



# PHOENIX

ENVIRONMENTAL SCIENCES

## **Terrestrial fauna survey for the Balla Balla Magnetite Project barge loading facility**

Prepared for Forge Resources Ltd

**February 2013**

Draft Report



Terrestrial fauna survey for the Balla Balla Magnetite Project barge loading facility

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Draft Report

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## EXECUTIVE SUMMARY

Forge Resources Ltd (Forge) is developing the Balla Balla Magnetite Project and associated infrastructure approximately 10 km north-west of Whim Creek, 85 km east of Karratha in the Pilbara region of WA. Forge proposes to develop the Balla Balla Magnetite Project barge loading facility (the Project) to transport magnetite ore via a conveyor system from mine to barges for transshipment to larger ocean going vessels. The Project involves construction of a dewatering plant, stockyards, overland and over water conveyor and associated infrastructure.

In November 2012, Phoenix Environmental Sciences Pty Ltd (Phoenix) was commissioned by Forge to undertake a Level 1 desktop and reconnaissance survey, followed by a Level 2 vertebrate and short-range endemic (SRE) invertebrate fauna assessment. Migratory shorebird surveys were also undertaken concurrently and are being addressed in a separate report (Phoenix 2013).

A Level 1 desktop survey was undertaken in November, 2012 followed by a Level 1 reconnaissance survey from 9 to 12 November, 2012. Based on the findings of the Level 1 assessment, a Level 2 survey was undertaken for vertebrate and SRE invertebrate fauna from 27 November to 7 December, 2012.

The objective of the Level 2 survey was to determine the potential for conservation significant vertebrate fauna and SRE invertebrates to be present in the study area and assess potential impacts of the Project on terrestrial fauna.

Five sites were systematically surveyed for vertebrate fauna representing all major fauna habitats in the study area and additional sampling was undertaken at several other sites. Survey methods comprised systematic trapping, timed avifauna surveys, echolocation call recordings for bats, spotlighting for nocturnal species, active and targeted searches and infrared motion camera trapping. Species records within the study area from the migratory shorebird survey were also included in the assemblage results in this report.

Eleven sites were surveyed for SRE invertebrates, including six dedicated SRE sites and the five systematic vertebrate sites. The collecting methods consisted of dry pitfall trapping, active searches and the sieving of combined leaf litter and soil samples.

Nine broad habitat types for terrestrial fauna and SRE invertebrates were identified in the study area: samphire plains, tussock and hummock grasslands, open shrubland, rocky outcrops and boulder piles, minor creeks and drainage lines, salt flats, coastal sand dunes, mangrove thickets and intertidal mudflats.

A total of 356 vertebrate fauna species were identified from the area of the desktop review, comprising eight amphibians, 95 reptiles, 202 birds and 51 mammals (42 native and nine introduced). Fifty seven of these are of conservation significance under State or Federal legislation; with the majority migratory avifauna. A further 13 species are listed as Priority on the Department of Environment and Conservation list.

The survey recorded 158 vertebrate fauna species representing 56 families in 20 orders across all terrestrial vertebrate fauna classes. This represents approximately 44% of the species identified in the desktop review. The fauna assemblage was strongly dominated by birds with a total of 98 species recorded, representing 62% of fauna records from the survey.

Twenty five vertebrate species of conservation significance were recorded during the survey, including 22 migratory avifauna; six of these are classified as Schedule 1 under the *Wildlife Conservation Act 1950*. Three Priority species (one P1 and two P4 species) were also recorded.

The extensive intertidal mudflats, mangroves and associated coastline are utilised by a large number of migratory shorebird species. The significance of the study area to migratory shorebirds is being documented in the migratory shorebird report for the Project (Phoenix 2013).

No reptile species of conservation significance were recorded during the survey. Targeted searches and trapping were conducted in potential habitat for Nevin's Lerista (*Lerista neviniae*; Schedule 1) but the species was not recorded. The likelihood of occurrence of Nevin's Lerista in the study area is considered low, based on the distance of closest records (50 km west), apparent narrow distribution and survey results.

The Australian Bustard (*Ardeotis australis*; DEC Priority 4) and Flock Bronzewing (*Phaps histrionicus*; DEC Priority 4) were recorded in the survey and are actively utilising the study area.

Only one mammal species of conservation significance was recorded during the survey, Little North-western Mastiff Bat (*Mormopterus loriae cobourgiana*; DEC Priority 1). The species was recorded at seven of ten SongMeter recording sites with calls virtually continuous throughout the night. Results indicate the species is foraging widely across the study area and the high abundance indicates large numbers are roosting in the dense mangrove thickets along the coastline.

The Project may result in a number of direct and indirect impacts on vertebrate fauna within the study area. None of these are likely to result in a significant impact to any conservation significant vertebrate fauna. Overall the Project is likely to result in minor, localised impacts to fauna assemblages and habitats. Most risks to fauna can be adequately managed through the implementation of appropriate mitigation and management measures (see section 0).

Impacts to Little North-western Mastiff Bat are considered unlikely to be significant; however, there are uncertainties regarding the threatening processes for this species and the potential for project-specific impacts are not fully understood.

A total of 61 SRE invertebrate taxa, including 27 confirmed, eight likely and 26 potential SREs were identified from the reference area of the desktop review. Database searches did not reveal any conservation significant SRE invertebrates from the area of the desktop review. A single potential SRE taxon, the unidentified camaenid land snail *Rhagada* sp. indet., was recovered through the desktop review inside the study area. The genus *Rhagada* is locally abundant outside the study area including the widely distributed *Rhagada richardsonii*; however, the study area records are considered to be potential SREs as it cannot be determined whether they are conspecific with *R. richardsonii*.

Four potential SRE taxa in three genera were recorded in the survey:

- unidentified trapdoor spiders in the genus *Aname* sp. indet. (family Nemesiidae)
- two species of slaters, *Buddelundia* '10 1016A' and *Buddelundia* '10 1016B' (family Armadillidae)
- the scorpions *Lychas* cf. *mjobergi* (family Buthidae).

None of the potential SRE specimens were collected from within the project footprint. Potential impacts on these by the Project are considered negligible as they are found in well-represented habitat outside the project footprint.

A fauna management plan (stand alone or incorporated into the existing management plans for the Project) should be developed that outlines all management measures that will be undertaken to manage impacts to fauna and fauna habitats.

A monitoring plan is recommended to monitor impacts on Little North-western Mastiff Bat during construction and operation given the uncertainties regarding potential impacts on this species.

No further management is required for SRE invertebrates.

# 1 INTRODUCTION

In November 2012, Phoenix Environmental Sciences Pty Ltd (Phoenix) was commissioned by Forge Resources Ltd (Forge) to undertake terrestrial fauna surveys for the Balla Balla Magnetite Project barge loading facility ('the Project'). The surveys entailed a Level 1 desktop and reconnaissance survey, followed by a Level 2 vertebrate and short-range endemic (SRE) invertebrate fauna assessment.

This report describes the results of the surveys which were undertaken between 9 November and 7 December, 2012. A migratory shorebird survey was also undertaken concurrently; the results of the study are provided in a separate report (Phoenix 2013).

The Project is located approximately 10 km northwest of Whim Creek, 85 km east of Karratha in the Pilbara bioregion of WA (Figure 1-1).

A broad study area was adopted for the Level 1 reconnaissance survey to accommodate several placement options being considered for the barge loading facility at the time of the survey (Figure 1-1). By the time of the Level 2 survey, the number of placement options had been refined to two; the Level 2 study area was therefore defined by these with a 2 km buffer applied to allow for alignment variations (Figure 1-1).

In this report 'study area' refers to the Level 2 survey area. Where the Level 1 survey is referred to the term 'Level 1 study area' is used.

## 1.1 BACKGROUND

Forge is proposing to develop a mine near Whim Creek with associated processing plant, shipment stockyard and barge loading facility infrastructure. The mine will comprise the extraction and processing of up to 10.3 mtpa of magnetite ore to produce 6 mtpa of magnetite concentrate over a 15 year mine life.

Environmental approval for the mine and associated infrastructure has previously been obtained (EPA 2009a) but approvals are still required for the barge loading facility. The surveys documented in this report were undertaken to support the environmental impact assessment for the barge loading facility.

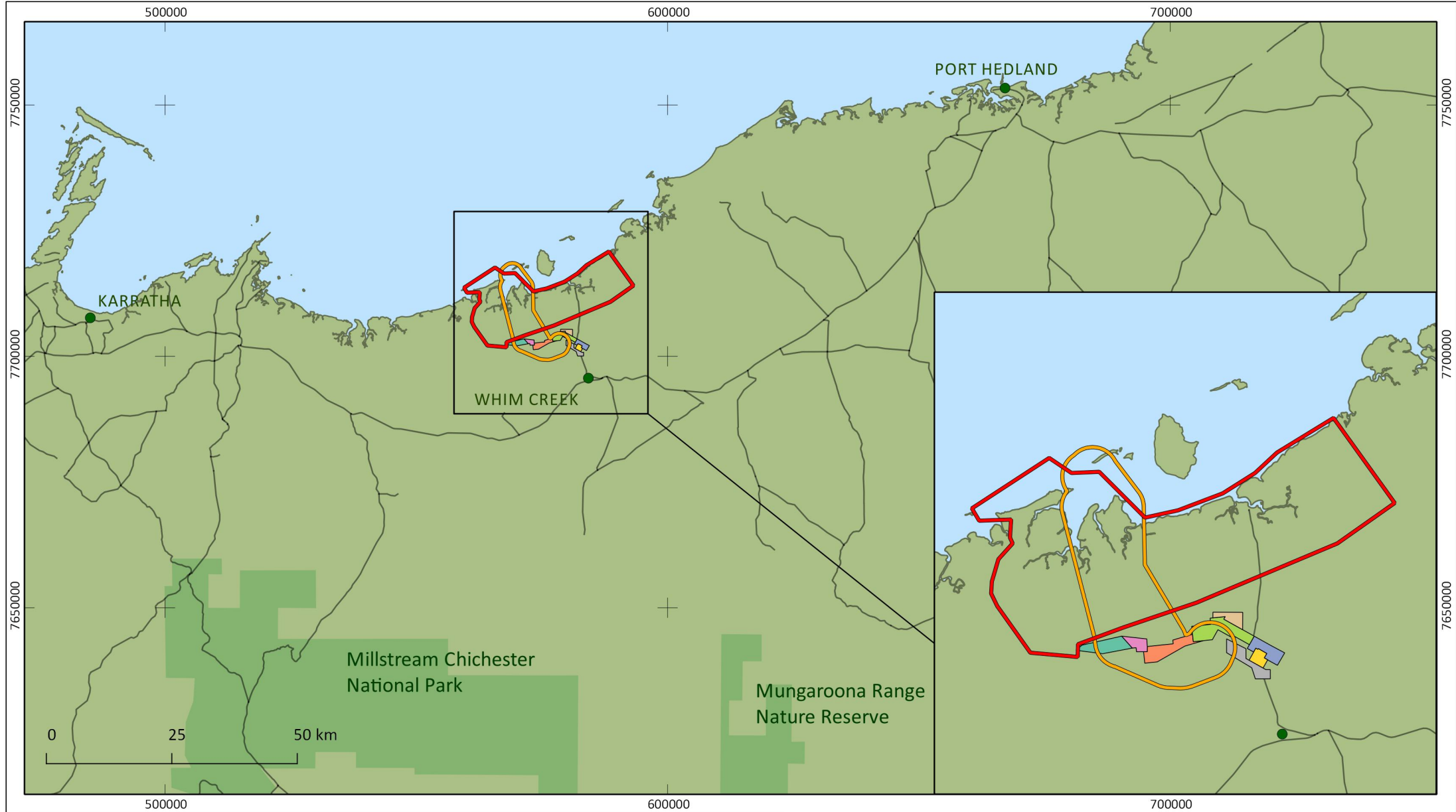
During operations, the magnetite product will be pumped as slurry from the processing plant at the mine site to a dewatering plant located at the stockyards. The dewatering plant forms part of the main process plant but is located remotely from the main plant at the stockyards approximately 7 km from the main plant.

The stockyard will have an automated stacking and reclaim system using a rail mounted stacker and bucket wheel reclaimer. An automated emergency stockpiling system will be installed that will require manual reclaim with a front end loader.

Product will be reclaimed from the live stockpiles by a rail mounted bucket wheel reclaimer and feed via an overland and over water conveyor to a barge loader.

A self-propelled barge (SPB) with a 15,000 dwt capacity will be loaded with product from a fixed point luffing and slewing barge loader mounted of a jetty.

The magnetite concentrate will be loaded onto barges for transshipment to larger ocean going vessels by an on-board reclaimer and conveyor system with a typical shipment size of 165,000 tonnes.



**Figure 1-1**  
**Location of the Balla Balla Magnetite Project**  
**barge loading facility and study areas**

**AUTHOR:** N. Dight      **CLIENT:** Forge Resources

**DATE:** 27 November 2012      **Scale:** 1:1000000

**Coordinate System:** Projection: UTM zone 50; Datum: WGS84



**PROJECT:** Balla Balla Magnetite Project barge loading facility

- |                                    |         |         |
|------------------------------------|---------|---------|
| Level 1 study area                 | M47/311 | M47/804 |
| Level 2 study area                 | M47/317 |         |
| National parks and nature reserves | M47/360 |         |
| M47/297                            | M47/361 |         |
| M47/298                            | M47/541 |         |

## 1.2 SCOPE OF WORK AND SURVEY OBJECTIVES

The survey aims and scope of works were as follows:

- undertake a desktop review of relevant databases, literature and spatial data to assess the potential for presence of conservation significant vertebrate and SRE invertebrate fauna species, and habitats in the Level 1 study area
- conduct a Level 1 reconnaissance survey across the Level 1 study area to
  - validate the findings of the desktop review
  - determine appropriate further survey effort and select sites for follow up Level 2 vertebrate and SRE surveys
  - assess potential for significant numbers of migratory shorebirds by undertaking a preliminary assessment of their diversity, abundance and distribution in the Level 1 study area and determine if more comprehensive shorebird surveys are required (these results are presented in (Phoenix 2013))
  - provide early feedback on potential significant fauna values that may warrant consideration in site selection, particularly for the barge loading facility
  - identify potential access constraints and solution to facilitate the Level 2 survey
- undertake a Level 2 vertebrate fauna survey in the study area to collect comprehensive assemblage data and determine if conservation significant species are present
- undertake an SRE invertebrate survey to determine if SRE species are present in the study area
- undertake specimen identifications and data analysis
- prepare maps showing significant species records and habitats in the study area
- prepare a technical report outlining survey methods, results, assessment of significant species and habitats, assessment of potential impacts on terrestrial fauna from the Project and recommendations for management and mitigation of impacts.

The vertebrate survey adhered to the principles and practices of the Technical Guide: *Terrestrial Vertebrate Fauna Surveys for Environmental Impact Assessment* (EPA & DEC 2010).

The SRE survey adhered to the principles and practices of Guidance Statement No. 20: *Sampling of short-range endemic invertebrate fauna for environmental impact assessment (EIA) in Western Australia* (EPA 2009b).

Both surveys conformed with the requirements of EPA Position Statement No. 3: *Terrestrial biological surveys as an element of biodiversity protection* (EPA 2002) and Guidance Statement No. 56: *Terrestrial fauna surveys for environmental impact assessment in Western Australia* (EPA 2004).



## 2 EXISTING ENVIRONMENT

### 2.1 INTERIM BIOGEOGRAPHIC REGIONALISATION OF AUSTRALIA

The Interim Biogeographic Regionalisation of Australia (IBRA) defines 'bioregions' as large land areas characterised by broad, landscape-scale natural features and environmental processes that influence the functions of entire ecosystems (DSEWPC 2011b; Thackway & Cresswell 1995). Their purpose is to record and categorise the large-scale geophysical patterns that occur across the Australian continent. The identified patterns in the landscape are linked to fauna and flora assemblages and processes at the ecosystem scale. They are a useful means for simplifying and reporting on more complex patterns of biodiversity (Thackway & Cresswell 1995).

Western Australia contains 26 IBRA bioregions and 53 subregions. By combining information for an IBRA region with information on protected areas within the region and its sub-regions, the level of protection of Australia's various landscapes can be established. IBRA is therefore a dynamic tool for monitoring progress towards building a comprehensive, adequate and representative reserve system (DSEWPC 2011b).

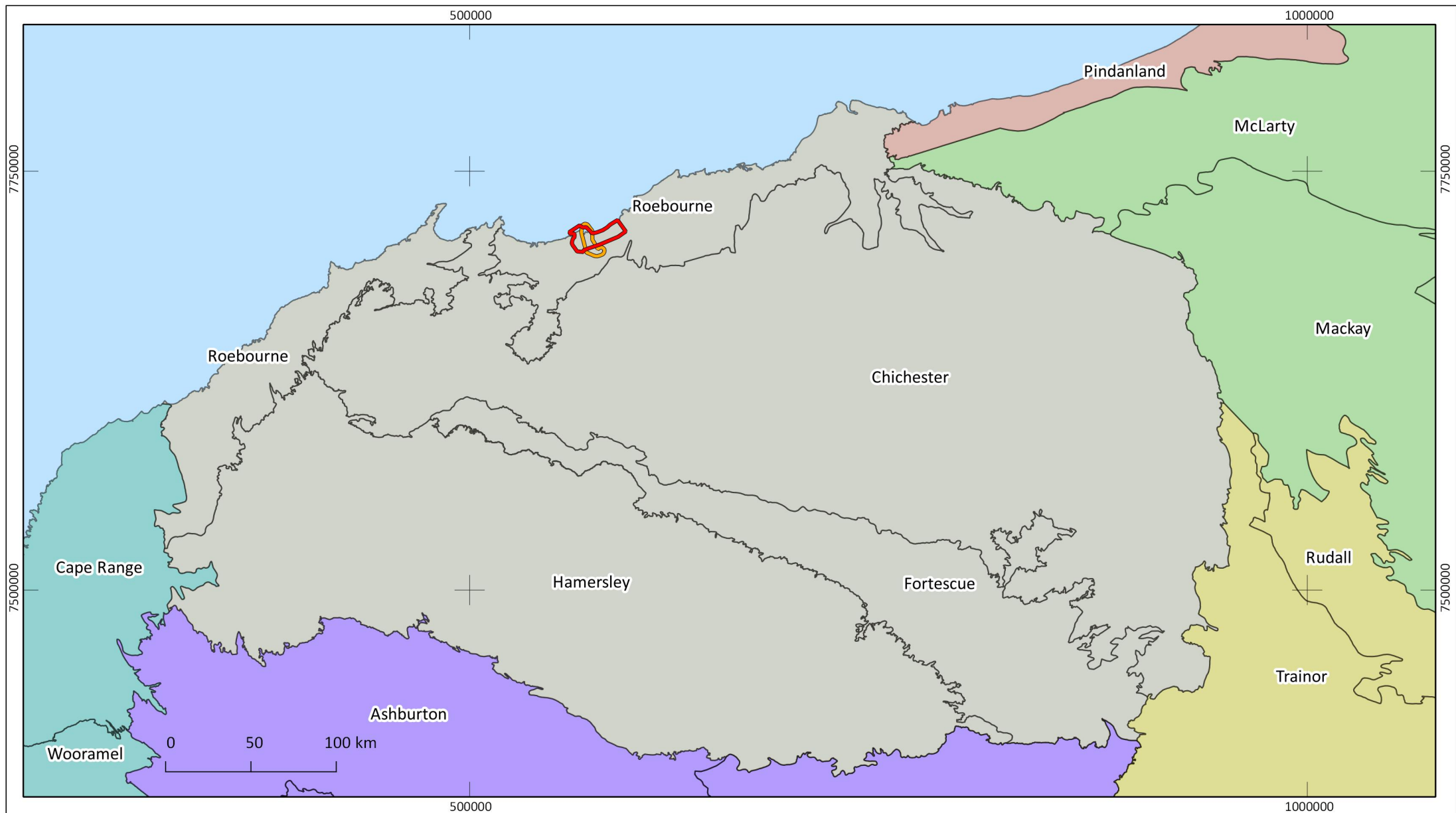
The study area falls within the Pilbara region, which covers an area of approximately 179,000 km<sup>2</sup> and is divided into four subregions (DSEWPC 2012b):

- **Chichester subregion (PIL1):** undulating Archaean granite and basalt plains supporting shrub steppe of *Acacia* over *Triodia* hummock grasslands.
- **Fortescue Plains subregion (PIL2):** alluvial plains and river frontages, northern limit of Mulga, deeply incised forge systems and extensive calcrete aquifer feeding permanent springs and large permanent wetlands.
- **Hamersley subregion (PIL3):** mountainous area of Proterozoic sedimentary ranges and plateaux dissected by gorges, Mulga woodland over grasses.
- **Roebourne synopsis (PIL4):** Quaternary alluvial and older colluvial coastal and sub-coastal plains with a grass savannah.

The study area is situated in the Roebourne synopsis (Figure 2-1) which is characterised by (Kendrick & Stanley 2001):

- alluvial and colluvial coastal and sub-coastal plains with dwarf shrub steppe of *Acacia* and a grass savannah of mixed bunch and hummock grasses and uplands dominated by *Triodia* hummock grasslands
- ephemeral drainage lines supporting *Eucalyptus victrix* and *Corymbia hamersleyana* woodlands
- marine alluvial flats and river deltas with samphire, *Sporobolus* and mangal
- mangrove communities along the coast of the subregion
- linear ranges of basalts across the coastal plains, with minor exposures of granite
- islands composed of basalt, limestone and/or Quaternary sand accumulations, or combinations of the three
- an arid (semi-desert) tropical climate with highly variable rainfall and cyclonic activity, primarily over summer.

Rare features within the subregion include the many offshore islands including the Dampier Archipelago and the Burrup Peninsula as well as the Cane River Swamp. The DeGrey River and the Leslie Saltfields system are recognised as wetlands of national significance.



**Figure 2-1**  
**Location of the Balla Balla Magnetite Project**  
**barge loading facility in relation to IBRA**  
**regions and subregions**

**AUTHOR:** N. Dight

**CLIENT:** Forge Resources

**DATE:** 27 November 2012

**Scale:** 1:3000000

**Coordinate System:** Projection: UTM zone 50; Datum: WGS84




**PHOENIX**  
 ENVIRONMENTAL SCIENCES

**PROJECT:** Balla Balla Magnetite Project barge loading facility

 Level 1 study area

 Level 2 study area

**Bioregions**

 Gascoyne

 Pilbara

 Carnarvon

 Great Sandy Desert

 Dampierland

 Little Sandy Desert

## 2.2 LAND SYSTEMS

The Department of Agriculture and Food Western Australia has mapped the land systems of the Roebourne subregion from aerial photography, providing the largest-scale interpretation of vegetation units for the study area (Payne & Leighton 2004; van Vreeswyk *et al.* 2004).

The Balla Balla study area comprises five land systems (Figure 2-2):

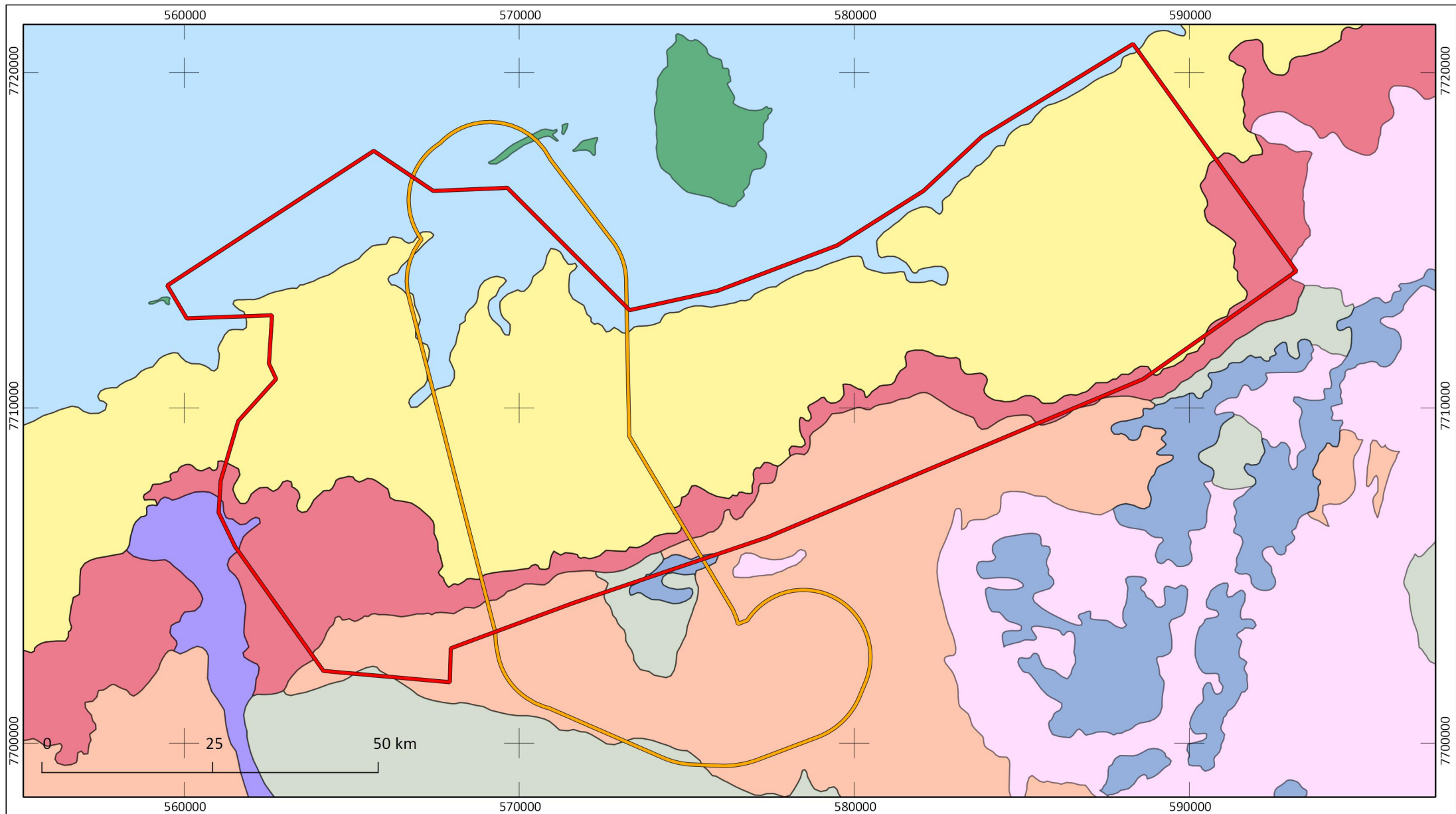
- **Cheerawarra:** sandy coastal plains and saline clay plains supporting soft and hard spinifex grasslands and minor tussock grasslands
- **Horseflat:** gilgaied clay plains supporting tussock grasslands and minor grassy snakewood shrublands
- **Littoral:** bare coastal mudflats with mangroves on seaward fringes, samphire flats, sandy islands, coastal dunes and beaches
- **Mallina:** sandy surfaced alluvial plains supporting soft spinifex (and occasionally hard spinifex) grasslands
- **Ruth:** hills and ridges of volcanic and other rocks supporting hard spinifex (occasionally soft spinifex) grasslands.

The dominant land systems of the study area are the Littoral and Horseflat land systems. The Littoral land system covers approximately 44 km<sup>2</sup> (35%) of the study area the Horseflat land system approximately 43 km<sup>2</sup> (34%). The remaining three land systems comprise less than 7 km<sup>2</sup> each of the study area; Mallina 6.4 km<sup>2</sup> (5%), Cherrawarral 3.3 km<sup>2</sup> (3%) and Ruth 1.5 km<sup>2</sup> (1%). The remaining 22% of the study area is covered by ocean and is therefore unclassified.

Important faunal habitats present within the five land systems include:

- coastal habitats including intertidal, beach, coastal dune and mangrove habitats providing foraging, roosting and nesting areas for migratory shorebirds and marine turtles
- rocky habitats providing potential shelter and roost sites for small to medium-sized mammals and habitat for SRE invertebrates
- open grasslands providing foraging habitat for ground dependant foraging birds such as the Australian Bustard
- creeklines with sufficient riparian vegetation providing a water source and resting/feeding stopovers for some conservation significant and migratory vertebrates, and moist sheltered environments for SRE invertebrates.

There are no major geographical features such as southern-facing rocky slopes or granite outcrops within the study area that typically supports some SRE invertebrates.



**Figure 2-2**  
**Land systems of the Level 1 and Level 2 study**  
**areas of the Balla Balla Magnetite Project**  
**barge loading facility**

**AUTHOR:** N. Dight      **CLIENT:** Forge Resources

**DATE:** 27 November 2012      **Scale:** 1:150000

**Coordinate System:** Projection: UTM zone 50; Datum: WGS84



**PHOENIX**  
 ENVIRONMENTAL SCIENCES

**PROJECT:** Balla Balla Magnetite Project barge loading  
 facility

- Level 1 study area
- Level 2 study area
- Offshore islands
- Cheerawarral land system
- Horseflat land system

- Littoral land system
- Mallina land system
- Ruth land system
- River land system
- Other land systems

## 2.3 CLIMATE AND WEATHER

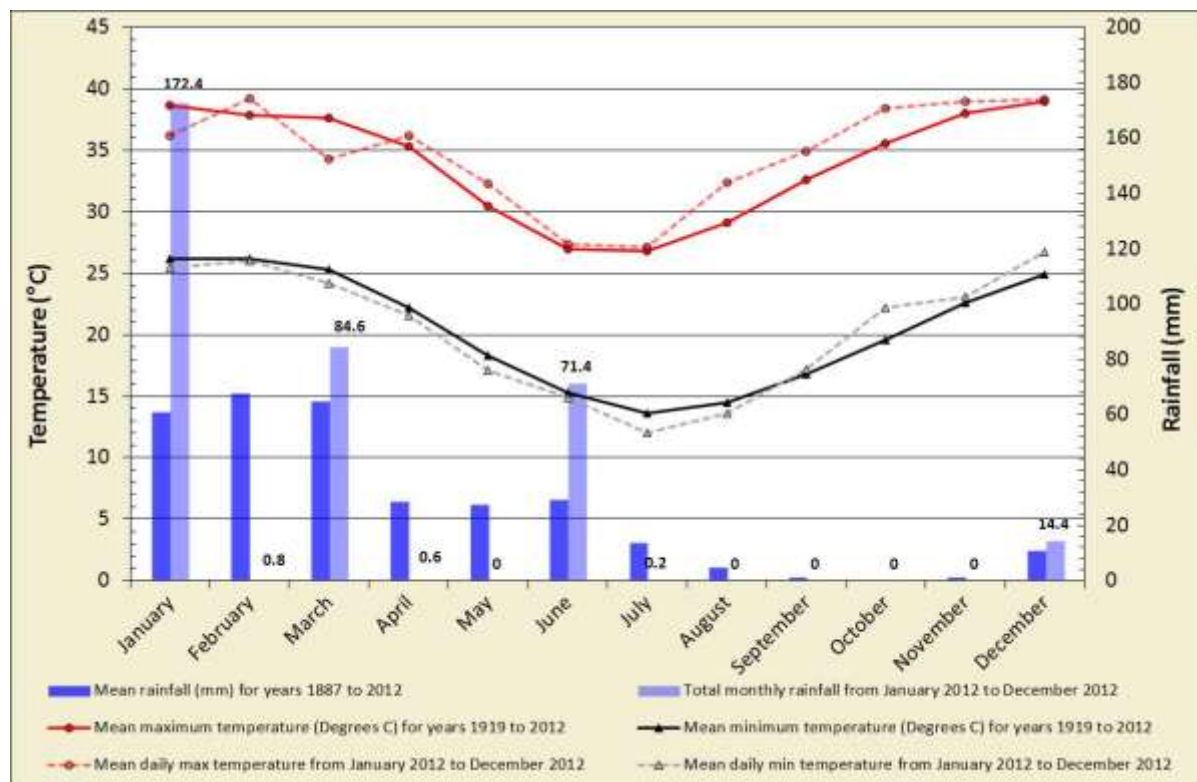
The Pilbara bioregion has an arid to tropical climate with average maximum temperatures over 40°C from November to February and an average maximum of 25°C during the winter months (Leighton 2004; McKenzie *et al.* 2009). Rainfall is highly variable but is more prevalent over summer months. The average rainfall over the broader Pilbara region is about 290 mm, ranging from a monthly average of approximately 2 mm in September to 66 mm in February. Rainfall patterns are driven by highly variable, year-to-year cyclonic activity that accounts for half of the yearly precipitation (McKenzie *et al.* 2009).

The nearest Bureau of Meteorology (BOM) weather station is located at Roebourne (Latitude: 20.76°S Longitude: 117.16°E station number: 4090) approximately 60 km west of the Balla Balla Magnetite Project barge loading facility. Roebourne records the highest maximum mean monthly temperature (39°C) in December, the lowest maximum mean annual temperature (26.8°C) in July and an average annual rainfall of 311.8 mm (BOM 2012) (Figure 2-3).

Average annual (pan) evaporation in the area is approximately 3,600 mm per year (Luke *et al.* 2003), which greatly exceeds the annual rainfall.

Records from Roebourne during the survey month November 2012 show no rainfall compared with the long term average of 1.5 mm for November in the driest period of the year. During November 2012, mean daily maximum and minimum temperatures were about average and somewhat above average in the preceding months (Figure 2-3).

The low rainfall and high temperature data for Roebourne suggest that the second half of 2012 represented less than ideal conditions for terrestrial fauna surveys in the study area.



**Figure 2-3** Climate data (average monthly temperatures and rainfall records) and weather (temperature and rainfall preceding survey) for Roebourne (BOM 2012)

## 2.4 LAND USE

Native grazing and pastoral activities have been historically dominant within the Pilbara bioregion. While these land uses are still prevalent, mineral exploration and mining activities are also now common (van Vreeswyk *et al.* 2004). Other land uses within the Pilbara bioregion include tourism, Unallocated Crown Land (UCL), Crown Reserves such as Jigalong Aboriginal Reserve and Conservation reserves such as Karijini and Millstream-Chichester National Parks. In 2009, land tenure in the broader Pilbara bioregion was approximately 60% pastoral lease, 10% conservation reserve, 5% Aboriginal Reserve and 25% UCL (McKenzie *et al.* 2009).

Within the Roebourne subregion pastoral activities are the major land use, followed by mineral exploration and mining activities. Major resource developments within Roebourne subregion have focused on coastal locations and some islands suitable for processing and transport facilities. Only 0.79% of land is under some form of conservation tenure including parts of the Millstream-Chichester National Park and various island nature reserves (Kendrick & Stanley 2001).

Primary land use tenure within the study area has historically been pastoral activities with prospective development interests for mineral exploration, mining and associated infrastructure.

### 2.4.1 Threatening processes

A number of vertebrate fauna species are vulnerable to the effects of particular land uses within the Pilbara bioregion (section 2.4). The vulnerability of many species is due to their inability to adapt to sudden or detrimental changes to their habitat, in which many have preference to particular habitats or micro habitats. The restricted ranges of SREs in combination with often very specific habitat preferences make them particularly vulnerable to adverse effects caused by some of the land uses mentioned above (section 2.4) (Harvey 2002).

There are several threatening processes to the invertebrate and vertebrate fauna of the Pilbara bioregion (Kendrick & Stanley 2001), in particular:

- **Wildfire and alteration of fire regimes.** Over 72% of the Pilbara region was burnt between 1993 and 2006 (van Leeuwen *et al.* 1995). For example, the extent of mulga woodland in the Pilbara region is decreasing as a consequence of too-frequent fires. These woodlands support assemblages of species, including SREs, which do not persist in the spinifex scrublands that are replacing the mulga.
- **Habitat alteration through grazing.** Livestock grazing started depleting the native grass cover along the main river channels in the early 1900s, resulting in increasingly occluded drainage systems with substantial bed loads. Simultaneously, the introduced Buffel Grass (*Cenchrus ciliaris*) rapidly colonised alluvial surfaces via these river systems. Subsequently, it has displaced indigenous shrubs and grasses from a variety of Pilbara environments (McKenzie *et al.* 2009).
- **Spread of introduced fauna including unmanaged livestock and feral bees.** Twelve introduced mammals compete with and/or prey on indigenous species in the Pilbara bioregion, including House Mouse (*Mus musculus*), Black Rat (*Rattus rattus*), feral Dog (*Canis lupus familiaris*) and Cat (*Felis catus*), Red Fox (*Vulpes vulpes*), European Rabbit (*Oryctolagus cuniculus*), Horse (*Equus caballus*), feral Pig (*Sus scrofa*) Camel (*Camelus dromedarius*) and European Cattle (*Bos Taurus*) (McKenzie & Burbidge 2002). The invasion of the Cane Toad (*Bufo marinus*) also poses a significant threat to native fauna in some areas of the Pilbara region.



- **Spread of weeds.** A total of 103 weed species are currently established in the Pilbara bioregion comprising 6.3% of the region's flora. Fourteen of these species alter the region at a landscape scale by altering fire patterns, modifying soil characteristics or competing directly with native species. Another 15 species significantly modify particular habitats such as wetlands, six are major threats to islands and a further 16 have potential threat to Pilbara environments (Keighery 2010).
- **Habitat destruction through mining and associated infrastructure.** Several large-scale mining and infrastructure projects are present or in development in the Pilbara (e.g. port developments at Cape Preston and Cape Lambert, Wodgina, Christmas Creek and Roy Hill mines with associated transport infrastructure). The cumulative effects of these projects are not well understood and include habitat fragmentation and edge effects. Large scale projects such as these and associated infrastructure developments such as railways also potentially impact surface and sub-surface hydrology which in turn may affect surface vegetation and therefore dependent fauna species and assemblages.
- **Climate change.** Current predictions suggest that the Pilbara bioregion may become warmer with more hot days and fewer cold nights and may experience less annual rainfall. Droughts may be more severe and storm events become more common (McKenzie *et al.* 2009). These effects may enhance the effects of other threatening processes, in particular the likelihood of fire and the introduction of more species from the tropics.

#### 2.4.2 Conservation reserves

The closest conservation reserves to the study area are Millstream Chichester National Park, approximately 70 km south of the Project, and Mungaroona Range Nature Reserve, approximately 70 km SSE of the Project (Figure 1-1).

Millstream Chichester National Park covers an area of 199,700 ha, mostly within the Fortescue Plains subregion. The park is regionally important for its natural and cultural values. It contains unique wetlands which, largely due to the associated aquifer, support a high diversity of flora and fauna including several conservation significant species (Traditional Owners - Millstream Park Council *et al.* 2011). The Millstream Pools within the park are listed in the national Directory of Important Wetlands (Environment Australia 2001) and are proposed for nomination as a Wetland of International Importance under the Ramsar Convention.

There is only limited understanding of the SRE invertebrate fauna of Millstream Chichester National Park; however, extensive sampling within close proximity, particularly the Pilbara Biological Survey have indicated a rich diversity of invertebrates in the area (Traditional Owners - Millstream Park Council *et al.* 2011).

Mungaroona Range Nature Reserve was gazetted in 1972 for the purpose of 'conservation of the flora and fauna' (Traditional Owners - Millstream Park Council *et al.* 2011). It is located approximately 70 km SSE of the Project (Figure 1-1). Knowledge of the fauna assemblage within the reserve is limited; however, the current management plan proposes to declare all of the reserve as wilderness (Traditional Owners - Millstream Park Council *et al.* 2011).

## 2.5 BIOLOGICAL CONTEXT

The Pilbara bioregion accommodates a rich species assemblage of vertebrate and invertebrate fauna, as well as flora (van Vreeswyk *et al.* 2004). Fauna within the bioregion have adapted its harsh arid climatic regime. Many Pilbara vertebrate fauna species are listed as threatened or priority species in need of protection and/or further research.

A comprehensive biological survey of the Pilbara bioregion was conducted by DEC from 2002–2007 (McKenzie *et al.* 2009). This survey provided a benchmark for environmental assessment studies in the Pilbara, as it comprehensively surveyed the biota and summarised faunistic and floristic data for the region for many groups of plants and animals. Survey data have provided substantial background information on the small mammal, bat and bird fauna of the region (Baynes & McDowell 2010; Burbidge *et al.* 2010; Gibson & McKenzie 2009; McKenzie & Bullen 2009) and for selected invertebrates, including target SRE taxa such as spiders (Durrant *et al.* 2010) and scorpions (Volschenk *et al.* 2010).

The study area is designated as a 'Guideline 2' area; mangrove areas of high conservation value (EPA 2001). There are also two 'Guideline 1' areas (mangroves of very high conservation value) located approximately 17 km east and west of the study area; being Sherlock Bay (area 17) and Ronsard Island area (area 18).

### 2.5.1 Vertebrate fauna

Within the Pilbara bioregion there are currently 44 declared threatened (critically endangered, endangered, vulnerable) fauna (15 mammals, 14 birds, 11 reptiles and four fish) and 34 listed Priority (P1-P4) species (10 mammals, seven birds, 16 reptiles and one fish) (DEC 2013; Western Australian Government 2012b). Of the declared threatened fauna, one is considered critically endangered (a bird species), seven are endangered (four mammals, two bird and one reptile) and 36 are vulnerable (11 mammals, 13 birds, eight reptiles and four fish).

The critically endangered bird species is the Night Parrot (*Pezoporus occidentalis*) and the endangered terrestrial species listed are the Northern Quoll (*Dasyurus hallucatus*), Northern Marsupial Mole (*Notoryctes caurinus*), and the Rufous Hare Wallaby (*Lagorchestes hirsutus*).

The Pilbara bioregion is relatively high in endemism with 22 described bioregional endemic vertebrate species and various undescribed species only recorded from the bioregion (**Error! Not a valid bookmark self-reference.**) (Catullo *et al.* 2011; Doughty *et al.* 2011; Doughty *et al.* 2012; Doughty & Oliver 2011; Doughty *et al.* 2010; McKenzie *et al.* 2003; McKenzie *et al.* 2009).

**Table 2-1 Bioregional endemic vertebrate fauna species of the Pilbara bioregion**

Common name	Scientific name
<b>Amphibians</b>	
Glandular Toadlet	<i>Uperoleia glandulosa</i>
Pilbara Toadlet	<i>Uperoleia saxatilis</i>
<b>Reptiles</b>	
Northern Pilbara Beak-faced Gecko	<i>Diplodactylus galaxias</i>
Pilbara Ground Gecko	<i>Lucasium wombeyi</i>

Common name	Scientific name
Pilbara Barking Gecko	<i>Underwoodisaurus seorsus</i>
Northern Pilbara Tree Dragon	<i>Diporiphora vescus</i>
Peace Delma	<i>Delma pax</i>
Ruddy Ctenotus	<i>Ctenotus rubicundus</i>
Pilbara Crevice Skink	<i>Egernia pilbarensis</i>
Western Pilbara Spiny-tailed Skink	<i>Egernia cygnitos</i>
Eastern Pilbara Spiny-tailed Skink	<i>Egernia epsisolus</i>
Pilbara Blue-tailed Lerista	<i>Lerista zietzi</i>
Pilbara Flame-tailed Lerista	<i>Lerista flammicauda</i>
Pilbara Rock Monitor	<i>Varanus pilbarensis</i>
Pilbara Death Adder	<i>Acanthophis wellsi</i>
Rufous Whipsnake	<i>Demansia rufescens</i>
Pilbara Blind Snake	<i>Ramphotyphlops pilbarensis</i>
Gane's Blind Snake	<i>Ramphotyphlops ganei</i>
<b>Mammals</b>	
Pilbara Ningau	<i>Ningau timealeyi</i>
Little Red Kaluta	<i>Dasykaluta rosamondae</i>
Western Pebble Mound Mouse	<i>Pseudomys chapmani</i>
Tan False Antechinus	<i>Pseudantechinus roryi</i>

### 2.5.2 Short-range endemic invertebrates

Short-range endemic fauna are defined as animals that display restricted geographic distributions, nominally less than 10,000 km<sup>2</sup>, that may also be disjunct and highly localised (Harvey 2002; Ponder & Colgan 2002). The most appropriate analogy is that of an island, where the movement of fauna is restricted by the surrounding marine waters, therefore isolating the fauna from other terrestrial populations. Isolating mechanisms and features such as roads, urban infrastructure, large creek lines and ridges can act to prevent the dispersal and gene flow of the less mobile invertebrate species.

Short-range endemism in terrestrial invertebrates is believed to have evolved through two primary processes (Harvey 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 slaters contain 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 may have settled in particular isolated habitat types by means of dispersal or phoresy (transport of one organism by another) and evolved in isolation into distinct species. Such habitat islands include rocky outcrops (pseudoscorpions in the genus *Synsphyronus* or spiders in the family Selenopidae are typical examples) or salt lakes (e.g. wolf spiders of the genus *Tetrallycosa*). Unlike relictual SREs in mesic habitats, habitat specialist SREs are restricted by environmental parameters other than humidity and are often found in arid environments such as the Pilbara.

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):

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

In Western Australia, the current knowledge of SREs is relatively poor and the rarity of collections from certain areas makes it difficult to assess the distribution and likely occurrence of SRE species. Potential SRE taxa of the Pilbara include the following groups that represent the target invertebrates of this survey (EPA 2009b):

- spiders and relatives (Arachnida)
  - spiders (Araneae), in particular trapdoor spiders (Mygalomorphae) and selected modern spiders (Araneomorphae) (here mainly flat rock spiders, family 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 (soil centipedes) and the Cryptopidae in the order Scolopendromorpha (tropical centipedes); other Scolopendromorpha are generally widespread and are not considered target taxa (e.g. Colloff *et al.* 2005; Koch 1983a, b, c, 1982)
  - millipedes (Diplopoda)
- crustaceans (Crustacea)
  - slaters (Isopoda)

- snails and relatives (Mollusca)
  - land snails (Eupulmonata).

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 2009b).

### 2.5.3 Categories of short-range endemism

Currently, there is no accepted system to determine the likelihood that a species is 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' – attributed to W. Cowper, 1731–1800).
- **Lack of taxonomic resolution.** Many potential SRE taxa (based on habitat constraints, SRE status of closely related species, or morphological peculiarities such as troglomorphy) 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 increasingly 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 2-2). These categories are dynamic and can change with every single survey as knowledge of SRE status is updated. For example, the millipede *Austrostrophus stictopygus* Hoffman, 2003 (order Spirobolida) has been shown widespread in the Pilbara based on material collected as part of environmental assessment studies following its initial description from few localities (Harvey *et al.* 2011; Hoffman 2003).

Life stages of species that cannot be identified at the species level, e.g. some females and juveniles, are 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 a few of the 120+ known species in this genus are currently considered SREs (Wojcieszek *et al.* 2011).

Although the different categories of 'SRE-likelihood' may help to set conservation priorities, SRE taxa of all categories should be assessed on their merit, in order to determine appropriate conservation measures that 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" (EPA 2002).

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

<b>SRE category</b>	<b>Criteria</b>	<b>Typical representative</b>
<b>Confirmed</b>	Confirmed or almost certainly SRE; taxonomy of the group is well known (but not necessarily published); group is well represented in collections, in particular from the region in question; high levels of endemism exists in documented species; inference is often possible from immature specimens	<i>Antichiropus</i> millipedes (Paradoxomatidae); scorpions in the genus <i>Aops</i> (Urodacidae)
<b>Likely</b>	Taxonomically poorly resolved group; unusual morphology for the group (e.g. some form of troglomorphism); often singleton in survey and few, if any, regional records	Opiliones in the genus <i>Dampetrus</i> ; some pseudoscorpions ( <i>Synsphyronus</i> ) and slaters (Philosciidae); some araneomorph spiders in the genus <i>Karaops</i> (Selenopidae)
<b>Potential</b>	Taxonomically poorly resolved group; often common in certain microhabitats in SRE surveys (i.e. litter dwellers), but no other regional records; congeners (= species in the same genus) often widespread	Mygalomorph spiders ( <i>Aname</i> , <i>Conothele</i> , <i>Missulena</i> , <i>Synothele</i> ), centipedes (Cryptopidae: <i>Cryptops</i> ; Geophilomorpha: <i>Sepedonophilus</i> , <i>Mecistocephalus</i> )

## 2.6 RELEVANT LEGISLATION AND AGREEMENTS

### *International*

Migratory species are protected under a number of international agreements:

- Japan-Australia Migratory Bird Agreement (JAMBA)
- China-Australia Migratory Bird Agreement (CAMBA)
- Convention on the Conservation of Migratory Species of Wild Animals (Bonn)
- Agreement between the Government of Australia and the Government of the Republic of Korea on the Protection of Migratory Birds (ROKAMBA).

### *Commonwealth*

Under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act), actions that have, or are likely to have, a significant impact on a matter of national environmental significance (NES) require approval from the Australian Government Minister for the Environment, Water, Heritage and the Arts (the Minister). The EPBC Act provides for the listing of nationally threatened native species as matters of NES.

Fauna species of national conservation significance may be classified as ‘critically endangered’, ‘endangered’, ‘vulnerable’ or ‘conservation dependent’.

Few invertebrate taxa from WA are listed as matters of NES and those that are mostly include species that have experienced significant range contractions and populations declines due to habitat loss, for example the Margaret River Marron (*Cherax tenuimanus*) (Critically Endangered) and the Graceful Sun-moth (*Synemon gratiosa*) (Endangered) (DSEWPC 2009).

The EPBC Act is also the enabling legislation for protection of migratory species under the international agreements listed above.

### **State**

Native species in Western Australia which are under identifiable threat of extinction are protected under the Western Australian *Wildlife Conservation Act 1950* (WC Act). Under the WC Act, the *Wildlife Conservation (Specially Protected Fauna) Notice 2012 (2)* (Western Australian Government 2012b) recognises four classifications of rare and endangered fauna:

- **Schedule 1:** Fauna that is rare or is likely to become extinct
- **Schedule 2:** Fauna presumed to be extinct
- **Schedule 3:** Migratory birds protected under an international agreement
- **Schedule 4:** Other specially protected fauna.

In addition, the Department of Environment and Conservation (DEC) produces a list of Priority species (last update: 10 January 2013) (DEC 2013) that have not been assigned statutory protection under the WC Act. Species on this list are considered to be of conservation priority because there is insufficient information to assess their conservation status or they are considered to be rare but not threatened and are in need of monitoring. The DEC Priority Fauna List categories are:

- **Priority 1:** Taxa with few, poorly known populations on threatened lands
- **Priority 2:** Taxa with few, poorly known populations on conservation lands
- **Priority 3:** Taxa with several, poorly known populations, some on conservation lands
- **Priority 4:** Taxa in need of monitoring – considered not currently threatened but could be if present circumstances change
- **Priority 5:** Taxa in need of monitoring – considered not currently threatened but subject to a conservation program, the cessation of which could result in the species becoming threatened.

Few SRE invertebrate taxa are listed under the WC Act and while there are several invertebrate species on DEC's Priority list (some of which are SRE taxa), these lists cannot be relied on as a complete guide to conservation significant invertebrate taxa within a particular location.

The most up-to-date listings of invertebrates and their distribution is available through database searches of the WA Museum invertebrate databases, including the Arachnology/Myriapodology database of the Department of Terrestrial Zoology and the Mollusca and Crustacea databases of the Department of Aquatic Zoology.



## 3 METHODS

### 3.1 DESKTOP REVIEW

#### 3.1.1 Habitat assessment

Initial characterisation of terrestrial fauna habitats in the Level 1 study area was undertaken using various remote geographical tools, including aerial photography (incl. Google™ Earth), land system maps and topographic maps.

The potential for the habitats of the Level 1 study area to support conservation significant vertebrate fauna and SRE invertebrates was then assessed based on species-specific habitat preferences and nearest records. The SRE habitat assessment considered key habitat types known to facilitate short-range endemism.

Sites with potential habitat for conservation significant vertebrate and SRE fauna were identified to focus the reconnaissance vertebrate field survey effort; particular attention was given to habitats utilised by threatened species listed under the EPBC Act.

Detailed habitat definition and mapping was undertaken later in the (Level 2) study area as part of the Level 2 survey.

#### 3.1.2 Database searches and literature review

Database searches and literature reviews of relevant publications were undertaken to compile a list of potential conservation significant species that may occur within the Level 1 study area based on the proximity of previous records.

The following database searches were undertaken:

- EPBC Act Protected Matters database (DEWHA 2011) for a rectangle polygon with the diagonal coordinates of 20°23'58.88"S/117°19'40.76"E (NW point) and 21° 2'1.72"S/118° 0'43.52"E (SE point)
- DEC/WA Museum NatureMap (DEC 2012) search from a centred point (117°43' 09"E/ 20°41' 51"S) with a 40 km buffer
- DEC Threatened Fauna database from a centred point (117°43'09"E/20°41' 51"S) with a 40 km buffer
- Birds Australia Birddata database (Birdlife Australia 2005–2007) search for a rectangle polygon with the diagonal coordinates of 20°23'58.88"S/117°19'40.76"E (NW point) and 21°2'1.72"S/118°0'43.52"E (SE point)
- WA Museum Arachnology and Myriapodology database for a rectangle polygon with the diagonal coordinates of 116°50'S/20°15'E (NW point) and 118°40'S/21°35'E (SE point)
- WA Museum Mollusca database for a rectangle polygon with the diagonal coordinates of 116°50'S/20°15'E (NW point) and 118°40'S/21°35'E (SE point)
- WA Museum Crustacea database for a rectangle polygon with the diagonal coordinates of 116°50'S/20°15'E (NW point) and 118°40'S/21°35'E (SE point).

