Goldsworthy Iron Ore Mining Operations – Cundaline and Callawa Mining Operations

Targeted Fauna Assessment

October 2008

bhpbilliton

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BHP Billiton Iron Ore

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Targeted Fauna Assessment

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Executive Summary

BHP Billiton Iron Ore Pty Ltd (BHPBIO) commissioned Outback Ecology Services (OES) to undertake a targeted fauna assessment of the Cundaline and Callawa deposits within the Goldsworthy Iron Ore Mining Operations. The Cundaline and Callawa deposits are located approximately 170 kilometres (km) and 190 km to the south-east of Port Hedland respectively, in the north-eastern Pilbara region of Western Australia.

This fauna assessment was prepared as part of the environmental assessment for the Cundaline and Callawa deposits. It draws from a number of previous vertebrate fauna surveys in the area including specific surveys undertaken within the Cundaline and Callawa study areas by *ecologia* (2005a, 2005b). This report contains the relevant components of the *ecologia* (2005a, 2005b) reports, including methods, results and fauna species lists. This fauna assessment also documents the terrestrial invertebrate short-range endemic (SRE) surveys undertaken by ENV and OES in 2008.

The specific objectives for the targeted fauna assessment are:

- Conduct an all-inclusive fauna database search and literature review of the two study areas drawing on information from comprehensive surveys conducted in 2005 by *ecologia*.
- Undertake a comprehensive terrestrial invertebrate short-range endemic (SRE) survey to identify species occurring or likely to occur within the study areas.
- Provide a description of available terrestrial SRE habitat within the study areas.
- Provide a description of available vertebrate fauna habitat assessment of the study areas.
- Assess survey findings in the regional context by comparisons with available data from other localities to provide an evaluation of SREs of conservation significance.

Short-range Endemics

With consideration to the existing study area environment and following consultation with specialists at the DEC, WAM and UWA, the following invertebrate groups prone to short-range endemism were targeted in this assessment: Mygalomorph Spiders (Mygalomorphae); Pseudoscorpions (Pseudoscorpionida); Scorpions (Scorpionida); Millipedes (Myriopods); and Terrestrial Molluscs (Pulmonata).

The surveys were completed in two stages. The first stage involved a targeted mygalomorph spider survey within the study areas by ENV Australia. The second stage was conducted by OES and involved a comprehensive survey for all invertebrate groups with potential for short-range endemism; a SRE habitat assessment; and a vertebrate fauna habitat assessment.

There were no known SRE invertebrate species identified as a result of the survey within the Cundaline and Callawa study areas. However, some specimens were collected where their potential for short-range endemism could not be determined due to taxonomy. These were: the mygalomorph spider *Conothele* sp., the pseudoscorpion *Austrohorus* sp., the centipede *Cryptops* sp. and centipedes from the Family Schendylidae.

Habitat with the potential to support SRE invertebrates was identified on both ridges in the form of south-west-facing and south-east-facing ridges. These south-west-facing and south-east-facing ridges make up a relatively small proportion of the overall study areas; however sections of these ridges lie within the proposed disturbance footprints of the Cundaline and Callawa mining operations..

Vertebrate Fauna Species

Systematic sampling and opportunistic collecting during the 2005 Cundaline field survey by *ecologia* yielded 11 mammal species (10 native), 41 birds, 18 reptiles and one amphibian. Systematic sampling and opportunistic collecting during the 2005 Callawa field survey by *ecologia* yielded 12 mammal species (11 native), 43 birds, 19 reptiles and one amphibian.

Eight conservation significant vertebrate fauna species have been recorded at Callawa and Cundaline, across two separate surveys since 2005: Northern Quoll, Pilbara Leaf-nosed Bat, Ghost Bat, Western Pebble-mound Mouse, Peregrine Falcon, Australian Bustard, Rainbow Bee-eater and Pilbara Olive Python.

At both the Cundaline and Callawa study areas, four main vertebrate fauna habitats were identified. These were: drainage lines, hilltops, ridges, and slopes and plains. Drainage lines and ridges provide good quality habitat for vertebrate fauna species as they contain areas of shelter and refuge (caves, crevices, water bodies, leaf litter and woody debris). Hilltops as well as slopes and plains provide less complex habitats for vertebrate fauna species, as very few of the above characteristics are present. Shelter is found for some vertebrate fauna species under rocky screes.

All vertebrate habitats present over the study area are widely represented throughout the region, and the vertebrate fauna assemblage recorded is similar to other regional sites. Considering the measures to manage potential impacts outlined in the previous Goldsworthy Environmental Management Plan, it is considered that the continuation of those measures for the planned Cundaline and Callawa mining operations would minimise potential impacts on vertebrate fauna.

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1.0 INTRODUCTION

1.1 Project Background

BHP Billiton Iron Ore Pty Ltd (BHPBIO) commissioned Outback Ecology Services (OES) to undertake a targeted fauna assessment of the Cundaline and Callawa deposits within the Goldsworthy Iron Ore Mining Operation. The Cundaline and Callawa deposits are located approximately 170 kilometres (km) and 190 km to the south-east of Port Hedland, respectively, in the north-eastern Pilbara region of Western Australia (**Figure 1**).

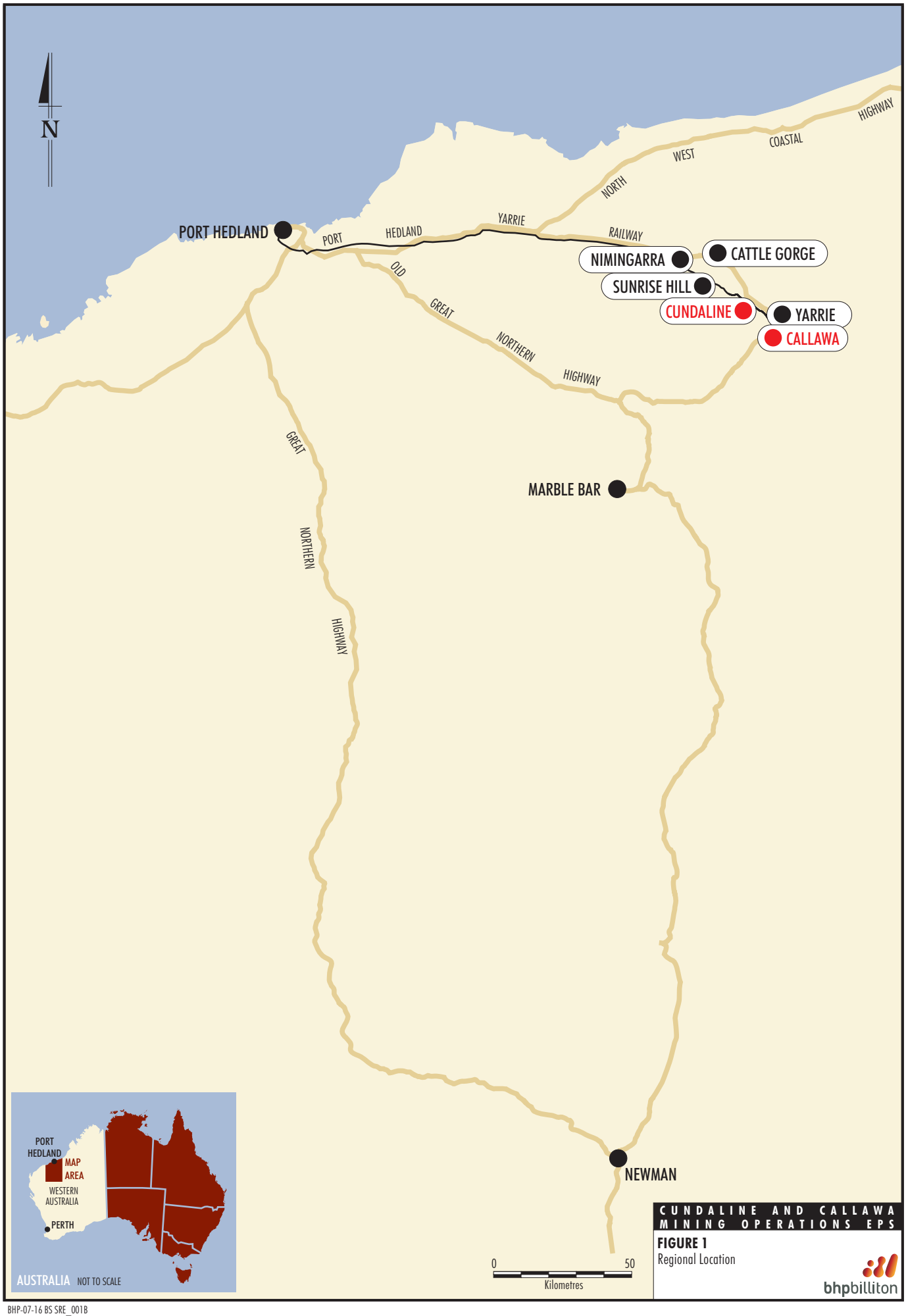
This fauna assessment was prepared as part of the environmental assessment for the Cundaline and Callawa deposits. It draws a number of previous vertebrate fauna surveys in the area including specific surveys undertaken within the Cundaline and Callawa study areas by *ecologia* (2005a, 2005b). This report contains the relevant components of the *ecologia* (2005a, 2005b) reports, including methods, results and fauna species lists. This fauna assessment also documents the terrestrial invertebrate short-range endemic (SRE) surveys undertaken by ENV Australia (ENV) and OES in 2008.

The mining components and activities that are proposed for the planned Cundaline and Callawa mining operations include:

- progressive open pit mining of overburden and ore;
- placement of overburden in mined-out voids and out-of-pit storage areas adjacent to the Cundaline and Callawa open pits;
- transportation of ore by haul truck or road train to the Yarrie crushing, screening and rail loading facilities, which are located approximately 20 km to the east of the Cundaline deposit and 2 km north of the Callawa deposit;
- stockpiling, crushing, screening and load-up of iron ore at the existing Yarrie facilities;
- continued groundwater abstraction from the Shay Gap Wellfield to meet operational demands, and distribution through the existing water supply system and pipeline extensions to the proposed mining operations at the Cundaline and Callawa deposits;
- either supply of power to the Cundaline and/or Callawa deposits via an electricity transmission line extension from the existing power supply network, or installation and use of direct generators at Cundaline and/or Callawa to meet power demand;
- construction and use of small day rooms, workshops and storage areas at the Cundaline and Callawa areas; and
- construction and use of haul and access roads to the Cundaline and Callawa areas.

Figure 2 shows the location of the planned Cundaline and Callawa mining operations in relation to the existing Goldsworthy Iron Ore Mining Operations. **Figures 3** and **4** show the Cundaline and Callawa

study areas, respectively, encompassing the deposits and associated mining components. These areas herein are referred to as the Cundaline and Callawa study areas.



CUNDALINE AND CALLAWA MINING OPERATIONS EPS

FIGURE 1
Regional Location

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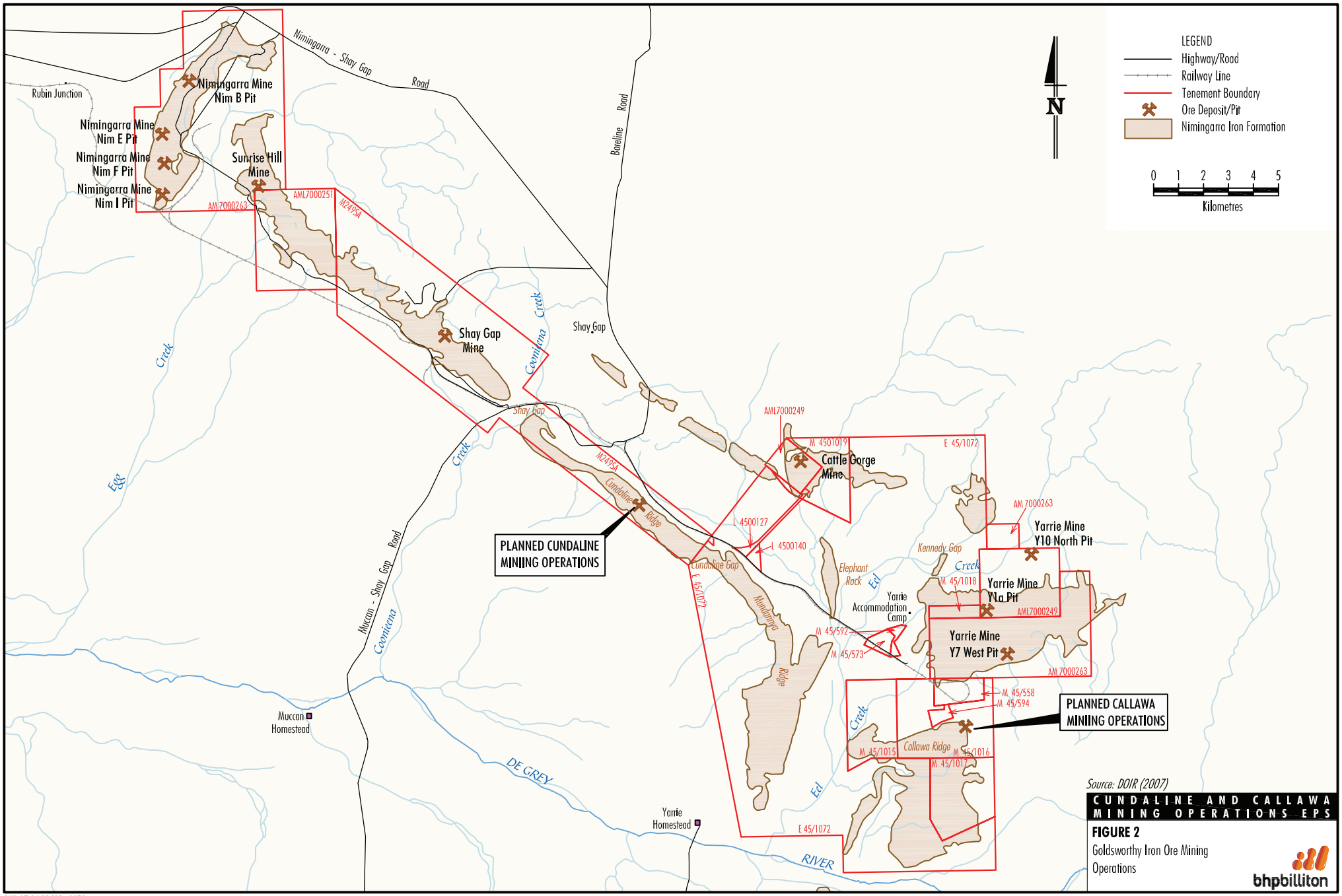
BHP-07-16 BS SRE_001B



Source: DOIR (2007)

CUNDALINE AND CALLAWA MINING OPERATIONS EPS

FIGURE 2

Goldsworthy Iron Ore Mining Operations

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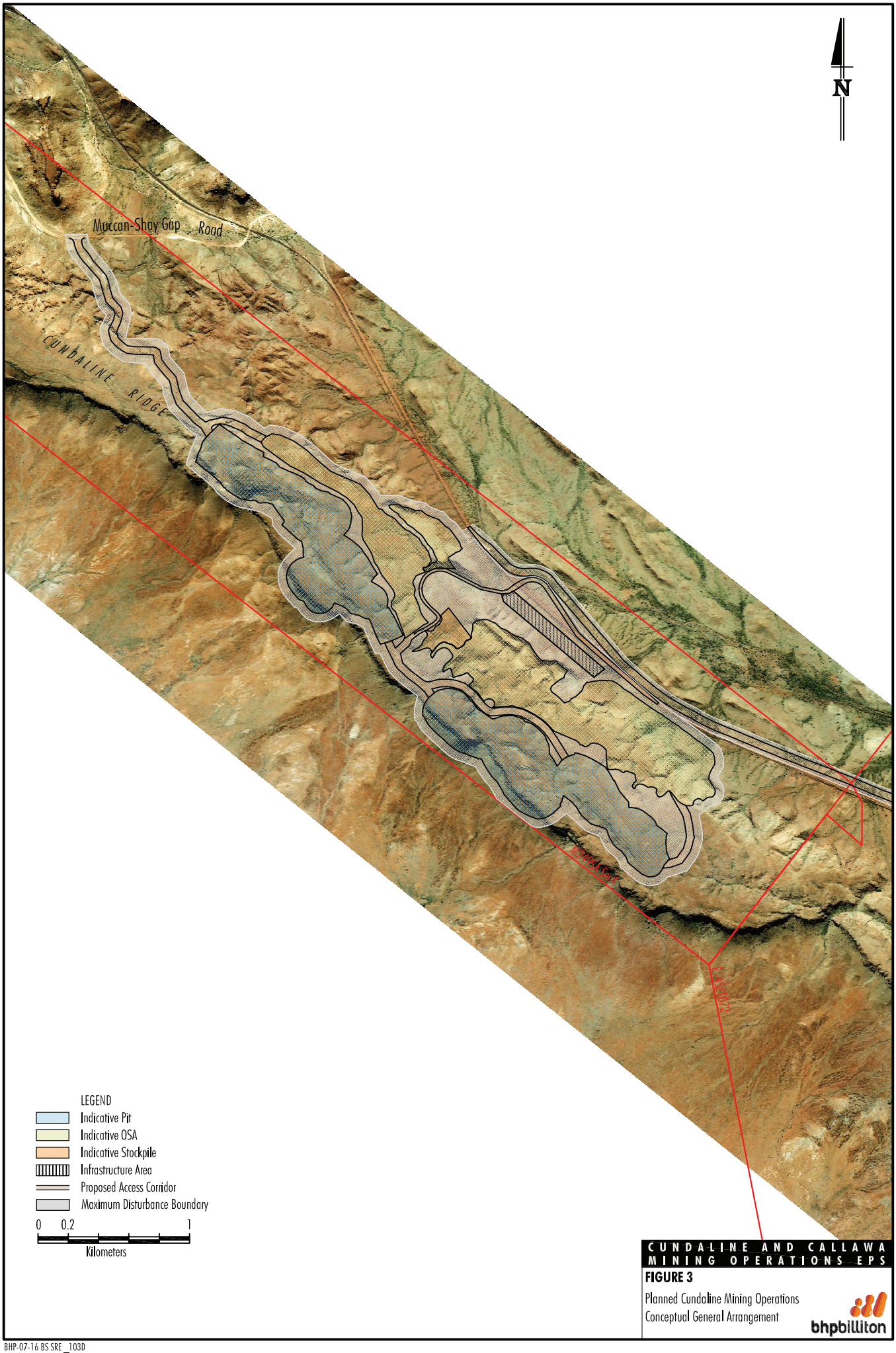
BHP-07-16 BS SRE _107C



