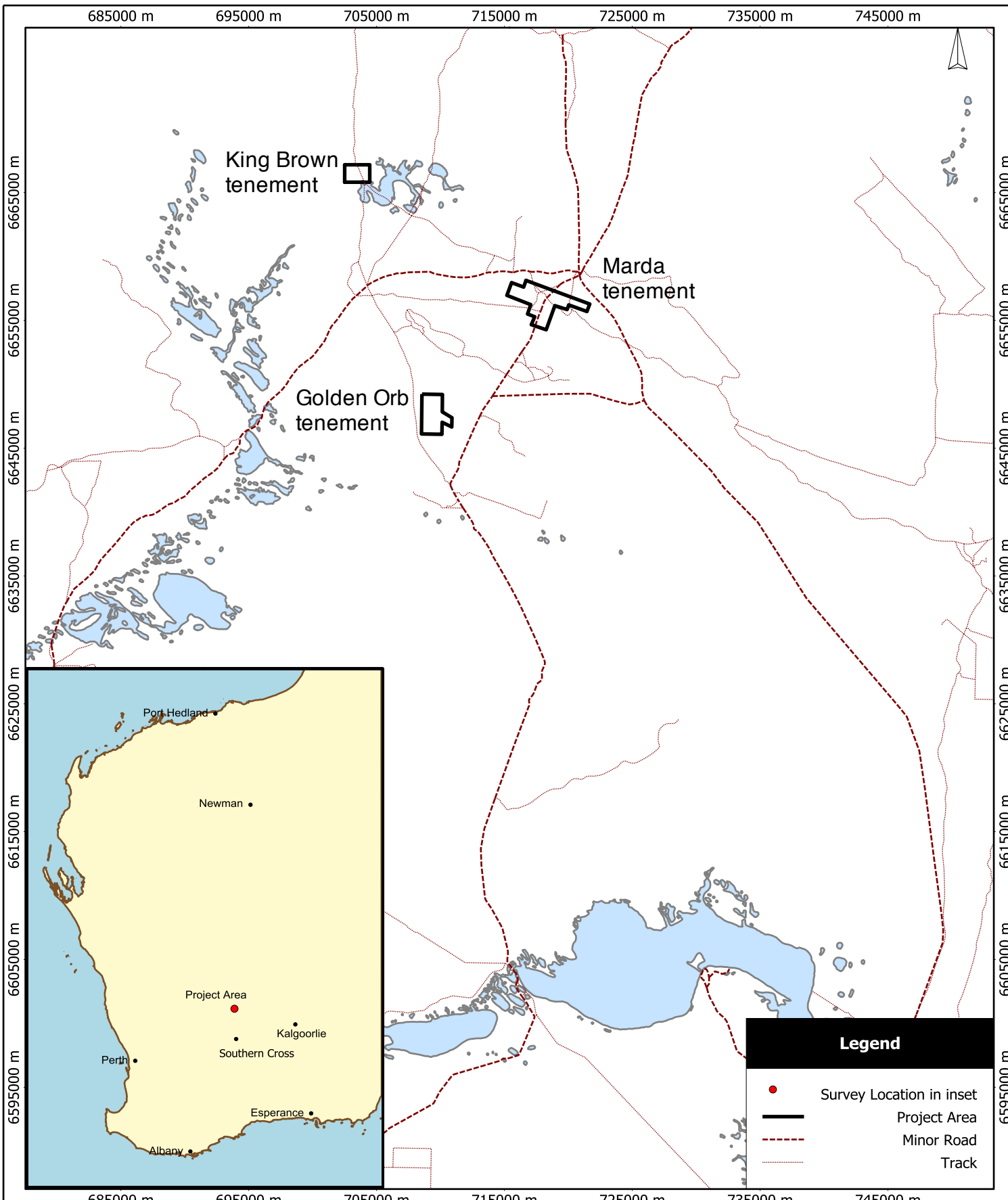
The area surveyed comprised approximately 1,700 ha, and was surveyed from 14 to 23 September 2011 by a team of two experienced zoologists. The survey area is outlined in detail in section 3.2 of this report.

The aims of the survey were to:

- identify SRE invertebrates occurring or likely to occur in the project area;
- describe SRE habitat in the project area;
- understand survey findings in a regional context to evaluate potential risks to SRE populations.

This information will be used to assist with environmental assessment of the project and, and to guide environmental management plans.

The SRE survey was designed according to Environmental Protection Authority (EPA) Guidance Statement No. 20: Sampling of Short Range Endemic Invertebrate Fauna for Environmental Impact Assessment in Western Australia (EPA, 2009), and EPA Guidance Statement No. 56: Terrestrial Fauna Surveys for Environmental Impact Assessment in Western Australia (EPA, 2004). The guidance indicates that a project in the Goldfields region with an impact greater than 50 ha requires a Level 2 SRE assessment.



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Location of Survey Areas in L2 S.R.E Survey of Marda, King Brown and Golden Orb tenements

Southern Cross Goldfields (SXG)

Figure 1.

1.3. SHORT RANGE ENDEMIC INVERTEBRATES

Harvey (2002) reviewed the occurrence of short range endemism (SRE) in Australian invertebrate fauna. The main criterion nominated for inclusion as a SRE species was that the species had a naturally small range of less than 10,000 square kilometres (km^2). Within this distribution, the actual areas occupied may be small, discontinuous or fragmented (Environmental Protection Authority, EPA 2009).

Given their potential to be restricted to very small areas, SRE species are generally at greater risk of changes in conservation status, local population or taxon extinctions than other, more widely distributed taxa. The potential presence of SRE taxa in development areas therefore represents a relevant factor for proposals being assessed by regulators.

Harvey (2002) identified several major groups of invertebrates as having a very high proportion of species that satisfied characterisation as SRE's. He found that those species possess a series of ecological and life-history traits including:

- poor powers of dispersal;
- confinement to discontinuous habitats;
- usually highly seasonal, only active during cooler, wetter periods;
- low fecundity.

Based on these traits and after reviewing the literature in Australia, Harvey (2002) listed a several invertebrate groups that either showed high levels of short range endemism or were likely to include SRE species after further taxonomic studies. The list of groups includes:

- mygalomorph (trapdoor) spiders;
- scorpions;
- pseudoscorpions;
- millipedes;
- slaters;
- land snails.

Invertebrates of these groups are of particular risk of supporting SRE taxa and survey methodologies should include specific systems that aim to record members of each taxon (EPA 2009).

1.3.1. TAXONOMY AND NOMENCLATURE

In many cases, collections of potential SRE species from fauna surveys have outpaced the taxonomy of each group. A new species can remain undescribed for years meaning information on distribution and taxonomy is difficult to collate. To counteract this potential risk, the Western Australian Museum (WAM) has developed a nomenclature system which labels new species of mygalomorph spiders and scorpions before they have been described in the literature.

Undescribed mygalomorph spider specimens are labelled numerically. For example, the first new species of mygalomorph in the database was labelled 'MYG1'. WAM now compares specimens collected during field surveys to these numerically labelled specimens as well as described species before declaring it a new species.

Undescribed scorpions and pseudoscorpions are labelled with the family or genus name followed by a locality or a unique feature i.e. 'hairy tail' or 'Nullagine'.

1.4. SURVEY GUIDANCE

The EPA has produced a series of position statements and guidance statements to aid in assessing the environmental impacts of developments in Western Australia. The following statements outline the minimal expectations of the EPA in regards to consideration of SRE fauna in an environmental impact assessment.

- EPA Position Statement No. 3: Terrestrial Biological Surveys as an Element of Biodiversity Protection (EPAk 2002)
- EPA Guidance Statement No. 20: Sampling of Short Range Endemic Invertebrate Fauna for Environmental Impact Assessment in Western Australia (EPA 2009)
- EPA Guidance Statement No. 56: Terrestrial Fauna Surveys for Environmental Impact Assessment in Western Australia (EPA 2004)

Combined, these guidance and position statements provide a number of general recommendations for consideration for planning environmental surveys, including the level of survey required, design and intensity factors, survey limitations and reporting criteria.

For the Goldfields region, Guidance Statement No. 56 indicates that a proposed project with an impact greater than 50 ha requires a Level 2 fauna assessment in order to adequately assess potential impacts.

Guidance Statement No. 20 aims to address the general standards required for SRE surveys and to develop a common framework by which they should be carried out. It also sets out the expectations in respect of the quality and quantity of data collected during SRE surveys, and how this data should be analysed and reported.

Importantly, the Guidance Statement recognises and discusses limitations on current knowledge in respect to SRE fauna. In particular, the limitations encountered after recording rare and cryptic taxa are discussed and the low probability of further survey success acknowledged. If such specimens are restricted to impact zones, risked based analysis based using habitat as a surrogate for distribution will be considered (EPA 2009).

2. EXISTING ENVIRONMENT

2.1. BIOGEOGRAPHY

The project area lies within the Southern Cross Subregion (COO2) of the Coolgardie Interim Biogeographic Regionalisation of Australia (IBRA) region (Commonwealth Department of Sustainability, Environment, Population and Communities, SEWPaC 2012).

Geology

The Coolgardie Bioregion is characterised by granite rocky outcrops, low greenstone hills, laterite uplands and broad plains; the bioregion does not have major rivers or creeks and includes numerous salt lakes. It lies on the Southern Cross Terrains of the Yilgarn Craton, which consists of greenstone belts and granites of Archaean age (2,400-3000 million years old) (Thackway and Cresswell 1995).

The Southern Cross Subregion has subdued relief, comprising gently undulating uplands dissected by broad valleys with bands of low greenstone hills. The valleys have Quaternary duplex and graduational soils, and include chains of saline playa-lakes. The granite basement outcrops. Upper levels in the landscape are the eroded remnants of a lateritic duricrust yielding yellow sandplains, gravelly sandplains and laterite breakaways (Cowan *et al*. 2001).

Soils

The Australian Soil Resource Information (ASRIS) Atlas compiled by CSIRO (CSIRO 2006) provides consistent soil descriptions for the whole of Australia. The Marda and Golden Orb tenements are within soil unit My45, while the King Brown tenement falls within soil unit SV2.

Soil unit My45 is described as: Undulating terrain with small gently sloping plains and some ranges on basic schists, gneisses, and allied rocks. The chief soils are neutral red earths with a variable content of ironstone gravel. Red-brown hardpan may occur in portions of the area, especially the northern portions. Associated are small sections of ranges with numerous rock outcrops containing greenstone."

Soil unit SV2 is described as: Saline valleys with some dunes including barchan forms, salt lake channels, mostly devoid of true soils, and their fringing areas. Common soils are gypseous and saline loams, together with grey-brown highly calcareous earths. Associated on fringe areas are various loamy soils, siliceous sand on dunes and lunettes, and some undescribed soils. Deposits of common salt, gypsum, lime, and alunite may occur.

Landforms

The Biological Survey of the Eastern Goldfields of Western Australia: Jackson – Kalgoorlie Study Area (Dell *et al*. 1985) maps the majority of the project area within the landform unit Undulating Plain (Greenstone). The landform unit Hill (Banded Ironstone Formation) occurs in the centre of the Marda tenement, in the form of a series of banded ironstone ridges.

The Undulating Plain (Greenstone) land unit consist of low rises and ridges, interspersed with colluvial flats 50-500 m wide. Most rises and ridges are less than 5 m above the flats. Ridge slopes rarely exceed 10 degrees. Soils are shallow on the rises and skeletal among bedrock exposures on the ridges. Broad colluvial flats are each drained by a single channel up to 1 m deep and 5 m wide. Soils on the colluvial flats rarely exceed 1 m in thickness.

The Hill (Banded Ironstone Formation) landform is characterised by hills rising up to 100 m above the surrounding plains. The hills have stony slopes with bedrock exposed on steep slopes and crests. The eroding upper slopes are 10° - 20° while the lower colluvial slopes are 5° - 10°. Soils on the upper slopes are mainly skeletal, becoming shallow on the lower slopes.

2.2. VEGETATION

Beard Vegetation Mapping

The project area lies within the Coolgardie Botanical District of the South-western Interzone between the South West and the Eremean Botanical Provinces (Beard 1990). This botanical district is characterised by eucalypt woodlands, becoming open and with saltbush-bluebush understorey on the more calcareous soils, with patches of shrub steppe adjoining the Great Victorian Desert (Beard 1990).

IBRA Vegetation Description

The vegetation of the IBRA Southern Cross Subregion (Cowan *et al*. 2001) is characterised by diverse eucalypt woodlands around the salt lakes and on the low greenstone hills and valley alluvials and broad calcareous plains. The woodlands are dominated by Salmon Gum (*Eucalyptus salmonophloia*), Gimlet (*E. salubris)*, Redwood (*E. transcontinentalis*) and Red Morrell (*E. longicornis*) and are rich in endemic species of eucalypt. The salt lakes support dwarf samphire (*Halosarcia* sp. and *Tetricornia* sp.) shrublands. The granite outcrops in the landscape support swards of *Borya constricta*, with stands of *Acacia acuminata* and York Gum (*E. loxophleba*). The upland areas of yellow sandplains, gravelly sandplains and laterite breakaways are characterised by Mallee woodlands with and scrub-heaths with sheoak (*Allocasuarina corniculata*) cypress pine (*Callitris preissii*), *Melaleuca uncinata* and Pukkati (*Acacia beauverdiana*). The same scrub community also occurs on sand lunettes associated with playas along the broad valley floors, and sand sheets around the granite outcrops. The scrubs are rich in endemic acacias and Myrtaceae.

Vegetation of the Project Area

Rapallo Environmental surveyed the flora and vegetation of the Marda tenement in 2011 (Rapallo 2012). Eight main vegetation communities were recorded. The vegetation type occurring covering the greatest area in the Marda tenement was *Eucalyptus* woodland. The other types were *Melaleuca* woodland on stony hillsides, mixed shrubs on Banded Ironstone Formation (BIF) and granite outcrops, creekline *Eucalyptus* woodland, *Eucalyptus griffithsii* woodland, *Eucalyptus ewartii* mallee woodland, *Acacia* woodland, and *Casuarina pauper* woodland.

The Priority Ecological Community (PEC) (DEC 2010b, 2011) Mt Jackson Range Vegetation Complex is considered to be present in the Marda tenement at locations with BIF ridges and hillsides, and at granite outcrops. The largest area of this PEC is located on the central BIF ridge in the Marda tenement and is currently not within the proposed project footprint. One small area of the PEC is located in the northern section of the tenement, within a proposed impact area (Rapallo 2012).

The Golden Orb tenement was surveyed in 2010 and 2011 (Botanica 2011a). Four vegetation communities were identified within the survey area: *Eucalyptus salmonophloia* / *E. salubris woodland*, *Eucalyptus corrugata* / *E. oleosa* woodland, *Allocasuarina dielsiana* / *Eucalyptus oleosa* woodland, and *Allocasuarina* over mixed shrubs on breakaway. None of these vegetation communities are of conservation significance.

The King Brown tenement was surveyed in 2010 and 2011 (Botanica 2011b). Five vegetation communities were identified within the tenement. These are Mixed *Eucalyptus* woodland over *Casuarina pauper*, *Casuarina pauper* over Chenopod shrubland, *Casuarina* shrubland on rocky rise, Low Mixed shrubland (with isolated *Eucalyptus salmonophloia*) and *Chenopod shrubland* on claypan (Botanica 2011c). None of the vegetation communities recorded in King Brown are of conservation significance.

2.3. CLIMATE

The Southern Cross Subregion (COO2) experiences an arid non-seasonal to semi-arid Mediterranean climate with an annual rainfall of 200-300 millimetres (mm) (Beard 1990).

The nearest Bureau of Meteorology (BOM) weather station to the project area that records a wide range of climatic data is located at Southern Cross Airfield, approximately 115 kilometres south of the project area; this station has been operational since 1996 and is still running. Summers are generally warm, with the highest temperatures recorded in January, while winters are cold with lowest temperatures experienced in June and July. Rainfall occurs year-round, with yearly totals ranging from 150 – 550 mm with an annual mean of 294.5 mm (Figure 2).

The SRE survey took place in September 2011, which is early spring. Rainfall in the five months preceding the survey was typical for the time of year with a total of 132.8 mm recorded for the months of May to September 2011. Temperatures during the survey were in the high 20s during the day, but at or below zero at night (BOM 2012).

During the SRE survey the weather station at Southern Cross recorded a total of 13.6 mm of rainfall, with the majority falling on the 19th of September. This rainfall event reached the project area a day earlier, and appeared heavier than the 13.6 mm recorded at Southern Cross. In response to this rainfall, increased activity of mygalomorph spider males was observed in the project area, with seven individuals being captured in the four trapping days that followed.

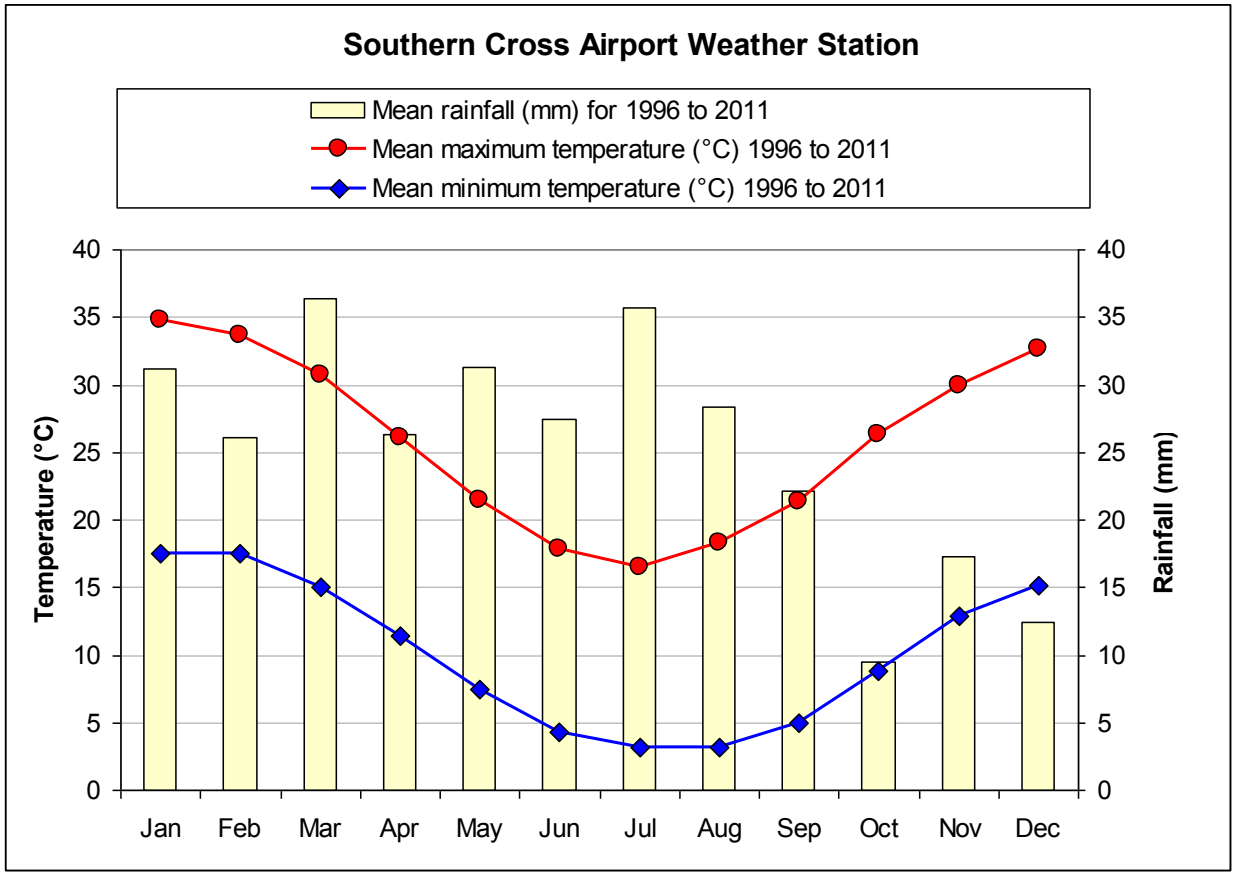


Figure 2 Southern Cross Weather Station – Average temperatures and rainfall

2.4. RESERVES AND ENVIRONMENTALLY SENSITIVE AREAS

The project area is not situated within an Environmentally Sensitive Area (ESA) as defined under the Environmental Protection (Environmentally Sensitive Areas) Notice (Western Australian Government 2005).

Conservation Reserves

The Department of Sustainability, Environment, Water, Population and Communities (SEWPaC) Protected Matters search tool (SEWPaC 2012) indicates that the project area does not occur within a conservation reserve. The nearest Nature Reserves to the project area are listed below (SEWPaC 2012), with distances given to the centre of the Marda tenement.