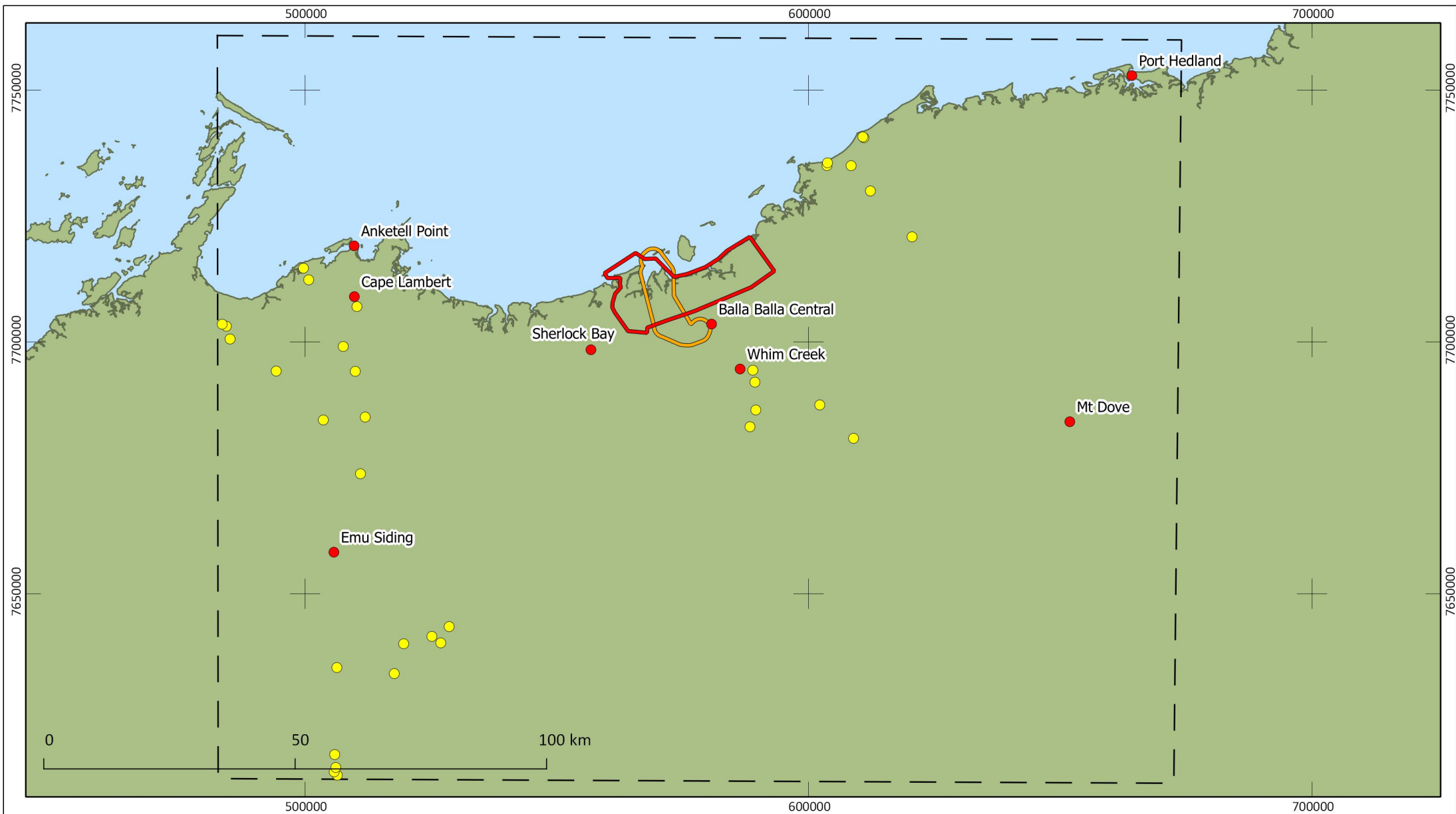
The area of the database searches adequately covered the entire Level 2 study area also. SRE invertebrate fauna database search areas were based on a rectangular search grid determined by the proposed maximum range of short-range endemism, 10,000km<sup>2</sup>, equivalent to approximately

100 km x 100 km (Harvey 2002)). Therefore, the search grid extended ca. 100 km from the centre of the study area across the mainland.

Thirty five survey sites from the Pilbara Biological Survey (McKenzie *et al.* 2009) were located within the area covered by the desktop review search areas (Figure 3-1). Data collected during the Pilbara Biological Survey is returned through the WA Museum and NatureMap databases.

A literature search was conducted for accessible reports of vertebrate and SRE invertebrate fauna surveys conducted within the vicinity of the Project to build on the potential species lists developed from the database searches. Reports for many of these surveys may not give detailed distribution data; however, distribution information for many of the vertebrates and invertebrates collected is available through the WA Museum database, which was accessed for this desktop review. Several mainland terrestrial fauna surveys and an island survey have been conducted near the study area:

- Reptiles of Depuch Island (Storr 1964b)
- Birds of Depuch Island (Storr 1964a)
- Mammals of Depuch Island, (Ride 1964)
- Balla Balla Vanadium Project fauna assessment (URS) (Bamford 2006; Slack-Smith 2005)
- Balla Balla infrastructure corridor fauna survey (Ferro Metals) (Bamford 2008)
- Flora and fauna assessment of the RGP5 DMMA A, Port Hedland Harbour (BHP Billiton Iron Ore) (Biota 2008c)
- Cape Lambert port B development fauna survey (Pilbara Iron) (Biota 2008a)
- Rio Tinto Iron Ore rail duplication Cape Lambert to Emu Siding fauna survey (Rio Tinto Iron Ore) (Biota 2008e)
- Port Hedland outer harbour fauna assessment (BHP Billiton Iron Ore) (ENV 2009; ENV & Phoenix 2009)
- Terrestrial vertebrate fauna survey for Anketell Point (API) (Phoenix 2010b)
- Short-range endemic invertebrate baseline survey of Anketell Point (API) (Phoenix 2010a)
- Port Hedland migratory shorebird survey (BHP Billiton Iron Ore) (Bennelongia 2011)
- Cape Lambert targeted SRE fauna survey (Cape Lambert Iron Ore) (Biota 2007)
- Cape Lambert Port development seasonal fauna survey (Cape Lambert Iron Ore) (Biota 2008b)
- Sherlock Bay fauna assemblage report (Sherlock Bay Nickel Corp Ltd) (Biota 2004)
- Whim Creek fauna assessment (Straits) (ENV 2006)
- Mt Dove vertebrate fauna assessment (Atlas Iron) (Atlas Iron 2011).



**Figure 3-1**  
**Location of the Balla Balla Magnetite Project**  
**barge loading facility in relation to Pilbara**  
**Biological Survey sites and mining and**  
**infrastructure projects**

**AUTHOR:** N. Dight      **CLIENT:** Forge Resources

**DATE:** 27 November 2012      **Scale:** 1:1000000

**Coordinate System:** Projection: UTM zone 50; Datum: WGS84



**PROJECT:** Land systems of the Balla Balla Magnetite  
 Project barge loading facility

Level 1 study area

Level 2 study area

Area for desktop review

Pilbara Biological Survey sites

Mining developments and exploration activities

## 3.2 LEVEL 1 RECONNAISSANCE SURVEY

A Level 1 reconnaissance survey was undertaken from 9 to 12 November 2012 to identify habitats for species of conservation significance, assess the presence and estimate abundance of migratory shorebirds, assess accessibility constraints and determine the scope of further survey requirements.

During the reconnaissance survey habitats of the Level 1 study area were assessed based on desktop review results and preliminary sites were selected for trapping or further investigation during the Level 2 survey. Habitat assessments were undertaken to determine the potential presence of conservation significant vertebrate and SRE fauna.

A total of six camera traps were deployed across the Level 1 study area targeting sites suitable for species of conservation significance. Camera traps remained in the field until retrieval during the Level 2 survey.

Migratory shorebird significance was assessed via a high tide and a low tide aerial transect that took in approximately 50% of Forestier Bay and, through four ground count sessions (species if level identifications and abundance data recorded). The aims being to determine if the area was likely to trigger referral under the EPBC Act due to the significance of the study area for shorebirds and therefore whether additional, targeted surveys would be required.

## 3.3 LEVEL 2 FIELD SURVEY

The survey effort, design and focus for the Level 2 survey were based on the results of the desktop review and Level 1 reconnaissance survey. Results of the Level 1 reconnaissance survey identified potential habitat and presence of species of conservation significance within the level 1 study area which provided the basis for targeted survey methods of particular species of conservation significance.

### 3.3.1 Habitat assessment and site selection

Site selection for the Level 2 survey was based on the results of the desktop review and Level 1 reconnaissance survey which were then refined after ground-trothing selected areas. At the broadest scale, site selection considered aspect, topography and land systems. At the finer scale, consideration was given to proximity to water bodies (drainage lines and creek), vegetation complexes and condition and soil type.

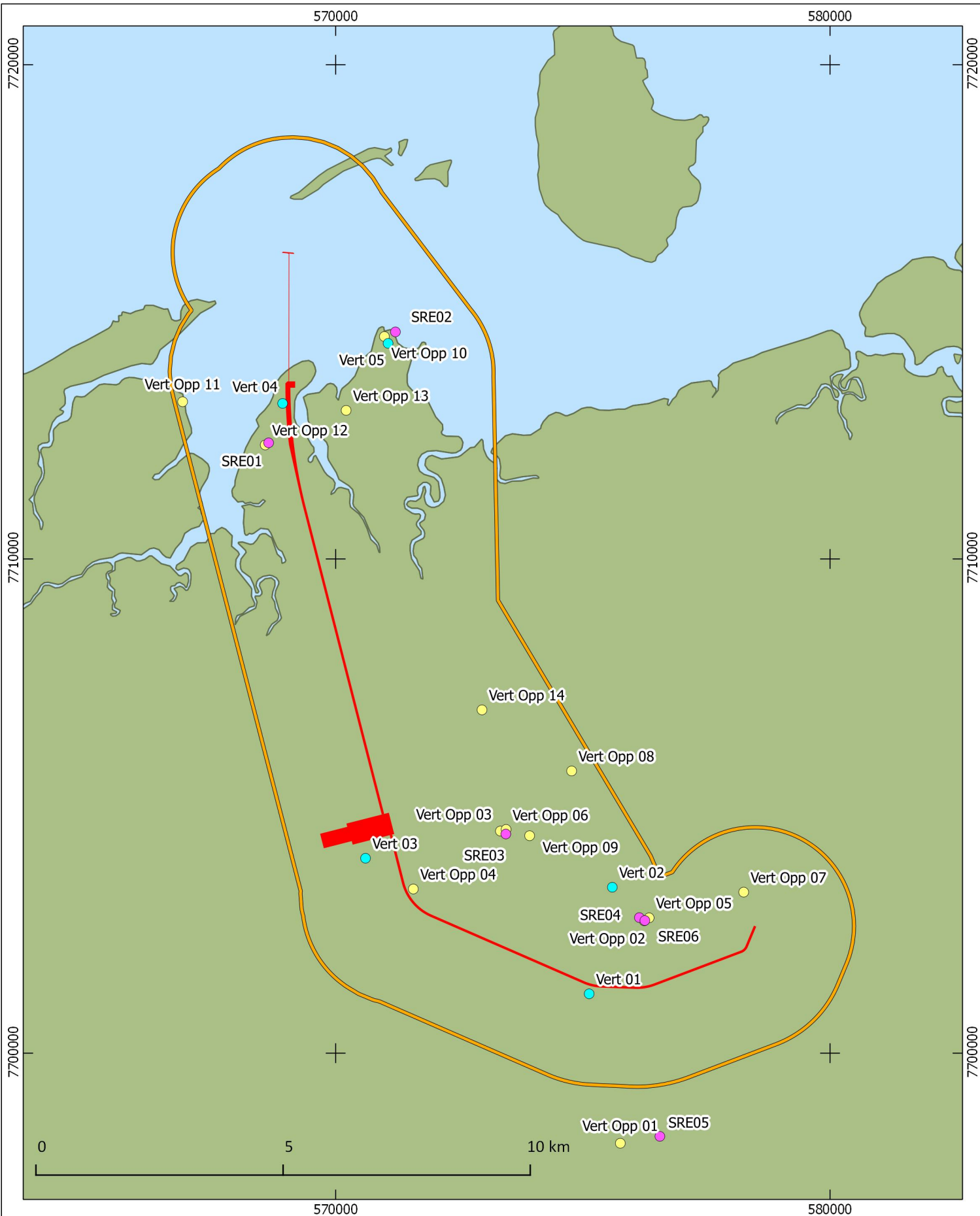
Sites were primarily chosen to represent the best example of a distinct habitat within the broader habitat associations of the study area. Consideration was also given to the project footprint and informing the assessment process (e.g. impact/non-impact area, or anticipating the potential effect of water flows outside the study area from the Project).

### 3.3.2 Vertebrate fauna

The Level 2 field survey took place from the 27 November to 7 December 2012. Five sites were systematically surveyed representing all major fauna habitats in the study area (Figure 3-2). Habitat descriptions and characteristics were recorded at each systematic site and at all opportunistic sites (**Error! Reference source not found.**; Appendix 2). Survey work was undertaken over 11 consecutive days and comprised:

- systematic trapping for mammals, reptiles and amphibians (for details see section 3.3.2.1)
- avifauna surveys (see 3.3.2.2)

- bat echolocation call recordings (see 3.3.2.3)
- spotlighting for nocturnal species (see 3.3.2.4)
- active searches (see 3.3.2.5)
- opportunistic records (see 3.3.2.6)
- infrared motion camera trapping (see 3.3.2.7)
- targeted searches for species of conservation significance (see 3.3.2.8).



**Figure 3-2**  
**Location of the short-range endemic and vertebrate survey sites**

- Level 2 study area
- Construction envelope
- Short-range endemic survey sites
- Vertebrate opportunistic survey sites
- Vertebrate survey sites

AUTHOR: N. Dight	CLIENT: Forge Resources
DATE: 8 February 2013	Scale: 1:100000
Coordinate System: Projection: UTM zone 50; Datum: WGS84	

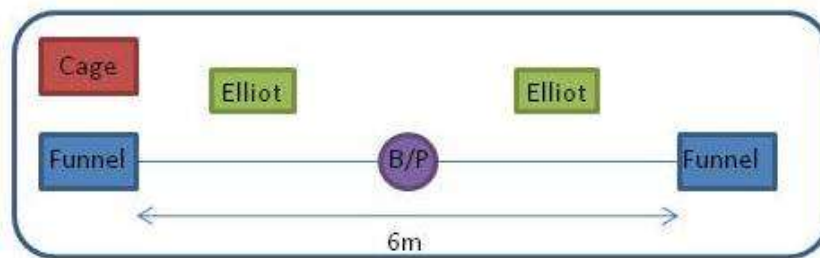
**PROJECT: Balla Balla Magnetite Project barge loading facility**



### 3.3.2.1 Systematic trapping for mammals, reptiles and amphibians

Trapping sites aimed to catch terrestrial mammals, reptiles and amphibians. The five systematic trap sites comprised of ten pit traps consisting of five PVC pipes (15 cm diameter x 50 cm depth) and five 20 L buckets installed at approximately 20 m intervals along a transect. The pits were installed flush with the substrate, with a 5 m long, 30 cm high aluminium drift fence bisecting each pit.

Twenty funnel traps measuring 75 cm x 18 cm x 18 cm were placed at each end of the ten aluminium drift fences. Twenty Elliott traps (9 cm x 10 cm x 33 cm) were placed in pairs, parallel to each of the ten pit traps at each site. Two Sheffield cage traps (60 cm x 20 cm x 20 cm) were placed at either end of the transect (Figure 3-3).



**Figure 3-3 Systematic trapping site conceptual layout**

The Elliott and Sheffield cage traps were baited with a universal bait mixture consisting of oats, peanut butter and sardines to attract small mammals.

Elliott and funnel traps were shrouded with reflective closed cell insulation (R2.5 rated) to provide shade and protection for any captured animals. All traps, including the cages, were given as much shade as possible, including leaf litter cover if necessary. Styrofoam cups and leaf litter were used to provide shade in the bottom of pit traps.

Traps were open for seven consecutive nights and checked twice daily when necessary (on the hottest days) within three hours of sunrise and again around midday. Baits were removed and replaced every second day.

The total vertebrate trapping effort for the five systematic trapping sites during the surveys was 1876 trap-nights (Table 3-1); where a trap-night is defined as one trap remaining open for one night.

**Table 3-1 Summary of trapping effort for the Level 2 vertebrate survey of the Balla Balla Magnetite Project barge loading facility**

Site #	Nights open	# pit traps	# funnel traps	# Elliott traps	# cage traps	# camera traps	Pit trap effort (nights)	Funnel trap effort (nights)	Elliott trap effort (nights)	Cage trap effort (nights)	Camera trap effort (nights)	Total trap nights
Vert 01	7	10	20	20	2	2	70	140	140	14	14	378
Vert 02	7	10	20	20	2	2	70	140	140	14	14	378
Vert 03	7	10	20	20	2	2	70	140	140	14	14	378
Vert 04	7	10	20	20	2	2	70	140	140	14	14	378
Vert 05	7	10	20	20	2		70	140	140	14		364
<b>TOTAL</b>												<b>1876</b>



### 3.3.2.2 Avifauna surveys

Up to six avifauna surveys were undertaken at each of the five systematic trapping sites (Figure 3-2). Surveys were conducted in 20 or 40 minute blocks to obtain sufficient records as some species return to an area after initial disturbance. Avifauna surveys were confined to the habitat type represented by each trapping site in order to collect assemblage data for each habitat. The surveys were conducted from sunrise to 10:30 am, which is generally the period of high activity for birds. Surveys consisted of bird recordings from visual sightings and call recognition.

Additional 20 minute surveys were also undertaken at some opportunistic sites (Figure 3-2). Opportunistic sightings were also recorded during travel between sites and while other field work was being completed or during travel, including observations made during spotlighting, active searches and images captured by remote camera trapping (sections 3.3.2.4, 3.3.2.5 and 3.3.2.7)

### 3.3.2.3 Bat echolocation call recordings

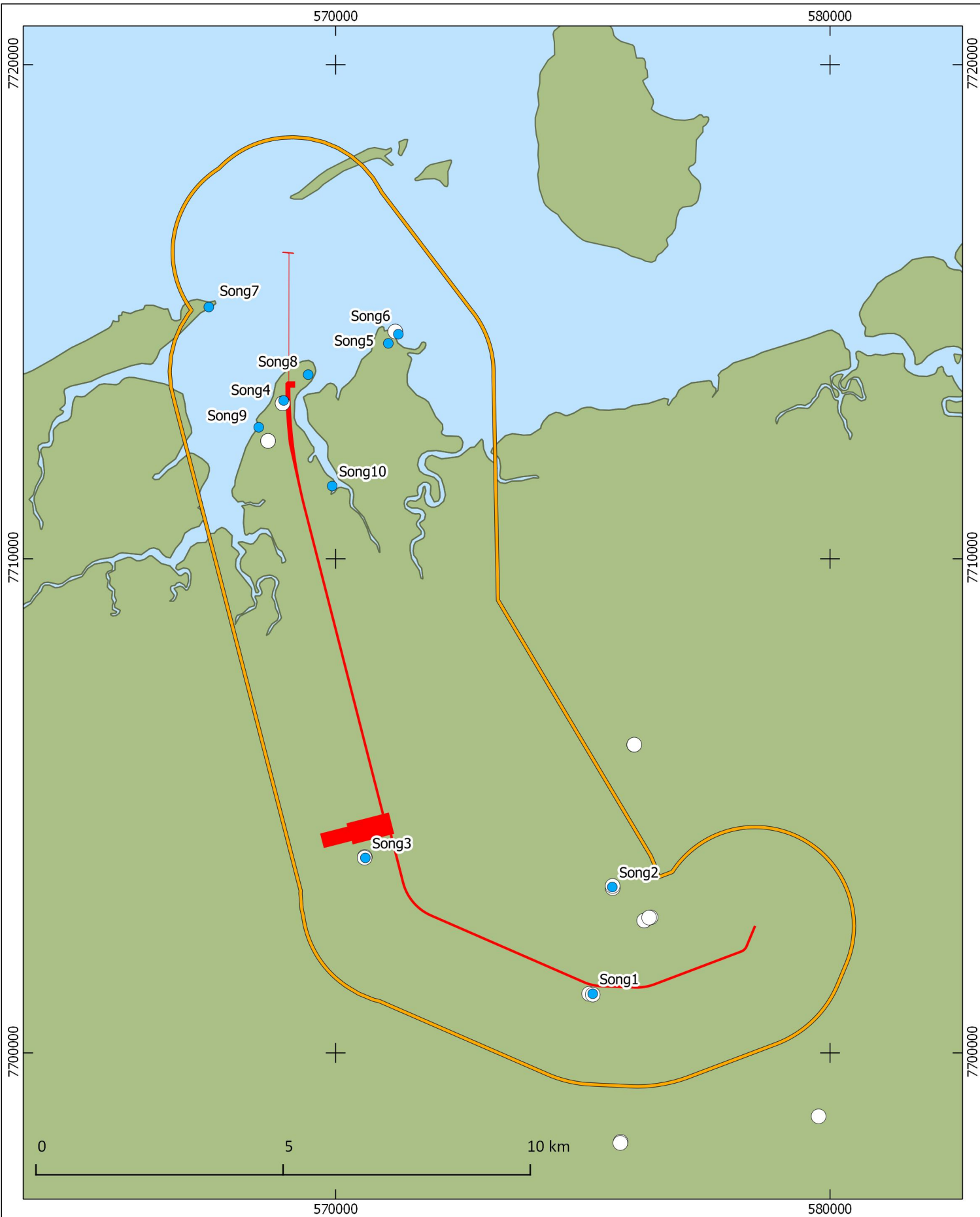
**SongMeter 2 recording devices were used to record bat echolocation calls at each systematic trapping site and five opportunistic sites (**

Figure 3-4). Recording devices were also deployed at five sites in areas of suitable mangrove habitat targeting the Priority 1 Little North-western Mastiff Bat (*Mormopterus loriae cobourgiana*). In total, ten nights of surveying were conducted, recording between eight and 12 continuous hours per night.

Recording devices were aimed at a 45° angle to the ground, and were set to record overnight. Areas of habitat likely to have increased insect activity and to attract bats (i.e. permanent water, creeklines and stands of trees) were targeted.

The SongMeter deployed at site Vert 05 failed to record for the duration of deployment; however, an additional unit was deployed at an opportunistic SongMeter site within close proximity to Vert 05.

The recorded data was analyzed by Mr. Bob Bullen, Bat Call WA.



**Figure 3-4**  
**Location of remote camera trap and**  
**SongMeter sites**

- Level 2 study area
- Construction envelope
- Remote camera sites
- SongMeter sites

AUTHOR: N. Dight

CLIENT: Forge Resources

DATE: 8 February 2013

Scale: 1:100000

Coordinate System: Projection: UTM zone 50; Datum: WGS84

PROJECT: Balla Balla Magnetite Project barge  
loading facility

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ENVIRONMENTAL SCIENCES

### 3.3.2.4 Spotlighting for nocturnal species

Spotlighting was undertaken to detect the presence of any nocturnal vertebrate species at all vehicle accessible trapping sites (Vert 01-03) and opportunistic sites (Vert Opp 01-09). The total time spent spotlighting at each site was a minimum of one person hour, for a total of 16 hours over the survey period.

Nocturnal searches were undertaken between sunset and 2200 hours when activity levels were highest for most nocturnal species. Each nocturnal survey consisted of searches using head torches to detect animal movement, eye shine, or other evidence of species presence. These searches particularly targeted reptiles and amphibians, but also nocturnal birds and mammals. Opportunistic sightings of species on roads using car-mounted spotlights were also recorded.

### 3.3.2.5 Active searches

Active surveys primarily targeted diurnal herpetofauna and mammals from direct sightings and secondary evidence of species occurrence. Active searching was undertaken at each of the five systematic trapping sites, as well as all 14 opportunistic sites.

Active surveys comprised searches of any observable microhabitats likely to support mammals, reptiles and amphibians. Techniques included: raking leaf and bark litter, overturning logs and stones, searching beneath the bark of trees, investigating dead trees and logs, investigating burrows, investigating infrastructure ruins or disused building materials such as tin piles and identifying any secondary evidence including tracks, diggings, scats, fur or sloughs (shed skins), predation or feeding sites, and fauna constructed structures such as pebble mounds. A minimum of one hour was spent active searching at each site and totaled 24 hours over the survey period.

### 3.3.2.6 Opportunistic records

All opportunistic observations of vertebrate species were recorded during the surveys (Figure 3-2). Opportunistic or non-systematic sampling involved recording all sightings of vertebrate fauna species while working and travelling within the study area, day and night. Opportunistic records included species sighted:

- before or just after the fixed-time of active searches or bird censuses
- during reconnaissance visits to the survey sites
- during trap line establishment
- while travelling to and from the survey sites.

### 3.3.2.7 Infrared motion camera trapping

Camera traps increase the likelihood of collecting evidence of animals that are not likely to be captured or sighted using the regular surveying techniques. Camera traps allow for long term recording of species presence without regularly disturbing the area. They are particularly useful for detecting species that are difficult to trap or detect due to their shy or cryptic nature. Such animals include many conservation significant species such as Northern Quoll (*Dasyurus hallucatus*), Water Rat (*Hydromys chrysogaster*), Black-flanked Rock Wallaby (*Petrogale lateralis lateralis*) and introduced species such as foxes and cats.

A total of 21 infrared motion-sensor camera traps (Reconyx Hyperfire™ HC600 and Bushnell Trophy Cams™) were deployed at 14 selected sites during the Level 1 reconnaissance and Level 2 field

surveys (Figure 3-4). Traps were deployed in areas that showed signs of animal movement or disturbance, provided a resource such as food or water (such as water troughs or dams), or provided potential habitat for conservation significant species (see examples in Figure 3-5). Some camera trapping targeted rock and boulder piles for Northern Quoll and mangrove habitats for Water Rat.

Camera traps were set to take three photos and collect between ten and 15 seconds of video footage every time movement was detected, 24 hours a day for the duration of deployment. The cameras contained no-glow infrared sensors and flashes to minimise disturbance to nocturnal species. Some camera traps were baited using a universal bait mix to lure fauna into the detection zone.

The six camera traps deployed during the Level 1 reconnaissance survey and retrieved during the Level 2 field surveys were active for between 18 and 21 days. Cameras were set to take three consecutive photos or 15 seconds of video footage when triggered by a motion in the cameras field of view depending on deployment location. A total of 1101 motion triggers were recorded resulting in 3255 images and 240 seconds of footage collected.

Camera traps deployed during the Level 2 survey were active for up to nine nights at each location. Each camera was set to take three consecutive photos or 10 seconds of video footage when triggered by a motion in the cameras field of view. A total of 1666 trigger events were recorded resulting in 48514 images and 490 seconds of footage collected.



**Figure 3-5** Red Fox and Spinifex Pigeons recorded using remote camera traps during the survey

### 3.3.2.8 Targeted searches

Targeted searches were undertaken in various areas of potential habitat within the study area for conservation significant species, particularly Northern Quoll, Black-flanked Rock Wallaby, Water Rat, Short-tailed Mouse (*Leggadina lakedownensis*), Western Pebble Mound Mouse (*Pseudomys chapmani*) and Nevin's Lerista (*Lerista neviniae*). Most targeted searches primarily involved searches for secondary evidence of species presence such as tracks, scats, feeding sites or fauna constructed structures.

Where possible targeted search methods followed those identified in threatened fauna survey guidelines (DSEWPC 2011d, e). Due to the inaccessibility of the coastal sites targeted spotlighting for some species was not possible.

Targeted searches for Northern Quoll focussed on searches for secondary evidence, such as individual scats or latrine sites. The searches targeted areas of suitable habitat, namely two some

isolated boulder piles on the coasts which were identified in the Level 1 survey as potential denning or shelter sites. Targeted searches for Northern Quoll followed guidance provided in the referral and survey guidelines for the species (DSEWPC 2011d).

The Black-flanked Rock Wallaby was targeted by searching for signs of activity including secondary evidence and suitable habitat resources (large rock crevices and retreat sites) and daytime and dusk observations for individuals moving amongst rocks or basking at a distance using binoculars. Aerial flyovers were also conducted at a distance with a helicopter over the rock piles sites near the coast. Searches for Black-flanked Rock Wallaby followed guidance provided in the threatened mammal survey guidelines (DSEWPC 2011d).

Targeted searches for Water Rat involved searches for secondary evidence such as feeding sites or platforms in and around beach and mangrove habitats. Searches for individuals active during the day were also undertaken where possible. Access was constrained at some locations due to the large tidal movement and general inaccessibility of the coastal section of the study area.

Small transects were searched for Short-tailed Mouse in areas with the potential to support the species, in search for burrows that could be targeted with additional trapping with camera traps or Elliot traps. The targeted searches for Short-tailed Mouse were constrained by the limited secondary evidence left by small rodents and difficulty in locating and identifying their tracks and scats.

Low or rolling stony/pebbly hills within the study area were searched for secondary evidence of Western Pebble Mound Mouse, particularly the distinctive pebble mound constructed by the species. Two field staff walked in transects approximately 10 m apart across areas of potential habitat in search for active, abandoned or relict mounds.

Targeted searches for Nevin's Lerista involved raking leaf litter and sand mounds totalling 4 person hours over the Level 2 survey period. Searches were undertaken across the Coastal dune habitat within the Level 2 study area which consisted of sandy substrates with low coastal vegetation. Searches were undertaken early morning when the species is most likely to be active prior to warm temperatures forcing the species to retreat deeper into the substrate. Two systematic trap sites established in suitable habitat for the species which included pit traps, funnel traps and opportunistic surveying such as raking.

### 3.3.2.9 Targeted shorebird surveys

Targeted migratory shorebird surveys were undertaken within a defined shorebird study area in conjunction with the Level 2 field survey. A separate report documents the migratory shorebird surveys ((Phoenix 2013)); however, any species identified at shorebird survey sites within the area of overlap of the two study areas are also included in the vertebrate assemblage dataset in this report.

Further information on the methodologies of the targeted shorebird surveys are provided in the separate targeted shorebird report (Phoenix 2013).

### 3.3.3 Short-range endemic invertebrates

The SRE invertebrate survey was completed concurrently with the Level 2 vertebrate fauna survey from 27 November to 7 December 2012. The collecting methods consisted of three sampling techniques to target SRE taxa of the region (see section 2.5.2 for list of taxa): dry pitfall trapping, active searches (foraging), and the sieving of combined leaf litter and soil samples (Table 3-2). A total of 11 sites were incorporated into the SRE survey protocol, of which six were dedicated SRE sites and five part of the vertebrate survey (Figure 3-2; Table 3-2). The five vertebrate fauna systematic trapping sites were utilised due to the overlap in habitat with SRE invertebrate fauna at some sites

to increase the collection effort of specimens. Habitat descriptions were recorded at each of the SRE sites (Appendix 3).

### 3.3.3.1 Dry pitfall trapping

Invertebrate specimens were collected from dry pit traps installed at the five sites as part of vertebrate systematic trapping (Table 3-2) (see also section 3.3.2.1).

### 3.3.3.2 Active searches (foraging)

Foraging was completed at 11 sites (Table 3-2) and incorporated the systematic inspection of logs, larger plant debris, the underside of bark of larger trees and the underside of rocks. Methodical searches were conducted amongst the leaf litter of shade-bearing tall shrubs and trees and spinifex bases were inspected thoroughly. Rocks and rock crevices were inspected, particularly for pseudoscorpions.

A temporally standardised approach was undertaken, whereby each site was sampled for a minimum of 1 person hour. Trapdoor spider burrows identified during the searches were excavated if they were considered to be inhabited. Excavation involved removing soil from around the burrow to carefully expose the burrow chamber and remove the spider.

### 3.3.3.3 Litter/soil sieving

Three combined leaf litter and soil samples were taken at each of the six SRE sites. The collection of leaf litter samples were standardised volumetrically by the diameter and height (310 mm x 50 mm = 1.55 L) of the sieves which were completely filled with compressed litter and the upper layers of underlying soil.

Samples were sieved through three stages of decreasing mesh size over a round tray and invertebrates were picked from the sieves and tray with forceps or an aspirator.

These samples particularly targeted small spiders (Araneomorphae), pseudoscorpions, buthid scorpions, millipedes, centipedes (in particular Geophilomorpha and Cryptopidae), smaller species of molluscs (e.g. Pupillidae) and slaters.

*In situ* collecting and sieving is preferred over transporting litter samples to the laboratory. Small invertebrates are best detected when moving and transport to the laboratory can kill a large proportion of the catch. In addition, if litter sieves in the field contain groups of interest, more extensive searches can be conducted, providing greater flexibility in the sampling protocol.

**Table 3-2 Summary of survey effort for the short-range endemic invertebrate survey of the Balla Balla Magnetite Project barge loading facility**

Site	Collecting techniques <sup>a</sup>	Number of dry pitfall traps	Foraging time (mins)	Litter sifts (no.)
SRE01	FO, LS	-	60	3
SRE02	FO, LS	-	60	3
SRE03	FO, LS	-	60	3
SRE04	FO, LS	-	60	3
SRE05	FO, LS	-	60	3
SRE06	FO, LS	-	60	3

Site	Collecting techniques <sup>a</sup>	Number of dry pitfall traps	Foraging time (mins)	Litter sifts (no.)
Vert 01	dPT, FO	10	60	-
Vert 02	dPT, FO	10	60	-
Vert 03	dPT, FO	10	60	-
Vert 04	dPT, FO	10	60	-
Vert 05	dPT, FO	10	60	-

a – dPT- dry pitfall; FO – foraging; LS – litter and soil sieve.

### 3.4 TAXONOMY AND NOMENCLATURE

#### 3.4.1 Morphological species identification

The nomenclature follows a number of taxon-specific references (

**Table 3-3). However, many invertebrate species are currently unnamed requiring morphospecies designation as listed in this report. These are adopted from the nomenclatural systems developed by the respective taxonomic authorities (**

Table 3-3). Reference collections for these morphospecies generally reside with WA Museum as expected by EPA (2004).

**Table 3-3 Nomenclatural references, morphospecies designations and reference collections**

Taxonomic group	Taxonomic reference for described species and higher taxa	Morphospecies designation and reference collection (invertebrates only)
Mammals	Menkhorst and Knight (2011)	
Birds	Simpson and Day (2010); Christidis and Boles (2008)	
Reptiles	Wilson and Swan (2010)	
Amphibians	Tyler and Doughty (2009)	
Araneae	Platnick (2012a, 2013)	“MYG”-numbering system for Mygalomorphae developed by V.W. Framenau (WAM, Phoenix) and continued by WAM, reference collection at WAM
Pseudoscorpiones	Harvey (2011)	“PSE”-morphospecies designations developed by M. Harvey (WAM), reference collection at WAM
Scorpiones	Rein (2011); Fet <i>et al.</i> (2000), Glauert (1925), Koch, (1977), Kovařík (1997), Kovařík (2002), Volschenk and	Morphospecies designation developed by E.S. Volschenk (Phoenix, WAM), reference collection at WAM

Taxonomic group	Taxonomic reference for described species and higher taxa	Morphospecies designation and reference collection (invertebrates only)
	Prendini (2008), Volschenk <i>et al.</i> (2000) Volschenk <i>et al.</i> (2012)	
Eupulmonata <sup>a</sup>	Smith (1992); C. Whisson (Collection Manager: Non-Marine Aquatics, WA Museum, Department of Aquatic Zoology, pers. comm.,)	Morphospecies designations developed by C. Whisson and S. Slack-Smith (WAM); reference collection at WAM
Isopoda	Schotte <i>et al.</i> (2008)	Morphospecies designations developed by S. Judd, reference material at WAM

<sup>a</sup> – For practical purposes, Eupulmonata (land snails) is here considered and orders (after DSEWPC 2012a); however, it is acknowledged that Bouchet *et al.* (2005) consider it a rank-free clade.

Recent changes in the taxonomy and nomenclature of vertebrates have also been incorporated. For example:

- The Pygmy Spiny-tailed Skink (*Egernia depressa*) species complex was recently revised and *E. depressa* was replaced in the Pilbara region with the Western Pygmy Spiny-tailed Skink (*E. cygnitos*) and the Eastern Pilbara Pygmy Spiny-tailed Skink (*E. epsisolus*) (Doughty *et al.* 2011).
- The arid zone *Diporiphora* species were revised and three new Pilbara species were described (*D. addunctus*, *D. paraconvergens* and *D. vesus*) with *D. weneckii* no longer considered to occur in Western Australia (Doughty *et al.* 2012)
- The Western Australian arid zone *Uperoleia* were revised resulting in the description of a new Pilbara species, the Pilbara Toadlet *U. saxatilis* (Catullo *et al.* 2011).

Species identifications were undertaken by Phoenix staff specialising in particular fauna groups and where necessary external sources were utilised for specimen identification and echolocation call analysis. (Table 3-4)

**Table 3-4 Taxonomic specialists that identified the vertebrate fauna and SRE invertebrates from the Balla Balla Magnetite Project barge loading facility survey**

Fauna	Personnel	Taxonomic group/s
<b>Vertebrates</b>	Mr Ryan Ellis <sup>1</sup>	Amphibia, Reptilia, Mammalia
	Dr Sean Doody <sup>4</sup>	Avifauna, Reptilia
	Mrs Julie Raines <sup>4</sup>	Avifauna, Mammalia
	Mr Bob Bullen <sup>4</sup>	Mammalia - Chiroptera (bats)
<b>Short-range</b>	Dr Volker W. Framenau <sup>1, 2</sup>	Araneae (Mygalomorphae, Araneomorphae),



Fauna	Personnel	Taxonomic group/s
endemic invertebrates		Opiliones, Diplopoda, Chilopoda
	Dr Erich S. Volschenk <sup>1, 2</sup>	Scorpiones, Pseudoscorpiones
	Ms Anna Leung <sup>1</sup>	Pseudoscorpiones, Amphipoda, Chilopoda (Geophilomorpha)
	Dr Mieke Burger <sup>3</sup>	Pseudoscorpiones
	Dr Simon Judd <sup>4</sup>	Isopoda
	Mr Corey Whisson <sup>3</sup>	Mollusca

<sup>1</sup>Phoenix Environmental Sciences; <sup>2</sup>Research Associate WA Museum; <sup>3</sup>WA Museum; <sup>4</sup>Freelance taxonomic consultant/ Sub-contractor.

### 3.5 STATISTICAL ANALYSES

Species accumulation estimates were calculated differently between vertebrates and invertebrates based on preferred analytical methods in the scientific literature.

#### 3.5.1 Vertebrate fauna

Species accumulation curves were calculated from all systematically recorded data (species captured at the vertebrate trapping sites, and the ornithological records collected at the each trapping site, and invertebrate collections) using PRIMER v5.0 software (Primer 2012). Opportunistically recorded data were not analysed.

Species accumulation curves provide a tool with which to gauge the completeness of a sampling event. A curve that reaches an asymptote indicates that the sample design, size and timing were sufficient and appropriate to inventory a majority of the expected target faunal assemblage.

The data set was not transformed prior to calculations and was based on abundance data. The data was permuted 999 times as part of the calculation process. The total assemblage recorded (systematically) at each site formed the basis of the analysis. The analysis was performed for the entire assemblage simultaneously and for each taxonomic group (birds, reptiles and mammals). The Sobs, Jackknife 1 and 2 and Bootstrap methods were performed for vertebrates.

#### 3.5.2 Short-range endemic invertebrates

For invertebrates, species richness estimates were calculated separately for SRE target taxa at the order level as this avoids groups generally collected in high numbers, such as slaters and snails, disproportionally influencing the other groups. A minimum of 20 specimens collected was considered the lowest number to provide reliable statistical results (Gotelli & Colwell 2001). Therefore, analyses were conducted only for snails.

Taxon richness from Mao Tau estimates (Colwell *et al.* 2004) was calculated using the software package EstimateS v8.2 (Colwell 2009) with 9,999 randomizations. In addition, the abundance based, non-parametric species estimators ACE, Chao1 and Jack Knife1 were used to estimate the total number of each target taxon within the study area. These estimators were chosen as they are

insensitive to pooling collection data (“grain size”) and perform well when tested against real data (Hortal *et al.* 2006; Walther & Moore 2005).

Species accumulation data was based on all SRE target taxa collected in the survey, not just those species eventually considered to belong to one of the three SRE categories. It is often impossible to provide statistically reliable estimates on actual SREs in the study area due to the low number of individuals collected. An assessment of the likelihood of finding more SREs was based on the estimate for each target group (i.e. mygalomorph spiders) and the percentage of SREs in this group.

### 3.6 PROJECT PERSONNEL

The personnel involved in the survey are presented (Table 3-5).

**Table 3-5 Project team for the Balla Balla Magnetite Project barge loading facility**

	Name	Qualifications	Role/s
<b>Vertebrate fauna</b>	Mr Jarrad Clark	B.Sc. (Env. Mgmt)	Project Manager, field surveys
	Mr Ryan Ellis	Dip. (Cons. Land Mgmt)	Field surveys, taxonomy, report writing, GIS
	Dr Sean Doody	B. Sc. (Zool.), M. Sc. (Biol. Sci.), Ph.D. (App. Sci.)	Field survey
	Mrs Julie Raines	B.Sc. (Zool) (Hons)	Field survey
	Mr Bob Bullen	B. Eng. (Aero. Eng.)	Bat echolocation analysis
<b>Short-range endemic invertebrate fauna</b>	Dr Volker W. Framenau	M.Sc. (Cons. Biol.), Ph.D. (Zool.)	Project Manager, taxonomy
	Dr Erich Volshenk	B.Sc. (Env. Biol.) (Hons) Ph.D. (Zool.)	Taxonomy
	Mr Nicholas Dight	B.Sc. (Biol.)	Report writing, GIS
	Mr Farhan Bokhari	B.Sc. (Zool) (Hons)	Field surveys, taxonomy
	Ms Anna Leung	B.Sc. (Env. Sci.) (Hons)	Field survey, taxonomy
<b>Review</b>	Mrs Karen Crews	B.Sc. (Env. Biol.) (Hons)	Report review

## 4 RESULTS

### 4.1 DESKTOP REVIEW

#### 4.1.1 Habitat assessment

Using remote geographical tools, aerial photography, land system maps and topographic maps, nine broad habitat types for terrestrial fauna and SRE invertebrates were identified in the study area. Habitats identified during the desktop review were:

- samphire plains
- tussock and hummock grasslands
- open shrubland
- rocky outcrops and boulder piles
- minor creeks and drainage lines
- salt flats
- coastal sand dunes
- mangrove thickets
- intertidal mudflats.

Grassy plains dominated by *Triodia* hummock grasses were the dominant broad habitat type covering approximately half of the terrestrial study area, not including the intertidal zone (Figure 4-1). Scattered patches of open shrubland sparsely occur amongst grasslands. A large salt flat creates a band across the study area towards the coast which is potentially inundated after cyclonic activity or extremely high tides (although was not observed to be inundated during a spring tide of 6.5 m).

Extensive intertidal flats and inlets with dense mangrove thickets dominate the coastline within the northern portion of the study area (Figure 4-1). Large tides up to 6.5 m result in a highly variable tide line along the coastline. Small areas of coastal dune habitat and two large rocky outcrops and boulder piles are located along the coastline the study area.

The extensive grasslands and scattered shrublands were identified as potential habitat for conservation significant species including, Bush Stone Curlew (P4), Australian Bustard (P4), Flock Bronzewing (P4), Short-tailed Mouse and Western Pebble-mound Mouse (P4) in areas with suitably rocky surfaces.

The intertidal mudflats within the study area were identified as providing potential foraging and roosting habitat for a number of migratory listed bird species. Mangrove thickets were identified as providing potential habitat for two conservation significant species, the Water Rat (P4) and Little North-western Mastiff Bat (P1).

Riparian vegetation associated with creeks and drainage lines within the study area were considered likely to provide potential refuge sites for a number of species that may forage in surrounding habitats, which provide less protection from the elements and predators. Minor creeks and drainage lines were also considered likely to be utilised by species of conservation significance when water is present by providing a water source and travel corridor for some species, particularly birds.

Boulder piles located in the north of the study area (Figure 4-1) were identified as potential habitat for Northern Quoll (EN) and Black-flanked Rock Wallaby (VU). The likelihood of occurrence was considered low as the rock piles are fairly small and isolated from any other suitable habitat in the vicinity of the study area.

Sand dunes associated with the peninsula where the proposed barge loading facility changes from overland to overwater were identified as potentially supporting Nevin's Lerista.

The small areas of exposed rocky outcrops, boulder piles and minor creek / drainage lines were identified as having the potential to support SRE species; however, some SRE species may be found within other habitat types including the grasslands and shrublands. For example, *Urodacus mckenziei* is restricted to low scrubland habitat in the Shark Bay region (Volschenk *et al.* 2000).

**Figure 4-1**  
**Fauna habitats of**  
**Level 2 study area of**  
**the Balla Balla**  
**Magnetite Project**  
**barge loading facility**

- Coastal sand dunes
- Intertidal flats
- Mangrove thickets
- Minor creeks and drainage lines
- Open shrubland
- Rocky outcrops and boulder piles
- Salt flats
- Samphire plain and algal mats
- Subtidal water
- Tussock and hummock grassland
- Construction envelope



**PROJECT: Balla Balla Magnetite**  
**Project barge loading facility**

**AUTHOR: N. Dight**

**CLIENT: Forge Resources**

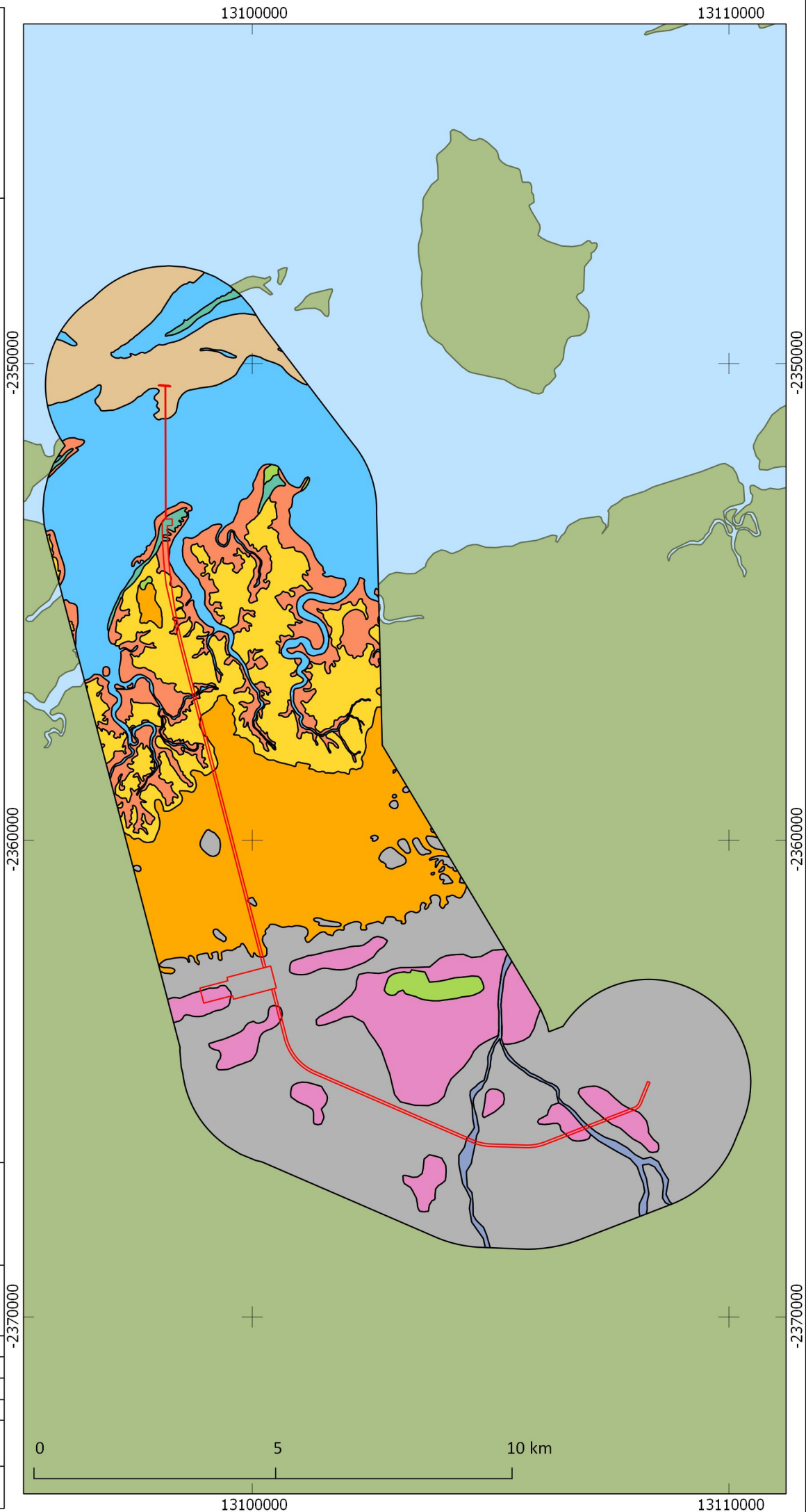
**Scale: 1:110345**

**DATE: 18 January 2013**

**Coordinate System:**

Projection: UTM zone 50; Datum: WGS84

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#### 4.1.2 Vertebrate fauna

A total of 356 vertebrate fauna species were identified within the area of the desktop review (Appendix 4). This comprised eight amphibians, 95 reptiles, 202 birds and 51 mammals (42 native and nine introduced). As some of the database records are historical, the search results are likely to overestimate the number of vertebrate species that may currently use the study area. An average of 126 vertebrate fauna species were identified during survey reports (n = 7) reviewed as part of the desktop review.

Multiple subspecies may be present within the survey area; however, may have only been reported at the species level, such as a number of reptiles including the Bearded Dragon (*Pogona minor*) and migratory shorebirds such as the Red Knot, Greater Sand Plover and Bar-tailed Godwit (Bennelongia 2011; Biota 2008b; ENV 2009; Phoenix 2010b). Therefore, an interpretation at the subspecies level including conservation significance of some subspecies is difficult.

A *Heteronotia* species closely related to *H. binoei* (Bynoe's Gecko) was recorded during surveys near Lake Poongkaliyarra, south of Roebourne. This undescribed species was first collected in 2004 (Biota 2008e) with few specimens collected since. Records for the species have been restricted to Dolerite boulder piles within close proximity to Lake Poongkaliyarra (Biota 2008e).

Previous surveys recorded *Planigale* species not identified to species level due to difficulties in identifying species in the field (Biota 2008d, e; Phoenix 2010b); however, the *Planigale* species complex is currently under taxonomic revision within the Pilbara region (R. How, Senior Curator, WA Museum, 2012, pers. comm.).

A total of 70 species of conservation significance (four reptiles, 56 birds and ten mammals) were identified in database searches for the reference areas as detailed in section 3.1.2 (Table 4-1). Of these, seven are listed as threatened (VU or EN) and 48 species as migratory under the EPBC Act (Table 4-1). A total of 57 species are listed under the WC Act, including 13 Schedule 1, 42 Schedule 3 (migratory) and two Schedule 4 species (Table 4-1). A further 13 species are listed as Priority species under the DEC priority fauna list (Table 4-1).

A number of these species were considered unlikely to be present within the study area due to a lack of suitable habitat or a lack of specific habitat requirements. These include the Pilbara Olive Python, Bilby, Crest-tailed Mulgara, Ghost Bat and Pilbara Leaf-nosed Bat.

**Table 4-1 Conservation significant vertebrates identified through the desktop review for the Balla Balla Magnetite Project barge loading facility**

Scientific name	Common name	EPBC Act	WC Act	DEC
<b>Reptiles</b>				
<i>Lerista neviniae</i>	Nevin's Lerista		S1	VU
<i>Notoscincus butleri</i>	Lined Soil-crevice Skink			P4
<i>Aspidites ramsayi</i>	Woma Python		S4	
<i>Liasis olivaceus barroni</i>	Pilbara Olive Python	VU	S1	VU
<b>Birds</b>				
<i>Anas querquedula</i>	Garganey	Mig	S3	
<i>Phaps histrionica</i>	Flock Bronzewing			P4
<i>Apus pacificus</i>	Fork-tailed Swift	Mig	S3	
<i>Macronectes giganteus</i>	Southern Giant-Petrel			P4

Scientific name	Common name	EPBC Act	WC Act	DEC
<i>Puffinus apacificus</i>	Wedge-tailed Shearwater	Mig	S3	
<i>Fregata ariel</i>	Lesser Frigatebird	Mig	S3	
<i>Sula leucogaster</i>	Brown Booby	Mig	S3	
<i>Ixobrychus flavicollis</i>	Black Bittern			P3
<i>Ardea modesta</i>	Eastern Great Egret	Mig	S3	
<i>Ardea ibis</i>	Cattle Egret	Mig	S3	
<i>Egretta sacra</i>	Eastern Reef Egret	Mig	S3	
<i>Plegadis falcinellus</i>	Glossy Ibis	Mig	S3	
<i>Pandion cristatus</i>	Eastern Osprey	Mig		
<i>Haliaeetus leucogaster</i>	White-bellied Sea-Eagle	Mig	S3	
<i>Falco hypoleucos</i>	Grey Falcon		S1	VU
<i>Falco peregrinus</i>	Peregrine Falcon		S4	
<i>Rallina fasciata</i>	Red-legged Crake	Mig	S3	
<i>Ardeotis australis</i>	Australian Bustard			P4
<i>Burhinus grallarius</i>	Bush Stone-curlew			P4
<i>Pluvialis fulva</i>	Pacific Golden Plover	Mig	S3	
<i>Pluvialis squatarola</i>	Grey Plover	Mig	S3	
<i>Charadrius mongolus</i>	Lesser Sand Plover	Mig	S1	EN
<i>Charadrius leschenaultii</i>	Greater Sand Plover	Mig	S1	VU
<i>Charadrius veredus</i>	Oriental Plover	Mig	S3	
<i>Limosa limosa</i>	Black-tailed Godwit	Mig	S3	
<i>Limosa lapponica</i>	Bar-tailed Godwit	Mig	S1	VU
<i>Numenius minutus</i>	Little Curlew	Mig	S3	
<i>Numenius phaeopus</i>	Whimbrel	Mig	S3	
<i>Numenius madagascariensis</i>	Eastern Curlew	Mig	S1	VU
<i>Numenius arquata</i>	Eurasian Curlew	Mig	S3	
<i>Xenus cinereus</i>	Terek Sandpiper	Mig	S3	
<i>Actitis hypoleucos</i>	Common Sandpiper	Mig	S3	
<i>Heteroscelus brevipes</i>	Grey-tailed Tattler	Mig	S3	
<i>Tringa nebularia</i>	Common Greenshank	Mig	S3	
<i>Tringa stagnatilis</i>	Marsh Sandpiper	Mig	S3	
<i>Tringa glareola</i>	Wood Sandpiper	Mig	S3	
<i>Arenaria interpres</i>	Ruddy Turnstone	Mig	S3	
<i>Calidris tenuirostris</i>	Great Knot	Mig	S1	VU
<i>Calidris canutus</i>	Red Knot	Mig	S1	VU
<i>Calidris alba</i>	Sanderling	Mig	S3	
<i>Calidris ruficollis</i>	Red-necked Stint	Mig	S3	
<i>Calidris subminuta</i>	Long-toed Stint	Mig	S3	
<i>Calidris acuminata</i>	Sharp-tailed Sandpiper	Mig	S3	
<i>Calidris ferruginea</i>	Curlew Sandpiper	Mig	S1	VU

Scientific name	Common name	EPBC Act	WC Act	DEC
<i>Limicola falcinellus</i>	Broad-billed Sandpiper	Mig	S3	
<i>Glareola maldivarum</i>	Oriental Pratincole	Mig	S3	
<i>Sternula albifrons</i>	Little Tern	Mig	S3	
<i>Sternula nereis</i>	Fairy Tern	VU	S1	
<i>Sterna caspia</i>	Caspian Tern	Mig	S3	
<i>Chlidonias leucopterus</i>	White-winged Black Tern	Mig	S3	
<i>Sterna dougallii</i>	Roseate Tern	Mig	S3	
<i>Sterna hirundo</i>	Common Tern	Mig	S3	
<i>Thalasseus bengalensis</i>	Lesser Crested Tern	Mig	S3	
<i>Merops ornatus</i>	Rainbow Bee-eater	Mig	S3	
<i>Hirundo rustica</i>	Barn Swallow	Mig	S3	
<i>Neochmia ruficauda subclaescens</i>	Star Finch			P4
<b>Mammals</b>				
<i>Dasyercus cristicauda</i>	Crest-tailed Mulgara	VU	S1	VU
<i>Dasyurus hallucatus</i>	Northern Quoll	EN	S1	EN
<i>Macrotis lagotis</i>	Bilby, Dalgyte	VU	S1	VU
<i>Petrogale lateralis lateralis</i>	Black-flanked Rock Wallaby	VU	S1	VU
<i>Macroderma gigas</i>	Ghost Bat			P4
<i>Rhinonictis aurantia</i>	Orange Leafnosed-bat	VU	S1	VU
<i>Mormopterus loriae cobourgiana</i>	Little North-western Mastiff Bat			P1
<i>Hydromys chrysogaster</i>	Water-rat			P4
<i>Leggadina lakedownensis</i>	Short-tailed Mouse			P4
<i>Pseudomys chapmani</i>	Western Pebble-mound Mouse			P4

EN – Endangered (EPBC Act); VU – Vulnerable (EPBC Act); Mig. – Migratory (EPBC Act).