CUNDALINE AND CALLAWA MINING OPERATIONS EPS

FIGURE 3

Planned Cundaline Mining Operations
Conceptual General Arrangement

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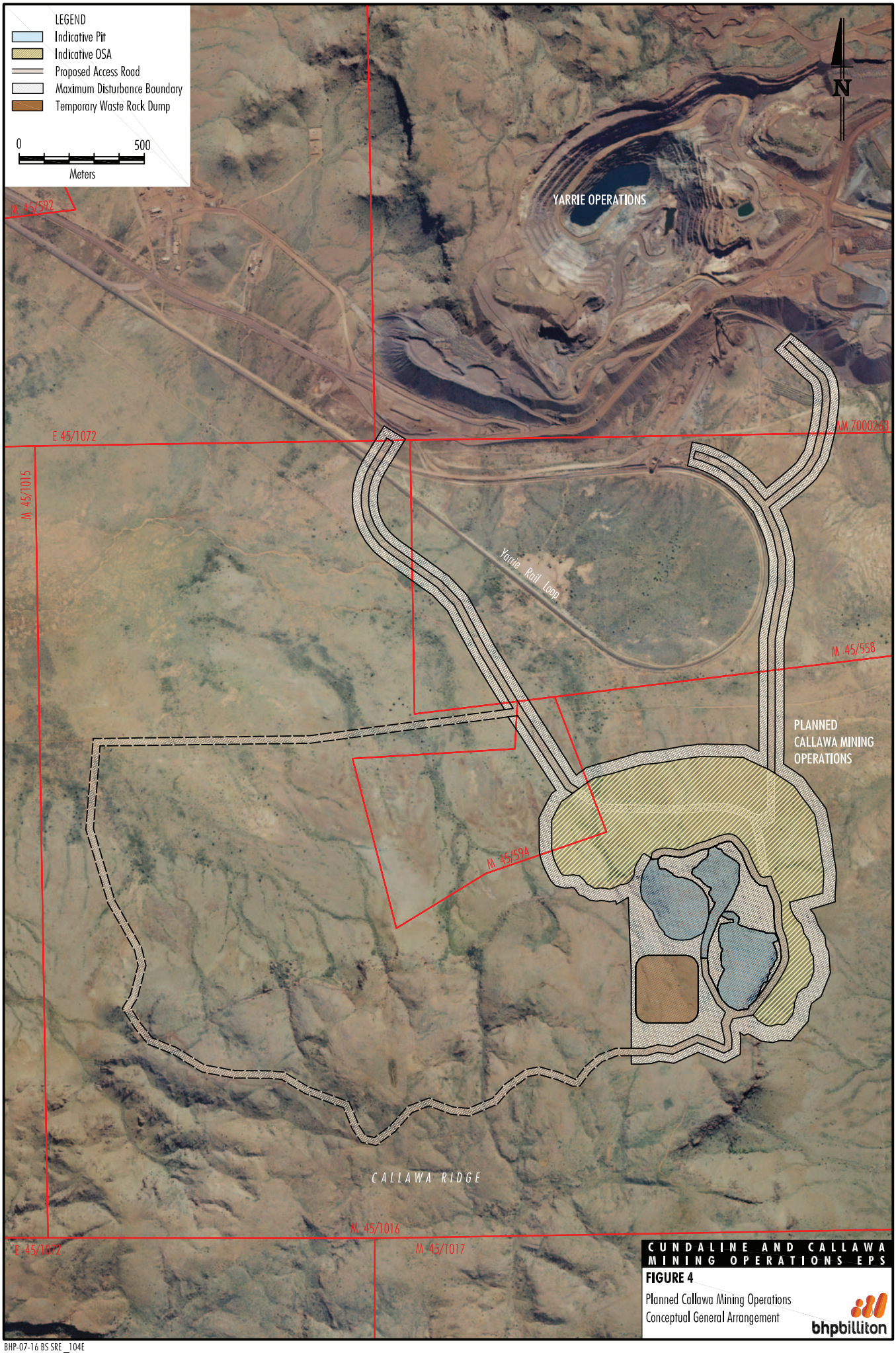
BHP-07-16 BS SRE _103D



CUNDALINE AND CALLAWA MINING OPERATIONS EPS

FIGURE 4

Planned Callawa Mining Operations
Conceptual General Arrangement

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BHP-07-16 BS SRE _104E

1.2 Short-range Endemism and Targeted Short-range Endemic Groups

Short-range Endemism

Endemism refers to the restriction of a species to a particular area, whether it is at the continental, national or local scale (Allen *et al.*, 2002). SRE species have restricted distributional ranges, usually less than 10,000 square kilometres (km^2) (Harvey, 2002).

A number of invertebrate groups have been identified as containing SRE species, such as Mygalomorph Spiders (Mygalomorphae), Pseudoscorpions (Pseudoscorpionida), Scorpions (Scorpionida), Millipedes (Myriopods) and Terrestrial Molluscs (Pulmonata) (Harvey, 2002). SRE species are generally characterised by poor dispersal, heavy reliance on discontinuous habitats, low growth rates, and low fecundity (Harvey, 2002).

In Western Australia, it is postulated that many terrestrial SRE invertebrate species have Gondwanan origins as they are relics of previously widespread species common to the southern hemisphere continents (Gondwanaland) during the Mesozoic and early Tertiary periods. The fragmentation, drifting apart and aridification of the continents has resulted in many species having restricted ranges dependant upon particular habitat requirements (Harvey, 2002; Main, 1999).

A species endemism is shaped by a range of factors such as climate variation, ecological specificity (e.g. habitat preference and physiology), life history attributes (e.g. reproductive strategies and dispersal capabilities), geological history and abiotic and biotic interactions (Ponder and Colgan, 2002; Main, 1982).

The following broad habitats have been recognised as potentially harbouring terrestrial SRE invertebrate fauna:

- Mountainous terrains/gorges - due to topographic relief providing refugial habitats that are absent from the surrounding landscape (Western Australia Environmental Protection Authority [EPA], 2004; Harvey, 2002), the presence of sheltered environments and geographically isolated habitats, and habitats receiving runoff water and plant nutrients which may produce relatively resource-rich areas (Morton *et al*., 1995).
- Rainforest patches - providing refugial habitats that are absent from the surrounding landscape (Larson, 2001), (e.g. Kimberley region) (Abbott, 1994).
- Freshwater habitats (e.g. rivers, pool and wetlands) – as species are restricted to the individual river systems or drainage basins. However, an ephemeral stream will probably never establish a differentiated population of aquatic invertebrates that lack a desiccation-resistant phase in their lifecycle (Ponder and Colgan, 2002).
- Islands (e.g. Barrow Island) (Morton *et al*., 1995).

Study of Short-range Endemic Groups

Considering the existing environment of the study area (Section 2), the results of the database and literature review (Section 3.1) and consultation between BHPBIO/Resource Strategies and Dr Mark Harvey (Western Australian Museum [WAM]), Professor Barbara York-Main (University of Western Australia [UWA]) and Professor Mike Johnson (UWA), invertebrate groups prone to short-range endemism which may occur within the study area are:

- Mygalomorph Spiders (Mygalomorphae);
- Pseudoscorpions (Pseudoscorpionida);
- Scorpions (Scorpionida);
- Millipedes (Myriopods); and
- Terrestrial Molluscs (Gastropoda).

These groups are described below.

Mygalomorph Spiders

Phylum **ARTHROPODA**
Class **ARACHNIDA**
Order **ARANEAE**
Sub-order **MYGALOMORPHA**

Harvey (2002) indicates that many mygalomorph spiders exhibit patterns of short-range endemism.

Mygalomorph Spiders comprise of the trapdoor and funnelweb spiders and are represented in Western Australia by eight families (Main, 2005). A large proportion of Mygalomorph Spider species are unnamed (Main, 2002).

In arid and semi-arid areas, mygalomorph spiders have been known to dig deep burrows (up to 60 centimetres [cm] deep) (Brunet, 1996), and exit burrows at night to feed when the temperature is lower and humidity is higher (Main, 1982). Nest micro-climate (e.g. soil moisture and temperature) is an important factor in mygalomorph spider burrow suitability (after Main, 1982).

Most mygalomorph spiders are sedentary and tend to live their entire lives within a single burrow (Main, 1982). Mygalomorph spiders are unlikely to establish new burrows, in the event their burrows are removed (after Main, 2002).

Mygalomorph spiders are sexually dimorphic, and as such both male and females are usually needed for specific identifications (Main, 2002; Framenau and Yoo, 2006). Mature males may abandon the nest when finding a mate (Main, 1982). Male mygalomorph spiders can be caught in pitfall traps at times when they are wandering in search of females (Main, 1982).

Pseudoscorpions

Phylum **ARTHROPODA**
Class **ARACHNIDA**
Order **PSEUDOSCORPIONES**

Harvey (2002) indicates that very few pseudoscorpions are SREs (after Harvey, 1998).

Pseudoscorpions occur in leaf litter, and under rocks and the bark of trees (Harvey and Yen, 1989). Similarly to scorpions, all pseudoscorpions are predators, feeding on small invertebrates (Harvey and Yen, 1989) and are generally only active during the night or in dark places during the day (Australian Museum, 2008a).

In some species of pseudoscorpion, it is common for individuals to cling to larger animals (usually insects), resulting in the pseudoscorpion being transported across distances (Harvey and Yen, 1989). The sexes are separate in pseudoscorpions (Harvey and Yen, 1989).

Scorpions

Phylum **ARTHROPODA**
Class **ARACHNIDA**
Order **SCORPIONES**

Scorpions are found all over Australia, occurring under rocks and logs, and in burrows, while a few species occur under the bark of trees, especially eucalypts (Harvey and Yen, 1989). Scorpions are predators and feed on beetles, millipedes and spiders (Harvey and Yen, 1989). Scorpions are generally only active during the night or in dark places during the day (Australian Museum, 2008a). Scorpions are typically solitary and the sexes are separate (Australian Museum, 2008a; Harvey and Yen, 1989).

Millipedes

Phylum **ARTHROPODA**
Class **DIPLOPODA**
Order **CHORDEUMATIDA, POLYDESMIDA**

Harvey (2002) indicates that many millipedes from the order Chordeumatida are SREs (after Shear and Mesibov, 1997).

Most millipedes are detritivores (Sierwald and Bond, 2007), obtaining nutrients from consumption of decomposing organic matter. Millipedes are susceptible to desiccation, movement is limited, and they are unlikely to be transported by larger animals (Sierwald and Bond, 2007).

Terrestrial Molluscs

Phylum **MOLLUSCA**
Class **GASTROPODA**
Order **ARCHAEOGASTROPODA, SORBEOCONCHA, EUPULMONATA, STYLOMMATOPHORA**

Harvey (2002) indicates that many snails of the order Archaeogastropoda are SREs. Numerous snails from the orders Sorbeoconcha and Eupulmonata are also SREs (after Ponder *et al*., 1993 and Miller *et al.,* 1999).

Snails of the order Archaeogastropoda are herbivorous and can be found amongst leaf litter, rocks or in trees (Harvey and Yen, 1989). The sexes are separate in the order Archaeogastropoda (Harvey and Yen, 1989).

Land snails prefer moist habitats, though some species of the order Archaeogastropoda are found in areas that are only occasionally moist (Harvey and Yen, 1989). EPA (2006) states that currently no mainland species of *Rhagada* sp. (order Stylommatophora) are known to have overlapping distributions. Land snails require a source of calcium for shell construction, usually sourced from soil or rock (Slack-Smith, 2002).

1.3 Report Scope and Objectives

The specific objectives for the targeted fauna survey were to:

- Conduct an all-inclusive fauna database review of the two study areas.
- Undertake a comprehensive terrestrial invertebrate SRE survey to identify species occurring or likely to occur within the study areas.
- Provide a description of available terrestrial SRE habitat within the study areas.
- Provide a description of available vertebrate fauna habitat assessment of the study areas.
- Assess survey findings in the regional context by comparisons with available data from other localities to provide an evaluation of SRE conservation significance.

2.0 EXISTING ENVIRONMENT

2.1 Climate

The study areas are located in the north-eastern Pilbara region of Western Australia. The Pilbara region experiences an arid-tropical climate which is characterised by a hot, relatively wet summer (between October and April) and a mild dry winter (between May and September). Tropical cyclones occur occasionally, usually in the months of January to April, bringing sporadic drenching rains to the region (Bureau of Meteorology [BOM] 2008).

The nearest BOM weather station with the most complete data set for the 2008 survey periods is located in Marble Bar, approximately 83 km south-west of the study areas. Significant variation in rainfall is noted across the Pilbara region, and as such, data provided should be used as a guide.

The average maximum summer temperature is 36.8 degrees Celsius (°C), with daily maximum temperatures over 40°C often recorded. In winter months, the mean maximum temperature is 29.6°C, with a mean minimum of 11.7°C (BOM, 2008). Marble Bar receives an average annual rainfall of 361.7 millimetres (mm) (BOM, 2008). The majority of rainfall falls between January and March, with the yearly maximum occurring in February (**Figure 5**).

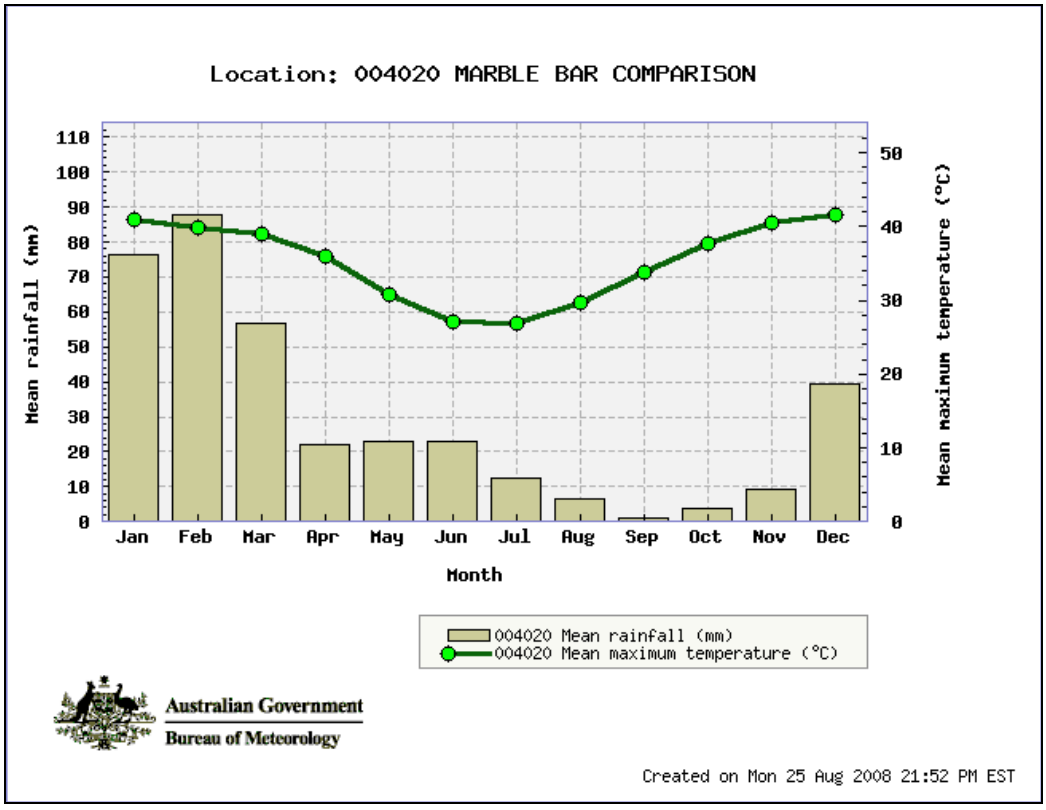


Figure 5 Climate Data for Marble Bar Comparison Station

2.2 Pilbara Biogeographic Region

Thackway and Cresswell (1995) describe a system of 85 'biogeographic regions' (bioregions) covering the whole of Australia; known as The Interim Biogeographic Regionalisation for Australia (IBRA). Bioregions are defined on the basis of climate, geology, landforms, vegetation and fauna (Environment Australia, 2000).

The study areas are located within the Chichester subregion (PIL1) of the Pilbara region (Thackway and Cresswell, 1995). The Chichester subregion is characterised by granite and basalt plains and ranges with shrub steppe, uplands dominated by hummock grasslands, ephemeral drainage lines with Eucalyptus and *Corymbia hamersleyana* woodlands, ridges and mesas, alluvial flats and river deltas (Kendrick and McKenzie, 2001). The subregion is rich and diverse in both its flora and fauna and contains many species endemic to the Pilbara region (Kendrick and McKenzie, 2001). The mountain tops and gorges of the Chichester subregion form species-rich refuges with yet undescribed flora and fauna species (Australian Natural Resource Atlas [ANRA], 2007).