- Mount Manning Range Nature Reserve (DEC) – 25 km to the east.
- Conservation Park WA48470 (adjacent to Mt Manning NR) – 18 km to the east.
- Walyahmoning Nature Reserve – 60 km to the south-west.
- Reserve WA36918 – 60 km to the south.
- Karroun Hill Nature Reserve (DEC) – 70 km to the west.
- Baladjie Lake Reserve – 75 km to the south

Great Western Woodlands

The project area lies within the Great Western Woodlands (DEC 2010a), an area of great biological richness covering nearly 16 million ha (Figure 3). The dominant vegetation type is woodland communities, covering 63% of the region, followed by shrubland (20%), mallee (10%) and grasslands (2%). The woodland communities are highly varied, and encompass many different vegetation communities. The Great Western Woodlands is a centre for eucalypt diversity, with 160 species of eucalypts recorded in the area, many of which are endemic. This represents 21% of all known eucalypt species in Australia.

The Great Western Woodlands supports a number of SRE invertebrates and subterranean fauna (often associated with BIF ranges) that occur nowhere else in the world. Three species of butterfly that are of conservation interest are known from the region including the iconic and critically endangered arid bronze azure.

Although still relatively intact, the Great Western Woodlands are under increasing pressure from introduced fauna, weeds, bushfires and grazing. Land clearing for residential, mining, industrial and infrastructure purposes is an ongoing issue, leading to loss of biodiversity and increased dry land salinity.

The DEC's management strategy for the Great Western Woodlands is outlined in A Biodiversity and Cultural Conservation Strategy for the Great Western Woodlands (DEC 2010a). Rather than defining specific management actions, the document outlines the DEC's general strategy for the Great Western Woodlands. The key element is to improve coordination and integration of the many fragmented planning and management elements in the area. The aims of the strategy are to achieve sustainable outcomes that ensure conservation of biodiversity and cultural values, while maintaining economic and social benefits.

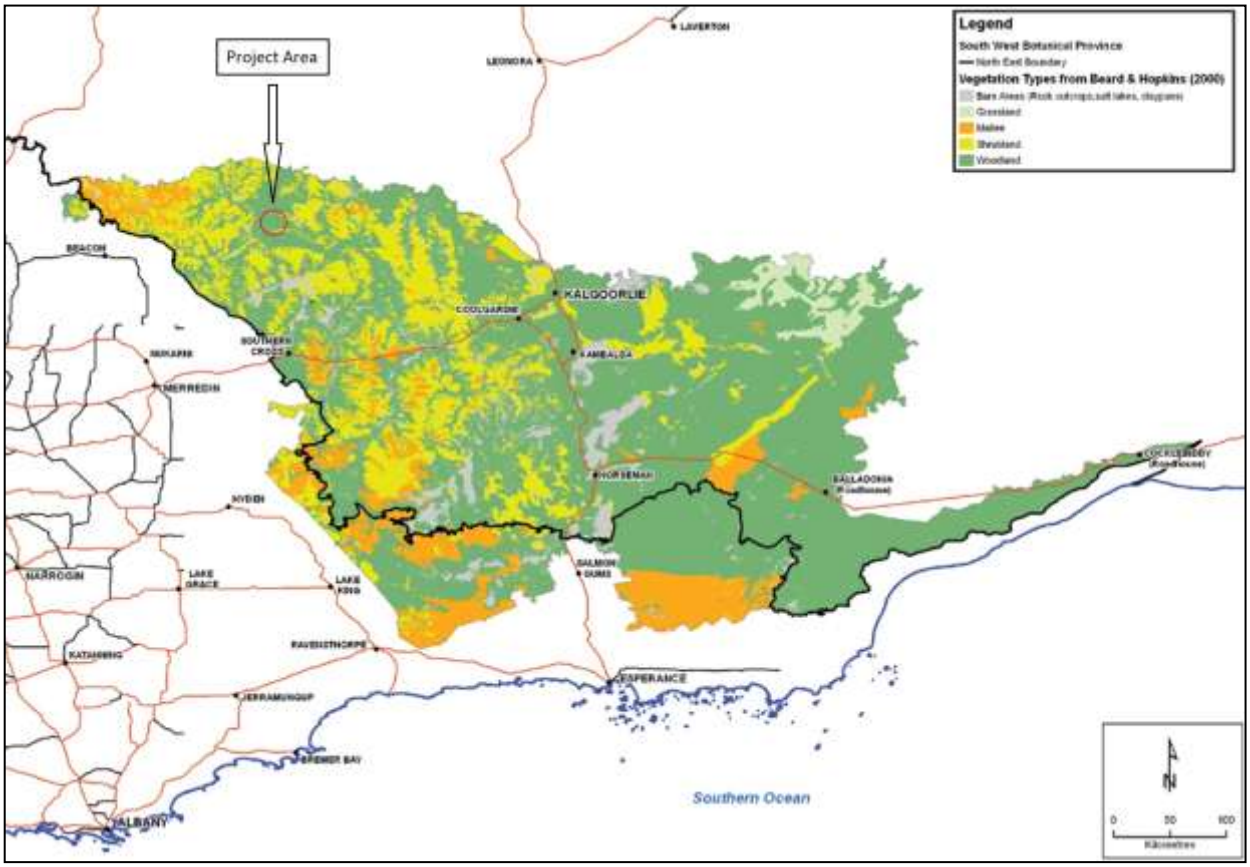


Figure 3 Location of the project area in the Great Western Woodlands

3. METHODS

3.1. DESKTOP SEARCH

A search for SRE species previously collected or identified from the region surrounding the project area was completed, using the databases listed in Table 2 and publically available reports of previous surveys in the vicinity of the project listed in Table 3. The WAM search areas extended beyond the immediate survey areas to place SRE values into a regional context.

Table 2 Database searches

Database Name	Latitude	Longitude	Search Area
WAM Terrestrial SRE Database	30°01'43"S to 30°21'01"S	119°00'23"E to 119°35'59"E	2,000 km^2 search box centred on Marda tenement
WAM Mollusc Database	29°46'40"S to 32°32'45"S	118°15'35"E to 120°11'13"E	56,700 km^2 search box centred on Southern Cross
DEC NatureMap search	30°12'05"S 30°17'04"S 30°06'57"S	119°16'02"E 119°10'41"E 119°06'51"E	40 km circular buffer around centre Marda 40 km circular buffer around centre Golden Orb 40 km circular buffer around centre King Brown
SEWPaC Protected Matters Search	30°12'05"S 30°17'04"S 30°06'57"S	119°16'02"E 119°10'41"E 119°06'51"E	10 km buffer around polygon (triangle) with centre of tenements as corners.

Table 3 Reports reviewed for desktop search

Report Title	Distance from Project area
Biota (2009a). Targeted survey for Short-Range Endemic Invertebrates at Mt Jackson. Biota Environmental Sciences, January 2009.	8 km SW of Marda 5 km north of Golden Orb
Bamford (2009). Review of Fauna Studies of the Mt Jackson Range, Western Australia, 2000 to 2008. M.J. & A.R. Bamford Consulting Ecologists, 15 April 2009.	8 km SW of Marda 5 km north of Golden Orb
Ninox Wildlife Consulting (2009). A fauna survey of the Carina Prospects: Yilgarn Iron Ore Project. Unpublished report for Polaris Metals NL.	75 km south-east of project area

3.2. FIELD SURVEY

A Level 2 SRE survey of the Marda tenement and Level 1 SRE surveys of the Golden Orb and King Brown tenements were completed between 14 and 23 September 2012. The survey area included the Marda tenement (925 ha), and the central parts of the Golden Orb and King Brown tenements targeting proposed impact areas and out of impact areas with comparable habitat. The total survey areas in Golden Orb and King Brown were approximately 600 ha and 200 ha, respectively.

EPA Guidance Statement No. 20 (EPA 2009) indicates that the optimal times for conducting surveys in the Goldfields region are in winter or in the cyclone season, when there is sufficient rainfall to stimulate enhanced activity in otherwise cryptic groups such as *Bothriembryon* (land snails) and male mygalomorph spiders. The SRE survey of the project area was completed in the middle of these two periods, with good rainfall preceding the survey (section 2.3).

Field survey activities included:

- Dry pitfall trapping 10 sites – Marda tenement only
- Hand foraging 28 sites – Marda, Golden Orb and King Brown tenements
- Leaf litter collection at each foraging and trapping site
- Habitat assessments at each forging and trapping site
- Opportunistic records while traversing project area

3.2.1. SURVEY PERSONNEL AND LICENSING

The survey was licensed under the Western Australian *Wildlife Conservation Act 1950* Regulation 17 Licence to take Fauna for Scientific Purposes, licence number SF008151. As part of the licence requirements, data collected during the survey will be submitted to the DEC.

The following personnel were involved in the field survey and preparation of this report:

- Marieke Weerheim Environmental Scientist for Rapallo Environmental
- Magnus Peterson Ecologist for Rapallo Environmental

3.2.2. DRY PITFALL TRAPPING

Dry pitfall traps were deployed in the Marda tenement as part of the Level 2 survey. A total of 10 trap sites were established within areas considered most likely to support SRE taxa (Figure 4). Five habitat associations were targeted for trapping, these were:

- South-facing slopes (and one north-facing slope)
- Hill sides / shallow hill slopes
- Outcrops / scree
- Plains
- Creek lines

Each trap site comprised a line of five 2.5 litre buckets, spaced approximately 5 metres (m) apart along a 30 m continuous drift fence. Habitat was assessed as outlined in section 3.2.5, GPS coordinates were recorded and photographs taken. Traps were left open for a minimum of 7 nights and were checked first thing in the morning every day.

Potential SRE taxa captured in traps were collected and vouchered according to the Guidelines for Preservation and Lodgement of Terrestrial Invertebrate Specimens (WAM, 2011). All other invertebrates were stored in ethanol as bulk samples. Bulk samples were taken back Perth, where they were sorted under a microscope at the Rapallo Environmental laboratory; potential SRE invertebrates were separated from the bulk samples and vouchered for taxonomic identification according to WAM (2011) guidelines.

3.2.3. HAND FORAGING

A total of 28 sites were hand foraged, 13 of these were located in the Marda tenement (Figure 4), eight in the Golden Orb tenement (Figure 5) and seven in the King Brown tenement (Figure 6). Eight habitat associations were targeted for hand foraging, these were:

- BIF hills Marda
- South facing slopes Marda
- Hill sides / shallow hill slopes Marda, Golden Orb, King Brown

- Rocky ridge / outcrops — Marda, Golden Orb
- Hill tops — Marda, King Brown
- Plateaus — Marda, Golden Orb
- Plains — Marda, Golden Orb, King Brown
- Creek lines — Marda, King Brown

At each forage site, SRE taxa were searched for by flipping rocks, raking litter, raking under clumps of dense vegetation, lifting bark and flipping old logs. Habitat was assessed as outlined in section 3.2.5, GPS coordinates were recorded and photographs taken. Potential SRE taxa collected during foraging were vouchered for taxonomic identification according to WAM (2009) Guidelines.

3.2.4. LEAF LITTER COLLECTION

Leaf litter was collected from each of the 10 trapping sites and 28 foraging sites. The species of tree or shrub from under which leaf litter was collected was recorded. Leaf litter was collected in a ten litre bucket and sifted on the spot using 1.5 millimetre sieves. The final mixture of organic matter was taken back to the Rapallo Environmental laboratory and run through either Tullgren Funnels or Winkler traps. Sifted samples were run for approximately 48 hours.

Specimens collected from the Tullgren Funnels and Winkler traps were sorted under a microscope at the Rapallo Environmental laboratory. Potential SRE taxa were separated from the bulk samples and vouchered for taxonomic identification according to WAM (2011) guidelines.

3.2.5. HABITAT ASSESSMENTS

SRE habitats were accessed at each trapping and hand forage survey site. These assessments comprised records of landform (e.g. ridge, hilltop, creekline, plain), vegetation, presence of rock outcropping, soil type and colour, leaf litter depth, and a general assessment of the likelihood of the habitat supporting SRE taxa.

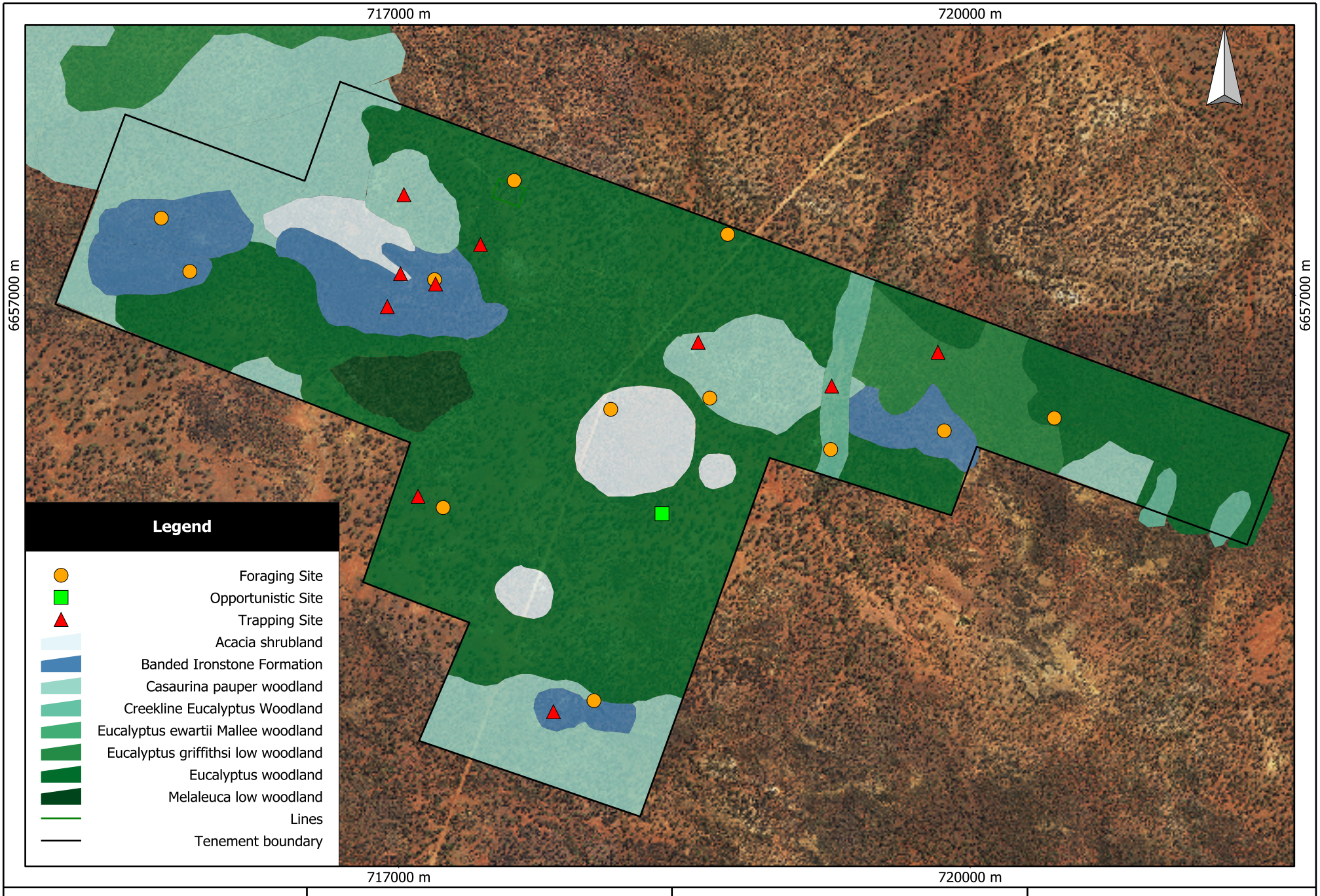
3.2.6. OPPORTUNISTIC RECORDS

While traversing the project area, records were taken of all potential SRE invertebrates and their burrows. A brief habitat description was recorded, as well as GPS coordinates and site photos.

3.3. TAXONOMIC IDENTIFICATION

All potential SRE taxa were stored in separate vials and labelled according to WAM (2011) guidelines. These vials were sent off to taxonomic experts for identification before being vouchered in the WAM collection. The following taxonomists were involved with specimen identification:

- Dr Mark Harvey (WAM) — Millipedes
- Dr Mieke Burger (WAM) — Pseudoscorpions
- Dr Corey Whisson (WAM) — Land snails
- Dr Erich Volschenk (Scorpion ID) — Scorpions
- Dr Volker Framenau (Phoenix) — Spiders
- Dr Simon Judd — Slaters



Rapallo

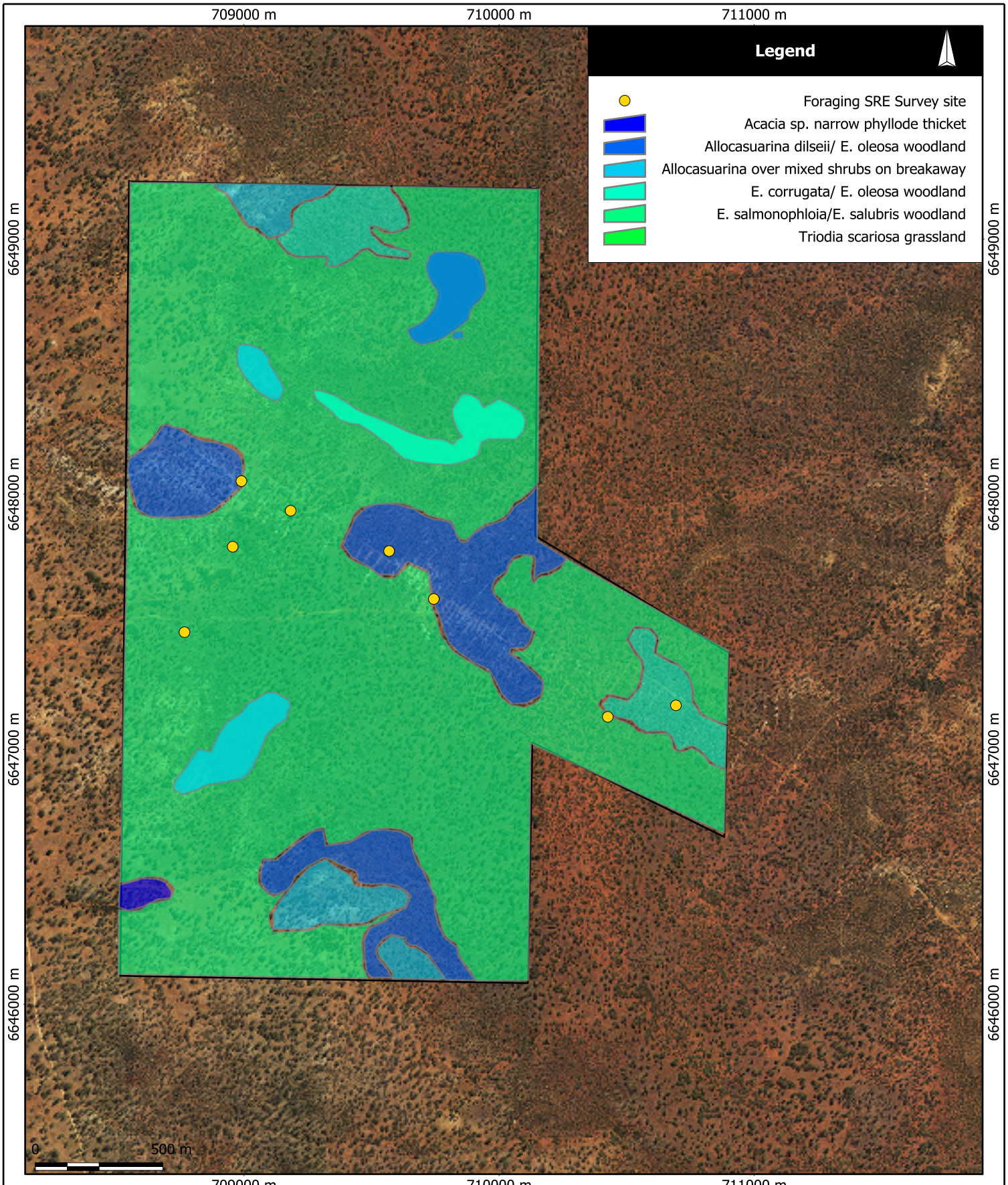
Original size: A4 Scale: 1:26,000
Datum MGA94(50)

0 500 m

Marda tenement with SRE survey sites and vegetation communities

Southern Cross Goldfields (SXG)

Figure 4.



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Datum: MGA94(50)

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Golden Orb tenement with vegetation communitaties and SRE survey sites

Southern Cross Goldfields (SXG)

Figure 5.

Rapallo

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Datum MGA94(50)

0 500 m

King Brown tenement with SRE survey sites and vegetation communities

Southern Cross Goldfields (SXG)

Figure 6.