S1 – Schedule 1 (WC Act); S3 – Schedule 3/migratory (WC Act) S4 – Schedule 4 (WC Act)

P1 – Priority 1 (DEC); P3 – Priority 3 (DEC); P4 – Priority 4 (DEC);

#### 4.1.3 Short-range endemic invertebrates

A total of 61 SRE invertebrate taxa, including 27 confirmed, eight likely and 26 potential SREs were identified from the reference area of the desktop review (Table 4-2; Appendix 5). Searches of the EPBC database and NatureMap did not reveal any conservation significant SRE invertebrates from the area of the desktop review. The WA Museum database for crustaceans did not include any terrestrial species, but was limited to subterranean forms.

A single potential SRE taxon, the unidentified camaenid land snail *Rhagada* sp. indet., was recovered through the desktop review inside the study area (Table 4-2). *Rhagada* is represented by at least four confirmed SRE species within the wider area of the desktop review (Table 4-2). The genus *Rhagada* is locally abundant outside the study area, including the widely distributed *Rhagada richardsonii* (Johnson *et al.* 2012). As it cannot be determined whether the records of *Rhagada* within the study area are conspecific with *R. richardsonii*, they are considered to be potential SREs.

All 62 taxa were identified outside the study area but within a range of approximately 100 km which may therefore include SREs from the study area (Figure 4-2; Figure 4-3; Figure 4-4; Figure 4-5; Figure



4-6; Figure 4-7; Figure 4-8; Figure 4-9; Figure 4-10). Sixteen represent higher taxonomic ranks that may contain SREs ("sp. indet."). Species-level comparison with any material collected from within the study area may not be possible. However, all records from the desktop review provide an important regional context for the study area.

Of the 62 taxa recorded, only seven species, primarily snails (Table 4-2) are formally described, confirming the poor taxonomic coverage of the region.

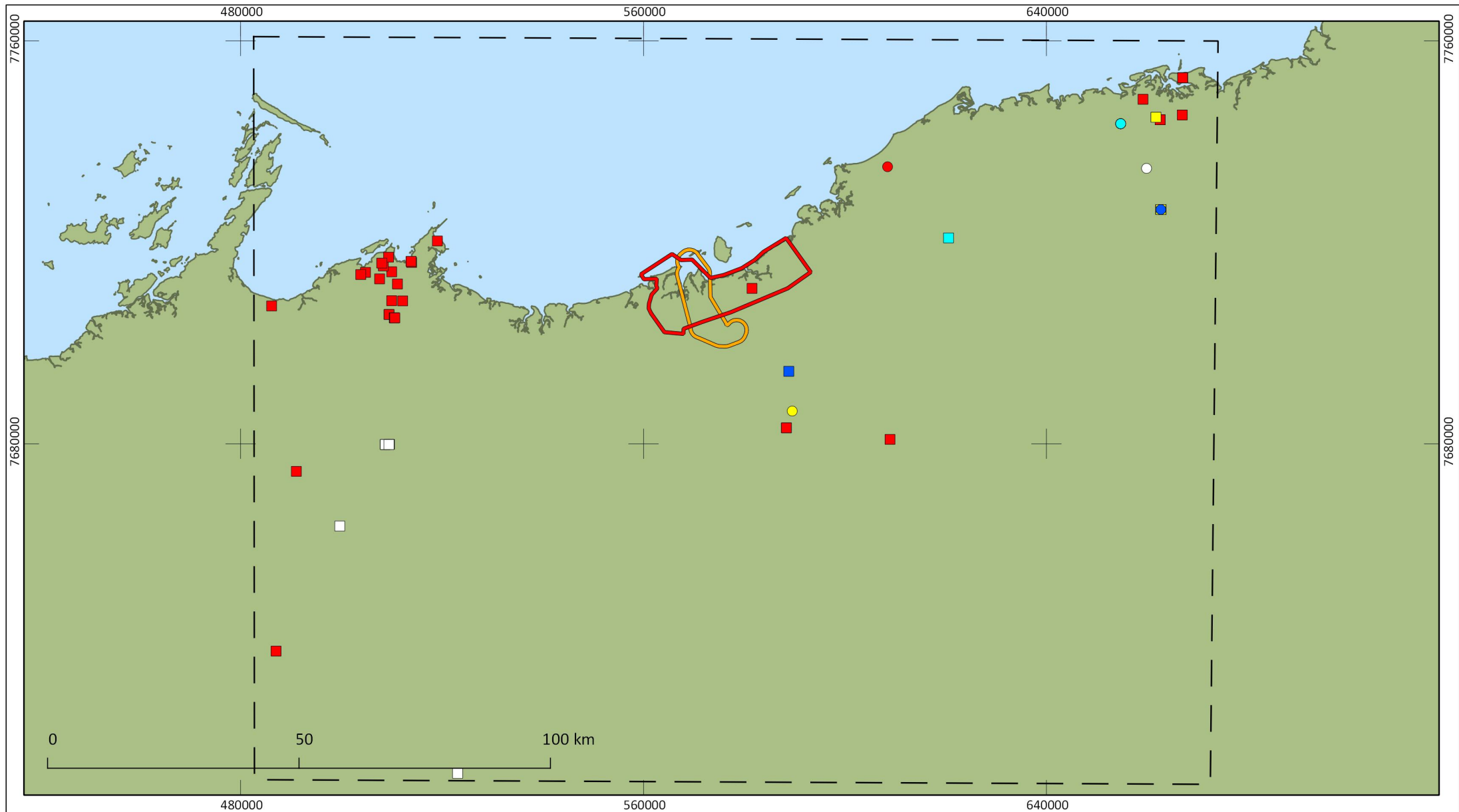
**Table 4-2 SRE invertebrates identified through the desktop review for the Balla Balla Magnetite Project barge loading facility**

Family	Genus	Species	Locality	SRE category <sup>a</sup>	Source
<b>Aranae (spiders)</b>					
Actinopodidae	<i>Missulena</i>	`MYG110`	Millstream Chichester NP	Potential	WA Museum
	<i>Missulena</i>	sp. indet.	Port Hedland	Potential	WA Museum
Barychelidae	<i>Synothele</i>	sp. indet.	Roebourne	Potential	WA Museum
Ctenizidae	<i>Conothele</i>	sp. indet.	Roebourne, Emu Siding, Finucane Island	Potential	WA Museum
Idiopidae	<i>Eucyrtops</i>	sp. indet.	Karratha	Potential	WA Museum
	<i>Euoplos</i>	`MYG081`	Lake Poongkaliyarra	Potential	WA Museum
Lycosidae	<i>Artoria</i>	sp. indet.	Millstream Station	Potential	WA Museum
Nemesiidae	<i>Aname</i>	`boodarie`	Boodarie Hill	Potential	WA Museum
	<i>Aname</i>	`MYG089`	Whim Creek	Potential	WA Museum
	<i>Aname</i>	`MYG106`	Whim Creek	Potential	WA Museum
	<i>Aname</i>	`MYG208`	Port Hedland	Potential	WA Museum
	<i>Aname</i>	`MYG209`	Port Hedland	Potential	WA Museum
	<i>Aname</i>	<i>ellenae</i>	Whim Creek	Confirmed	WA Museum; Harvey <i>et al.</i> (2012)
	<i>Aname</i>	sp. indet.	Port Hedland, Balla Balla, Karratha, South Hedland, Point Samson, Cossack, Cape Lambert, Wickham, Cleaverville, Mallina Homestead, Tom Price, Roebourne	Potential	WA Museum; Biota (2008b, e)
	<i>Kwonkan</i>	`MYG007`	Port Hedland	Potential	WA Museum
	<i>Teyl</i>	sp. indet.	Karratha	Potential	WA Museum
	<i>Yilgarnia</i>	`MYG092`	Whim Creek	Likely	WA Museum
Selenopidae	<i>Karaops</i>	`binjiriganbarr`	Lake Poongkaliyarra, Roebourne	Likely	WA Museum
	<i>Karaops</i>	`jaburrara`	Wickham	Likely	WA Museum
	<i>Karaops</i>	`kanparra`	Port Hedland	Likely	WA Museum
	<i>Karaops</i>	`murdimaa`	Millstream	Likely	WA Museum
	<i>Karaops</i>	`yurlburr`	Python Pool	Likely	WA Museum
	<i>Karaops</i>	sp. indet.	Mt Gregory, Mallina Homestead, Python Pool, Mt Herbert, Wickham, Wodgina, Dixon Island	Likely	WA Museum
<b>Opiliones (harvestmen)</b>					

Family	Genus	Species	Locality	SRE category <sup>a</sup>	Source
Assamiidae	<i>Dampetrus</i>	sp. indet.	Port Hedland, Mt Herbert	Likely	WA Museum
<b>Pseudoscorpiones (pseudoscorpions)</b>					
Chernetidae	<i>Troglochernes</i>	sp. nov. '001'	Mount Dove	Confirmed	WA Museum
<b>Scorpiones (scorpions)</b>					
Urodacidae	<i>Urodacus</i>	sp. indet.	Port Hedland	Potential	WA Museum
<b>Chilopoda (centipedes)</b>					
Mecistocephalidae	gen. indet.	sp. indet.	Karratha to Millstream Chichester NP, Dixon Island	Potential	WA Museum
Cryptopidae	<i>Cryptops</i>	sp. indet.	Tom Price	Potential	WA Museum
<b>Diplopoda (millipedes)</b>					
Paradoxosomatidae	<i>Antichiropus</i>	'DIP011'	Wickham	Confirmed	WA Museum
	<i>Antichiropus</i>	'DIP023'	Millstream Chichester National Park	Confirmed	WA Museum
	<i>Antichiropus</i>	'DIP024'	Millstream Chichester National Park	Confirmed	WA Museum
	<i>Antichiropus</i>	'DIP025'	Mt Welcome Station, Whim Creek	Confirmed	WA Museum
	<i>Antichiropus</i>	'DIP028'	Whim Creek Hotel	Confirmed	WA Museum
	<i>Antichiropus</i>	'DIP032'	Anketell Point, Karratha to Millstream Chichester National Park	Confirmed	WA Museum
	<i>Antichiropus</i>	'DIP033'	Wodgina	Confirmed	WA Museum
	<i>Antichiropus</i>	'wickham'	Wickham	Confirmed	WA Museum
	<i>Antichiropus</i>	sp. indet.	Cape Lambert, Millstream Chichester National Park, Mt Welcome Station	Confirmed	WA Museum
	'DIPAAC'	'DIP030'	Whim Creek	Confirmed	WA Museum
	gen. indet.	sp. indet.	Wodgina	Confirmed	WA Museum
	gen. indet.	sp. indet.	Wodgina	Confirmed	WA Museum
<b>Eupulmonata (land snails)</b>					
Bithyniidae	<i>Gabbia</i>	aff. <i>smithii</i>	Karratha	Potential	WA Museum
	<i>Gabbia</i>	cf. <i>naperiensis</i>	Whim Creek	Potential	WA Museum
	<i>Gabbia</i>	cf. <i>smithii</i>	Whim Creek	Potential	WA Museum
	<i>Gabbia</i>	sp. indet.	Karratha	Potential	WA Museum
	<i>Quistrachia</i>	'depuch island'	Depuch Island	Confirmed	WA Museum
Camaenidae	<i>Quistrachia</i>	'W'	Quartz Hill, Pilbara, Port Hedland	Confirmed	WA Museum

Family	Genus	Species	Locality	SRE category <sup>a</sup>	Source
	<i>Quistrachia</i>	`X anketell point`	Anketell Point, Cleaverville, Karratha, Port Hedland	Confirmed	WA Museum
	<i>Quistrachia</i>	cf. <i>herberti</i>	Pinderi Hills	Confirmed	WA Museum
	<i>Quistrachia</i>	<i>herberti</i>	Mt Herbert, Tom Price, Chichester Range NP, Roebourne, Millstream Chichester NP, Harding River, Karratha	Confirmed	WA Museum
	<i>Quistrachia</i>	<i>legendrei</i> sp. `burrup`	Rocky Hill, Burrup Peninsula, V34 Creek, Sloping Point, Karratha	Confirmed	WA Museum
	<i>Quistrachia</i>	<i>legendrei</i> sp. `dampier arch.`	Legendre Island	Confirmed	WA Museum
	<i>Quistrachia</i>	<i>legendrei</i> sp. cf. `burrup`	Dolphin Island	Confirmed	WA Museum
	<i>Quistrachia</i>	sp. indet.	Millstream, Karratha	Potential	WA Museum
	<i>Rhagada</i>	<i>angulata</i>	Legendre Island, V43 Creek, Burrup Peninsula, Dolphin Island, Sloping Point	Confirmed	WA Museum
	<i>Rhagada</i>	cf. <i>pilbarana</i>	Karratha	Confirmed	WA Museum
	<i>Rhagada</i>	<i>elachystoma</i>	Legendre Island	Confirmed	WA Museum
	<i>Rhagada</i>	<i>intermedia</i>	Legendre Island, Delambre Island	Confirmed	WA Museum
	<i>Rhagada</i>	<i>pilbarana</i>	Mt Herbert, Python Pool, Roebourne, Harding River, Millstream, Karratha	Confirmed	WA Museum
	<i>Rhagada</i>	sp. indet.	Legendre Island, South West Creek, Mt Herbert, Roebourne, Millstream, Karratha, Turner River, Sloping Point, Burrup Peninsula, V34 Creek, Hany Island, Millstream, South Hedland, Balla Balla, Whim Creek, Reading Head Lookout	Potential	WA Museum; Biota (2008e); Slack-Smith (2005)
	gen. nov.	sp. nov.	Wodgina, Anson, Port Hedland	Potential	WA Museum
	gen indet.	sp. indet.	Karratha, Millstream, Port Hedland	Potential	WA Museum
	<i>Dupucharopa</i>	<i>millestriata</i>	Depuch Island	Confirmed	Solem (1984)
Charopidae					

a – see section 2.5.3 for explanation of SRE categories



**Figure 4-2**  
Records of short-range endemic trapdoor spiders (Mygalomorphae: Nemesiidae) from the desktop review



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**Coordinate System:** Projection: UTM zone 50; Datum: WGS84

**PROJECT:** Balla Balla Magnetite Project barge loading facility

Level 1 study area

Level 2 study area

Area for desktop review

Aname `boodarie`

Aname `MYG089`

Aname `MYG106`

Aname `MYG208`

Aname `MYG209`

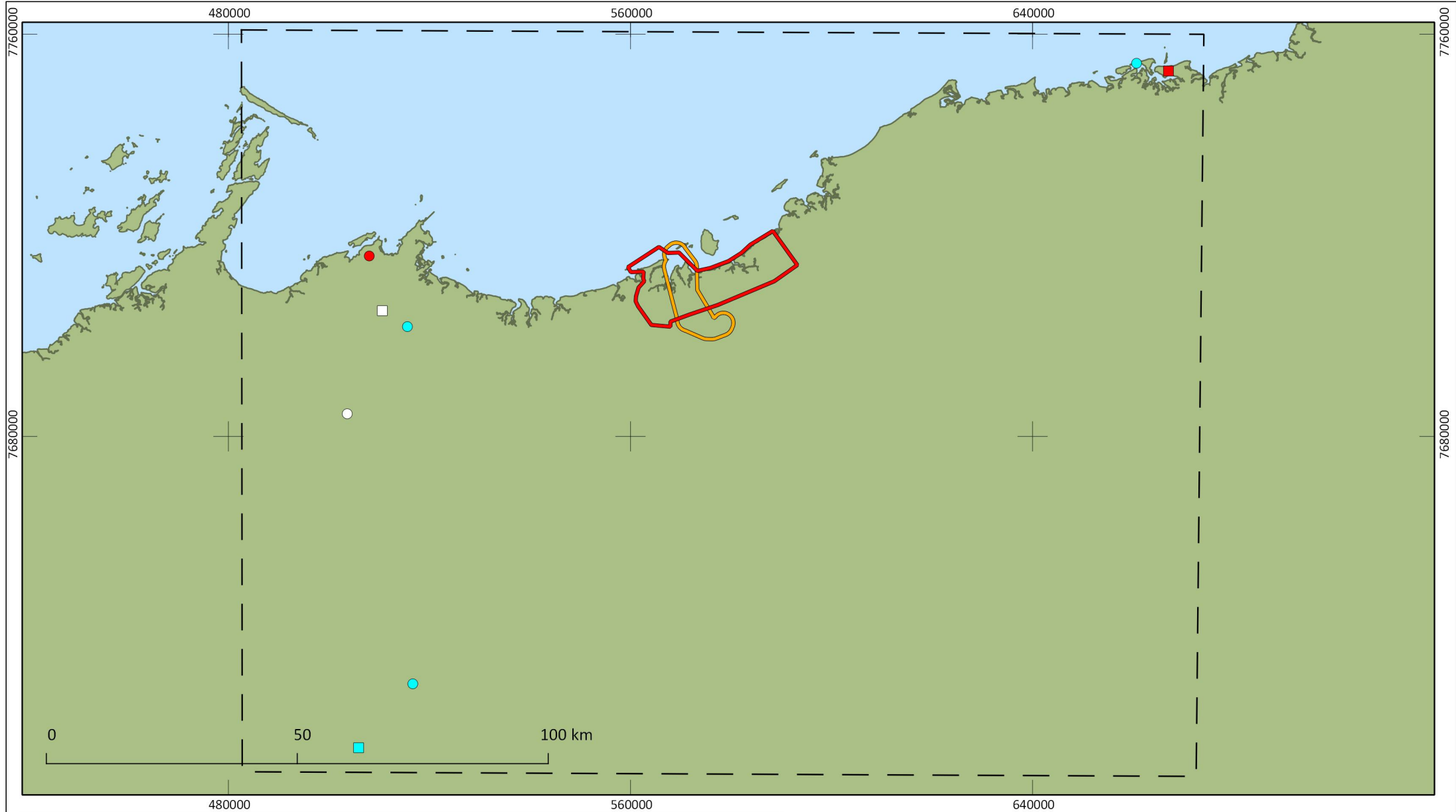
Aname elleneae

Aname sp. indet.

Kwonkan `MYG007`

Teyl sp. indet.

Yilgarnia `MYG092`



**Figure 4-3**  
**Records of short-range endemic trapdoor spiders (Mygalomorphae: Actinopodidae, Barychelidae, Ctenizidae and Idiopidae) from the desktop review**

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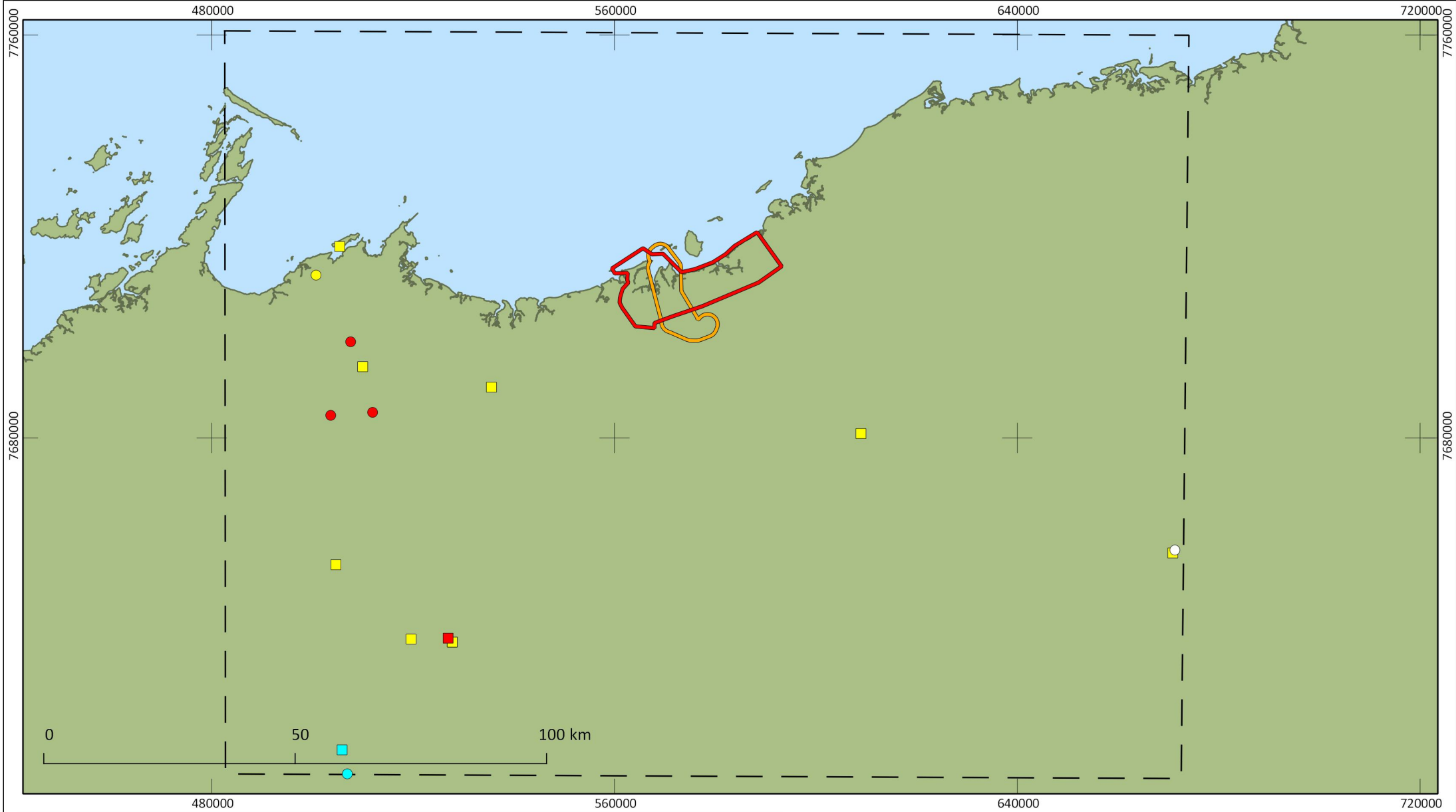
**DATE:** 30 November 2012      **Scale:** 1:1000000

**Coordinate System:** Projection: UTM zone 50; Datum: WGS84



**PROJECT:** Balla Balla Magnetite Project barge loading facility

- Level 1 study area
- Level 2 study area
- Area for desktop review
- Conothele sp. indet.
- Eucyrtops sp. indet.
- Euoplos 'MYG081'
- Missulena 'MYG110'
- Missulena sp. indet.
- Synothele sp. indet.



**Figure 4-4**  
**Records of short-range endemic modern spiders (Araneomorphae) from the desktop review**



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**PROJECT:** Balla Balla Magnetite Project barge loading facility

Level 1 study area

Level 2 study area

Area for desktop review

Artoria sp. indet.

Karaops `binjiriganbarr`

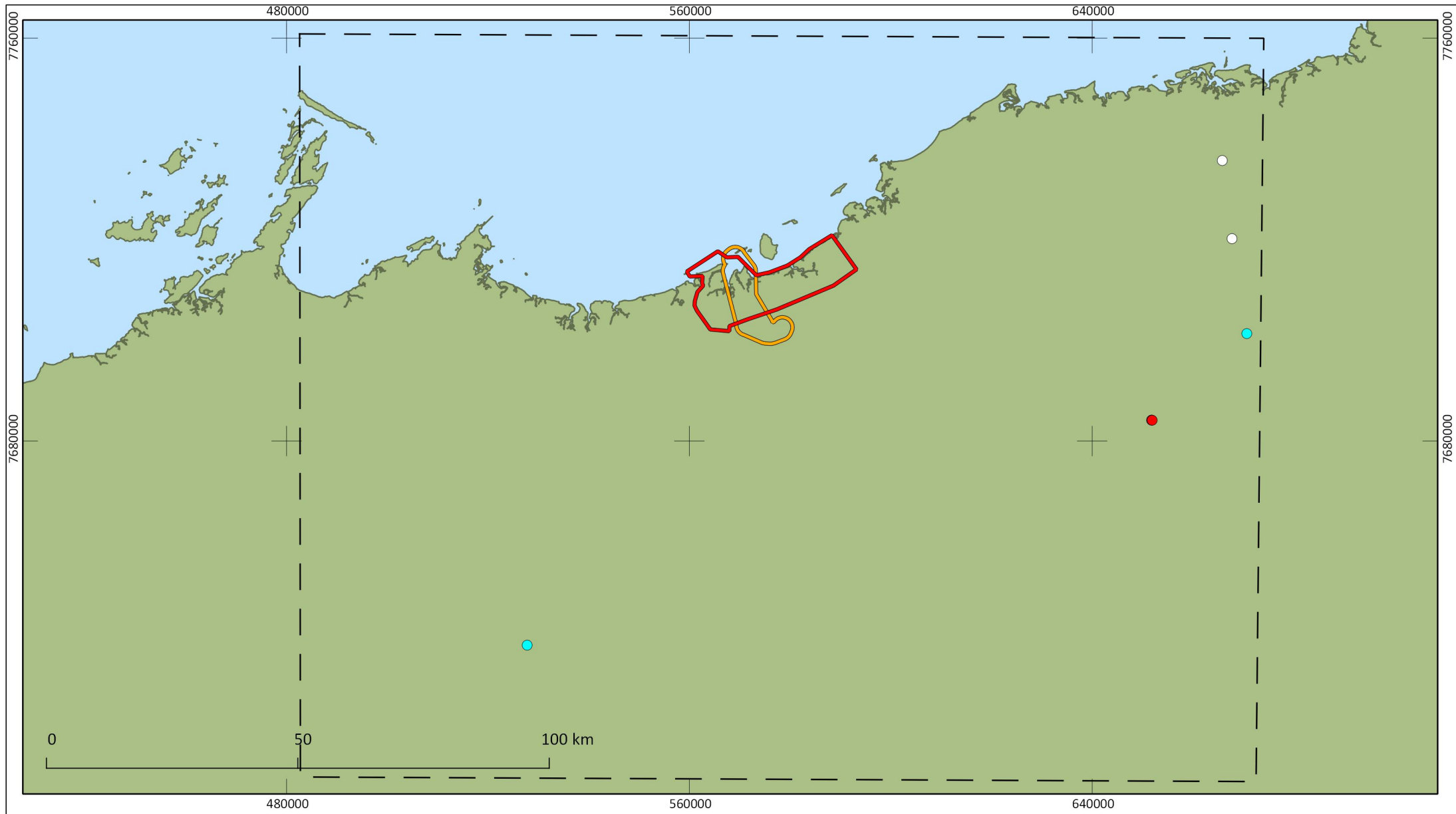
Karaops `jaburrara`

Karaops `kanparra`

Karaops `murdimaa`

Karaops `yurlburr`

Karaops sp. indet.



**Figure 4-5**  
**Records of short-range endemic harvestmen**  
**(Opiliones), pseudoscorpions**  
**(Pseudoscorpiones) and scorpions (Scorpiones)**  
**from the desktop review**

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**PROJECT:** Balla Balla Magnetite Project barge loading facility

Level 1 study area

Level 2 study area

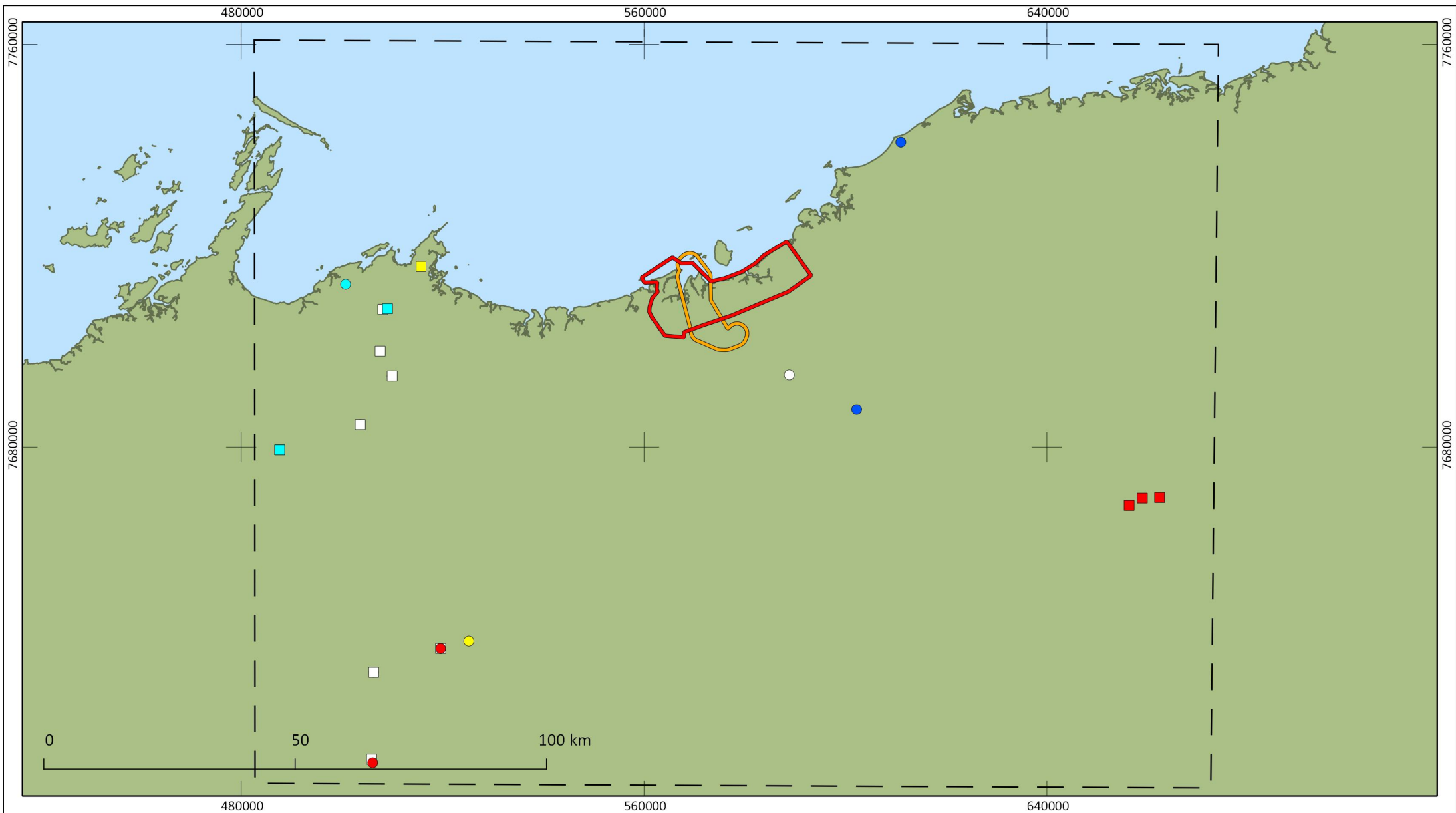
Area for desktop review

*Dampetrus* sp. indet.

*Trogloderus* 'sp. nov. 001'

*Urodacus* sp. indet.





**Figure 4-6**  
**Records of short-range endemic millipedes**  
**(Diplopoda: Antichiropus) from the desktop**  
**review**



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**Coordinate System:** Projection: UTM zone 50; Datum: WGS84

**PROJECT:** Balla Balla Magnetite Project barge loading facility

Level 1 study area

Level 2 study area

Area for desktop review

Antichiropus 'DIP011'

Antichiropus 'DIP023'

Antichiropus 'DIP024'

Antichiropus 'DIP025'

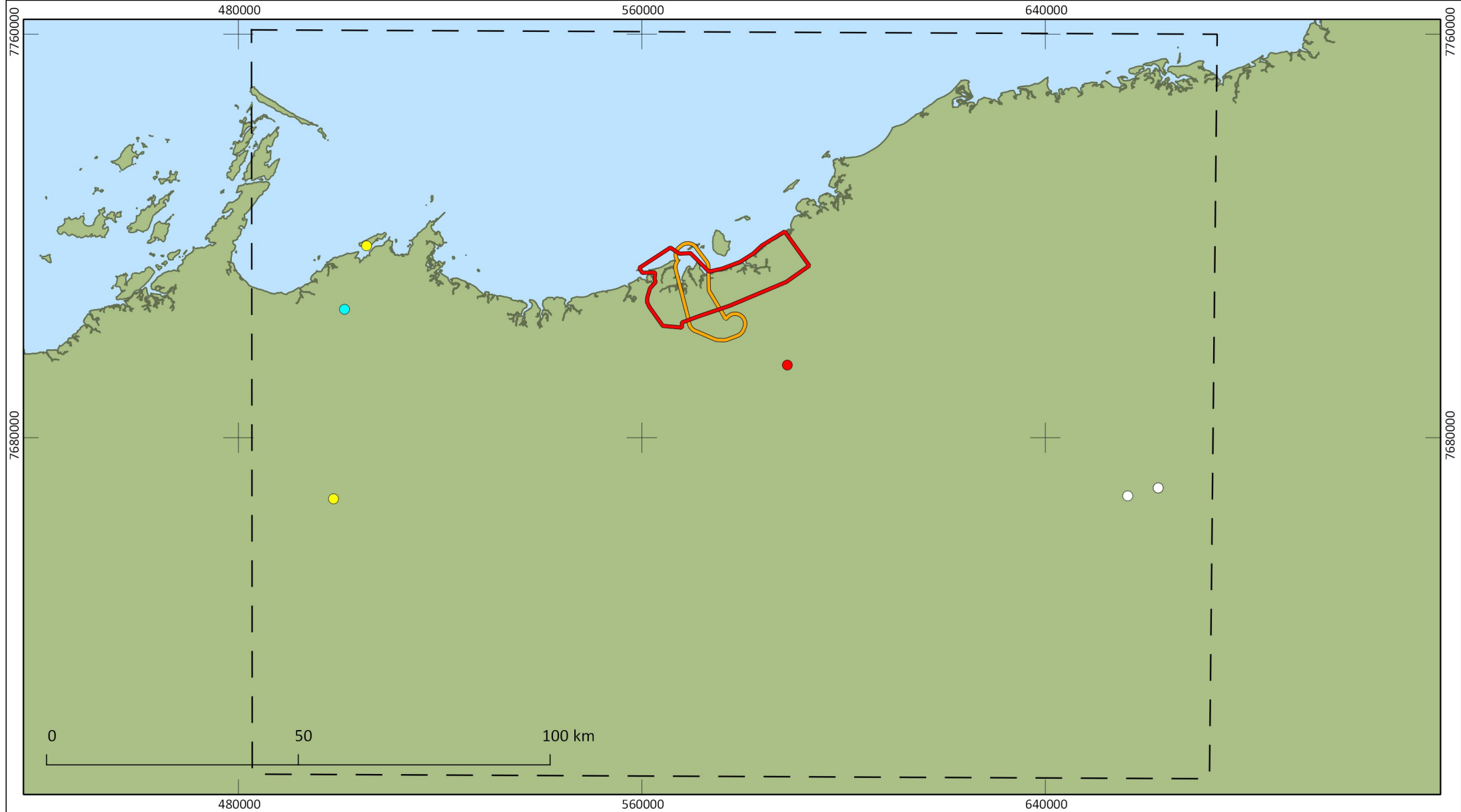
Antichiropus 'DIP028'

Antichiropus 'DIP032'

Antichiropus 'DIP033'

Antichiropus 'wickham'

Antichiropus sp. indet.



**Figure 4-7**  
**Records of short-range endemic centipedes (Chilopoda) and millipedes (Diplopoda) from the desktop review**



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**DATE:** 30 November 2012      **Scale:** 1:1000000

**Coordinate System:** Projection: UTM zone 50; Datum: WGS84

**PROJECT:** Balla Balla Magnetite Project barge loading facility

Level 1 study area

Level 2 study area

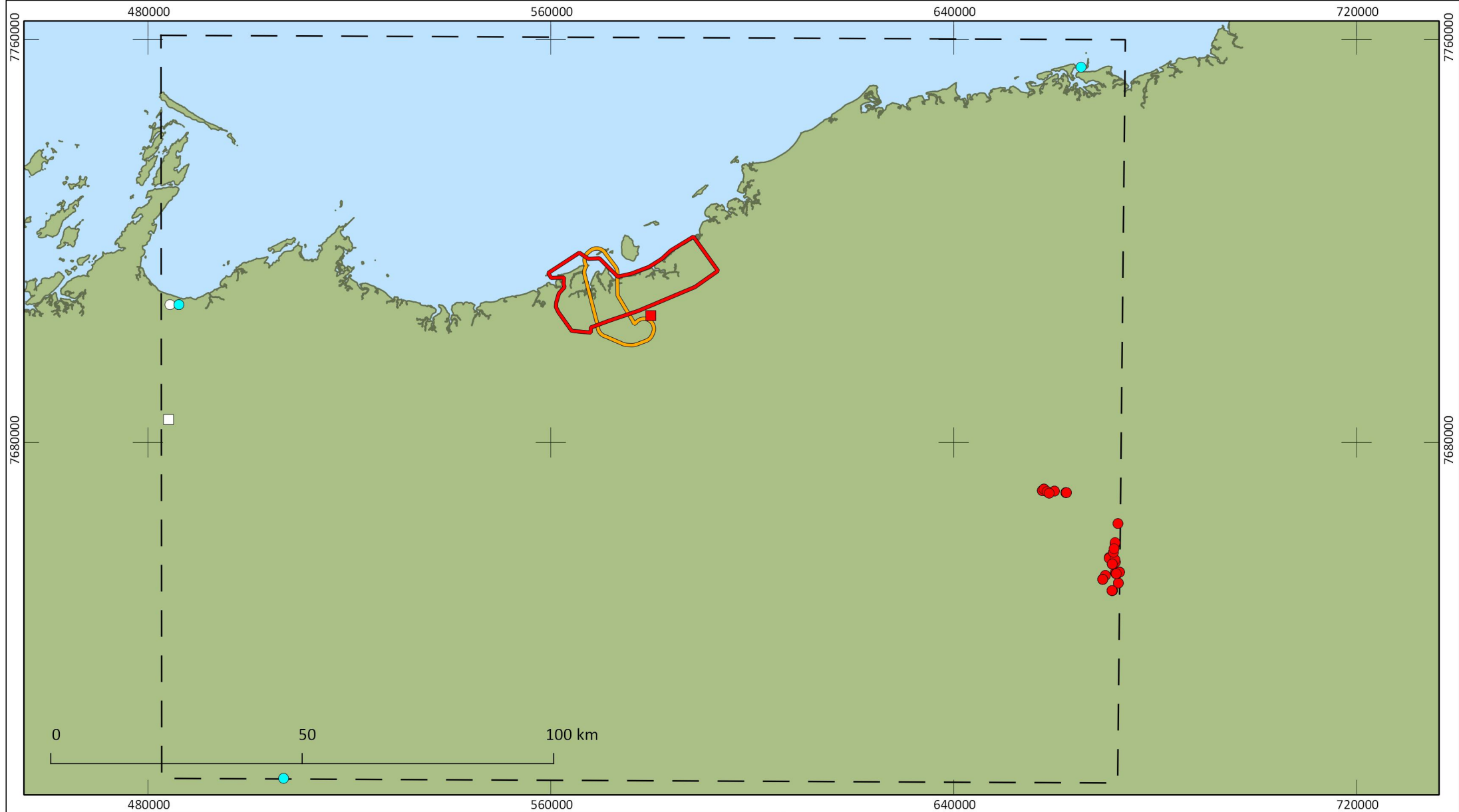
Area for desktop review

Cryptops sp. indet.

DIPAAC 'DIP030'

Mecistocephalidae (gen. indet.) sp. indet.

Paradoxosomatidae sp. indet.



**Figure 4-8**  
**Records of short-range endemic land snails**  
**(Eupulmonata: unknown Camaenidae and**  
**Gabbia) from the desktop review**



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**PROJECT:** Balla Balla Magnetite Project barge loading facility

Level 1 study area

Level 2 study area

Area for desktop review

Camaenidae (fam. indet.) sp. indet.

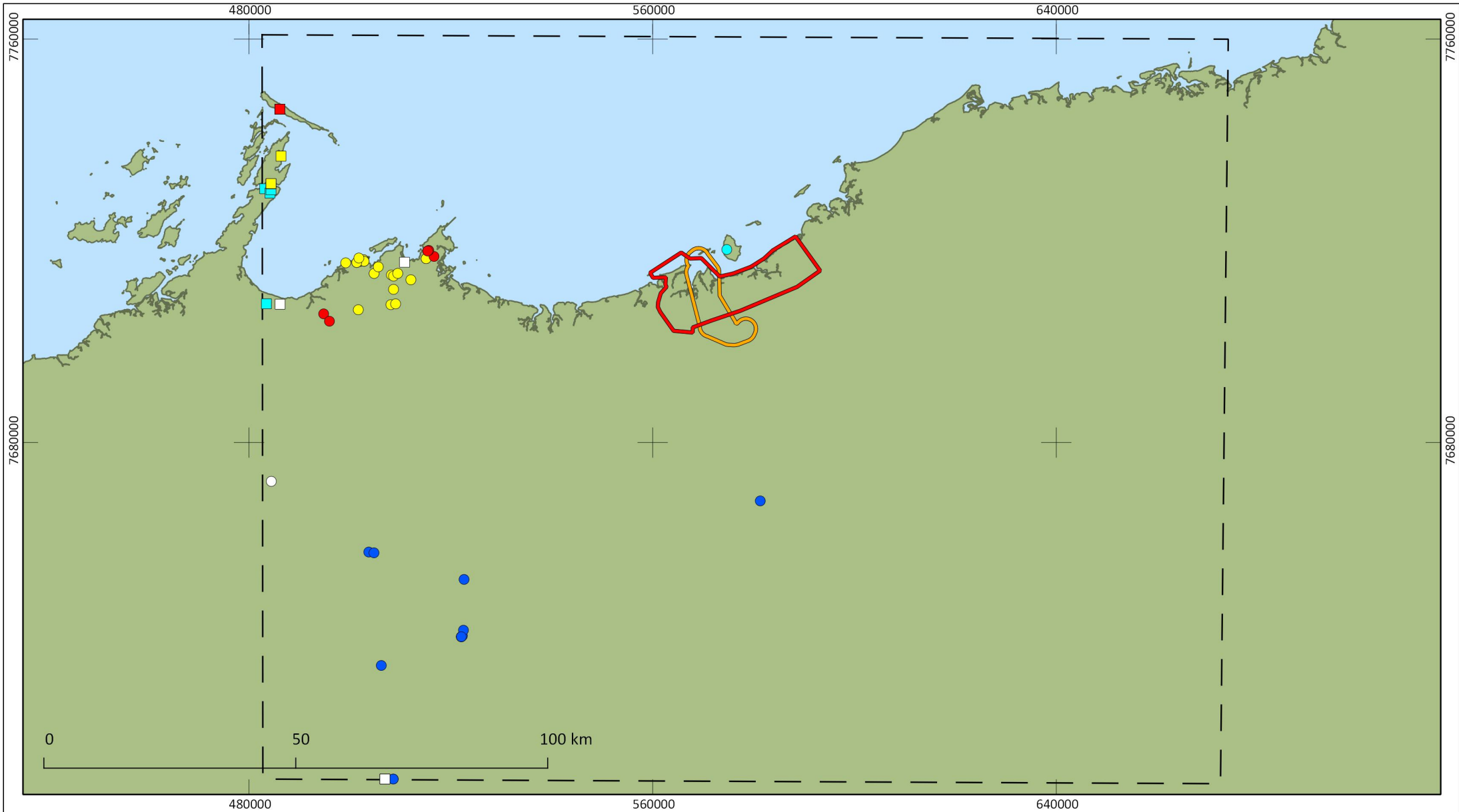
Camaenidae gen. nov. sp. nov.

Gabbia aff. smithii

Gabbia cf. naperiensis

Gabbia cf. smithii

Gabbia sp. indet.



**Figure 4-9**  
**Records of short-range endemic land snails**  
**(Mollusca: Quistrachia) from the desktop**  
**review**



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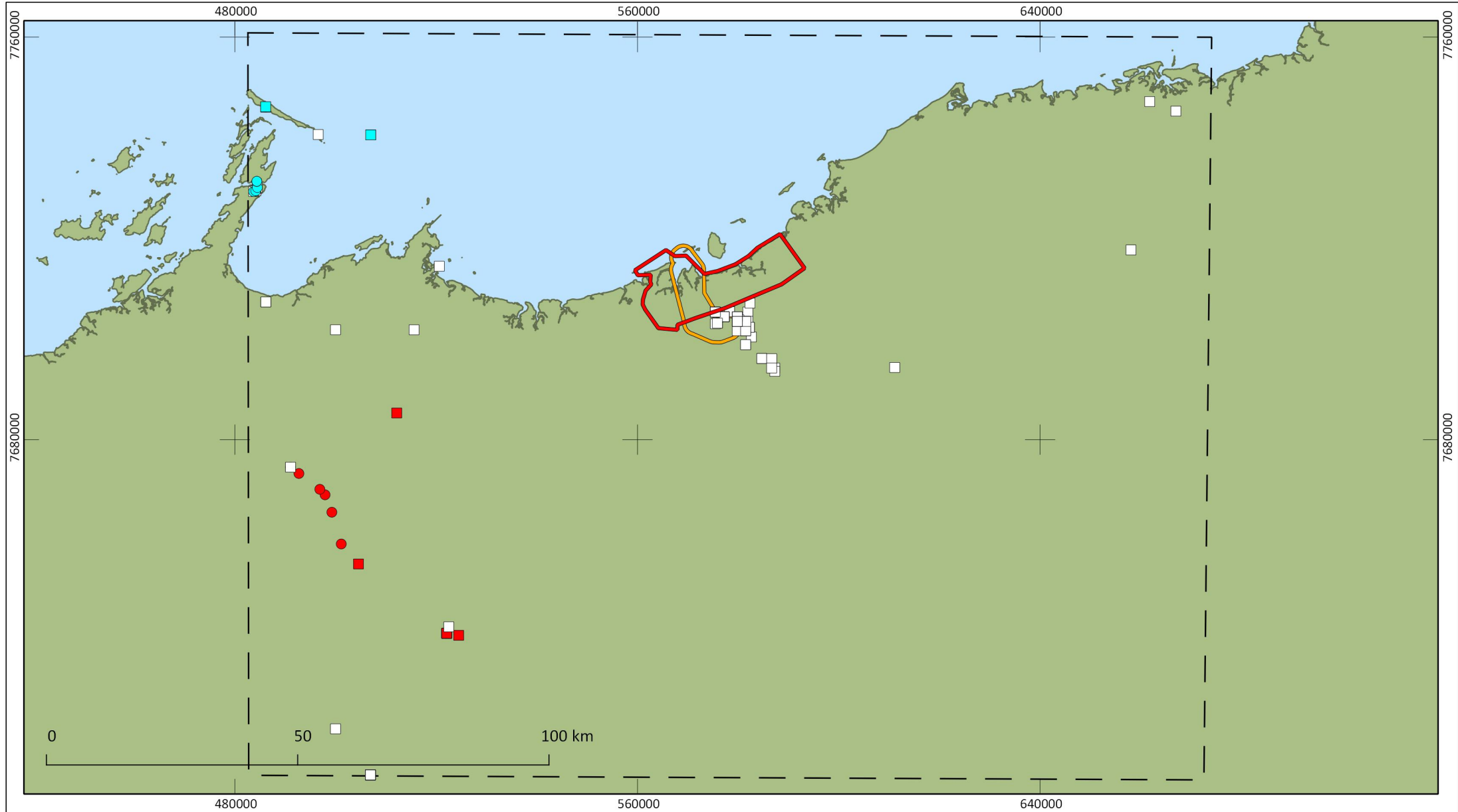
**AUTHOR:** N. Dight **CLIENT:** Forge Resources

**DATE:** 30 November 2012 **Scale:** 1:1000000

**Coordinate System:** Projection: UTM zone 50; Datum: WGS84

**PROJECT:** Balla Balla Magnetite Project barge loading facility

- Level 1 study area
- Level 2 study area
- Area for desktop review
- Quistrachia 'depuch island'
- Quistrachia 'W'
- Quistrachia 'X anketell point'
- Quistrachia cf. herberti
- Quistrachia herberti
- Quistrachia legendrei sp. 'burrup'
- Quistrachia legendrei sp. 'dampier arch'
- Quistrachia legendrei sp. cf. 'burrup'
- Quistrachia sp. indet.



**Figure 4-10**  
**Records of short-range endemic land snails**  
**(Eupulmonata: Rhagada) from the desktop**  
**review**



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**PROJECT:** Balla Balla Magnetite Project barge loading facility

- Level 1 study area
- Level 2 study area
- Area for desktop review
- Rhagada angulata
- Rhagada cf. pilbarana
- ◻ Rhagada intermedia
- ◻ Rhagada pilbarana
- Rhagada sp. indet.
- Rhagada elachystoma

## 4.2 LEVEL 1 RECONNAISSANCE SURVEY

A Level 1 reconnaissance survey took place between 9 and 12 November 2012. A total of nine of habitat types were identified during the field survey confirming the initial habitat assessment of the desktop review.

Small areas of possible habitat were identified for the following conservation significant species, although the likelihood of occurrence was considered low:

- Bilby (*Macrotis lagotis*; VU, EPBC)
- Crest-tailed Mulgara (*Dasyercus cristicauda*; VU, EPBC)
- Northern Quoll (*Dasyurus hallucatus*; EN, EPBC)

More substantive areas of habitat considered capable of supporting additional conservation significant species were also identified:

- Nevin's Lerista (*Lerista neviniae*; VU, WC Act)
- Water Rat (*Hydromys chrysogaster*; P4, DEC)
- Little North-western Mastiff Bat (*Mormopterus loriae cobourgiana*; P1, DEC).

The spinifex grassland habitat identified for Bilby (where pockets of relatively dense shrub cover were present), Crest-tailed Mulgara and Brush-tailed Mulgara in the study area was generally degraded in nature due to heavy grazing and stock damage and the likelihood of occurrence of the three species was low for the most part; however there was relatively large areas of relatively dense shrubland identified from the air that warranted further investigation.

Two exposed outcrops with boulder piles identified as potential habitat for Northern Quoll during the desktop review were considered unlikely to support the species due to their small size and isolation from any other suitable habitat in the vicinity of the study area.

Sand dunes associated with the peninsula from which the proposed barge loading facility changes from overland to overwater potentially support Nevin's Lerista. Occurrence was determined as unlikely due to the isolation of the habitat from other known populations of the species, but further investigation during the Level 2 field survey was recommended, as the species distribution nearer Karratha is relatively patchy.

Habitat was identified for two additional priority fauna species, Water Rat and Little North-western Mastiff Bat with likelihood of occurrence considered moderate to high due to the presence of rocky shorelines with suitable cover available, records of the Water Rat from Depuch Island and, due to extensive mangrove thickets in good condition along the shoreline (Churchill 2008; Van Dyck & Strahan 2008).

Level 2 review of the images from the six camera traps deployed during the reconnaissance survey failed to record any species of conservation significance.

Little suitable habitat for SRE invertebrate fauna was identified during the Level 1 reconnaissance survey in the study area, namely an exposed outcrop and rock piles on the coastal peninsula in the north of the study area and multiple creek systems were identified as areas likely to support SRE taxa.

## 4.3 LEVEL 2 FIELD SURVEY

### 4.3.1 Survey sites

Five systematic vertebrate trapping sites and six systematic SRE survey sites were selected during the Level 2 field survey representing four of the nine broad fauna habitats within the study area. Systematic vertebrate trapping sites were not established in some habitat types due to the habitat structure and substrate or daily inundation with water in tidal areas, particularly intertidal mudflats and mangroves, rocky outcrops, boulder fields and salt pan habitats. Additional opportunistic sites were selected in these habitats to compensate for lack of systematic surveys (Table 4-3).

A total of 14 opportunistic vertebrate sites complemented the systematic survey sites (Table 4-3). Opportunistic survey sites targeted habitats not represented by systematic survey sites or particular microhabitats targeting species unlikely to be recorded at systematic sites such as rock dwelling species amongst outcrops. Opportunistic sites were generally surveyed with lower intensity.