2.3 Land Systems of the Project Area

A regional survey of land systems in the Pilbara region was undertaken between 1995 and 1999 by the Department of Agriculture (now the Department of Agriculture and Food) and the Department of Land Administration (now Landgate). The purpose of the survey was to develop a comprehensive description of the biophysical resources and an assessment of the condition of the soils and the vegetation of the Pilbara (Van Vreeswyk *et al.,* 2004). A component of the survey was the mapping of land types, land units and land systems of the Pilbara including the study areas (**Table 1**).

Table 1 Summary of Land Systems over the Study Areas

Land Type	Description	Land Systems
Land Type 1	Hills and ranges with Spinifex grasslands	Black, Boolaloo, Capricorn, Granite, Houndstooth, Mckay, Newman, Robertson, Rocklea, Ruth, Talga
Land Type 3	Plateaux, mesas and breakaways with Spinifex grasslands	Callawa, Coongimah, Kumina, Nanutarra, Oakover, Robe
Land Type 8	Stony plains with Spinifex grasslands	Boolgeeda, Lochnivar, Macroy, Paterson, Peedamulla, Pyramid, Satirist, Stuart, Taylor
Land Type 11	Sandplains with Spinifex grasslands	Buckshot, Divide, Giralia, Gregory, Little Sandy, Nita, Uaroo
Land Type 13	Alluvial plains with soft Spinifex grasslands	Mallina, Paradise, Urandy

Source: Van Vreeswyk *et al*., 2004

The study areas are located predominantly over Land Type 3 (Callawa Land System) and Land Type 1 (Robertson Land System) (Van Vreeswyk *et al*., 2004). The Robertson land system is described as "Hills and ranges with Spinifex grasslands" and Callawa land system as "Plateaux, mesas and breakaways with Spinifex grasslands" (Van Vreeswyk *et al*., 2004).

2.4 Landuse

Land tenure in the Pilbara region is both Aboriginal reserve and leasehold reserve, national parks and reserves and crown land which falls under a range of pastoral and mining leases. Aboriginal rock art can be found throughout the Pilbara region. The first mining explorations in the Pilbara region commenced in the early 1800s and currently the Pilbara region provides the great majority of Western Australia's petroleum, gas and iron ore export, while gold mining is also an important industry (ANRA, 2007).

The dominant landuses in the Chichester subregion include mining, pastoralism in the form of cattle grazing, native pasture, conservation, urban development and Aboriginal lands and reserves (Kendrick and McKenzie, 2001). The Chichester subregion has 6.56% of its land surface reserved under some form of conservation. The Chichester subregion contains one national park (Millstream-Chichester National Park), one conservation park (Meentheena Conservation Park) and one large nature reserve (Mungaroona Nature Reserve).

3.0 ASSESSMENT METHODS

The methods used to assess the potential impacts on SRE and terrestrial vertebrate fauna habitat is described in this section and includes a database and literature review, and field survey.

3.1 Short-range Endemic Database and Literature Review

The SRE database and literature review was undertaken to:

- identify the occurrence of existing records of potential SRE groups in the wider area;
- to facilitate the identification of available invertebrate SRE habitat within the study area; and
- to assist with the assessment of the conservation significance of the field survey results.

Although a specific database of SRE species is not available, a review of the following databases was undertaken for records of individuals from the target SRE groups:

- A search of the Australian Museum database (Australian Museum, 2008b) for invertebrates was conducted in a 200 x 200 km search area.
- A search of Biomaps - an online database which provides "tools for accessing and analysing biodiversity data" (Australian Museum and Rio Tinto, 2008).
- A search of the maps produced for land snails (order Eupulmonata) using the Australian Museum Collections of Mollusc within the *Biodiversity Analysis Tool*[1] (Commonwealth Department of the Environment, Water, Heritage and Arts [DEWHA], 2008).

The literature review included a review of:

- previous biological survey work undertaken within the Cundaline and Callawa study areas by *ecologia* (2005a; 2005b);
- previous biological survey work undertaken within the wider Goldsworthy area (*ecologia,* 2005e); and
- SRE survey work conducted within the Pilbara region (e.g. Chevron Australia, 2007; Johnson *et al*., 2004; OES, 2006; 2008a, 2008b, 2008c; ENV Australia, 2008).

3.2 Terrestrial Vertebrate Fauna Database and Literature Review

3.2.1 Terrestrial Vertebrate Fauna Database Searches

Database searches were made prior to the field survey. Search areas were defined using a central point with a 100 km buffer (the 'search area').

[1] Biodiversity Analysis Tool - is a component of the Australian Biodiversity Information Facility and is an online mapping system which 'enables the user to understand patterns in the distribution of biodiversity' (DEWHA, 2008). Biodiversity information for other short-range endemic groups listed in Section 1.2 is not provided by the Biodiversity Analysis Tool.

Database searches of these areas were made using the following databases and internet tools:

- The WAM (2008).
- Threatened and Priority Fauna Database held by the Western Australia Department of Environment and Conservation (DEC).
- The Protected Matters and Environmental Reporting Tools of DEWHA.
- The Birds Australia database (2008).
- The Australian Museum database (2008).
- The ANRA (2007) of the National Land and Water Resources Audit.

Information from the sources outlined above was augmented with additional information relating to species' likelihood of occurrence based upon personal experience and general patterns of distribution and known habitat preferences. Many of the species present on regional lists have specific habitat requirements that may be present in the general area, but not in the study areas. Some species, therefore, will be included in lists but are unlikely to be present in the actual study areas. Relevant texts from which information on general patterns of distribution was obtained included:

- Mammals: Menkhorst and Knight (2004); Van Dyck and Strahan (2008).
- Birds: Heatwole (1987); Higgins (1999); Higgins *et al*. (2001); Johnstone and Storr (1998, 2004); Morcombe (2003); Pizzey and Knight (2007); Slater *et al*. (2007).
- Reptiles: Storr *et al*. (1983, 1989, 1999, 2002); Cogger (2000); Wilson and Swan (2003, 2008).
- Amphibians: Cogger (2000); Tyler *et al*. (2000).

3.2.2 Previous Vertebrate Fauna Studies in the Study Areas

A review of literature was undertaken to provide a list of mammals, reptiles, amphibians and birds that have been recorded or have the potential to occur within the study areas. A number of vertebrate fauna surveys have been conducted in the surrounding Goldsworthy area for mining developments such as:

- Yarrie operations, located approximately 2 km north of the planned Callawa mining operations (Dames and Moore, 1992; *ecologia*, 1999);
- Cattle Gorge operations, located approximately 6 km north-east of the planned Cundaline mining operations (*ecologia*, 2004, 2005d);
- Shay Gap operations, located approximately 10 km north-west of the planned Cundaline mining operations (*ecologia*, 2005e);

- Sunrise Hill operations, located approximately 20 km north-west of the planned Cundaline mining operations (*ecologia*, 2005e); and
- Nimingarra operations, located approximately 24 km north-west of the planned Cundaline mining operations (*ecologia,* 2005e, 2005d).

The Cundaline and Callawa study areas were surveyed for terrestrial vertebrate fauna by *ecologia* in 2005. Studies conducted include:

- *ecologia* (2005a) *Cundaline Biological Assessment Survey*; and
- *ecologia* (2005b) Callawa Biological Assessment Survey.

An outline of the methods used in these surveys is provided below.

The Cundaline survey was undertaken by *ecologia* from 23 to 29 May, 2005. Six systematic sampling sites were established over a large study area across the Cundaline Ridge.

The Callawa survey was undertaken by *ecologia* from 9 to 28 June, 2005. Six systematic sampling sites were established over a large study area across the Callawa Ridge.

The survey methods used were systematic trapping and systematic searching, nocturnal spotlight searching and opportunistic records. Fauna groups targeted were mammals, birds, reptiles and amphibians.

Trapping Grids

Trapping grids consisted of:

- pit traps (16 cm diameter, minimum 35 cm deep PVC tubes; and 20 litre (L) buckets 30 cm diameter, 40 cm deep) set along a flywire drift fence 30 cm high and 5 metres (m) in length;
- a funnel trap was placed on each end of the drift fence (for 9 out of 10 pit traps);
- various sized cage traps; and
- ten medium Elliott traps (9 x 9 x 32 cm).

Bird census

A bird census was performed at each of the 12 survey sites. The number of individuals of each species at each site was recorded over a 60 minute period.

Bats

Bats were sampled primarily via echolocation call detection through an Anabat detector (Titley Electronics, Ballina, NSW). The transformed calls were stored on minidiscs using a Sony MZ-R900

Minidisc recorder and played back through a ZCAIM (Zero-Crossings Analysis Interface Module) for analysis.

The Anabat system was set up at five locations for the Cundaline survey and at three locations for the Callawa survey. Sampling locations were based on the presence of suitable bat habitat such as caves and gorges. Echolocation call was sampled between 5.00 pm and 8.00 pm to correspond with bats leaving predicted roosting sites.

Opportunistic Sightings and Secondary Evidence

Opportunistic sightings of vertebrate fauna were recorded during targeted searching, whilst travelling and during trap establishment within the Cundaline and Callawa study areas during the day or night. Secondary evidence of vertebrate fauna recorded included tracks, diggings, scats, burrows, and nests.

Survey Effort

Survey effort during the Cundaline survey totalled 390 pit trap nights, 390 Elliot trap nights, 351 funnel trap nights, 78 cage trap nights, 13.5 hours spotlighting and 34 hours active searching.

Survey effort during the Callawa survey totalled 960 pit trap nights, 960 Elliot trap nights, 864 funnel trap nights, 192 cage trap nights, 5 hours spotlighting and 46.16 hours active searching.

3.3 Short-range Endemic Field Survey

Guidelines for conducting SRE surveys were being drafted by the DEC and the EPA at the time of writing this report. Due to the absence of available guidelines, OES has maintained consultation with SRE specialists from the DEC, UWA and the WAM. Recommendations from regulators and SRE specialists were incorporated into the survey timing (Section 3.2.1), survey design (Section 3.3.2), location of sampling sites (Section 3.3.3) and survey techniques (Section 3.3.4).

Additionally, the objectives and methodology adopted for this survey are aligned, where practicable, with the following EPA Guidelines:

- Guidance Statement No. 56: *Guidance for the Assessment of Environmental Factors: Terrestrial Fauna Surveys for Environmental Impact Assessment in Western Australia* (EPA, 2004); and
- Position Statement No. 3: *Terrestrial Biological Surveys as an Element of Biodiversity Protection* (EPA, 2002).

3.3.1 Survey Timing and Weather

Three separate surveys were undertaken as part of the SRE assessment of the study areas. ENV Australia conducted the first two surveys which focused on the collection of mygalomorph spiders at Callawa from 11 to 18 April 2008 and Cundaline from 26 April to the 1 May 2008. During ENV's surveys at Cundaline and Callawa minimum temperatures ranged from 18.1º to 23.3ºC and 17.0º to

26.8ºC, respectively, while maximum temperatures ranged from 35.8º to 37.4ºC and 36.3º to 39.0ºC, respectively. The third survey conducted by OES was over a ten day period from 2º to 12ºJuly 2008 and included a comprehensive survey, targeting all terrestrial invertebrate groups outlined in Section 1.2. The weather during the survey was fine and sunny with no rain. Minimum temperatures ranged from 7.5º to 17.2ºC while maximum temperatures ranged from 27.0º to 30.9ºC. **Table 2** summarises climatic data recorded for the region during the survey periods.

The amount of rainfall received six weeks prior to and during a survey may have influenced the number of SRE species captured. SREs (particularly mygalomorph spiders) are known to be most active just prior, during and after a rainfall event (B. Y. Main, pers. comm., August 2008).

Table 2 Meteorological Data Recorded During the Survey Periods

Date	Minimum Temperature (°C)	Maximum Temperature (°C)	Rainfall (mm)	Average Relative Humidity (%)
Callawa ENV survey[1]				
11/04/08	26.8	39.0	0	19.5
12/04/08	26.3	37.1	0	26.5
13/04/08	24.6	37.0	0	20.0
14/04/08	22.6	38.2	0	14.0
15/04/08	24.6	38.4	0	12.0
16/04/08	20.0	37.2	0	10.0
17/04/08	17.0	36.3	0	8.5
Cundaline ENV survey[1]				
26/04/08	23.3	36.5	0	13.0
27/04/08	18.5	37.4	0	15.0
28/04/08	18.5	37.2	0	27.0
29/04/08	18.1	36.9	0	19.0
30/04/08	21.0	36.2	0	25.0
1/05/08	19.4	35.8	0	24.0
Cundaline and Callawa OES survey[2]				
2/7/2008	15.9	30.9	0	19
3/7/2008	17.2	27.7	0	34
4/7/2008	13.6	29.1	0	63
5/7/2008	13.5	28.7	0	54
6/7/2008	13.4	28.4	0	21
7/7/2008	15.2	27.0	0	20
8/7/2008	16.2	29.7	0	14
9/7/2008	13.1	28.4	0	26
10/7/2008	9.3	27.8	0	22
11/7/2008	7.5	28.0	0	19
12/7/2008	8.7	29.3	0	19

[1] Marble Bar Meteorological Station.

[2] Port Hedland Meteorological Station (Marble Bar data not available).

Within the six weeks prior to ENV's April surveys of the Cundaline and Callawa study areas, the region experienced 39.2 mm and 44.4 mm of rain, respectively. Within the six weeks prior to the OES July survey of Cundaline and Callawa, the region received a total of 90.6 mm of rainfall. No rainfall was recorded during any of the three survey periods. The amount of rainfall prior to and during the sampling periods is shown in **Figure 6**. Rainfall data was sourced from the Marble Bar Meteorological Station from the 29 February 2008 to 24 June 2008 and from the Port Hedland Meteorological Station from the 25 June 2008 to 18 July 2008, as the Marble Bar data was unavailable during the entire period.

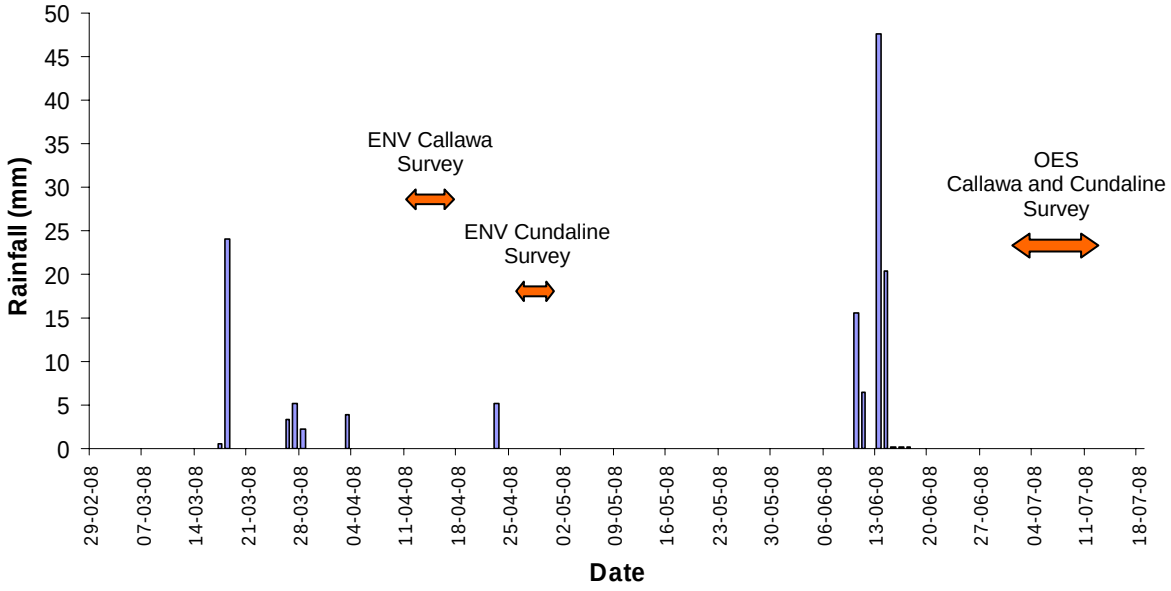


Figure 6 Rainfall Recorded Prior to and During the SRE Survey Periods

3.3.2 Survey Design

The survey was designed following consultation with the DEC, and specialists from the UWA and the WAM.

Autumn Survey

Sampling for mygalomorph spiders was conducted at Callawa from the 11 to 18 April 2008; and at Cundaline from the 26 April to the 1 May 2008, by ENV.