3.4. SURVEY LIMITATIONS

The potential limitations of the survey, as outlined in *EPA Guidance Statement No. 56: Terrestrial Fauna Surveys for Environmental Impact Assessment in Western Australia* (EPA 2004) are discussed in Table 4.

Table 4 Potential limitations and discussion about their relevance to the survey

Potential Limitation	Discussion
Competency/ Experience	Mr Magnus Peterson has more than 40 years' experience conducting biological surveys in Australia, including many years working in the Southern Goldfields. Ms Weerheim has 10 years' experience conducting fauna surveys in Australia, including 6 years in Western Australia.
Proportion of Fauna Identified or recorded	The survey took place over a 10-day period in spring, which covers only a single season in a single year. Climatic conditions can be quite different between seasons and in the same season between years. These factors influence invertebrate activity levels and the likelihood of detecting potential SRE taxa. Different taxa of invertebrates, including closely related species, also have different seasonal activity. This indicates that additional surveys in different seasons and different years would likely result in recording additional taxa, including SRE taxa not encountered during this survey. However, for the purpose of a single-phase level 2 SRE survey, the data collected was adequate, especially following a day of heavy rainfall which triggered mygalomorph activity and led to seven individuals being captured.
Availability of Information	Sufficient contextual information was available for the survey area. This included: online information, published reports from earlier fauna surveys in the Goldfields region, earlier survey data collected by Rapallo Environmental, and WAM and DEC database records of SRE invertebrates collected from the vicinity of the project area.
Proportion of task achieved and further work may be required	The survey covered the entire Marda tenement as well as most of the Golden Orb and King Brown tenements, with sites established in all potential SRE habitats. Sites were established both inside and outside of proposed project impact areas. Although temporally the survey only covered a single season, and a single year, as outlined above, spatially the survey covered all available SRE habitats and has provided an adequate sample of the project area for the purpose of a Level 2 survey in Marda, and Level 1 surveys in Golden Orb and King Brown.
Timing, weather, season	The selection of the spring season was an appropriate time to record many potential SRE taxa. The weather was cool and moist in the survey area and these conditions were conducive for recording relict invertebrate taxa including potential SRE species. The period of heavy rainfall early in the survey triggered mygalomorph activity, which enabled sampling of this group which in other seasons or under different weather conditions can be very hard to detect.
Disturbances	The Marda and King Brown tenements, and the central part of the Golden Orb tenement are heavily disturbed by exploration drilling programs and excavations over an extended period of time, with some disturbances going back 100 years or more. However, many of the old drill lines have begun to regenerate, and size of the disturbed areas are relatively small compared to the total size of the tenements. There was no evidence of recent fire in any of the tenements. Heavy rainfall occurred on the 18th of September; trap lines were closed and re-opened on the evening of the 19th. The single day of delay did not affect survey results and this rainfall event resulted in increased invertebrate activity with SRE taxa being recorded in trap sites.
Survey Intensity	The scope and intensity of the survey were suitable for the purpose of a single-phase Level 2 SRE survey in Marda, and a Level 1 SRE survey in Golden Orb and King Brown. Survey intensity was appropriate for the size of the project areas and proportion of habitats.
Resources	The field staff had adequate resources to plan and complete the survey including sufficient contextual information (as outlined above), and sufficient equipment.
Access	There were no access issues. A network of good quality access roads and tracks runs through the tenements, and the remainder of the areas could be reached easily on foot.

4. RESULTS

4.1. SUMMARY

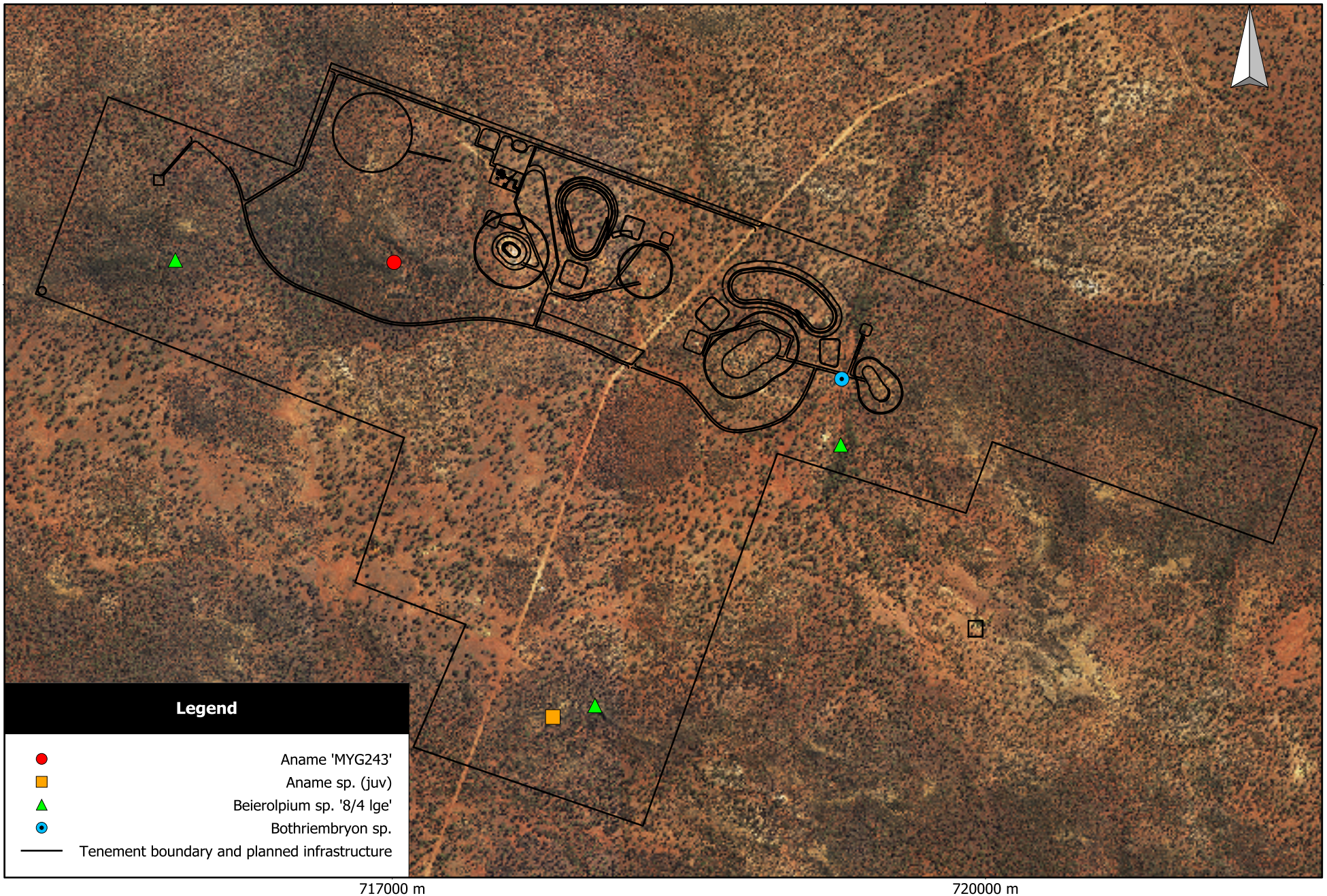
A total of 325 specimens were submitted for identification and assessment of SRE status with taxonomists of the WAM, Phoenix and ScorpionID. Of the 28 taxa identified, four were identified as being potential SRE (Appendix I). Results of taxonomic identifications are summarised in Table 5 and discussed in detail in sections 4.3 to 4.9.

Four potential SRE taxa were collected during the survey. These were two taxa of mygalomorph spiders (*Aname* sp. 'MYG243' and *Aname* sp. (juv), one pseudoscorpion (*Beierolpium* sp. '8/4 lge') and one land snail of the family Bullimulidae (*Bothriembryon* sp.). All four of these taxa were recorded from the Marda tenement, while the pseudoscorpion taxon was also recorded from two foraging sites in the Golden Orb tenement. No potential SRE taxa were recorded from the King Brown tenement.

Table 5 Summary of the SRE status of taxa collected in the survey and submitted for identification

Family	Species	SRE Status
MYGALOMORPH (TRAPDOOR) SPIDERS		
Nemesiidae	*Aname* sp. 'MYG243'	**Potential SRE**: New species.
Nemesiidae	*Aname* sp. (juv) (?'MYG243')	**Potential SRE**: Immature specimen of potentially 'MYG243', potentially different species; adult male needed to confirm taxonomy.
Nemesiidae	*Aname tepperi*	Widespread in WA and into SA, Not a SRE
ARANEOMORPH SPIDERS		
Lycosidae	*Hogna* sp. (juv.)	Immature, not identified to species. Member of a genus of common *Lycosidae*, Not a SRE.
Oonopidae	*Oonopidae* sp.	Araneomorph spider family common in leaf litter, Not a SRE
Theridiidae	*Theridiidae* sp. (juv)	Immature specimen, Not a SRE
PSEUDOSCORPIONS		
Chernetidae	*Nesidiochernes* sp.	Widespread in southern Australia, Not a SRE
Chernetidae	*Sundochernes* sp. 'PSE027'	New species, Unlikely to be a SRE
Chernetidae	*Chernetidae* sp. (juv)	Immature specimens; not identified to species level, SRE status indeterminate.
Chernetidae	*Nesidochernes sp.*	Female and immature specimens; not identified to species level, SRE status indeterminate
Chthoniidae	*Austrochthonius* sp.	Abundant in samples, Not a SRE
Garypidae	*Synsphyronus* sp. 'PSE026'	Found in leaf litter; Unlikely to be a SRE
	Synshphyronus sp. (juv)	Immature specimens; not identified to species level, SRE status indeterminate.
Garypinidae	*Solinus* sp. (juv)	Genus is widespread, Not a SRE
Olpiidae	*Beierolpium* sp. '8/4 lge'	**Potential SRE**: Systematic status of genus not fully assessed.
Olphiidae	*Beierolpium* sp. (juv.)	Immature specimens; not identified to species level, SRE status indeterminate.
Olpiidae	*Indolpium* sp.	Represented in other regions of WA, Unlikely to be a SRE
SCORPIONS		
Buthidae	*Lychas jonesae*	Widespread in arid Australia, Not a SRE
MILLIPEDES		

Family	Species	SRE Status
Paradoxosomatidae	*Antichiropus* sp. 'Mt Gibson 1'	Larger distribution than most *Antichiropus* species, Not a SRE
Paradoxosomatidae	*Parodoxisomatidae sp.*	Immature specimen; not identified to species level, SRE status indeterminate.
Synxenidae	*Phryssonotus novaehollaniae* (Silvestri, 1923)	Widespread species, Not a SRE
ISOPODS (SLATERS)		
Armadillidae	*Buddelundia* sp. 39	Collected at three other distant locations in southern WA, Not a SRE
LAND SNAILS		
Bulimulidae	*Bothriembryon* sp.	**Potential SRE**: Immature specimen, additional collection recommended.
Punctidae	*Westralaoma aprica* Iredale, 1939	Widespread across the northern wheat belt and western goldfields - Not a SRE
Punctidae	*Westralaoma aprica* Iredale, 1939	Widespread across the northern wheat belt and western goldfields - Not a SRE
Pupillidae	*Gastrocopta bannertonensis* (Gabriel, 1930)	Widespread in southern Australia, Not a SRE
Pupillidae	*Gastrocopta* sp. (juv)	Immature specimen; not identified to species level, unlikely to be SRE.
Pupillidae	*Pupoides myoporinae* (Tate, 1880)	Widespread in southern Australia, Not a SRE



Rapallo

Original size: A4 Scale: 1:26,000
Datum MGA94(50)

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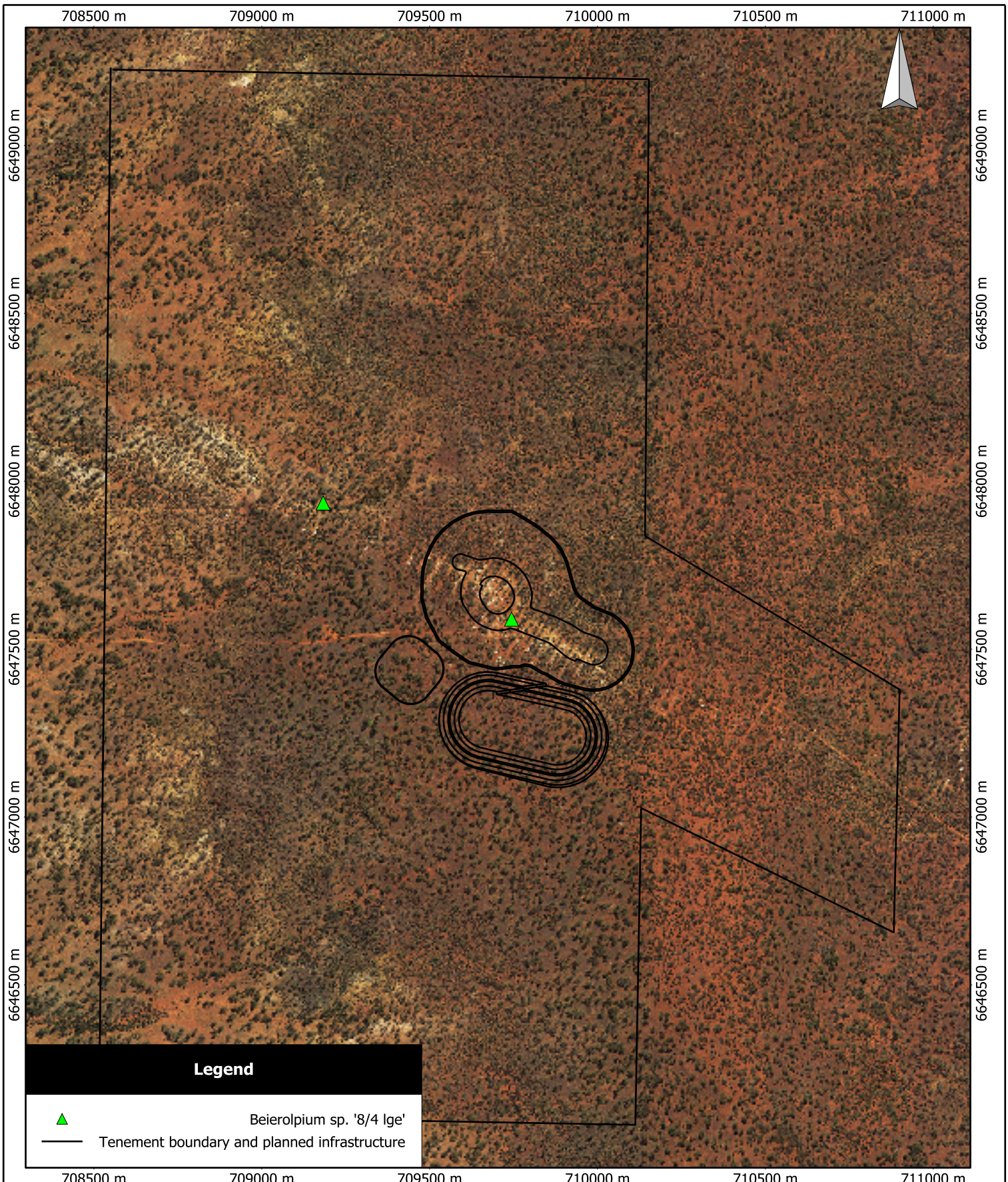
Marda tenement with SRE species locations and planned development and infrastructure

Southern Cross Goldfields (SXG)

Figure 7.



Rapallo

Original size: A4 Scale: 1:15,000
Datum: MGA94(50)

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Golden Orb tenement with SRE Fauna locations and planned infrastructure

Southern Cross Goldfields (SXG)

Figure 4.

4.2. DESKTOP SEARCH RESULTS

A search of the WAM databases, NatureMap, and previous survey reports, identified 15 taxa of SRE, and one non-SRE taxon listed by the DEC as Priority 4, that have the potential to occur in the project area (Table 6). None of these taxa were collected during the survey; their likelihood to occur in the project area is discussed in sections 4.3 to 4.9.

Table 6 Database records of SRE taxa and DEC Priority taxa recorded from the vicinity of the project

Taxon	Data source	Distance from project
MYGALOMORPH (TRAPDOOR) SPIDERS		
Aganippe castellum – **DEC Priority 4**	NatureMap, Bamford (2009), Biota (2009)	5 to 10 km from project
Teyl 'MYG021'	Ninox (2009)	75 km SE of project
MILLIPEDES		
Antichiropus `Mt Jackson 1? (female)`	WAM SRE Database	5 to 10 km from project
Antichiropus `Mt Jackson 1`	WAM SRE Database	5 to 10 km from project
Antichiropus `Mt Jackson 2? (female)`	WAM SRE Database	5 to 10 km from project
Antichiropus `Mt Jackson 2`	WAM SRE Database	5 to 10 km from project
LAND SNAILS		
Bothriembryon paracelsus	WAM Mollusc Database	50 - 250 km from project
Bothriembryon sedgwicki	WAM Mollusc Database	50 - 250 km from project
Bothriembryon sp.	WAM Mollusc Database	50 - 250 km from project
Bothriembryon sp. nov. 'Mt Jackson'	WAM Mollusc Database	50 - 250 km from project
Bothriembryon sp. nov. 'Coolgardie'	WAM Mollusc Database	50 - 250 km from project
Bothriembryon sp. nov. 'Holleton'	WAM Mollusc Database	50 - 250 km from project
Bothriembryon sp. nov. 'Rothsay'	WAM Mollusc Database	50 - 250 km from project
Sinumelon kalgum	WAM Mollusc Database	50 - 250 km from project
Sinumelon vagente	WAM Mollusc Database	50 - 250 km from project
Succinea sp.	WAM Mollusc Database	50 - 250 km from project

4.3. MYGALOMORPH SPIDERS

Mygalomorph ("trap-door") spiders are a primary target in SRE surveys due to their long lifespans, low female mobility and high level of ecological specialisations which have resulted in the evolution of many rare and localised species.

During the SRE survey of the project area, seven mygalomorph spiders from the family Nemesiidae were collected at six trapping sites within the Marda tenement. Five specimens were lodged for identification with Phoenix Environmental Sciences and were identified as comprising two, potentially three species. One, potentially two, of these species were identified as potential SRE (Phoenix 2012: Appendix II).

The desktop search revealed that two SRE mygalomorph spider species, one from the family Idiopidae, and one from the family Nemesiidae, were recorded within 75 km of the project area (section 4.2). The likelihood of these species occurring in the project area is discussed below.

4.3.1. FAMILY: IDIOPIDAE

The spider family Idiopidae is one of a number of trapdoor spider families occurring in Western Australia and is represented by several genera including *Aganippe*, *Anidiops* and *Idiosoma* (Main & Framenau 2009). Most of these genera possess SRE species.

No specimens from the family Idiopidae were recorded in the project area during the SRE survey of the project area; however the database search revealed records of the Priority 4 species *Aganippe castellum* from the vicinity of the project area.

Aganippe castellum

The Tree-stem Trapdoor Spider *Aganippe castellum* is listed by the DEC as Priority 4, but is no longer considered to be an SRE (M. Burger *pers. comm*. 23 March 2012). It has been recorded at a number of locations within the vicinity of the project area, with the nearest records from the Mt Jackson Range, within 5 to 10 km from the Marda and Golden Orb tenements (Bamford 2009, Biota 2009a, NatureBase; WAM records supplied 23 March 2012). This species is known from the wheatbelt region and has also been recorded in the Yilgarn region from the Die Hardy Range, Mt Jackson Range, Helena and Aurora Ranges, Koolyanobbing Range and Windarling Range (Bamford 2009, Biota 2009).

The species' critical habitat comprises flood-prone depressions and flats that support myrtaceous shrub communities. In particular, those areas supporting Broombush (*Melaleuca uncinata*) and Sheoaks (such as *Allocasuarina acutivalvis*) in sandy loam soils (Avon Catchment Council 2007). It builds its burrows at the base of trees or shrubs.

Although the project area contains floodplains and depressions, most of these low-lying areas support eucalypt woodlands with a saltbush understorey, rather than myrtaceous shrubs (Botanica 2011ab, Rapallo 2012). *Melaleuca uncinata* was not recorded in the Marda, Golden Orb or King Brown tenement, while *Allocasuarina acutivalvis* communities in the project area were associated with BIF, breakaways or rocky rises, rather than sandy loam (Botanica 2012ab, Rapallo 2012). The exception is a section of the haul road to Golden Orb containing the vegetation community Melaleuca low woodland, where *Allocasuarina acutivalvis* occurs on a clay-loam soil (Rapallo 2012). This area, however, did not form part this SRE survey.