Two of the survey sites were located directly within the project footprint; however, all survey sites represented habitats to be impacted under the proposal (Table 4-3; Figure 3-2)

Site descriptions detail geography, vegetation, soil, rockiness, litter, and disturbance and include site photographs (Appendices 1–3).

**Table 4-3 Survey site locations and habitat type of terrestrial fauna survey for Balla Balla Magnetite Project barge loading facility**

Site *	Habitat type	Project footprint	Easting (GDA94)	Northing (GDA94)	Zone
Vert 01	Grassland / Open Shrubland	No	575128	7701201	50K
Vert 02	Minor creekline	No	575596	7703357	50K
Vert 03	Open shrubland	No	570604	7703944	50K
Vert 04	Coastal sand dunes	Yes	568927	7713147	50K
Vert 05	Coastal sand dunes	No	571061	7714362	50K
Vert Opp 01	Grassland	No	575758	7698177	50K
Vert Opp 02	Minor creekline	No	576241	7702678	50K
Vert Opp 03	Grassland	No	573332	7704494	50K
Vert Opp 04	Grassland	Yes	571571	7703322	50K
Vert Opp 05	Grassland	No	576340	7702738	50K
Vert Opp 06	Grassland / Rocky Outcrop	No	573447	7704527	50K
Vert Opp 07	Grassland	No	578253	7703258	50K
Vert Opp 08	Grassland	No	574773	7705710	50K
Vert Opp 09	Grassland	No	573923	7704400	50K
Vert Opp 10	Rocky Outcrop & Boulder Piles	No	570986	7714500	50K
Vert Opp 11	Mangrove thickets	No	566904	7713181	50K
Vert Opp 12	Rocky Outcrop & Boulder Piles	No	568575	7712307	50K
Vert Opp 13	Mangrove thickets	No	570212	7713006	50K
Vert Opp 14	Salt flats	No	572960	7706946	50K
SRE 01	Rocky Outcrop & Boulder Piles	No	568644	7712350	50K



Site *	Habitat type	Project footprint	Easting (GDA94)	Northing (GDA94)	Zone
SRE 02	Rocky Outcrop & Boulder Piles	No	571209	7714594	50K
SRE 03	Rocky Outcrop & Boulder Piles	No	573442	7704434	50K
SRE 04	Minor creekline	No	576143	7702743	50K
SRE 05	Grassland	No	576558	7698317	50K
SRE 06	Minor creekline	No	576254	7702684	50K

\* – Vert...- vertebrate systematic survey site; Vert Opp...- vertebrate opportunistic survey site;  
SRE...-SRE invertebrate survey site

### 4.3.2 Statistical analyses

#### 4.3.2.1 Species accumulation curves

A total of 158 vertebrate species and eight invertebrate taxa from SRE target groups were recorded during the surveys **Error! Reference source not found.**

The species accumulation curves generated from the systematically recorded dataset indicates that across the entire assemblage and within each of the three vertebrate groups (reptiles, avifauna, and mammals) a majority of the assemblage was recorded (**Error! Reference source not found.a-d**). When looking at the curves for each group however, it is apparent that avifauna are largely driving the flattening of the curve (**Error! Reference source not found.c**) and that a number of reptiles (**Error! Reference source not found.b**) and mammals (**Error! Reference source not found.d**) were not detected.

Not detecting some species would be of concern if those species were likely to be conservation significant; however, no additional terrestrial conservation significant species are expected to be present in the study area based on the habitats present and their condition.

Only one SRE group, snails, were collected in sufficient numbers to allow a reliable estimate of species richness to be calculated. Species richness indicators suggest that that up to two more snail species were present in the study area, depending on the estimator used.

It should be acknowledged that estimators generally underestimate 'true' species diversity and these should therefore be considered minimum species richness estimators (Gotelli & Colwell 2001).



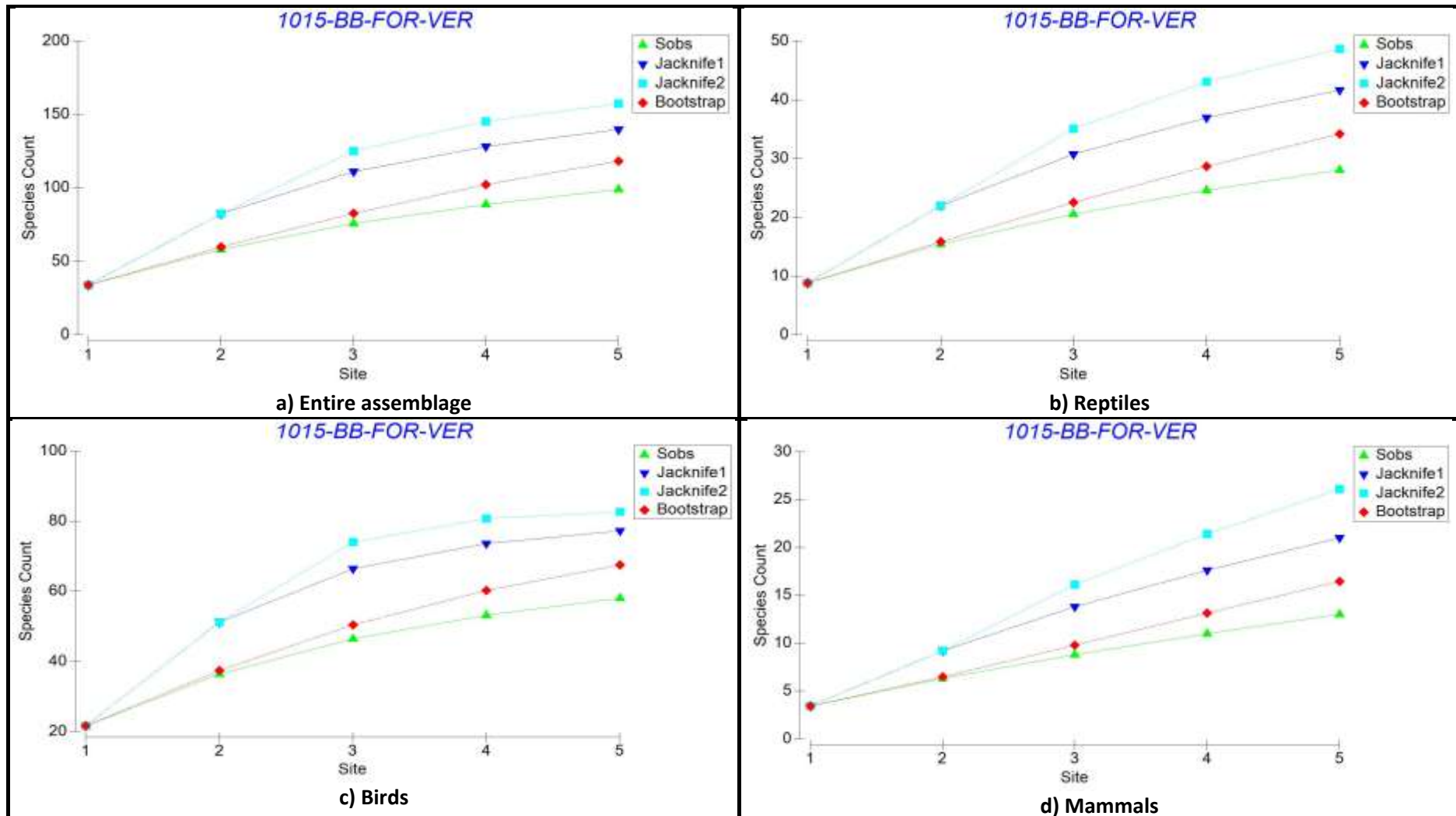
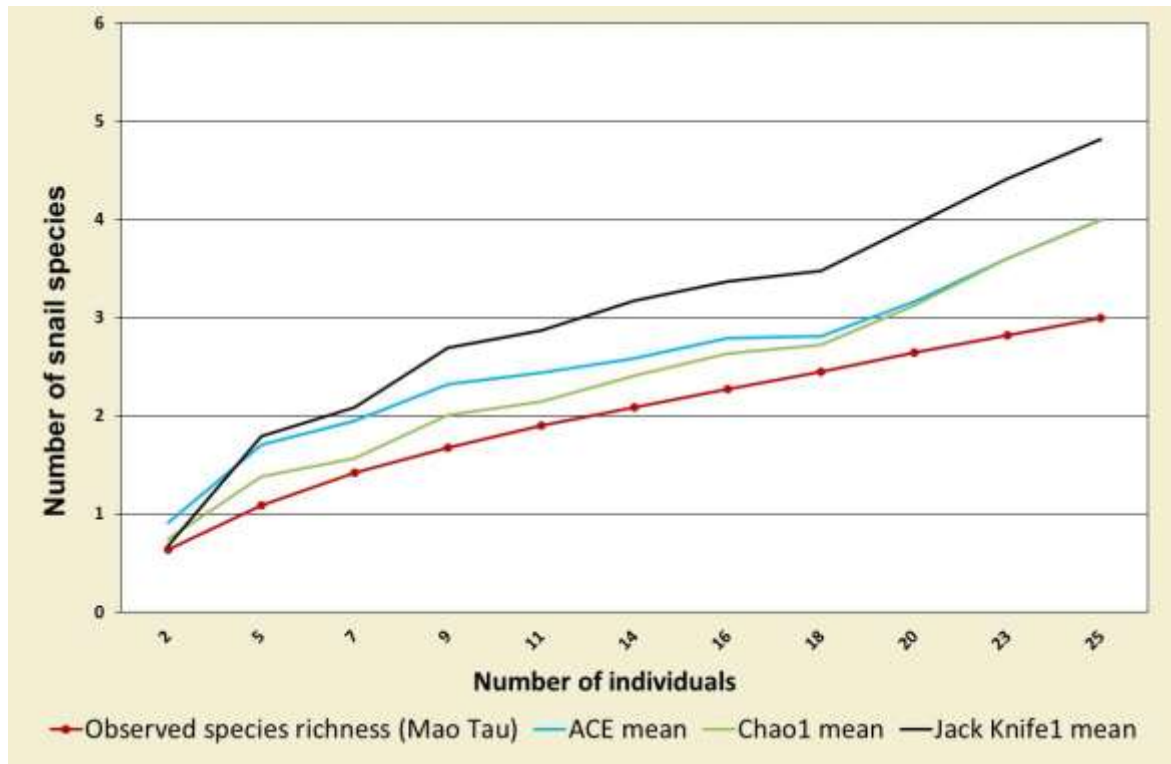


Figure 4-11 Species accumulation curves (Sobs, Jack Knife1 and 2 and Bootstrap) for the entire assemblage (a), reptiles (b), avifauna (c) and mammals (d) for Balla Balla Magnetite Project barge loading facility



**Figure 4-12** Individual based species accumulation curves, with observed species richness, as well as species estimators (ACE, Chao1 and Jack Knife1) for snails for Balla Balla Magnetite Project barge loading facility

### 4.3.3 Vertebrate fauna

The surveys recorded 158 vertebrate fauna species representing 56 families in 20 orders across all terrestrial vertebrate fauna classes (Table 4-4; Appendix 4). This represents approximately 44% of the 356 species identified in the desktop review. The fauna assemblage was strongly dominated by birds with a total of 98 species recorded, representing 62% of fauna records from the survey.

Five bird species not identified in the desktop review were recorded during the survey:

- Beach Stone-curlew (*Esacus magnirostris*)
- Banded Lapwing (*Vanellus tricolor*)
- Long-toed Stint (*Calidris subminuta*)
- Roseate Tern (*Sterna dougallii*)
- Common Tern (*Sterna hirundo*).

**A total of 25 species of conservation significance were recorded during the survey (**

Figure 4-14; sections 4.3.3.3 and 4.3.3.4). Of these 22 species are listed as migratory under the EPBC Act. At the State level, six species are listed as Schedule 1 (one endangered and five vulnerable) and 15 species are listed as Schedule 3 (migratory) under the WC Act. Three Priority species (one P1 and two P4 species) were recorded during the survey.

**Table 4-4** Vertebrate taxa recorded during the survey and the total number of species potentially occurring in the study area of the Balla Balla Magnetite Project barge loading facility

<b>Taxa</b>	<b>No. of species recorded during this survey</b>	<b>Total no. of species potentially occurring in study area<sup>1</sup></b>
Amphibians	1	8
Reptiles	35	95
Birds	98	202
Mammals (native)	17	42
Mammals (introduced)	7	9
<b>Total fauna species</b>	<b>158</b>	<b>356</b>

1 - data derived from relevant literature, published and unpublished reports, and various databases

**Figure 4-13**  
**Threatened and Priority vertebrate**  
**fauna recorded records during**  
**from the Level 2 survey**

- Level 2 study area

Construction envelope

Australian Bustard

Bar-tailed Godwit

Eastern Curlew

Flock Bronzewing


Great Knot

Greater Sand Plover

Lesser Sand Plover

Little North-western mastiff Bat

Red Knot



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ENVIRONMENTAL SCIENCES

PROJECT: Balla Balla Barge Loading Facility Project	
AUTHOR: N. Dight	CLIENT: Forge Resources
DATE: 8 February 2013	Scale: 1:120000

Coordinate System: Projection: UTM zone 50; Datum: WGS84

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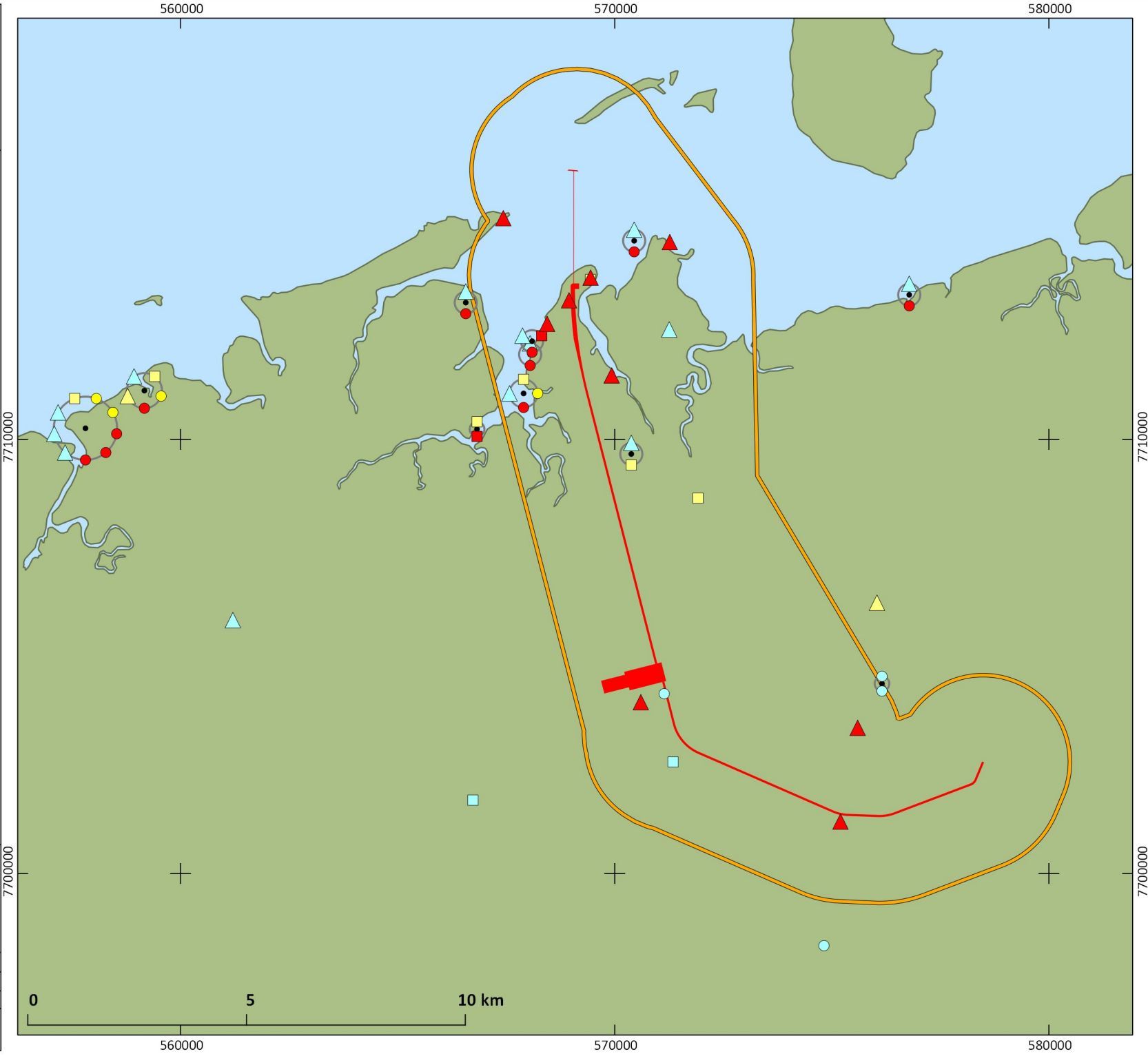
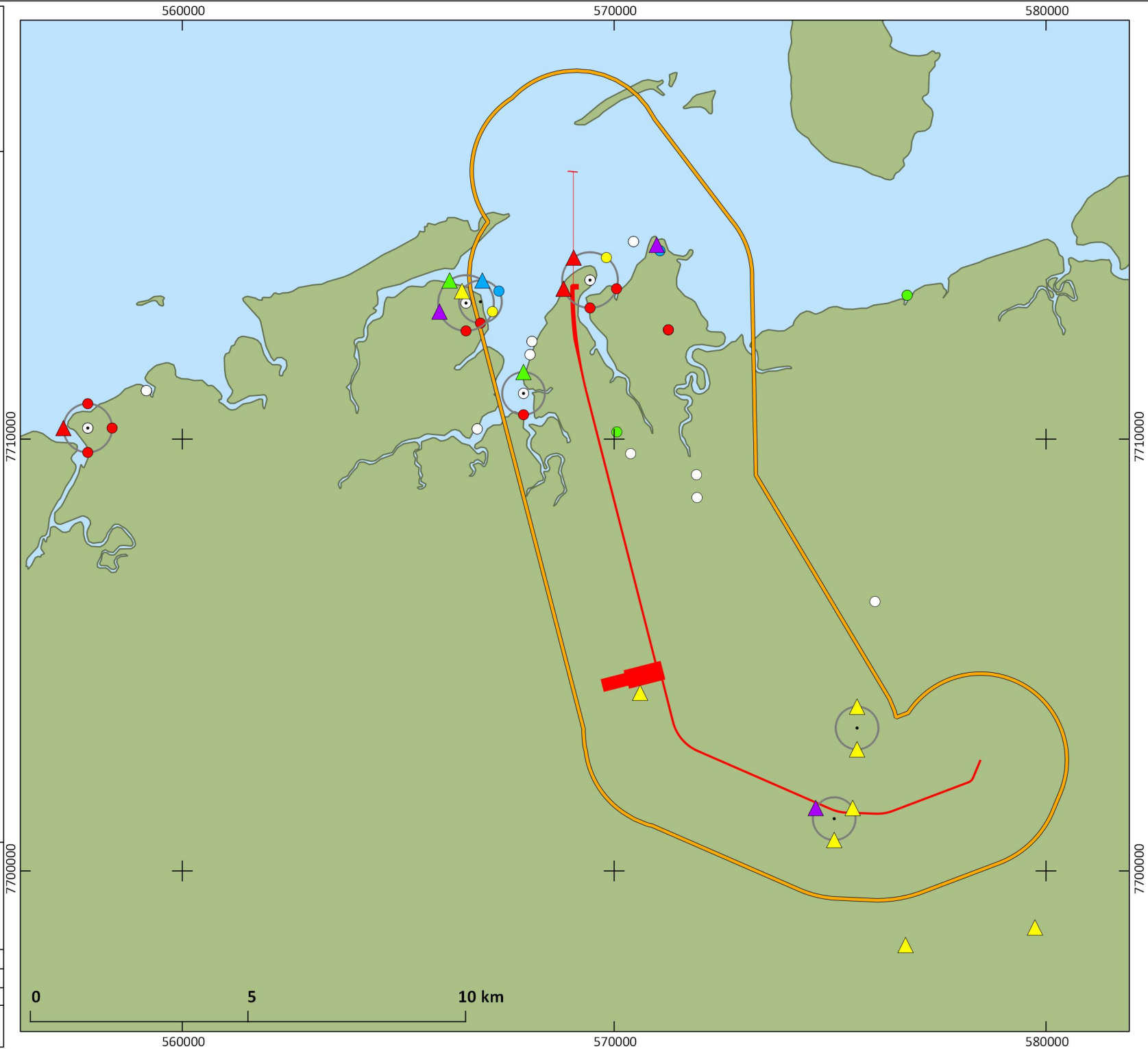


Figure 4-14  
Migratory avifauna records from  
the Level 2 survey

- Level 2 study area
- Construction envelope

Non-shorebird migratory species

- Caspian Tern
- Common Tern
- Eastern Osprey
- Great Egret
- Lesser Crested Tern
- Little Tern
- Rainbow Bee-eater
- Reef Heron
- Rosette Tern
- White-bellied Sea-Eagle
- Shorebird migratory species



### 4.3.3.1 Amphibians

A single amphibian species was recorded in the study area during the survey (Table 4-5) representing 12% of the potential eight species occurring in the study area (Appendix 4); despite the presence of freshwater dams and wells. No amphibian species of conservation significance are likely to occur in the study area.

Previous systematic surveys (Bamford 2006; Biota 2008b, e; ENV 2009; Phoenix 2010b) recorded an average of three amphibian species; most of these surveys were undertaken over two seasons. Arid zone amphibian species typically burrow deep into the substrate during dry periods and emerge after rainfall, resulting in difficulty locating individuals during dry periods. The study area had not received rain for five months prior to the survey.

**Table 4-5 Amphibian species recorded during the survey for the Balla Balla Magnetite Project barge loading facility**

Family; species	Common name	Desktop Survey	Current Survey
<b>Hylidae</b>			
<i>Litoria rubella</i>	Little Red Tree Frog	•	•

### 4.3.3.2 Reptiles

A total of 35 reptile species were recorded within the study area during the survey (Table 4-6). Records from the survey represent 37% of the potential 95 species identified during the desktop review (Table 4-6; Appendix 4). The most common family recorded was Scincidae (skinks) with 14 species, followed by Agamidae (dragons) with nine species. The most frequently recorded species during the survey was the Variegated Tree Dtoella (*Gehyra variegata*) which was recorded 40 times, followed by *Lerista bipes* with 36 records (from a creekline and the coastal dunes).

From the desktop review, previous surveys conducted south of the study area recorded an average of 38 species, most of which were bi-seasonal surveys as opposed to the current results obtained through a single season survey.

No reptile species of conservation significance were recorded during the survey. However, potential habitat for the Lined Soil-crevice Skink (*Notoscincus butleri*; P4) was identified along vegetated creeklines and fringing spinifex habitats. Knowledge of the species' habitat preferences is limited; previous records have come from arid rocky and sandy areas associated with spinifex dominated vegetation, near creek and river margins (Cogger 2000; Wilson & Swan 2010; Wilson & Knowles 1988). The species has been recorded 63.5 km west of the study area (DEC 2012).

Level 1 targeted searches and two trap sites in potential habitat yielded no Nevin's Lerista (*Lerista neviniae*; S1). The species is known from a limited number of records, between Anketell Point and Cape Lambert east of Karratha (Biota 2008f; Phoenix 2010b; Smith & Adams 2007). Despite a number of attempts to locate the species more widely, none have succeeded and the species distribution appears to be limited to an area between Anketell Point and Cape Lambert.

The likelihood of occurrence of Nevin's Lerista in the study area is considered low, based on the distance of closest records (50 km west), apparent narrow distribution and survey results.

The Pilbara Olive Python is considered unlikely to occur within the study area due to the lack of suitable habitat for the species. Coorinjinaa Pool, a rocky freshwater pool located approximately 5.8 km to the east of the study area is likely to support the species. A unconfirmed record from



Depuch Island in 1801 of a grey “Boa-like” snake, approximately five foot long (Storr 1964b) was possibly that of a Pilbara Olive Python.

A species record of interest during the survey was an *Eremiascincus* species with affinities to the Northern Bar-lipped Skink (*Eremiascincus isolepis*). It was recorded on 26 occasions at sites Vert 04 and Vert 05. Further examination of specimens from the WA Museum identified the specimens collected during the survey as *E. isolepis*. The *E. isolepis* species morphology is variable and possibly represents a species complex containing undescribed taxa; however, further taxonomic study is required. This record represents a range extension of approximately 70 km north east from the nearest confirmed record near Karratha.

**Table 4-6 Reptile species recorded during the survey for the Balla Balla Magnetite Project barge loading facility**

Family; species	Common name	Desktop Survey	Current Survey
<b>Agamidae</b>			
<i>Amphibolurus gilberti</i>	Gilbert’s Dragon	●	●
<i>Amphibolurus longirostris</i>	Long-nosed Dragon	●	●
<i>Ctenophorus caudicinctus caudicinctus</i>	Ring-tailed Dragon	●	●
<i>Ctenophorus isolepis isolepis</i>	Military Dragon	●	●
<i>Ctenophorus nuchalis</i>	Central Netted Dragon	●	●
<i>Diporiphora vascus</i>	Northern Pilbara Tree Dragon	●	●
<i>Pogona minor minor</i>	Western Bearded Dragon	●	●
<i>Pogona minor mitchelli</i>	No Common Name	●	●
<i>Tympanocryptus cephalus</i>	Pebble Dragon	●	●
<b>Diplodactylidae</b>			
<i>Lucasium stenodactylum</i>	Sand-plain Gecko	●	●
<i>Rhynchoedura ornata</i>	Western beaked Gecko	●	●
<b>Gekkonidae</b>			
<i>Gehyra punctata</i>	Spotted Dtella	●	●
<i>Gehyra variegata</i>	Variegated Dtella	●	●
<i>Heteronotia binoei</i>	Bynoe's Gecko	●	●
<b>Scincidae</b>			
<i>Carlia triacantha</i>	Desert Rainbow Skink	●	●
<i>Cryptoblepharus buechananii</i>	Buchanan's Snake-eyed Skink	●	●
<i>Ctenotus helenae</i>	Clay-soil Ctenotus	●	●
<i>Ctenotus pantherinus ocellifer</i>	Leopard Ctenotus	●	●
<i>Ctenotus saxatilis</i>	Rock Ctenotus	●	●
<i>Ctenotus schomburgkii</i>	No Common Name	●	●
<i>Egernia cygnitos</i>	Western Pilbara Spiny-tailed Skink	●	●
<i>Eremiascincus isolepis</i>	Northern Bar-lipped Skink	●	●
<i>Lerista bipes</i>	North-western Slider	●	●
<i>Lerista clara</i>	No Common Name	●	●
<i>Menetia greyii</i>	Common Dwarf Skink	●	●
<i>Morethia ruficauda exquisita</i>	Lined Fire-tailed Skink	●	●
<i>Notoscincus ornatus ornatus</i>	Ornate Soil-crevice Skink	●	●

Family; species	Common name	Desktop Survey	Current Survey
<i>Tiliqua multifasciata</i>	Central Blue-tongue	●	●
<b>Varanidae</b>			
<i>Varanus acanthurus</i>	Spiny-tailed Monitor	●	●
<i>Varanus gouldii</i>	Sand Monitor	●	●
<i>Varanus panoptes rubidus</i>	Yellow-spotted Monitor	●	●
<i>Varanus tristis tristis</i>	Black-headed Monitor	●	●
<b>Typhlopidae</b>			
<i>Ramphotyphlops ammodytes</i>	No Common Name	●	●
<b>Boidae</b>			
<i>Antaresia perthensis</i>	Pygmy Python	●	●
<b>Elapidae</b>			
<i>Pseudechis australis</i>	Mulga Snake	●	●

#### 4.3.3.3 Avifauna

A total of 98 bird species were recorded during the survey (Table 4-7), representing 48% of species potentially occurring in the study area identified during the desktop review (Table 4-7, Appendix 4). The assemblage records include the species identified in the migratory shorebird survey in shorebird sites overlapping the study area (Phoenix 2013).

The most dominant family recorded during the survey was Scolopacidae (sandpipers and relatives) with 12 species, followed by Meliphagidae (honeyeaters), Laridae (terns) and Accipitridae (hawks and eagles) each with eight species recorded. Red-capped Plovers were the most frequent species recorded with 275 records followed by the Greater Sand Plover with 150 records. The most commonly recorded species inland was the Zebra finch with 186 records followed by the Flock Bronzewing with 140 records.

From the desktop review, the average number of bird species recorded during previous surveys undertaken near the study area recorded an average of 68 species.

Five bird species not identified during the desktop review were recorded in the study area during the survey:

- Beach Stone-curlew (*Esacus magnirostris*)
- Banded Lapwing (*Vanellus tricolor*)
- Long-toed Stint (*Calidris subminuta*)
- Roseate Tern (*Sterna dougallii*)
- Common Tern (*Sterna hirundo*).

A total of 24 species of conservation significance were recorded during the survey (Figure 4-13; Figure 4-14). Of these 22 are listed as 'migratory' under the EPBC Act and 15 under the WC Act. Six species are listed as schedule 1 under the WC Act and two species listed as Priority 4 by DEC. Five species recently raised from Schedule 3 (migratory) to Schedule 1 (one EN and four VU) of the WC Act, were recorded during the survey.

The following conservation significant birds were recorded during the survey:



- 
- Lesser Sand Plover (*Charadrius mongolus*; EPBC migratory, WC Act Schedule 1 -EN)
  - Greater Sand Plover (Mongolian) (*Charadrius leschenaultii leschenaultii*; EPBC migratory, WC Act Schedule 1 -VU)
  - Bar-tailed Godwit (northern Siberian) (*Limosa lapponica menzbieri*; EPBC migratory, WC Act Schedule 1 -VU)
  - Eastern Curlew (*Numenius madagascariensis*; EPBC migratory, WC Act Schedule 1 -VU)
  - Great Knot (*Calidris tenuirostris*; EPBC migratory, WC Act Schedule 1 -VU)
  - Red Knot (*Calidris canutus*; EPBC migratory, WC Act Schedule 1 -VU)
  - Eastern Great Egret (*Ardea modesta*; EPBC migratory, WC Act Schedule 3)
  - Eastern Osprey (*Pandion cristatus*; EPBC migratory, WC Act Schedule 3)
  - White-bellied Sea Eagle (*Haliaeetus leucogaster*; EPBC migratory)
  - Whimbrel (*Numenius phaeopus*; EPBC migratory, WC Act Schedule 3)
  - Terek Sandpiper (*Xenus cinereus*; EPBC migratory, WC Act Schedule 3)
  - Common Sandpiper (*Actitis hypoleucos*; EPBC migratory, WC Act Schedule 3)
  - Grey-tailed Tattler (*Heteroscelus brevipes*; EPBC migratory, WC Act Schedule 3)
  - Ruddy Turnstone (*Arenaria interpres*; EPBC migratory, WC Act Schedule 3)
  - Sanderling (*Calidris alba*; EPBC migratory, WC Act Schedule 3)
  - Red-necked Stint (*Calidris ruficollis*; EPBC migratory, WC Act Schedule 3)
  - Long-toed Stint (*Calidris subminuta*; EPBC migratory, WC Act Schedule 3)
  - Little Tern (*Sternula albifrons*; EPBC migratory, WC Act Schedule 3)
  - Caspian Tern (*Sterna caspia*; EPBC migratory, WC Act Schedule 3)
  - Roseate Tern (*Sterna dougallii*; EPBC migratory, WC Act Schedule 3)
  - Common Tern (*Sterna hirundo*; EPBC migratory, WC Act Schedule 3)
  - Rainbow Bee-eater (*Merops ornatus*; EPBC migratory, WC Act Schedule 3)
  - Flock Bronzewing (*Phaps histrionic*; DEC Priority 4)
  - Australian Bustard (*Ardeotis australis*; DEC Priority 4).

The extensive intertidal mudflats, mangroves and associated coastline are utilised by a large number of migratory shorebird species including species recently raised to Schedule 1 under the WC Act. The coastal habitats of the study area and mudflats are likely to provide suitable roosting and foraging habitat for a number of additional migratory shorebird species. The significance of the study area to migratory shorebirds is being documented in the migratory shorebird report for the Project and is not discussed further here (Phoenix 2013).

The EPBC migratory listed Rainbow Bee-eater was recorded at three systematic and three opportunistic vertebrate fauna survey sites during the survey (Figure 4-14). Most records collected during the survey were in creek and drainage lines or near sources of fresh water, i.e. wells and water troughs. The species is likely to regularly occur across the study area in these habitats.

Two large flocks of the Priority 4 Flock Bronzewing were recorded during the survey (Figure 4-13). The species is likely to occur throughout the southern portion of the study area where preferred habitat consisting of open grassy plains is abundant.

The Priority 4 Australian Bustard was recorded four times in the study area during the survey (Figure 4-13). Three solitary animals and a pair were recorded. The Australian Bustard has a large range and is likely to regularly occur within the southern portion of the study area where preferred grassy plain habitat for the species is abundant (Ziembicki 2010, 2009).

Although not recorded, a number of species may potentially occur in the study area, including the Bush Stone-curlew (*Burhinus grallarius*; DEC Priority 4), Peregrine Falcon (*Falco peregrinus*; WC Act Schedule 4) and Grey Falcon (*Falco hypoleucos*; WC Act Schedule 1 -VU). Although the Bush Stone-curlew was not recorded during the survey the species could potentially inhabit the riparian vegetation along creek and drainage lines and scrublands with sufficient cover. The Peregrine and Grey falcons both have large ranges and may forage over the open grassland in the southern portion of the study area from time to time (Debus 2012; Johnstone & Storr 1998). The mayday nest in some hills located 10 km south of the study area.

**Table 4-7 Bird species recorded during the survey for the Balla Balla Magnetite Project barge loading facility**

Family; species	Common name	Desktop survey	Current survey
<b>Casuariidae</b>			
<i>Dromaius novaehollandiae</i>	Emu	•	•
<b>Anatidae</b>			
<i>Cygnus atratus</i>	Black Swan	•	•
<b>Columbidae</b>			
<i>Phaps histrionica</i>	Flock Bronzewing	•	•
<i>Ocyphaps lophotes</i>	Crested Pigeon	•	•
<i>Geophaps plumifera</i>	Spinifex Pigeon	•	•
<i>Geopelia cuneata</i>	Diamond Dove	•	•
<i>Geopelia striata</i>	Peaceful Dove	•	•
<b>Eurostopodidae</b>			
<i>Eurostopodus argus</i>	Spotted Nightjar	•	•
<b>Ardeidae</b>			
<i>Ardea modesta</i>	Eastern Great Egret	•	•
<i>Egretta novaehollandiae</i>	White-faced Heron	•	•
<i>Egretta garzetta</i>	Little Egret	•	•
<b>Accipitridae</b>			
<i>Pandion cristatus</i>	Eastern Osprey	•	•
<i>Elanus axillaris</i>	Black-shouldered Kite	•	•
<i>Haliaeetus leucogaster</i>	White-bellied Sea-Eagle	•	•
<i>Haliastur sphenurus</i>	Whistling Kite	•	•
<i>Haliastur indus</i>	Brahminy Kite	•	•
<i>Circus assimilis</i>	Spotted Harrier	•	•
<i>Circus approximans</i>	Swamp Harrier	•	•
<i>Aquila audax</i>	Wedge-tailed Eagle	•	•

Family; species	Common name	Desktop survey	Current survey
<b>Falconidae</b>			
<i>Falco berigora</i>	Brown Falcon	•	•
<b>Otididae</b>			
<i>Ardeotis australis</i>	Australian Bustard	•	•
<b>Burhinidae</b>			
<i>Esacus magnirostris</i>	Beach Stone-curlew		•
<b>Haematopodidae</b>			
<i>Haematopus longirostris</i>	Australian Pied Oystercatcher	•	•
<i>Haematopus fuliginosus opthalmicus</i>	Sooty Oystercatcher	•	•
Recurvirostridae			
<i>Himantopus himantopus</i>	Black-winged Stilt	•	•
<i>Cladorhynchus leucocephalus</i>	Banded Stilt	•	•
<b>Charadriidae</b>			
<i>Charadrius ruficapillus</i>	Red-capped Plover	•	•
<i>Charadrius mongolus</i>	Lesser Sand Plover	•	•
<i>Charadrius leschenaultii leschenaultii</i>	Greater Sand Plover (Mongolian)	•	•
<i>Elseyornis melanops</i>	Black-fronted Dotterel	•	•
<i>Vanellus tricolor</i>	Banded Lapwing		•
<b>Scolopacidae</b>			
<i>Limosa lapponica menzbieri</i>	Bar-tailed Godwit (northern Siberian)	•	•
<i>Numenius phaeopus</i>	Whimbrel	•	•
<i>Numenius madagascariensis</i>	Eastern Curlew	•	•
<i>Xenus cinereus</i>	Terek Sandpiper	•	•
<i>Actitis hypoleucos</i>	Common Sandpiper	•	•
<i>Heteroscelus brevipes</i>	Grey-tailed Tattler	•	•
<i>Arenaria interpres</i>	Ruddy Turnstone	•	•
<i>Calidris tenuirostris</i>	Great Knot	•	•
<i>Calidris canutus</i>	Red Knot	•	•
<i>Calidris alba</i>	Sanderling	•	•
<i>Calidris ruficollis</i>	Red-necked Stint	•	•
<i>Calidris subminuta</i>	Long-toed Stint		•
<b>Turnicidae</b>			
<i>Turnix velox</i>	Little Button-quail	•	•
<b>Laridae</b>			
<i>Sternula albifrons</i>	Little Tern	•	•
<i>Gelochelidon nilotica</i>	Gull-billed Tern	•	•
<i>Sterna caspia</i>	Caspian Tern	•	•
<i>Chlidonias hybrida</i>	Whiskered Tern	•	•
<i>Sterna dougallii</i>	Roseate Tern		•
<i>Sterna hirundo</i>	Common Tern		•
<i>Thalasseus bergii</i>	Crested Tern	•	•
<i>Chroicocephalus novaehollandiae</i>	Silver Gull	•	•

Family; species	Common name	Desktop survey	Current survey
<b>Cacatuidae</b>			
<i>Eolophus roseicapillus</i>	Galah	•	•
<i>Cacatua sanguinea</i>	Little Corella	•	•
<b>Psittacidae</b>			
<i>Barnardius zonarius</i>	Australian Ringneck	•	•
<i>Melopsittacus undulatus</i>	Budgerigar	•	•
<b>Cuculidae</b>			
<i>Chalcites basalis</i>	Horsfield's Bronze-Cuckoo	•	•
<b>Halcyonidae</b>			
<i>Dacelo leachii</i>	Blue-winged Kookaburra	•	•
<i>Todiramphus pyrrhopygius</i>	Red-backed Kingfisher	•	•
<i>Todiramphus sanctus</i>	Sacred Kingfisher	•	•
<i>Todiramphus chloris</i>	Collared Kingfisher	•	•
<b>Meropidae</b>			
<i>Merops ornatus</i>	Rainbow Bee-eater	•	•
<b>Maluridae</b>			
<i>Malurus leucopterus</i>	White-winged Fairy-wren	•	•
<i>Malurus lamberti</i>	Variegated Fairy-wren	•	•
<b>Acanthizidae</b>			
<i>Smicrornis brevirostris</i>	Weebill	•	•
<i>Gerygone tenebrosa</i>	Dusky Gerygone	•	•
<b>Meliphagidae</b>			
<i>Certhionyx variegatus</i>	Pied Honeyeater	•	•
<i>Lichenostomus virescens</i>	Singing Honeyeater	•	•
<i>Lichenostomus penicillatus</i>	White-plumed Honeyeater	•	•
<i>Manorina flavigula</i>	Yellow-throated Miner	•	•
<i>Acanthagenys rufogularis</i>	Spiny-cheeked Honeyeater	•	•
<i>Epthianura tricolor</i>	Crimson Chat	•	•
<i>Sugomel niger</i>	Black Honeyeater	•	•
<i>Lichmera indistincta</i>	Brown Honeyeater	•	•
<b>Pomatostomatidae</b>			
<i>Pomatostomus temporalis</i>	Grey-crowned Babbler	•	•
<b>Campephagidae</b>			
<i>Coracina novaehollandiae</i>	Black-faced Cuckoo-shrike	•	•
<i>Lalage sueurii</i>	White-winged Triller	•	•
<b>Pachycephalidae</b>			
<i>Pachycephala rufiventris</i>	Rufous Whistler	•	•
<i>Pachycephala lanioides</i>	White-breasted Whistler	•	•
<i>Colluricincla harmonica</i>	Grey Shrike-thrush	•	•
<b>Artamidae</b>			
<i>Artamus leucorhynchus</i>	White-breasted Woodswallow	•	•
<i>Artamus superciliosus</i>	White-browed Woodswallow	•	•

Family; species	Common name	Desktop survey	Current survey
<i>Artamus cinereus</i>	Black-faced Woodswallow	•	•
<i>Cracticus nigrogularis</i>	Pied Butcherbird	•	•
<i>Cracticus tibicen</i>	Australian Magpie	•	•
<b>Rhipiduridae</b>			
<i>Rhipidura albiscapa</i>	Grey Fantail	•	•
<i>Rhipidura phasiana</i>	Mangrove Grey Fantail	•	•
<i>Rhipidura leucophrys</i>	Willie Wagtail	•	•
<b>Corvidae</b>			
<i>Corvus orru</i>	Torresian Crow	•	•
<b>Monarchidae</b>			
<i>Grallina cyanoleuca</i>	Magpie-lark	•	•
<b>Petroicidae</b>			
<i>Peneonanthe pulverulenta</i>	Mangrove Robin	•	•
<b>Alaudidae</b>			
<i>Mirafrja javanica</i>	Horsfield's Bushlark	•	•
<b>Megaluridae</b>			
<i>Cincloramphus mathewsi</i>	Rufous Songlark	•	•
<i>Cincloramphus cruralis</i>	Brown Songlark	•	•
<b>Timaliidae</b>			
<i>Zosterops luteus</i>	Yellow White-eye	•	•
<b>Hirundinidae</b>			
<i>Petrochelidon nigricans</i>	Tree Martin	•	•
<b>Estrildidae</b>			
<i>Taeniopygia guttata</i>	Zebra Finch	•	•
<b>Motacillidae</b>			
<i>Anthus novaeseelandiae</i>	Australasian Pipit	•	•

#### 4.3.3.4 Mammals

A total of 24 species were recorded within the study area during the survey, including 17 native and seven introduced species (Table 4-8). Records from the survey represent 47% of the potential 51 species identified during the desktop review (Appendix 4). The most common families recorded were Vespertilionidae (ordinary bats) and Muridae (rodents), each with six species. The most frequently recorded species during the survey was the House Mouse (*Mus musculus*) which was recorded 34 times, followed by Red Kangaroo (*Macropus rufus*) with 14 records.

From the desktop review, an average of 17 mammal species were recorded during previous surveys in which systematic surveying was undertaken. Most of these surveys entailed two seasons of sampling, suggesting that the current results are representative of the area.

Bat fauna was well represented during the survey with nine of the potential 17 species identified in the desktop review being recorded, including two subspecies of the Lesser Long-eared Bat (*Nyctophilus geoffroyi*). The two subspecies identified were *Nyctophilus geoffroyi geoffroyi* and *Nyctophilus geoffroyi palescens* which were identified from echolocation call recordings. Previous

surveys from the desktop review did not identify the Lesser Long-eared Bat to subspecies level (Biota 2008b; ENV 2009; Phoenix 2010b).

Only one mammal species of conservation significance was recorded during the survey, Little North-western Mastiff Bat (*Mormopterus loriae cobourgiana*; DEC Priority 1). The species was recorded at seven of the ten SongMeter recording sites with calls virtually continuous throughout the night (Figure 4-13). Results of the echolocation recording analysis indicate the species is foraging widely across the study area and the high abundance indicates large numbers of the species are roosting in the dense mangrove thickets along the coastline of the study area (Appendix 6).

Although not recorded, potential habitat was identified for three species of conservation significance; the Western Pebble Mound Mouse (*Pseudomys chapmani*; DEC Priority 4), Short-tailed Mouse (*Leggadina lakedownensis*; DEC Priority 4) and Water Rat (*Hydromys chrysogaster*; DEC Priority 4).

The Water Rat was not recorded during the survey despite targeted searches for the species; however, is likely to be present in the study area in particular around mangrove thickets and areas of rocky shoreline where suitable cover and foraging habitat is present (Figure 4-1). The presence of extensive mangrove thickets along the coast also provides potential links between habitats. The species generally inhabits areas in close proximity to permanent water bodies, both marine and freshwater and is occasionally recorded around human infrastructure such as jetties and ports. The Water Rat has previously been recorded on Depuch Island indicating presence of the species within close proximity to the study area (DEC 2012; Ride 1964).

A small area of low rocky hills and hill slopes was identified as potential habitat for the Western Pebble-mound Mouse during the survey (Figure 4-1). Despite targeted searches for their distinctive pebble mound, the species was not recorded. The species is considered likely to be present in this area, possibly in low numbers due to the small, isolated area of suitable habitat.

The Short-tailed Mouse is considered likely to occur within the study area in the grassland habitats consisting of tussock and hummock grasses on clay soils in the southern portion of the study area (Figure 4-1), habitat identified as the species' preferred habitat (Menkhorst & Knight 2011; Van Dyck & Strahan 2008). Like many other species of arid zone rodents, populations of Western Pebble-mound Mouse and Short-tailed Mouse are likely to increase and become more abundant during and after seasons of good rainfall. Populations are likely to gradually decline and become less abundant over drier periods or during seasons of drought (Van Dyck & Strahan 2008; Watts & Aslin 1981).

The grassland habitat identified in the Level 1 study area for Bilby, Crest-tailed Mulgara and Brush-tailed Mulgara during the Level 1 reconnaissance survey was further assessed during the Level 2 survey and found to be unsuitable for these species. The three burrowing species show preference for sandy soils, as opposed to the hard clay substrate present within the first 20 cm of the grassland habitat throughout the study area (Menkhorst & Knight 2011; Van Dyck & Strahan 2008). Therefore Bilby and Mulgara are considered unlikely to occur within the study area.

Despite targeted searches in areas identified as potential Northern Quoll and Black-flanked Rock Wallaby habitat, no records or secondary evidence was recorded during the survey. The two species are considered unlikely to occur in the study area due to the small size of the habitat present and absence of any connective habitat that may be used by the species to disperse. Previous records indicate a presence of both species in close proximity to the study area with records of the Black-flanked Rock Wallaby from Depuch Island located north of the study area (DEC 2012; Haouchar *et al.* 2012; Ride 1964) and records of the Northern Quoll from the Whim Creek area approximately 15 km south-east of the study area (DEC 2012).

**Table 4-8 Mammal species recorded during the survey for the Balla Balla Magnetite Project barge loading facility**

Family; species	Common name	Desktop survey	Current survey
<b>Dasyuridae</b>			
<i>Ningaui timealeyi</i>	Pilbara Ningau	•	•
<i>Sminthopsis macroura</i>	Stripe-faced Dunnart	•	•
<i>Sminthopsis youngsoni</i>	Lesser Hairy-footed Dunnart	•	•
<b>Macropodidae</b>			
<i>Macropus robustus</i>	Euro	•	•
<i>Macropus rufus</i>	Red Kangaroo	•	•
<b>Emballonuridae</b>			
<i>Saccolaimus flaviventris</i>	Yellow-bellied Sheathtail-bat	•	•
<i>Taphozous georgianus</i>	Common Sheathtail-bat	•	•
<b>Vespertilionidae</b>			
<i>Chalinolobus gouldii</i>	Gould's Wattled Bat	•	•
<i>Nyctophilus arnhemensis</i>	Arnhem Land Long-eared Bat	•	•
<i>Nyctophilus geoffroyi</i>	Lesser Long-eared Bat	•	•
<i>Nyctophilus geoffroyi geoffroyi</i>	No Common Name		•
<i>Nyctophilus geoffroyi palescens</i>	No Common Name		•
<i>Scotorepens greyii</i>	Little Broad-nosed Bat	•	•
<i>Vespadelus finlaysoni</i>	Finlayson's Cave Bat	•	•
<b>Molossidae</b>			
<i>Mormopterus loriae cobourgiana</i>	Little North-western Mastiff Bat	•	•
<b>Muridae</b>			
<i>Mus musculus</i>	House Mouse	•	•
<i>Pseudomys delicatulus</i>	Delicate Mouse	•	•
<i>Pseudomys desertor</i>	Desert Mouse	•	•
<i>Pseudomys hermannsburgensis</i>	Sandy Inland Mouse	•	•
<i>Rattus rattus</i>	Black Rat	•	•
<b>Canidae</b>			
<i>Canis lupus</i>	Dog/Dingo	•	•
<i>Vulpes vulpes</i>	Red Fox	•	•
<b>Felidae</b>			
<i>Felis catus</i>	Cat	•	•
<b>Equidae</b>			
<i>Equus caballus</i>	Horse	•	•
<b>Bovidae</b>			
<i>Bos taurus</i>	European Cattle	•	•

#### 4.3.3.5 Conservation significant species

This section provides an overview of the conservation significant species that were either recorded in the surveys or are considered likely to be present due to the presence of suitable habitat within the study area.

In total 26 species listed as threatened (EPBC Act; WC Act), Priority (DEC) or Migratory (EPBC Act) were recorded in the surveys. A further 36 conservation significant species may occur.

Migratory shorebird species have been largely excluded from this section as they are being addressed in detail in the migratory shorebird survey report for the Project ((Phoenix 2013)).

##### 4.3.3.5.1 Lined Soil-crevice Skink (*Notoscincus butleri*)

Status: Priority 4 (DEC)

Distribution and ecology: The Lined Soil-crevice Skink is a small terrestrial skink that grows up to 220 mm total length. The species is endemic to the Pilbara region with records scattered across the far west of the region from south of Karratha and Dampier, including West Intercourse Island, to approximately 40 km northwest of Tom Price. Little data is available on the species preferred habitats; however, the limited records are often associated with spinifex dominated vegetation near creek and river margins (Cogger 2000; Wilson & Swan 2010; Wilson & Knowles 1988). The conservation listing as Priority 4 by the DEC for this species is in relation to the lack of knowledge of the species, its endemism in the Pilbara region and potential threats that may lead to the species decline.

Records and likely distribution in the study area: The Lined Soil-crevice Skink was not recorded during the survey; however, the species may possibly occur in the study area in the suitably vegetated creeklines which are consistent with other habitat records for the species. The nearest record of the Lined Soil-crevice Skink is approximately 64 km west of the study area (DEC 2012). No specimens have been recorded as far north as the study area limiting the likelihood of occurrence.

##### 4.3.3.5.2 Flock Bronzewing (*Phaps histrionica*)

Status: Priority 4 (DEC)

Distribution and ecology: This species inhabits treeless or sparsely wooded grassy plains of north-west WA, south to Carnarvon, and also occurs in the Kimberley and in the arid and semi-arid north-eastern interior of Australia (Johnstone & Storr 1998). The species nests on bare ground amongst low-lying vegetation. It is often associated with permanent water (Garnett & Crowley 2000). Species numbers have declined greatly in the last century due to the degradation of its habitat by livestock.

Records and likely distribution in the study area: The Flock Bronzewing was recorded twice during the survey. Two large flocks of 60 and 80 birds were recorded in open grassy plains in the south-west of the study area. The species is likely to be a frequent visitor in the study area to forage amongst the grassy plains.

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

Status: Migratory (EPBC Act); Schedule 3 (WC Act)

Distribution and ecology: The Fork-tailed Swift is a widespread migratory species that overwinters in Australia. It can be found across most of WA and is uncommon to moderately common in the north-west. They are mostly found over inland plains, and also above foothills, in coastal areas and over settlements. They occur in a wide range of dry or open habitats, including riparian woodlands, tea-



tree swamps, low scrub, heathland, saltmarsh, grassland and spinifex sandplains, open farmland and inland and coastal sand-dunes. Fork-tailed Swifts are often found in areas that experience updraughts around cliffs, and normally forage several hundred metres above ground level (DSEWPC 2011a).

Records and likely distribution in the study area: The Fork-tailed Swift was not recorded during the survey and searches of databases revealed nearby records of the species approximately 94 km east of the study area (DEC 2012). Due to the species migratory nature it is likely to occur occasionally in the study area.

#### **4.3.3.5.4 Black Bittern (*Ixobrychus flavicollis*)**

Status: Priority 3 (DEC)

Distribution and ecology: The Black Bittern occurs in the Kimberley, Pilbara and South West regions of WA as well as parts of eastern Australia. Its preferred habitat is freshwater pools, swamps and lagoons surrounded by trees and it shelters in dense vegetation at the water's edge. The species can be locally moderately common, particularly in the Kimberley region but is generally uncommon in other areas of Western Australia (Johnstone & Storr 1998).

Records and likely distribution in the study area: No records of the Black Bittern were collected during the survey; however database searches revealed nearby records approximately 50 km to the south and west of the study area (DEC 2012) and it is therefore considered likely to occasionally occur.

#### **4.3.3.5.5 Eastern Great Egret (*Ardea modesta*)**

Status: Migratory (EPBC Act); Schedule 3 (WC Act)

Distribution and ecology: The Eastern Great Egret can be found in inland rivers, lakes and shallow freshwater or saltwater wetlands and inundated samphire. This species is highly mobile and can be found throughout most of the western fringes of the State in coastal areas and towards the semi-arid interior (Johnstone & Storr 1998).

Records and likely distribution in the study area: The Eastern Great Egret was recorded from two sites in the vicinity of the study area as well as being identified in the desktop review.

#### **4.3.3.5.6 Cattle Egret (*Ardea ibis*)**

Status: Migratory (EPBC Act); Schedule 3 (WC Act)

Distribution and ecology: The Cattle Egret is a worldwide widespread, polytypic, medium-size Ardeidae. In Australia, they are more common in eastern states than on the west coast. The species is uncommon in south-western WA and breed in small numbers near Kununurra. The origin of the species in Australia is not certain. It may have been introduced but a natural colonisation from individuals reaching the northern coast through Indonesian islands is more probable (McKilligan 2005).