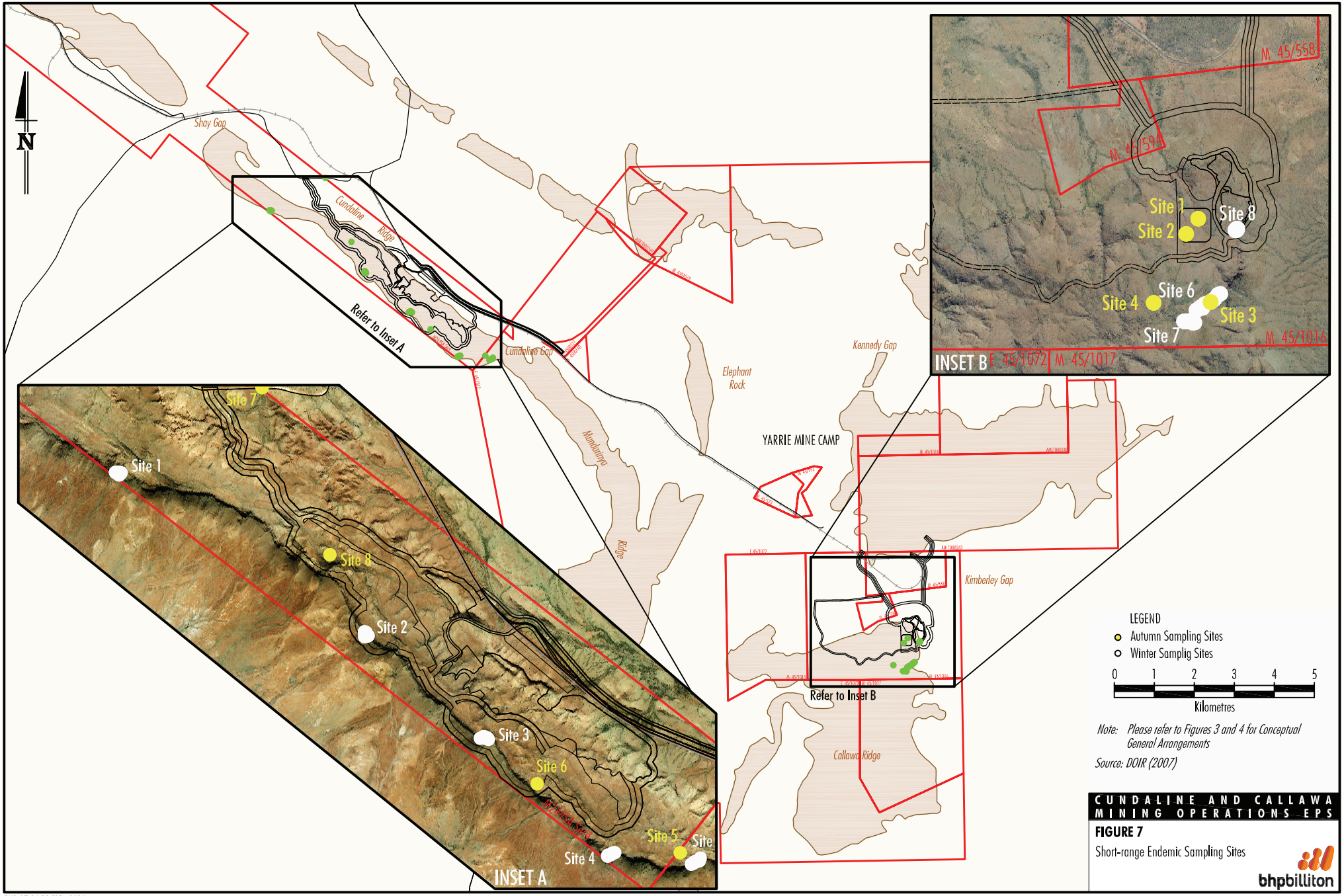
Four sampling sites, each consisting of ten pitfall traps along a 4 m long drift fence, were established in each of the study areas. The pitfall traps on the Cundaline Ridge were left open for five nights and the

pitfall traps on the Callawa Ridge were left open for six to seven nights. The traps were checked daily for by-catch.

Opportunistic searches were conducted amongst leaf litter. The litter was placed onto a white sheet and sorted.

Winter Survey

An additional eight sites (five at Cundaline and three at Callawa) were established by OES in winter along the Callawa Ridge and Cundaline Ridge (**Figure 7**). The number of sampling sites chosen was based on the occurrence of potential SRE habitat within the study areas.



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3.3.3 Sampling Sites

Autumn Survey

During the autumn surveys of the Cundaline and Callawa study areas, a total of eight sampling sites were established, four within each study area (**Table 3**). The location of these sites is shown in **Figure 7**.

Table 3 Autumn Survey Short-range Endemic Sampling Site Locations

Site Name	Site Type	Study Area	Site Co-ordinates Datum: WGS 84	
S01	Impact	Callawa	20º33'00.4"S	120º10'21.3"E
S02	Reference	Callawa	20º38'33.8"S	120º18'11.9"E
S03	Reference	Callawa	20º38'51.6"S	120º18'18.4"E
S04	Reference	Callawa	20º38'51.6"S	120º18'02.6"E
S05	Reference	Cundaline	20º34'34.7"S	120º12'15.0"E
S06	Impact	Cundaline	20º34'12.5"S	120º11'28.3"E
S07	Reference	Cundaline	20º32'08.1"S	120º10'00.0"E
S08	Impact	Cundaline	20º33'00.4"S	120º10'21.3"E

Winter Survey

During the winter survey of the Cundaline and Callawa study areas, a total of eight sampling sites were established (**Table 4**). The location of these sites is shown in **Figure 7**. Five sites were established along the Cundaline Ridge (Sites 1 to 5), and the remaining three sites were located along Callawa Ridge (Sites 6 to 8).

Table 4 Winter Survey Short-range Endemic Sampling Site Locations

Site Name	Site Type	Study Area	Co-ordinates Datum: WGS 84	
S01	Reference	Cundaline	20º32'34.6"S	120º09'13.5"E
S02	Impact	Cundaline	20º33'25.5"S	120º10'32.4"E
S03	Impact	Cundaline	20º33'58.1"S	120º11'11.3"E
S04	Reference	Cundaline	20º34'35.0"S	120º11'52.0"E
S05	Reference	Cundaline	20º34'37.7"S	120º12'19.9"E
S06	Reference	Callawa	20º38'51.6"S	120º18'18.2"E
S07	Reference	Callawa	20º38'56.5"S	120º18'12.3"E
S08	Impact	Callawa	20º38'33.0"S	120º18'25.9"E

Representative sampling sites were chosen with consideration to the proposed zone of direct impact, as well as the zone of wider interest. The targeted habitats contained:

- deep litter deposits accumulated under vegetation;
- south-west-facing and south-east-facing ridges, gorges, rocky outcrops, deep crevices and caves that provided shade and shelter; and
- ephemeral creeklines that provided moisture, friable soils, and deep litter.

Site selection was limited by accessibility with in the study areas which is primarily governed by existing exploration/drill tracks.

A description of the sampling sites selected by OES is provided below:

Site 01 was a reference site established in the north-western end of the Cundaline study area on the south-west face of the Cundaline Ridge (**Plate 1**). The area was shaded for most of the day with some afternoon sun in the more exposed areas. The cliff face was approximately 20m high and had been undercut by water flow and formed a large overhang providing sheltered and relatively moist conditions. Vegetation was dominated by a large grove of *Ficus* sp. that had contributed to substantial levels of decomposing leaf litter. Moisture levels are likely to be higher than in the surrounds as ficus usually need access to water. There were also a number of grasses such as *Eragrostis* sp. and *Cymbopogon* sp. present as well as a low story of Acacias and Eucalypts. A clear transition from these species into *Triodia* sp. was apparent on the exposed regions of the slope.

Plate 1 **Site 01 - Reference site located within the northern section of the Cundaline study area**

Site 02 was located in a potential impact area within the southern section of the Cundaline northern ore deposit (**Plate 2**). This site was made up of a south-west rocky slope with a series of rocky outcrops rather than a defined cliff-face. The lack of a defined cliff face increases the exposure of this site in comparison to the other sites. As a result, the vegetation was dominated by *Triodia* sp., *Acacia* sp. and *Grevillea wickhamii* subsp. *hispidula*. In the more sheltered areas beneath the outcrops grasses such as *Eragrostis* sp. and *Cymbopogon* sp. were present.

Plate 2 Site 02 - Proposed impact area of the Cundaline study area

Site 03 was located within a proposed impact area against a south to south-west facing ridge approximately 15 m high, within the southern ore deposit of Cundaline Ridge (**Plate 3**). The site was shaded for most of the day providing cool moist conditions. These conditions were conducive to several *Ficus* sp. plants which were observed to be growing at the base of the rock face. Litter accumulation and decomposition was greatest beneath these *Ficus* sp. plants. An understorey comprised grass species dominated by *Eragrostis* sp. and *Cymbopogon* sp. There was a clear transition from these grasses to *Triodia* sp. further down the slope in areas that were exposed.

Plate 3 Site 03 - Proposed impact area of the Cundaline study area

Site 04 was a reference site established at the southern end of the Cundaline study area. The ridge was approximately 15 m high and had a south to south-west aspect (**Plate 4**). The site was relatively well sheltered throughout the day and had a diverse vegetation assemblage as a result. Dominant species included *Acacia* sp. and *Eucalyptus leucophloia*, with an understorey of *Eragrostis* sp. and *Cymbopogon* sp. There were also a number of *Ficus* sp. present along with a number of ferns (*Cheilanthes* sp.). *Triodia* sp. and *Grevillea wickhamii* subsp. *hispidula* were present on the lower exposed sections of the slope.

Plate 4 **Site 04 - Reference site located at the southern end of the Cundaline study area**

Site 05 was a reference site located in the south-east section of the Cundaline study area. The ridge was approximately 20 m high and had a southern aspect (**Plate 5**). Vegetation at this site was predominantly *Eucalypts* spp. and *Acacia* spp. with an understorey of scattered *Eragrostis* sp. *Triodia* sp. became dominant within 5 m of the base of the ridge with a number of *Grevillea wickhamii* subsp. *hispidula* also being present in exposed areas of the slope. One *Ficus* sp. plant was present at this site.

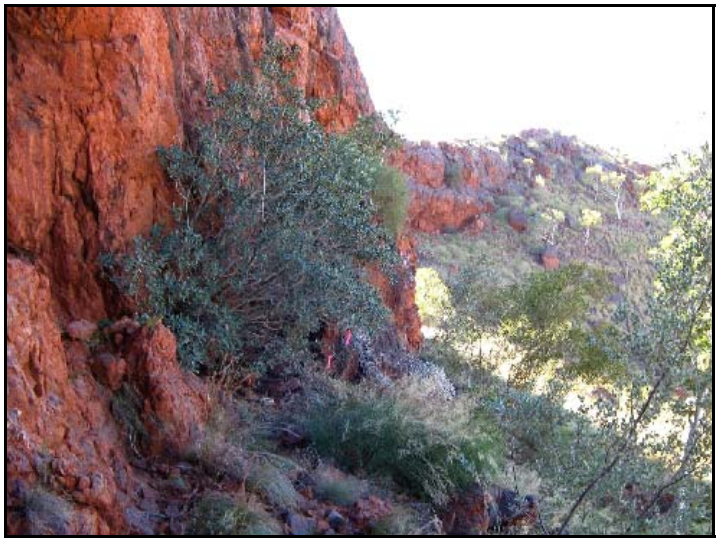


Plate 5 **Site 05 - Reference site located within the south-east section of the Cundaline study area**

Site 06 was a reference site within the Callawa study area (**Plate 6**). This site was dominated by rocky outcropping, offering both protected and exposed areas. The exposed areas supported a vegetation community dominated by a number of *Acacia* spp. and *Triodia* sp., where as the more sheltered regions supported *Eucalypts* spp., *Eragrostis* sp. and *Cymbopogon* sp. grasses with some *Ficus* sp. There were substantial amounts of leaf litter that had accumulated beneath the *Ficus* sp. Sampling sites were located within the sheltered regions of this site.

Plate 6 **Site 06 - Reference site within Callawa study area with rocky outcropping**

Site 07 was a reference site located in a drainage line in the southern section of the Callawa study area (**Plate 7**). The drainage line was internally draining in a west direction which offered a protected south-facing slope and an exposed north facing slope. Sampling and pit trapping sites were located on the south-facing slope which offered shelter from outcropping. Dominant vegetation included *Eragrostis* sp. and *Acacia* sp., in the sheltered regions with *Triodia* sp. becoming dominant in the more exposed regions.

Plate 7 **Site 07 - Reference site located in a drainage line within the Callawa study area**

Site 08 was located within the proposed impact area of the Callawa deposit. The ridge was approximately 20 m high and faced a southern direction (**Plate 8**). The shelter provided by the ridge allowed for a diverse range of vegetation to become established and was dominated mostly by *Acacia* spp. and *Eucalypt* spp. Grass species were dominated by *Cymbopogon* sp. with some *Eragrostis* sp. being present. A number of caves were also present at this site. *Triodia* sp. did not become dominant at this site until some distance down the slope.

Plate 8 Site 08 - Proposed impact area within the Callawa deposit

3.3.4 Survey Methods

Autumn Survey

The autumn survey by ENV utilised pitfall trapping to target mygalomorph spiders. This survey is reported in this report; a separate report has not been prepared.

Winter Survey

The winter survey by OES utilised pitfall trapping to target mygalomorph spiders. The survey techniques used for the comprehensive SRE survey within the study area was based on recommendations and guidance provided by Mark Harvey (WAM), Shirley Slack-Smith (WAM), Barbara York-Main (UWA) as well as DEC staff.

A summary of the methods for the comprehensive survey is provided in **Table 5**.

Table 5 Short-range Endemic Survey Methodology at Each Sampling Site

Methodology	Target Group	Sampling Effort/ Site
Dry pitfall trapping	All groups	10 traps over 7 days
Targeted searching	All groups	5 hours per site
Litter collection	All groups	5 samples per site
Soil sieving	Terrestrial molluscs	5 samples per site
UV night searching	Scorpions	30 minutes per site

A description of each survey technique is provided below.

Pitfall Trapping

Both the autumn and winter surveys utilised the same pit traps at one site on the Callawa Ridge. This site was called Site 3 by ENV but was renamed as Site 6 by OES. For ease of reporting, this site will herein be referred to as Site 6. The ten traps at Site 6 were from the original vertebrate fauna trapping program installed by *ecologia* in 2005. These pitfall traps included three 150 mm PVC pipe pit traps and seven 15 L bucket pit traps. These traps all had 3 m long by 25 cm high flywire fences, the base of which was buried into the ground. The trapping methods incorporated at all other sites differed between the autumn and comprehensive winter surveys.

Autumn Survey

The autumn survey conducted by ENV utilised ten pitfall traps with fencing, at each site (total 80 pitfall traps). The pitfall traps comprised metal containers approximately 1.2 L (10 cm diameter x 15 cm high) dug into the ground so that the tops were flush with the natural soil profile (**Plate 9**). Drift fences (gutter guard) were approximately 150 cm long and 15 cm high and were set to pass over the centre of the pitfall trap. The base of each fence was dug into the ground. Traps were sheltered with a segment of cardboard.

Plate 9 ENV pitfall trap showing fencing and trap cover

Winter Survey

For each of the eight sampling sites established for the winter survey by OES, a total of ten pitfall traps were established at approximately 10 m intervals, depending on the availability of a suitable substrate (total of 80 pitfall traps). Pitfall traps consisted of a cylindrical 4 L plastic container (20 cm diameter x 20 cm high) dug into the ground (**Plate 10**). This is a relatively large diameter for a pitfall trap and large pitfall trap diameters have been shown to increase the trapping efficiency (Brennan *et. al.,* 2005). The method of wet pitfall trapping with killing and preserving fluid was not utilised upon advice provided from the DEC, to reduce the risk of invertebrate and vertebrate fauna by-catch mortality. Particular attention was given to ensure the top of the container was flush with the natural surface profile and all obstructions with the potential to reduce catch were removed.

To increase the efficiency of the pitfall traps, two drift fences (flywire mesh) measuring approximately 75 cm in length and 15 cm in height were set on each side of the container. The base of the fences was buried into the ground and the ends were anchored by wire stakes. It is recognised that catch rates increase with drift fence length (after Brennan *et. al.,* 2005), however, the availability of substrate around the pit trap for fence installation was often limited and variable between trapping sites. The two 75 cm lengths of fence per trap were found to be a practical length given the substrate while also permitting for consistency between trapping sites.

To provide shade for any fauna caught in the traps, a lid was suspended approximately 5 cm over the trap by four pegs. A 'rescue rock' was placed at the bottom of the trap to provide refuge for caught fauna in the event of the trap filling with water during rain. Traps were set for a period of seven nights and checked daily for catch and pitfall maintenance. The exception was Site 8 at the Callawa study area where traps were set for six nights with two additional traps. This equated to 72 trapping nights (12 traps x six nights) for Site 8 compared to 70 trap nights (10 traps x 7 nights) for all other sites. Invertebrate and vertebrate by-catch was released.

Plate 10 Pitfall trap showing fencing and suspended lid

Pitfall traps were removed and holes backfilled after the autumn survey by ENV and after the winter survey by OES. GPS co-ordinates of each trap location were recorded.

Targeted-searching

Each sampling site, including the general surrounds was systematically searched for the target groups in the following areas:

- amongst layers of deep leaf litter, particularly *Ficus* sp.;
- under logs, rocks and in crevices;
- at the base of shrubs, trees and Spinifex; and
- under bark and amongst debris.

At each site, two people undertook targeted searching for 2.5 hours each; this totalled five person hours per site.

Mygalomorph spiders were targeted by searching for burrow entrances which are typically cryptic in appearance and can be made of mud/clay or silk lids. Active searching is considered to be the most effective method of collecting female mygalomorph spiders which can help reveal a spider's home range within a study area. Male specimens are generally required for identification to the species level. Selected burrows were excavated and resident spiders collected with forceps (after Main, 2002).

The presence of scorpion burrows (which are typically in the form of horizontal slits) was also noted and scorpions were dug and collected from these burrows where possible.

Litter Collection

Five samples of leaf litter, approximately 1 L in volume, were collected from areas of accumulation under trees and around rocks. The top layer of litter was scraped back to reveal the decomposition layer above the soil. Samples of the decomposition layer were taken at various localities around the sampling site and collected in small plastic zip lock bags. The filled bags were sealed, kept cool and transported to the OES laboratory.