The high number of records in close proximity to the project area, indicate that the Melaleuca low woodland community along the Golden Orb haul road is likely to support A. castellum. It is recommended that any future invertebrate surveys of the project area target this area to assess whether A. castellum indeed occurs there. Since the proposed haul road will only impact part of this vegetation community, its construction may impact on some individual burrows of A. castellum, but would not affect the population.

4.3.2. FAMILY: NEMESIIDAE

The spider family Nemesiidae is one of a number of trapdoor spider families occurring in Western Australia and is represented by several genera including *Aname*, *Chenistonia*, *Yilgarnia*, *Stanwellia*, *Teyl*, *Swolnpes* and *Kwonkan* (Main & Framenau 2009). Despite inclusion in the infra-order Mygalomorphae (trap-door spiders), this family does not contain species that cover the entrance to their burrow systems with lids. Most of these genera possess SRE species.

During the SRE survey of the project area, seven mygalomorph specimens, all from the genus *Aname* (Nemesiidae), were collected from six trapping sites in the Marda tenement. Three specimens were mature males and were identified as *Aname tepperi*. One mature male collected from site MS05 comprised an unnamed species not previously represented in the WAM collections. It has been given the morphospecies designation *Aname* sp.'MYG243'. The fifth specimen was an immature specimen that could only be identified to genus level. For the purposes of this report, this juvenile is called *Aname* sp. indet. (juv.) (Phoenix 2012: Appendix II).

The genus *Aname* currently includes 33 named species from Australia, and is well represented by four named (as well as numerous unnamed) species from many different regions of Western Australia. *Aname* currently contains a highly morphologically diverse array of species, from very small to large spiders. Males generally have a spur and spine on the first tibia that often opposes a frequently incrassate metatarsus. Members of the genus *Aname* are thought to be most common in sclerophyll forest, but are also known from deserts and rainforests (Raven 1981). *Aname* is often the most speciose mygalomorph genus collected during surveys, with 12 species recorded from the Pilbara Biological survey (Durrant et al. 2010) and 13 species found during the Carnarvon Basin survey (Main *et al*. 2000). Many *Aname* species appear to have restricted distributions as shown by a review of species from northern Australia (Phoenix 2012, Raven 1985).

Aname tepperi

Aname tepperi is a species that is widespread in southwest and central W.A., and its distribution also extends into S.A. (Main 1982). It is not a SRE species (Phoenix 2012: Appendix II). *Aname tepperi* was collected from the following sites within the Marda tenement: MS02 and MS03 located within the proposed project footprint, and MS04 and MS09 located outside of proposed impact areas.

Aname sp. 'MYG243'

This species was not previously represented in the WAM reference collection and has been informally designated in their collection as species 'MYG243'. The genus *Aname* includes many widespread, but also some range-restricted, species and therefore *Aname* sp. 'MYG243' is considered a potential SRE (Phoenix 2012: Appendix II). A review of the WAM *Aname* material of the region is required to assess the distribution of the species. There is considerable material of the genus from around Southern Cross in the WA Museum collection, but it has not been assessed against the more recently established morphospecies designations (Phoenix 2012). *Aname* sp. 'MYG243' was collected from site MS05 in the Marda tenement, which is located in the BIF ridge in the centre of the tenement. This BIF ridge comprises a restricted and isolated habitat, which increases the likelihood of *Aname* sp. 'MYG243' being an SRE occurring only in the Marda tenement. The BIF ridge is currently outside of the proposed impact areas and the potential impact of the project on this taxon is therefore low. Any changes to the project design that involve the BIF ridge will require detailed surveys for *Aname* sp. 'MYG243' to establish its occurrence along the entire length of the ridge to ensure the population remains secure.

Aname sp. indet. (juv.)

It is not possible to identify this young juvenile to species level; however, based on somatic characters this individual is not *Aname tepperi*. This specimen may represent a juvenile individual of *Aname* sp. 'MYG243', but it could also represent a different as yet undescribed species. The genus *Aname* includes some range-restricted species and therefore *Aname* sp. indet. (juv.) is considered a potential SRE

(Phoenix 2012: Appendix II). This species was collected from trap site MS10 within the Marda tenement, which is located on a smaller BIF outcrop at the southern end of the tenement, not connected to the areas where Aname *sp*. 'MYG243' was collected. This site is currently outside of the proposed impact zone.

***Teyl* sp. 'MYG021'**

The desktop search identified that the potential SRE species *Teyl* sp. 'MYG021' had been recorded from approximately 75 km south-east of the project area (Ninox 2009). No specimens of the genus *Teyl* were recorded in the project area during the survey. Little is known of the ecology of this species and its likelihood to occur in the project area is difficult to determine.

4.4. ARANEOMORPH SPIDERS

From an evolutionary perspective, Araneomorph spiders are a relatively modern group of spiders. Because of structural adaptations to increasing aridity, Araneomorph spdiers are much less likely to yield SRE species than their mygalomorph counterparts.

4.4.1. FAMILY: LYCOSIDAE

One juvenile Wolf Spider (Lycosidae) was collected from a turret-style burrow during foraging surveys. This was the only specimen collected, but turrets were observed at nine other locations throughout the survey area. The collected specimen belongs to the genus *Hogna* and could not be identified to species level since it was immature. A mature spider would be required for identification at species level. This group is well-represented in the WAM collection with several widespread species (Framenau *et al*. 2006). Wolf spiders are unlikely to include many SREs and are generally not targeted in SRE surveys (EPA 2009, Phoenix 2012: Appendix II).

4.4.2. FAMILY: OONOPIDAE

A single specimen identified as Oonopidae sp. indet. (female) was collected from the Marda tenement at trapping site MS08. The family Oonopidae is common in leaf litter and is not targeted in SRE surveys (Phoenix 2012: Appendix II).

4.4.3. FAMILY: THERIDIIDAE

A single juvenile spider from the family Theridiidae was collected from the Marda tenement at trapping site MS01. It was not possible to identify it further than family as it was a juvenile. Spiders from this family are not SREs (WAM 2012a: Appendix III).

4.5. PSEUDOSCORPIONS

As part of the SRE survey of the Marda tenements, pseudoscorpions were targeted and samples were collected across all forage and trap-sites. A total of 240 pseudoscorpion specimens (in four families, and seven genera) were collected from all sites combined, to facilitate identification of any potential SRE species. This total was comprised of 179 specimens from Marda (including both trapping and foraring sites), 31 specimens from Golden Orb (foraging sites only), and 30 specimens from the more distant King Brown (also from foraging only). Of the 240 specimens collected only 40 were mature individuals capable of being accurately identified to species level: these specimens were identified to comprise seven

different species of which one species in the genus *Beierolpium* was a potential SRE (see further comments under family Olpiidae) (WAM 2012a: Appendix III).

Short range endemism is not prolific within the Australian pseudoscorpion fauna (Harvey 2002). Generally, short range endemism in the group is confined to subterranean taxa and taxa that live in surface cave systems. While it is possible that SRE taxa will emerge from taxonomic revisions of the group, the current taxonomy suggests most surface-based, non-cave dwelling pseudoscorpions are not SRE's (Harvey 2002).

The WAM database has no records of pseudoscorpions within a 50 kilometre radius of the survey area. Seven pseudoscorpion species from four families were collected during the survey.

4.5.1. FAMILY: CHERNETIDAE

One mature female and 16 juveniles, identified as belonging to the genus *Nesidiochernes*, were collected from three sites at King Brown (KBF01, KBF04, and KBF07). These specimens were not identified to species level. However, the specimens are very similar to, and may be conspecific with, *N. australicus*, a species that is very widely distributed in southern Australia but originally described from New South Wales. Species in this genus are not SRE (WAM 2012a: Appendix III).

A new unnamed species, *Sundochernes* sp. 'PSE027', was found during this survey. Two mature females were collected outside of the impact zone at two Marda trapsites (MS07, MS09), and 12 juveniles (not able to be identified beyond genus level) were collected at Marda, Golden Orb, and King Brown, with one juvenile recorded within the project footprint area in Marda at site MS01. The distribution range of this species is unknown, but based on knowledge of other species in this genus is unlikely to be a SRE.

4.5.2. FAMILY CHTHONIIDAE

Sixteen mature males, nine mature females, and 146 juveniles of a single species of *Austrochthonius* were collected during this survey. This was the most abundant species of pseudoscorpion sampled during the survey, and was recorded from all three tenements, both inside and outside of proposed impact areas (Appendix I).

Species of *Austrochthonius* occur in leaf litter and soil environments throughout much of south-western Australia, as well as subterranean ecosystems in Cape Range and near Busselton (Harvey 1991, Harvey & Mould 2006). The taxonomy of the Western Australian representatives is not resolved but there are clearly a number of species represented in the collections of the WAM. This species from north of Southern Cross is not considered a SRE (WAM 2012a: Appendix III).

4.5.3. FAMILY: GARYPIDAE

Three mature males and two mature females of the morphospecies *Synsphyronus* sp.'PSE026'were collected during the survey from two sites at Marda (MS02, MF01) and one site at King Brown (KBF06). Many species of *Synsphyronus* may represent SRE species (Harvey 1987), but these species are generally found in ground-surface habitats such as under rocks. The tree-dwelling species tend to be much more widely distributed, and are not considered SRE. *Synsphyronus* sp. 'PSE026` was found in a leaf litter sample and therefore is not likely to be a SRE species (WAM 2012a: Appendix III).

A single juvenile from the genus *Solinus* was also collected in Marda (MF06) during this survey. The specimen was not identifiable to species level, but species in this genus are widespread (WAM 2012a: Appendix III).

4.5.4. FAMILY OLPIIDAE

Species from the family Olpiidae are generally not prone to short-range endemism. However taxonomic revisions of many genera in this family are required and this may result in the eventual identification of SRE species. The family Olpiidae is widespread throughout Australia.

Two genera from the family were collected in the project area: *Beierolpium*, and *Indolpium*. Species-level identification within the two genera is not currently possible as research is lacking for their species-level taxonomy. As such, the SRE status of each taxon cannot be confidently commented on (WAM 2012a: Appendix III).

Four mature males and two mature females of *Beierolpium* sp. '8/4' were collected at five sites in the survey area, three sites at Marda (MF02, MF06, MF11) and two sites at Golden Orb (GOF03, GOF07). It is possible that these specimens represent one or even several SRE species, but a full taxonomic revision of *Beierolpium* in Western Australia is necessary to confirm the systematic status of members of this genus and to firmly establish the identity of these specimens (WAM 2012a: Appendix III). The '8/4' species designation refers to the number of trichobothria (sensory hairs) on the fixed and movable chelal fingers in the adults, which diagnoses this morphospecies and is a feature that is likely to coincide with species distinction.

If *Beierolpium* sp. '8/4' is an SRE, then it is unlikely that its restricted distribution is dependent on vegetation since the mature individuals were collected in leaf litter from a wide variety of plant taxa, including several *Eucalyptus* species, *Banksia arborea* and *Casuarina pauper* (Appendix I). Juvenile *Beierolpium* were additionally recorded in leaf litter from *Acacia acuminata*, *Acacia* sp. and *Melaleuca* sp. Also the mature specimens were collected from a wide variety of landforms within the survey area (creeklines, plains and BIF hills), which suggests that landform does not have a specific restrictive influence on the distribution of this species. Of the five sites where this taxon was collected, only one site in the Golden Orb tenement is within a proposed impact area. The potential impact of the project on this taxon is therefore low.

A single mature female and one juvenile specimen of an *Indolpium* species were collected from King Brown (KBF01) and Marda (MS03) (Appendix I). Similar specimens have been collected from other regions of Western Australia. Based on our current levels of knowledge it is unlikely that these specimens represent SRE species (WAM 2012a: Appendix III).

4.6. SCORPIONS

The species level taxonomies of the two largest of the three scorpion families known from Australia are in need of further revision. The lack of taxonomic clarity for many genera means that determining SRE status is extremely difficult. Short range endemism in the West Australian scorpion fauna is not common. However, some families are more prone to endemism than others (i.e. there is a growing list of potential SREs in the families Buthidae and Urodacidae).

The WAM database has no records of scorpions within a 50 kilometre radius of the survey area. Two specimens, both from the family Buthidae, were collected from the Marda tenement during our survey. No scorpions were encountered at the Golden Orb or King Brown tenements.

4.6.1. FAMILY: BUTHIDAE

The family Buthidae is the most speciose and widespread of all scorpion families (Fet & Lowe 2000). Only the genera *Isometrus*, *Isometroides* and *Lychas* have been recorded in WA. The genus *Lychas* is widespread across the Australian mainland. The taxonomy of this genus is problematic, with numerous undescribed species known from Australia (Volschenk *et al*. 2010). The situation is further complicated

with the genus also being represented in Africa, India and eastern Asia (Fet & Lowe 2000). All known Australian species are endemic and are currently under revision. Most species of *Lychas* appear to have wide distributions. However, a small number of undescribed species in this genus are known to be SREs.

Two male specimens were collected from Marda at trapping sites MS06 and MS07, both located outside proposed impact areas. These specimens were identified as *Lychas jonesae*. This is a well-defined and clearly recognised species and is not a SRE. *Lychas jonesae* is widely distributed throughout southern Australia and has been recorded from arid parts of Western Australia, South Australia and Victoria (ScorpionID 2012: Appendix IV).

4.7. MILLIPEDES

The WAM database search yielded 11 records of SRE millipedes from within 20 km of the project area. The specimens belonged to the family Paradoxosomatidae, genus *Antichiropus*, and comprised two (potentially four) species.

During the SRE survey of the project area, two species of millipede were collected; one from the family Paradoxosomatidae and the other from the family Synxenidae.

4.7.1. FAMILY: PARADOXOSOMATIDAE

A single male from the morphospecies *Antichiropus*`sp. Mt Gibson 1` and a juvenile of most likely the same species were collected in the Marda tenement at trapping site MS05 (Appendix I). In his revision of Australian SRE taxa, Harvey (2002) noted that almost all of the then 90 described taxa of *Antichiropus* millipedes were SREs. However, this particular species has a much wider distribution than most *Antichiropus* species and therefore it is not considered a SRE (WAM 2012a: Appendix III).

4.7.2. FAMILY: SYNXENIDAE

Twelve juvenile millipedes were collected in the survey area at both Golden Orb (GOF05) and Marda (MF11 and MS01). These were identified as Polyxenid millipedes, otherwise known as pincushion millipedes, which are adapted to dry conditions and inhabit microhabitats of bark and rock faces (Wright & Westh 2006). A single widespread species from the family Synxenidae has been reported in Western Australia, *Phryssonotus novaehollandiae* (see Mesibov 2012). It is likely that the twelve juvenile synxenid millipedes collected during this survey are from this species (WAM 2012a: Appendix III).

4.8. ISOPODS

Six individuals (two males and four females) of a single isopod species, *Buddelundia* sp. 39 (Armadillidae), were collected at a single site at Marda (MF10) through forage collections. The species was locally abundant, with individuals recorded under several rocks at this foraging site. *Buddelundia* sp. 39 is not an SRE, as it has also been collected at Leonora, Cashmere Downs and Bulga Downs (Phoenix 2012: Appendix II).

4.9. LAND SNAILS

A search of the WAM database identified ten potential SRE species within 50 to 250 km of the project area (section 4.2). Seven of these species belong to the Bulimulid genus *Bothriembryon*, while the other

three are Camaenids from the genera *Sinumelon* and *Succinea*. During the SRE survey of the project area, five species of land snail were recorded from the families Bulimulidae, Punctidae and Pupillidae; one of these, *Bothriembryon* sp. was identified by the WAM as potentially SRE.

4.9.1. FAMILY: BULIMULIDAE

A single juvenile specimen, collected live at the Marda tenement, was identified as belonging to the genus *Bothriembryon*. Because it was a juvenile specimen, it could not be identified past genus level. The distributionally closest species, *Bothriembryon sedgwicki*, was described from the Nangeenan area to the south-west of the survey area. Based on specimens in the collections of the WA Museum, it may possibly exist at Marvel Loch; Lake Johnston and north of Coolgardie. The genus *Bothriembryon* contains many SRE species.

The *Bothriembryon* sp. specimen was collected from trapping site MS02, which is located in a creek line running in-between a proposed mining pit and waste dump. Although not directly within the project footprint, the record is within 50 m of currently proposed impact. Is recommended that further collecting for *Bothriembryon* be undertaken, particularly a large series of specimens (preferably live-taken or freshly dead) so that a species level identification can be made (WAM 2012b: Appendix V).

4.9.2. FAMILY: PUNCTIDAE

The microscopic snail specimens taken during this survey most closely resemble the two species *Westralaoma aprica* and *W. expicta*. *W. expicta* is distinctive in their shells' smaller size, shape and noticeable radial ribbing. Both species were described by Iredale (1939) from specimens taken in the Nangeenan area, but based on a few records in the collections of the WA Museum, both species appear to be widely distributed across the northern wheat belt and western goldfields regions (WAM 2012b: Appendix V).

4.9.3. FAMILY: PUPILLIDAE

The seven tiny dextral specimens collected during this survey exhibit shell characters most consistent with those of the species *Gastrocopta bannertonensis* (Gabriel 1930). This species has a wide geographic distribution in southern Australia, having been recorded from the southern regions of Western Australia; South Australia and New South Wales. There is also an isolated record of its presence in an area to the north-west of Alice Springs in the Northern Territory (Pokryszko1996, WAM 2012b: Appendix Y2).

Two live and two dead specimens of the species *Pupoides myoporinae* (Tate, 1880) were collected at two sites in the survey area. *P. myoporinae* has a wide but disjunct distribution across most of southern Australia, with a western range of apparently-scattered populations from Yalata in South Australia to Hines Hill in Western Australia, and with a more restricted eastern range from the Eyre Peninsula to Bannerton in Victoria (Solem 1986, 1991). It is often found to be sympatric with the larger, dextral coiling *Pupoides adelaidae* (Adams & Angas 1864, WAM 2012b: Appendix V).

4.10. HABITAT ANALYSIS

The area surveyed, despite being semi-arid, contained a diverse array of habitats/microhabitats based on soil types and floristics (Appendix VI). Three areas (Marda, Golden Orb and King Brown) were targeted during the survey, though the primary focus was on surveying the Marda tenement.

4.10.1. MARDA TENEMENT – TRAPPING SITES

The Marda area was assessed using 10 trap sites (MS01 to 10) and 13 foraging sites (MF01-13). The ten trap sites were selected to cover the area as well as specifically examine the variety of available major habitats/microhabitats in detail. Three trap sites (MS01-03) were within the impact zone, while the remaining seven trap sites were outside the impact zone, though some of these latter sites were utilised as replicates of impact zone sites for statistical purposes.

Plain / floodplain

Two sites (MS01, MS09) were selected in plains/floodplains. They were essentially similar with the vegetation being comprised of tall open *Eucalyptus* woodland over chenopods (saltbush), *Eremophila* and *Ptilotus* on reddish soils. They differed slightly with MS01 having a slightly stonier soil and an understorey of *Acacia*, and *Senna,* while the similar replicate MS09 was on a loamier soil with an understorey only of *Eremophila*.

Creekline

Two sites (MS02 and MS07) were located in a creekline/floodplain habitat. Both of these sites comprised an open shrubland of *Acacia acuminata* (narrow phyllode form throughout the tenements) and *Santalum acuminatum* over *Senna* on red-brown sandy clays. The two sites differed with MS02 having a better defined creekline and some emergent *Eucalyptus* species (mallees), while the replicate MS07 possessed *Ptilotus* and more dense grasses and forbs.

Hillside

Another two sites (MS03, MS08) were selected on shallow-sloped hillsides with somewhat stony soils. The vegetation of these two sites was comprised of tall *Casuarina pauper* over an understorey of *Acacia*, *Eremophila*, *Ptilotus* and chenopods. They differed very slightly with MS03 containing *Olearia* in the understorey while the replicate MS08 possessed *Dodonaea* in the understorey.

BIF hill

The remaining four trap sites were located in the complex of banded ironstone formation (BIF) hills occurring across the tenement, particularly the largest hill in the central region of the tenement, and none of these BIF sites were replicates of each other or of impact sites. The largest BIF hill had 3 traplines (MS04, MS05 and MS06) located on it and near to each other because of its high vegetation diversity, due to higher water runoff from steeper slopes combined with shaded south-facing slopes reducing the evaporation levels within the contained microhabitats.. Increased moisture retention in this ecosystem required intensive survey because of the greater potential for SRE relict species to be found in these moist microhabitats.

The trap sites MS04 and MS05 were close to each other only separated by a sheltered narrow valley and both possessed vegetation communities comprised of *Eucalyptus* sp. (mallees) over *Acacia* and *Allocasuarina acutivalvis* sitting on solid blocks of banded ironstone on a steep sided slope. However they differed with MS04 located on a south-facing slope possessing *Lepidosperma* sedges, *Grevillea*, *Prostanthera* and *Cyanicula* orchids in the understorey while MS05 was a north-facing slope possessing *Thysanotus* and greater density of *Acacia* in the understorey.