In Australia, Cattle Egrets have benefited from human settlements (irrigation, grazing). They can feed on a wide range of prey (vertebrates and invertebrates) that they find in swamps and open grasslands, inland as well as on the coast. The species is partially migratory with movement between New-Zealand and Australia.

Records and likely distribution in the study area: No records of the Cattle Egret were collected during the survey; however, the desktop review revealed a record of the species approximately 63 km east

of the study area. The Cattle Egret is considered likely to occur within the study area along the shoreline and inland when water is present in creeklines and dams.

#### **4.3.3.5.7 Eastern Reef Egret (*Egretta sacra*)**

Status: Migratory (EPBC Act); Schedule 3 (WC Act)

Distribution and ecology: The Eastern Reef Egret occurs along much of Australia's coastline, including the west and south coasts of WA and islands. Its habitat preferences include tidal estuarine mudflats, inshore reefs, mangrove creeks and rocky shores (Geering *et al.* 2007; Johnstone & Storr 1998).

Records and likely distribution in the study area: No records of the Eastern Reef Egret were collected during the survey; however, the species has previously been recorded on West Moore Island (DEC 2012), Depuch Island (Storr 1964a), at Port Hedland (ENV 2009) and Anketell Point (Phoenix 2010b). The species is considered likely to occur within the study area along the shoreline in mangrove and intertidal habitats, as well as inland habitats when water is present.

#### **4.3.3.5.8 Glossy Ibis (*Plegadis falcinellus*)**

Status: Migratory (EPBC Act); Schedule 3 (WC Act)

Distribution and ecology: The preferred habitat of the Glossy Ibis is well-watered flatlands such as shallows, flats and pools of freshwater lakes, swamps and rivers, flooded samphire and sewage ponds. The most notable habitat for this bird in WA is the north-east and south-west Kimberley and the Swan Coastal Plain (Johnstone & Storr 1998).

Records and likely distribution in the study area: The Glossy Ibis was not recorded during the survey; however, the species has previously been recorded approximately 25 km south of the study area (DEC 2012) and is considered likely to occur.

#### **4.3.3.5.9 Eastern Osprey (*Pandion cristatus*)**

Status: Migratory (EPBC Act)

Distribution and ecology: The Eastern Osprey is common around the northern Australian coast and inhabits coastal waters and estuaries. It often travels long distances to find its prey usually following large rivers far inland to where large pools lie (Morcombe 2004b).

Records and likely distribution in the study area: The Eastern Osprey was recorded during the survey and further records were identified during the desktop review at Depuch Island (Storr 1964a), Balla Balla (Bamford 2008), Cape Lambert (Biota 2008b), Port Hedland (ENV 2009) and Anketell Point (Phoenix 2010b).

#### **4.3.3.5.10 White-bellied Sea-Eagle (*Haliaeetus leucogaster*)**

Status: Migratory (EPBC Act); Schedule 3 (WC Act)

Distribution and ecology: White-bellied Sea-eagles are found quite uniformly across most of coastal Australia, in every state, including WA. They occur through a wide variety of coastal habitats and sometimes follow watercourses inland. The nest is usually built on high rocks, a shrub or a tall tree (Johnstone & Storr 1998). Two eggs are laid and young are fed with fish, snakes and birds.

Records and likely distribution in the study area: The White-bellied Sea-Eagle was recorded three times during the survey. All records of the species were from coastal habitats. Due to the large range

of the species it is likely a pair with young may regularly foraging along the coastline within and around the study area.

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

Status: Schedule 1 (WC Act); Vulnerable (DEC)

Distribution and ecology: The Grey Falcon is a widespread but rare species inhabiting much of the semi-arid interior of Australia. Its distribution is centred on inland drainage systems. It has a large foraging range extending from timbered plains, such as *Acacia* shrublands, into open grasslands. Preys are mainly birds (Sutton 2010), but also invertebrates and mammals. Nests are usually those disused by other species, particularly other raptors, in the tallest trees along watercourses and sometimes in telecommunication towers.

There are no confirmed threats to the Grey Falcon but it is thought that clearing of the semi-arid zone for marginal farming has reduced habitat availability and overgrazing of arid zone rangelands may affect prey abundance (Garnett *et al.* 2011).

Records and likely distribution in the study area: The Grey Falcon was not recorded during the survey; however, due to the large foraging range the species may occasionally forage on the open shrubland and grassland habitats of the study area. If present, nesting may take place along the Sherlock River where tall eucalypts, which are preferred for nesting, are present. The Grey Falcon has previously been recorded approximately 50 km west and east of the study area (DEC 2012).

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

Status: Schedule 4 (WC Act)

Distribution and ecology: The Peregrine Falcon is a widespread bird of prey found across Australia, with a large foraging range. In Western Australia, it can be rare or scarce to moderately common.

The Peregrine Falcon's preferred habitat includes cliffs and wooded watercourses. Nesting occurs mainly on cliff ledges, granite outcrops, quarries and in trees with old raven or Wedge-tailed Eagle nests (Johnstone & Storr 1998).

Birds constitute a very large proportion of their diet, if not the exclusive part (Johnstone & Storr 1998; Ratcliffe 1980). Historically, the widespread use of DDT caused worldwide global decline of the Peregrine Falcon. The main current threat to the species in Australia is habitat loss, particularly woodland trees for nesting (DSEWPC 2011c).

Records and likely distribution in the study area: No records of the Peregrine Falcon were collected during the survey. No suitable nesting habitat is present within the study area either; however, due to the large foraging range the species may forage within and in the vicinity of the study area. The nearest record of the Peregrine Falcon is approximately 42 km south-west of the study area (DEC 2012).

#### **4.3.3.5.13 Australian Bustard (*Ardeotis australis*)**

Status: Priority 4 (DEC)

Distribution and ecology: The Australian Bustard is the heaviest flying bird in Australia (Ziembicki 2010). They are nomadic, distributed across much of the northern arid areas of the state and may be found singly, in pairs or family parties or in leks. Abundance will vary seasonally according to rainfall and food availability (Johnstone & Storr 1998). The species has a broad preference for open habitats, ranging from open grassland plains to low shrub lands and grassy open woodlands. They tend to

avoid densely vegetated areas and favour flat terrain over hilly areas. They may also be associated with watercourses, particularly in more arid regions (Ziembicki 2010).

Bustards have a broad omnivorous diet that includes seeds, fruits, leaves, flowers, green shoots, various invertebrates and small vertebrates. Bustards are highly opportunistic, and will gorge on favoured food items when available (Ziembicki 2009). Breeding takes place from March to September (mainly March to April and July to August). One to three (commonly one) eggs are laid on bare, preferably stony ground, by a bush or tussock (Johnstone & Storr 1998).

The DEC doesn't explicitly detail the reasons for the conservation status of the Australian Bustard but Garnett and Crowley (2000) list habitat loss (fragmentation and clearing for agriculture), predation, disturbance, pesticides and traditional and illegal hunting as the main threats to the species across Australia with particular emphasis within the southeast distribution range.

Records and likely distribution in the study area: The Australian Bustard was recorded four times during the survey. Single individuals and a pair were recorded on numerous occasions during the survey and are likely to frequently occur in the grassland habitat located in the southern portion of the study area.

#### **4.3.3.5.14 Bush Stone-curlew (*Burhinus grallarius*)**

Status: Priority 4 (DEC)

Distribution and ecology: The Bush Stone-curlew is a relatively large bird that prefers lightly wooded country near daytime shelter such as thickets or long grass. It can be found across much of Australia except the arid interior and southern coast. In Western Australia, the species is considered to be uncommon to common in the northern subhumid and semiarid zones, and rare to uncommon and locally extinct further south (Johnstone & Storr 1998). The species is considered sedentary (stable home range and non-migratory) (Garnett & Crowley 2000).

The Bush Stone-curlew is a ground-dwelling species and therefore susceptible to predation and local disturbance by humans. Their numbers tend to decline around human settlements.

Records and likely distribution in the study area: The Bush Stone-curlew was not recorded during the survey; however, it has previously been recorded less than 5 km south of the study area (DEC 2012) and it is considered likely to occur along creeklines in riparian vegetation and possibly in areas of open shrubland where more vegetative cover is present.

#### **4.3.3.5.15 Lesser Sand Plover (*Charadrius mongolus*)**

Status: Migratory (EPBC Act); Schedule 1 (WC Act); Endangered (DEC)

Distribution and ecology: The Lesser Sand Plover is a small, migratory plover species widely distributed around coastal areas of Australia including the north-western and upper west coasts of WA and, less frequently, further south. It forages on intertidal sand-, mud- and reef-flats and near-coastal saltlakes (Geering *et al.* 2007; Johnstone & Storr 1998; Morcombe 2004a).

Records and likely distribution in the study area: The Lesser Sand Plover was recorded from 11 sites during the survey as well as being identified during the desktop review.

#### **4.3.3.5.16 Eastern Curlew (*Numenius madagascariensis*)**

Status: Migratory (EPBC Act); Schedule 1 (WC Act); Vulnerable (DEC)

Distribution and ecology: The Eastern Curlew has a widespread, mainly coastal distribution across Australia. It breeds in Siberia, Mongolia and Manchuria before the majority of the population

migrates to Australia. During the non-breeding period, a quarter of the world's population resides in south-east Queensland (Geering *et al.* 2007). It also occurs on the west coast of Australia, and less frequently on the south coast (Johnstone & Storr 1998). It forages on intertidal mudflats, especially with exposed seagrass beds or areas with burrowing crabs or shrimp (Geering *et al.* 2007).

Records and likely distribution in the study area: The Eastern Curlew was recorded at three sites during the survey as well as being identified in the desktop review.

#### **4.3.3.5.17 Great Knot (*Calidris tenuirostris*)**

Status: Migratory (EPBC Act); Schedule 1 (WC Act); Vulnerable (DEC)

Distribution and ecology: The Great Knot has a widespread, mainly coastal distribution across Australia. It breeds in Siberia and most of the population migrates to Australia, particularly to the northern coastline. It often flocks with the Red Knot (Geering *et al.* 2007). It is most commonly found on muddy substrates in estuaries or sheltered coasts, feeding at the sea edge (Geering *et al.* 2007; Johnstone & Storr 1998).

Records and likely distribution in the study area: The Great Knot was recorded at two sites during the survey as well as records being identified in the desktop review.

#### **4.3.3.5.18 Curlew Sandpiper (*Calidris ferruginea*)**

Status: Migratory (EPBC Act); Schedule 1 (WC Act); Vulnerable (DEC)

Distribution and ecology: The Curlew Sandpiper has a widespread distribution across coastal Australia. It forages on intertidal mudflats and more rarely on inland freshwater wetlands (Geering *et al.* 2007; Johnstone & Storr 1998).

Records and likely distribution in the study area: No records of the Curlew Sandpiper were recorded during the survey; however, the species has previously been recorded approximately 12 km east of the study area (DEC 2012) and is considered likely to occur in the intertidal flat and salt flat habitats of the study area.

#### **4.3.3.5.19 Fairy Tern (*Sternula nereis*)**

Status: Vulnerable (EPBC Act); Schedule 1 (WC Act); Vulnerable (DEC)

Distribution and ecology: The Fairy Tern is a partly migratory bird found on the lower north-west coast, west coast and south coast of WA as well as south-eastern Australia and Tasmania. It inhabits sheltered seas close to land, coastal lakes and some estuaries. They rest in flocks of up to 50 individuals (Johnstone & Storr 1998).

Records and likely distribution in the study area: No records of the Fairy Tern were recorded during the survey; however, it has previously been recorded from Port Hedland (ENV 2009) and is considered likely to occur along the coastal habitats of the study area.

#### **4.3.3.5.20 Rainbow Bee-eater (*Merops ornatus*)**

Status: Migratory (EPBC Act); Schedule 3 (WC Act)

Distribution and ecology: The Rainbow Bee-eater is a migratory bird that moves between Australia and Asia commonly seen singly or in pairs. It can be found across Australia, with complex seasonal movements depending on location and rainfall, preferring the more watered areas of the country. In Western Australia, the Rainbow Bee-eater can be found in lightly wooded, preferably sandy country,

near water. Occurring as a resident, breeding visitor, postnuptial nomad, passage migrant or winter visitor, and being highly mobile, they can be scarce to locally common.

The species is often associated with creeklines supporting sandy banks in which burrows can be created (Johnstone & Storr 1998). Its diet consists primarily of bees (especially hive bees) and flies, but is known to predate on other invertebrates. Breeding occurs from August to November; however, breeding can occur at other times of year if environmental conditions are suitable. Four to six eggs are laid in an open chamber at the end of a burrow dug into sandy banks, angled ground and occasionally creeklines themselves (Johnstone & Storr 1998).

**Records and likely distribution in the study area: The Rainbow Bee-eater was recorded eight times during the survey at a number of systematic and opportunistic survey sites (**

Figure 4-14). Most records of the species during the survey were in habitats or in areas associated with water, such as creek and drainage lines and water troughs.

#### **4.3.3.5.21 Barn Swallow (*Hirundo rustica*)**

Status: Migratory (EPBC Act); Schedule 3 (WC Act)

Distribution and ecology: Barn Swallows only occur in Australia as migrants. They are found along the northern coast of the continent. In WA, they occur in the coastal Pilbara and coastal Kimberley.

They can occur in large flocks of several hundreds of individuals, sometimes mixed with other swallow species. They feed on a wide range of invertebrates they catch in-flight usually over the water (coastal ocean but also inland freshwater) (Johnstone & Storr 2004).

Records and likely distribution in the study area: No records of the Barn Swallow were collected during the survey. Due to the species migratory nature it is likely to occur occasionally in the study area. The nearest record of the species is located approximately 97 km east of the study area near Port Hedland (DEC 2012).

#### **4.3.3.5.22 Star Finch (*Neochmia ruficauda subclaescens*)**

Status: Priority 4 (DEC)

Distribution and ecology: The Star Finch is a small granivorous bird present in north-western WA in low densities with a patchy distribution. They are usually found in small flocks in grasslands and eucalypt woodlands typically near permanent water. The species can occur in arid habitat after the wet season, if the conditions are good for breeding (Johnstone & Storr 2004).

Habitat alteration (essentially due to grazing), clearance and drainage are responsible for the decline of the species throughout most of its range (Garnett & Crowley 2000).

Records and likely distribution in the study area: The Star Finch was not recorded during the survey; however, the species may occasionally occur along creeklines and associated riparian habitat when water is present. The species was recorded at Coorinjina Pool, approximately 5 km east of the study area where water was still present.

#### **4.3.3.5.23 Little North-western Mastiff Bat (*Mormopterus loriae cobourgiana*)**

Status: Priority 1 (DEC)

Distribution and ecology: The Little North-western Mastiff Bat occurs along the northern coast of Western Australia (Lake McLeod to Point Torment) and the Northern Territory (Darwin to the Queensland border). It occurs sparsely across its range but can form large transient aggregations

(Milne *et al.* 2008). WA populations have predominantly been recorded from mangrove stands, particularly those that include mature Grey Mangroves (*Avicennia marina*; Milne *et al.* 2008). They emerge early in swarms and later disperse to forage for insects above and beside the forest canopy (Churchill 1998). The extent of their foraging range is not known. This species is of significance due to its restricted distribution and currently limited knowledge of the species.

Records and likely distribution in the study area: The Little North-western Mastiff Bat was identified by echolocation recordings SongMeter on seven occasions during the survey at seven different sites. It was recorded in large numbers generally across the study area suggesting substantive roosts occupy the dense mangrove patches in the vicinity of the study area (Figure 4-13). The large numbers of the Little North-western Mastiff Bat identified during the survey have not previously been recorded elsewhere (B. Bullen, Chiropterologist, Batcall WA, 2012, pers. comm., 13 December).

#### **4.3.3.5.24 Water Rat (*Hydromys chrysogaster*)**

Status: Priority 4 (DEC)

Distribution and ecology: The Water Rat is a large, diurnal rodent specialised for aquatic life, widespread throughout Australia and New Guinea including offshore islands. It lives and feeds near freshwater (or near fresh) lakes and rivers and requires relatively permanent water. Despite its widespread distribution, it is rarely plentiful in one area. Notably, it persists in areas heavily settled by humans (Watts & Aslin 1981), although changes to hydrology caused by humans have caused decline in the south-west population. Threats include predation by Red Foxes (*Vulpes vulpes*) and Feral Cats (*Felis catus*) (Milne *et al.* 2008).

Records and likely distribution in the study area: The Water Rat was not recorded during the survey; however, has previously been found at Depuch Island (Ride 1964) and is considered likely to occur in the mangrove thickets present along the shoreline of the study area, particularly given that it is possible to walk to Depuch Island during extremely low tides.

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

Status: Priority 4 (DEC)

Distribution and ecology: The secretive Short-tailed Mouse is a small, rare rodent, occurring in scattered populations with annually fluctuating numbers. It occurs across northern tropical Australia, including the Pilbara and the Kimberley and on two Western Australian islands – Thevenard Island (natural population) and Serrurier Island (introduced). They occupy a diverse range of habitats including hummock and tussock grasslands, tropical woodlands, samphire, sedge lands and stony ranges within semi-arid to tropical monsoon climates (Van Dyck & Strahan 2008). Distribution records have been sporadic since its relatively recent discovery in 1969 on the Cape York Peninsula. It is for this reason and their secretive behaviour that relatively little is known about their distribution and ecology (Milne *et al.* 2008).

Records and likely distribution in the study area: No records of the Short-tailed Mouse were collected during the survey; however, the species has previously been recorded approximately 21 km south west of the study area (DEC 2012) and is considered likely to occur in the open shrubland and grassland habitats located in the south of the study area.

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

Status: Priority 4 (DEC)

Distribution and ecology: The Western Pebble-mound Mouse is widespread in the ranges of the central and southern Pilbara and extends into the Little Sandy Desert Ranges (Van Dyck & Strahan

2008). Originally classified as a Priority 1 species, recent survey records have found the species is widespread and its conservation status has since been downgraded to Priority 4.

These mice construct large mounds from small pebbles. Colonies of up to 25 mice may live inside a mound. Pebble size averages 3.5 grams and the mounds may cover 0.5–9.0 m<sup>2</sup>. The mounds are located on the gentle slopes of rocky ranges covered in rocky mulch, hard spinifex and sparse trees and shrubs (*Eucalyptus*, *Senna*, *Acacia* and *Ptilotus*). They are also often found near Acacia-dominated drainage lines (Van Dyck & Strahan 2008).

Threats to the Western Pebble-mound Mouse are not well known but predation by the Feral Cat (*Felis catus*) and Red Fox (*Vulpes vulpes*) may be responsible for the species' range contraction and mining activities may locally be responsible for small-scale population reduction (Morris 2000).

Records and likely distribution in the study area: No direct records of the Western Pebble-mound Mouse or secondary evidence were collected during the survey. A small area of suitable low stony hill habitat was present (Figure 4-1) and therefore the species is considered likely to occur. The nearest record of the species is located approximately 20 km south east of the study area (DEC 2012).

#### 4.3.4 Short-range endemic invertebrates

A total of 48 individual specimens from SRE target groups (see section 2.5.2) were collected from the study area, representing six individually recognised species and two unidentified higher taxa from five orders, six families and seven genera (Appendix 7).

Four taxa in three genera from three families and three orders comprising 21 individuals (45% of total catch) are considered to include species from one SRE categories (Table 4-9).

Four species are considered to be potential SREs:

- unidentified trapdoor spiders in the genus *Aname* sp. indet. (family Nemesiidae)
- two species of slaters, *Buddelundia* '10 1016A' and *Buddelundia* '10 1016B' (family Armadillidae)
- the scorpions *Lychas* cf. *mjobergi* (family Buthidae).

None of the potential SRE specimens were collected from within the project footprint (Figure4-16).

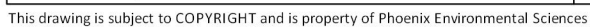


**Table 4-9 SRE invertebrate taxa recorded during the survey**

Family	Genus and species	SRE status	Sites	No. of specimens	Habitat/s
<b>Order Araneae (spiders) – infraorder Myalomorphae (trapdoor spiders)</b>					
Nemesiidae	<i>Aname</i> sp. indet.	Potential	Vert 01, Vert 03	2	Tussock and hummock grassland, open shrubland
<b>Order Scorpiones (scorpions)</b>					
Buthidae	<i>Lychas</i> cf. <i>mjobergi</i>	Potential	Vert 01, Vert 03	2	Tussock and hummock grassland, open shrubland
<b>Order Isopoda (slaters)</b>					
Armadillidae	<i>Buddelundia</i> '10 1016A'	Potential	Vert 01, Vert 03	8	Tussock and hummock grassland, open shrubland
	<i>Buddelundia</i> '10 1016B'	Potential	SRE 01	8	Rocky outcrop and boulder piles
<b>Total</b>				<b>21</b>	



Figure 4-15 Specimens collected from the Level 2 survey: A, *Aname* sp. indet; B, *Lychas* cf. *mjobergi*; C, *Buddelundia* '10 1106A'; D, *Buddelundia* '10 1106A'



#### 4.3.4.1 Araneae – Mygalomorphae (trapdoor spiders)

The Araneae (spiders) are characterised by a number of unique characters, including abdominal appendages modified as spinnerets, silk glands and associated spigots, cheliceral venom glands and male pedipalp tarsi modified as secondary genitalia from sperm transfer (Coddington & Levi 1991). Spiders are one of the largest and most diverse orders of arachnids with more than 40,000 described species worldwide (Platnick 2012b), and approximately 3,400 species named from Australia (Framenau 2012).

Trapdoor spiders represent one of the focal groups in surveys of SRE taxa (Harvey 2002). A number of mygalomorph spiders, e.g. *Idiosoma nigrum*, *Kwonkan eboracum* and *Moggridgea tingle* are listed on Schedule 1 of the *Wildlife Conservation (Specially Protected Fauna) Notice 2012 (2)* (Western Australian Government 2012b). The Western Australian mygalomorph fauna is vast and many families and genera remain taxonomically poorly known (e.g. Barychelidae: *Idiommatia*; Idiopidae: *Aganippe*; Nemesiidae: *Aname*, *Chenistonia*, *Kwonkan*).

No SRE mygalomorph spider was recorded from study area in the desktop review.

Two mygalomorph spider specimens in the genus *Aname* (family Nemesiidae) were collected in the study area (Table 4-9).

Due to the low number of individuals collected, it was not statistically meaningful to calculate species accumulation curves for mygalomorph spiders.

##### 4.3.4.1.1 Family Nemesiidae (wishbone trapdoor spider)

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.

##### Genus *Aname*

The genus *Aname* currently includes 37 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 two studies from northern Australia, including the Pilbara (Harvey *et al.* 2012; Raven 1985). Therefore, unidentifiable specimens are considered potential SREs.

##### *Aname* sp. indet.

Two juvenile specimens of *Aname* were collected in tussock and hummock grassland and open shrubland in the study area (Table 4-9; Figure 4-16; Appendix 7). The specimens could not be identified to species level based on morphology alone, but are considered potential SREs based on distribution patterns within the genus.

#### 4.3.4.2 Pseudoscorpiones (false scorpions or pseudoscorpions)

The Western Australian pseudoscorpion fauna is fairly diverse with representatives of 17 different families (Harvey 2011). 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 (Harvey 1992).

No SRE pseudoscorpions were recorded from the study area in the desktop review.

Two unidentified pseudoscorpion specimens in the family Olpiidae were collected during the survey (Appendix 7). Representatives of the family belong to the most frequently collected pseudoscorpions in the Pilbara and their terrestrial representatives are generally not believed to contain many, if any, SREs (M. Harvey, Senior Curator, WA Museum, 2012, pers. comm.).

Due to the low number of individuals collected, it was not statistically meaningful to calculate species accumulation curves for pseudoscorpions.

#### 4.3.4.3 Scorpiones (scorpions)

Scorpions are characterised by the presence of chelate pedipalps, pectines and an elongate metasoma furnished with a sting. Scorpions are important components of arid ecosystems because their levels of diversity and abundance contribute significantly to the biomass of animal assemblages and they are important predators and prey for other species (Volschenk *et al.* 2010).

The DEC Pilbara Biological Survey recovered two families of scorpions, Buthidae and Urodacidae. The buthids were represented by two genera, *Lychas* (10 species) and *Isometroides* (2 species). The family Urodacidae was represented by 10 species in the single genus *Urodacus* (Volschenk *et al.* 2010). However, the regional scorpion fauna is clearly more diverse both at the species and the genus level, than was recorded in this comprehensive survey. For example, the urodacid genus *Aops* was recently described from Barrow Island (Volschenk & Prendini 2008) and has since also be found on the mainland in the Pilbara.

No SRE scorpions were recorded from the study area in the desktop review.

A total of two specimens of scorpions representing a single species in the genus *Lychas* (Buthidae) were collected in the survey (Table 4-9; Appendix 7).

Due to the low number of individuals collected, it was not statistically meaningful to calculate species accumulation curves for scorpions.

##### 4.3.4.3.1 Family Buthidae

The family Buthidae is the most diverse and widespread of all scorpion families (Fet & Lowe 2000). In Australia, Buthidae are represented by the genera *Australobuthus*, *Isometrus*, *Isometroides*, *Lychas*, and *Hemilychas*. 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* (E. S. Volschenk, unpublished data). Most Authors refer to Koch (1977) for keys and identification. This 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 the publication is not up-to-date. Most Australian buthid species appear to have wide distributions; however, a few taxa have confirmed SRE distributions (E. S. Volschenk unpublished data).

**Genus *Lychas***

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 to the country and are currently under revision by E.S. Volschenk. Most species of *Lychas* appear to have wide distributions; however, a small number of undescribed species are known to be SREs.

***Lychas* cf. *mjobergi***

Two specimens of *Lychas* cf. *mjobergi* were collected in tussock and hummock grassland and open shrubland in the study area (Table 4-9; Figure 4-16; Appendix 7). These specimens appear most similar to *Lychas mjobergi*; however, there are some notable morphological differences that appear to warrant recognition as its own species. Owing to absence of species like this from other collections made in the Pilbara, this species is considered a potential SRE.

**4.3.4.4 Isopoda (slaters)**

Almost 200 described species of Oniscidea, a suborder of the Isopoda containing the supralittoral, terrestrial and secondarily aquatic slaters (or woodlice), have been recorded from Australia (Green *et al.* 2010). The WA fauna is comparatively poorly known with many undescribed species (Judd & Horwitz 2003). Slaters are an ideal biological model for faunistic and biogeographical studies, due to their reduced dispersal ability and narrow habitat preferences (Taiti & Argano 2009). Consequently, they belong to one of the target groups of SRE surveys. The isopod fauna of south-west WA is fairly well known based on a taxonomic study by Judd (2004).

No SRE slaters were recovered from the study area by the desktop review.

A total of 17 specimens of slaters were collected in the study area representing two species of *Buddelundia* in the family Armadillidae (Table 4-9; Appendix 7). Both are considered potential SREs.

Due to the low number of individuals collected, it was not statistically meaningful to calculate species accumulation curves for slaters.

**4.3.4.4.1 Family Armadillidae**

Armadillidae typically have a convex dorsal surface and the animal can roll up into a ball. Most species of the Armadillidae are found in the southern hemisphere and mainly occur in the tropical and subtropical zone (Lewis 1998), although the genus *Buddelundia* is also widespread in south-western WA. The family is diverse in Australia, currently 24 genera are described; many species live in litter or under wood and stones in forest or woodland or near the coast (Green *et al.* 2010). The armadillid genus *Buddelundia* is endemic to Australia (Lewis 1998).

**Genus *Buddelundia***

Members of the genus *Buddelundia* belong to the most common terrestrial isopods in WA. The genus is currently under taxonomic revision by S. Judd. Most species of *Buddelundia* often have a very wide distribution and therefore the genus is not expected to have many SRE species (S. Judd 2012, email to V.W. Framenau, 3 October). However, some species are currently known from localised population and may therefore represent SREs.

***Buddelundia* '10 1106A' and '10 1016B'**

The *Buddelundia* '10' species complex is common in coastal areas of Western Australia and includes many undescribed species (S. Judd 2013, email to V.W. Framenau, 16 January). Distribution patterns

of morphospecies in the complex are currently unresolved but it is possible that some species represent SREs. Therefore, the two species in this complex, here collected in tussock and hummock grassland, open shrubland, and a rocky outcrop and boulder piles (Table 4-9; Figure 4-16; Appendix 7) are considered potential SREs.

#### 4.3.4.5 Eupulmonata (Snails)

Molluscs are one of the most diverse groups of invertebrates and the Australian fauna is characterised by a high degree of endemism (Beesley *et al.* 1998). Land snails belong to the target groups for SRE surveys due to their limited dispersal capabilities, in combination with often strict dependencies on particular soils (EPA 2009b; Harvey 2002). These characteristics have also resulted in a significant global decline of non-marine molluscs (Lydeard *et al.* 2004).

An unidentified camaenid land snail in the genus *Rhagada* was recovered from the study area in the desktop review (Table 4-2; Figure 4-10).

A total of 25 specimens of snails representing three species in three genera and two families were collected in the study area (Appendix 7); none of these are SREs. *Cochlicella acuta* and *Theba pisana* (family Helicidae) are introduced species that often occur in plague proportions (Odendaal *et al.* 2008; USDA 2010). *Rhagada convicta* (Camaenidae) is common throughout the Pilbara region of Western Australia (Johnson *et al.* 2012).

Species richness estimators suggest that up to two more species of snails were present during the survey in the study area (Table 4-4; Figure 4-12).

##### 4.3.4.5.1 Family Camaenidae

The Camaenidae is one of the most diverse land snail families in Australia both in species richness and morphology. Shell diameter ranges between 5 to 70 mm and shell shapes vary from discoidal and lenticular to globose, trochoidal, conical and elongate (Stanisic *et al.* 2010). The family is found Australia-wide with the exception of Tasmania and south-west WA (Stanisic *et al.* 2010).

In northern WA, the Camaenidae are the dominant group of land snails, with greatest diversity in the Kimberley region, where 19 of the 25 camaenid genera include SREs (Harvey *et al.* 2011; Solem 1997). In the Ningbing Ranges east of Kununurra, for example, the median geographical range of the 26 species occupying the area is less than one square-kilometre (Cameron 1992). Many of these ranges are shrinking, due to grazing and fire (Solem 1997) which resulted in the listing of 31 camaenid species under the Wildlife Conservation Act 1950 (Western Australian Government 2010, 2012a).

Based on the latest taxonomic revision, the Pilbara camaenid fauna comprised 27 species from six genera, distributed in latitude between Port Hedland and Cape Range, with no evidence of sympatry between congeneric species (Solem 1997). However, recent targeted sampling of camaenid land snails in the region has shown that many forms are parapatric, allowing direct genetic tests of reproductive isolation. This has revealed that some species have broader distributions than formerly thought, while other described species are actually complexes of multiple species, some with very narrow distributions. The molecular analyses have also shown the unreliability of shell characteristics on their own for assessing species taxonomy in many of these snails (Stankowski 2011). However, molecular 'barcoding' of COI sequence data may also not provide satisfactory results to distinguish species in some camaenid genera (Köhler & Johnson 2012).

**Genus *Rhagada***

The genus *Rhagada* is endemic to WA and, with 29 species, the second most diverse genus of the Camaenidae in the state (Johnson *et al.* 2004; Johnson *et al.* 2012; Solem 1997). Solem (1997) has reported 18 species from the northern tip of Dampier Land through Bernier Island, Shark Bay.

As in other camaenid land snails in northern WA, recent molecular studies have revealed that there are taxonomic uncertainties when species are assessed based on morphology alone (Johnson *et al.* 2012; Stankowski 2011). For example, detailed molecular and morphological analyses have shown continuity among morphologically diverse forms of *Rhagada* on Rosemary Island (Dampier Archipelago), suggesting that they represent a single species (Stankowski 2011). In contrast, other populations of *Rhagada* from the central Pilbara with no apparent morphological differences represent molecularly highly divergent lineages (Harvey *et al.* 2011).

***Rhagada* sp. indet.**

An unidentified species of *Rhagada* was recovered in the desktop review (Table 4-2; Figure 4-10). These were reported as the widespread *Rhagada richardsonii* in Slack-Smith (2005); however, the taxonomic status of the species in this group remains unresolved. Therefore, these *Rhagada* record are here considered to represent a potential SRE.

## 5 SURVEY LIMITATIONS

Guidance Statement 56 (EPA 2004) identified potential limitations that may be encountered in terrestrial fauna surveys. With respect to this guidance, the following limitations were encountered in the vertebrate fauna survey:

- Habitats north of the salt flats in the study area were inaccessible by vehicle for night works such as spotlighting; however, additional diurnal surveys were undertaken to supplement the survey effort in these habitats.
- Habitat degradation resulting from stock (e.g. Cattle) may be responsible for the lower number of some species recorded at some sites during the Level 2 survey.
- High temperatures recorded during the survey are likely to have resulted in less activity of some species such as diurnal mammals and reptiles. During periods of higher temperatures (particularly between late morning and early afternoon) individuals are likely to have altered their activity patterns to cooler periods such as early morning and late afternoon, when staff were busy clearing traps.
- Hermit crabs were problematic at the two coastal sites (Vert 04 and Vert 05). Due to the abundance of hermit crabs around the sites, traps were regularly full, reducing the likelihood of capturing other species in Elliot traps, buckets, pipes and funnels and potentially preying on other vertebrate fauna captured, such as reptiles.
- Disturbance of Elliot traps at survey sites by Crows was problematic at two sites, Vert 01 and Vert 02. Once the birds discovered the potential food source within the traps they regularly attempted to retrieve baits causing the traps to be set off and reducing likelihood of capturing other fauna. When this occurred traps were often re-set during the afternoon.



## 6 DISCUSSION

### 6.1 VERTEBRATE FAUNA

This section presents an assessment of potential impacts to vertebrate fauna from the Project. In assessing development proposals, the EPA's broad objective for vertebrate fauna is to maintain the abundance, diversity, geographic distribution, and productivity of fauna at species and ecosystem levels through the avoidance or management of adverse impacts and improvement in knowledge.

Accordingly, the main aim of this assessment was to determine whether the Project will result in the decline of vertebrate fauna abundance, diversity, distribution or productivity, with particular emphasis on conservation significant species.

A total of 25 vertebrate species of conservation significance were recorded during the field survey through direct sightings and bat echolocation call analysis (Figure 4-14; sections 4.3.3.3 and 4.3.3.4). Of these 22 species are listed as migratory under the EPBC Act. At the State level, six species are listed as Schedule 1 under the WC Act (one endangered and five vulnerable) and 15 species are listed as Schedule 3 (migratory). Three Priority, one P1 and two P4 species were also recorded. Up to 37 terrestrial vertebrate fauna species of conservation significance may potentially occur in the study area (Table 6-2).

A total of 14 species of migratory shorebirds were recorded during the survey (including species records from a concurrent shorebird survey) and a further 14 species are considered likely to occur. Impacts on migratory shorebirds are not addressed in this report; refer to Phoenix (Phoenix 2013) for a detailed discussion on, and impact assessment for, migratory shorebirds in the study area.

Species of conservation significance were recorded from four habitats within the study area, namely: grasslands; minor creek and drainage lines; mangrove thickets and intertidal mudflats. Intertidal mudflats and salt flats are of particular importance to migratory shorebirds (see (Phoenix 2013)).

The Project may have the following direct and indirect impacts on vertebrate fauna within the study area:

- direct loss of fauna
- displacement of individual fauna
- habitat loss or modification
- introduction and spread of introduced flora and fauna
- visual and acoustic disturbance
- fire
- pollution
- dust
- hydrological impacts.

The potential impacts are discussed in detail below. None of these are likely to result in a significant impact to any conservation significant vertebrate fauna. Overall the Project is likely to result in minor, localised impacts to fauna assemblages and habitats. Most risks to fauna can be adequately managed through the implementation of appropriate mitigation and management measures (see section 0).

### 6.1.1 Direct loss of fauna

Direct loss of fauna can occur directly or indirectly over a period of time. Mortalities from vehicle or machinery movements can occur regularly in areas of increased human presence. This impact can be increased by factors such as roadside vegetation, traffic intensity or time of day (Kölcker *et al.* 2006; Rowden *et al.* 2008). Animals are also likely to be killed during earthworks particularly during habitat clearing when large machinery are used (Gleeson & Gleeson 2012). Species most at risk of mortality during clearing are smaller amphibians, reptiles, mammals and ground dwelling birds unable to avoid large clearing machinery easily and those that move to retreat sites in the line of machinery movement when disturbed.

Static infrastructure such as power lines and fencing may affect vertebrate fauna, particularly birds and bats by the introduction of an unexpected obstacle in a flight path. Power lines are a threat to birds, particularly large birds such as bustards due to the limited visibility of wires (Martin & Shaw 2010). Erection of new fencing in areas can result in the death of bats and birds; though many can adjust to the presence of static infrastructure over time.

Of the species of conservation significance recorded during the survey the Australian Bustard and Flock Bronzewing are most likely to be impacted by vehicle mortalities. The Australian Bustard will often move along cleared tracks and roads increasing the likelihood of a vehicle impact. Flock Bronzewings will often forage amongst grasses and when disturbed will often fly away. Vehicle and machinery disturbance may result in flocks being flushed into oncoming vehicles and machinery.

Loss of fauna may occur during construction and operation of the Project; however, direct fauna mortalities are unlikely to be significant. Fencing for the Project (if required) may result in direct mortalities of individual fauna, particularly birds and bats that may become entangled. Collision with the raised conveyor by fauna may also occur; however, this is not likely to cause high mortality rates as no large aerial structures or overhead wires are planned.

It is understood that vehicle traffic will be minimal thus reducing the risk of fauna mortalities. The minor risk of mortality from vehicles can be reasonably managed provided speed limits are applied to all vehicles.

### 6.1.2 Displacement of individual fauna

Displacement of fauna is often the result of a primary disturbance (e.g. light spill, habitat loss, noise, etc.). Animals can be deterred by activities temporarily or permanently depending on the species and the nature of the disturbance. Some groups of species are more easily disturbed than others (Ruddock & Whitfield 2007).

The Project is likely to result in localised displacement of fauna during clearing and construction; however, it is unlikely to cause a significant impact on any vertebrate species. Many are likely to adapt and return to habitats in the vicinity of the Project after primary disturbance (such as habitat clearing and heavy machinery movement and operation) has ceased.

The Project may cause temporary displacement of conservation significant species including the Australian Bustard and Flock Bronzewing in grassland habitats and the Little North-western Mastiff Bat in the mangrove thickets and associated habitats.

It is unclear if the Project will result in any significant and permanent local displacement of Little North-western Mastiff Bat (see also section 6.1.5). Monitoring is recommended to assess the ongoing effects of the Project on the local population.

### 6.1.3 Habitat loss, modification and fragmentation

Habitat loss and modification is a result of any activities in which the structure of a habitat is removed or otherwise affected. Habitat loss may reduce resource and shelter for native fauna. Recent studies indicate that ground-dwelling mammals are more exposed to predation when the ground vegetation cover is removed or reduced (Arthur et al. 2005) (Körtner et al. 2007).

The degradation of habitat is often associated with secondary impacts including as fire, the assisted introduction of introduced flora and fauna species, dust and hydrological impacts resulting in a decline of habitat condition whereby the area no longer provide optimum or suitable conditions for some species to persist.

Habitat fragmentation is also a secondary impact caused by primary disturbances. After the creation of a track or even a fire, a previously continuous habitat can be divided into several disconnected remnant patches. This can result in more predation (May & Norton 1996), genetic isolation of populations (Brooker & Brooker 1994), dispersal of individuals (Brooker *et al.* 1999) or reduced access to resource habitats (Gleeson & Gleeson 2012).

Construction of the Project will result in the removal of native vegetation and modification consequently leading to a loss and degradation of fauna habitat. Additional human activity during construction may lead to further degradation of fauna habitats outside the clearing footprint.

Design changes to the Project have resulted in the reduction in clearing of some important fauna habitats, namely mangroves and the intertidal flats. The Project also completely avoids direct disturbance to rocky outcrops and boulder piles.

Based on the current project footprint, the total area of habitat likely to be disturbed Project is 279 ha, (2.35% of the study area) across eight habitat types (Table 6-1). The extent of habitat loss relative to extent in the study area is less than 3% for all habitat types except the coastal dunes (Table 6-1). Percentage loss of coastal sand dune habitat is approximately 7.5%; no conservation significant species are particularly dependent this habitat in the study area.

Fragmentation from the physical presence of the overland conveyor is not likely to have significant effects on any conservation significant species. The installation of culverts along the conveyor will facilitate movement of small terrestrial species.

**Table 6-1 Habitat type extent and predicted loss based on the current project footprint**

Habitat	Area within study area (ha)	Area within project footprint ha (%)
Samphire plain and algal mats	1,307	19 (1.45%)
Tussock and hummock grassland	4,223	93 (2.20%)
Open shrubland	1,006	9 (0.89%)
Minor creeks and drainage lines	109	1 (0.91%)
Salt flats	1,900	20 (1.05%)
Coastal sand dunes	67	5 (7.46%)
Mangrove thickets	909	9 (0.99%)
Intertidal flats	2,307	2 (0.08%)

Habitat	Area within study area (ha)	Area within project footprint ha (%)
Total	11,828	279 (2.35%)

#### 6.1.4 Introduction and spread of introduced flora and fauna

The introduction of flora and fauna species in Australia has caused great damage to native ecosystems, especially over the last 200 years. In the arid interior of WA, 90% of the medium-sized mammals are extinct or have experienced a range contraction since the 1920s (Burbidge & McKenzie 1989). The introduction of several herbivores and carnivores by humans has played a major role in this decline, both directly and indirectly (McKenzie *et al.* 2007). The total or local extinction of native mammals may have had impacts on several arid ecosystem processes such as seed dispersal (James & Elridge 2007).

Human activities can facilitate the spread of non-native species (Gleeson & Gleeson 2012). The increase in many introduced species, particularly House Mice, Black Rats and Cats is often a result of increased human presence in an area. The seeds of introduced flora can easily be carried through vehicles (e.g. underparts, tyres), humans (e.g. footwear and clothing) or machinery (e.g. diggers) (Gleeson & Gleeson 2012).

The introduction of feral vertebrate species such as cats, foxes, rabbits and cattle can result in the degradation of habitat and decline in native fauna through increased competition with and predation on native fauna.

Many introduced flora species; particularly grasses are colonizing and will grow quickly in disturbed areas and compete with native flora. For example Buffel Grass (*Cenchrus ciliaris*) is an aggressive grass that can change a landscape and eventually impact bird, mammal and reptile species (Marshall *et al.* 2012). It is a popular plant amongst farmers with an ability to support heavy grazing in arid environments (Marshall *et al.* 2012).

A total of seven introduced mammals were recorded during the survey, all of which have significantly impacted native fauna across Western Australia since their introduction. The grassland and shrubland habitats in the study area are in fairly degraded condition, most likely due to the presence of European Cattle in the area over a long period.

There is a risk of introduced fauna and flora reaching the area via the barges and larger ocean going vessels used to transport the ore product. The Asian House Gecko (*Hemidactylus frenatus*) has already been recorded a number of times in WA from port and transport facilities. The threat is considered to be low provided appropriate management measures are established.

Inappropriate management of food wastes during construction or operation may attract more feral animals to the area, including Dogs, Cats, Foxes, Black Rats and House Mice.

#### 6.1.5 Visual and acoustic disturbance

Increased light and noise can directly impact vertebrate fauna, particular nocturnal species in habitats adjacent to the Project. Many vertebrate fauna species, particularly nocturnal species can be sensitive to disturbances created by increased lighting at night and noise levels. Some species, particularly birds and bats are vulnerable to disturbance. Birds are most likely to be more prone to noise disturbances than mammals, reptiles and amphibians. Acoustics play a major role in bird communication, mostly for breeding (territory defence, mate choice, predation).

The Project may cause some local disturbance to fauna during construction due to noise emissions from heavy machinery and night lighting, if it is required. Noise and light (if required) disturbance may also occur during operation but is likely to have local-scale effects only.

Light disturbance may temporarily affect the activity patterns and foraging abilities of the Little North-western Mastiff Bat in the immediate vicinity of the Project, resulting in localised decline. It is also possible that the species may increase in localised concentrations where insect prey abundance increases in response to artificial lighting. Other members of the genus are known to exist in close proximity to human presence (Scanlon & Petit 2008) but no detailed studies have been conducted for this species.

#### **6.1.6 Fire**

In an arid environment naturally occurring fire is a key contributing factor to natural habitat structure. Changes in fire frequency and intensity may result in degradation of a habitat over time affecting its integrity and resulting in a decline of resources for vertebrate fauna.

Project activities may increase the risk of altered fire regimes in the vicinity of the Project. In particular, the use of heavy machinery and flammable materials in proximity to highly flammable vegetation (namely the *Triodia* grasslands) may increase risk of accidental fire.

The risk of a substantive accidental fire is considered to be low because the fuel load across most of the study area is low, particularly in the coastal habitats.

#### **6.1.7 Pollution**

Pollution events can be local (oil spill under a car caused by a damaged hose) but also much more significant (large scale pollution of surface or ground water, failure of contaminant holding infrastructures such as pools of contaminants) (Environment Australia 2002). The effects in time and space of the pollution on fauna will depend on the nature of the contaminant and the amount released, the magnitude and type of incident, the habitat and nature of the terrain surrounding the site of the incident (Lloyd *et al.* 2002).

Pollution events may potentially occur during both construction and operation of the Project. Particularly vulnerable habitats to pollution events in the study area are the aquatic and riparian habitats. In the event of a large-scale pollution event in Forestier Bay, impacts may be significant for mangrove and shoreline inhabiting species, in particular the Little North-western Mastiff Bat and Water Rat.

The current project design has been developed to minimise the risk of large pollution events into Forestier Bay and therefore the risk of such an event occurring and leading to significant impacts on fauna is considered to be low.

#### **6.1.8 Dust**

Deposition of dust on vegetation can limit its photosynthetic ability, potentially resulting in a reduction of vegetation cover. A reduction in vegetation cover affects habitat structure for fauna resulting in fewer resources available, particularly for small ground-dwelling species.

The Project may result in increased dust emissions and increased deposition in the immediate vicinity, particularly during clearing for construction where large areas of exposed substrate are present. Vehicular activity along unsealed roads may also increase dust emissions. Emissions from the stockpiles are expected to be low as the product from the dewatering plant will be discharged and stacked with moisture content above the Dust Extinction Moisture Content (DEM). Dust

suppression water cannons will be used to maintain the stockpiles above the DEM of the product. The potential impacts of dust are considered to be minimal due to the relatively short construction timeframe and limited vehicle activity.

### **6.1.9 Altered hydrology**

Any disruption caused to hydrological flows may lead to downstream degradation of fauna habitat. Creek lines often provide important breeding and foraging grounds for a number of species, including conservation significant species such as Rainbow Bee-eater and Lined Soil-crevice Skink.

The Project intersects several minor creek lines, drainage paths and intertidal areas. Consideration has been given to the maintenance of hydrological flows, particularly with the design of a tressle over a large portion of the causeway. It is understood that predicted surface flow disturbances will be minor and therefore secondary effects on fauna habitat are likely to be minimal.

**Table 6-2 Summary of conservation significant vertebrate species likelihood of occurrence**

Scientific name	Common name	EPBC Act	WC Act	DEC	Records	Likelihood of occurrence	Summary		Suitable habitats for species							
								Samphire plain	Grassland	Open shrubland	Rocky outcrops and boulder pile	Minor creek and drainage line	Salt flat	Coastal sand dune	Mangrove thicket	Intertidal mudflat
Reptiles																
<i>Lerista neviniae</i>	Nevin's Lerista		S1	VU	Desktop	Unlikely	Endemic to Cape Lambert area, 50 km west of study area								●	
<i>Notoscincus butleri</i>	Lined Soil-crevice Skink			P4	Desktop	Possible	Potential habitat present					●				
<i>Aspidites ramsayi</i>	Woma Python		S4		Desktop	Unlikely	Potential habitat not present									
<i>Liasis olivaceus barroni</i>	Pilbara Olive Python	VU	S1	VU	Desktop	Unlikely	Potential habitat not present									
Birds																
<i>Anas querquedula</i>	Garganey	Mig	S3		Desktop	Likely	Potential habitat present									
<i>Phaps histrionica</i>	Flock Bronzewing			P4	Field survey	Recorded	Present in study area		●							
<i>Apus pacificus</i>	Fork-tailed Swift	Mig	S3		Desktop	Possible	Potential foraging habitat present		●	●	●	●				
<i>Macronectes giganteus</i>	Southern Giant-Petrel	EN Mig		P4	Desktop	Unlikely	Migratory marine species, records north of the Midwest region sparse									●

Scientific name	Common name	EPBC Act	WC Act	DEC	Records	Likelihood of occurrence	Summary		Suitable habitats for species							
								Samphire plain	Grassland	Open shrubland	Rocky outcrops and boulder pile	Minor creek and drainage line	Salt flat	Coastal sand dune	Mangrove thicket	Intertidal mudflat
<i>Puffinus apacificus</i>	Wedge-tailed Shearwater	Mig	S3		Desktop	Likely	Potential habitat present						●	●		●
<i>Fregata ariel</i>	Lesser Frigatebird	Mig	S3		Desktop	Likely	Potential habitat present						●	●	●	●
<i>Sula leucogaster</i>	Brown Booby	Mig	S3		Desktop	Likely	Potential foraging habitat present								●	●
<i>Ixobrychus flavicollis</i>	Black Bittern			P3	Desktop	Likely	Potential habitat present					●	●		●	●
<i>Ardea modesta</i>	Eastern Great Egret	Mig	S3		Field Survey	Recorded	Present in study area					●	●		●	●
<i>Ardea ibis</i>	Cattle Egret	Mig	S3		Desktop	Likely	Potential habitat present					●	●		●	●
<i>Egretta sacra</i>	Eastern Reef Egret	Mig	S3		Desktop	Likely	Potential habitat present					●	●		●	●
<i>Plegadis falcinellus</i>	Glossy Ibis	Mig	S3		Desktop	Likely	Potential habitat present					●	●		●	●
<i>Pandion cristatus</i>	Eastern Osprey	Mig			Field Survey	Recorded	Present in study area					●	●	●	●	●
<i>Haliaeetus leucogaster</i>	White-bellied Sea-Eagle	Mig	S3		Field Survey	Recorded	Present in study area					●	●	●	●	●
<i>Falco hypoleucos</i>	Grey Falcon		S1	VU	Desktop	Possible	May forage in study area, Suitable nesting habitat not present		●	●		●				



Scientific name	Common name	EPBC Act	WC Act	DEC	Records	Likelihood of occurrence	Summary		Suitable habitats for species							
								Samphire plain	Grassland	Open shrubland	Rocky outcrops and boulder pile	Minor creek and drainage line	Salt flat	Coastal sand dune	Mangrove thicket	Intertidal mudflat
<i>Falco peregrinus</i>	Peregrine Falcon		S4		Desktop	Possible	May forage in study area, Suitable nesting habitat present		●	●	●	●				
<i>Rallina fasciata</i>	Red-legged Crake	Mig	S3		Desktop	Likely	Potential foraging and roosting habitat present					●	●			●
<i>Ardeotis australis</i>	Australian Bustard			P4	Field Survey	Recorded	Present in study area		●	●		●				
<i>Burhinus grallarius</i>	Bush Stone-curlew			P4	Desktop	Possible	Potential habitat present			●		●				
<i>Pluvialis fulva</i>	Pacific Golden Plover	Mig	S3		Desktop	Likely	Potential foraging and roosting habitat present						●			●
<i>Pluvialis squatarola</i>	Grey Plover	Mig	S3		Desktop	Likely	Potential foraging and roosting habitat present						●			●
<i>Charadrius mongolus</i>	Lesser Sand Plover	Mig	S1	EN	Field Survey	Recorded	Present in study area						●			●
<i>Charadrius leschenaultii</i>	Greater Sand Plover	Mig	S3		Field Survey	Recorded	Present in study area						●			●
<i>Charadrius veredus</i>	Oriental Plover	Mig	S3		Desktop	Likely	Potential foraging and roosting habitat present						●			●

Scientific name	Common name	EPBC Act	WC Act	DEC	Records	Likelihood of occurrence	Summary		Suitable habitats for species								
								Samphire plain	Grassland	Open shrubland	Rocky outcrops and boulder pile	Minor creek and drainage line	Salt flat	Coastal sand dune	Mangrove thicket	Intertidal mudflat	
<i>Limosa limosa</i>	Black-tailed Godwit	Mig	S3		Desktop	Likely	Potential foraging and roosting habitat present							●			●
<i>Limosa lapponica</i>	Bar-tailed Godwit	Mig	S3		Field Survey	Recorded	Present in study area							●			●
<i>Numenius minutus</i>	Little Curlew	Mig	S3		Desktop	Likely	Potential foraging and roosting habitat present							●			●
<i>Numenius phaeopus</i>	Whimbrel	Mig	S3		Field Survey	Recorded	Present in study area							●			●
<i>Numenius madagascariensis</i>	Eastern Curlew	Mig	S1	VU	Field Survey	Recorded	Present in study area							●			●
<i>Numenius arquata</i>	Eurasian Curlew	Mig	S3		Desktop	Likely	Potential foraging and roosting habitat present							●			●
<i>Xenus cinereus</i>	Terek Sandpiper	Mig	S3		Field Survey	Recorded	Present in study area							●			●
<i>Actitis hypoleucos</i>	Common Sandpiper	Mig	S3		Field Survey	Recorded	Present in study area							●			●
<i>Heteroscelus brevipes</i>	Grey-tailed Tattler	Mig	S3		Field Survey	Recorded	Present in study area							●			●
<i>Tringa nebularia</i>	Common Greenshank	Mig	S3		Desktop	Likely	Potential foraging and roosting habitat							●			●

Scientific name	Common name	EPBC Act	WC Act	DEC	Records	Likelihood of occurrence	Summary		Suitable habitats for species							
								Samphire plain	Grassland	Open shrubland	Rocky outcrops and boulder pile	Minor creek and drainage line	Salt flat	Coastal sand dune	Mangrove thicket	Intertidal mudflat
							present									
<i>Tringa stagnatilis</i>	Marsh Sandpiper	Mig	S3		Desktop	Likely	Potential foraging and roosting habitat present						●			●
<i>Tringa glareola</i>	Wood Sandpiper	Mig	S3		Desktop	Likely	Potential foraging and roosting habitat present						●			●
<i>Arenaria interpres</i>	Ruddy Turnstone	Mig	S3		Field Survey	Recorded	Present in study area						●			●
<i>Calidris tenuirostris</i>	Great Knot	Mig	S1	VU	Field Survey	Recorded	Present in study area						●			●
<i>Calidris canutus</i>	Red Knot	Mig	S3		Field Survey	Recorded	Present in study area						●			●
<i>Calidris alba</i>	Sanderling	Mig	S3		Field Survey	Recorded	Present in study area						●			●
<i>Calidris ruficollis</i>	Red-necked Stint	Mig	S3		Field Survey	Recorded	Present in study area						●			●
<i>Calidris subminuta</i>	Long-toed Stint	Mig	S3		Field Survey	Recorded	Present in study area						●			●
<i>Calidris acuminata</i>	Sharp-tailed Sandpiper	Mig	S3		Desktop	Likely	Potential foraging and roosting habitat present						●			●

Scientific name	Common name	EPBC Act	WC Act	DEC	Records	Likelihood of occurrence	Summary		Suitable habitats for species								
								Samphire plain	Grassland	Open shrubland	Rocky outcrops and boulder pile	Minor creek and drainage line	Salt flat	Coastal sand dune	Mangrove thicket	Intertidal mudflat	
<i>Calidris ferruginea</i>	Curlew Sandpiper	Mig	S1	VU	Desktop	Likely	Potential foraging and roosting habitat present							●			●
<i>Limicola falcinellus</i>	Broad-billed Sandpiper	Mig	S3		Desktop	Likely	Potential foraging and roosting habitat present							●			●
<i>Glareola maldivarum</i>	Oriental Pratincole	Mig	S3		Desktop	Likely	Potential foraging and roosting habitat present							●		●	●
<i>Sternula albifrons</i>	Little Tern	Mig	S3		Field Survey	Recorded	Present in study area							●		●	●
<i>Sternula nereis</i>	Fairy Tern	VU	S1	VU	Desktop	Likely	Potential habitat present							●		●	●
<i>Sterna caspia</i>	Caspian Tern	Mig	S3		Field Survey	Recorded	Present in study area							●		●	●
<i>Chlidonias leucopterus</i>	White-winged Black Tern	Mig	S3		Desktop	Likely	Potential habitat present							●		●	●
<i>Sterna dougallii</i>	Roseate Tern	Mig	S3		Field Survey	Recorded	Present in study area							●		●	●
<i>Sterna hirundo</i>	Common Tern	Mig	S3		Field Survey	Recorded	Present in study area							●		●	●
<i>Thalasseus bengalensis</i>	Lesser Crested Tern	Mig	S3		Desktop	Likely	Potential habitat present							●		●	●

Scientific name	Common name	EPBC Act	WC Act	DEC	Records	Likelihood of occurrence	Summary	Suitable habitats for species								
								Samphire plain	Grassland	Open shrubland	Rocky outcrops and boulder pile	Minor creek and drainage line	Salt flat	Coastal sand dune	Mangrove thicket	Intertidal mudflat
<i>Merops ornatus</i>	Rainbow Bee-eater	Mig	S3		Field Survey	Recorded	Present in study area					•				
<i>Hirundo rustica</i>	Barn Swallow	Mig	S3		Desktop	Likely	Potential habitat present									
<i>Neochmia ruficauda subclarescens</i>	Star Finch			P4	Desktop	Likely	Potential habitat present					•				
<b>Mammals</b>																
<i>Dasyercus cristicauda</i>	Crest-tailed Mulgara	VU	S1	VU	Desktop	Unlikely	Potential habitat not present									
<i>Dasyurus hallucatus</i>	Northern Quoll	EN	S1	EN	Desktop	Unlikely	Suitable habitat not present									
<i>Macrotis lagotis</i>	Greater Bilby	VU	S1	VU	Desktop	Unlikely	Potential habitat not present									
<i>Petrogale lateralis lateralis</i>	Black-flanked Rock Wallaby	VU	S1	VU	Desktop	Unlikely	Suitable habitat not present									
<i>Macroderma gigas</i>	Ghost Bat			P4	Desktop	Possible	May forage in study area, Suitable roosting habitat not present									
<i>Rhinonicteris aurantia</i>	Orange Leaf-nosed Bat	VU	S1	VU	Desktop	Possible	May forage in study area, Suitable roosting habitat not present									
<i>Mormopterus loriae cobourgiana</i>	Little North-western Mastiff Bat			P1	Field Survey	Recorded	Present in study area		•	•		•		•	•	

Scientific name	Common name	EPBC Act	WC Act	DEC	Records	Likelihood of occurrence	Summary	Suitable habitats for species								
								Samphire plain	Grassland	Open shrubland	Rocky outcrops and boulder pile	Minor creek and drainage line	Salt flat	Coastal sand dune	Mangrove thicket	Intertidal mudflat
<i>Hydromys chrysogaster</i>	Water-rat			P4	Desktop	Likely	Potential habitat present								•	•
<i>Leggadina lakedownensis</i>	Short-tailed Mouse			P4	Desktop	Likely	Potential habitat present	•	•				•			
<i>Pseudomys chapmani</i>	Western Pebble-mound Mouse			P4	Desktop	Likely	Potential habitat present		•							

EN – Endangered (EPBC Act); VU – Vulnerable (EPBC Act); Mig. – Migratory (EPBC Act); S1 – Schedule 1 (WC Act); S3 – Schedule 3/migratory (WC Act); S4 – Schedule 4 (WC Act); P1 – P4 Priority 1 – 4 (DEC).