Soil Sieving

At each site, five soil samples were collected and sieved (total of 40 soil samples). Areas were targeted for soil sieving where terrestrial snails were likely to occur, such as: under vegetation, at the base of cliffs, under rock ledges and the soil under decomposing leaf material. The soil fraction between 1 mm and 10 mm was retained and transported to the OES laboratory for sorting. All terrestrial mollusc specimens were sent to the WAM for identification.

Ultraviolet Spotlighting

Two people conducted 30 minutes of UV spotlighting at each sample site; this totalled one person hour per site. Different sites were searched during each night of spotlighting. The main focus of spotlighting was the collection of scorpions. Handheld ultraviolet torches were used to locate scorpions which are nocturnal and fluoresce under ultraviolet light.

Assessment of Habitat

Prior to the field survey, aerial imagery was used to identify sheltered gorges and ridgelines within the study area and surrounds. During the survey, a SRE habitat assessment was conducted within the study area. The following factors were taken into consideration when identifying SRE habitat:

- aspect;
- topography;
- rock outcrops;
- soil type;
- vegetation;
- litter cover;
- existing disturbance; and
- water sources.

Habitats were assessed according to their condition and complexity in relation to each of the targeted SRE groups. The methodology relies on visual methods to assess habitat features.

3.3.5 Sorting and Identification of Specimens

With the exception of mollusc, all specimens were preserved *in situ* using 70 % ethanol. The third left leg of spiders and scorpions were removed following preservation of the specimen and then preserved in 100 % ethanol for future DNA analysis.

All samples and specimens collected in the field were transported to the OES Perth laboratory for sorting and distribution to taxonomic experts. Leaf litter samples were placed in Berlese funnels for 48 hours to extract invertebrates (**Plate 11**). The incandescent globes mounted above these funnels provide a heat source which dries out leaf litter, and a bright light source which causes invertebrates to move down through the leaf material into a collection vial containing ethanol. Specimens retrieved from the ethanol catchment vials were sorted using standard identification keys (e.g. Brunet, 1994, 1996; Commonwealth Scientific and Industrial Research Organisation [CSIRO], 1970; Commonwealth Department of the Environment and Heritage [DEH], 2006; Harvey and Yen, 1989; Raven *et al.,* 2002).

Plate 11 Cundaline and Callawa leaf litter samples in Berlese funnels at the OES Laboratory

The sieved soil samples were spread in a plastic tray and inspected under a 2.75 x magnifier. Terrestrial snail specimens were placed in vials fitted with suitable padding.

All collected specimens were prepared as per the WAM guidelines on the preservation and lodgement of specimens (**Appendix A**) and delivered to the Museum for identification and evaluation. These specimens included mygalomorph spiders, scorpions, millipedes, pseudoscorpions and terrestrial snails.

The taxonomic specialists for each invertebrate group were as follows:

- millipede, scorpion, pseudoscorpion and mygalomorph spiders specimens were identified by Dr Mark Harvey of the WAM (**Appendix B**); and
- terrestrial mollusc specimens were identified by Dr Shirley Slack-Smith and Cory Whisson of the WAM (**Appendix C**).

Barbara York Main also confirmed spider identifications.

3.3.6 Survey Limitations and Constraints

As stated in Section 3.2, no specific formal guidance is available for the survey of terrestrial SRE invertebrates. Moreover, prescriptive survey guidelines, including standard methodologies, have not been established by regulatory authorities.

The aim of the survey was to investigate the presence of potential SRE species at the Cundaline and Callawa Ridges. Like any biodiversity sampling survey, it is recognised that there are limitations to surveying SRE species, and that a SRE survey provides a snapshot of the invertebrates which may be present in an area at the time of surveying.

Through consultation with the relevant specialists (Section 3.3), the survey has been designed to minimise the survey limitations (e.g. methods appropriate to target SRE groups). However there were limitations that may, or may not, have affected the results of the survey, these limitations may have been:

- Climatic conditions – Rainfall and the associated humid conditions are widely considered by experts to be conducive to invertebrate activity, particularly SRE species (Main pers comm. 2008). Mygalomorph spiders in particular are typically sedentary with movement of male spiders from fixed burrows restricted to specific climatic conditions associated with rainfall events. Therefore restricted opportunities for sampling either through pit-trapping or other techniques occur.
- No rainfall was recorded during the April and June surveys (**Figure 6**), which may have been a contributing factor towards the low pitfall trap success. However, March/April and June/July seem to be the best times to survey Mygalomorph Spiders in the Pilbara, and specifically within 6 to 7 weeks of a rain event (Jackson. T [DEC], pers. comm., 2008). In the Pilbara, the wet season concludes in late March and June is the dry season, therefore the amount of rainfall prior to and during the surveys was expected. Each survey was completed within a 6 to 7 week period after rainfall (**Figure 6**); however it is suggested that mygalomorph activity would have been highest during and shortly after these rainfall events. Coinciding trapping surveys with rainfall events is challenging in relation to field logistics and available personnel resources, however if achieved is likely to yield increased collection of male mygalomorph specimens which are typically required for species identification.
- Night Searching Constraints - Due to health and safety requirements associated with the demand of daytime field work, the required distance to travel to and from sites and the number of sites, night searching was restricted to the early hours of the evening, between 6.30 pm and 9.00 pm (sunset was at approximately 5.33 pm, and civil twilight at 5.57 pm, based on Port Hedland times). It is possible that scorpions may have been missed during spotlighting as they may not have been active during these hours.

3.4 Terrestrial Fauna Habitat Assessment

The broad fauna habitats occurring within the Cundaline and Callawa study areas were identified, assessed and described separately for their complexity and the quality of habitats that they provide for fauna. The following criteria were taken into consideration when undertaking the habitat assessment: landscape features, estimate of litter cover percentage and type, soils, outcropping, estimate percentage of bare ground, types of disturbance (e.g. evidence of fire, tracks); and the levels of disturbance in terms of the effect that it has had on the vegetation (e.g. density of overstorey vegetation, density of shrubs).

4.0 RESULTS/DISCUSSION: SHORT-RANGE ENDEMICS

4.1 Mygalomorph Spiders

During the April/May surveys, no mygalomorph specimens were collected within the Callawa or Cundaline study areas (**Table 6**). During the winter survey in July, a total of seven mygalomorph spiders were collected from the Cundaline study area and no mygalomorph spiders were collected from the Callawa study area.

Table 6 Mygalomorph Spider Specimens Collected from the Cundaline and Callawa Study Areas between 2 and 12 June 2008

Site No.	Specimen Co-ordinates Datum: WGS 84		Family	Genus	Species	Collection Method
01	20º32'34.1"S	120º09'12.5"E	Amaurobioidea	1	1	Pit trap 7
03	20º33'57.7"S	120º11'11.5"E	Ctenizidae	*Conothele*	2	Active search
03	20º33'57.7"S	120º11'11.5"E	Ctenizidae	*Conothele*	2	Active search
03	20º33'57.7"S	120º11'11.5"E	Ctenizidae	*Conothele*	2	Active search
03	20º33'57.7"S	120º11'11.5"E	Ctenizidae	*Conothele*	2	Active search
04	20º34'34.6"S	120º11'52.4"E	Ctenizidae	*Conothele*	2	Active search
04	20º34'34.6"S	120º11'52.4"E	Ctenizidae	*Conothele*	2	Active search

[1] Specimen unable to be identified/determined due to lack of taxonomic knowledge.

[2] Specimens not suitable for accurate identification.

Superfamily Amaurobioidea

One male specimen from the superfamily Amaurobioidea was collected from a pit trap at Site 1. It has not been possible to identify the specimen as the taxonomy of the group in the Pilbara is uncertain; however it is unlikely to represent a SRE species (Harvey, 2008a; **Appendix B**).

Family Ctenizidae: *Conothele* sp.

Six immature specimens belonging to the genus *Conothele* were collected at Cundaline during active searching. Four of these specimens were collected from Site 03 within the proposed impact area and two specimens were collected from Site 04, a reference site south of the proposed impact area (**Table 6**; **Figure 7**; **Plate 12**). The taxonomic status of the genus *Conothele* in WA is very uncertain, with the entire group representing unnamed species (Harvey, 2008a; **Appendix B**). The taxonomy of the genus is based on the first leg and pedipalp of adult male specimens to allow identification to species level. Since the specimens were immature, they could not be identified and it was not possible to determine if the species is associated with short-ranged endemism. However, given the close proximity of the two sites (1.3 km) along the same ridge, it is likely that specimens from both Site 03 and Site 04 represent the same species (M. Harvey, pers. comm., August 2008). The cryptic nature of the trapdoor burrows could indicate the species range along the ridge is larger than was found in this survey.

Plate 12 Specimen from the genus *Conothele* collected from Site 03 and Site 04: burrow (left) and spider (right)

From the current level of taxonomic knowledge, no mygalomorph species collected within the Cundaline or Callawa study areas were known to represent SRE species. However, the uncertain taxonomic status of the genus *Conothele* (all species of the genus are unnamed) and the collection of immature specimens infer it is not possible to determine if the *Conothele* sp. from Cundaline Ridge has been collected elsewhere or whether it is a SRE species.

4.2 Scorpions

A total of 11 scorpions from two genera were collected from Cundaline and Callawa study areas in the July survey, during active searching, and night spotlighting (**Table 7**).

Table 7 Scorpion Specimens Collected from the Cundaline and Callawa Study Areas between 2 and 12 June 2008 Survey

Site Number	Specimen Co-ordinates Datum: WGS 84		Family	Genus	Species	Collection Method
01	20º32’33.8”S	120º09’13.5”E	Buthidae	*Lychas*	1	Active searching
01	20º32’33.8”S	120º09’13.5”E	Buthidae	*Lychas*	1	Active searching
01	20º32’34.3”S	120º09’12.7”E	Buthidae	*Lychas*	1	Active searching
02	20º33’24.4”S	120º10’32.3”E	Buthidae	*Lychas*	1	Night spotlighting
03	20º33’57.9”S	120º11’11.9”E	Buthidae	*Lychas*	1	Active searching
05	20º34’38.1”S	120º12’19.2”E	Buthidae	*Lychas*	1	Night spotlighting
06	20º38’53.7”S	120º18’14.4”E	Buthidae	*Lychas*	1	Active searching
06	20º38’53.2”S	120º18’15.2”E	Buthidae	*Lychas*	1	Night spotlighting
06	20º38’52.9”S	120º18’15.6”E	Buthidae	*Lychas*	1	Active searching
06	20º38’52.1”S	120º18’16.8”E	Urodacidae	*Urodacus*	1	Active searching – dug from burrow
07	20º38’56.9”S	120º18’13.3”E	Urodacidae	*Urodacus*	1	Active searching – dug from burrow

[1] Specimen unable to be identified/determined due to lack of taxonomic knowledge.

Family Buthidae: *Lychas* sp.

Lychas were collected from a number of sites in both study areas. Although the identity of the specimens is uncertain, Harvey (2008a; **Appendix B**) is confident that they do not represent a SRE species.

Family Urodacidae: *Urodacus* sp.

The taxonomy of the *Urodacus* genus in northern Western Australia is poorly understood, however the species collected is unlikely to be a SRE (Harvey, 2008a:;**Appendix B**).

From the current level of taxonomic knowledge, no scorpions collected within the Cundaline or Callawa study areas were found to represent SRE species.

4.3 Pseudoscorpions

A total of 20 pseudoscorpions were recorded from the Cundaline and Callawa study areas during the July survey; eight specimens were collected during active searches and 12 specimens were recorded from leaf litter samples placed in Berlese funnel traps **(Table 8)**. The pseudoscorpions represented three genera from the family Olpiidae.

Table 8 Pseudoscorpion Specimens Collected from the Cundaline and Callawa Study Areas between the 2 and 12 June 2008 Survey

Site Number	Specimen Co-ordinates Datum: WGS 84		Family	Genus	Collection Method
01	20º32'33.6"S	120º09'11.2"E	Olpiidae	*Euryolpium*	Active searching
01	20º32'33.6"S	120º09'11.2"E	Olpiidae	*Euryolpium*	Active searching
01	20º32'33.6"S	120º09'11.2"E	Olpiidae	*Euryolpium*	Active searching
01	20º32'33.6"S	120º09'11.2"E	Olpiidae	*Euryolpium*	Active searching
01	20º32'33.6"S	120º09'11.2"E	Olpiidae	*Euryolpium*	Berlese funnel traps
01	20º32'33.6"S	120º09'11.2"E	Olpiidae	*Euryolpium*	Berlese funnel traps
01	20º32'33.6"S	120º09'11.2"E	Olpiidae	*Euryolpium*	Berlese funnel traps
02	20º33'25.8"S	120º10 33.2"E	Olpiidae	*Euryolpium*	Active searching
02	20º33'25.8"S	120º10 33.2"E	Olpiidae	*Austrohorus*	Berlese funnel traps
02	20º33'25.8"S	120º10 33.2"E	Olpiidae	*Austrohorus*	Berlese funnel traps
02	20º33'25.8"S	120º10 33.2"E	Olpiidae	*Austrohorus*	Berlese funnel traps
02	20º33'25.8"S	120º10 33.2"E	Olpiidae	*Austrohorus*	Berlese funnel traps
02	20º33'25.8"S	120º10 33.2"E	Olpiidae	*Austrohorus*	Berlese funnel traps
03	20º33'58.1"S	120º11'09.8"E	Olpiidae	*Austrohorus*	Active searching
03	20º33'58.1"S	120º11'09.8"E	Olpiidae	*Austrohorus*	Berlese funnel traps
04	20º34'35.4"S	120º11'51.1"E	Olpiidae	*Austrohorus*	Active searching
06	20º38'53.7"S	120º18'14.4"E	Olpiidae	*Euryolpium*	Active searching
06	20º38'53.7"S	120º18'14.4"E	Olpiidae	*Indolpium*	Berlese funnel traps
07	20º38'56.5"S	120º18'10.9"E	Olpiidae	*Euryolpium?*	Berlese funnel traps
08	20º38'33.1"S	120º18'25.6"E	Olpiidae	*Austrohorus*	Berlese funnel traps

***Austrohorus* sp.**

This small species was collected from a number of sites during the survey, and is very similar to other specimens of *Austrohorus* collected elsewhere in the Pilbara. From the current taxonomic knowledge of the genus, it is not possible to state whether this species is a SRE (Harvey, 2008a, 2008b; **Appendix B**).

***Euryolpium* sp.**

This was the most commonly collected species during the survey. Based on current knowledge of the genus, it appears that this species is not a SRE species (Harvey, 2008a; **Appendix B**).

***Indolpium* sp.**

There was a single specimen of this species collected during the survey; however other specimens have been collected in the region (Harvey, 2008b). Based on current taxonomic knowledge, it appears that this species is not a SRE species (Harvey, 2008a; **Appendix B**)

From the current level of taxonomic knowledge, no pseudoscorpions collected within the Cundaline or Callawa study areas were found to represent SRE species.

4.4 Myriapods and Centipedes

No millipedes were collected during the survey within the Cundaline and Callawa study areas. Numerous centipede specimens were collected representing six species from four families (

Table 9).

Order Geophilida

Family Schendylidae

Geophilid centipedes are very difficult to identify and their taxonomy is poorly known. It is possible that some Geophilid species in Western Australia represent SRE species, however, this cannot be determined without a full taxonomic review of the Geophilid order (Harvey, 2008a; **Appendix B**). The status of the specimen from Cundaline study area is uncertain. The one species recorded during the survey was collected from Site 3, which lies in the proposed impact area.

Order Scutigerida

Family Scutigerida: *Pilbarascutigera incola*

Pilbarascutigera incola is widely distributed throughout the Pilbara and elsewhere in Western Australia (Edgecombe and Barrow, 2007) and thus is not a SRE (Harvey, 2008a; **Appendix B**).

Table 9 Millipede and Centipede Specimens Collected from the Cundaline and Callawa Study Areas between the 2 and 12 June 2008 Survey

Site Number	Specimen Co-ordinates Datum: WGS 84		Family	Genus	Species	Collection Method
01	20º32'33.6"S	120º09'11.2"E	Scolopendridae	*Scolopendra*	*morsitans*	Active Search
03	20º33'58.1"S	120º11'09.8"E	Scolopendridae	*Scolopendra*	*morsitans*	Active search
03	20º33'58.1"S	120º11'09.8"E	Schendylidae	1	1	Active search
03	20º33'58.1"S	120º11'09.8"E	Scutigeridae	*Pilbarascutigera*	*incola*	Pit trap
03	20º33'58.1"S	120º11'09.8"E	Scolopendridae	*Scolopendra*	*morsitans*	Active Search
03	20º33'58.1"S	120º11'09.8"E	Scolopendridae	*Scolopendra*	*morsitans*	Active Search
03	20º33'58.1"S	120º11'09.8"E	Scolopendridae	*Scolopendra*	*morsitans*	Active Search
04	20º34'35.4"S	120º11'51.1"E	Scolopendridae	*Scolopendra*	*morsitans*	Active Search
05	20º34'38.1"S	120º12'19.2"E	Scolopendridae	*Scolopendra*	*morsitans*	Active Search
05	20º34'38.1"S	120º12'19.2"E	Scolopendridae	*Scolopendra*	*morsitans*	Active Search
05	20º34'38.1"S	120º12'19.2"E	Scolopendridae	*Scolopendra*	*morsitans*	Active Search
05	20º34'38.1"S	120º12'19.2"E	Scolopendridae	*Scolopendra*	*morsitans*	Active Search
06	20º38'53.7"S	120º18'14.4"E	Cryptopidae	*Cryptops*	1	Active Search
06	20º38'53.7"S	120º18'14.4"E	Scolopendridae	*Cormocephalus*	*strigosus*	Active Search
06	20º38'53.7"S	120º18'14.4"E	Scolopendridae	*Ethmostigmus*	*curtipes*	Active Search
06	20º38'53.7"S	120º18'14.4"E	Scolopendridae	*Ethmostigmus*	*curtipes*	Active Search
06	20º38'53.7"S	120º18'14.4"E	Scolopendridae	*Scolopendra*	*morsitans*	Active Search
08	20º38'33.1"S	120º18'25.6"E	Scolopendridae	*Scolopendra*	*morsitans*	Active Search
08	20º38'33.1"S	120º18'25.6"E	Scolopendridae	*Scolopendra*	*morsitans*	Active Search

[1] Specimen unable to be identified/determined due to lack of taxonomic knowledge.