Site MS06 was further south on the same hill, and on a south facing slope like MS04, but was on a more gradual slope and was more exposed to the drying effects of wind because this slope led to the plain below and south of the main BIF hill. The vegetation of MS06 was a low shrubland comprised of *Acacia*, *Grevillea* and *Allocasuarina acutivalvis* over everlastings, on a red-brown clay soil with pisoliths.

The final trap site MS10 was on an isolated weathered BIF hill at the southern end of the tenement, with a drier aspect than the 3 other BIF hill trap sites. This hill was vegetated with *Casuarina pauper* and

Allocasuarina acutivalvis on a weathered capstone that had shallow caves around its edge. The lower slopes of the hill possessed *Eucalyptus* sp. (mallees).

4.10.2. MARDA TENEMENT – FORAGING SITES

The thirteen foraging sites were scattered widely across the Marda tenement to maximise coverage of any potential unique habitats/microhabitats not encountered in the more specific trapping program. The preliminary data from this SRE survey suggest that the BIF hills within the Marda tenement are the habitats containing the most conducive microhabitats for potential and actual SRE mygalomorph species. However the sampling period, while sufficiently cool and wet in spring for collecting many relict groups of organisms, did not cover other periods of the year (winter and summer) when different potential SRE faunas are often active and encountered. There is often a high level of seasonality to the activity of different genera, and sometimes species, of mygalomorph spiders.

Plain / Floodplain

Foraging area MF01 was located in a plain with tall open *Eucalyptus* woodland over *Eremophila, Atriplex* and *Ptilotus*. MF04 was located in a red-brown clay plain with a stony quartz/chert surface and was vegetated with open *Eucalyptus* woodland over *Atriplex*, *Ptilotus*, *Maireana* and *Eremophila scoparia.* Foraging area MF05 was also located on an open plain with a *Eucalyptus* woodland over *Exocarpus*, *Eremophila*, *Acacia*, and *Atriplex* on an orange-brown clay with ironstone and chert pebble surface. MF13 was located along the Bullfinch-Evanston road and was a gentle slope/plain with an orange rocky clay soil with stones. It was vegetated with *Casuarina pauper* over an *Acacia acuminata* shrubland with low *Ptilotus* and everlastings. These forage sites were utilized to extend microhabitat coverage of the survey and re-emphasize the importance of the moist creek and BIF hill sites in the search for SRE taxa.

BIF hill

MF02 was a small rocky BIF hill with an orange-brown stony clay soil (ironstones present) vegetated with *Acacia*, *Allocasuarina acutivalvis*, *Dodonaea*, *Ptilotus, Maireana*, *Thysanotus* and Fabaceae scrub and with *Eucalyptus* species on plain below. MF02 was an even drier eastward extension of trap site MS10, though a separate hill, and possessed a different vegetation complex. MF03 was a weathered granitoid BIF outcrop with an open shrubland of *Casuarina pauper* and *Eucalyptus* sp. over *Acacia acuminata* and *Leptospermum* sp. on an orange soil.

MF06 targeted an ironstone/orange banded rock BIF hill in the western end of the tenement vegetated with large *Banksia arborea* and *Casuarina pauper* over *Acacia*, *Allocasuarina acutivalvis*, *Grevillea*, *Eremophila*, *Dodonaea* and *Ptilotus*.

MF07 was the westernmost of the forage sites and was also located on a degraded BIF hill with hard orange rocky clay and was vegetated with *Eucalyptus* and *Casuarina pauper* over *Allocasuarina acutivalvis*, *Eremophila*, *Melaleuca*, *Dodonaea*, *Acacia* with a ground layer of *Lobelia*, *Hibbertia*, *Ptilotus* and small *Acacia*.

MF08 was located near trap site MS04 but traversed the drier northern slope/side not covered in the trap sites on this BIF hill, the largest and most significant in the tenement. It was composed of solid BIF with boulders and ledges and an orange-brown clay soil, and was vegetated on the crest and northern face with *Allocasuarina acutivalvis* over *Grevillea*, *Exocarpus*, *Eremophila*, *Acacia* over *Hibbertia*, *Thysanotus*, *Lepidosperma*, ferns and everlastings. MF09 was located on a hillslope-plain with a dark orange clay substrate and ironstone pisolith surface, south of the main BIF hill, near the centre of the tenement. It was vegetated with tall open *Eucalyptus* woodland over *Acacia*, *Eremophila* and *Ptilotus*.

MF10 traversed the south-facing slope of a rocky rise composed of heavily weathered orange BIF with a shallow layer of clay covered in rocks. This forage area was vegetated with a very open *Eucalyptus* and *Casuarina pauper* woodland over *Acacia tetragonaphylla*, *Acacia acuminata*, *Allocasuarina acutivalvis*

and *Eremophila*, *Grevillea*, *Dodonaea* and *Ptilotus*. MF11 covered a creekline with an orange loamy clay soil and some gravel, and was vegetated with tall (20m) *Eucalyptus* over *Exocarpus*, *Acacia acuminata*, *Santalum spicatum* with smaller *Eremophila* over *Ptilotus*.

Plateau

Foraging site MF12 was the easternmost of the forage sites within Marda, and covered a habitat type not seen/encountered elsewhere in the tenement. It was located on a low flat degraded plateau with a thin orange gravelly clay soil and was vegetated with scattered emergent *Eucalyptus* over *Allocasuarina campestris* and *Grevillea* scrub, with smaller *Acacia* over *Thysanotus*, *Dianella* and *Dodonaea*.

4.10.3. GOLDEN ORB – FORAGING SITES

The Golden Orb area was located circa 12 km south of Marda and was oriented in a northwest-southeast direction. The diverse vegetation (including species not seen in the Marda tenement) and the heath formations lend themselves to containing potential SRE species. However the lack of large BIF hills in this tenement mean that it is not as prospective for SRE taxa as the Marda tenement.

Eight forage sites were traversed to sample the diverse array of habitats existing within this tenement.

Rocky ridge

GOF01 was located around a low linear weathered rocky quartz/granitoid ridge in the north-west of the tenement. It was vegetated with emergent *Eucalyptus* over tall *Melaleuca*, *Allocasuarina acutivalvis*, *Santalum spicatum*, *Acacia* and *Exocarpus* with a groundlayer of *Calytrix* sp. (pink-flowered), *Atriplex* and *Dodonaea,* as well as lichens on the rocks.

Plateau

GOF02 was located in the south-east end of the tenement on a low plateau (raised plain) of orange lateritic clay soil, and was vegetated with a dense heath of low *Acacia* over pink-flowered *Grevillea paradoxa*, *Melaleuca* over *Eremophila* and peas (Fabaceae).

Plain / Floodplain

GOF03 was in the centre of the tenement, within the project impact zone, on a gently sloping plain composed of orange loamy clay, and was heavily disturbed and largely cleared by human activity. The remaining vegetation at this site indicated it was originally *Casuarina pauper* woodland with occasional emergent *Eucalyptus* over *Acacia*, *Eremophila* and *Grevillea*.

GOF04 was located in the south-west corner of the tenement on a low undisturbed hillslope with orange clay and a surface layer of pisolithic ironstone, vegetated with a *Casuarina pauper* woodland and emergent *Eucalyptus* over *Acacia*, *Eremophila*, *Atriplex* and *Ptilotus*. It was a non-impact area replicate of the disturbed site GOF03.

Forage site GOF05 was a gently sloping plain in the western end of the tenement, with orange clay soil covered in ironstone rocks, and was vegetated with scattered emergent *Eucalyptus* over dense *Acacia acuminata* shrubs with *Exocarpus*, *Grevillea*, *Santalum* and *Eremophila*. GOF06 was a hillslope with shallow orange gravelly clay in the centre of the tenement (NW of GOF03), and was vegetated with a tall shrubland of *Allocasuarina campestris*, *Allocasuarina acutivalvis*, *Grevillea* and *Acacia* over *Eremophila*, *Philotheca* and daisies.

GOF07 was in the west of the tenement and was an orange loamy clay plain with a tall open *Eucalyptus* woodland over *Eremophila*, *Acacia*, *Santalum acuminatum* and *Ptilotus*, *Dodonaea* and chenopods.

The final forage site, GOF08, was on a floodplain with a shallow orange loamy clay soil at the south eastern end of the tenement, and was vegetated with a very open *Callitris* (Cypress Pine) and *Eucalyptus* woodland over *Acacia* and *Eremophila*.

4.10.4. KING BROWN – FORAGING SITES

The King Brown area was located where two low rocky hill-lines/ridges converged and almost surrounded the northern end of a saline system (incipient playa/salt lake), which was dominated by samphires on its powdery clay-loam surface. In summary the more uniform vegetation, greater aridity and saline nature of King Brown, combined with the east-west aspect of the hill-slopes within the tenement, make it overall less likely to harbor SRE species than either Marda or Golden Orb, and all potential SRE sites were sampled.

Seven forage sites (KBF01-07) were located to sample the combined major vegetation/topography units present within this tenement.

Plain / Floodplain

KBF01 was on the west side of the access track into the tenement and was located on a pale orange rocky clay plain covered in calcrete, ironstone and quartz and was vegetated with an open *Casuarina pauper*/*Eucalyptus* woodland over *Exocarpus*, *Eremophila*, *Acacia* and chenopods (saltbush/samphires).

KBF03 was west of KBF01 on a stony loam/clay plain with ironstone and quartz at the base of a hill, and was vegetated with scattered emergent *Eucalyptus*/*Casuarina pauper* over an *Acacia acuminata*/*tetragonaphylla* thicket with *Senna*, *Eremophila* and *Ptilotus*.

KBF04 was the northernmost of the forage sites in this tenement and was located on the west side of the access track on an orange-brown rocky clay-loam plain below the western ridge. It was vegetated with *Casuarina pauper* woodland bordering an *Acacia acuminata* shrubland over *Ptilotus* and chenopods.

Hillslope

KBF02 was east of the access track on a west-facing hillslope composed of orange rocky clay with an ironstone, calcrete and quartz surface and occasional boulders and was also vegetated with a *Casuarina pauper*/*Eucalyptus* woodland over *Eremophila*, *Acacia*, *Ptilotus* and chenopods.

Hilltop

KBF05 was the only hilltop site able to be located within the boundaries of the tenement and was situated on top of the eastern ridge on an orange loamy clay with rocky areas. It was vegetated with *Acacia* sp./emergent *Casuarina pauper* scrub over a second *Acacia* species, *Dodonaea* and *Eremophila* with a ground cover of everlastings and daisies.

KBF06 was the southernmost foraging site within the tenement and was situated closest to the saline system. It was located on a plain at the base of a hill, in an area of powdery pink-brown clay-loam with some surface rocks (ironstone, quartz). The vegetation comprised *Eucalyptus salubris* (mallees) over *Casuarina pauper*, *Acacia*. *Eremophila*, *Pittosporum* and *Atriplex* with *Halosarcia*.

Creekline

The final foraging site within King Brown, KBF07 was located along a creekline within an orange-brown sandy clay plain and was vegetated with tall *Eucalyptus* and *Casuarina pauper* over *Exocarpus*, *Acacia*, *Eremophila* and *Senna* with a ground layer of *Atriplex*, *Halosarcia*, *Rhagodia* and *Ptilotus*.

5. DISCUSSION AND RECOMMENDATIONS

1. **Further Surveys**: While it is not considered critical to the advancement of the project, further surveys could assist in developing a better understanding of the distribution of the new, and potential SRE, invertebrate taxa recorded during this survey. Survey aims would include:

   - Collecting mature specimens of *Bothriembryon* sp. and expand the range of localities from which it is currently known.
   - Recording invertebrate species and potential SRE taxa with a different seasonal activity pattern from the ones collected during spring.

2. **Native Vegetation Management Plan**: A native vegetation management plan should be developed with the aim of:

   - protecting creek line habitats and minimising of clearing near creek lines and drainage lines
   - restrict access to creek lines not required for the Project Area
   - limit the number of access tracks across creek lines and drainage lines where possible
   - managing and excluding impacts from areas where potential SRE's have been found outside current proposed impact zones, especially the BIF ridges.
   - progressively rehabilitate habitats that support SRE's such as creek lines
   - fire management to ensure long term viability of habitats that are recognised to support potential SRE's in the Project Area. This should include development and management of fire breaks especially at sites supporting potential SRE's.

3. **Mine Planning**: A few simple mine planning adjustments could result in effective benefits for potential SRE taxa. Ideas include:

   - Design and position infrastructure in away from key SRE habitats such as creek lines and BIF habitats, and where possible ensure roads and structures do not cross of block off drainage lines and creeks;
   - Equipment that causes vibrations (such as crushing plants) should be placed a distance away from key habitats as mygalomorph spiders appear to be attracted to vibration.

4. **Collection and Observation**: Future employees should be educated about SRE's and recognise groups which are potential SRE's. Future environmental officers should be licensed by DEC to be able to collect potential SRE specimens if they are found during the day to day running of the project.

5. **Noise, Vibration and Light Management**: Noise, vibration and altered light regimes can impact the behaviour of SRE taxa, especially mygalomorph spiders, often resulting in death. Equipment and infrastructure (i.e. processing plants) should be located in areas/habitats deemed as low risk for the potential SRE's found on the Project Area (i.e. not adjacent to creek lines/ drainage habitats)

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Appendices

Appendix I: Invertebrate Taxa Collected and Vouchered from the Marda, Golden Orb and King Brown Tenements, and SRE status following taxonomic identification

APPENDIX I-A: Summary of invertebrate taxa collected and vouchered in each of the tenements, and SRE status following taxonomic identification

Taxonomic Group	Taxon Name	Marda	Golden Orb	King Brown	Grand Total
Spider	*Aname* 'MYG243' – **Potential SRE**	1			1
	Aname sp. (juv) – **Potential SRE**	1			1
	Aname tepperi	5			5
	Hogna sp. indet.	1			1
	Oonopidae sp. indet.	1			1
	Theridiidae sp. (juv.)	1			1
Pseudoscorpion	*Austrochthonius* sp.	134	4		138
	Austrochthonius sp. (juv.)	14	17	2	33
	Beierolpium sp. (juv.)	7	2	3	12
	Beierolpium sp. '8/4 lge' – **Potential SRE**	5	7		12
	Chernetidae sp. (juv.)	7	1	5	12
	Indolpium sp.	1		1	2
	Nesidiochernes sp.			16	16
	Nesidiochernes sp. (juv.)			1	1
	Solinus sp. (juv.)	1			1
	Sundochernes sp. 'PSE027'	2			2
	Synsphyronus sp. (juv.)	1		1	2
	Synsphyronus sp. 'PSE026'	7		1	8
Scorpion	*Lychas jonesae*	2			2
Millipede	*Antichiropus* 'Mt Gibson 1'	1			1
	Paradoxosomatidae sp.	1			1
	Phryssonotus novaehollandiae	11	1		12
	(not identified)	5			5
Slater	*Buddelundia* 'sp. 39'	6			6
Land Snail	*Bothriembryon* sp. – **Potential SRE**	1			1
	Gastrocopta bannertonensis	3	4	8	15
	Gastrocopta sp. (juv.)	1			1
	Pupoides myoporinae	1		2	3
	Westralaoma aprica		2	11	13
	Westralaoma expicta	13			13
	(not identified)	1	1		2
Grand Total		**235**	**39**	**51**	**325**

APPENDIX I-B: Invertebrate taxa collected and vouchered from each trapping, foraging and opportunistic collection site in the Marda tenement, and SRE status following taxonomic identification

Marda tenement - Potential SRE Collected		Dry pitfall traping sites										Foraging sites										OppSite	Totals
Taxonomic Group	**Taxon Name**	MS01	MS02	MS03	MS04	MS05	MS06	MS07	MS08	MS09	MS10	MF01	MF02	MF04	MF05	MF06	MF07	MF08	MF09	MF10	MF11	TURRET 9	
Spider	*Aname* 'MYG243' – **Potential SRE**					1																	1
	Aname sp. (juv) – **Potential SRE**										1												1
	Aname tepperi		1	1	1					2													5
	Hogna sp. indet.																					1	1
	Oonopidae sp. indet.								1														1
	Theridiidae sp. (juv.)	1																					1
Pseudoscorpion	*Austrochthonius* sp.	75			15	18		9									5				12		134
	Austrochthonius sp. (juv.)	2	5	1						1				4						1			14
	Beierolpium sp. (juv.)					1				1		3		1	1								7
	Beierolpium sp . '8/4 lge' – **Potential SRE**												2			2					1		5
	Chernetidae sp. (juv.)	1									4						1				1		6
	Indolpium sp.			1																			1
	Solinus sp. (juv.)															1							1
	Sundochernes sp. 'PSE027'							1		1													2
	Synsphyronus sp. (juv.)										1												1
	Synsphyronus sp. 'PSE026'		4									3											7
Scorpion	*Lychas jonesae*						1	1															2
Millipede	*Antichiropus* 'Mt Gibson 1'					1																	1
	Paradoxosomatidae sp.					1																	1
	Phryssonotus novaehollandiae	10																			1		11
	(not identified)	1					1	2			1												5
Slater	*Buddelundia* 'sp. 39'																			6			6
Snail	*Bothriembryon* sp. – **Potential SRE**		1																				1
	Gastrocopta bannertonensis											1							2				3
	Gastrocopta sp. (juv.)					1																	1
	Pupoides myoporinae														1								1
	Westralaoma expicta	6						1						1			1	2	2				13
	(not identified)										1												1
Grand Total		**96**	**11**	**3**	**16**	**23**	**2**	**14**	**1**	**5**	**8**	**7**	**2**	**6**	**2**	**3**	**7**	**2**	**4**	**7**	**15**	**1**	**235**

APPENDIX I-C: Invertebrate taxa collected and vouchered from each foraging site in the Golden Orb tenement, and SRE status following taxonomic identification

Golden Orb tenement - Potential SRE Collected		Foraging sites							Totals
Taxonomic Group	**Taxon Name**	GOF01	GOF02	GOF03	GOF04	GOF05	GOF07	GOF08	
Pseudoscorpion	*Austrochthonius* sp.					4			4
	Austrochthonius sp. (juv.)		1		15			1	17
	Beierolpium sp. (juv.)	1			1				2
	Beierolpium sp . '8/4 lge' – **Potential SRE**			2			5		7
	Chernetidae sp. (juv.)							1	1
Millipede	*Phryssonotus novaehollandiae*					1			1
Snail	*Gastrocopta bannertonensis*			1				3	4
	Westralaoma aprica							2	2
	(not identified)					1			1
Grand Total		**1**	**1**	**3**	**16**	**6**	**5**	**7**	**39**

APPENDIX I-D: Invertebrate taxa collected and vouchered from each foraging site in the King Brown tenement, and SRE status following taxonomic identification

King Brown tenement - Potential SRE Collected		Foraging sites							Totals
Taxonomic Group	**Taxon Name**	KBF01	KBF02	KBF03	KBF04	KBF05	KBF06	KBF07	
Pseudoscorpion	Austrochthonius sp. (juv.)			2					2
	Austrochthonius sp. (juv.)			2	1				3
	Beierolpium sp. (juv.)					5			5
	Indolpium sp.	1							1
	Nesidiochernes sp.				4			12	16
	Nesidiochernes sp. (juv.)	1							1
	Synsphyronus sp. (juv.)	1							1
	Synsphyronus sp. 'PSE026'						1		1
Snail	*Gastrocopta bannertonensis*	6	2						8
	Pupoides myoporinae	2							2
	Westralaoma aprica					9		2	11
Grand Total		**11**	**2**	**4**	**5**	**14**	**1**	**14**	**51**

Appendix II: Phoenix (2012) report of taxonomic identification report of spiders and isopods collected from the project area

PHOENIX
ENVIRONMENTAL SCIENCES

Short-range endemic invertebrates from north of Southern Cross (Western Australia)

Prepared for Rapallo

January 2012

Taxonomic Report

Short-range endemic invertebrates from north of Southern Cross (Western Australia)

Prepared for Rapallo

Taxonomic report

Author/s: Volker W. Framenau

Reviewer/s:

Date: 10 January 2012

Submitted to: Marieke Weerheim, Rapallo

Chain of authorship and review			
Name	**Task**	**Version**	**Date**
Volker W. Framenau	Draft for client comments		30 November 2011
Marieke Weerheim	Technical review		8 December 2011
Volker W. Framenau	Interim for client comments		8 December 2011
Volker W. Framenau	Final submitted to client		10 January 2012

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EXECUTIVE SUMMARY

In November 2011, Phoenix Environmental Sciences Pty Ltd (Phoenix) was commissioned by Rapallo to identify invertebrates collected north of Southern Cross (Western Australia). A total of nine samples were identified and screened for short-range endemic (SRE) taxa.