## 6.2 SRE INVERTEBRATES

The EPA's objectives in relation to SRE fauna are to:

- ensure the protection of key habitats for SRE species
- maintain the distribution, abundance and productivity of populations of SRE taxa
- ensure that the conservation status of SRE taxa is not adversely changed as a result of development proposals (EPA 2009b).

In assessing development proposals, the EPA aims to ensure that proposals do not potentially threaten the viability of, or lead to the extinction of any SRE species (EPA 2009b).

No significant SRE habitat was recorded in project footprint and no SRE species were collected there. Although it cannot be completely confirmed that the SREs reported from the study area do not occur in the project footprint, potential impacts on these by the Project are considered negligible as they are found in well-represented habitat outside the project footprint (Table 6-3).

**Table 6-3 Summary of potential impacts to SRE species**

Species	SRE category	Records inside/outside project footprint	Potential impacts
<i>Aname</i> sp. indet.	Potential	-/2	Negligible
<i>Buddelundia</i> '10 1016A'	Potential	-/2	Negligible
<i>Buddelundia</i> '10 1016B'	Potential	-/8	Negligible
<i>Lychas</i> cf. <i>mjobergi</i>	Potential	-/8	Negligible
<i>Rhagada</i> sp. indet.	Potential	-/not specified (desktop review)	Negligible

## 6.3 RECOMMENDATIONS

Central to conservation strategies for threatened species is the protection of habitat. Protection of habitat for conservation significant species has the added benefit of protecting broader species assemblages and helping to maintain whole of ecosystem functions. This concept is equally relevant at the Project level and focus should be on avoiding or minimising impacts to important habitat as much as individual animals.

Not all the potential impacts of the Project on fauna can be completely avoided and therefore recommendations are made to minimise and/or rectify each potential impacts where possible (Table 6-4).

**Table 6-4 Recommendations to minimise impacts to fauna**

<b>Overarching recommendations</b>	
Develop a fauna management plan (stand alone or incorporated into the existing management plans for the Project) that outlines all management measures that will be undertaken to manage impacts to fauna and fauna habitats.	
Develop and implement a monitoring plan to monitor impacts on Little North-western Mastiff Bat during construction and operation. This is the only conservation significant species of concern in the study area for which threatening processes and project-specific impacts are not fully understood.	
<b>Potential impact: direct loss of individual fauna</b>	
Avoidance	Avoid construction of overhead wires and fencing (as far as practicable). Use existing tracks and roads when possible rather than new ones. Control the speed limit for all vehicles and avoid driving at night time. Design roads and tracks that allow maximum visibility to avoid road kills.
Minimisation	Undertake staff training and education to create awareness of the local fauna and associated risks with operations and provide awareness information where needed (e.g. meeting rooms, crib rooms).
<b>Potential impact: displacement of fauna</b>	
Avoidance	Limit all types of disturbances to the strict minimum and if possible far from sensitive habitats such as creek and drainage lines, mangrove thickets and intertidal flats. Undertake construction during periods where faunal activity is reduced, i.e. over winter months.
Minimisation	Minimise the amount of disturbance in any one area during the construction of the Project
Rectification	Monitoring (pre-, during- and post-construction) may need to be undertaken to assess significance of impacts on the Little North-western Mastiff Bat including displacement.
<b>Potential impact: habitat loss and modification</b>	
Avoidance	Prevent any habitat loss or modification outside the approved clearing footprint



	Use already cleared areas for infrastructure placement as much as possible rather than clearing new areas.
Minimisation	Minimise vegetation and soil clearing to as far as practicable.  Install culverts along the overland conveyor to maintain connectivity east and west of the structure.
Rectification	Restore impacted habitats wherever possible.
<b>Potential impact: introduction and spread of introduced flora and fauna</b>	
Avoidance	Control access by fauna to rubbish, food wastes and accommodation in general.  Develop management measures to minimise the risk of introduction and spread of introduced species. In particular, quarantine measures should be implemented for transport vessels and associated activities to minimise the risk of introducing flora or fauna to the study area.
Minimisation	Implement staff training and education to create awareness of introduced species and associated impacts on native flora and fauna.
<b>Potential impact: visual and acoustic disturbance</b>	
Avoidance	Restrict artificial lighting to a practicable minimum and avoid directing lights towards fauna habitats, particularly in areas species are most likely to be impacted, i.e. intertidal flats, mangroves and creek and drainage lines.
Minimisation	Reduce noise emissions in general when possible.
Rectification	Remove artificial lighting in areas no longer required after construction has ceased.
<b>Potential impact: fire</b>	
Avoidance	Create firebreaks and fire containment areas around all areas works are undertaken.  Reduce fuel loads in areas where possible.  Keep all flammable materials and equipment safely stored.  Install appropriate fire fighting equipment on all heavy and light machinery.
Minimisation	Develop standard operating procedures pertaining to managing fire risk, specifically related to clearing, construction, use and maintenance of the conveyor and associated infrastructure.  Provide adequate fire equipment and staff training to control fires.
<b>Potential impact: pollution</b>	
Avoidance	Ensure all chemicals are safely stored and adequate spill response procedures are in place for unexpected spills.
Minimisation	Provide adequate equipment and staff training to respond appropriately to pollution. This must be designed according to the amount and type of chemicals kept on site.  Develop adequate pollution management procedures.

	Educate staff to manage rubbish and wastes appropriately.
Rectification	Ensure all spills reported and dealt with immediately in accordance with pollution management procedures.
<b>Potential impact: dust</b>	
Avoidance	<p>Reduce amount of clearing where necessary and avoid leaving areas of bare ground with exposed substrates as far as practicable.</p> <p>Undertake dust suppression on tracks and any other dust-emitting sites.</p> <p>Cover storage of fine material.</p> <p>Rehabilitate open areas with exposed substrates that may be easily moved by vehicles and wind.</p>
Minimisation	<p>Limit vehicle speed to reduce dust.</p> <p>Use wet sprinklers on stockpiles and limit their height and slope. Protect with adequate windbreaks.</p>
<b>Potential impact: hydrological impacts</b>	
Avoidance	<p>Where possible the design of the Project should allow for surface water movement.</p> <p>Hydrological impacts should be minimised by installing culverts in appropriate locations along the length of the Project to maintain hydrological flows in as natural states as possible. Particular attention should be paid to areas the Project crosses creek and drainage lines.</p>

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**Appendix 1     Vertebrate fauna systematic trapping site descriptions**


Site number	Vert 01
Site type	Systematic survey site
Easting	575128
Northing	7701201
Zone	50K
Impact / Non-impact area	Non-impact area
Habitat	Plain
Habitat type	Spinifex grassland; Open shrubland
Dominant tree	None
Tree cover	0
Dominant shrub	<i>Acacia</i>
Shrub cover	0-25%
Dominant grass	Spinifex
Grass cover	51-75%
Slope	None
Soil texture	Sandy clay
Soil colour	Red / Brown
Surface	Fine gravel, Coarse gravel
Rock cover	0-25%
Leaf litter distribution	0-25%
Litter distribution	Under trees/shrubs
Dead wood	Moderate
Disturbance details	Grazing medium; Vehicle tracks; Livestock tracks
Fire history	None evident
Fire intensity	
<b>Description:</b>  Open shrubland of <i>mixed shrubs primarily Acacia and Grevillia</i> to 3m with mixed shrubs over dense mature spinifex hummocks	
<p style="text-align: center;">NO PHOTO AVAILABLE</p>	

Site number	Vert 02
Site type	Systematic survey site
Easting	575596
Northing	7703357
Zone	50K
Impact / Non-impact area	Non-impact area
Habitat	Minor creek
Habitat type	Riparian zone
Dominant tree	<i>Eucalyptus/Corymbia</i>
Tree cover	0-25%
Dominant shrub	<i>Acacia</i>
Shrub cover	0-25%
Dominant grass	Spinifex
Grass cover	26-50%
Slope	None
Soil texture	Sand; Clay loam
Soil colour	Brown
Surface	Fine gravel; Coarse gravel
Rock cover	0-25%
Leaf litter distribution	Even
Litter distribution	25-50%
Dead wood	Moderate
Disturbance details	Livestock tracks
Fire history	None evident
Fire intensity	
<b>Description:</b>  Minor creekline with Eucalypts to 6m with mixed shrubs to 3m over mature spinifex hummock and other grasses. Numerous hollow bearing trees present. Dead wood cover moderate. Creek currently dry.	
NO PHOTO AVAILABLE	

<b>Site number</b>	<b>Vert 03</b>
<b>Site type</b>	Systematic survey site
<b>Easting</b>	570604
<b>Northing</b>	7703944
<b>Zone</b>	50K
<b>Impact / Non-impact area</b>	Non-impact area
<b>Habitat</b>	Plain
<b>Habitat type</b>	Open shrubland
<b>Dominant tree</b>	None
<b>Tree cover</b>	0-25%
<b>Dominant shrub</b>	<i>Acacia</i>
<b>Shrub cover</b>	51-75%
<b>Dominant grass</b>	Spinifex
<b>Grass cover</b>	26-50%
<b>Slope</b>	None
<b>Soil texture</b>	Clay loam
<b>Soil colour</b>	Red / Orange
<b>Surface</b>	Slight cracking; Fine gravel; Coarse gravel
<b>Rock cover</b>	25-50%
<b>Leaf litter distribution</b>	0-25%
<b>Litter distribution</b>	Under trees/shrubs
<b>Dead wood</b>	Sparse
<b>Disturbance details</b>	Grazing – high; Vehicle tracks; Drill pads
<b>Fire history</b>	None evident
<b>Fire intensity</b>	
<b>Description:</b>  Open shrubland with mixed shrubs to 1.5m over scattered spinifex and other grasses. Scattered tall shrubs with moderate leaf litter. Pebble and coarse gravel surface with hard clay loam below.	
	


<b>Site number</b>	<b>Vert 04</b>
<b>Site type</b>	Systematic survey site
<b>Easting</b>	568927
<b>Northing</b>	7713147
<b>Zone</b>	50K
<b>Impact / Non-impact area</b>	Impact area
<b>Habitat</b>	Coastal Sand dunes
<b>Habitat type</b>	Grassland; Open shrubland
<b>Dominant tree</b>	<i>Acacia</i> (not mulga)
<b>Tree cover</b>	0-25%
<b>Dominant shrub</b>	Other (coastal shrubs)
<b>Shrub cover</b>	0-25%
<b>Dominant grass</b>	Other grasses
<b>Grass cover</b>	51-75
<b>Slope</b>	None
<b>Soil texture</b>	Sand
<b>Soil colour</b>	Brown; Grey
<b>Surface</b>	Loose soil
<b>Rock cover</b>	None
<b>Leaf litter distribution</b>	0-25%
<b>Litter distribution</b>	Under trees
<b>Dead wood</b>	Moderate
<b>Disturbance details</b>	None evident
<b>Fire history</b>	None evident
<b>Fire intensity</b>	
<b>Description:</b>  Low coastal dunes with sparse <i>Acacia</i> with scattered mangroves to 4m over mixed shrubs to 2.5m with moderate mixed coastal grasses to 1m.	
	





<b>Site number</b>	<b>Vert 05</b>
<b>Site type</b>	Systematic survey site
<b>Easting</b>	571061
<b>Northing</b>	7714362
<b>Zone</b>	50K
<b>Impact / Non-impact area</b>	Non-impact area
<b>Habitat</b>	Coastal Sand dunes
<b>Habitat type</b>	Grassland; Open shrubland
<b>Dominant tree</b>	None
<b>Tree cover</b>	0
<b>Dominant shrub</b>	Other (coastal shrubs)
<b>Shrub cover</b>	26-50%
<b>Dominant grass</b>	Spinifex & Other grasses
<b>Grass cover</b>	51-75
<b>Slope</b>	None
<b>Soil texture</b>	Sand
<b>Soil colour</b>	Brown; Grey
<b>Surface</b>	Loose soil
<b>Rock cover</b>	None
<b>Leaf litter distribution</b>	0-25%
<b>Litter distribution</b>	Under trees
<b>Dead wood</b>	Dense
<b>Disturbance details</b>	None evident
<b>Fire history</b>	None evident
<b>Fire intensity</b>	
<b>Description:</b>  Low coastal dunes with sparse <i>Acacia</i> to 2.5m with mixed coastal shrubs to 1m over spinifex and other grasses. Mangrove thickets along water's edge. Sandy soil with coarse shell grit surface and substrate towards water's edge.	
	





**Appendix 2     Vertebrate fauna opportunistic survey site descriptions**


Site number	Vert Opp 01
Site type	Opportunistic survey site
Easting	575758
Northing	7698177
Zone	50K
Impact / Non-impact area	Non-impact area
Habitat	Plain
Habitat type	Grassland
Dominant tree	None
Tree cover	0-25 %
Dominant shrub	Other
Shrub cover	0-25 %
Dominant grass	Spinifex
Grass cover	51-75 %
Slope	Gentle
Soil texture	Sandy Clay
Soil colour	Red / Brown
Surface	Fine gravel; Coarse Gravel; Stones; Loose soil;
Rock cover	0-25 %
Leaf litter distribution	Under trees / shrubs
Litter distribution	0-25 %
Dead wood	None
Disturbance details	Grazing – High; Vehicle Tracks; Livestock Tracks; Large Scale Clearing
Fire history	None evident
Fire intensity	
<b>Description:</b>  Spinifex grassland with scattered small to medium shrubs to 1.5 m. Single eucalypt near bore. Areas with no vegetation and loose rock on surface from bore excavation. Working bore with trough present. Heavily grazed by cattle.	
	

<b>Site number</b>	<b>Vert Opp 02</b>
<b>Site type</b>	Opportunistic survey site
<b>Easting</b>	576241
<b>Northing</b>	7702678
<b>Zone</b>	50K
<b>Impact / Non-impact area</b>	Non-impact area
<b>Habitat</b>	Minor Creek
<b>Habitat type</b>	Open Woodland
<b>Dominant tree</b>	<i>Eucalyptus / Corymbia</i>
<b>Tree cover</b>	51-75 %
<b>Dominant shrub</b>	<i>Acacia</i>
<b>Shrub cover</b>	0-25 %
<b>Dominant grass</b>	Spinifex
<b>Grass cover</b>	26-50 %
<b>Slope</b>	Gentle
<b>Soil texture</b>	Sandy Clay
<b>Soil colour</b>	Red / Brown
<b>Surface</b>	Loose soil
<b>Rock cover</b>	0-25 %
<b>Leaf litter distribution</b>	>75 %
<b>Litter distribution</b>	Even
<b>Dead wood</b>	Moderate
<b>Disturbance details</b>	Grazing – High; Vehicle Tracks
<b>Fire history</b>	None evident
<b>Fire intensity</b>	
<b>Description:</b>  Minor creek line with scattered eucalypts to 12m. Sparse understory with scattered small to med shrubs. Spinifex on creek banks and surrounding area. Creekline dry.	
	


<b>Site number</b>	<b>Vert Opp 03</b>
<b>Site type</b>	Opportunistic survey site
<b>Easting</b>	573332
<b>Northing</b>	7704494
<b>Zone</b>	50K
<b>Impact / Non-impact area</b>	Non-impact area
<b>Habitat</b>	Plain
<b>Habitat type</b>	Grassland
<b>Dominant tree</b>	None
<b>Tree cover</b>	0-25 %
<b>Dominant shrub</b>	<i>Acacia</i>
<b>Shrub cover</b>	0-25 %
<b>Dominant grass</b>	Spinifex
<b>Grass cover</b>	51-75 %
<b>Slope</b>	Gentle
<b>Soil texture</b>	Sandy Loam; Clay
<b>Soil colour</b>	Red / Brown
<b>Surface</b>	Fine gravel; Coarse gravel; Loose soil
<b>Rock cover</b>	25-50 %
<b>Leaf litter distribution</b>	0-25 %
<b>Litter distribution</b>	Under trees
<b>Dead wood</b>	Sparse
<b>Disturbance details</b>	Drill Pads and Tracks; Grazing – Low; Large-scale Clearing
<b>Fire history</b>	None evident
<b>Fire intensity</b>	
<b>Description:</b>  Spinifex grassland at base of rocky hill. Scattered medium to tall shrubs. Open areas with gravel topsoil. Large area cleared for drilling activities. Spoil heaps from clearing present. Disused infrastructure with scattered tin and building materials.	
	


<b>Site number</b>	<b>Vert Opp 04</b>
<b>Site type</b>	Opportunistic survey site
<b>Easting</b>	571571
<b>Northing</b>	7703322
<b>Zone</b>	50K
<b>Impact / Non-impact area</b>	Impact area
<b>Habitat</b>	Plain
<b>Habitat type</b>	Grassland
<b>Dominant tree</b>	None
<b>Tree cover</b>	0-25 %
<b>Dominant shrub</b>	None
<b>Shrub cover</b>	0 %
<b>Dominant grass</b>	Other grasses
<b>Grass cover</b>	76-100 %
<b>Slope</b>	Gentle
<b>Soil texture</b>	Clay Loam
<b>Soil colour</b>	Red / Brown
<b>Surface</b>	Slight cracking; Coarse gravel; Loose soil
<b>Rock cover</b>	0-25 %
<b>Leaf litter distribution</b>	0-25 %
<b>Litter distribution</b>	
<b>Dead wood</b>	None
<b>Disturbance details</b>	Grazing – High; Vehicle Tracks
<b>Fire history</b>	None evident
<b>Fire intensity</b>	
<b>Description:</b>  Grassland with unknown grass species to 50cm. Most grasses dead with no new growth present. No shrub or tree cover. Heavily grazed with large areas of exposed soil scattered with stones. Bore nearby located nearby.	
	

<b>Site number</b>	<b>Vert Opp 05</b>
<b>Site type</b>	Opportunistic survey site
<b>Easting</b>	576340
<b>Northing</b>	7702738
<b>Zone</b>	50K
<b>Impact / Non-impact area</b>	Non-impact area
<b>Habitat</b>	Plain
<b>Habitat type</b>	Grassland
<b>Dominant tree</b>	None
<b>Tree cover</b>	0-25 %
<b>Dominant shrub</b>	<i>Acacia</i>
<b>Shrub cover</b>	0-25 %
<b>Dominant grass</b>	Other grasses
<b>Grass cover</b>	0-25 %
<b>Slope</b>	Gentle
<b>Soil texture</b>	Clay Loam
<b>Soil colour</b>	Red / Brown
<b>Surface</b>	Loose soil
<b>Rock cover</b>	0-25 %
<b>Leaf litter distribution</b>	0-25 %
<b>Litter distribution</b>	Under shrubs
<b>Dead wood</b>	None
<b>Disturbance details</b>	Grazing – High; Vehicle Tracks; Livestock Tracks; Large-scale Clearing
<b>Fire history</b>	None evident
<b>Fire intensity</b>	
<b>Description:</b>  Sparse grassland of unknown species. Most dead with no new growth present. Area heavily grazed with large areas of bare ground. Large area cleared for tracks and bore site. Working bore and trough present.	
	


<b>Site number</b>	<b>Vert Opp 06</b>
<b>Site type</b>	Opportunistic survey site
<b>Easting</b>	573447
<b>Northing</b>	7704527
<b>Zone</b>	50K
<b>Impact / Non-impact area</b>	Non-impact area
<b>Habitat</b>	Hilltop
<b>Habitat type</b>	Grassland
<b>Dominant tree</b>	None
<b>Tree cover</b>	0-25 %
<b>Dominant shrub</b>	Other
<b>Shrub cover</b>	0-25 %
<b>Dominant grass</b>	Spinifex
<b>Grass cover</b>	26-50 %
<b>Slope</b>	Moderate
<b>Soil texture</b>	Clay Loam
<b>Soil colour</b>	Red / Brown
<b>Surface</b>	Coarse Gravel; Stones; Surface Plates
<b>Rock cover</b>	50-75 %
<b>Leaf litter distribution</b>	0-25 %
<b>Litter distribution</b>	Under shrubs
<b>Dead wood</b>	None
<b>Disturbance details</b>	Vehicle Tracks
<b>Fire history</b>	None evident
<b>Fire intensity</b>	
<b>Description:</b>  Rocky hilltop of spinifex grassland with scattered small shrubs. Rocky surface and areas of exposed rock with vertical crevices.	
	





<b>Site number</b>	<b>Vert Opp 07</b>
<b>Site type</b>	Opportunistic survey site
<b>Easting</b>	578253
<b>Northing</b>	7703258
<b>Zone</b>	50K
<b>Impact / Non-impact area</b>	Non-impact area
<b>Habitat</b>	Plain
<b>Habitat type</b>	Grassland
<b>Dominant tree</b>	None
<b>Tree cover</b>	0-25 %
<b>Dominant shrub</b>	<i>Acacia</i>
<b>Shrub cover</b>	0-25 %
<b>Dominant grass</b>	Spinifex
<b>Grass cover</b>	76-100 %
<b>Slope</b>	Gentle
<b>Soil texture</b>	Clay Loam
<b>Soil colour</b>	Red Brown
<b>Surface</b>	Surface Crust; Loose Soil
<b>Rock cover</b>	0-25 %
<b>Leaf litter distribution</b>	0-25 %
<b>Litter distribution</b>	Under shrubs
<b>Dead wood</b>	Sparse
<b>Disturbance details</b>	Grazing – Low; Vehicle Tracks
<b>Fire history</b>	None evident
<b>Fire intensity</b>	
<b>Description:</b>  Spinifex grassland with scattered small shrubs to 2.5 m. Patches of large mature spinifex. Large open areas with exposed substrate and surface crust.	
	


<b>Site number</b>	<b>Vert Opp 08</b>
<b>Site type</b>	Opportunistic survey site
<b>Easting</b>	574773
<b>Northing</b>	7705710
<b>Zone</b>	50K
<b>Impact / Non-impact area</b>	Non-impact area
<b>Habitat</b>	Plain
<b>Habitat type</b>	Grassland
<b>Dominant tree</b>	None
<b>Tree cover</b>	0-25 %
<b>Dominant shrub</b>	None
<b>Shrub cover</b>	0-25 %
<b>Dominant grass</b>	Other grasses
<b>Grass cover</b>	76-100 %
<b>Slope</b>	Gentle
<b>Soil texture</b>	Sandy Loam; Clay Loam
<b>Soil colour</b>	Red / Brown
<b>Surface</b>	Fine Gravel; Loose Soil
<b>Rock cover</b>	0-25 %
<b>Leaf litter distribution</b>	0-25 %
<b>Litter distribution</b>	None
<b>Dead wood</b>	None
<b>Disturbance details</b>	Grazing – High; Vehicle Tracks; Livestock Tracks
<b>Fire history</b>	None evident
<b>Fire intensity</b>	
<b>Description:</b>  Grassland with unknown grass species to .5 m. Vegetation sparse with large open areas with exposed substrate.	
	




<b>Site number</b>	<b>Vert Opp 09</b>
<b>Site type</b>	Opportunistic survey site
<b>Easting</b>	573923
<b>Northing</b>	7704400
<b>Zone</b>	50K
<b>Impact / Non-impact area</b>	Non-impact area
<b>Habitat</b>	Hill Slope
<b>Habitat type</b>	Grassland
<b>Dominant tree</b>	None
<b>Tree cover</b>	0-25 %
<b>Dominant shrub</b>	<i>Acacia</i>
<b>Shrub cover</b>	0-25 %
<b>Dominant grass</b>	Spinifex
<b>Grass cover</b>	51-75 %
<b>Slope</b>	Moderate
<b>Soil texture</b>	Clay Loam
<b>Soil colour</b>	Red / Brown
<b>Surface</b>	Fine Gravel; Coarse Gravel; Stones
<b>Rock cover</b>	75-100 %
<b>Leaf litter distribution</b>	0-25 %
<b>Litter distribution</b>	Under shrubs
<b>Dead wood</b>	Sparse
<b>Disturbance details</b>	Drill Pads and Tracks
<b>Fire history</b>	None evident
<b>Fire intensity</b>	
<b>Description:</b>  Spinifex grassland with scattered small to med shrubs (mixed species) on rocky hill slope. Rocky surface of stones and gravel with scattered areas of exposed rock. Large areas of clearing up hill for tracks and drill pads.	
	

<b>Site number</b>	<b>Vert Opp 10</b>
<b>Site type</b>	Opportunistic survey site
<b>Easting</b>	570986
<b>Northing</b>	7714500
<b>Zone</b>	50K
<b>Impact / Non-impact area</b>	Non-impact area
<b>Habitat</b>	Hill Slope
<b>Habitat type</b>	Grassland
<b>Dominant tree</b>	None
<b>Tree cover</b>	0-25 %
<b>Dominant shrub</b>	<i>Acacia</i>
<b>Shrub cover</b>	26-50 %
<b>Dominant grass</b>	Other grasses
<b>Grass cover</b>	26-50 %
<b>Slope</b>	Moderate
<b>Soil texture</b>	Sandy Loam
<b>Soil colour</b>	Brown
<b>Surface</b>	Boulders; Stones; Loose Soil
<b>Rock cover</b>	50-75 %
<b>Leaf litter distribution</b>	26-50 %
<b>Litter distribution</b>	Under shrubs
<b>Dead wood</b>	Moderate
<b>Disturbance details</b>	None evident
<b>Fire history</b>	None evident
<b>Fire intensity</b>	
<b>Description:</b>  Rocky hill slope with scattered small to med shrubs over unidentified grass. Large boulders and rock piles. Rocky coastline and mangroves surrounding base of hill.	
	

<b>Site number</b>	<b>Vert Opp 11</b>
<b>Site type</b>	Opportunistic survey site
<b>Easting</b>	566904
<b>Northing</b>	7713181
<b>Zone</b>	50K
<b>Impact / Non-impact area</b>	Non-impact area
<b>Habitat</b>	Intertidal zone
<b>Habitat type</b>	Mangrove thicket
<b>Dominant tree</b>	Mangrove
<b>Tree cover</b>	76-100 %
<b>Dominant shrub</b>	None
<b>Shrub cover</b>	0 %
<b>Dominant grass</b>	None
<b>Grass cover</b>	0 %
<b>Slope</b>	Gentle
<b>Soil texture</b>	Sandy Loam
<b>Soil colour</b>	Grey; Black
<b>Surface</b>	Loose soil
<b>Rock cover</b>	0 %
<b>Leaf litter distribution</b>	None
<b>Litter distribution</b>	0 %
<b>Dead wood</b>	0-25 %
<b>Disturbance details</b>	None evident
<b>Fire history</b>	None evident
<b>Fire intensity</b>	
<b>Description:</b>	
Dense intertidal mangrove thicket on sandy shoreline. Silt on surface. High tide line variable.	
	


<b>Site number</b>	<b>Vert Opp 12</b>
<b>Site type</b>	Opportunistic survey site
<b>Easting</b>	568575
<b>Northing</b>	7712307
<b>Zone</b>	50K
<b>Impact / Non-impact area</b>	Non-impact area
<b>Habitat</b>	
<b>Habitat type</b>	
<b>Dominant tree</b>	None
<b>Tree cover</b>	0-25 %
<b>Dominant shrub</b>	<i>Acacia</i>
<b>Shrub cover</b>	0-25 %
<b>Dominant grass</b>	Other grasses
<b>Grass cover</b>	0-25 %
<b>Slope</b>	Gentle; Moderate
<b>Soil texture</b>	Sandy Loam
<b>Soil colour</b>	Grey / Brown
<b>Surface</b>	Fine Gravel; Loose Soil; Boulders
<b>Rock cover</b>	51-75 %
<b>Leaf litter distribution</b>	0-25 %
<b>Litter distribution</b>	Under shrubs
<b>Dead wood</b>	Sparse
<b>Disturbance details</b>	None evident
<b>Fire history</b>	None evident
<b>Fire intensity</b>	
<b>Description:</b>  Exposed outcrop and boulder pile with scattered small to medium shrubs to 2 m over mixed grasses to .5 m. Large boulder pile with large crevices. Rocky areas Surrounded by salt flat.	
	

Site number	Vert Opp 13
Site type	Opportunistic survey site
Easting	570212
Northing	7713006
Zone	50K
Impact / Non-impact area	Non-impact area
Habitat	Intertidal zone
Habitat type	Mangrove thicket
Dominant tree	Mangrove
Tree cover	76-100 %
Dominant shrub	None
Shrub cover	0 %
Dominant grass	None
Grass cover	0 %
Slope	Gentle
Soil texture	Sandy Loam
Soil colour	Grey; Black
Surface	Loose soil
Rock cover	0 %
Leaf litter distribution	None
Litter distribution	0 %
Dead wood	0-25 %
Disturbance details	None evident
Fire history	None evident
Fire intensity	
<b>Description:</b>  Dense intertidal mangrove thicket on sandy shoreline. Silt on surface. High tide line variable.	
<p style="text-align: center;">NO PHOTO AVAILABLE</p>	

<b>Site number</b>	<b>Vert Opp 14</b>
<b>Site type</b>	Opportunistic survey site
<b>Easting</b>	572960
<b>Northing</b>	7706946
<b>Zone</b>	50K
<b>Impact / Non-impact area</b>	Non-impact area
<b>Habitat</b>	Plain
<b>Habitat type</b>	Grassland
<b>Dominant tree</b>	None
<b>Tree cover</b>	0-25 %
<b>Dominant shrub</b>	None
<b>Shrub cover</b>	0-25 %
<b>Dominant grass</b>	Spinifex; Other grasses
<b>Grass cover</b>	0-25 %
<b>Slope</b>	Gentle
<b>Soil texture</b>	Sandy Loam
<b>Soil colour</b>	Grey / Brown
<b>Surface</b>	Loose Soil
<b>Rock cover</b>	0-25 %
<b>Leaf litter distribution</b>	0-25 %
<b>Litter distribution</b>	None
<b>Dead wood</b>	None
<b>Disturbance details</b>	None evident
<b>Fire history</b>	None evident
<b>Fire intensity</b>	
<b>Description:</b>  Salt flat with scattered small islands supporting Spinifex and other grasses to .5 m. Area possibly inundated with water after severe conditions, extreme tides or climatic activity.	
	



**Appendix 3 SRE invertebrate survey site descriptions**

<b>Site number</b>	<b>SRE 01</b>
<b>Site type</b>	SRE survey site
<b>Easting</b>	568644
<b>Northing</b>	7712350
<b>Zone</b>	50K
<b>Impact / Non-impact area</b>	Non-impact area
<b>Habitat</b>	Hill Slope
<b>Habitat type</b>	Rocky Outcrop & Boulder Piles
<b>Dominant tree</b>	None
<b>Tree cover</b>	0-25 %
<b>Dominant shrub</b>	<i>Acacia</i>
<b>Shrub cover</b>	0-25 %
<b>Dominant grass</b>	Other grasses
<b>Grass cover</b>	0-25 %
<b>Slope</b>	Gentle; Moderate
<b>Soil texture</b>	Sandy Loam
<b>Soil colour</b>	Grey / Brown
<b>Surface</b>	Fine Gravel; Loose Soil; Boulders
<b>Rock cover</b>	51-75 %
<b>Leaf litter distribution</b>	0-25 %
<b>Litter distribution</b>	Under shrubs
<b>Dead wood</b>	Sparse
<b>Disturbance details</b>	None evident
<b>Fire history</b>	None evident
<b>Fire intensity</b>	
<b>Description:</b>  Exposed outcrop and boulder pile with scattered small to medium shrubs to 2 m over mixed grasses to .5 m. Large boulder pile with large crevices. Rocky areas surrounded by salt flat.	
	


<b>Site number</b>	<b>SRE 02</b>
<b>Site type</b>	SRE survey site
<b>Easting</b>	571209
<b>Northing</b>	7714594
<b>Zone</b>	50K
<b>Impact / Non-impact area</b>	Non-impact area
<b>Habitat</b>	Hill Slope
<b>Habitat type</b>	Rocky Outcrop & Boulder Piles
<b>Dominant tree</b>	None
<b>Tree cover</b>	0-25 %
<b>Dominant shrub</b>	<i>Acacia</i>
<b>Shrub cover</b>	26-50 %
<b>Dominant grass</b>	Other grasses
<b>Grass cover</b>	26-50 %
<b>Slope</b>	Moderate
<b>Soil texture</b>	Sandy Loam
<b>Soil colour</b>	Brown
<b>Surface</b>	Boulders; Stones; Loose Soil
<b>Rock cover</b>	50-75 %
<b>Leaf litter distribution</b>	26-50 %
<b>Litter distribution</b>	Under shrubs
<b>Dead wood</b>	Moderate
<b>Disturbance details</b>	None evident
<b>Fire history</b>	None evident
<b>Fire intensity</b>	


**Description:**


Rocky hill slope with scattered small to med shrubs over unidentified grass. Large boulders and rock piles. Rocky coastline and mangroves surrounding base of hill.






<b>Site number</b>	<b>SRE 03</b>
<b>Site type</b>	SRE survey site
<b>Easting</b>	573442
<b>Northing</b>	7704434
<b>Zone</b>	50K
<b>Impact / Non-impact area</b>	Non-impact area
<b>Habitat</b>	Hill slope
<b>Habitat type</b>	Rocky Outcrop & Boulders
<b>Dominant tree</b>	None
<b>Tree cover</b>	0-25 %
<b>Dominant shrub</b>	Other
<b>Shrub cover</b>	0-25 %
<b>Dominant grass</b>	Spinifex
<b>Grass cover</b>	26-50 %
<b>Slope</b>	Moderate
<b>Soil texture</b>	Clay Loam
<b>Soil colour</b>	Red / Brown
<b>Surface</b>	Coarse Gravel; Stones; Surface Plates
<b>Rock cover</b>	50-75 %
<b>Leaf litter distribution</b>	0-25 %
<b>Litter distribution</b>	Under shrubs
<b>Dead wood</b>	None
<b>Disturbance details</b>	Vehicle Tracks
<b>Fire history</b>	None evident
<b>Fire intensity</b>	
<b>Description:</b>  Rocky hilltop of spinifex grassland with scattered small shrubs. Rocky surface and areas of exposed rock with vertical crevices.	
	

<b>Site number</b>	<b>SRE 04</b>
<b>Site type</b>	SRE survey site
<b>Easting</b>	576143
<b>Northing</b>	7702743
<b>Zone</b>	50K
<b>Impact / Non-impact area</b>	Non-impact area
<b>Habitat</b>	Open Woodland
<b>Habitat type</b>	Minor Creek
<b>Dominant tree</b>	<i>Eucalyptus / Corymbia</i>
<b>Tree cover</b>	51-75 %
<b>Dominant shrub</b>	<i>Acacia</i>
<b>Shrub cover</b>	0-25 %
<b>Dominant grass</b>	Spinifex
<b>Grass cover</b>	26-50 %
<b>Slope</b>	Gentle
<b>Soil texture</b>	Sandy Clay
<b>Soil colour</b>	Red / Brown
<b>Surface</b>	Loose soil
<b>Rock cover</b>	0-25 %
<b>Leaf litter distribution</b>	>75 %
<b>Litter distribution</b>	Even
<b>Dead wood</b>	Moderate
<b>Disturbance details</b>	Grazing – High; Vehicle Tracks
<b>Fire history</b>	None evident
<b>Fire intensity</b>	
<b>Description:</b>  Minor creek line with scattered eucalypts to 12m. Sparse understory with scattered small to med shrubs. Spinifex on creek banks and surrounding area. Creekline dry.	
	

<b>Site number</b>	<b>SRE 05</b>
<b>Site type</b>	SRE survey site
<b>Easting</b>	576558
<b>Northing</b>	7698317
<b>Zone</b>	50K
<b>Impact / Non-impact area</b>	Non-impact area
<b>Habitat</b>	Plain
<b>Habitat type</b>	Grassland
<b>Dominant tree</b>	None
<b>Tree cover</b>	0-25 %
<b>Dominant shrub</b>	Other
<b>Shrub cover</b>	0-25 %
<b>Dominant grass</b>	Spinifex
<b>Grass cover</b>	51-75 %
<b>Slope</b>	Gentle
<b>Soil texture</b>	Sandy Clay
<b>Soil colour</b>	Red / Brown
<b>Surface</b>	Fine gravel; Coarse Gravel; Stones; Loose soil;
<b>Rock cover</b>	0-25 %
<b>Leaf litter distribution</b>	Under trees / shrubs
<b>Litter distribution</b>	0-25 %
<b>Dead wood</b>	None
<b>Disturbance details</b>	Grazing – High; Vehicle Tracks; Livestock Tracks; Large Scale Clearing
<b>Fire history</b>	None evident
<b>Fire intensity</b>	
<b>Description:</b>  Spinifex grassland with scattered small to medium shrubs to 1.5 m. Single eucalypt near bore. Areas with no vegetation and loose rock on surface from bore excavation. Working bore with trough present. Heavily grazed by cattle.	
	

<b>Site number</b>	<b>SRE 06</b>
<b>Site type</b>	SRE survey site
<b>Easting</b>	1576254
<b>Northing</b>	7702684
<b>Zone</b>	50K
<b>Impact / Non-impact area</b>	Non-impact area
<b>Habitat</b>	Open Woodland
<b>Habitat type</b>	Minor Creek
<b>Dominant tree</b>	<i>Eucalyptus / Corymbia</i>
<b>Tree cover</b>	51-75 %
<b>Dominant shrub</b>	<i>Acacia</i>
<b>Shrub cover</b>	0-25 %
<b>Dominant grass</b>	Spinifex
<b>Grass cover</b>	26-50 %
<b>Slope</b>	Gentle
<b>Soil texture</b>	Sandy Clay
<b>Soil colour</b>	Red / Brown
<b>Surface</b>	Loose soil
<b>Rock cover</b>	0-25 %
<b>Leaf litter distribution</b>	>75 %
<b>Litter distribution</b>	Even
<b>Dead wood</b>	Moderate
<b>Disturbance details</b>	Grazing – High; Vehicle Tracks
<b>Fire history</b>	None evident
<b>Fire intensity</b>	
<b>Description:</b>  Minor creek line with scattered eucalypts to 12m. Sparse understory with scattered small to med shrubs. Spinifex on creek banks and surrounding area. Creekline dry.	
	

**Appendix 4     Vertebrate species records from desktop review and surveys**

Taxonomy		Status				Databases			Previous reports reviewed													Current survey
Family; Species	Common name	EPBC Act	WC Act	DEC	Introduced	EPBC Protected Matters	DEC Threatened Fauna Database	NatureMap	Birddata	(Storr 1964b)	(Storr 1964a)	(Ride 1964)	(Bamford 2006)	(Bamford 2008)	(Biota 2008c)	(Biota 2008b)	(Biota 2008e)	(Biota 2008d)	(ENV 2009)	(Phoenix 2010b)	(Bennelongia 2011)	
Amphibians																						
Hylidae																						
<i>Cyclorana australis</i>	Giant Frog																		•			
<i>Cyclorana maini</i>	Sheep Frog							•					•			•	•		•	•		
<i>Cyclorana platycephala</i>	Water-holding Frog																			•		
<i>Litoria rothii</i>	Northern Laughing Tree Frog																		•			
<i>Litoria rubella</i>	Little Red Tree Frog							•					•				•		•			•
Limnodynastidae																						
<i>Notaden nichollsi</i>	Desert Spadefoot							•								•			•	•		
<i>Platyplectrum spenceri</i>	Centralian Burrowing Frog																		•			
Myobatrachidae																						
<i>Uperoleia russelli</i>	Northwest Toadlet																•		•			
Reptiles																						
Agamidae																						
<i>Amphibolurus gilberti</i>	Ta-Ta or Gilbert's Dragon															•				•		•
<i>Amphibolurus longirostris</i>	Long-nosed Dragon							•					•	•	•	•	•	•	•	•		•
<i>Ctenophorus caudicinctus caudicinctus</i>	Ring-tailed Dragon							•		•				•		•	•	•	•	•		•
<i>Ctenophorus isolepis isolepis</i>	Military Dragon							•					•	•		•	•	•	•	•		•
<i>Ctenophorus nuchalis</i>	Central Netted Dragon							•					•			•	•	•	•	•		•
<i>Diporiphora vescus</i>	Northern Pilbara Tree Dragon															•	•		•	•		•
<i>Pogona minor</i>	Dwarf Bearded Dragon															•	•	•				
<i>Pogona minor minor</i>	Western Bearded Dragon							•											•			•
<i>Pogona minor mitchelli</i>	Mitchell's Bearded Dragon							•											•	•		•

Taxonomy		Status				Databases				Previous reports reviewed														Current survey
Family; Species	Common name	EPBC Act	WC Act	DEC	Introduced	EPBC Protected Matters	DEC Threatened Fauna Database	NatureMap	Birddata	(Storr 1964b)	(Storr 1964a)	(Ride 1964)	(Bamford 2006)	(Bamford 2008)	(Biota 2008c)	(Biota 2008b)	(Biota 2008e)	(Biota 2008d)	(ENV 2009)	(Phoenix 2010b)	(Bennelongia 2011)			
<i>Tympanocryptis cephalus</i>	Pebble Dragon							●									●					●		
Diplodactylidae																								
<i>Diplodactylus conspicillatus</i>	Fat-tailed Gecko							●									●	●	●	●				
<i>Diplodactylus savagei</i>	Southern Pilbara Beak-faced Gecko							●																
<i>Lucasium stenodactylum</i>	Sand-plain Gecko							●								●	●	●	●	●		●		
<i>Lucasium wombeyi</i>	Pilbara Ground Gecko							●												●				
<i>Oedura marmorata</i>	Marbled Velvet Gecko																			●				
<i>Rhynchoedura ornata</i>	Western Beaked Gecko							●									●					●		
<i>Strophurus ciliaris aberrans</i>	Northern Spiny-tailed Gecko															●		●	●	●				
<i>Strophurus elderi</i>	Jewled Gecko							●												●				
<i>Strophurus jeanae</i>	Southern Phasmid Gecko							●								●				●				
Carphodactylidae																								
<i>Nephrurus levis pilbarensis</i>	Pilbara Smooth Knob-tailed Gecko							●											●					
Gekkonidae																								
<i>Gehyra pilbara</i>	Pilbara Dtella									●										●				
<i>Gehyra punctata</i>	Spotted Dtella							●		●						●	●		●	●		●		
<i>Gehyra purpurascens</i>	Purplish Dtella							●																
<i>Gehyra variegata</i>	Variegated Tree Dtella							●					●			●			●	●		●		
<i>Heteronotia binoei</i>	Bynoe's Gecko							●		●						●	●	●	●	●		●		
<i>Heteronotia spelea</i>	Desert Cave Gecko							●																
<i>Heteronotia sp.</i>	No Common Name																●							
Pygopodidae																								
<i>Delma butleri</i>	Unbanded Delma																		●	●				
<i>Delma pax</i>	Peace Delma							●								●	●	●		●				
<i>Delma tincta</i>	Excitable Delma							●								●	●		●	●				
<i>Lialis burtonis</i>	Burton's Legless Lizard							●								●		●		●				

Taxonomy		Status				Databases				Previous reports reviewed												Current survey
Family; Species	Common name	EPBC Act	WC Act	DEC	Introduced	EPBC Protected Matters	DEC Threatened Fauna Database	NatureMap	Birddata	(Storr 1964b)	(Storr 1964a)	(Ride 1964)	(Bamford 2006)	(Bamford 2008)	(Biota 2008c)	(Biota 2008b)	(Biota 2008e)	(Biota 2008d)	(ENV 2009)	(Phoenix 2010b)	(Bennelongia 2011)	
<i>Pygopus nigriceps</i>	Western Hooded Scaly-foot																●					
Scincidae																						
<i>Carlia munda</i>	Shaded-litter Rainbow Skink																●	●	●		●	
<i>Carlia triacantha</i>	Desert Rainbow Skink																		●			●
<i>Cryptoblepharus buchananii</i>	Buchanan's Snake-eyed Skink									●								●				●
<i>Cryptoblepharus plagiocephalus</i>	No Common Name							●														
<i>Cryptoblepharus ustulatus</i>	No Common Name																	●			●	
<i>Ctenotus duricola</i>	No Common Name							●										●	●	●	●	
<i>Ctenotus grandis titan</i>	Grand Ctenotus							●									●	●		●	●	
<i>Ctenotus hanloni</i>	No Common Name																	●	●			
<i>Ctenotus helenae</i>	Clay-soil Ctenotus							●		●			●						●	●		●
<i>Ctenotus pantherinus ocellifer</i>	Leopard Ctenotus							●						●		●	●	●	●	●		●
<i>Ctenotus piankai</i>	No Common Name																		●			
<i>Ctenotus robustus</i>	No Common Name																	●				
<i>Ctenotus rubicundus</i>	Ruddy Ctenotus							●										●			●	
<i>Ctenotus rufescens</i>	No Common Name																			●		
<i>Ctenotus saxatilis</i>	Rock Ctenotus							●									●	●	●	●	●	●
<i>Ctenotus schomburgkii</i>	No Common Name							●										●			●	●
<i>Ctenotus serventyi</i>	No Common Name							●									●	●	●	●	●	
<i>Cyclodomorphus melanops</i>	Slender Blue-tongue																●	●	●		●	
<i>Egernia cygnitos</i>	Western Pilbara Spiny-tailed Skink							●									●	●		●	●	●
<i>Egernia formosa</i>	Goldfields Crevice-skink							●														
<i>Egernia pilbarensis</i>	Pilbara Crevice-skink																	●			●	
<i>Eremiascincus fasciolatus</i>	Narrow-banded Sand Swimmer							●					●				●			●	●	
<i>Eremiascincus isolepis</i>	Northern Bar-lipped Skink																	●			●	●
<i>Lerista bipes</i>	North-western Sand-slider							●		●							●		●	●	●	●

Taxonomy		Status				Databases				Previous reports reviewed												Current survey
Family; Species	Common name	EPBC Act	WC Act	DEC	Introduced	EPBC Protected Matters	DEC Threatened Fauna Database	NatureMap	Birddata	(Storr 1964b)	(Storr 1964a)	(Ride 1964)	(Bamford 2006)	(Bamford 2008)	(Biota 2008c)	(Biota 2008b)	(Biota 2008e)	(Biota 2008d)	(ENV 2009)	(Phoenix 2010b)	(Bennelongia 2011)	
<i>Lerista clara</i>	No Common Name							•												•		•
<i>Lerista jacksoni</i>	Jackson's Lerista							•														
<i>Lerista muelleri</i>	Wood mulch-slider							•									•		•	•		
<i>Lerista neviniae</i>	Nevin's Lerista		S1	VU												•		•		•		
<i>Lerista verhmens</i>	No Common Name							•								•	•					
<i>Menetia greyii</i>	Common Dwarf Skink							•		•						•	•	•	•	•		•
<i>Morethia ruficauda exquisita</i>	Lined Fire-tailed Skink							•		•						•	•		•	•		•
<i>Notoscincus butleri</i>	Lined Soil-Ocrevice Skink			P4														•		•		
<i>Notoscincus ornatus ornatus</i>	Ornate Soil-crevice Skink							•		•												•
<i>Proablepharus reginae</i>	Western Soil-crevice Skink							•														
<i>Tiliqua multifasciata</i>	Central Blue-tongue															•	•		•	•		•
Varanidae																						
<i>Varanus acanthurus</i>	Spiny-tailed Monitor							•					•			•	•		•	•		•
<i>Varanus brevicauda</i>	Short-tailed Pygmy Monitor							•									•		•	•		
<i>Varanus bushi</i>	Pilbara Mulga Monitor																		•	•		
<i>Varanus eremius</i>	Pygmy Desert Monitor															•			•	•		
<i>Varanus giganteus</i>	Perentie															•			•	•		
<i>Varanus gouldii</i>	Sand Monitor													•					•	•		•
<i>Varanus panoptes rubidus</i>	Yellow-spotted Monitor																			•		•
<i>Varanus pilbarensis</i>	Pilbara Rock Monitor																•			•		
<i>Varanus tristis tristis</i>	Black-headed Monitor							•														•
Typhlopidae																						
<i>Ramphotyphlops ammodytes</i>	No Common Name							•									•	•	•	•		•
<i>Ramphotyphlops grypus</i>	Long-beaked Blind Snake							•								•	•		•			
Boidae																						
<i>Antaresia perthensis</i>	Pygmy Python							•		•			•							•		•