Order Scolopendrida

Family Cryptopidae: *Cryptops* sp.

It is possible that some species of *Cryptops* in Western Australia represent SRE species; however the status of the specimen from the Callawa study area can not be determined without a full taxonomic review of the genus (Harvey, 2008a; **Appendix B**).

Family Scolopendridae: *Cormocephalus strigosus*

Cormocephalus strigosus is widely distributed throughout mainland Australia and thus is not a SRE species (Harvey, 2008a; **Appendix B**).

Family Scolopendridae: *Ethmostigmus curtipes*

Ethmostigmus curtipes is widely distributed throughout mainland Australia and thus is not a SRE species (Harvey, 2008a; **Appendix B**).

Family Scolopendridae: *Scolopendra morsitans*

Scolopendra morsitans is widely distributed throughout mainland Australia and thus is not a SRE species (Harvey, 2008a; **Appendix B**).

Based on the current level of taxonomic knowledge, no centipedes collected within the Callawa or Cundaline study areas were found to represent SRE species.

4.5 Terrestrial Molluscs

Terrestrial mollusc specimens were collected at both the Cundaline and Callawa study areas in litter samples, soils samples (between 10 mm and 1mm sieve) and whilst actively searching. A total of 78 terrestrial mollusc specimens were collected during the survey, 33 from the Cundaline study area, and 45 specimens from the Callawa study area (**Table 10**). Live specimens were found at sites 01, 05, 06, and 08. Terrestrial mollusc specimens were found at sites 01 and 05 on Cundaline Ridge, and sites 06, 07 and 08 on Callawa Ridge.

Table 10 Terrestrial Mollusc Specimens Collected from the Cundaline and Callawa Study Areas between 2 and 12 June 2008 Survey

Site Number	Specimen Co-ordinates Datum: WGS 84		Family	Species	Collection Method
01	20º32'33.6"S	120º09'11.2"E	Camaenidae	1	Active Search
05	20º34'38.1"S	120º12'19.2"E	Camaenidae	1	Active Search
06	20º38'33.1"S	120º18'25.6"E	Camaenidae	1	Active Search
07	20º38'56.5"S	120º18'10.9"E	Camaenidae	1	Active Search
08	20º38'53.7"S	120º18'14.4"E	Camaenidae	1	Active Search

[1] Specimen unable to be identified/determined due to lack of taxonomic knowledge.

The camaenid landsnails collected appear to belong to a single un-named species of a currently un-named genus.

4.6 Vertebrate By-catch

A total of nine vertebrate specimens were found in the pit traps over the seven nights of trapping undertaken in the winter survey **(Table 11**).

Table 11 Vertebrate by-catch Collected from the Cundaline and Callawa Study Areas during the July 2008 Survey

Site Number	Vertebrate	No. Specimens	Specimen Co-ordinates Datum: WGS 84		Species
01	Skink	2	20º32'33.6"S	120º09'11.2"E	*Ctenotus* sp.
01	Gecko	1	20º32'33.6"S	120º09'11.2"E	*Gehyra punctata*
02	Skink	2	20º33'25.8"S	120º10 33.2"E	*Ctenotus* sp
06	Skink	2	20º38'33.1"S	120º18'25.6"E	*Ctenotus* sp
07	Skink	2	20º38'56.5"S	120º18'10.9"E	*Ctenotus saxatilis*

4.7 Potential SRE Habitat

The general characteristics of habitats typical considered to support SRE species are described in Section 1.2 and a general description of the landscape features at Cundaline and Callawa is provided in Section 2.3. The study areas are characteristic of the terrain in the region, made up of exposed hill tops that drop away over extensive ridges to slopes and alluvial Spinifex plains, with the occasional intersection of the ridges by major and minor drainage lines.

The potential habitat for SRE species within the study areas is considered likely to be associated with the following:

- south-west facing ridges and slopes of the Cundaline Ridge;
- south-east facing ridges and slopes of the Callawa Ridge; and
- relatively deeper gullies and gorges within the Callawa Ridge.

South-facing ridges, slopes and gorges are generally cooler and more humid and typically provide suitable refuge habitat (Dell, 2007). South-facing ridges, slopes and gorges receive little or no sunlight throughout the day, thus making them cooler and moister compared to the surrounding exposed hills and north facing ridgelines. Gorges are generally associated with ephemeral creeklines that are abundant sources of water and moisture during the wet season. They are also sites of accumulation of leaf litter, rocks, boulders and sand washed down the creeklines. High ridges provide shelter in way of rocks, boulders, crevices and caves. Trees often follow the sheltered ridges and creeklines in gorges, which provide direct leaf litter and logs and further shade.

Different landscape features occurring in the study area are discussed below in relation to the potential occurrence of SRE invertebrate species.

Drainage Lines

Drainage lines on the Cundaline and Callawa Ridges have a moderate to high potential to support SRE species. The sheltered regions created by the steep to moderate rocky slopes provide a relatively moister and cooler environment compared to the surrounding exposed ridge tops and plains. Additionally, the moister conditions support vegetation which in turn provides opportunity for the accumulation of decomposing leaf litter which would be suitable food sources for detritivores such as millipedes and snails as well as predators such as mygalomorph spiders, pseudoscorpions, scorpions and centipedes.

Hilltop

Hilltops form the upper horizon of the geological formation on the Cundaline and Callawa Ridges. These areas make up a large proportion of the landscape within the study areas. The hilltops are largely flat and exposed with sparse vegetation such as *Grevillea wickhamii* subsp. *hispidula* and Spinifex. They consist of large rock outcrops and stony skeletal soils, and are thus generally unsuitable for burrowing fauna.

The hard, rocky hilltops support only sparse vegetation, dominated by grasses, with fewer shrubs and small trees present. In turn, litter cover is low, ranging from 0 to 15%, consisting of leaves and twigs. Although some microhabitat is provided by the Spinifex hummocks and the crevices in the rocky soils, these areas have low microhabitat complexity. The lack of tall shrubs and trees in these habitats also limits habitat diversity on these landscapes.

Hilltops have a relatively low potential to support SRE species within the Cundaline and Callawa study areas. The exposed rocky nature of the hilltops would provide little shelter and the limited vegetation would provide limited sources for leaf litter accumulation. Additionally, hilltops are a relatively common habitat type in the areas surrounding the Cundaline and Callawa Ridges so it is unlikely that any species would develop ranges restricted only to the hilltops within the study area.

Ridge

The Cundaline and Callawa Ridges are distinctive features of the landscape even though they only make up a relatively small proportion of the overall study area. They consist of exposed rock and bare skeletal soils overlying large cliffs above vegetated slopes below. Vegetation generally consists of *Eucalyptus* sp., *Acacia* sp. and *Ficus* sp., with some *Triodia* sp., and the grasses *Themeda* sp. and *Eragrostis* sp. in more sheltered areas. Litter cover is variable, ranging from 5 to 60%, depending on the proximity of vegetation with substantial amounts present under *Ficus* spp. often forming deep accumulations of decomposing leaf material.

Ridges that face in a south-west to south-east direction are considered to have the highest potential to support SRE species. The ridges provide areas at their base which are in almost constant shade and this forms a cool moist microclimate. This microclimate supports vegetation dominated by grasses such as *Themeda* sp. and *Eragrostis* sp. along with ferns (*Cheilanthes* sp.) and *Ficus* sp. The SRE invertebrates that have become dependant upon these habitats are often relics of previously widespread species during the Mesozoic and early Tertiary periods that became fragmented as the continent became more arid (Main, 1976).

Slopes and Plains

Below both the Cundaline and Callawa Ridges, the scree slopes are made up of hard rocky soils and boulders accumulated from the ridgelines above. The rocky soil restricts vegetation to predominantly Spinifex grasslands, which provide little leaf litter and limited cover. The plains below are less rocky, and are comprised of sandier soils. Spinifex grasslands also dominate here, with some *Eucalyptus* spp. and *Acacia* spp. shrubs and trees also present. Although some microhabitat is provided by the Spinifex hummocks and the crevices in the rocky soils, these areas have low microhabitat complexity. The lack of tall shrubs and trees in these habitats also limits habitat diversity on these landscapes.

The slopes and plains on the Cundaline and Callawa Ridges provide a low potential for SRE invertebrate habitat. The slopes and plains provide little relief from the hot summers and this effect on vegetation results in little opportunity to support relictual species. Additionally, the slopes and particularly the plains are not a limited habitat type within the areas surrounding the Cundaline and Callawa study areas.

5.0 RESULTS/DISCUSSION: TERRESTRIAL VERTEBRATE FAUNA

5.1 Vertebrate Fauna Habitat Assessment

Fauna habitats are often associated with specific land formations. Sixteen representative sites were chosen to ascertain the types of broad fauna habitats found at both Cundaline and Callawa study areas. Each site was assessed for a number of habitat variables including: percentage leaf litter cover, vegetation, landscape features, disturbance and others. At both the Cundaline and Callawa study areas, four main fauna habitats were identified. These were drainage lines, hilltops, ridges and slopes and plains.

Drainage Lines

This landform grouping includes both major and minor drainage lines. These areas typically consist of steep to moderate rocky slopes, often with bare rock and boulders, descending down to stony soils and silty to gritty alluvium at the base of the drainage line. The presence of alluvium and rocky pool areas suggest these areas temporarily flow with water after periods of rainfall. Bare ground ranges from 5 to 30%, in the lower areas of the drainage line, and up to 70% on the upper exposed slopes. Litter cover is variable, ranging from 0 to 30% on the upper slopes, and 40 to 70% at the base of the drainage line. Litter origin is predominantly from the surrounding shrubs and trees, and consists of leaves, branches and logs.

Vegetation along the drainage lines is dense and diverse, providing shade and shelter and serving as important corridors for fauna movement between the harsher surrounding terrains. Shrubs and grasses dominate, such as *Themeda* sp., *Eragrostis* sp. and *Triodia* sp., with *Eucalyptus* sp., *Acacia monticola* and other *Acacia* sp. present to a lesser extent (**Plate 13**). Upslope from the drainage lines, both density and diversity of vegetation rapidly decreases. Fire appeared to be the only disturbance at these sites, with the upper storey and understorey vegetation height and density suggesting these sites had not been burned within the last three to five years.

Plate 13 Drainage line at Callawa study area

Major and minor drainage lines provide important microhabitats for birds, reptiles and mammals. Embankments can be utilised by burrowing reptiles and mammals, as well as some bird species such as the Rainbow Bee-eater (Cogger, 2000; Strahan, 2002; Johnstone and Storr, 1998, 2004). Drainage lines act as corridors for fauna movement and dispersal (Cogger, 2000; Strahan, 2002; Johnstone and Storr, 1998, 2004). Litter (leaves, branches and logs) is utilised by many vertebrate fauna species including fossorial reptiles, amphibians and small mammals (Cogger, 2000; Strahan, 2002).

Drainage lines provide a moderate potential for bat habitat particularly in larger drainage lines for two reasons. Firstly, outside of the study area, it had been noted that permanent water bodies could occur in drainage lines where water had carved out deep rock pools. Secondly, the rocky ridges along the sides of drainage lines have the potential for cave formation.

Both major and minor drainage lines are relatively common across both the Cundaline and Callawa study areas. Minor drainage lines tend to be more common internally on the ridges, whereas major drainage lines tend to be more common externally, descending to the flat plains below the ridgelines. However, within the Cundaline study area, drainage lines make up a smaller portion of the landscape. Within the Callawa study area, drainage lines, particularly minor drainage lines, make up a large portion of the landscape.

Hilltop

The hilltops form the upper horizon of the project area, and are relatively common across both the Cundaline and Callawa study areas, and make up a large portion of the landscape. They consist of large rock outcrops and stony skeletal soils, and are thus unsuitable for burrowing fauna. The areas are largely flat, with 40 to 70 % bare ground, and are dissected by a small number of minor drainage lines.

The hard, rocky hilltops support only sparse vegetation, dominated by grasses, with fewer shrubs and small trees present (**Plate 14**). In turn, litter cover is low, ranging from 0 to 15%, consisting of leaves and twigs. *Triodia* spp. is the dominant grass species, shrub species include *Grevillea wickhamii* subsp. *hispidula*, and some *Acacia* spp. and *Eucalyptus* spp. Although some microhabitat is provided by the Spinifex hummocks and the crevices in the rocky soils, these areas have low microhabitat complexity. The lack of tall shrubs and trees in these habitats also limits habitat diversity on these landscapes.

Plate 14 Hilltop at Cundaline study area

Hilltop habitats have moderate fauna species richness due to the lack of shelter in the form of leaf litter, bark and woody debris (Cogger, 2000; Strahan, 2002). Burrowing and fossorial species would find the skeletal substrates hard to penetrate (Cogger, 2000; Strahan, 2002). The lack of water, even in ephemeral form, discourages the presence of amphibians (Cogger, 2000). Avian species found within scattered woodland on hilltops are also found over other habitats (Johnstone and Storr, 1998, 2004).

Fire disturbance at these hilltop sites is limited; most sites had not been burned within the last three to five years. The exception is the Cundaline hilltop adjacent to Site 1, which experienced a fire event during the survey period, burning much of the vegetation that had previously been present. Vehicle tracks are present across the hilltops, but are limited to less rocky areas.

Ridge

Ridges make up the distinctive ridgelines that snake along the ranges of the region, including the Cundaline and Callawa ridgelines and gorges, and make up a small portion of the landscape. They consist of exposed rock and bare skeletal soils overlying large cliffs above vegetated slopes below (**Plate 15)**. Caves and crevices in the cliff face provide potential fauna habitat and the sheltered vegetation below the ridgeline provide further microhabitat structure and complexity. Soils in the lower slopes are rocky, with up to 70% bare rock and soil. Vegetation generally consists of *Eucalyptus* spp., *Acacia* spp. and *Ficus* spp., with some *Triodia* spp., and the grasses *Themeda* spp. and *Eragrostis* sp. in more sheltered areas. Litter cover is variable, ranging from 5 to 60%, depending on the proximity of vegetation (with substantial amounts present under *Ficus* spp.) and consists of leaves, branches and logs.

Plate 15 Ridge at Callawa study area

Ridge habitats have a moderate diversity of fauna species, as many species favour this type of environment. Caves and crevices provide shelter for many reptile, mammal and bird species. Sand/loam substrate at the base of outcrops provide shelter for fossorial reptile species and woodlands in gullies are utilised by reptiles, mammals and birds (Cogger, 2000; Strahan, 2002; Johnstone and Storr, 1998, 2004). Ephemeral water holes are quickly utilised by amphibian species (Cogger, 2000).

Ridges provided the highest potential for bat habitat within the study area. Although the potential for permanent water was low, cave formations were relatively common and likely to occur within the ridge habitat type in both study areas. More suitable bat habitat has been identified outside the planned disturbance areas during BHPBIO quarterly bat monitoring program (refer to Section 5.3.1).

Fire disturbance along the ridges has been limited, with vegetation health and development suggesting most sites had not been burned within the last three to five years.

Slopes and Plains

The scree slopes below the ridgelines are made up of hard rocky soils and boulders accumulated from the ridgelines above (**Plate 16**). The rocky soil restricts vegetation to predominantly Spinifex grasslands, which provide little leaf litter (0 to 10%) and limited cover, with bare ground 20 to 50%. The plains below are less rocky, and are comprised of sandier soils. Spinifex grasslands also dominate here, with some *Eucalyptus*/ *Corymbia* spp. and *Acacia* spp. shrubs and trees also present. Although some microhabitat is provided by the Spinifex hummocks and the crevices in the rocky soils, these areas have low microhabitat complexity. The lack of tall shrubs and trees in these habitats also limits habitat diversity on these landscapes. However, breakaways along the slope can contain small caves and crevices providing important refuge for fauna.

Plate 16 Slopes and plains at Cundaline study area

Scree slopes are low in fauna species richness due to the hard rocky substrate. As with hill crests, ephemeral waterbodies are rare, this discourages the presence of amphibians. Spinifex species provide shelter and foraging opportunities for reptiles and small mammals (Cogger, 2000; Strahan, 2002). Rocks and screes provide shelter for reptiles and small mammals. Breakaways along the slope can contain small caves and crevices providing important refuge for fauna.

There has been limited fire disturbance on the slopes and plains areas; with vegetation health and development suggesting most sites had not been burned within the last three to five years. The exception is the slopes and plains within the Cundaline study area adjacent to Site 1, which experienced a fire event during the survey period, burning much of the vegetation that had previously been present.

Biological surveys in the area have concluded that the drainage lines and ridges support the highest diversity of vertebrate fauna (*ecologia*, 2005a, 2005b). Fire disturbance along the ridges has been limited; with vegetation health and development suggesting most sites had not been burned within the last three to five years.

5.2 Vertebrate Fauna Composition

Systematic sampling and opportunistic collecting during the 2005 Cundaline field survey yielded 11 mammal species (10 native), 41 birds, 18 reptiles and one amphibian (*ecologia*, 2005a).