There are uncertainties in determining the range-restrictions of many invertebrates in Western Australia due to lack of surveys, lack of taxonomic resolutions within target taxa and problems in identifying certain life stages. To account for these uncertainties Phoenix uses a three-tier categorisation for short-range endemism: confirmed SRE, likely SRE and potential SRE.

The material included two potential SREs:

- *Aname* 'MYG243' (Nemesiidae – Wishbone Spiders): species currently known from this survey only. The genus includes widespread, but also some range-restricted species
- *Aname* sp. indet. (juv.) (Nemesiidae – Wishbone Spiders): immature specimen, cannot be identified to species level; mature male required to assess distribution of the species; may represent *Aname* 'MYG243'.

The following species from the SRE target groups are not considered SREs:

- Acari sp. indet. (mite): not further identified, mites do not belong to the SRE target groups
- *Aname tepperi* (Nemesiidae – Wishbone Spiders): widespread in WA and into SA
- *Hogna* sp. indet. (juv.) (Lycosidae – Wolf Spider): immature specimen, cannot be identified to species level; member of a group of common Lycosidae
- Oonopidae sp. indet. (female): araneomorph spider family common in leave litter; not targeted in SRE surveys
- *Buddelundia* sp. 39 (Armadillidae): not an SRE, also collected at Leonora, Cashmere Downs and Bulga Downs.

1 SCOPE OF WORKS

In November 2011, Phoenix Environmental Sciences Pty Ltd (Phoenix) was commissioned by Rapallo to identify terrestrial invertebrates collected north of Southern Cross (Western Australia). A total of nine samples were screened for short-range endemic (SRE) taxa.

2 BACKGROUND

2.1.1 Short-range endemic invertebrates

Short-range endemic fauna (also known as narrow-range taxa) are defined as animals that display restricted geographic distributions, nominally less than 10,000 km^2, that may also be disjunct and highly localised (Harvey 2002; Ponder & Colgan 2002). Short-range endemism in terrestrial arthropods is believed to have evolved through two primary processes (Harvey 2002; Ponder & Colgan 2002):

- **Relictual short-range endemism**: relictual SREs are thought to have had wider distributions during more mesic geological periods. Australia's aridification over the last 60 million years resulted in a contraction of the ranges of these species into relatively small habitat pockets where moist conditions persist (relictual Gondwanan habitats). Evolutionary processes over long periods of isolation typically resulted in each population developing into a distinctive species. Millipedes and terrestrial snails are typical relictual SREs and they are generally found in deep gullies often on the south-facing slopes of mountains, hills and ridges. Relictual SREs often inhabit areas with: high rainfall, areas where topography induces fog, areas with permanent water (swamps, creek lines and river systems) or deep litter beds. Sometimes habitats have various combinations of these features.
- **Habitat specialisation**: habitat specialist SREs are restricted to specific isolated habitat types. Unlike relictual SREs in mesic habitats, habitat specialist SREs are restricted by environmental parameters other than microclimatic, moist conditions. Such habitat islands include rocky outcrops (pseudoscorpions in the genus *Synsphyronus* or selenopid spiders are typical examples here), salt lakes (e.g. wolf spiders of the genus *Tetralycosa*) or isolated dune systems (species in the scorpion genus *Urodacus*).

Invertebrate groups that contain SRE taxa are generally well distributed across the Australian landscape and well adapted to semi-arid environments due to a variety of behavioural and morphological features that have developed to avoid desiccation and predation. They generally possess (Harvey 2002; Ponder & Colgan 2002):

- poor powers of dispersal
- confinement to discontinuous habitats
- seasonality, i.e. only active in cooler or wetter months
- slow growth
- low levels of fecundity.

The current knowledge of SREs in WA is relatively poor and the rarity of collections from certain regions makes it difficult to assess the distribution and likely occurrence of SRE species. Habitats such as mountains containing gullies/gorges and south-facing slopes, wetlands and rivers often include unique habitat attributes set amongst a relatively homogeneous surrounding landscape. These isolated micro habitats often harbour SRE taxa (Harvey 2002). Potential SRE taxa include the following groups (EPA 2009):

- spiders and relatives (Arachnida)
    - spiders (Araneae), in particular trapdoor spiders (Mygalomorphae) and selected modern spiders (Araneomorphae) (here mainly Flat Rock Spiders, Selenopidae)
    - harvestmen (Opiliones)
    - false scorpions (Pseudoscorpiones)
    - true scorpions (Scorpiones)
    - whip spiders (Schizomida) (although the majority of SREs in this order are troglobites) (Harvey *et al.* 2008; Harvey *et al.* 2011)
- multipedes (Myriapoda)
    - centipedes (Chilopoda), mainly the order Geophilomorpha and the Cryptopidae in the order Scolopendromorpha; other Scolopendromorpha are generally widespread and are not considered target taxa (e. g. Colloff *et al.* 2005; Koch 1982, 1983a, b, c)
    - millipedes (Diplopoda)
- crustaceans (Crustacea)
    - slaters (Isopoda)
- snails and relatives (Mollusca)
    - land snails (Eupulmonata, Gastropoda)
- earth worms (Oligochaeta).

Whilst other invertebrate groups have recently been proposed to contain a substantial proportion of range-restricted species, e.g. epigaeic (ground-dwelling), often wingless beetles in the Pilbara (Guthrie *et al.* 2010), these are currently not targeted in SRE invertebrate surveys (EPA 2009).

2.1.2 Categories of short-range endemism

There is currently no accepted system in place to define the varying probabilities of a species to be an SRE. The uncertainty in categorising a specimen as SRE originates in a number of factors including:

- **Poor regional survey density** (sometimes taxon-specific): A regional fauna is simply not known well enough to assess the distribution of species. This factor also considers the fact that, simply because a species has not been found regionally, does not mean it is really absent; this confirmation ('negative proof') is almost impossible to obtain ("absence of proof is not proof of absence").
- **Lack of taxonomic resolution**: many potential SRE taxa (based on preferences for typical SRE habitats, SRE status of closely related species, or morphological peculiarities such as troglomorphism) have never been taxonomically treated and identification to species level is very difficult or impossible as species-specific character systems have not been defined. Good taxonomic resolution does not necessarily require a published revision, but generally requires a taxonomist to be actively working on this group or a well-established, preferably publicly available, reference collection (i.e. museum collection).
- **Problems of identification**: SRE surveys often recover life stages of potential SRE taxa that cannot be confidently identified based on morphological characters, even if revisions exist. These include, for example, juvenile or female millipedes, mygalomorph spiders and scorpions. Molecular techniques are increasing being employed to overcome these identification problems.

Considering these factors of uncertainty, Phoenix currently employs a simple three-tier system to categorise the different probabilities of short-range endemism: confirmed, likely or potential SRE (Table 2-1). These categories are dynamic and can change with every survey.

Life stages of species that cannot be identified at the species level, e.g. some females and juveniles, are here assessed based on the knowledge of the higher taxon they belong to, i.e. family or genus. For example, all juvenile or female *Antichiropus* millipedes would be classified as 'confirmed SRE' as all but two of the known species in this genus are considered SREs (Wojcieszek *et al.* 2011).

The different categories of 'SRE-likelihood' may help to set conservation priorities; however, SRE taxa of all categories should be considered to determine appropriate conservation measures in order to adhere to the Precautionary Principle within Environmental Impact Assessments. That is, "*where there are threats of serious or irreversible environmental damage, lack of full scientific certainty should not be used as a reason to postpone measures to prevent environmental degradation*" (e. g. EPA 2002) .

Table 2-1 Phoenix SRE categories reflecting survey, taxonomic and identification uncertainties

SRE category	Criteria	Typical representative
(Confirmed) SRE	Confirmed or almost certainly SRE; taxonomy of the group is well known (but not necessarily published); group well represented in collections, in particular from the region in question; high levels of endemism in documented species; inference is often possible from immature specimens	*Antichiropus* millipedes and araneomorph spiders in the genus *Karaops* (Selenopidae)
Likely	Taxonomically poorly resolved group; unusual morphology for the group (i.e. some form of troglomorphism); often singleton in survey and few, if any, regional records	Opiliones, some pseudoscorpions and slaters, many mygalomorph spiders
Potential	Taxonomically poorly resolved group; often common in certain microhabitats in SRE surveys (i.e. litter dwellers), but no other regional records; congeners often widespread	Cryptopidae, Geophilida

2.2 IDENTIFICATION AND PERSONNEL

All spiders were examined in 70% or 100% ethanol under Leica M205A and M80 stereomicroscopes.

The method of identification for each taxon, i.e. by taxonomic literature or comparison with type or other reference material, is indicated in the taxonomic part of this report. Phoenix personnel involved in the identification are listed in Table 2-2.

Table 2-2 Personnel involved in identification

Taxonomic group	Title	Qualification
Dr Volker Framenau	Manager, Terrestrial Invertebrates (Phoenix)	One of Australia's leading arachnologists with taxonomic expertise in major araneomorph and mygalomorph spiders; established the WAM mygalomorph reference collection
Dr Simon Judd	Taxononomic consultant	Leading taxonomist on WA isopods

2.3 TAXONOMY AND NOMENCLATURE

The taxonomic nomenclature of invertebrates follows the references detailed in Table 2-3.

Morphospecies designations of undescribed species are generally adopted from the systems of the scientist(s) working on the group. For mygalomorph spiders, the Western Australian Museum has established a morphological reference collection of males that aids in the identification of spiders. Morphospecies are numbered consecutively with the prefix "MYG", e.g. *Aname* 'MYG001' (Nemesiidae).

Table 2-3 Nomenclatural references, morphospecies designations and reference collections for the invertebrates from north of Southern Cross.

Taxonomic group	Taxonomic reference for described species and higher taxa	Morphospecies designation and reference collection
Araneae (Mygalomorphae)	Platnick (2011)	"MYG"-numbering system developed by V.W. Framenau (WAM, Phoenix), reference collection at WAM
Araneae (Araneomorphae)	Platnick (2011)	
Isopoda	Schotte *et al.* (2008 onwards)	

2.4 SPECIMEN DEPOSITORY

The EPA guidance statement No. 20 ('*Sampling of short-range invertebrate fauna for environmental impact assessment in Western Australia*') (EPA 2009) recommends that all specimens representing SRE target groups are lodged with the WAM to enhance the knowledge of the distribution of putatively rare species. Phoenix adheres to this recommendation and all conservation significant specimens of the survey were lodged with the Western Australian Museum.

3 RESULTS

3.1 SUMMARY

The survey material belongs to at least six morphospecies in five genera and five families (Table 3-1, Appendix 1). One of these species, only *Aname* 'MYG243' and a juvenile *Aname* (both Nemesiidae) or considered potential SREs.

Table 3-1 SRE status of invertebrates from north of Southern Cross

Taxon	SRE status	Remarks
Acari (mites)		
Acari sp. indet.	Unknown	Mites are unlikely to include many SREs and are generally not targeted in SRE surveys (EPA 2009). Not further commented on here.
Araneae (spiders)		
Nemesiidae (Wishbone Spiders)		
Aname tepperi (Hogg, 1902)	Not SRE	Widespread in southern WA and into SA
Aname 'MYG243'	Potential SRE	Currently known from this survey only; genus includes widespread but also range-restricted species.
Aname sp. indet. (juv.)	Potential SRE	Cannot be identified to species level (male required); not *Aname tepperi*, maybe *Aname* 'MYG243'.
Lycosidae (Wolf Spiders)		
Hogna sp. indet. (juv.)	Not SRE	Cannot be identified to species level (mature spider required); group well-represented in WA Museum collection with several widespread species (Framenau *et al.* 2006). Wolf spiders are unlikely to include many SREs and are generally not targeted in SRE surveys (EPA 2009). Not further commented on here.
Oonopidae (Goblin Spiders)		
Oonopidae sp. indet. (female)	Not SRE	Common spiders in leaf litter
Isopoda (Slaters)		
Armadillidae		
Buddelundia sp. 39	Not SRE	Also collected from Leonora, Cashmere Downs and Bulga Downs

3.2 MYGALOMORPHAE (TRAPDOOR SPIDERS)

Trapdoor spiders represent one of the focal groups in surveys of short-range endemic taxa (EPA 2009; Harvey 2002). A number of mygalomorph spiders, e.g. *Idiosoma nigrum* Main, 1952, *Kwonkan eboracum* Main, 1983, and *Moggridgea tingle* Main, 1991, are listed on Schedule 1 ("Fauna that is rare or likely to become extinct") of the Wildlife Conservation (Specially Protected Fauna) Notice 2010(2) of the Western Australian Government (Western Australian Government 2010).

The Western Australian mygalomorph fauna is vast and remains taxonomically poorly known for many families and genera (e.g. Barychelidae: *Idiommata*; Idiopidae: *Aganippe*; Nemesiidae: *Aname*, *Chenistonia*, *Kwonkan*).

3.2.1 Family Nemesiidae (Wishbone Spiders)

Members of the mygalomorph spider family Nemesiidae are represented in Western Australia by several genera, including *Aname*, *Chenistonia*, *Yilgarnia*, *Stanwellia*, *Teyl*, *Swolnpes* and *Kwonkan* (Main & Framenau 2009). They usually dig burrows in the soil, and do not cover their burrow entrances with lids.

3.2.1.1 Genus *Aname*

The genus *Aname* currently includes 33 named species in Australia and is well represented by four named and numerous unnamed species from many different regions in Western Australia. *Aname* currently represent a highly diverse array of species of very small to large spiders. Males generally have a spur and spine on the first tibia of males opposing an often incrassate metatarsus. Members of the genus *Aname* are believed to be most common in sclerophyll forest, but are also known from rainforests and deserts (Raven 1981). *Aname* regularly belongs to the most diverse mygalomorph genera in biological spider surveys and with 12 species the Pilbara survey (Durrant *et al.* 2010) resulted in a similar number as found during the Carnarvon Basin survey (13 species) (Main *et al.* 2000). Many *Aname* species appear to have restricted distributions as shown by a review of species from northern Australia (Raven 1985).

***Aname tepperi* (Hogg, 1902)**

Aname tepperi is a species that is widespread in southwest and central WA and also occurs into SA (Main 1982). It is not a short-range endemic species.

***Aname* 'MYG243'**

This specimen was previously not present in the WA Museum reference collection and has here been assigned the morphospecies designation 'MYG243'. The genus *Aname* includes many widespread, but also range-restricted species and therefore *Aname* 'MYG243' is considered a potential SRE. A review of the WA Museum *Aname* material of the region is required to assess the distribution of the species. There is considerable material of the genus from around Southern Cross in the WA Museum but it has not been assessed against the more recently established morphospecies collection.

***Aname* sp. indet. (juv.)**

It is not possible to identify this young juvenile to species level; however, based on somatic characters this is not Aname tepperi (see above). The specimen may represent Aname 'MYG243'. The genus Aname includes many widespread, but also range-restricted species and therefore *Aname* sp. indet. (juv.) is considered a potential SRE.

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APPENDIX 1 IDENTIFICATION OF INVERTEBRATES FROM NORTH OF SOUTHERN CROSS

WAM registration (T-)	Fieldnumber	Order	Family	Genus and species	Latitude	Longitude	♂	♀	Juv.	total
118012	MF10-SAR-110921-013	Acari			30°12'13.378"S	119°16'16.369"E				1
118014	MS09-SMY-110921-015	Araneae	Nemesiidae	*Aname tepperi*	30°12'31.118"S	119°15'19.496"E	1			1
118013	MS04-SMY-110920-012	Araneae	Nemesiidae	*Aname tepperi*	30°11'54.863"S	119°15'22.108"E	1			1
118011	MS03-SMY-110922-016	Araneae	Nemesiidae	*Aname tepperi*	30°12'3.907"S	119°16'13.871"E	1			1
118015	MS05-SMY-110922-018	Araneae	Nemesiidae	*Aname* 'MYG243'	30°11'53.228"S	119°15'15.192"E	1			1
118010	MS10-SMY-110923-020	Araneae	Nemesiidae	*Aname* sp. indet.	30°13'7.374"S	119°15'46.91"E			1	1
disposed	MFTUR9-SAR-110923-021	Araneae	Lycosidae	*Hogna* sp. indet.	30°12'33.245"S	119°16'7.441"E			1	1
	MS08-SAR-110923	Araneae	Oonopidae	Oonopidae sp. indet.	30°11'39.745"	119°15'15.558		1		
	MF10-ISO-110921	Isopoda	Armadillidae	*Buddelundia* sp. 39	30°12'13.378	119°16'16.369	2	4		

Appendix III: WAM (2012a) report of taxonomic identification report of pseudo-scorpions and millipedes collected from the project area

Arachnids and diplopods from ca. 100km North of Southern Cross (Western Australia)

Report to *Rapallo Environmental*

13 February 2012

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Summary

The samples from near Southern Cross submitted to the Western Australian Museum on 9th December 2011 (WAMTS004) contained millipedes (Paradoxosomatidae: *Antichiropus*, and Synxenidae) pseudoscorpions (Chernetidae: *Nesidiochernes*, *Sundochernes*; Chthoniidae: *Austrochthonius*; Garypidae: *Synspyronus*; Garypinidae: *Solinus*; Olpiidae: *Beierolpium*, *Indolpium*), a spider (Theiridiidae) and mites. The mites were not identified but were kept. Reference to their accession numbers are found in the appendix should further work be requested on these arachnids.

Short-Range Endemism

The terrestrial invertebrate fauna of inland Australia contains a plethora of species, and just the arthropods were recently estimated to consist of more than 250,000 species (Yeates, Harvey et al. 2004; Chapman 2009). The vast majority of these are found within the Insecta and Arachnida, although significant numbers of millipedes are to be expected. For many years, the prospect of including invertebrates in assessments of biological systems subject to alteration proved daunting and were largely ignored as being too diverse and too difficult to comprehend to satisfy the rapid turn-around needed for environmental surveys.

In a recent publication, the issue of Short-Range Endemism in the Australian invertebrate fauna was examined (Harvey 2002), and series of major groups were nominated as having a very high proportion of individual species that satisfied a certain set of criteria. The main criterion nominated for inclusion as a Short-Range Endemic (SRE) was that the species had a naturally small range of less than 10,000 km^2. Harvey (2002) found that those species possessed a series of ecological and life-history traits, including:

- poor powers of dispersal;
- confinement to discontinuous habitats;
- usually highly seasonal, only active during cooler, wetter periods; and
- low levels of fecundity.

The Western Australian fauna contains a number of SRE taxa, including millipedes, land snails, trap-door spiders, some pseudoscorpions, slaters, and onychophorans and these represent focal groups in Environmental Impact Assessment studies in the state (EPA 2009). The south coast region is relatively well known compared with other regions of the state (Framenau, Moir et al. 2008), but there are many poorly known species and gaps in our understanding of the distributions of many species.

Methods

Millipedes, pseudoscorpions, a spider and mites were collected by *Rapallo Environmental* from around 100 km north of Southern Cross, Western Australia and were submitted to the Western Australian Museum on 9th December 2011 (WAMTS004). A number of the specimens were damaged and not included in this report (they are noted at the end of Appendix 1). A number of hexapod specimens were also sorted out from the specimen vials and kept, but these are unlikely to be registered. The samples identified at the museum were examined using Leica dissecting microscopes (MZ 6 & MZ16).

ARACHNIDA

ORDER ARANEAE

Family Theridiidae

A single juvenile spider from the family Theridiidae was collected during this survey (Appendix 1). It was not possible to identify it further than family as it was a juvenile. Spiders from this family are not short-range endemics.

ORDER PSEUDOSCORPIONES

The Western Australian pseudoscorpion fauna is fairly diverse with representatives of 17 different families. They are found in a variety of biotopes, but can be most commonly collected from the bark of trees, from the underside of rocks, or from leaf litter habitats. The material from this survey included 238 individuals from five families: Chernetidae, Chthoniidae, Garypidae, Garypinidae, and Olpiidae (Appendix 1).

Family Chernetidae

Nesidiochernes sp. (family Chernetidae)

The genus *Nesidiochernes* is found throughout many different regions of Australasia and the Pacific (Harvey 2009). One female and fifteen juveniles were collected near Southern Cross (Appendix 1). These specimens are very similar to and may be conspecific with a species that is very widely distributed in southern Australia, *N. australicus*, originally described from New South Wales. Species in this genus are not short-range endemics.

***Sundochernes* `sp. PSE027` (family Chernetidae)**

A new species of *Sundochernes*, `sp. PSE027` was found during this survey. Two females and probably 10 juveniles (juveniles were not able to be identified beyond family level) were collected (Appendix 1). This distribution range of this specimen is unknown, but based on knowledge of other species of this genus; it is unlikely to be a short-range endemic.