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<i>Antaresia stimsoni stimsoni</i>	Stimson's Python							•													
<i>Aspidites melanocephalus</i>	Black-headed Python																		•		
<i>Aspidites ramsayi</i>	Woma Python		S4																•		
<i>Liasis olivaceus barroni</i>	Pilbara Olive Python	VU	S1	VU		•															
<b>Elapidae</b>																					
<i>Acanthophis wellsi</i>	Pilbara Death Adder																		•	•	
<i>Brachyuropsis approximans</i>	North-western Shovel-nosed snake															•			•	•	
<i>Demansia psammophis</i>	Yellow-faced Whipsnake																		•	•	
<i>Demansia rufescens</i>	Rufous Whipsnake							•								•		•	•	•	
<i>Furina ornata</i>	Moon Snake															•		•			
<i>Parasuta monachus</i>	Monk Snake																			•	
<i>Pseudechis australis</i>	Mulga Snake							•											•	•	•
<i>Pseudonaja mengdeni</i>	Western Brown Snake							•								•			•	•	
<i>Pseudonaja modesta</i>	Ringed Brown Snake																•		•		
<i>Simoselaps anomalus</i>	Desert Banded Snake							•											•		
<i>Suta fasciata</i>	Rosen's Snake							•													
<i>Suta punctata</i>	Spotted Snake							•						•						•	
<i>Vermicella snelli</i>	Pilbara Bandy-bandy							•								•					
<b>Birds</b>																					
<b>Casuariidae</b>																					
<i>Dromaius novaehollandiae</i>	Emu							•	•				•					•	•		•
<b>Phasianidae</b>																					
<i>Coturnix pectoralis</i>	Stubble Quail							•	•												
<i>Coturnix ypsilophora</i>	Brown Quail							•	•					•		•			•	•	
<b>Anatidae</b>																					
<i>Dendrocygna eytoni</i>	Plumed Whistling-Duck							•	•										•		

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<i>Cygnus atratus</i>	Black Swan							•	•								•		•			•
<i>Tadorna tadornoides</i>	Australian Shelduck								•											•		
<i>Chenonetta jubata</i>	Australian Wood Duck							•	•													
<i>Malacorhynchus membranaceus</i>	Pink-eared Duck								•										•			
<i>Anas querquedula</i>	Garganey	Mig	S3						•													
<i>Anas gracilis</i>	Grey Teal							•	•										•	•		
<i>Anas superciliosa</i>	Pacific Black Duck							•	•										•			
<i>Aythya australis</i>	Hardhead							•	•										•			
<i>Oxyura australis</i>	Blue-billed Duck								•													
<b>Podicipedidae</b>																						
<i>Tachybaptus novaehollandiae</i>	Australasian Grebe								•										•			
<i>Poliiocephalus poliocephalus</i>	Hoary-headed Grebe								•													
<i>Podiceps cristatus</i>	Great Crested Grebe								•													
<b>Columbidae</b>																						
<i>Phaps chalcoptera</i>	Common Bronzewing							•	•													
<i>Phaps elegans</i>	Brush Bronzewing								•													
<i>Phaps histrionica</i>	Flock Bronzewing			P4			•	•														•
<i>Ocyphaps lophotes</i>	Crested Pigeon							•	•				•	•	•	•	•	•	•	•		•
<i>Geophaps plumifera</i>	Spinifex Pigeon							•	•				•	•	•	•	•	•	•	•		•
<i>Geopelia cuneata</i>	Diamond Dove							•	•				•	•		•	•	•	•	•		•
<i>Geopelia striata</i>	Peaceful Dove							•	•				•	•		•	•	•	•			•
<i>Geopelia humeralis</i>	Bar-shouldered Dove							•	•						•					•		
<b>Podargidae</b>																						
<i>Podargus strigoides</i>	Tawny Frogmouth							•	•										•			
<b>Eurostopodidae</b>																						
<i>Eurostopodus argus</i>	Spotted Nightjar							•	•				•	•					•	•		•

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Aegothelidae																								
Aegotheles cristatus	Australian Owlet-nightjar							•	•		•		•						•	•				
Apodidae																								
Apus pacificus	Fork-tailed Swift	Mig	S3			•			•															
Porcellariidae																								
Macronectes giganteus	Southern Giant-Petrel	EN / Mig		P4		•																		
Puffinus apacificus	Wedge-tailed Shearwater	Mig	S3			•	•	•	•															
Fregatidae																								
Fregata ariel	Lesser Frigatebird	Mig	S3				•		•										•					
Sulidae																								
Sula leucogaster	Brown Booby	Mig	S3				•		•															
Anhingidae																								
Anhinga novaehollandiae	Australasian Darter								•								•		•					
Phalacrocoracidae																								
Microcarbo melanoleucos	Little Pied Cormorant								•								•		•	•				
Phalacrocorax carbo	Great Cormorant								•															
Phalacrocorax sulcirostris	Little Black Cormorant							•	•											•				
Phalacrocorax varius	Pied Cormorant							•	•					•					•	•				
Pelecanidae																								
Pelecanus conspicillatus	Australian Pelican							•	•					•					•	•				
Ciconiidae																								
Ephippiorhynchus asiaticus	Black-necked Stork							•	•					•										
Ardeidae																								
Ixobrychus flavicollis	Black Bittern			P3					•															
Ardea pacifica	White-necked Heron							•	•				•											

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<i>Ardea modesta</i>	Eastern Great Egret	Mig	S3			•	•	•	•							•			•			•
<i>Ardea intermedia</i>	Intermediate Egret							•	•													
<i>Ardea ibis</i>	Cattle Egret	Mig	S3			•																
<i>Butorides striata</i>	Striated Heron							•	•				•	•					•	•		
<i>Egretta novaehollandiae</i>	White-faced Heron								•					•				•	•	•		•
<i>Egretta garzetta</i>	Little Egret								•					•	•	•	•		•	•		•
<i>Egretta sacra</i>	Eastern Reef Egret	Mig	S3				•	•	•		•								•	•		
<i>Nycticorax caledonicus</i>	Nankeen Night-Heron							•	•													
<b>Threskiornithidae</b>																						
<i>Plegadis falcinellus</i>	Glossy Ibis	Mig	S3				•	•	•													
<i>Threskiornis molucca</i>	Australian White Ibis								•										•	•		
<i>Threskiornis spinicollis</i>	Straw-necked Ibis							•	•													
<i>Platalea regia</i>	Royal Spoonbill							•	•													
<i>Platalea flavipes</i>	Yellow-billed Spoonbill							•	•													
<b>Accipitridae</b>																						
<i>Pandion cristatus</i>	Eastern Osprey	Mig						•	•		•			•		•			•	•		•
<i>Elanus axillaris</i>	Black-shouldered Kite								•				•			•			•	•		•
<i>Elanus scriptus</i>	Letter-winged Kite								•													
<i>Lophoictinia isura</i>	Square-tailed Kite								•													
<i>Haliaeetus leucogaster</i>	White-bellied Sea-Eagle	Mig	S3			•	•	•	•		•					•			•	•		•
<i>Haliastur sphenurus</i>	Whistling Kite							•	•					•			•		•	•		•
<i>Haliastur indus</i>	Brahminy Kite							•	•		•			•		•		•	•	•		•
<i>Milvus migrans</i>	Black Kite							•	•										•	•		
<i>Accipiter fasciatus</i>	Brown Goshawk							•	•				•							•		
<i>Accipiter cirrocephalus</i>	Collared Sparrowhawk							•	•											•		
<i>Circus assimilis</i>	Spotted Harrier							•	•				•	•			•	•	•	•		•

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<i>Circus approximans</i>	Swamp Harrier							•	•						•							•
<i>Aquila audax</i>	Wedge-tailed Eagle							•	•				•	•			•	•	•	•		•
<i>Hieraaetus morphnoides</i>	Little Eagle								•		•			•					•			
<b>Falconidae</b>																						
<i>Falco cenchroides</i>	Nankeen Kestrel							•	•		•		•	•		•	•	•	•	•		
<i>Falco berigora</i>	Brown Falcon							•	•				•	•		•	•		•	•		•
<i>Falco longipennis</i>	Australian Hobby							•	•										•	•		
<i>Falco hypoleucos</i>	Grey Falcon		S1	VU					•													
<i>Falco peregrinus</i>	Peregrine Falcon		S4				•		•		•											
<b>Gruidae</b>																						
<i>Grus rubicunda</i>	Brolga							•	•													
<b>Rallidae</b>																						
<i>Porphyrio porphyrio</i>	Purple Swamphen							•	•													
<i>Rallina fasciata</i>	Red-legged Crake	Mig	S3						•													
<i>Fulica atra</i>	Eurasian Coot							•	•								•					
<b>Otididae</b>																						
<i>Ardeotis australis</i>	Australian Bustard			P4			•	•	•										•	•		•
<b>Burhinidae</b>																						
<i>Burhinus grallarius</i>	Bush Stone-curlew			P4			•	•	•													
<i>Esacus magnirostris</i>	Beach Stone-curlew																					•
<b>Haematopodidae</b>																						
<i>Haematopus longirostris</i>	Australian Pied Oystercatcher								•		•					•			•	•		•
<i>Haematopus fuliginosus ophthalmicus</i>	Sooty Oystercatcher							•	•		•					•			•	•		•
<b>Recurvirostridae</b>																						
<i>Himantopus himantopus</i>	Black-winged Stilt							•	•							•				•		•

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<i>Recurvirostra novaehollandiae</i>	Red-necked Avocet							•	•													
<i>Cladorhynchus leucocephalus</i>	Banded Stilt								•													•
<b>Charadriidae</b>																						
<i>Pluvialis fulva</i>	Pacific Golden Plover	Mig	S3				•	•	•													
<i>Pluvialis squatarola</i>	Grey Plover	Mig	S3				•		•										•		•	
<i>Charadrius ruficapillus</i>	Red-capped Plover							•	•							•			•	•	•	
<i>Charadrius mongolus</i>	Lesser Sand Plover	Mig	S1	EN															•	•	•	•
<i>Charadrius leschenaultii leschenaultii</i>	Greater Sand Plover (Mongolian)	Mig	S1	VU												•			•	•	•	•
<i>Charadrius veredus</i>	Oriental Plover	Mig	S3			•													•			
<i>Charadrius australis</i>	Inland Dotterel								•													
<i>Elseya melanops</i>	Black-fronted Dotterel							•	•								•		•			•
<i>Erythrogonys cinctus</i>	Red-kneed Dotterel							•	•													
<i>Vanellus tricolor</i>	Banded Lapwing																					•
<b>Scolopacidae</b>																						
<i>Limosa limosa</i>	Black-tailed Godwit	Mig	S3																	•		
<i>Limosa lapponica menzbieri</i>	Bar-tailed Godwit (northern Siberian)	Mig	S1	VU			•		•							•			•	•	•	•
<i>Numenius minutus</i>	Little Curlew	Mig	S3				•		•							•					•	
<i>Numenius phaeopus</i>	Whimbrel	Mig	S3				•	•	•					•	•	•			•	•	•	•
<i>Numenius madagascariensis</i>	Eastern Curlew	Mig	S1	VU			•	•	•						•	•			•	•	•	•
<i>Numenius arquata</i>	Eurasian Curlew	Mig	S3													•						
<i>Xenus cinereus</i>	Terek Sandpiper	Mig	S3				•		•										•	•	•	•
<i>Actitis hypoleucos</i>	Common Sandpiper	Mig	S3				•	•	•					•					•	•	•	•
<i>Heteroscelus brevipes</i>	Grey-tailed Tattler	Mig	S3				•		•							•			•	•	•	•
<i>Tringa nebularia</i>	Common Greenshank	Mig	S3				•	•	•							•			•	•	•	

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<i>Tringa stagnatilis</i>	Marsh Sandpiper	Mig	S3				●	●	●										●	●		
<i>Tringa glareola</i>	Wood Sandpiper	Mig	S3				●	●	●								●				●	
<i>Arenaria interpres</i>	Ruddy Turnstone	Mig	S3				●	●	●								●			●	●	●
<i>Calidris tenuirostris</i>	Great Knot	Mig	S1	VU			●		●										●		●	●
<i>Calidris canutus</i>	Red Knot	Mig	S1	VU															●		●	●
<i>Calidris alba</i>	Sanderling	Mig	S3																		●	●
<i>Calidris ruficollis</i>	Red-necked Stint	Mig	S3				●	●	●								●		●	●	●	●
<i>Calidris subminuta</i>	Long-toed Stint	Mig	S3																			●
<i>Calidris acuminata</i>	Sharp-tailed Sandpiper	Mig	S3						●													
<i>Calidris ferruginea</i>	Curlew Sandpiper	Mig	S1	VU			●	●	●										●		●	
<i>Limicola falcinellus</i>	Broad-billed Sandpiper	Mig	S3																		●	
Turnicidae																						
<i>Turnix velox</i>	Little Button-quail							●	●				●	●			●		●	●		●
Glareolidae																						
<i>Glareola maldivarum</i>	Oriental Pratincole	Mig	S3			●	●	●	●													
<i>Stiltia isabella</i>	Australian Pratincole							●	●				●									
Laridae																						
<i>Sternula albifrons</i>	Little Tern	Mig	S3					●											●	●		●
<i>Sternula nereis</i>	Fairy Tern	VU	S1	VU															●			
<i>Gelochelidon nilotica</i>	Gull-billed Tern								●										●	●		●
<i>Sterna caspia</i>	Caspian Tern	Mig	S3				●	●	●					●		●			●	●		●
<i>Chlidonias hybrida</i>	Whiskered Tern								●										●	●		●
<i>Chlidonias leucopterus</i>	White-winged Black Tern	Mig	S3				●		●													
<i>Sterna dougallii</i>	Roseate Tern	Mig	S3																			●
<i>Sterna hirundo</i>	Common Tern	Mig	S3																			●
<i>Thalasseus bengalensis</i>	Lesser Crested Tern	Mig	S3													●			●	●		

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<i>Thalasseus bergii</i>	Crested Tern							•	•							•			•	•		•
<i>Chroicocephalus novaehollandiae</i>	Silver Gull								•		•					•			•	•		•
<b>Cacatuidae</b>																						
<i>Eolophus roseicapillus</i>	Galah								•				•	•		•	•	•	•	•		•
<i>Cacatua sanguinea</i>	Little Corella							•	•							•	•		•	•		•
<i>Nymphicus hollandicus</i>	Cockatiel							•	•				•	•			•		•	•		
<b>Psittacidae</b>																						
<i>Barnardius zonarius</i>	Australian Ringneck								•											•		•
<i>Melopsittacus undulatus</i>	Budgerigar							•	•		•		•	•		•	•		•	•		•
<b>Cuculidae</b>																						
<i>Centropus phasianinus</i>	Pheasant Coucal							•	•							•	•		•	•		
<i>Chalcites basal</i>	Horsfield's Bronze-Cuckoo								•				•			•			•	•		•
<i>Chalcites osculans</i>	Black-eared Cuckoo								•													
<i>Cacomantis pallidus</i>	Pallid Cuckoo								•								•		•	•		
<b>Strigidae</b>																						
<i>Ninox connivens peninsularis</i>	Barking Owl (Pilbara)								•													
<i>Ninox novaeseelandiae</i>	Southern Boobook							•	•		•		•									
<b>Tytonidae</b>																						
<i>Tyto javanica</i>	Eastern Barn Owl								•										•			
<b>Halcyonidae</b>																						
<i>Dacelo leachii</i>	Blue-winged Kookaburra							•	•								•			•		•
<i>Todiramphus pyrrhopygius</i>	Red-backed Kingfisher								•		•					•	•	•	•	•		•
<i>Todiramphus sanctus</i>	Sacred Kingfisher							•	•				•	•		•			•	•		•
<i>Todiramphus chloris</i>	Collared Kingfisher							•	•					•		•			•	•		•
<b>Meropidae</b>																						
<i>Merops ornatus</i>	Rainbow Bee-eater	Mig	S3			•	•	•	•				•	•		•	•		•	•		•



Taxonomy		Status				Databases			Previous reports reviewed														Current survey
Family; Species	Common name	EPBC Act	WC Act	DEC	Introduced	EPBC Protected Matters	DEC Threatened Fauna Database	NatureMap	Birddata	(Storr 1964b)	(Storr 1964a)	(Ride 1964)	(Bamford 2006)	(Bamford 2008)	(Biota 2008c)	(Biota 2008b)	(Biota 2008e)	(Biota 2008d)	(ENV 2009)	(Phoenix 2010b)	(Bennelongia 2011)		
Ptilonorhynchidae																							
Ptilonorhynchus guttatus	Western Bowerbird								•											•			
Maluridae																							
Malurus leucopterus	White-winged Fairy-wren							•	•				•	•	•	•	•		•	•		•	
Malurus lamberti	Variegated Fairy-wren							•	•							•	•	•	•	•		•	
Amytornis striatus whitei	Striated Grasswren (Pilbara)							•	•														
Acanthizidae																							
Smicrornis brevirostris	Weebill							•	•							•		•				•	
Gerygone fusca	Western Gerygone							•	•											•			
Gerygone tenebrosa	Dusky Gerygone							•	•							•			•	•		•	
Pardalotidae																							
Pardalotus rubricatus	Red-browed Pardalote							•	•				•				•		•	•			
Pardalotus striatus	Striated Pardalote								•		•												
Meliphagidae																							
Certhionyx variegatus	Pied Honeyeater																			•		•	
Lichenostomus virescens	Singing Honeyeater							•	•		•		•	•	•	•	•	•	•	•		•	
Lichenostomus keartlandi	Grey-headed Honeyeater							•	•		•						•			•			
Lichenostomus penicillatus	White-plumed Honeyeater							•	•				•	•			•		•	•		•	
Manorina flavigula	Yellow-throated Miner							•	•				•	•		•	•	•	•	•		•	
Acanthagenys rufogularis	Spiny-cheeked Honeyeater							•														•	
Epthianura tricolor	Crimson Chat								•											•		•	
Epthianura aurifrons	Orange Chat																			•			
Sugomel niger	Black Honeyeater								•										•	•		•	
Lichmera indistincta	Brown Honeyeater							•	•					•		•	•	•	•	•		•	
Melithreptus gularis	Black-chinned Honeyeater							•	•														
Pomatostomatidae																							

Taxonomy		Status				Databases				Previous reports reviewed												Current survey
Family; Species	Common name	EPBC Act	WC Act	DEC	Introduced	EPBC Protected Matters	DEC Threatened Fauna Database	NatureMap	Birddata	(Storr 1964b)	(Storr 1964a)	(Ride 1964)	(Bamford 2006)	(Bamford 2008)	(Biota 2008c)	(Biota 2008b)	(Biota 2008e)	(Biota 2008d)	(ENV 2009)	(Phoenix 2010b)	(Bennelongia 2011)	
<i>Pomatostomus temporalis</i>	Grey-crowned Babbler								•													•
<b>Campephagidae</b>																						
<i>Coracina novaehollandiae</i>	Black-faced Cuckoo-shrike							•	•	•			•	•		•	•	•	•	•		•
<i>Coracina papuensis</i>	White-bellied Cuckoo-shrike								•													
<i>Lalage sueurii</i>	White-winged Triller								•				•	•		•	•		•	•		•
<b>Pachycephalidae</b>																						
<i>Pachycephala melanura</i>	Mangrove Golden Whistler								•					•					•	•		
<i>Pachycephala rufiventris</i>	Rufous Whistler							•	•	•												•
<i>Pachycephala lanioides</i>	White-breasted Whistler							•	•					•	•				•	•		•
<i>Colluricincla harmonica</i>	Grey Shrike-thrush							•	•													•
<i>Oreoica gutturalis pallescens</i>	Crested Bellbird															•	•	•		•		
<b>Artamidae</b>																						
<i>Artamus leucorhynchus</i>	White-breasted Woodswallow							•	•				•	•	•	•	•		•	•		•
<i>Artamus personatus</i>	Masked Woodswallow								•				•									
<i>Artamus superciliosus</i>	White-browed Woodswallow																		•			•
<i>Artamus cinereus</i>	Black-faced Woodswallow							•	•				•	•		•	•	•	•	•		•
<i>Artamus minor</i>	Little Woodswallow							•	•													
<i>Cracticus nigrogularis</i>	Pied Butcherbird							•	•	•				•		•	•	•		•		•
<i>Cracticus tibicen</i>	Australian Magpie							•	•								•			•		•
<b>Rhipiduridae</b>																						
<i>Rhipidura albiscapa</i>	Grey Fantail								•	•						•						•
<i>Rhipidura phasiana</i>	Mangrove Grey Fantail							•	•					•		•			•	•		•
<i>Rhipidura leucophrys</i>	Willie Wagtail							•	•	•			•	•	•	•	•	•	•	•		•
<b>Corvidae</b>																						
<i>Corvus bennetti</i>	Little Crow							•	•					•								
<i>Corvus orru</i>	Torresian Crow								•	•			•			•	•	•	•	•		•

Taxonomy		Status				Databases			Previous reports reviewed													Current survey
Family; Species	Common name	EPBC Act	WC Act	DEC	Introduced	EPBC Protected Matters	DEC Threatened Fauna Database	NatureMap	Birddata	(Storr 1964b)	(Storr 1964a)	(Ride 1964)	(Bamford 2006)	(Bamford 2008)	(Biota 2008c)	(Biota 2008b)	(Biota 2008e)	(Biota 2008d)	(ENV 2009)	(Phoenix 2010b)	(Bennelongia 2011)	
Monarchidae																						
Grallina cyanoleuca	Magpie-lark							•	•				•	•		•	•	•	•	•		•
Petroicidae																						
Petroica goodenovii	Red-capped Robin								•											•		
Peneonanthe pulverulenta	Mangrove Robin							•	•										•	•		•
Alaudidae																						
Mirafra javanica	Horsfield's Bushlark							•	•				•	•		•	•		•	•		•
Acrocephalidae																						
Acrocephalus australis	Australian Reed-Warbler							•	•													
Megaluridae																						
Megalurus gramineus	Little Grassbird							•	•													
Cincloramphus mathewsi	Rufous Songlark							•	•								•		•			•
Cincloramphus cruralis	Brown Songlark							•	•				•	•			•		•			•
Eremiornis carteri	Spinifexbird							•	•										•	•		
Timaliidae																						
Zosterops luteus	Yellow White-eye							•	•		•			•		•			•	•		•
Hirundinidae																						
Cheramoeca leucosterna	White-backed Swallow																			•		
Hirundo rustica	Barn Swallow	Mig	S3			•																
Hirundo neoxena	Welcome Swallow								•		•										•	
Petrochelidon ariel	Fairy Martin								•				•				•		•	•		
Petrochelidon nigricans	Tree Martin								•				•	•			•		•	•		•
Estrildidae																						
Taeniopygia guttata	Zebra Finch							•	•				•	•	•	•	•	•	•	•		•
Neochmia ruficauda subclarescens	Star Finch			P4				•	•							•	•					
Emblema pictum	Painted Finch							•	•		•		•	•		•	•	•	•	•		

Taxonomy		Status				Databases			Previous reports reviewed														Current survey
Family; Species	Common name	EPBC Act	WC Act	DEC	Introduced	EPBC Protected Matters	DEC Threatened Fauna Database	NatureMap	Birdata	(Storr 1964b)	(Storr 1964a)	(Ride 1964)	(Bamford 2006)	(Bamford 2008)	(Biota 2008c)	(Biota 2008b)	(Biota 2008e)	(Biota 2008d)	(ENV 2009)	(Phoenix 2010b)	(Bennelongia 2011)		
Motacillidae																							
Anthus novaeseelandiae	Australasian Pipit								•				•	•	•	•			•	•		•	
Mammals																							
Tachyglossidae																							
Tachyglossus aculeatus	Echidna												•				•			•			
Dasyuridae																							
Dasyercus cristicauda	Crest-tailed Mulgara	VU	S1	VU		•																	
Dasykaluta rosamondae	Little Red Kaluta															•			•	•			
Dasyurus hallucatus	Northern Quoll	EN	S1	EN		•	•	•															
Ningauai timealeyi	Pilbara Ningauai																•	•	•		•	•	
Planigale sp.	Unidentified Planigale Species																•	•		•			
Planigale ingrami	Long-tailed Planigale															•							
Sminthopsis macroura	Stripe-faced Dunnart							•					•			•	•	•		•		•	
Sminthopsis youngsoni	Lesser Hairy-footed Dunnart															•		•	•			•	
Thylacomyidae																							
Macrotis lagotis	Bilby	VU	S1	VU		•																	
Macropodidae																							
Macropus robustus	Euro							•					•	•	•	•	•	•	•	•		•	
Macropus rufus	Red Kangaroo							•				•	•	•		•		•		•		•	
Petrogale lateralis lateralis	Black-flanked Rock Wallaby	VU	S1	VU			•	•				•											
Petrogale rothschildi	Rothschild's Rock Wallaby							•															
Pteropodidae																							
Pteropus alecto	Black Flying-fox							•															
Pteropus scapulatus	Little Red Flying-fox																		•				
Megadermatidae																							
Macroderma gigas	Ghost Bat			P4			•	•															

Taxonomy		Status				Databases				Previous reports reviewed														Current survey
Family; Species	Common name	EPBC Act	WC Act	DEC	Introduced	EPBC Protected Matters	DEC Threatened Fauna Database	NatureMap	Birddata	(Storr 1964b)	(Storr 1964a)	(Ride 1964)	(Bamford 2006)	(Bamford 2008)	(Biota 2008c)	(Biota 2008b)	(Biota 2008e)	(Biota 2008d)	(ENV 2009)	(Phoenix 2010b)	(Bennelongia 2011)			
Hipposideridae																								
Rhinonictis aurantia	Orange Leafnosed-bat	VU	S1	VU		●																		
Emballonuridae																								
Saccolaimus flaviventris	Yellow-bellied Sheathtail-bat							●					●			●	●		●	●		●		
Taphozous georgianus	Common Sheathtail-bat							●					●			●	●	●	●	●		●		
Vespertilionidae																								
Chalinolobus gouldii	Gould's Wattled Bat																●	●	●	●		●		
Chalinolobus morio	Chocolate Wattled Bat																	●						
Nyctophilus arnhemensis	Arnhem Land Long-eared Bat																		●	●		●		
Nyctophilus geoffroyi	Lesser Long-eared Bat															●			●	●				
Nyctophilus geoffroyi geoffroyi																						●		
Nyctophilus geoffroyi palescens																						●		
Scotorepens greyii	Little Broad-nosed Bat																●		●	●		●		
Vespadelus finlaysoni	Finlayson's Cave Bat							●								●	●	●	●	●		●		
Vespadelus regulus	Southern Forest Bat																							
Molossidae																								
Chaerephon jobensis	Northern Freetail-bat																●		●	●				
Mormopterus beccarii	Beccari's Freetail-bat																		●					
Mormopterus loriae cobourgiana	Little North-western Mastiff Bat			P1												●		●	●	●		●		
Tadarida australis	White-striped Freetail-bat																			●				
Muridae																								
Hydromys chrysogaster	Water-rat			P4			●	●				●												
Leggadina lakedownensis	Short-tailed Mouse			P4			●	●									●							
Mus musculus	House Mouse				●											●	●		●	●		●		
Notomys alexis	Spinifex Hopping-mouse																	●	●	●				
Pseudomys chapmani	Western Pebble-mound Mouse			P4																●				

Taxonomy		Status				Databases			Previous reports reviewed													Current survey
Family; Species	Common name	EPBC Act	WC Act	DEC	Introduced	EPBC Protected Matters	DEC Threatened Fauna Database	NatureMap	Birddata	(Storr 1964b)	(Storr 1964a)	(Ride 1964)	(Bamford 2006)	(Bamford 2008)	(Biota 2008c)	(Biota 2008b)	(Biota 2008e)	(Biota 2008d)	(ENV 2009)	(Phoenix 2010b)	(Bennelongia 2011)	
<i>Pseudomys delicatulus</i>	Delicate Mouse							•														•
<i>Pseudomys desertor</i>	Desert Mouse							•								•	•	•		•		•
<i>Pseudomys hermannsburgensis</i>	Sandy Inland Mouse							•								•	•		•	•		•
<i>Pseudomys nanus</i>	Western Chestnut Mouse																		•			
<i>Rattus rattus</i>	Black Rat				•			•												•		•
<i>Rattus tunneyi</i>	Pale Field-rat							•														
<i>Zyomys argurus</i>	Common Rock-rat							•											•			
<b>Leporidae</b>																						
<i>Oryctolagus cuniculus</i>	Rabbit				•	•													•			
<b>Canidae</b>																						
<i>Canis lupus</i>	Dog/Dingo												•							•		•
<i>Canis lupus dingo</i>	Dingo				•							•										
<i>Canis lupus familiaris</i>	Dog				•														•			
<i>Vulpes vulpes</i>	Red Fox				•	•		•				•			•	•			•	•		•
<b>Felidae</b>																						
<i>Felis catus</i>	Cat				•	•		•									•	•	•	•		•
<b>Equidae</b>																						
<i>Equus caballus</i>	Horse				•												•		•			•
<b>Bovidae</b>																						
<i>Bos taurus</i>	European Cattle				•										•				•			•
<i>Capra hircus</i>	Goat				•											•						

**Appendix 5 Short-range endemic invertebrates identified in the desktop review**

WAM reg. no.	Family	Genus	Species	Location	Latitude	Longitude
<b>Aranae (spiders)</b>						
97323	Actinopodidae	<i>Missulena</i>	`MYG110`	Millstream-Chichester National Park; 6 km N. of Millstream homestead; site PW11	-21.54	117.06
31023	Actinopodidae	<i>Missulena</i>	sp. indet.	Spinifex Camp; Port Hedland	-20.32	118.60
117867	Barychelidae	<i>Synothele</i>	sp. indet.	4.9 km W. of Roebourne	-20.75	117.10
26781	Ctenizidae	<i>Conothele</i>	sp. indet.	Roebourne area	-20.78	117.15
99601	Ctenizidae	<i>Conothele</i>	sp. indet.	Emu Siding to Rosella; 82.8 km SE. of Karratha	-21.43	117.16
125186	Ctenizidae	<i>Conothele</i>	sp. indet.	Finucane Island; GHD site 1	-20.30	118.54
98255	Idiopidae	<i>Eucyrtops</i>	sp. indet.	Karratha; ca. 20 km ENE; site SRE23; 05	-20.66	117.08
96997	Idiopidae	<i>Euoplos</i>	`MYG081`	9 km NW. of Lake Poongkaliyarra; Pilbara Biological Survey site DRC05	-20.94	117.04
5922	Lycosidae	<i>Artoria</i>	sp. indet.	Millstream Station; near homestead	-21.58	117.07
31840	Nemesiidae	<i>Aname</i>	`boodarie`	Boodarie Hill area; 15 km SW. of Port Hedland	-20.40	118.48
31841	Nemesiidae	<i>Aname</i>	`boodarie`	Boodarie Hill area; 15 km SW. of Port Hedland	-20.40	118.48
31842	Nemesiidae	<i>Aname</i>	`boodarie`	Boodarie Hill area; 15 km SW. of Port Hedland	-20.40	118.48
31843	Nemesiidae	<i>Aname</i>	`boodarie`	Boodarie Hill area; 15 km SW. of Port Hedland	-20.40	118.48
31844	Nemesiidae	<i>Aname</i>	`boodarie`	Boodarie Hill area; 15 km SW. of Port Hedland	-20.40	118.48
31845	Nemesiidae	<i>Aname</i>	`boodarie`	Boodarie Hill area; 15 km SW. of Port Hedland	-20.40	118.48
31846	Nemesiidae	<i>Aname</i>	`boodarie`	Boodarie Hill area; 15 km SW. of Port Hedland	-20.40	118.48
31847	Nemesiidae	<i>Aname</i>	`boodarie`	Boodarie Hill area; 15 km SW. of Port Hedland	-20.40	118.48
31848	Nemesiidae	<i>Aname</i>	`boodarie`	Boodarie Hill area; 15 km SW. of Port Hedland	-20.40	118.48
31849	Nemesiidae	<i>Aname</i>	`boodarie`	Boodarie Hill area; 15 km SW. of Port Hedland	-20.40	118.48

WAM reg. no.	Family	Genus	Species	Location	Latitude	Longitude
31850	Nemesiidae	<i>Aname</i>	`boodarie`	Boodarie Hill area; 15 km SW. of Port Hedland	-20.40	118.48
31851	Nemesiidae	<i>Aname</i>	`boodarie`	Boodarie Hill area; 15 km SW. of Port Hedland	-20.40	118.48
31852	Nemesiidae	<i>Aname</i>	`boodarie`	Boodarie Hill area; 15 km SW. of Port Hedland	-20.40	118.48
31853	Nemesiidae	<i>Aname</i>	`boodarie`	Boodarie Hill area; 15 km SW. of Port Hedland	-20.40	118.48
31854	Nemesiidae	<i>Aname</i>	`boodarie`	Boodarie Hill area; 15 km SW. of Port Hedland	-20.40	118.48
31855	Nemesiidae	<i>Aname</i>	`boodarie`	Boodarie Hill area; 15 km SW. of Port Hedland	-20.40	118.48
31856	Nemesiidae	<i>Aname</i>	`boodarie`	Boodarie Hill area; 15 km SW. of Port Hedland	-20.40	118.48
31857	Nemesiidae	<i>Aname</i>	`boodarie`	Boodarie Hill area; 15 km SW. of Port Hedland	-20.40	118.48
31858	Nemesiidae	<i>Aname</i>	`boodarie`	Boodarie Hill area; 15 km SW. of Port Hedland	-20.40	118.48
31859	Nemesiidae	<i>Aname</i>	`boodarie`	Boodarie Hill area; 15 km SW. of Port Hedland	-20.40	118.48
31860	Nemesiidae	<i>Aname</i>	`boodarie`	Boodarie Hill area; 15 km SW. of Port Hedland	-20.40	118.48
31861	Nemesiidae	<i>Aname</i>	`boodarie`	Boodarie Hill area; 15 km SW. of Port Hedland	-20.40	118.48
31862	Nemesiidae	<i>Aname</i>	`boodarie`	Boodarie Hill area; 15 km SW. of Port Hedland	-20.40	118.48
31863	Nemesiidae	<i>Aname</i>	`boodarie`	Boodarie Hill area; 15 km SW. of Port Hedland	-20.40	118.48
31864	Nemesiidae	<i>Aname</i>	`boodarie`	Boodarie Hill area; 15 km SW. of Port Hedland	-20.40	118.48
31865	Nemesiidae	<i>Aname</i>	`boodarie`	Boodarie Hill area; 15 km SW. of Port Hedland	-20.40	118.48
31866	Nemesiidae	<i>Aname</i>	`boodarie`	Boodarie Hill area; 15 km SW. of Port Hedland	-20.40	118.48
31867	Nemesiidae	<i>Aname</i>	`boodarie`	Boodarie Hill area; 15 km SW. of Port Hedland	-20.40	118.48
31868	Nemesiidae	<i>Aname</i>	`boodarie`	Boodarie Hill area; 15 km SW. of Port Hedland	-20.40	118.48
31869	Nemesiidae	<i>Aname</i>	`boodarie`	Boodarie Hill area; 15 km SW. of Port Hedland	-20.40	118.48
31870	Nemesiidae	<i>Aname</i>	`boodarie`	Boodarie Hill area; 15 km SW. of Port Hedland	-20.40	118.48



WAM reg. no.	Family	Genus	Species	Location	Latitude	Longitude
31871	Nemesiidae	<i>Aname</i>	`boodarie`	Boodarie Hill area; 15 km SW. of Port Hedland	-20.40	118.48
31872	Nemesiidae	<i>Aname</i>	`boodarie`	Boodarie Hill area; 15 km SW. of Port Hedland	-20.40	118.48
31873	Nemesiidae	<i>Aname</i>	`boodarie`	Boodarie Hill area; 15 km SW. of Port Hedland	-20.40	118.48
31874	Nemesiidae	<i>Aname</i>	`boodarie`	Boodarie Hill area; 15 km SW. of Port Hedland	-20.40	118.48
31875	Nemesiidae	<i>Aname</i>	`boodarie`	Boodarie Hill area; 15 km SW. of Port Hedland	-20.40	118.48
97005	Nemesiidae	<i>Aname</i>	`MYG089`	47 km NNE. of Whim Creek Hotel; Pilbara survey site DRE05	-20.48	118.04
97315	Nemesiidae	<i>Aname</i>	`MYG106`	11 km SSE. of Whim Creek Hotel; Pilbara Biological Survey site DRE10	-20.92	117.86
106660	Nemesiidae	<i>Aname</i>	`MYG208`	c. 18 km SSW. of Port Hedland	-20.48	118.53
106664	Nemesiidae	<i>Aname</i>	`MYG209`	c. 26 km S. of Port Hedland	-20.55	118.56
97312	Nemesiidae	<i>Aname</i>	<i>ellenae</i>	12.5 km S. of Whim Creek Hotel; Pilbara Biological Survey site DRE11B	-20.95	117.85
117279	Nemesiidae	<i>Aname</i>	<i>ellenae</i>	45 km NE. of Whim Creek Hotel; Pilbara Biological Survey site DRE07	-20.61	118.16
27254	Nemesiidae	<i>Aname</i>	sp. indet.	Port Hedland	-20.32	118.60
27845	Nemesiidae	<i>Aname</i>	sp. indet.	Balla	-20.70	117.78
27992	Nemesiidae	<i>Aname</i>	sp. indet.	Port Hedland	-20.32	118.60
31433	Nemesiidae	<i>Aname</i>	sp. indet.	Port Hedland; Westrac Equipment Pty Ltd	-20.32	118.60
44341	Nemesiidae	<i>Aname</i>	sp. indet.	Karratha	-20.73	116.87
56745	Nemesiidae	<i>Aname</i>	sp. indet.	South Hedland	-20.38	118.60
75454	Nemesiidae	<i>Aname</i>	sp. indet.	Point Samson	-20.62	117.18
88595	Nemesiidae	<i>Aname</i>	sp. indet.	5.3 km W. of Cossack	-20.66	117.13
88600	Nemesiidae	<i>Aname</i>	sp. indet.	5.5 km W. of Cossack	-20.65	117.13
96520	Nemesiidae	<i>Aname</i>	sp. indet.	Cape Lambert; 24.3 km NE. of Karratha	-20.68	117.07

WAM reg. no.	Family	Genus	Species	Location	Latitude	Longitude
96521	Nemesiidae	<i>Aname</i>	sp. indet.	Cape Lambert; 25.4 km E. of Karratha	-20.75	117.09
96522	Nemesiidae	<i>Aname</i>	sp. indet.	Cape Lambert; 25.4 km E. of Karratha	-20.75	117.09
98256	Nemesiidae	<i>Aname</i>	sp. indet.	Wickham; ca. 4.2 km W; site SRE20; HC	-20.67	117.10
98257	Nemesiidae	<i>Aname</i>	sp. indet.	Cleaverville; ca. 6.5 km WNW; site SRE24	-20.66	117.08
98258	Nemesiidae	<i>Aname</i>	sp. indet.	Cleaverville; ca. 3.5 km S; site SRE17	-20.67	117.05
98259	Nemesiidae	<i>Aname</i>	sp. indet.	Wickham; ca. 6 km NW; site SRE22	-20.65	117.09
98260	Nemesiidae	<i>Aname</i>	sp. indet.	Cleaverville; ca. 6.5 km WNW; site SRE23	-20.66	117.08
98261	Nemesiidae	<i>Aname</i>	sp. indet.	Cleaverville; ca. 3.5 km S; site SRE16	-20.68	117.04
98742	Nemesiidae	<i>Aname</i>	sp. indet.	Cape Lambert; drillhole ID MA336	-20.72	117.10
102933	Nemesiidae	<i>Aname</i>	sp. indet.	Cape Lambert Port; 5.5 km NNE. of Wickham	-20.65	117.13
106662	Nemesiidae	<i>Aname</i>	sp. indet.	c. 26 km S. of Port Hedland	-20.55	118.56
106663	Nemesiidae	<i>Aname</i>	sp. indet.	c. 26 km S. of Port Hedland	-20.55	118.56
106665	Nemesiidae	<i>Aname</i>	sp. indet.	c. 26 km S. of Port Hedland	-20.55	118.56
106666	Nemesiidae	<i>Aname</i>	sp. indet.	c. 26 km S. of Port Hedland	-20.55	118.56
106669	Nemesiidae	<i>Aname</i>	sp. indet.	c. 26 km S. of Port Hedland	-20.55	118.56
106670	Nemesiidae	<i>Aname</i>	sp. indet.	c. 26 km S. of Port Hedland	-20.55	118.56
106671	Nemesiidae	<i>Aname</i>	sp. indet.	c. 26 km S. of Port Hedland	-20.55	118.56
107087	Nemesiidae	<i>Aname</i>	sp. indet.	c. 9 km SSW. of Port Hedland	-20.39	118.55
107089	Nemesiidae	<i>Aname</i>	sp. indet.	c. 9 km SSW. of Port Hedland	-20.39	118.56
107090	Nemesiidae	<i>Aname</i>	sp. indet.	c. 9 km SSW. of Port Hedland	-20.39	118.56
107091	Nemesiidae	<i>Aname</i>	sp. indet.	c. 9 km SSW. of Port Hedland	-20.39	118.56

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WAM reg. no.	Family	Genus	Species	Location	Latitude	Longitude
107092	Nemesiidae	<i>Aname</i>	sp. indet.	c. 9 km SSW. of Port Hedland	-20.39	118.56
107093	Nemesiidae	<i>Aname</i>	sp. indet.	c. 7 km SW. of Port Hedland	-20.36	118.53
109328	Nemesiidae	<i>Aname</i>	sp. indet.	10 km S. of Mallina Homestead; Pilbara Biological Survey site DRE13	-20.97	118.05
109358	Nemesiidae	<i>Aname</i>	sp. indet.	12.5 km S. of Whim Creek Hotel; Pilbara Biological Survey site DRE11B	-20.95	117.85
112992	Nemesiidae	<i>Aname</i>	sp. indet.	Anketell Rail Corridor; NNW. Tom Price	-21.35	116.88
114647	Nemesiidae	<i>Aname</i>	sp. indet.	Karratha to Millstream-Chichester National Park	-21.03	116.91
117864	Nemesiidae	<i>Aname</i>	sp. indet.	4.9 km W. of Roebourne	-20.75	117.10
117865	Nemesiidae	<i>Aname</i>	sp. indet.	4.9 km W. of Roebourne	-20.75	117.10
117866	Nemesiidae	<i>Aname</i>	sp. indet.	4.9 km W. of Roebourne	-20.75	117.10
117871	Nemesiidae	<i>Aname</i>	sp. indet.	5.8 km NW. of Roebourne	-20.72	117.12
117872	Nemesiidae	<i>Aname</i>	sp. indet.	9.2 km NW. of Roebourne	-20.69	117.11
106661	Nemesiidae	<i>Kwonkan</i>	`MYG007`	c. 26 km S. of Port Hedland	-20.55	118.56
106667	Nemesiidae	<i>Kwonkan</i>	`MYG007`	c. 26 km S. of Port Hedland	-20.55	118.56
106668	Nemesiidae	<i>Kwonkan</i>	`MYG007`	c. 26 km S. of Port Hedland	-20.55	118.56
107088	Nemesiidae	<i>Kwonkan</i>	`MYG007`	c. 9 km SSW. of Port Hedland	-20.39	118.55
88664	Nemesiidae	<i>Teyl</i>	sp. indet.	36.7 km SE. of Karratha	-20.98	117.08
88665	Nemesiidae	<i>Teyl</i>	sp. indet.	36.7 km SE. of Karratha	-20.98	117.08
88666	Nemesiidae	<i>Teyl</i>	sp. indet.	36.7 km SE. of Karratha	-20.98	117.08
88667	Nemesiidae	<i>Teyl</i>	sp. indet.	37.2 km SE. of Karratha	-20.98	117.09
88668	Nemesiidae	<i>Teyl</i>	sp. indet.	37.2 km SE. of Karratha	-20.98	117.09
88671	Nemesiidae	<i>Teyl</i>	sp. indet.	56.2 km S. of Karratha	-21.13	117.00

WAM reg. no.	Family	Genus	Species	Location	Latitude	Longitude
88672	Nemesiidae	<i>Teyl</i>	sp. indet.	100.7 km S. of Karratha	-21.57	117.22
97008	Nemesiidae	<i>Yilgarnia</i>	`MYG092`	5 km E. of Whim Creek Hotel; Pilbara Biological Survey site DRE08	-20.85	117.85
79393	Selenopidae	<i>Karaops</i>	`binjiriganbarr`	9 km NW. of Lake Poongkaliyarra; Pilbara Survey site DRC5	-20.94	117.04
79394	Selenopidae	<i>Karaops</i>	`binjiriganbarr`	5 km N. of Lake Poongkaliyarra; Pilbara Survey site DRC7	-20.93	117.11
79396	Selenopidae	<i>Karaops</i>	`binjiriganbarr`	8 km SW. of Roebourne; Pilbara Survey site DRC9	-20.81	117.07
79397	Selenopidae	<i>Karaops</i>	`jaburrara`	13.5 km W. of Wickham; Pilbara Survey site DRC11	-20.69	117.01
106657	Selenopidae	<i>Karaops</i>	`kanparra`	c. 55 km S. of Port Hedland	-21.17	118.65
79405	Selenopidae	<i>Karaops</i>	`murdimaa`	6 km N. of Millstream; Pilbara Survey site PW11	-21.54	117.06
79403	Selenopidae	<i>Karaops</i>	`yurlburr`	2.3 km ESE. of Python Pool; Pilbara Survey site PW1	-21.34	117.26
79395	Selenopidae	<i>Karaops</i>	sp. indet.	3.5 km WNW. of Mt Gregory; Pilbara Survey site DRC8	-20.85	117.10
79398	Selenopidae	<i>Karaops</i>	sp. indet.	10 km S. of Mallina Homestead; Pilbara Survey site DRE13	-20.97	118.05
79404	Selenopidae	<i>Karaops</i>	sp. indet.	5 km WSW. of Python Pool; Pilbara Survey site PW3	-21.34	117.19
92502	Selenopidae	<i>Karaops</i>	sp. indet.	Mt Herbert; 80.5 km SE. of Karratha; A20080811.CH01-02	-21.35	117.27
92504	Selenopidae	<i>Karaops</i>	sp. indet.	Mt Herbert; 80.5 km SE. of Karratha; A20080811.CH01-01	-21.35	117.27
92505	Selenopidae	<i>Karaops</i>	sp. indet.	Wickham; 54.2 km E. of Karratha; A20080813CH09-01	-20.89	117.34
113414	Selenopidae	<i>Karaops</i>	sp. indet.	c. 3km W of Wodgina Mine Site; site H2	-21.18	118.65
114678	Selenopidae	<i>Karaops</i>	sp. indet.	Karratha to Millstream-Chichester National Park	-21.21	117.05
114805	Selenopidae	<i>Karaops</i>	sp. indet.	Dixon Island; 24 km NE. of Karratha	-20.64	117.05
<b>Opiliones (harvestmen)</b>						
71899	Assamiidae	<i>Dampetrus</i>	sp. indet.	site HDG1; 53 km S. of Port Hedland	-20.78	118.64
92621	Assamiidae	<i>Dampetrus</i>	sp. indet.	Mt Herbert; 80.5 km SE. of Karratha; A20080811.CH01-01	-21.35	117.27

WAM reg. no.	Family	Genus	Species	Location	Latitude	Longitude
<b>Pseudoscorpiones (pseudoscorpions)</b>						
103643	Chernetidae	<i>Troglochernes</i>	sp. nov. `001`	Mount Dove	-20.94	118.46
103664	Chernetidae	<i>Troglochernes</i>	sp. nov. `001`	Mount Dove	-20.94	118.46
103667	Chernetidae	<i>Troglochernes</i>	sp. nov. `001`	Mount Dove	-20.94	118.46
103693	Chernetidae	<i>Troglochernes</i>	sp. nov. `001`	Mount Dove	-20.94	118.46
103706	Chernetidae	<i>Troglochernes</i>	sp. nov. `001`	Mount Dove	-20.94	118.46
<b>Scorpiones (scorpions)</b>						
87436	Urodacidae	<i>Urodacus</i>	sp. indet.	27 km South of Port Hedland; site HDG 5	-20.47	118.59
118657	Urodacidae	<i>Urodacus</i>	sp. indet.	34km south of Port Hedland; site HDG3	-20.61	118.61
<b>Chilopoda (centipedes)</b>						
<b>Geophilomorpha (soil centipedes)</b>						
114685	Mecistocephalidae	gen. indet.	sp. indet.	Karratha to Millstream-Chichester National Park	-21.09	116.99
114807	Mecistocephalidae	gen. indet.	sp. indet.	Dixon Island; 24 km NE. of Karratha	-20.64	117.05
<b>Scolopendromorpha (tropical centipedes)</b>						
113054	Cryptopidae	<i>Cryptops</i>	sp. indet.	Anketell Rail Corridor; NNW. Tom Price	-20.75	117.01
<b>Diplopoda (millipedes)</b>						
76051	Paradoxosomatidae	<i>Antichiropus</i>	`DIP011`	13.5 km W. of Wickham; Pilbara Biological Survey site DRC11	-20.69	117.01
76143	Paradoxosomatidae	<i>Antichiropus</i>	`DIP023`	Pilbara Survey site PW 3; Millstream-Chichester National Park	-21.34	117.19
76150	Paradoxosomatidae	<i>Antichiropus</i>	`DIP023`	Pilbara Survey site PW 10; Millstream-Chichester National Park	-21.55	117.06
76148	Paradoxosomatidae	<i>Antichiropus</i>	`DIP024`	Pilbara Survey site PW 12; Millstream-Chichester National Park	-21.38	117.06
76149	Paradoxosomatidae	<i>Antichiropus</i>	`DIP024`	Pilbara Survey site PW 2; Millstream-Chichester National Park	-21.33	117.24

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WAM reg. no.	Family	Genus	Species	Location	Latitude	Longitude
76153	Paradoxosomatidae	<i>Antichiropus</i>	`DIP024`	Pilbara Survey site PW 3; Millstream-Chichester National Park	-21.34	117.19
76142	Paradoxosomatidae	<i>Antichiropus</i>	`DIP025`	Pilbara Survey site DRC 5; Mt Welcome Station; W. of Mt Roe	-20.94	117.04
76171	Paradoxosomatidae	<i>Antichiropus</i>	`DIP025`	Pilbara Survey site DRC 8; Mt Welcome Station; W. of Mt Roe	-20.85	117.10
124545	Paradoxosomatidae	<i>Antichiropus</i>	`DIP025`	5 km E. of Whim Creek Hotel; Pilbara Biological Survey site DRE08	-20.85	117.85
76057	Paradoxosomatidae	<i>Antichiropus</i>	`DIP028`	20 km ESE. of Whim Creek Hotel; Pilbara Biological Survey site DRE12	-20.91	117.98
76074	Paradoxosomatidae	<i>Antichiropus</i>	`DIP028`	53 km NNE. of Whim Creek Hotel; Pilbara Biological Survey site DRE03	-20.43	118.06
102546	Paradoxosomatidae	<i>Antichiropus</i>	`DIP032`	Anketell Point; ca. 30 km E. of Karratha; Molecular Species	-20.73	117.09
114681	Paradoxosomatidae	<i>Antichiropus</i>	`DIP032`	Karratha to Millstream-Chichester National Park; Molecular Species	-20.99	116.88
113374	Paradoxosomatidae	<i>Antichiropus</i>	`DIP033`	c. 25 km N of Wodgina; site PS05	-21.08	118.51
113375	Paradoxosomatidae	<i>Antichiropus</i>	`DIP033`	c. 25 km N of Wodgina; site PS03	-21.06	118.53
113377	Paradoxosomatidae	<i>Antichiropus</i>	`DIP033`	c. 25 km N of Wodgina; site WE23	-21.06	118.56
107683	Paradoxosomatidae	<i>Antichiropus</i>	`wickham`	2.7 km N of Wickham; WSRE.R4	-20.66	117.15
73498	Paradoxosomatidae	<i>Antichiropus</i>	sp. indet.	Cape Lambert; 24.2 km E. of Karratha	-20.73	117.08
76151	Paradoxosomatidae	<i>Antichiropus</i>	sp. indet.	Pilbara Survey site PW 11; Millstream-Chichester National Park	-21.54	117.06
76154	Paradoxosomatidae	<i>Antichiropus</i>	sp. indet.	Pilbara Survey site PW 3; Millstream-Chichester National Park	-21.34	117.19
76155	Paradoxosomatidae	<i>Antichiropus</i>	sp. indet.	Pilbara Survey site PW 12; Millstream-Chichester National Park	-21.38	117.06
76156	Paradoxosomatidae	<i>Antichiropus</i>	sp. indet.	Pilbara Survey site DRC 5; Mt Welcome Station; W. of Mt Roe	-20.94	117.04
76166	Paradoxosomatidae	<i>Antichiropus</i>	sp. indet.	Pilbara Survey site DRC 8; Mt Welcome Station; W. of Mt Roe	-20.85	117.10
76170	Paradoxosomatidae	<i>Antichiropus</i>	sp. indet.	Pilbara Survey site DRC 9; Mt Welcome Station; W. of Mt Roebourne	-20.81	117.07
114680	Paradoxosomatidae	<i>Antichiropus</i>	sp. indet.	Karratha to Millstream-Chichester National Park	-20.99	116.88
76053	Paradoxosomatidae	DIPAAAC	`DIP030`	5 km E. of Whim Creek Hotel; Pilbara Biological Survey site DRE08	-20.85	117.85

WAM reg. no.	Family	Genus	Species	Location	Latitude	Longitude
113372	Paradoxosomatidae	gen. indet.	sp. indet.	c. 25 km N of Wodgina; site WE23	-21.06	118.56
113373	Paradoxosomatidae	gen. indet.	sp. indet.	c. 25 km N of Wodgina; site PS05	-21.08	118.51
113376	Paradoxosomatidae	gen. indet.	sp. indet.	c. 25 km N of Wodgina; site WE23	-21.06	118.56
<b>Isopoda (slaters)</b>						
<b>Eupulmonata (snails)</b>						
83548	Bithyniidae	<i>Gabbia</i>	aff. smithii	KARRATHA	-20.73	116.85
12742	Bithyniidae	<i>Gabbia</i>	cf. naperiensis	WHIM CREEK	-20.75	117.77
12743	Bithyniidae	<i>Gabbia</i>	cf. naperiensis	WHIM CREEK	-20.75	117.77
12741	Bithyniidae	<i>Gabbia</i>	cf. smithii	WHIM CREEK	-20.75	117.77
81266	Bithyniidae	<i>Gabbia</i>	sp. indet.	KARRATHA	-20.94	116.85
9586	Camaenidae	new genus	sp. indet.	KARRATHA	-20.73	116.87
9587	Camaenidae	new genus	sp. indet.	MILLSTREAM	-21.58	117.07
9588	Camaenidae	new genus	sp. indet.	MILLSTREAM	-21.58	117.07
9589	Camaenidae	new genus	sp. indet.	KARRATHA	-20.73	116.87
9590	Camaenidae	new genus	sp. indet.	PORT HEDLAND	-20.30	118.58
9592	Camaenidae	new genus	sp. indet.	KARRATHA	-20.73	116.87
33119	Camaenidae	new genus	sp. nov.	WODGINA	-21.06	118.52
33120	Camaenidae	new genus	sp. nov.	WODGINA	-21.06	118.52
33121	Camaenidae	new genus	sp. nov.	WODGINA	-21.06	118.56
33122	Camaenidae	new genus	sp. nov.	WODGINA	-21.22	118.63
43984	Camaenidae	new genus	sp. nov.	WODGINA	-21.06	118.53