Systematic sampling and opportunistic collecting during the 2005 Callawa field survey yielded 12 mammal species (11 native), 43 birds, 19 reptiles and one amphibian (*ecologia*, 2005b).

A complete list of vertebrate fauna species previously recorded and/or expected to occur within the study areas is presented in **Appendix D**.

5.2.1 Mammals

A total of 13 mammal species have been previously recorded at the Cundaline and Callawa study areas (*ecologia,* 2005a, 2005b; **Appendix D**). The difference in species composition between sites was small, and the total number of species found between the two sites differed by only one species (11 species found at the Cundaline study area and 12 species found at the Callawa study area) (*ecologia,* 2005a, 2005b; **Appendix D**). One species recorded within the Cundaline study area, the Little Broad-nosed Bat (*Scotorepens greyii*), was not found at the Callawa study area (*ecologia,* 2005a, 2005b; **Appendix D**). While two species not recorded at the Cundaline study area were found at the Callawa study area, namely the Northern Quoll (*Dasyurus hallucatus*) and the Red Kangaroo (*Macropus rufus*) (*ecologia,* 2005a, 2005b; **Appendix D**), although these are likely to occur throughout the greater Goldsworthy area.

5.2.2 Birds

A total of 56 bird species have been previously recorded at the Cundaline and Callawa study areas (*ecologia,* 2005a, 2005b; **Appendix D**). The difference in species composition between sites was small, and the total number of species found between the two sites differed by only two species (41 species found at the Cundaline study area and 43 species found at the Callawa study area) (*ecologia,* 2005a, 2005b; **Appendix D**). The majority of bird species recorded have a broad distribution across Western Australia (*ecologia*, 2005a).

5.2.3 Reptiles and Amphibians

A total of 26 reptile species and one amphibian species have been previously recorded at the Cundaline and Callawa study areas (*ecologia,* 2005a, 2005b; **Appendix D**). The difference in species composition between sites was small, and the total number of reptile species found between the two sites differed by only one species (18 species found at the Cundaline study area and 19 species found at the Callawa study area), while the same amphibian species (the Desert Tree Frog [*Litoria rubella*]) was found at both areas (*ecologia,* 2005a, 2005b; **Appendix D**). Results indicate that the Cundaline survey area had seven unique records of reptile species that were not found at the Callawa study area, while a total of eight species not found at the Cundaline study area were found at the Callawa study area (*ecologia,* 2005a, 2005b; **Appendix D**).

5.3 Conservation Significant Terrestrial Vertebrate Fauna

This section provides a summary of the occurrence of conservation significant fauna species surveyed at the Cundaline and Callawa study areas.

The conservation significance of terrestrial vertebrate fauna occurring, or potentially occurring, within the study areas are described in the following sections, including:

- Threatened fauna species listed under the Commonwealth *Environment Protection and Biodiversity Conservation Act, 1999* (EPBC Act), and declared threatened fauna and other specially protected fauna listed under the Western Australian *Wildlife Conservation Act, 1950* (WC Act) (Section 5.3.1).
- Priority fauna recognised by the DEC (Section 5.3.2).
- Species not listed under any Acts, but considered of conservation significance due to patterns of distribution (for instance bioregional endemics - Section 5.3.3).
- Migratory species listed under the EPBC Act and international agreements which include the Japan-Australia Migratory Bird Agreement (JAMBA), the China-Australia Migratory Bird Agreement (CAMBA), Republic of Korea Australia Migratory Bird Agreement (ROKAMBA) and the Bonn Convention (The Convention on the Conservation of Migratory Species of Wild Animals) (Section 5.3.4).

5.3.1 Threatened Fauna Species

Fauna species that have been formally recognised as rare, threatened with extinction or as having high conservation value are protected by law under Commonwealth and State legislation.

At the national level, fauna are protected under the EPBC Act. BHPBIO referred the planned Cundaline and Callawa mining operations to the DEWHA under the EPBC Act in order to confirm whether the planned activities were considered to constitute a controlled action on matters of National Environmental Significance (including the EPBC Act listed Pilbara Leaf-nosed Bat and Northern Quoll). The DEHWA evaluated the referral and notified BHPBIO that the proposal was not a controlled action.

Within Western Australia fauna can be listed under various Schedules within the WC Act. Definitions of conservation significance are presented in **Appendix E**.

Four fauna species listed as threatened under the EPBC Act and/or the WC Act have been recorded at Cundaline and Callawa study areas and are listed in **Table 12**.

Table 12 Threatened Species Recorded at Callawa and Cundaline

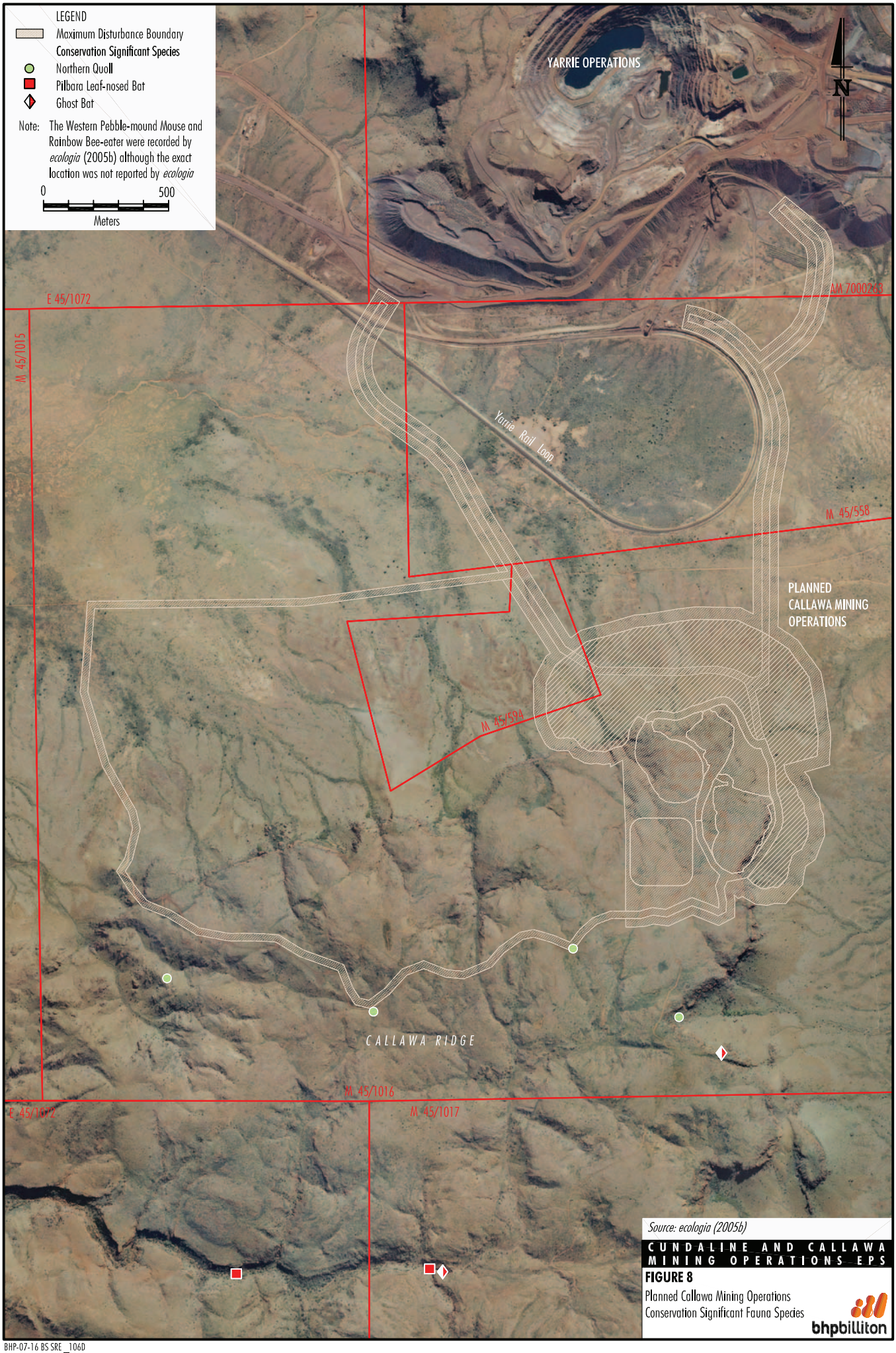
Scientific Name	Common Name	Conservation Status[1]		Source
		EPBC Act	WC Act	
Mammals				
Dasyurus hallucatus	Northern Quoll	EN	-	3
Rhinonicterus aurantia	Pilbara Leaf-nosed Bat	VU	S1	3
Birds				
Falco peregrinus	Peregrine Falcon	-	S4	2
Reptiles				
Liasis olivaceus barroni	Pilbara Olive Python	VU	S1	2

[1] EPBC Act : VU Vulnerable, EN Endangered.
WC Act : Schedule 1, S4.
[2] *ecologia* (2005a).
[3] *ecologia* (2005b).

The fauna species listed in **Table 12** are discussed below:

- **Northern Quoll** (*Dasyurus hallucatus*)

  The Northern Quoll was recorded at Callawa in 2005, within gorge, ridge and hilltop habitats (*ecologia*, 2005b). The locations of where the Northern Quoll was found within the study area are shown on **Figure 8**. The Northern Quoll has also been recorded at the Yarrie Mine (approximately 2 km north of the planned Callawa mining operations) (*ecologia*, 2005e), Cattle Gorge (approximately 6 km north-east of the planned Cundaline mining operations (*ecologia*, 2004, *ecologia*, 2005b), Nimingarra (approximately 24 km north-west of the planned Cundaline mining operations) and Sunrise Hill (approximately 20 km north-west of the planned Cundaline mining operations (*ecologia*, 2005e (**Figure 2**). The Northern Quoll formerly occurred across northern Australia from the Pilbara to southern Queensland, but is now confined to disjunct populations (Van Dyck and Strahan, 2008). Reasons for its population decline include; predation by introduced predators such as dingos and foxes, introduction of Cane Toads, vegetation clearance and habitat loss (Van Dyck and Strahan, 2008). This species favours wooded habitats, and rocky escarpments (Van Dyck and Strahan, 2008).



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- **Pilbara (Orange) Leaf-nosed Bat** (*Rhinonicterus aurantia*)

  The Pilbara (Orange) Leaf-nosed Bat was recorded at both Cundaline and Callawa in 2005 (*ecologia,* 2005a, 2005b). The locations of where the Pilbara Leaf-nosed Bat was found within the study areas are shown on **Figure 8** and **9**. A single call of the Pilbara Leaf-nosed Bat was recorded by *ecologia* (2005a) in 2005 from a rock-face located within the proposed disturbance area for the Cundaline mine (**Figure 3**). *Ecologia* (2005a) inferred from the call that the individual may have been passing by or momentarily taking shelter. *Ecologia* (2005a) described the rock face as 'highly eroded with numerous small caves and cracks situated within the rock, however, none of the caves were of any considerable depth or size.' Quarterly monitoring at the Cundaline ridge since 2005 has only recently recorded calls of the Pilbara Leaf-nosed Bat (Specialised Zoological, 2008a). However, the low number of calls and late time of recording indicates that the cave monitored on the Cundaline ridge is unlikely to be used as a roost (Specialised Zoological, 2008a).

  Further surveys and quarterly bat monitoring since 2004 have identified numerous caves in the Goldsworthy region where the Pilbara Leaf-nosed Bat has been recorded (*ecologia*, 2005c, 2006a, 2006b, 2006c, 2007; ENV Australia, 2007a, 2007b). Monitoring also indicates that a stable community uses a monitored bat roost cave, located approximately 1 km south of the planned Callawa mining operations (ENV Australia, 2007a) (**Figures 8 and 9**).

  The Pilbara Leaf-nosed Bat roosts in humid caves, crevices and mine shafts associated with seeping groundwater (Van Dyck and Strahan, 2008). Disjunct populations are found in the east and west of the Pilbara (Van Dyck and Strahan, 2008).

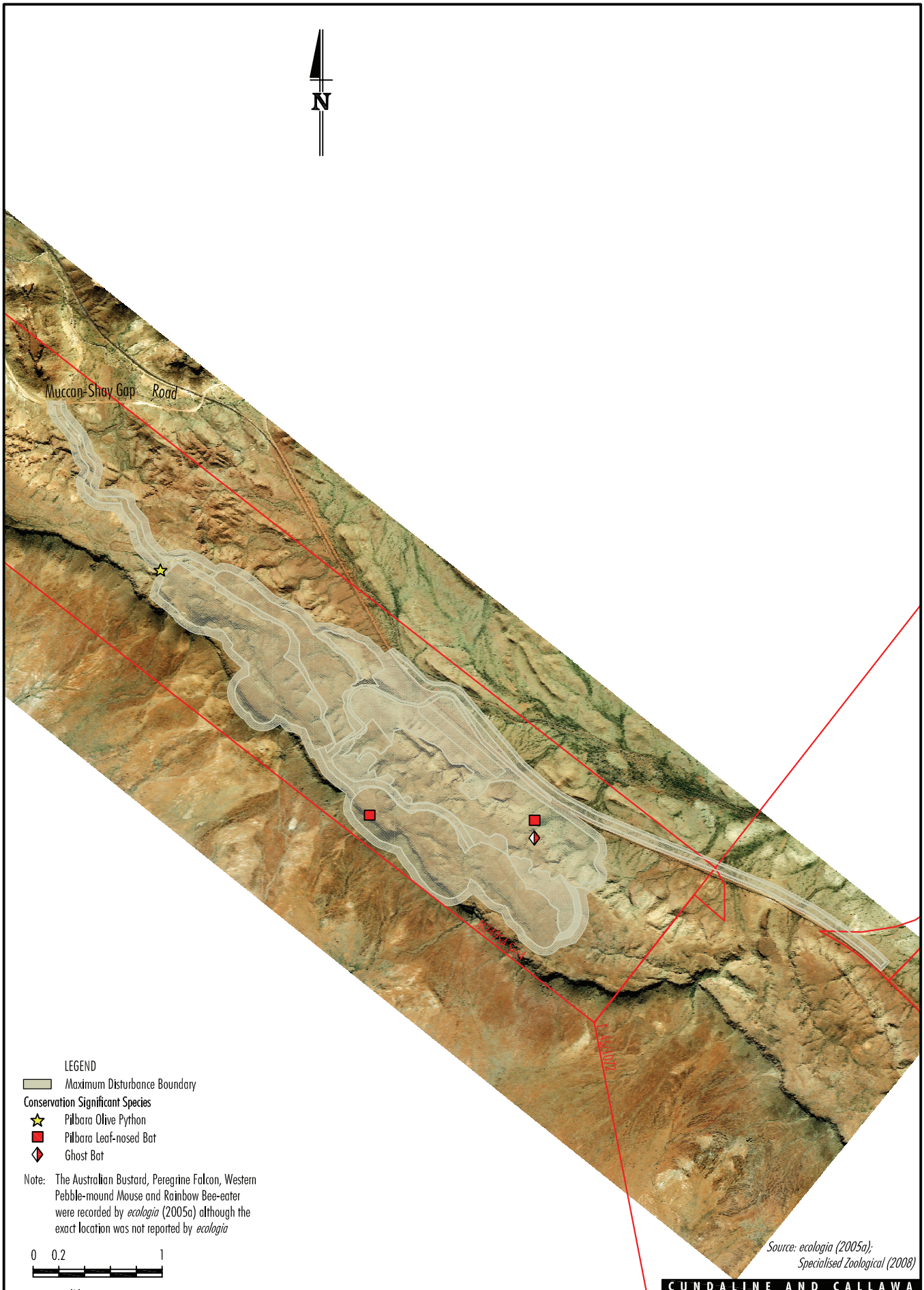
- **Peregrine Falcon** (*Falco peregrinus*)

  The Peregrine Falcon is a large falcon that is widely distributed throughout Australia (Pizzey and Knight, 2007). The species is nomadic to partially sedentary and inhabits cliffs along coasts, rivers and ranges (Pizzey and Knight, 2007). The Birds Australia database (2008) has records of the Peregrine Falcon for the Pilbara bioregion. It was recorded flying through the Cundaline study area in 2005 (*ecologia*, 2005a).

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

  The Pilbara Olive Python is distributed across the Pilbara and Gascoyne regions of Western Australia. Pearson (2003) has reported that the Pilbara Olive Python is widespread across the Pilbara, with many significant populations remaining. Olive Python records within the WAM Faunabase database also support these findings.

  One specimen was found in the hilltop Habitat during the 2005 Cundaline study (*ecologia,* 2005a). The location of the Pilbara Olive Python within the study area is shown on **Figure 9**.



Source: ecologia (2005a); Specialised Zoological (2008)

CUNDALINE AND CALLAWA MINING OPERATIONS EPS

FIGURE 9

Planned Cundaline Mining Operations
Conservation Significant Fauna Species

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BHP-07-16 BS SRE _105E

The Pilbara Olive Python has also been recorded on the Callawa Ridge (Dames and Moore, 1992), at Cattle Gorge (approximately 6 km north-east of the planned Cundaline mining operations (*ecologia*, 2004; *ecologia*, 2005a), and the Yarrie operations (approximately 2 km north of the planned Callawa mining operations (BHPBIO, 2005).

The Pilbara Olive Python prefers rocky escarpments and gorges, often along watercourses (Wilson and Swan, 2003).