Family Chthoniidae

***Austrochthonius* sp. (family Chthoniidae)**

Species of *Austrochthonius* occur in leaf litter and soil environments throughout much of south-western Australia, as well as subterranean ecosystems in Cape Range and near Busselton (Harvey 1991; Harvey and Mould 2006). The taxonomy of the Western Australian representatives is not resolved but there are clearly several species represented in the collections of the Western Australian Museum. Sixteen males, nine females, and 149 juveniles of a single species were collected during this survey (Appendix 1). Based on our current knowledge, this species from near Southern Cross is not a short-range endemic.

Family Garypidae

***Synsphyronus* `sp. PSE026` (family Garypidae)**

Many species of *Synsphyronus* may represent short-range endemic species (Harvey 1987), but these species are generally found in ground habitats such as under rocks; the tree-dwelling species tend to be much more widely distributed, and are not short-range endemics. *Synsphyronus* `sp. PSE026` was found in from a leaf little sample and therefore is likely not to be a short-range endemic species. Three males, two females, and five juvenile specimens of *S. heptatrichus* were collected during the survey (Appendix 1).

Family Garypinidae

***Solinus* sp. (family Garypinidae)**

A single juvenile from the genus *Solinus* was collected during this survey (Appendix 1). The specimen was not identifiable to species, but species in this genus are widespread.

Family Olpiidae

***Beierolpium* `sp. 8/4 lge` (family Olpiidae)**

Three males, two females and 17 juvenile specimens of *Beierolpium* were collected during this survey (Appendix 1). The systematic status of members of this genus has not been fully assessed. At present it is not possible to firmly establish the identity of these species until a complete systematic revision of the Western Australian members of *Beierolpium* is undertaken. The `sp. 8/4` species representation refers to the number of trichobothria (sensory hairs) on the fixed and movable chelal fingers in the adults, which is a feature that is likely to coincide with species distinction. It is possible that these specimens represent short-range endemic species, but a full taxonomic revision of the genus *Beierolpium* in Western Australia is necessary to confirm their status.

***Indolpium* sp. (family Olpiidae)**

A single female and one juvenile specimen of *Indolpium* were collected just north of Southern Cross (Appendix 1). Similar specimens have been collected from other regions of Western Australia. Based on our current levels of knowledge; it is unlikely that these specimens represent short-range endemic species.

DIPLOPODA

ORDER POLYDESMIDA

Family Paradoxosomatidae

Genus *Antichiropus*

The genus *Antichiropus* is the most abundant and diverse millipede group in Western Australia. This genus was first named in 1911 for seven species (Attems 1911), and additional species were added by Jeekel (1982) and Shear (Shear 1992). As the result of large field surveys and taxonomic work at the Western Australian Museum, the genus is now known to consist of over 110 species, ranging as far north as the Pilbara, and extending onto the Nullarbor Plain and the Eyre Peninsula in South Australia. With the exception of *Antichiropus variabilis*, which inhabits the jarrah forests of south-western WA, and *Antichiropus* 'PM1' from the northern Wheatbelt and the Geraldton sandplain, most species of the genus are known to be short-range endemics, and many are known from only a few hundred square kilometres (Harvey, Sampey et al. 2000; Harvey 2002).

Although the vast majority of *Antichiropus* species currently lack formal taxonomic descriptions and scientific names, MSH has spent the past decade comparing different species of the genus and assigning temporary codes to each of the species. The distinction between species is largely based upon differences in the structure of the male gonopods. These are modified legs on the seventh abdominal segment that are used to store sperm prior to mating. The shape of

the gonopod of each *Antichiropus* species is different, making the identification of individual species a relatively simple task. These differences in gonopod morphology have been used in millipede taxonomy for 150 years, and have been shown to be good indicators of valid biological species.

***Antichiropus* `sp. Mt Gibson 1` (family Paradoxosomatidae)**

A single male from the morphospecies *Antichiropus* `sp. Mt Gibson 1` and a juvenile of more than likely the same species were collected during this survey (Appendix 1). This particular species has a much larger distribution than most *Antichiropus* species and therefore it is not considered a short-range endemic.

ORDER POLYXENIDA

Family Synxenidae

***Phryssonotus novaehollaniae* (Silvestri, 1923) (family Synxenidae)**

Polyxenid millipedes, otherwise known as pincushion millipedes are adapted to dry conditions and inhabit microclimates of bark and rock faces (Wright and Westh 2006). A single widespread species from the family Synxenidae has been reported in Western Australia: *Phryssonotus novaehollandiae* (see Mesibov 2012). It is likely that the twelve juvenile synxenid millipedes were collected during this survey are from this species (Appendix 1).

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Appendix 1. Arachnids and Diplopods from North of Southern Cross.

REGNO	FLDNO	CLASS	ORDER	FAMILY	GENUS	SPECIES	LATITUDE	LONGITUDE	M	F	Juv.	TOTAL	REMARKS
116731	GOF03-PSE-110920	Arachnida	Acari				30°17`07.00"S	119°10`50.50"E					ex T116704
116735	GOF04-PSE-110920	Arachnida	Acari				30°17`11.83"S	119°10`14.05"E					ex T116705
120334	GOF05-PSE-110920	Arachnida	Acari				30°17`00.84"S	119°10`20.88"E					ex T116706
120335	GOF07-PSE-110920	Arachnida	Acari				30°17`11.83"S	119°10`14.05"E					ex T116707
120337	GOF08-PSE-110921	Arachnida	Acari				30°17`21.57"S	119°11`16.35"E					ex T116708
120341	KBF01-PSE-110922	Arachnida	Acari				30°06`55.21"S	119°06`46.68"E					ex T116709
120343	KBF03-PSE-110922	Arachnida	Acari				30°06`53.98"S	119°06`42.62"E					ex T116710
120344	KBF04-PSE-110922	Arachnida	Acari				30°06`40.85"S	119°06`39.24"E					ex T116711
120345	KBF05-PSE-110922	Arachnida	Acari				30°06`57.90"S	119°07`19.39"E					ex T116712
120346	KBF07-PSE-110922	Arachnida	Acari				30°07`03.62"S	119°07`03.04"E					ex T116714
120348	MF01-PSE-110916	Arachnida	Acari				30°12`32.94"S	119°15`24.47"E					ex T116715
120349	MF02-PSE-110916	Arachnida	Acari				30°13`05.35"S	119°15`54.82"E					ex T116716
120351	MF04-PSE-110916	Arachnida	Acari				30°11`45.4"S	119°16`19.24"E					ex T116717
120353	MF05-PSE-110916	Arachnida	Acari				30°11`36.97"S	119°15`37.14"E					ex T116718
120355	MF06-PSE-110916	Arachnida	Acari				30°11`53.54"S	119°14`33.85"E					ex T116719
120357	MF07-PSE-110917	Arachnida	Acari				30°11`44.55"S	119°14`28.03"E					ex T116720
120361	MF11-PSE-110921	Arachnida	Acari				30°12`21.73"S	119°16`40.30"E					ex T116722
120365	MS01-PSE-110923	Arachnida	Acari				30°12`04.81"S	119°17`00.96"E					ex T116723
120367	MS02-PSE-110923	Arachnida	Acari				30°12`10.91"S	119°16`40.24"E					ex T116724
120369	MS03-PSE-110923	Arachnida	Acari				30°12`03.90"S	119°16`13.87"E					ex T116725
120370	MS04-PSE-110923	Arachnida	Acari				30°11`54.86"S	119°15`22.10"E					ex T116726
120372	MS05-PSE-110923	Arachnida	Acari				30°11`53.22"S	119°15`15.19"E					ex T116727

REGNO	FLDNO	CLASS	ORDER	FAMILY	GENUS	SPECIES	LATITUDE	LONGITUDE	M	F	Juv.	TOTAL	REMARKS
120374	MS07-PSE-110923	Arachnida	Acari				30°11`47.99"S	119°15`30.77"E					Ex T116728
120376	MS09-PSE-110923	Arachnida	Acari				30°12`31.11"S	119°15`19.49"E					Ex T116729
120379	MS10-PSE-110923	Arachnida	Acari				30°13`07.37"S	119°15`46.91"E					ex T116730
120363	MS01-PSE-110923	Arachnida	Araneae	Theridiidae			30°12`04.81"S	119°17`00.96"E			1	1	ex T116723
116708	GOF08-PSE-110921	Arachnida	Pseudoscorpiones	Chernetidae		`sp. (juv.)`	30°17`21.57"S	119°11`16.35"E			1	1	
116711	KBF04-PSE-110922	Arachnida	Pseudoscorpiones	Chernetidae	*Nesidiochernes*		30°06`40.85"S	119°06`39.24"E			4	4	
116712	KBF05-PSE-110922	Arachnida	Pseudoscorpiones	Chernetidae		`sp. (juv.)`	30°06`57.90"S	119°07`19.39"E			5	5	
116714	KBF07-PSE-110922	Arachnida	Pseudoscorpiones	Chernetidae	*Nesidiochernes*		30°07`03.62"S	119°07`03.04"E		1	11	12	
116722	MF11-PSE-110921	Arachnida	Pseudoscorpiones	Chernetidae		`sp. (juv.)`	30°12`21.73"S	119°16`40.30"E			1	1	
116723	MS01-PSE-110923	Arachnida	Pseudoscorpiones	Chernetidae		`sp. (juv.)`	30°12`04.81"S	119°17`00.96"E			1	1	
116728	MS07-PSE-110923	Arachnida	Pseudoscorpiones	Chernetidae	*Sundochernes*	`sp. PSE027`	30°11`47.99"S	119°15`30.77"E		1		1	
116729	MS09-PSE-110923	Arachnida	Pseudoscorpiones	Chernetidae	*Sundochernes*	`sp. PSE027`	30°12`31.11"S	119°15`19.49"E		1		1	
120340	KBF01-PSE-110922	Arachnida	Pseudoscorpiones	Chernetidae	*Nesidiochernes*	`sp. (juv.)`	30°06`55.21"S	119°06`46.68"E			1	1	ex T116709
120356	MF07-PSE-110917	Arachnida	Pseudoscorpiones	Chernetidae		`sp. (juv.)`	30°11`44.55"S	119°14`28.03"E			1	1	ex T116720
120377	MS10-PSE-110923	Arachnida	Pseudoscorpiones	Chernetidae		`sp. (juv.)`	30°13`07.37"S	119°15`46.91"E			1	1	ex T116730
116703	GOF02-PSE-110917	Arachnida	Pseudoscorpiones	Chthoniidae	*Austrochthonius*	`sp. (juv.)`	30°17`19.95"S	119°11`26.30"E			1	1	
116706	GOF05-PSE-110920	Arachnida	Pseudoscorpiones	Chthoniidae	*Austrochthonius*	`sp.`	30°17`00.84"S	119°10`20.88"E		1	3	4	
116720	MF07-PSE-110917	Arachnida	Pseudoscorpiones	Chthoniidae	*Austrochthonius*	`sp.`	30°11`44.55"S	119°14`28.03"E		1	4	5	
116721	MF10-PSE-110921	Arachnida	Pseudoscorpiones	Chthoniidae	*Austrochthonius*	`sp. (juv.)`	30°12`13.37"S	119°16`16.36"E			1	1	
116726	MS04-PSE-110923	Arachnida	Pseudoscorpiones	Chthoniidae	*Austrochthonius*	`sp.`	30°11`54.86"S	119°15`22.10"E	1	2	12	15	
116727	MS05-PSE-110923	Arachnida	Pseudoscorpiones	Chthoniidae	*Austrochthonius*	`sp.`	30°11`53.22"S	119°15`15.19"E	7	1	10	18	
116734	GOF04-PSE-110920	Arachnida	Pseudoscorpiones	Chthoniidae	*Austrochthonius*	`sp. (juv.)`	30°17`11.83"S	119°10`14.05"E			15	15	ex T116705
120336	GOF08-PSE-110921	Arachnida	Pseudoscorpiones	Chthoniidae	*Austrochthonius*	`sp. (juv.)`	30°17`21.57"S	119°11`16.35"E			1	1	ex T116708

REGNO	FLDNO	CLASS	ORDER	FAMILY	GENUS	SPECIES	LATITUDE	LONGITUDE	M	F	Juv.	TOTAL	REMARKS
120342	KBF03-PSE-110922	Arachnida	Pseudoscorpiones	Chthoniidae	*Austrochthonius*	`sp. (juv.)`	30°06`53.98"S	119°06`42.62"E			2	2	ex T116710
120350	MF04-PSE-110916	Arachnida	Pseudoscorpiones	Chthoniidae	*Austrochthonius*	`sp. (juv.)`	30°11`45.4"S	119°16`19.24"E			4	4	ex T116717
120352	MF05-PSE-110916	Arachnida	Pseudoscorpiones	Chthoniidae	*Austrochthonius*	`sp. (juv.)`	30°11`36.97"S	119°15`37.14"E			1	1	ex T116718
120359	MF11-PSE-110921	Arachnida	Pseudoscorpiones	Chthoniidae	*Austrochthonius*	`sp.`	30°12`21.73"S	119°16`40.30"E	1		11	12	Ex T116722
120362	MS01-PSE-110923	Arachnida	Pseudoscorpiones	Chthoniidae	*Austrochthonius*	`sp.`	30°12`04.81"S	119°17`00.96"E	2	3	70	75	ex T116723
120366	MS02-PSE-110923	Arachnida	Pseudoscorpiones	Chthoniidae	*Austrochthonius*	`sp. (juv.)`	30°12`10.91"S	119°16`40.24"E			5	5	ex T116724
120368	MS03-PSE-110923	Arachnida	Pseudoscorpiones	Chthoniidae	*Austrochthonius*	`sp. (juv.)`	30°12`03.90"S	119°16`13.87"E			1	1	ex T116725
120373	MS07-PSE-110923	Arachnida	Pseudoscorpiones	Chthoniidae	*Austrochthonius*	`sp.`	30°11`47.99"S	119°15`30.77"E	5	1	3	9	ex T116728
120378	MS10-PSE-110923	Arachnida	Pseudoscorpiones	Chthoniidae	*Austrochthonius*	`sp. (juv.)`	30°13`07.37"S	119°15`46.91"E			3	3	ex T116730
120380	MS01-GAS-110923	Arachnida	Pseudoscorpiones	Chthoniidae	*Austrochthonius*	`sp. (juv.)`	30°12`04.81"S	119°17`00.96"E			2	2	ex Molluscs
116713	KBF06-PSE-110922	Arachnida	Pseudoscorpiones	Garypidae	*Synsphyronus*	`sp. PSE026`	30°07`09.64"S	119°07`08.55"E	1			1	
116715	MF01-PSE-110916	Arachnida	Pseudoscorpiones	Garypidae	*Synsphyronus*	`sp. PSE026`	30°12`32.94"S	119°15`24.47"E		1	2	3	
116724	MS02-PSE-110923	Arachnida	Pseudoscorpiones	Garypidae	*Synsphyronus*	`sp. PSE026`	30°12`10.91"S	119°16`40.24"E	2	1	1	4	
116730	MS10-PSE-110923	Arachnida	Pseudoscorpiones	Garypidae	*Synsphyronus*	`sp. (juv.)`	30°13`07.37"S	119°15`46.91"E			1	1	
120339	KBF01-PSE-110922	Arachnida	Pseudoscorpiones	Garypidae	*Synsphyronus*	`sp. (juv.)`	30°06`55.21"S	119°06`46.68"E			1	1	ex T116709
116719	MF06-PSE-110916	Arachnida	Pseudoscorpiones	Garypinidae	*Solinus*	`sp. (juv.)`	30°11`53.54"S	119°14`33.85"E			1	1	
116702	GOF01-PSE-110917	Arachnida	Pseudoscorpiones	Olpiidae	*Beierolpium*	`sp. (juv.)`	30°16`52.47"S	119°10`21.97"E			1	1	
116704	GOF03-PSE-110920	Arachnida	Pseudoscorpiones	Olpiidae	*Beierolpium*	`sp. 8/4 lge`	30°17`07.00"S	119°10`50.50"E	1		1	1	
116705	GOF04-PSE-110920	Arachnida	Pseudoscorpiones	Olpiidae	*Beierolpium*	`sp. (juv.)`	30°17`11.83"S	119°10`14.05"E			1	1	
116707	GOF07-PSE-110920	Arachnida	Pseudoscorpiones	Olpiidae	*Beierolpium*	`sp. 8/4 lge`	30°17`11.83"S	119°10`14.05"E		1	4	5	
116709	KBF01-PSE-110922	Arachnida	Pseudoscorpiones	Olpiidae	*Indolpium*		30°06`55.21"S	119°06`46.68"E		1		1	
116710	KBF03-PSE-110922	Arachnida	Pseudoscorpiones	Olpiidae	*Beierolpium*	`sp. (juv.)`	30°06`53.98"S	119°06`42.62"E			2	2	
116716	MF02-PSE-110916	Arachnida	Pseudoscorpiones	Olpiidae	*Beierolpium*	`sp. 8/4 lge`	30°13`05.35"S	119°15`54.82"E		1	1	2	

REGNO	FLDNO	CLASS	ORDER	FAMILY	GENUS	SPECIES	LATITUDE	LONGITUDE	M	F	Juv.	TOTAL	REMARKS
116717	MF04-PSE-110916	Arachnida	Pseudoscorpiones	Olpiidae	*Beierolpium*	`sp. (juv.)`	30°11`45.4"S	119°16`19.24"E			1	1	
116718	MF05-PSE-110916	Arachnida	Pseudoscorpiones	Olpiidae	*Beierolpium*	`sp. (juv.)`	30°11`36.97"S	119°15`37.14"E			1	1	
116725	MS03-PSE-110923	Arachnida	Pseudoscorpiones	Olpiidae	*Indolpium*		30°12`03.90"S	119°16`13.87"E			1	1	
120338	KBF01-PSE-110922	Arachnida	Pseudoscorpiones	Olpiidae	*Beierolpium*	`sp. (juv.)`	30°06`55.21"S	119°06`46.68"E			1	1	ex T116709
120347	MF01-PSE-110916	Arachnida	Pseudoscorpiones	Olpiidae	*Beierolpium*	`sp. (juv.)`	30°12`32.94"S	119°15`24.47"E			3	3	ex T116715
120354	MF06-PSE-110916	Arachnida	Pseudoscorpiones	Olpiidae	*Beierolpium*	`sp. 8/4 lge`	30°11`53.54"S	119°14`33.85"E	2			1	ex T116719
120358	MF11-PSE-110921	Arachnida	Pseudoscorpiones	Olpiidae	*Beierolpium*	`sp. 8/4 lge`	30°12`21.73"S	119°16`40.30"E	1			1	ex T116722
120371	MS05-PSE-110923	Arachnida	Pseudoscorpiones	Olpiidae	*Beierolpium*	`sp. (juv.)`	30°11`53.22"S	119°15`15.19"E				1	ex T116727
120375	MS09-PSE-110923	Arachnida	Pseudoscorpiones	Olpiidae	*Beierolpium*	`sp. (juv.)`	30°12`31.11"S	119°15`19.49"E			1	1	ex T116729
	MS01-MIL-110923	Diplopoda	Not kept, bad specimen				30°12`04.81"S	119°17`00.96"E				18	
	MS06-MIL-110923	Diplopoda	Not kept, bad specimen				30°11`58.88"S	119°15`12.74"E				1	
	MS07-MIL-110923	Diplopoda	Not kept, bad specimen				30°11`47.99"S	119°15`30.77"E				12	
	MS10-MIL-110923	Diplopoda	Not kept, bad specimen				30°13`07.37"S	119°15`46.91"E				1	
116732	MS05-MIL-110922	Diplopoda	Polydesmida	Paradoxosomatidae	*Antichiropus*	`Mt Gibson 1 `	30°11`53.22"S	119°15`15.19"E	1			1	
116733	MS05-MIL-110923	Diplopoda	Polydesmida	Paradoxosomatidae			30°11`53.22"S	119°15`15.19"E			1	1	
116736	GOF05-PSE-110920	Diplopoda	Polyxenida	Synxenidae	*Phryssonotus*	*novaehollandiae**	30°17`00.84"S	119°10`20.88"E			1	1	ex T116706
120360	MF11-PSE-110921	Diplopoda	Polyxenida	Synxenidae	*Phryssonotus*	*novaehollandiae**	30°12`21.73"S	119°16`40.30"E			1	1	ex T116722
120364	MS01-PSE-110923	Diplopoda	Polyxenida	Synxenidae	*Phryssonotus*	*novaehollandiae**	30°12`04.81"S	119°17`00.96"E			10	10	ex T116723

*Authority for *Phryssonotus novaehollaniae* - (Sivestri, 1923)

Appendix IV: ScorpionID (2012) report of taxonomic identifications of scorpions collected from the project area

ScorpionID

172D Odin Road, Innaloo, WA, 6018 | Ph: 0457 11 13 17 | email: evolsche@gmail.com

Marda Tenement Scorpion Identification Report

Report ID: RA.Ma.2011.11
Prepared for: Rapallo
By Dr Erich S. Volschenk
Wednesday, 22 February

Rapallo is undertaking a short-range endemic survey at Marda Tenement, and has requested:
- Taxonomic identifications of scorpion from the survey;
- SRE assessment of the species represented in the collection, and;
- Lodgement of these specimens in the Western Australian Museum Arachnology Collection

The collection is comprised of 2 samples.