WAM reg. no.	Family	Genus	Species	Location	Latitude	Longitude
43985	Camaenidae	new genus	sp. nov.	WODGINA	-21.06	118.52
43987	Camaenidae	new genus	sp. nov.	WODGINA	-21.22	118.63
43989	Camaenidae	new genus	sp. nov.	WODGINA	-21.22	118.63
43990	Camaenidae	new genus	sp. nov.	WODGINA	-21.06	118.56
43991	Camaenidae	new genus	sp. nov.	WODGINA	-21.06	118.53
43992	Camaenidae	new genus	sp. nov.	WODGINA	-21.06	118.52
43993	Camaenidae	new genus	sp. nov.	WODGINA	-21.06	118.53
43994	Camaenidae	new genus	sp. nov.	WODGINA	-21.06	118.52
43995	Camaenidae	new genus	sp. nov.	WODGINA	-21.24	118.65
43996	Camaenidae	new genus	sp. nov.	WODGINA	-21.24	118.65
43997	Camaenidae	new genus	sp. nov.	WODGINA	-21.06	118.52
43998	Camaenidae	new genus	sp. nov.	WODGINA	-21.06	118.53
43999	Camaenidae	new genus	sp. nov.	WODGINA	-21.06	118.53
60762	Camaenidae	new genus	sp. nov.	ANSON	-21.21	118.66
60763	Camaenidae	new genus	sp. nov.	ANSON	-21.21	118.66
60764	Camaenidae	new genus	sp. nov.	ANSON	-21.21	118.66
60765	Camaenidae	new genus	sp. nov.	ANSON	-21.19	118.65
60766	Camaenidae	new genus	sp. nov.	ANSON	-21.19	118.65
60767	Camaenidae	new genus	sp. nov.	ANSON	-21.21	118.67
60768	Camaenidae	new genus	sp. nov.	ANSON	-21.21	118.67
60769	Camaenidae	new genus	sp. nov.	ANSON	-21.21	118.67



WAM reg. no.	Family	Genus	Species	Location	Latitude	Longitude
60770	Camaenidae	new genus	sp. nov.	ANSON	-21.21	118.66
60771	Camaenidae	new genus	sp. nov.	ANSON	-21.19	118.65
60772	Camaenidae	new genus	sp. nov.	ANSON	-21.19	118.65
60773	Camaenidae	new genus	sp. nov.	ANSON	-21.21	118.66
60774	Camaenidae	new genus	sp. nov.	ANSON	-21.19	118.65
60775	Camaenidae	new genus	sp. nov.	ANSON	-21.21	118.66
60776	Camaenidae	new genus	sp. nov.	ANSON	-21.21	118.66
60777	Camaenidae	new genus	sp. nov.	ANSON	-21.21	118.66
60778	Camaenidae	new genus	sp. nov.	ANSON	-21.21	118.66
60779	Camaenidae	new genus	sp. nov.	ANSON	-21.21	118.66
61315	Camaenidae	new genus	sp. nov.	PORT HEDLAND	-21.21	118.66
61316	Camaenidae	new genus	sp. nov.	PORT HEDLAND	-21.21	118.67
61317	Camaenidae	new genus	sp. nov.	PORT HEDLAND	-21.21	118.66
64799	Camaenidae	new genus	sp. nov.	WODGINA MINE	-21.24	118.65
64800	Camaenidae	new genus	sp. nov.	WODGINA MINE	-21.18	118.65
64801	Camaenidae	new genus	sp. nov.	WODGINA MINE	-21.20	118.67
64802	Camaenidae	new genus	sp. nov.	WODGINA MINE	-21.06	118.56
64803	Camaenidae	new genus	sp. nov.	WODGINA MINE	-21.18	118.66
64804	Camaenidae	new genus	sp. nov.	WODGINA MINE	-21.15	118.66
64805	Camaenidae	new genus	sp. nov.	WODGINA MINE	-21.18	118.65
64806	Camaenidae	new genus	sp. nov.	WODGINA MINE	-21.19	118.66

WAM reg. no.	Family	Genus	Species	Location	Latitude	Longitude
64807	Camaenidae	new genus	sp. nov.	WODGINA MINE	-21.18	118.65
64810	Camaenidae	new genus	sp. nov.	WODGINA MINE	-21.18	118.65
64812	Camaenidae	new genus	sp. nov.	WODGINA MINE	-21.18	118.66
64814	Camaenidae	new genus	sp. nov.	WODGINA MINE	-21.24	118.65
64815	Camaenidae	new genus	sp. nov.	WODGINA MINE	-21.12	118.66
64816	Camaenidae	new genus	sp. nov.	WODGINA MINE	-21.15	118.66
64817	Camaenidae	new genus	sp. nov.	WODGINA MINE	-21.06	118.56
64818	Camaenidae	new genus	sp. nov.	WODGINA MINE	-21.19	118.66
64820	Camaenidae	new genus	sp. nov.	WODGINA MINE	-21.18	118.65
65057	Camaenidae	new genus	sp. nov.	WODGINA	-21.21	118.64
65058	Camaenidae	new genus	sp. nov.	WODGINA	-21.22	118.63
65059	Camaenidae	new genus	sp. nov.	WODGINA	-21.06	118.56
65060	Camaenidae	new genus	sp. nov.	WODGINA	-21.24	118.65
65061	Camaenidae	new genus	sp. nov.	WODGINA	-21.22	118.66
65062	Camaenidae	new genus	sp. nov.	WODGINA	-21.06	118.54
65063	Camaenidae	new genus	sp. nov.	WODGINA	-21.22	118.63
65064	Camaenidae	new genus	sp. nov.	WODGINA	-21.24	118.65
65065	Camaenidae	new genus	sp. nov.	WODGINA	-21.19	118.65
65066	Camaenidae	new genus	sp. nov.	WODGINA	-21.22	118.66
65067	Camaenidae	new genus	sp. nov.	WODGINA	-21.19	118.65
65068	Camaenidae	new genus	sp. nov.	WODGINA	-21.21	118.64

WAM reg. no.	Family	Genus	Species	Location	Latitude	Longitude
65069	Camaenidae	new genus	sp. nov.	WODGINA	-21.06	118.56
65070	Camaenidae	new genus	sp. nov.	WODGINA	-21.12	118.66
65071	Camaenidae	new genus	sp. nov.	WODGINA	-21.06	118.54
65072	Camaenidae	new genus	sp. nov.	WODGINA	-21.06	118.54
65073	Camaenidae	new genus	sp. nov.	WODGINA	-21.06	118.56
65074	Camaenidae	new genus	sp. nov.	WODGINA	-21.22	118.66
65075	Camaenidae	new genus	sp. nov.	WODGINA	-21.24	118.65
65076	Camaenidae	new genus	sp. nov.	WODGINA	-21.21	118.64
65077	Camaenidae	new genus	sp. nov.	WODGINA	-21.22	118.63
65854	Camaenidae	new genus	sp. nov.	WODGINA MINE SITE	-21.17	118.65
65857	Camaenidae	new genus	sp. nov.	WODGINA MINE SITE	-21.15	118.66
65862	Camaenidae	new genus	sp. nov.	WODGINA MINE SITE	-21.18	118.66
65866	Camaenidae	new genus	sp. nov.	WODGINA MINE SITE	-21.17	118.65
65876	Camaenidae	new genus	sp. nov.	WODGINA MINE SITE	-21.16	118.66
65884	Camaenidae	new genus	sp. nov.	WODGINA	-21.22	118.63
65886	Camaenidae	new genus	sp. nov.	WODGINA	-21.22	118.63
65888	Camaenidae	new genus	sp. nov.	WODGINA	-21.06	118.53
65892	Camaenidae	new genus	sp. nov.	WODGINA	-21.22	118.63
65899	Camaenidae	new genus	sp. nov.	WODGINA	-21.06	118.56
65901	Camaenidae	new genus	sp. nov.	WODGINA	-21.06	118.52
65905	Camaenidae	new genus	sp. nov.	WODGINA	-21.22	118.63

WAM reg. no.	Family	Genus	Species	Location	Latitude	Longitude
65907	Camaenidae	new genus	sp. nov.	WODGINA	-21.06	118.52
12242	Camaenidae	<i>Quistrachia</i>	`depuch island`	DEPUCH ISLAND	-20.63	117.72
61496	Camaenidae	<i>Quistrachia</i>	`W`	QUARTZ HILL	-20.75	116.95
61676	Camaenidae	<i>Quistrachia</i>	`W`	PILBARA	-20.76	116.96
83881	Camaenidae	<i>Quistrachia</i>	`W`	PORT HEDLAND	-20.64	117.15
83886	Camaenidae	<i>Quistrachia</i>	`W`	PORT HEDLAND	-20.65	117.16
83890	Camaenidae	<i>Quistrachia</i>	`W`	PORT HEDLAND	-20.64	117.15
83892	Camaenidae	<i>Quistrachia</i>	`W`	PORT HEDLAND	-20.64	117.15
7701	Camaenidae	<i>Quistrachia</i>	`X anketell point`	ANKETELL POINT	-20.66	117.03
12243	Camaenidae	<i>Quistrachia</i>	`X anketell point`	CLEAVERVILLE	-20.65	117.02
63252	Camaenidae	<i>Quistrachia</i>	`X anketell point`	ANKETELL POINT	-20.74	117.02
63253	Camaenidae	<i>Quistrachia</i>	`X anketell point`	ANKETELL POINT	-20.68	117.05
63254	Camaenidae	<i>Quistrachia</i>	`X anketell point`	ANKETELL POINT	-20.66	117.03
64511	Camaenidae	<i>Quistrachia</i>	`X anketell point`	ANKETELL POINT	-20.73	117.09
64514	Camaenidae	<i>Quistrachia</i>	`X anketell point`	ANKETELL POINT	-20.65	117.03
64516	Camaenidae	<i>Quistrachia</i>	`X anketell point`	ANKETELL POINT	-20.66	116.99
64523	Camaenidae	<i>Quistrachia</i>	`X anketell point`	ANKETELL POINT	-20.68	117.08
64524	Camaenidae	<i>Quistrachia</i>	`X anketell point`	ANKETELL POINT	-20.68	117.08
64525	Camaenidae	<i>Quistrachia</i>	`X anketell point`	ANKETELL POINT	-20.65	117.03
64526	Camaenidae	<i>Quistrachia</i>	`X anketell point`	ANKETELL POINT	-20.73	117.08
64527	Camaenidae	<i>Quistrachia</i>	`X anketell point`	ANKETELL POINT	-20.66	117.02

WAM reg. no.	Family	Genus	Species	Location	Latitude	Longitude
64528	Camaenidae	<i>Quistrachia</i>	`X anketell point`	ANKETELL POINT	-20.66	117.01
64530	Camaenidae	<i>Quistrachia</i>	`X anketell point`	ANKETELL POINT	-20.69	117.12
64537	Camaenidae	<i>Quistrachia</i>	`X anketell point`	ANKETELL POINT	-20.71	117.08
64539	Camaenidae	<i>Quistrachia</i>	`X anketell point`	ANKETELL POINT	-20.68	117.09
64549	Camaenidae	<i>Quistrachia</i>	`X anketell point`	ANKETELL POINT	-20.66	117.01
81468	Camaenidae	<i>Quistrachia</i>	`X anketell point`	KARRATHA	-20.67	117.05
83883	Camaenidae	<i>Quistrachia</i>	`X anketell point`	PORT HEDLAND	-20.65	117.15
83897	Camaenidae	<i>Quistrachia</i>	`X anketell point`	PORT HEDLAND	-20.65	117.15
61924	Camaenidae	<i>Quistrachia</i>	<i>cf. herberti</i>	PINDERI HILLS	-21.05	116.85
5701	Camaenidae	<i>Quistrachia</i>	<i>herberti</i>	MOUNT HERBERT	-21.32	117.22
5804	Camaenidae	<i>Quistrachia</i>	<i>herberti</i>	TOM PRICE	-21.08	117.78
8976	Camaenidae	<i>Quistrachia</i>	<i>herberti</i>	MOUNT HERBERT	-21.33	117.21
14867	Camaenidae	<i>Quistrachia</i>	<i>herberti</i>	CHICHESTER RANGE NATIONAL PARK	-21.33	117.21
14868	Camaenidae	<i>Quistrachia</i>	<i>herberti</i>	MT HERBERT	-21.33	117.21
14869	Camaenidae	<i>Quistrachia</i>	<i>herberti</i>	MT HERBERT	-21.33	117.21
28052	Camaenidae	<i>Quistrachia</i>	<i>herberti</i>	ROEBOURNE	-21.33	117.21
61494	Camaenidae	<i>Quistrachia</i>	<i>herberti</i>	MOUNT HERBERT	-21.33	117.22
61498	Camaenidae	<i>Quistrachia</i>	<i>herberti</i>	MOUNT HERBERT	-21.23	117.22
61674	Camaenidae	<i>Quistrachia</i>	<i>herberti</i>	MILLSTREAM CHICHESTER NP	-21.58	117.08
61675	Camaenidae	<i>Quistrachia</i>	<i>herberti</i>	MILLSTREAM CHICHESTER NP	-21.58	117.08
61848	Camaenidae	<i>Quistrachia</i>	<i>herberti</i>	HARDING RIVER	-21.38	117.06

WAM reg. no.	Family	Genus	Species	Location	Latitude	Longitude
81225	Camaenidae	<i>Quistrachia</i>	<i>herberti</i>	KARRATHA	-21.18	117.04
81237	Camaenidae	<i>Quistrachia</i>	<i>herberti</i>	KARRATHA	-21.18	117.05
12075	Camaenidae	<i>Quistrachia</i>	<i>legendrei</i> sp. `burrup`	ROCKY HILL	-20.52	116.85
12086	Camaenidae	<i>Quistrachia</i>	<i>legendrei</i> sp. `burrup`	BURRUP PENINSULA	-20.53	116.84
12091	Camaenidae	<i>Quistrachia</i>	<i>legendrei</i> sp. `burrup`	V34 CREEK	-20.53	116.85
12097	Camaenidae	<i>Quistrachia</i>	<i>legendrei</i> sp. `burrup`	SLOPING POINT	-20.53	116.85
12105	Camaenidae	<i>Quistrachia</i>	<i>legendrei</i> sp. `burrup`	KARRATHA	-20.73	116.84
5702	Camaenidae	<i>Quistrachia</i>	<i>legendrei</i> sp. `dampier arch.`	LEGENDRE ISLAND	-20.38	116.87
5703	Camaenidae	<i>Quistrachia</i>	<i>legendrei</i> sp. `dampier arch.`	LEGENDRE ISLAND	-20.38	116.87
15630	Camaenidae	<i>Quistrachia</i>	<i>legendrei</i> sp. `dampier arch.`	LEGENDRE ISLAND	-20.38	116.87
28061	Camaenidae	<i>Quistrachia</i>	<i>legendrei</i> sp. `dampier arch.`	LEGENDRE ISLAND	-20.38	116.87
61846	Camaenidae	<i>Quistrachia</i>	<i>legendrei</i> sp. `dampier arch.`	LEGENDRE ISLAND	-20.38	116.87
12100	Camaenidae	<i>Quistrachia</i>	<i>legendrei</i> sp. cf. `burrup`	DOLPHIN ISLAND	-20.52	116.85
12108	Camaenidae	<i>Quistrachia</i>	<i>legendrei</i> sp. cf. `burrup`	DOLPHIN ISLAND	-20.52	116.85
12115	Camaenidae	<i>Quistrachia</i>	<i>legendrei</i> sp. cf. `burrup`	DOLPHIN ISLAND	-20.52	116.85
42675	Camaenidae	<i>Quistrachia</i>	<i>legendrei</i> sp. cf. `burrup`	DOLPHIN ISLAND	-20.47	116.87
28113	Camaenidae	<i>Quistrachia</i>	sp. indet.	MILLSTREAM	-21.58	117.07
28114	Camaenidae	<i>Quistrachia</i>	sp. indet.	MILLSTREAM	-21.58	117.07

WAM reg. no.	Family	Genus	Species	Location	Latitude	Longitude
28115	Camaenidae	<i>Quistrachia</i>	sp. indet.	MILLSTREAM	-21.58	117.07
28117	Camaenidae	<i>Quistrachia</i>	sp. indet.	KARRATHA	-20.73	116.87
64581	Camaenidae	<i>Quistrachia</i>	sp. indet.	KARRATHA	-20.66	117.10
5841	Camaenidae	<i>Rhagada</i>	<i>angulata</i>	LEGENDRE ISLAND	-20.38	116.87
12124	Camaenidae	<i>Rhagada</i>	<i>angulata</i>	V34 POOL CREEK	-20.53	116.85
12125	Camaenidae	<i>Rhagada</i>	<i>angulata</i>	BURRUP PENINSULA	-20.54	116.84
12126	Camaenidae	<i>Rhagada</i>	<i>angulata</i>	V34 CREEK	-20.53	116.85
12135	Camaenidae	<i>Rhagada</i>	<i>angulata</i>	DOLPHIN ISLAND	-20.52	116.85
12140	Camaenidae	<i>Rhagada</i>	<i>angulata</i>	SLOPING POINT	-20.53	116.85
28065	Camaenidae	<i>Rhagada</i>	<i>angulata</i>	DOLPHIN ISLAND	-20.52	116.85
28099	Camaenidae	<i>Rhagada</i>	<i>angulata</i>	DOLPHIN ISLAND	-20.52	116.85
81226	Camaenidae	<i>Rhagada</i>	<i>cf. pilbarana</i>	KARRATHA	-21.04	116.93
81233	Camaenidae	<i>Rhagada</i>	<i>cf. pilbarana</i>	KARRATHA	-21.17	117.01
81234	Camaenidae	<i>Rhagada</i>	<i>cf. pilbarana</i>	KARRATHA	-21.08	116.98
81236	Camaenidae	<i>Rhagada</i>	<i>cf. pilbarana</i>	KARRATHA	-21.11	116.99
81239	Camaenidae	<i>Rhagada</i>	<i>cf. pilbarana</i>	KARRATHA	-21.07	116.97
81242	Camaenidae	<i>Rhagada</i>	<i>cf. pilbarana</i>	KARRATHA	-21.03	116.91
5943	Camaenidae	<i>Rhagada</i>	<i>elachystoma</i>	LEGENDRE ISLAND	-20.38	116.87
5945	Camaenidae	<i>Rhagada</i>	<i>elachystoma</i>	LEGENDRE ISLAND	-20.38	116.87
5947	Camaenidae	<i>Rhagada</i>	<i>elachystoma</i>	LEGENDRE ISLAND	-20.38	116.87
1345	Camaenidae	<i>Rhagada</i>	<i>intermedia</i>	LEGENDRE ISLAND	-20.38	116.87

WAM reg. no.	Family	Genus	Species	Location	Latitude	Longitude
5989	Camaenidae	<i>Rhagada</i>	<i>intermedia</i>	DELAMBRE ISLAND	-20.43	117.07
5990	Camaenidae	<i>Rhagada</i>	<i>intermedia</i>	DELAMBRE ISLAND	-20.43	117.07
12231	Camaenidae	<i>Rhagada</i>	<i>intermedia</i>	LEGENDRE ISLAND	-20.38	116.87
28088	Camaenidae	<i>Rhagada</i>	<i>intermedia</i>	LEGENDRE ISLAND	-20.38	116.87
28107	Camaenidae	<i>Rhagada</i>	<i>intermedia</i>	DELAMBRE ISLAND	-20.43	117.07
28109	Camaenidae	<i>Rhagada</i>	<i>intermedia</i>	DELAMBRE ISLAND	-20.43	117.07
8827	Camaenidae	<i>Rhagada</i>	<i>pilbarana</i>	MOUNT HERBERT	-21.33	117.21
8828	Camaenidae	<i>Rhagada</i>	<i>pilbarana</i>	PYTHON POOL	-21.33	117.24
14920	Camaenidae	<i>Rhagada</i>	<i>pilbarana</i>	MOUNT HERBERT	-21.33	117.21
14921	Camaenidae	<i>Rhagada</i>	<i>pilbarana</i>	MOUNT HERBERT	-21.33	117.21
14922	Camaenidae	<i>Rhagada</i>	<i>pilbarana</i>	MOUNT HERBERT	-21.33	117.21
28055	Camaenidae	<i>Rhagada</i>	<i>pilbarana</i>	ROEBOURNE	-21.33	117.21
28119	Camaenidae	<i>Rhagada</i>	<i>pilbarana</i>	HARDING RIVER	-20.93	117.12
28120	Camaenidae	<i>Rhagada</i>	<i>pilbarana</i>	MILLSTREAM	-21.58	117.07
28121	Camaenidae	<i>Rhagada</i>	<i>pilbarana</i>	MILLSTREAM	-21.58	117.07
28122	Camaenidae	<i>Rhagada</i>	<i>pilbarana</i>	MILLSTREAM	-21.58	117.07
28123	Camaenidae	<i>Rhagada</i>	<i>pilbarana</i>	MILLSTREAM	-21.58	117.07
28124	Camaenidae	<i>Rhagada</i>	<i>pilbarana</i>	MILLSTREAM	-21.58	117.07
28125	Camaenidae	<i>Rhagada</i>	<i>pilbarana</i>	MILLSTREAM	-21.58	117.07
28126	Camaenidae	<i>Rhagada</i>	<i>pilbarana</i>	MILLSTREAM	-21.58	117.07
81228	Camaenidae	<i>Rhagada</i>	<i>pilbarana</i>	KARRATHA	-21.20	117.04



WAM reg. no.	Family	Genus	Species	Location	Latitude	Longitude
1344	Camaenidae	<i>Rhagada</i>	sp. indet.	LEGENDRE ISLAND	-20.38	116.87
6174	Camaenidae	<i>Rhagada</i>	sp. indet.	SOUTH WEST CREEK	-20.37	118.55
6175	Camaenidae	<i>Rhagada</i>	sp. indet.	MOUNT HERBERT	-21.32	117.22
6176	Camaenidae	<i>Rhagada</i>	sp. indet.	ROEBOURNE	-20.78	117.00
6177	Camaenidae	<i>Rhagada</i>	sp. indet.	ROEBOURNE	-20.78	117.15
6206	Camaenidae	<i>Rhagada</i>	sp. indet.	MILLSTREAM	-21.50	117.00
6218	Camaenidae	<i>Rhagada</i>	sp. indet.	KARRATHA	-20.73	116.87
6224	Camaenidae	<i>Rhagada</i>	sp. indet.	TURNER RIVER	-20.63	118.52
8877	Camaenidae	<i>Rhagada</i>	sp. indet.	KARRATHA	-20.73	116.87
12151	Camaenidae	<i>Rhagada</i>	sp. indet.	SLOPING POINT	-20.53	116.85
12162	Camaenidae	<i>Rhagada</i>	sp. indet.	BURRUP PENINSULA	-20.54	116.84
12163	Camaenidae	<i>Rhagada</i>	sp. indet.	V34 CREEK	-20.53	116.85
12179	Camaenidae	<i>Rhagada</i>	sp. indet.	V34 POOL CREEK	-20.53	116.85
12276	Camaenidae	<i>Rhagada</i>	sp. indet.	HAUY ISLAND	-20.43	116.97
28158	Camaenidae	<i>Rhagada</i>	sp. indet.	MILLSTREAM	-21.58	117.07
28159	Camaenidae	<i>Rhagada</i>	sp. indet.	MILLSTREAM	-21.58	117.07
28160	Camaenidae	<i>Rhagada</i>	sp. indet.	MILLSTREAM	-21.58	117.07
28161	Camaenidae	<i>Rhagada</i>	sp. indet.	MILLSTREAM	-21.58	117.07
28162	Camaenidae	<i>Rhagada</i>	sp. indet.	MILLSTREAM	-21.58	117.07
28163	Camaenidae	<i>Rhagada</i>	sp. indet.	MILLSTREAM	-21.58	117.07
28164	Camaenidae	<i>Rhagada</i>	sp. indet.	MILLSTREAM	-21.58	117.07

WAM reg. no.	Family	Genus	Species	Location	Latitude	Longitude
28165	Camaenidae	<i>Rhagada</i>	sp. indet.	MILLSTREAM	-21.58	117.07
28166	Camaenidae	<i>Rhagada</i>	sp. indet.	MILLSTREAM	-21.58	117.07
28167	Camaenidae	<i>Rhagada</i>	sp. indet.	MILLSTREAM	-21.58	117.07
28168	Camaenidae	<i>Rhagada</i>	sp. indet.	MILLSTREAM	-21.58	117.07
28169	Camaenidae	<i>Rhagada</i>	sp. indet.	MILLSTREAM	-21.58	117.07
28170	Camaenidae	<i>Rhagada</i>	sp. indet.	MILLSTREAM	-21.58	117.07
28171	Camaenidae	<i>Rhagada</i>	sp. indet.	MILLSTREAM	-21.58	117.07
28172	Camaenidae	<i>Rhagada</i>	sp. indet.	MILLSTREAM	-21.58	117.07
28173	Camaenidae	<i>Rhagada</i>	sp. indet.	MILLSTREAM	-21.58	117.07
28174	Camaenidae	<i>Rhagada</i>	sp. indet.	MILLSTREAM	-21.58	117.07
59265	Camaenidae	<i>Rhagada</i>	sp. indet.	SOUTH HEDLAND SUBURB	-20.38	118.60
59478	Camaenidae	<i>Rhagada</i>	sp. indet.	BALLA BALLA	-20.77	117.78
59479	Camaenidae	<i>Rhagada</i>	sp. indet.	BALLA BALLA	-20.77	117.78
59480	Camaenidae	<i>Rhagada</i>	sp. indet.	BALLA BALLA	-20.78	117.78
59481	Camaenidae	<i>Rhagada</i>	sp. indet.	BALLA BALLA	-20.75	117.75
59482	Camaenidae	<i>Rhagada</i>	sp. indet.	BALLA BALLA	-20.77	117.78
59483	Camaenidae	<i>Rhagada</i>	sp. indet.	WHIM CREEK	-20.83	117.81
59484	Camaenidae	<i>Rhagada</i>	sp. indet.	BALLA BALLA	-20.79	117.79
59485	Camaenidae	<i>Rhagada</i>	sp. indet.	BALLA BALLA	-20.77	117.79
59486	Camaenidae	<i>Rhagada</i>	sp. indet.	WHIM CREEK	-20.83	117.81
59487	Camaenidae	<i>Rhagada</i>	sp. indet.	BALLA BALLA	-20.77	117.77

WAM reg. no.	Family	Genus	Species	Location	Latitude	Longitude
59488	Camaenidae	<i>Rhagada</i>	sp. indet.	BALLA BALLA	-20.75	117.79
59489	Camaenidae	<i>Rhagada</i>	sp. indet.	BALLA BALLA	-20.78	117.79
59490	Camaenidae	<i>Rhagada</i>	sp. indet.	BALLA BALLA	-20.77	117.78
59491	Camaenidae	<i>Rhagada</i>	sp. indet.	BALLA BALLA	-20.75	117.75
59492	Camaenidae	<i>Rhagada</i>	sp. indet.	BALLA BALLA	-20.77	117.79
59493	Camaenidae	<i>Rhagada</i>	sp. indet.	BALLA BALLA	-20.78	117.79
59494	Camaenidae	<i>Rhagada</i>	sp. indet.	BALLA BALLA	-20.73	117.79
59495	Camaenidae	<i>Rhagada</i>	sp. indet.	BALLA BALLA	-20.77	117.73
59496	Camaenidae	<i>Rhagada</i>	sp. indet.	BALLA BALLA	-20.76	117.77
59497	Camaenidae	<i>Rhagada</i>	sp. indet.	WHIM CREEK	-20.85	117.84
59498	Camaenidae	<i>Rhagada</i>	sp. indet.	WHIM CREEK	-20.86	117.84
59499	Camaenidae	<i>Rhagada</i>	sp. indet.	WHIM CREEK	-20.77	117.72
59500	Camaenidae	<i>Rhagada</i>	sp. indet.	WHIM CREEK	-20.83	117.83
59501	Camaenidae	<i>Rhagada</i>	sp. indet.	WHIM CREEK	-20.85	118.07
59502	Camaenidae	<i>Rhagada</i>	sp. indet.	WHIM CREEK	-20.77	117.78
59503	Camaenidae	<i>Rhagada</i>	sp. indet.	WHIM CREEK	-20.77	117.77
59504	Camaenidae	<i>Rhagada</i>	sp. indet.	WHIM CREEK	-20.75	117.72
59505	Camaenidae	<i>Rhagada</i>	sp. indet.	WHIM CREEK	-20.77	117.78
59506	Camaenidae	<i>Rhagada</i>	sp. indet.	WHIM CREEK	-20.77	117.77
59507	Camaenidae	<i>Rhagada</i>	sp. indet.	WHIM CREEK	-20.76	117.77
59508	Camaenidae	<i>Rhagada</i>	sp. indet.	WHIM CREEK	-20.81	117.78

WAM reg. no.	Family	Genus	Species	Location	Latitude	Longitude
59509	Camaenidae	<i>Rhagada</i>	sp. indet.	WHIM CREEK	-20.76	117.77
59510	Camaenidae	<i>Rhagada</i>	sp. indet.	WHIM CREEK	-20.78	117.77
59511	Camaenidae	<i>Rhagada</i>	sp. indet.	WHIM CREEK	-20.78	117.78
59512	Camaenidae	<i>Rhagada</i>	sp. indet.	WHIM CREEK	-20.76	117.74
59513	Camaenidae	<i>Rhagada</i>	sp. indet.	WHIM CREEK	-20.78	117.78
59514	Camaenidae	<i>Rhagada</i>	sp. indet.	WHIM CREEK	-20.75	117.72
59515	Camaenidae	<i>Rhagada</i>	sp. indet.	WHIM CREEK	-20.75	117.72
59516	Camaenidae	<i>Rhagada</i>	sp. indet.	WHIM CREEK	-20.85	117.83
59517	Camaenidae	<i>Rhagada</i>	sp. indet.	WHIM CREEK	-20.75	117.72
59518	Camaenidae	<i>Rhagada</i>	sp. indet.	WHIM CREEK	-20.76	117.74
59519	Camaenidae	<i>Rhagada</i>	sp. indet.	WHIM CREEK	-20.75	117.72
59520	Camaenidae	<i>Rhagada</i>	sp. indet.	WHIM CREEK	-20.76	117.77
59521	Camaenidae	<i>Rhagada</i>	sp. indet.	WHIM CREEK	-20.78	117.78
59522	Camaenidae	<i>Rhagada</i>	sp. indet.	WHIM CREEK	-20.77	117.77
59523	Camaenidae	<i>Rhagada</i>	sp. indet.	WHIM CREEK	-20.77	117.78
59524	Camaenidae	<i>Rhagada</i>	sp. indet.	WHIM CREEK	-20.76	117.77
59525	Camaenidae	<i>Rhagada</i>	sp. indet.	WHIM CREEK	-20.77	117.77
59526	Camaenidae	<i>Rhagada</i>	sp. indet.	WHIM CREEK	-20.76	117.74
59527	Camaenidae	<i>Rhagada</i>	sp. indet.	WHIM CREEK	-20.81	117.78
59528	Camaenidae	<i>Rhagada</i>	sp. indet.	WHIM CREEK	-20.76	117.74
59529	Camaenidae	<i>Rhagada</i>	sp. indet.	WHIM CREEK	-20.75	117.72

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WAM reg. no.	Family	Genus	Species	Location	Latitude	Longitude
59530	Camaenidae	<i>Rhagada</i>	sp. indet.	WHIM CREEK	-20.77	117.77
61634	Camaenidae	<i>Rhagada</i>	sp. indet.	BALLA BALLA	-20.77	117.73
65037	Camaenidae	<i>Rhagada</i>	sp. indet.	READING HEAD LOOKOUT	-20.67	117.20
81244	Camaenidae	<i>Rhagada</i>	sp. indet.	KARRATHA	-21.03	116.91
	Charopidae	<i>Dupucharopa</i>	<i>millestriata</i>	Depuch Island	-20.63	117.72

**Appendix 6     Bat echolocation call analysis report**

# **Balla Balla Fauna Survey November 2012**

## **Echolocation Survey of Bat Activity.**

Prepared for Phoenix Environmental Sciences

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## **Background**

Phoenix Environmental Sciences (Phoenix) carried out an echolocation based survey during November and December 2012 at the proposed Balla Balla project site. This survey included completing nine recording nights using SM2 full spectrum bat detectors. Bat Call WA (Bat Call) has reviewed the recordings made and provided species lists and activity levels for the bats present.

## **Introduction**

### *Mangrove obligate bats of the Pilbara*

The Little north-western free-tailed bat (*Mormopterus loriae cobourgiana*) is listed as Priority 1 (taxa with few, poorly known populations on threatened lands) under Western Australian Department of Environment and Conservation priority fauna. This listing is on the basis of the impact to habitats providing suitable roosts. It is a geographically isolated, mangrove obligate, form of the mesic tropical *Mormopterus loriae* complex that occurs in rainforest, monsoon forest riparian zones and mangrove communities (McKenzie and Bullen 2009). It ranges from Exmouth Gulf in the south to the Dampier peninsular in the north. Its range is separated by approximately 1000 km of the Kimberley coastline from the northern species complex. The few known roosts are concentrated in mangrove mosaics along the coastline.

The north-western free-tailed bats flight is swift and direct that forages for its prey along the shoreline and associated creek estuaries. It is most often observed in flight at dusk as it emerges from its roost trees (Milne *et al.* 2008)). McKenzie and Bullen (2009) give its “mode” flight speed (i.e. the speed most often measured during free flight) as  $7.8 \text{ m s}^{-1}$  (28 kph). Author’s unpublished data show the species to be capable of level flight speeds in excess of  $12.5 \text{ m s}^{-1}$  (45 kph).

Documented north-western free-tailed bat roosts are few but all are associated with stands of mangrove. Numbers of *M. loriae* at a site may vary from a few to many hundred (Milne *et al.* 2008). Little is known about the foraging range except that it is rarely detected away from the coastline.



Two other unique mangrove obligate species, *Nyctophilus arnhemensis* and *N. geoffroyi palescens*, are often encountered in the same mangrove stands. The latter is an unnamed but distinct sub-species of the landward *N. geoffroyi* described by Thomas (1913) and included herein following McKenzie and Bullen (2009). These three together make up the core of the mangrove community. They each have allopatric con-generic counterparts in the regions landward environments (McKenzie and Bullen 2009).

## **Methodology**

### *Habitats*

Sites for the survey were chosen by Phoenix (Figure 1). The study area was covered with emphasis placed on detecting the priority *M. lorae* species, both at the mangrove stands and at the landward creek lines. Site-specific details are presented in Table 1. The general locations of the sites selected are given relative to local features in Figure 1.

### *Survey Timing, Moon Phase and Weather*

The systematic echolocation survey was conducted between 28<sup>th</sup> November and 3<sup>rd</sup> December 2012. The survey was conducted in a hot and dry period. All sampling evenings were warm with minimum temperatures around 25<sup>o</sup>C overnight. The moon in this period was between full and last quarter.

### *Survey Team*

Staff of Phoenix conducted the bat sampling work. No activities were conducted that directly impacted upon the bat fauna present.

R.D. Bullen of Bat Call completed analysis of echolocation recordings.

### *Systematic Sampling*

The systematic survey consisted of completing nine overnight bat sound recordings at nine sites, beginning at twilight, at locations within the survey area (Table 1). The recordings were “continuous” (Hyder *et al.* 2010) made using SM2BAT SongMeter (Wildlife Acoustics Inc, USA) detectors. The jumper and audio settings used for the SM2BAT followed the manufacturers recommendations for bat detection contained in the user manual (Wildlife

Acoustics 2010). Selectable filters and triggers were also set using the manufacturer's recommendations, see Table 2.

For the SM2BAT recordings, once reformatted as .wav files, COOL EDIT 2000 (Now available as AUDITION from Adobe Systems Inc.) was used to display each sequence for identification. Calls were identified manually. Only good quality call sequences were used. Details of calls analysed are provided in Table 3 as recommended by Australasian Bat Society (ABS 2006). Reference data for the species identified are available in Bullen and McKenzie 2002, McKenzie and Bullen 2003 and McKenzie and Bullen 2009.

Bat activity was then characterised as “Low”, “Medium” or “High” based on the rate of call sequences recorded.

- Low species activity is referred when a species is recorded with call spacing less often than ten minutes,
- Medium species activity refers to call recordings more often than 10 minutes but less often than two minutes apart for a significant time period followed by sporadic records for the remainder of the session.
- High species activity refers to call recording more often than two minutes apart for significant periods followed by reasonably regular records for the remainder of the session.

### **Survey Limitations**

All practical aspects of the survey including site access, team make-up and experience levels, equipment used, logistics and safety support were the responsibility of Phoenix. All sites surveyed were accessible by helicopter and the recorders were set at ground level with the microphone pointing horizontally. Bat sound recording was carried out overnight beginning at twilight. The survey method using SM2 detectors gives optimum recorder effectiveness.

Bat species density is impossible to estimate from echolocation records. Bat activity is therefore substituted as an approximate guide to the relative numbers of each species using the study area. At coastal sites bat activity is often impacted for part or all of the night by high winds. Such windy conditions are detected by the SM2 as a high level of background noise in the 10 to 50

kHz range. On these nights the lower activity level should be taken as indicating the general presence of the species at the site rather than a comparative activity level.

## **Results**

Species recorded and the characteristics of their calls are presented in Table 3. Activity levels for all species are given in Table 4.

### *North-western free-tailed bat activity.*

Calls were detected at seven of the nine sites (Figure 2). Virtually continuous calls all night were recorded at sites 9 and 10. At five other more exposed sites the species was detected in numbers when the wind was relatively calm. The high number of calls and the temporal pattern of the calls detected are consistent with bats foraging across the seaward areas of the study area and the creek estuaries on the landward side. The high number of calls also indicates that the thick mangrove stands within the study area are used extensively as roost by the species.

### *Other mangrove obligate species*

The two other mangrove obligate bat species activity levels were confirmed as medium or low (see criteria above) depending upon night and site. Higher number of *N. arnhemensis* and the presence of the smaller *N. geoffroyi palescens* were generally detected at sites with high *M. loriae* activity.

### *Mangrove and landward community overlap.*

The more productive creek line at site 2 showed the overlap of the two bat communities present and presumably foraging with the majority of the landward coastal plain community present along with the larger two mangrove species.

## **Discussion and Recommendations**

Detailed evaluation of the bat species presence and activity levels in this area of the Pilbara has only recently begun to be accurately measured. Previous work (e.g. McKenzie and Bullen 2009) indicated the potential in the area for North-western free-tailed bat roosts to exist but did not provide any detail. The discovery during commercial survey work in the last few years of a minimal number of potential roosts in the coastal mangroves has highlighted the importance of these for the species.

The results of this survey indicate that the North-western free-tailed bat is foraging generally across the study area and probably roosting in the extensive mangrove stands. As a result, development of these stands and the zone adjacent to them will directly impact upon this presence. The projected project development is a relatively small one and, stand-alone, will not significantly impact the species presence. It is though one of a number that are proposed for development along this coast. It is the combined effect of these projects that may have a significant impact and therefore must be taken into account when considering the management of the species locally.

There are two recommendations for further work.

1. Regular monitoring of North-western free-tailed bat activity levels at the project should begin with the commencement of significant development activities. The impact of infrastructure construction and any pollution resulting from the port activities on the presence of the bat should be measured.
2. Immediate focus should be given to locating the alignment of the haul roads feeding the port facility away from the mature mangrove stands.

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Table 1 Site Specific details.

<b>Date</b>	<b>Site</b>	<b>Habitat</b>	<b>Recording Time</b>	<b>Easting</b>	<b>Northing</b>
27 Nov	Site 1	Landward creekline	Overnight recordings using SM2-7566	575200	7701197
28 Nov	Site 2	Landward creekline	Overnight recordings using SM2-7566	575596	7703357
28 Nov	Site 3	Dunes behind salt flats	Overnight recordings using SM2-5288	570601	7703947
29 Nov	Site 4	Dunes behind mangrove stand	Overnight recordings using SM2-5288	568948	7713204
30 Nov	Site 6	Dunes behind mangrove stand	Overnight recordings using SM2-5288	571268	7714546
2 Dec	Site 7	Exposed beach near mangrove stand	Overnight recordings using SM2-7566	567434	7715096
2 Dec	Site 8	Exposed beach	Overnight recordings using SM2-4174	569444	7713727
3 Dec	Site 9	Dunes behind mangrove stand	Overnight recordings using SM2-4174	568444	7712662
3 Dec	Site 10	Dunes near mangrove stand	Overnight recordings using SM2-7566	569930	7711473

All sites are in zone 50K

Table 2 SM2 Audio settings used during survey.

Parameter	Setting
Sample rate	384,000 kHz
Channel used	Left
Compression protocol	WAC4 (12 bit audio samples)
Gain - left channel	0.00
Digital high pass filter Left channel	fs/48 (giving 8 kHz minimum frequency)
Digital high pass filter Left channel	Off
Triggering level Left channel	6SNR (adaptive +6 dB triggering)
Triggering window Left channel	1.0 sec.

Note: These settings are as recommended in Wildlife Acoustics (2010) except the high pass filter. This is set lower to 8kHz to record any *Tadarida australis* that may be present

Table 3: Summary of Echolocation call characteristics for microbat species present.

Genus species Authority	Common name	Abbreviation	Typical $F_{peakC}$ kHz	Ave. $Q$	Typical Duration msec	Typical Call Shape
<i>Chalinolobus gouldii</i> (Grey 1841)	Gould's wattled bat	Cg	32	10	7 - 11	FM
<i>Mormopterus loriae cobourgiana</i> Johnson 1959	Little north-western free-tailed bat	MI	32	10	7 - 14	Shallow FM
<i>Nyctophilus arnhemensis</i> Johnson 1959	Northern long-eared bat	Na	52	3	5	Steep FM
<i>Nyctophilus geoffroyi</i> Leach 1821	Lesser long-eared bat	Ngg	45	3	5	Steep FM
<i>Nyctophilus geoffroyi palescens</i> (Thomas 1913)	Unnamed sub-species of the Lesser long-eared bat	Ngp	48	3	5	Steep FM
<i>Saccolaimus flaviventris</i> (Peters 1867)	Yellow-bellied sheath-tailed bat	Sf	18	9	12 - 21	CF - FM
<i>Scotorepens greyii</i> (Gray 1843)	Little broad-nosed bat	Sg	38	10	7 - 13	FM
<i>Taphozous georgianus</i> Thomas 1915	Common sheath-tailed bat	Tg	24.5	14	9 - 18	CF– shallow FM
<i>Vespadelus finlaysoni</i> (Kitchener, Jones and Caputi 1987)	Inland cave bat	Vf	55	14	4 - 8	FM

Note:  $F_{peakC}$  and  $Q$  are defined in McKenzie and Bullen 2003, 2009.



Table 4. Microbat lists obtained presented by site.

Date	Site	<i>Chalinolobus gouldii</i>	<i>Mormopterus loriae</i>	<i>Nyctophilus arnhemensis</i>	<i>Nyctophilus geoffroyi geoffroyi</i>	<i>Nyctophilus geoffroyi palescens</i>	<i>Saccolaimus flaviventris</i>	<i>Scotorepens greyii</i>	<i>Taphozous georgianus</i>	<i>Vespadelus finlaysoni</i>
27 Nov	Site 1		Low	Low			Low		Low	
28 Nov	Site 2	Low	Low	Low	Low		Low	Low	Med	High
28 Nov	Site 3						Low			
29 Nov	Site 4 Note 2.		Low	Low						Low
30 Nov	Site 6 Note 2.		High					Low		Low
2 Dec	Site 7									Low

Date	Site	<i>Chalinolobus gouldii</i>	<i>Mormopterus loriae</i>	<i>Nyctophilus arnhemensis</i>	<i>Nyctophilus geoffroyi geoffroyi</i>	<i>Nyctophilus geoffroyi palescens</i>	<i>Saccolaimus flaviventris</i>	<i>Scotorepens greyii</i>	<i>Taphozous georgianus</i>	<i>Vespadelus finlaysoni</i>
2 Dec	Site 8 Note 2.		Med	Med		Low		Low		Low
3 Dec	Site 9		High	Med			Low	Low		High
3 Dec	Site 10		High			Low		Low	Low	

Note 1: Low activity refers to call spacings that repeat less often than 10 minutes.

Med activity refers to call records that repeat more often than 10 minutes but less often than 2 minutes for significant periods of time then sporadically for the duration of the recording.

High activity refers to calls that repeat more often than 2 minutes for significant periods of time then periodically for the duration of the recording.

Note 2: bat activity was restricted at this site due to high winds

Figure 1. Planned site locations at “Balla Balla” relative to district features and the study area boundary.

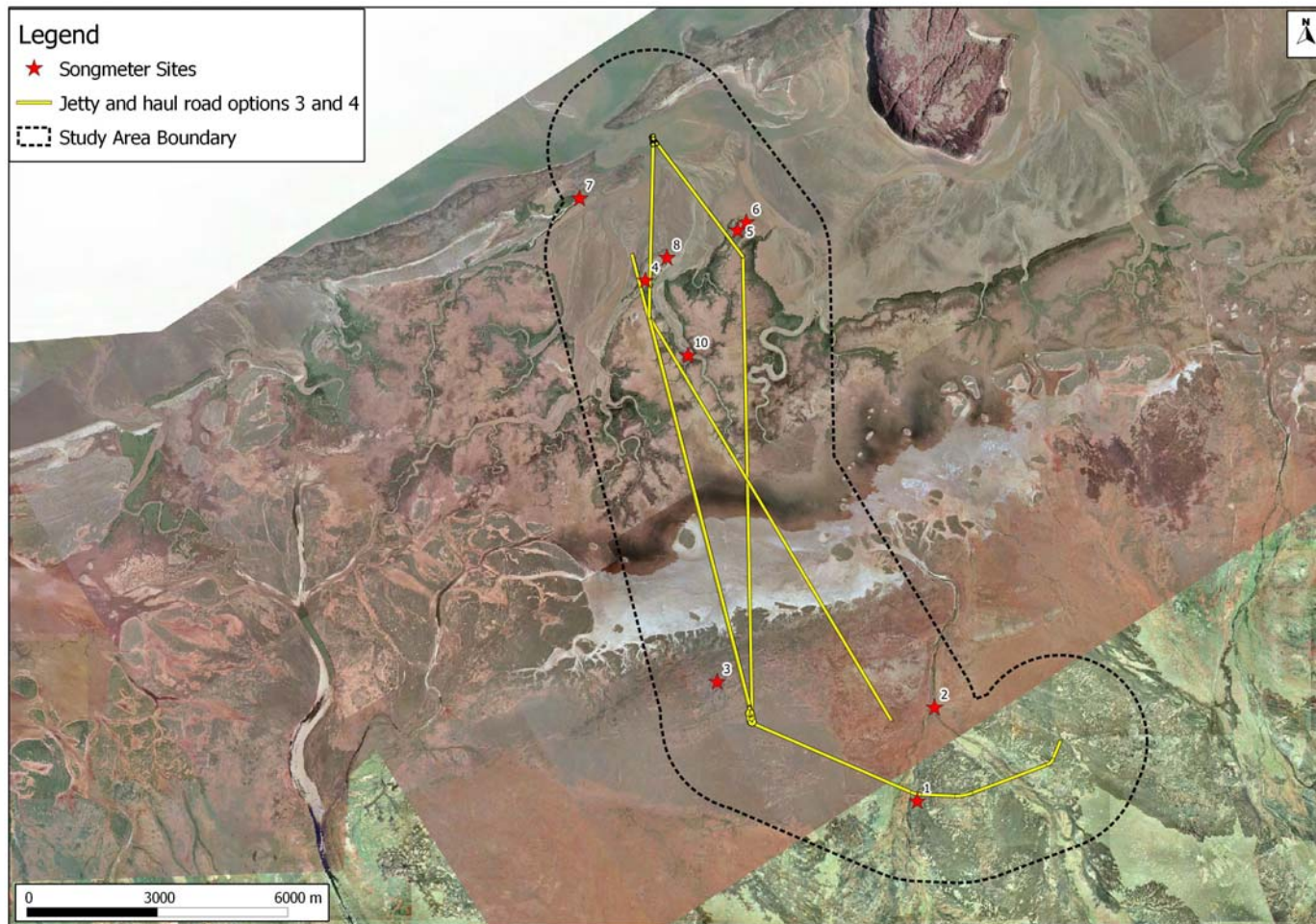
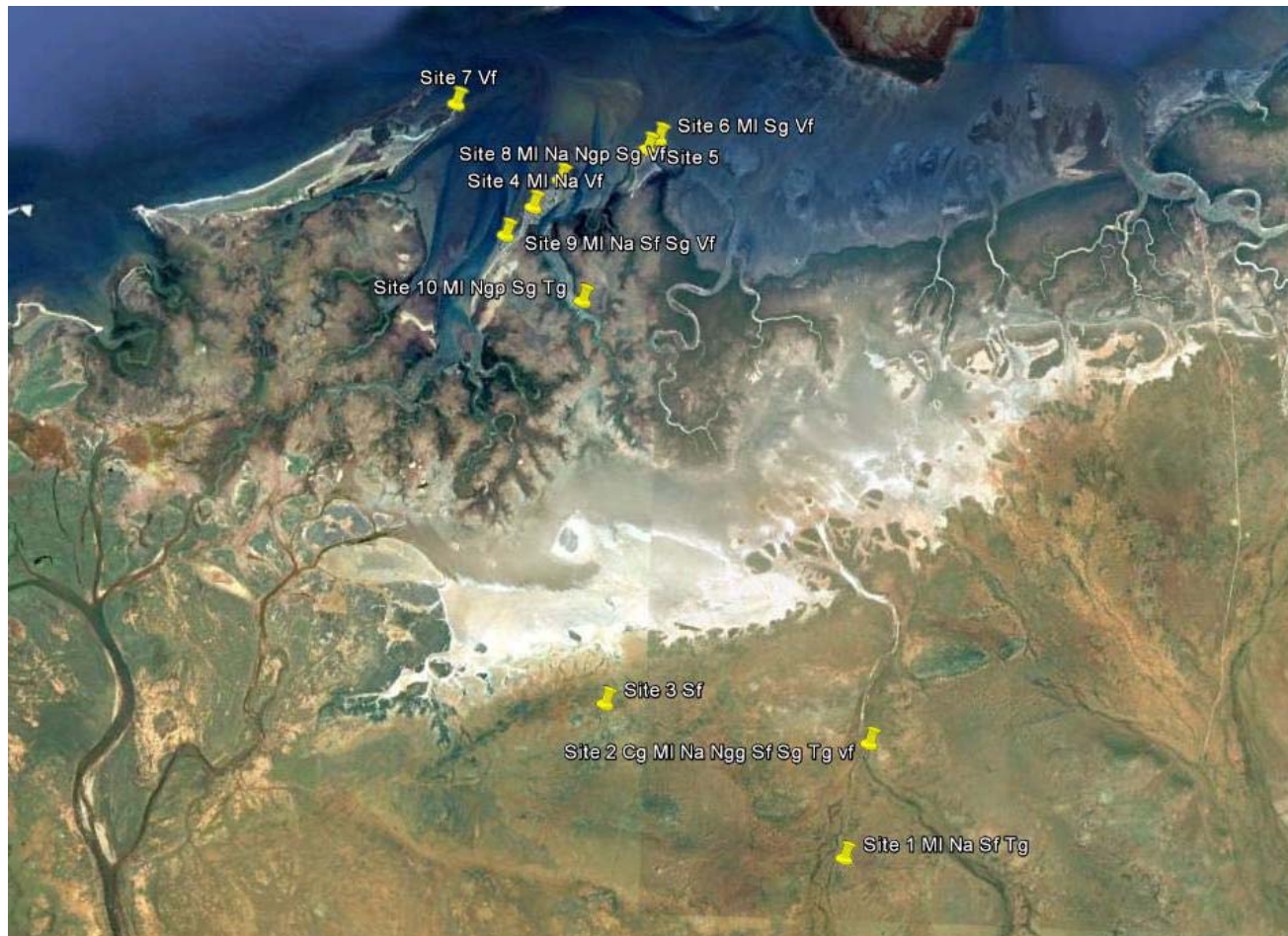


Figure 2. Results of survey at “Balla Balla”. The pins indicate sites where overnight recordings were made. The abbreviations associated with the pins indicate the species that were detected at the site. The five sites associated with the mature mangrove stands clearly show the presence of the mangrove community of bats at the site. The landward site 2 shows the overlap of the mangrove and landward bat communities that are using the creek estuaries for foraging.





**Appendix 7     Short-range endemic invertebrate target taxa recorded during survey**

Higher taxon	Genus and species	SRE 01	SRE 06	Vert 01	Vert 02	Vert 03	Vert 05	Total
<b>Order Araneae (spiders) – infraorder Myalomorphae (trapdoor spiders)</b>								
Nemesiidae	<i>Aname</i> sp. indet.			1		1		2
<b>Order Pseudoscorpiones (pseudoscorpions)</b>								
Olpiidae	Olpiidae sp. indet.		2					2
<b>Order Scorpiones (scorpions)</b>								
Buthidae	<i>Lychas</i> cf. <i>mjobergi</i>			1		1		2
<b>Order Isopoda (slaters)</b>								
Armadillidae	<i>Buddelundia</i> '10 1016A'			1		8		9
Aramadillidae	<i>Buddelundia</i> ' 10 1016B'	8						8
<b>Order Eupulmonata (land snails)</b>								
Camaenidae	<i>Rhagada convicta</i> (Cox, 1870)		1	9	3	2	8	23
Helicidae	<i>Cochlicella acuta</i> (Müller, 1774)			1				1
Helicidae	<i>Theba pisana</i> (Müller, 1774)					1		1
<b>Total</b>		<b>8</b>	<b>3</b>	<b>13</b>	<b>3</b>	<b>13</b>	<b>8</b>	<b>48</b>