FAMILY: Buthidae CL Koch, 1837

The family Buthidae is the most diverse and wide spread of all scorpion families (Fet & Lowe 2000). In Australia, Buthidae is represented by the genera *Australobuthus* Locket; *Isometrus* Ehrenberg; *Isometroides* Keyserling , *Lychas* C.L. Koch, and *Hemilychas* Hirst. In Western Australia, only the genera *Isometrus*, *Isometroides* and *Lychas*, have been recorded. The taxonomy of the constituent species of *Isometrus*, *Isometroides* and *Lychas* is very problematic and each genus contains numerous undescribed species, most notably in the genus *Lychas* (Volschenk unpublished data). Most Authors refer to LE Koch (1977) for keys and identification. That revision represents an important study of the Australian scorpions; however, several taxonomic decisions made by Koch (1977) have been rejected by subsequent authors and the taxonomy in that publication is not up to date. Most Australian buthid species appear to have wide distributions; however, a few taxa have confirmed SRE distributions (Volschenk unpublished data).

GENUS: *Lychas* CL Koch, 1845

The genus *Lychas* is widespread across the Australian mainland. The taxonomy of this genus is problematic, with numerous undescribed species known in Australia (Volschenk *et al.* 2010). The situation is further complicated with the genus being also represented in Africa, India and eastern Asia (Fet & Lowe 2000). All of the Australian species are endemic and are currently under revision by ES Volschenk. Most species of *Lychas* appear to have wide distributions; however, a small number of undescribed species are known to be SRE's.

Species: *Lychas jonesae* Glauert, 1925

SRE STATUS
Lychas jonesae is not an SRE.

TAXONOMIC RESOLUTION
Lychas jonesae is a well-defined and clearly recognised species.

DISTRIBUTION
Lychas jonesae is widely distributed throughout Southern Australia and has been recorded from arid parts of Western Australia, South Australia and Victoria (Volschenk Unpublished data).

RECOMENDATIONS
Lychas jonesae is not an SRE and no management is recommended.

WAM Rego.	Client Rego.	♂	♀	Juv.	Location	Notes	Identified by
T114292	MS07	1			WA: Southern Cross, 114 km N		Volschenk E.S.
T114295	MS06			1	WA: Southern Cross, 114 km N		Volschenk E.S.

Number of samples: 2

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Appendix V: WAM (2012b) report of taxonomic identifications of land snails collected from the project area

Land snails from ca. 100km north of Southern Cross (Western Australia)

Report to *Rapallo Environmental*

13 February 2012

Corey S. Whisson

Department of Aquatic Zoology, Western Australian Museum,
Locked Bag 49, Welshpool DC, Western Australia 6986, Australia

SUMMARY

The samples from approximately 100km north of Southern Cross, submitted to the Western Australian Museum in December 2011, contained five species of land snails belonging to the families Bulimulidae; Camaenidae and Pupillidae. None of the species (except possibly *Bothriembryon* sp.) are considered short-range endemic species. Further collecting of *Bothriembryon* specimens is recommended to assist in identification to species level.

METHODS

18 vials of land snail specimens were collected by the environmental consultancy *Rapallo Environmental* during a faunal survey of the area approximately 106-125 km N of Southern Cross, Western Australia in September 2011. These specimens were presented to the Mollusc Section of the Western Australian Museum for identification and comment on the 9th of December 2011 (WAMTS-004).

Specimen data, giving the site numbers and co-ordinates, habitat information and the collecting methods employed were provided with the specimens.

Land snail specimens were examined under a *Leica* MZ95 dissecting microscope. They were compared with dry and preserved specimens in the Molluscan Collections of the Western Australian Museum and with descriptions and figures in relevant publications. As we have limited material from the project area, most survey specimens have been registered and deposited into the Western Australian Museum's Mollusc Collection.

RESULTS

The land snails collected during this survey belong to the terrestrial pulmonate families Bulimulidae; Camaenidae and Pupillidae (Appendix A).

All of the species identified from this survey are considered to form part of the indigenous Western Australian fauna.

Family Bulimulidae

Bothriembryon sp.

The single live-taken juvenile specimen collected during this survey belongs to the genus *Bothriembryon*. Because it was a juvenile specimen, it could not be identified past genus level.

The closest species, *Bothriembryon sedgwicki*, was described from the Nangeenan area. Based on specimens in the collections of the WA Museum, it may possibly exist at Marvel Loch; Lake Johnston and north of Coolgardie.

The genus *Bothriembryon* contains many species that exhibit Short Range Endemism (SRE). It is recommended that further collecting for *Bothriembryon* be undertaken, particularly a large series of specimens (preferably live-taken or freshly dead) so that a species-level identification can be made.

Family Punctidae

***Westralaoma aprica* Iredale, 1939**

The microscopic specimens taken during this survey most closely resemble the species *Westralaoma aprica*.

W.aprica was described by Iredale (1939) from specimens taken in the Nangeenan area, but based on a few isolated records in the collections of the WA Museum, it appears to be widely distributed across the northern wheat belt and western goldfields regions.

***Westralaoma expicta* Iredale, 1939**

The microscopic specimens taken during this survey most closely resemble the species *W. expicta* in their shells' smaller size, shape and noticeable radial ribbing.

W.expicta was described by Iredale (1939) from specimens taken in the Nangeenan area, but based on specimens in the collections of the WA Museum, it appears to be widely distributed across the northern wheat belt and western goldfields regions.

Family Pupillidae

***Gastrocopta bannertonensis* (Gabriel, 1930)**

The specimens collected during this survey exhibit shell characters most consistent with those of the tiny dextral species *Gastrocopta bannertonensis* (Gabriel, 1930). This species has a wide geographic distribution in southern Australia, having been recorded from the southern regions of Western Australia; South Australia and New South Wales. There is also an isolated record of its presence in an area to the north-west of Alice Springs in the Northern Territory (Pokryszko 1996).

***Pupoides myoporinae* (Tate, 1880)**

Pupoides myoporinae (Tate, 1880) has a wide but disjunct distribution across most of southern Australia, with a western range of apparently-scattered populations from Yalata in South Australia to Hines Hill in Western Australia, and with a more restricted eastern range from the Eyre Peninsula to Bannerton in Victoria (Solem 1986, 1991).

It is often found to be sympatric with the larger, dextral coiling *Pupoides adelaidae* (Adams & Angas, 1864).

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Appendix A: Land snails from north of Southern Cross.

Site	Family	Genus	Species	Reg. No. (WAM S)	No. Specimens
GOF03-GAS-110920	Pupillidae	*Gastrocopta*	*bannertonensis*	83177	1 dead-taken
GOF05-GAS-110920		No	Molluscs	N/A	N/A
GOF08-GAS-110921	Punctidae	*Westralaoma*	*aprica*	83178	2 dead-taken
GOF08-GAS-110921	Pupillidae	*Gastrocopta*	*bannertonensis*	83179	3 dead-taken
KBF01-GAS-110922	Pupillidae	*Gastrocopta*	*bannertonensis*	83180	6 dead-taken
KBF01-GAS-110922	Pupillidae	*Pupoides*	*myoporinae*	83181	2 dead, 1 live-taken
KBF02-GAS-110922	Pupillidae	*Gastrocopta*	*bannertonensis*	83182	2 dead-taken
KBF05-GAS-110922	Punctidae	*Westralaoma*	*aprica*	83183	9 dead-taken
KBF07-GAS-110922	Punctidae	*Westralaoma*	*aprica*	83184	2 dead-taken
MF01-GAS-110916	Pupillidae	*Gastrocopta*	*bannertonensis*	83185	1 dead-taken
MF04-GAS-110916	Punctidae	*Westralaoma*	*expicta*	83186	1 dead-taken
MF05-GAS-110916	Pupillidae	*Pupoides*	*myoporinae*	83187	1 live-taken
MF07-GAS-110917	Punctidae	*Westralaoma*	*expicta*	83188	1 dead-taken
MF08-GAS-110917	Punctidae	*Westralaoma*	*expicta*	83189	2 live-taken
MF09-GAS-110918	Pupillidae	*Gastrocopta*	*bannertonensis*	83190	1 dead-taken
MF09-GAS-110918	Punctidae	*Westralaoma*	*expicta*	83191	3 dead-taken
MS01-GAS-110923	Punctidae	*Westralaoma*	*expicta*	83192	6 live-taken
MS02-GAS-110923	Bulimulidae	*Bothriembryon*	sp.	83193	1 live-taken
MS02-GAS-110923	Pupillidae	*Gastrocopta*	*bannertonensis*	83194	1 dead-taken
MS05-GAS-110923	Pupillidae	*Gastrocopta*	sp. (juv.)	Not Kept	1 dead-taken
MS07-GAS-110923	Punctidae	*Westralaoma*	*expicta*	83195	1 dead-taken
MS10-GAS-110923		No	Molluscs	N/A	N/A

Appendix VI: Habitat descriptions of all trapping and foraging sites in the Marda, Golden Orb and King Brown tenements

Appendix VI: Habitat descriptions of all trapping and foraging sites in the Marda, Golden Orb and King Brown tenements

Marda tenement - Dry pitfall trapping sites	
Site	**Habitat**
MS01	Landform: Floodplain. Vegetation: Open tall Eucalypt woodland over scattered Acacia, Senna and Persoonia shrubland over chenopods, grasses and herbs.Outcrops: N. Soil: Orange-brown Clay loam with top layer of ironstone pisoliths. Leaf litter collected from: Eucalyptus sp.
MS02	Landform: Creekline. Vegetation: Acacia and Santalum with occasional emergent mallee EucalyptsOutcrops: N. Soil: Orange-red Clay-loam with riverine sand. Leaf litter collected from: Acacia acuminata
MS03	Landform: Hillside - very shallow hill slope. Vegetation: Casuarina pauper over Acacia, Eremophila, Olearia over Atriplex and PtilotusOutcrops: N. Soil: Orange-brown Loamy clay. Leaf litter collected from: Casuarina pauper
MS04	Landform: South-facing slope: Isolated hill. Vegetation: Mallee Eucalypts over Acacia, Allocasuarina acutivalvis, Philotheca, Grevillea over sedges with small patch of orchidsOutcrops: BIF. Soil: Red-brown BIF with shallow clay-loam covered in BIF rocks. Leaf litter collected from: Acacia sp.
MS05	Landform: North-facing slope opposite south-facing slope receiving lots of water runoff: isolated hill. Vegetation: Scattered eucalypts over Acacia and Allocasuarina acutivalvis over Thysanotus, PhylothecaOutcrops: BIF. Soil: Orange-brown Shallow clay loam over weathered BIF rock. Leaf litter collected from: Acacia sp.
MS06	Landform: South-facing slope (shallow): Isolated hill. Vegetation: Shrubland with Acacia, Allocasuarina acutivalvis, Grevillea over everlastingsOutcrops: N. Soil: Orange Clay-loam with rocks. Leaf litter collected from: Grevillea sp. (big white flowers)
MS07	Landform: Floodplain. Vegetation: Open shrubland of Acacia acuminata, Eremophila, Santalum over Senna over Ptilotus, grasses, herbsOutcrops: N. Soil: Orange-borwn Sandy clay-loam. Leaf litter collected from: Acacia sp.
MS08	Landform: Hillside - very shallow hill slope. Vegetation: Casuarina pauper over Acacia, Eremophila over Ptilotus, Dodenea, chenopodsOutcrops: N. Soil: Red-brown Sandly clay-loam. Leaf litter collected from: Casuarina pauper
MS09	Landform: Floodplain. Vegetation: Tall open Eucalypt woodland over Eremophila over Atriplex, Ptilotus, small EremophilaOutcrops: N. Soil: Red-brown Loam with stony surface. Leaf litter collected from: Eucalyptus sp.
MS10	Landform: South-facing scree slope with outcropping and shallow caves: Rocks very porous. Vegetation: Not described: see photosOutcrops: BIF. Soil: Red-brown and dark blue Weathered BIF scree slope with very shallow soil. Leaf litter collected from: Eucalyptus sp.
Marda tenement - Foraging sites	
Site	**Habitat**
MF01	Landform: Plain. Vegetation: Tall open Eucalypt woodland over Eremophila over Atriplex, Ptilotus, small EremophilaOutcrops: N. Soil: Red-brown Loam with stony surface (ironstone). Leaf litter collected from: Eucalyptus sp.
MF02	Landform: Small rocky BIF hill. Vegetation: Not described: see photosOutcrops: BIF. Soil: Orange-brown Stony clay. Leaf litter collected from: Eucalyptus sp.
MF03	Landform: Weathered granitoid BIF outcrop. Vegetation: Open shrubland of Casuarina pauper and Eucalypts over Acacai acuminata over LeptospermumOutcrops: BIF. Soil: Orange Very weathered rocks. Leaf litter collected from: not recorded
MF04	Landform: Plain. Vegetation: Open Eucalypt woodland over Atriplex, Ptilotus, Maireana, Eremophila, ScopariaOutcrops: N. Soil: Red-brown Clay with stony surface (quartz/chert). Leaf litter collected from: Eucalyptus sp.

MF05	Landform: Plain. Vegetation: Open Eucalypt woodland over Exocarpus, Eremophila, Acacia, AtriplexOutcrops: N. Soil: Orang-brown Clay with stony surface (ironstone and chert). Leaf litter collected from: Eucalyptus sp.
MF06	Landform: BIF Hill. Vegetation: Banksia arborea and Casuarina pauper over Acacia, Allocasuarina acutivalvis, Casuarina over Acacia, Grevillea, Eremophila, Dodenea and PtilotusOutcrops: BIF. Soil: Orange and blue Rocky BIF. Leaf litter collected from: Banksia arborea
MF07	Landform: Hill top. Vegetation: Shrubland with emergent Eucalypts and Casuarina pauper over Allocasuarania acutivalvis, Eremophila, Melaleuca, Dodenea, Acacia, over Lobelia, Ptilotus, small Acacias and HibbertiaOutcrops: BIF. Soil: Orange Very hard rocky clay. Leaf litter collected from: Eucalyptus sp.
MF08	Landform: BIF hill. Vegetation: Allocasuarina acutivalvis over Grevillea, Exocarpus, Eremophila, Acacia over Thysanotus, Hibbertia, sedges, ferns, everlastingsOutcrops: BIF. Soil: Orange-brown Solid BIF rock with boulders and stones. Leaf litter collected from: Allocasuarina sp.
MF09	Landform: Hill slope. Vegetation: Open Eucalypt woodland over Acacia, Eremophila over Ptilotus, ChenopodsOutcrops: N. Soil: Dark orange Clay with ironstone pisoliths. Leaf litter collected from: Eucalyptus sp.
MF10	Landform: South-facing slope of rocky rise. Vegetation: Very open Eucalypt and Casuarina pauper woodland over Acacia tetragonophila, Acacia acuminata, Allocasuarina acutivalvis over Eremophila, Grevillea, Dodenea, PtilotusOutcrops: BIF. Soil: Orange Heavily weathered BIF with shallow layer of clay covered in rocks. Leaf litter collected from: Allocasuarina acutivalvis
MF11	Landform: Creekline. Vegetation: Tall (20 m) Eucalypts over Exocarpus, Acacia acuminata, Santalum spicatum over Eremophila over PtilotusOutcrops: N. Soil: Orange Loamy clay with some gravel. Leaf litter collected from: Eucalyptus sp.
MF12	Landform: Plateau. Vegetation: Scattered emergent Eucalypts over Allocasuarina campestris, Grevilla, over Acacia over Thysanotus, Dionella, Dodenea Outcrops: N. Soil: Orange Thin gravely clay . Leaf litter collected from: Allocasuarina campestris and Grevillea
MF13	Landform: Plain - gentle slope. Vegetation: Casuarina pauper over Acacia acuminata shrubland over Ptilotus and EverlastingsOutcrops: N. Soil: Orange Rocky clay with stones. Leaf litter collected from: Acacia acuminata
Golden Orb tenement - Foraging sites	
Site	**Habitat**
GOF01	Landform: Low weathered rocky ridge. Vegetation: Low shrubland with emergent Eucalypts over Melaleuca, Allocasuarina acutivalvis, Santalum spicatum, Acacia, Exocarpus over Calytrix, Atriplex, Dodenea over lychens. Outcrops: Quartz. Soil: Pale orange-yellow Weathered quartz and granitoids. Leaf litter collected from: Melaleuca
GOF02	Landform: Plateau (raised plain). Vegetation: Dense heath of Acacia over Grevillea (pink), Melaleuca over Eremophila and peasOutcrops: N. Soil: Orange Lateritic clay. Leaf litter collected from: Grevillea
GOF03	Landform: Plain - gentle slope. Vegetation: Heavily disturbed and largely cleared Casuarina pauper woodland with occasional emergent Eucalypt, over Acacia, Eremophila, Grevillea.Outcrops: N. Soil: Orange Loamy clay. Leaf litter collected from: Casuarina pauper
GOF04	Landform: Hill slope. Vegetation: Casuarina pauper woodland with emergent Eucalypts over Acacia, Eremophila, Atriplex, PtilotusOutcrops: N. Soil: Orange Clay with lateritic ironstone cover. Leaf litter collected from: Casuarina pauper
GOF05	Landform: Plain - gentle slope. Vegetation: Scattered emergent eucalypts over dense Acacia acuminata shrub with Exocarpus, Grevillea, Santalum, EremophilaOutcrops: N. Soil: Orange Clay with cover of rocks and stones (ironstone). Leaf litter collected from: Acacia sp.
GOF06	Landform: Hill slope. Vegetation: Allocasuarina campestris, Allocasuarina acutivalvis, Grevillea, Acacia over Eremophila, Philotheca and daisiesOutcrops: N. Soil: Orange Shallow gravely clay. Leaf litter collected from: Allocasuarina campestris

GOF07	Landform: Plain. Vegetation: Open Eucalypt woodland over Eremophila, Acacia, Santalum acuminatum over Chenopods, Ptilotus, DodeneaOutcrops: N. Soil: Orange Loamy clay. Leaf litter collected from: Eucalypt (flaky barked)
GOF08	Landform: Floodplain. Vegetation: Very open Callitris and Eucalypt woodland over Acacia and EremophilaOutcrops: N. Soil: Orange Shallow loamy clay. Leaf litter collected from: Callitris
King Brown tenement - Foraging sites	
Site	**Habitat**
KBF01	Landform: Plain. Vegetation: Open Casuarina pauper and Eucalyp woodland over Exocarpus, Eremophila, Acacia over chenopodsOutcrops: N. Soil: Pale orange Rocky clay with calcrete, ironstone, quartz. Leaf litter collected from: Eucalyptus
KBF02	Landform: Hill slope. Vegetation: Open Casuarina pauper and Eucalyp woodland Eremophila, Acacia over chenopods and PtilotusOutcrops: Boulders. Soil: Pale orange Rocky clay with calcrete, ironstone, quartz. Leaf litter collected from: Casuarina pauper
KBF03	Landform: Plain at base of hill. Vegetation: Scattered emergent Eucalypts and Casuarina pauper over thicket of Acacia acuminata and Acacia tetragonophilla over Senna, Eremophila, PtilotusOutcrops: N. Soil: Red-brown Stony loamy clay (quartz, ironstone). Leaf litter collected from: Acacia acuminata
KBF04	Landform: Plain at base of hill. Vegetation: Casuarina pauper woodland bordering on Acacia acuminata shrubland over Chenopods and PtilotusOutcrops: N. Soil: Orange-brown Rocky loamy clay. Leaf litter collected from: Casuarina pauper
KBF05	Landform: Hilltop. Vegetation: Emergent Casuarina pauper over Acacia sp. over smaller Eremophila, Dodenea over smaller Acias, everlastings and daisiesOutcrops: N. Soil: Orange Loamy clay with rocky cover. Leaf litter collected from: Acacia sp.
KBF06	Landform: Plain - Margin of salt lake. Vegetation: Mallee Eucalypts over Casuarina pauper, Acacia, Eremophila over Atriplex and HalosarciaOutcrops: N. Soil: Pale pink brown Loamy clay high in salt with somesurface rocks (quartz, ironstone). Leaf litter collected from: Eucalyptus salubris
KBF07	Landform: Creekline. Vegetation: Tall Eucalyps and Casuarina pauper over Exocarpus, Acacia, Eremophila, Senna over Atriplex, Halosarcia, Rhagodia and PtilotusOutcrops: N. Soil: Orange-brown Sandy clay. Leaf litter collected from: Exocarpus

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