- **Mulgara (*Dasycercus cristicauda*)**

The Mulgara is a small carnivorous marsupial that occurs in the arid sandy regions from the eastern Pilbara to central Australia (DEW-SPRAT, 2007). This species inhabits sand plains dominated by *Triodia* species, where it burrows between low sand dunes (Gibson and McKenzie, 2005). The Mulgara also prefers habitat that has not been recently burnt (Gibson and McKenzie, 2005). The Mulgara is infrequently recorded in part due to boom-bust cycles, contracting to core habitat areas in lean times, and irrupting after favourable conditions prevail (Gibson and McKenzie, 2005). The species has been recorded near Cattle Gorge approximately 6 km north-east of the planned Cundaline mining area (DEC, 2008; *ecologia*, 2005e). Limited potential habitat for the Mulgara occurs within the study areas.

Other Threatened Fauna Species

The desktop searches also identified an additional four fauna species listed under the EPBC Act and/or the WC Act and/or listed as a Priority species by the DEC which are considered unlikely to occur in the study area. These species are described in **Table 13**.

Table 13 Threatened Species Considered Unlikely to Occur within the Study Areas

Scientific Name	Common Name	Conservation Status[1]			Notes
		EPBC Act	WC Act	Priority	
Mammals					
Notoryctes caurinus	Northern Marsupial Mole	EN	S1	-	The Northern Marsupial Mole is a little known insectivorous marsupial that spends virtually its entire life underground (DEW-SPRAT, 2007). The species is distributed sparsely across the arid areas of northern Western Australia, in habitats with a sandy soil (DEW-SPRAT, 2007). Very few records of the species are known, probably because it rarely comes to the surface (DEW-SPRAT, 2007). The species has been recorded at Wallal Downs approximately 150 km north-east of the study area (DEC, 2008). Given that its presence is hard to establish without digging deep trenches to search for recent tunnels, it could possibly occur in the sandy areas of the study areas.
Macrotis lagotis	Greater Bilby	VU	S1	-	The Greater Bilby once occurred over the study areas and a Threatened and Priority Fauna database search revealed numerous records with the most recent (2008) occurring at Eighty Mile Beach approximately 100 km north-east of the study area (DEC, 2008). The Greater Bilby has been recorded in areas of the Gibson and Great Sandy Deserts south to Warburton, the Pilbara and Dampierland bioregions, as well as the Kimberley (Faunabase, 2008; Pavey, 2006).

Table 13 (Cont.) Threatened Species Considered Unlikely to Occur within the Study Areas

Scientific Name	Common Name	Conservation Status[1]			Notes
		EPBC Act	WC Act	Priority	
Birds					
Polytelis alexandrae	Princess Parrot/ Alexandra's Parrot	VU	-	P4	The Princess Parrot occurs over red desert sand plains and dunes and along tree-lined watercourses (Pizzey and Knight, 2007). It was last sighted in the Hamersley region nearly a century ago (Pizzey and Knight, 2007). Given the absence of sightings near the study areas since and the fact that its preferred habitat is relatively scarce within the study areas, it is unlikely that the Princess Parrot occurs within the study area.
Reptiles					
Egernia kintorei	Great Desert Skink	VU	S1	-	The Great Desert Skink inhabits arid sandy areas within the Great Sandy Desert and the Gibson Desert (Pearson *et al.*, 2001). It has not been recorded in the study areas and is unlikely to occur there.

[1] EPBC Act: VU Vulnerable, EN Endangered
WC Act : Schedule 1
DEC Priority Species List: Priority 4

5.3.2 Priority Fauna Species

DEC recognises species not listed under the WC Act, but for which there is some concern, and has produced a supplementary list of 'Priority' fauna. Three fauna species listed as Priority species by the DEC have been recorded at the Cundaline and Callawa study areas and are listed in **Table 14**.

Table 14 Priority Species Recorded within the Study Areas

Scientific Name	Common Name	DEC Priority List[1]	Source
Mammals			
*Pseudomys chapmani**	Western Pebble-mound Mouse	P4	2,3,
Macroderma gigas	Ghost Bat	P4	3
Birds			
Ardeotis australis	Australian Bustard	P4	2

[1] DEC Priority Species List 4: Priority 4.
[2] *ecologia* (2005a).
[3] *ecologia* (2005b).
* Abandoned mounds only found.

The fauna species listed in **Table 14** are discussed below.

- **Western Pebble-Mound Mouse** (*Pseudomys chapmani*)

  The Western Pebble-mound Mouse is now a Pilbara endemic. Abandoned mounds have been found in the Murchison and Gascoyne region (Van Dyck and Strahan, 2008). Inactive pebble mounds of this species have been recorded in the Cundaline and Callawa study areas in eucalypt woodland on gravel substrates and hillcrests (*ecologia,* 2005a, 2005b). The Western Pebble-mound Mouse constructs mounds that can cover anywhere from 0.5 to 9.0 square metres (m^2) (Van Dyck and Strahan, 2008).

- **Ghost Bat** (*Macroderma gigas*)

  Ghost Bats are patchily distributed over northern Australia occupying a wide variety of diverse habitats including the arid Pilbara to the rainforests of North Queensland (Van Dyck and Strahan, 2008). This species requires an undisturbed cave, deep fissure or disused mine shaft within which to roost (Van Dyck and Strahan, 2008). Thus, the study areas may contain suitable roosting and/or foraging resources. The Ghost Bat was recorded at both the Cundaline ridge (ecologia, 2005a) and the Callawa ridge (*ecologia*, 2005b, 2005c, 2006a, 2006b, 2006c; ENV, 2007b; Specialised Zoological, 2008a, 2008b). The locations of where the Ghost Bat was found within the study areas are shown on **Figure 8** and **9**. It has also been recorded at Nimingarra (approximately 24 km north-west of the planned Cundaline mining operation) (*ecologia*, 2005d, 2006a; ENV Australia, 2007a; Specialised Zoological, 2008a, 2008b), Yarrie operations (approximately 2 km north of the planned Callawa mining operation) (Dames and Moore, 1992) and Cattle Gorge (approximately 6 km north-east of the planned Cundaline mining operation) (*ecologia*, 2005d; ENV Australia, 2007a, 2007b).

- **Australian Bustard** (*Ardeotis australis*)

  The Australian has been recorded at the Cundaline study area in 2005 (*ecologia,* 2005a). This species has also been recorded by *ecologia* at Cattle Gorge (*ecologia*, 2004; BHPBIO, 2005).

  The Australian Bustard has a wide distribution across Australia and there is a WAM record of its presence south-west of the study areas (FaunaBase, 2008). The Australian Bustard is found in areas of open to lightly timbered woodlands and grasslands, especially tussock grasses like Spinifex, arid scrub and open dry woodlands of mulga (Johnstone and Storr, 1998; Morcombe, 2003).

Desktop searches identified an additional six fauna species listed by the DEC as Priority species which may possibly occur in the study areas (**Table 15**).

Table 15 Priority Species Considered to Possibly Occur within the Cundaline and Callawa Study Areas

Scientific Name	Common Name	DEC Priority List
Mammals		
Sminthopsis longicaudata	Long-tailed Dunnart	P3
Leggadina lakedownensis	Lakeland Downs Mouse	P4
Birds		
Burhinus grallarius	Bush Stone-curlew	P4
Falco hypoleucos	Grey Falcon	P4
Neochmia ruficauda subclarescens	Star Finch	P4
Heteromunia pectoralis	Pictorella Mannikin	P4

The fauna species listed in **Table 15** are discussed below.

- **Long-tailed Dunnart** (*Sminthopsis longicauda*)
  The Long-tailed Dunnart has not been recorded in the study area however database searches suggest that it may occur in the region. The Long-tailed Dunnart is found in low densities in the Pilbara, Murchison, North-eastern Goldfields, Ashburton and Gibson Desert regions of Western Australia, and is also found in the Northern Territory. The Long-tailed Dunnart inhabits rocky landscapes that support a low open woodland or shrubland of Acacias with an understorey of Spinifex hummocks or perennial grasses (Burbidge *et al.,* 1995). The species may possibly occur in the study areas as suitable habitat exists.

- **Lakeland Downs Mouse** (*Leggadina lakedownensis*)
  The Lakeland Downs Mouse is known to occupy a diverse range of habitats including Spinifex and tussock grasslands, samphire and sedgelands, Acacia shrublands, tropical Eucalyptus and Melaluca woodlands and stony ranges (Van Dyck and Strahan, 2008). Most habitats are seasonally inundated on red or white sandy-clay soils (Dyck and Strahan, 2008). This species was recorded at Yarrie in 1998 (DEC, 2008).

- **Bush Stone-curlew** (*Burhinus grallarius*)
  The Bush Stone-curlew has been recorded at Sunrise Hill located approximately 20 km north-west of the planned Cundaline mining operations (*ecologia*, 2005a; 2005e).

  The Bush Stone-curlew has been recorded at Marble Bar (approximately 75 km south-west of the study areas) and Pardoo (approximately 70 km north-west of the study areas) (DEC, 2008).

  The Bush Stone-curlew inhabits open to lightly timbered woodlands of mallee and mulga that has an understorey of small sparse shrubs, grass or litter (Johnstone and Storr, 1998).

- **Grey Falcon** (*Falco hypoleucos*)
  The Grey Falcon is a medium-sized falcon which occurs primarily in the northern half of Australia. The Grey Falcon was recorded at Meentheena approximately 80 km south-east of the study areas (DEC, 2008). The species inhabits open woodland areas on coastal and riverine plains in the arid and semi-arid interior of the country (Johnstone and Storr, 1998; Morcombe, 2003). Within the study area, eucalypt woodlands on drainage lines or valley plains may provide suitable habitat for the Grey Falcon. The species requires tall trees for nesting and utilises large stick nests built by other birds such as crows and ravens or other raptor species (Morcombe, 2003). While this species has not been recorded in the study areas it may potentially utilise habitat within the study areas as it is wide ranging.

- **Star Finch** (*Neochmia ruficauda subclarescens*)

  The Star Finch was recorded at Cattle Gorge, located approximately 6 km north-east of the planned Cundaline mining operations (*ecologia*, 2005e). The species is known to inhabit areas with long grasses and shrubs within swamps and permanent water courses (Johnstone and Storr, 2004). Permanent water courses have not been recorded within the study areas.

- **Pictorella Mannikin** (*Heteromunia pectoralis*)

  The Pictorella Mannikin was recorded at Cattle Gorge, located approximately 6 km north-east of the planned Cundaline mining operations (*ecologia*, 2005e). The species is known to inhabit lightly wooded grasslands with short grass and Spinifex over red soils (Johnstone and Storr, 2004). The species requires low trees or shrubs in which to build a dome nest (Garnett and Crowley, 2000).

5.3.3 Locally and Regionally Significant Species

Other species of conservation significance include endemics, those with restricted or fragmented ranges, or those that are at the extreme limits of their distribution. SRE fauna are those with naturally restricted distributional ranges.

Fauna species that are known to be endemic to the Pilbara region and have been recorded in the Cundaline and Callawa study areas and surrounds are listed in **Table 16**. The Pilbara does not have any endemic bird or frog species (ANRA, 2007; Kendrick and McKenzie, 2001).

Table 16 Vertebrate Fauna Species Endemic to the Pilbara Region and Recorded at the Study Area

Group	Common Name	Scientific Name	Source
Mammals	Western Pebble-mound Mouse	*Pseudomys chapmani*	1,2
	Pilbara Leaf-nosed Bat	*Rhinonicteris aurantia*	1,2
Reptiles	-	*Diplodactylus savagei*	1,2
	-	*Diplodactylus wombeyi*	1
	-	*Delma elgans*	2
	-	*Delma pax*	2
	Pilbara Rock Monitor	*Varanus pilbarensis*	1,2
	Pilbara Olive Python	*Liasis olivaceus barroni*	1

[1] *ecologia* (2005a).

[2] *ecologia* (2005b).

5.3.4 Migratory Bird Species

Migratory species listed under the EPBC Act and international agreements which include the JAMBA, CAMBA, ROKAMBA and the Bonn Convention, recorded in the Cundaline and Callawa study areas are listed in **Table 17**.

The EPBC Act incorporates the migratory species listed under the JAMBA, CAMBA and Bonn Convention.

Table 17 Migratory Species Recorded within the Study Area

Scientific Name	Common Name	Source
Merops ornatus	Rainbow Bee-eater	[1]

[1] *ecologia* (2005b).

The fauna species listed in **Table 17** are discussed below.

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

  The Rainbow Bee-eater was recorded at both the Cundaline and Callawa study areas in 2005 (*ecologia,* 2005a and 2005b). The Rainbow Bee-eater has also been recorded at Hope Downs (Hope Downs Management Services, 2000). The Rainbow Bee-eater occupies numerous habitats including open woodlands with sandy loamy soil, sandridges, sandpits, riverbanks, road cuttings, beaches, dunes, cliffs, mangroves and rainforests (Morcombe, 2003).

Desktop searches identified an additional seven migratory bird species which may possibly occur in the study areas (**Table 18**) (DEC, 2008).

Table 18 Migratory Species Considered to Potentially Occur within the Study Area

Scientific Name	Common Name
Ardea modesta[1]	Eastern Great Egret
Ardea ibis[2]	Cattle Egret
Haliaeetus leucogaster	White-bellied Sea Eagle
*Charadrius veredus**	Oriental Plover
*Glareola maldivarium**	Oriental Pratincole
Numenius madagascariensis	Eastern Curlew
Apus pacificus	Fork-tailed Swift

* Non-breeding migrants.
[1] Listed as White Egret/Great Egret *Egetta alba* under JAMBA and CAMBA.
[2] Listed as *Bubulcus ibis* under JAMBA, ROKAMBA.

All of these species are associated with inland rivers and lakes that contain surface water and/or near coastal areas. It is unlikely that these species would utilise habitat within the study area, with the exception of the Fork-tailed Swift. The Fork-tailed Swift is known to occupy open country from semi-deserts to coastal areas, islands and occasionally forests and cities (Pizzey and Knight, 2007). The Fork-tailed Swift was not recorded in the study areas.

6.0 POTENTIAL IMPACTS

6.1 Potential Impacts: SRE

No known SRE invertebrates were collected during the survey of the Cundaline and Callawa study areas.

There are currently large gaps in the taxonomic knowledge of the invertebrate groups with the potential for short-range endemism. Some specimens were collected where their potential for short-range endemism could not be determined. These were: the mygalomorph spider *Conothele* sp., the pseudoscorpion *Austrohorus* sp., the centipede *Cryptops* sp. and geophilid centipede sp from the Family Schendylidae.

The camaenid landsnails which were collected appear to belong to a single un-named species of a currently un-named genus, this landsnail was collected in large quantities (78 specimens) across the survey sites, on both Cundaline and Callawa ridges, which suggests that it is locally abundant, is not restricted and occurs more widely across the Goldsworthy area.

The presence or absence of SRE invertebrates during a survey should not be used as the only indicator of short-range endemism within the study areas. Instead, importance should be placed on habitat that has the highest potential for supporting SREs. These habitats are the south-west-facing and south-east-facing ridges and gorges identified and described in Section 4.7. Parts of the south-west-facing and south-east-facing ridges and gorges receive little or no direct sunlight throughout the day, thus providing a cool and moist microclimate suitable for relictual species. The south-west-facing and south-east-facing ridges make up a relatively small proportion of the overall study areas; however sections of these ridges lie within the proposed disturbance footprints of the Cundaline and Callawa mining operations.

6.2 Potential Impacts: Terrestrial Vertebrate Fauna

This section assesses the potential impacts of the planned Cundaline and Callawa mining operations on vertebrate fauna. Generally, potential impacts are associated with:

- habitat removal/modification (Section 6.2.1);
- conservation significant species (Section 6.2.2);
- noise (Section 6.2.3);
- light (Section 6.2.4);
- introduced flora (Section 6.2.5); and
- introduced fauna (Section 6.2.5).

Threatening processes relevant to the Pilbara Region have been identified by the ANRA (2007). Impacts identified in the bioregion by the assessment include changed fire regimes, grazing pressure, feral animals, weeds and vegetation clearing. These are discussed below, where relevant.

6.2.1 Habitat Removal/Modification

The planned Cundaline and Callawa mining operations would result in the removal of habitat via land clearance. Land Clearance is listed as key threatening processes under the EPBC Act. Fauna currently residing in the habitat within the proposed disturbance areas would be displaced, however the habitats present over the study area are widely represented throughout the region, and the vertebrate fauna assemblage recorded is similar to other regional sites.

The planned Cundaline and Callawa mining operations would also result in the modification of habitat by the reduction in habitat connectivity, particularly for fauna species which inhabit rocky ridge and gorge habitats (e.g. Rock Wallabies). Habitat which occurs in between proposed disturbance areas would also become isolated for some species.

No permanent water source is present at the study area. However, ephemeral drainage lines which provide an intermittent source of water would be impacted.

Land clearance may also result in the direct loss of individuals through clearance activities, the most likely species at risk are those that inhabit arboreal habitats (e.g. hollow roosting bats), inhabit subterranean habitats (e.g. some snakes) or have low mobility (e.g. small reptiles). Nesting birds and their young may also be directly impacted, although this potential impact may be reduced by considering the timing of clearance activities. Mobile fauna able to avoid direct impact will be displaced into surrounding habitat.

Considering the management measures outlined in the previous Goldsworthy Environmental Management Plan (including minimisation of vegetation clearance, progressive rehabilitation and fire management), it is considered that the continuation of those measures for the planned Cundaline and Callawa mining operations would reduce the potential impacts on vertebrate fauna.

The planned Cundaline and Callawa mining operations would result in the long-term loss of habitat for some species dependant on Rocky Gorge habitat, as these habitats cannot be re-created by revegetation. Although, habitat removal/modification is not likely to significant impact any vertebrate fauna, as the vertebrate fauna assemblage recorded at the Cundaline and Callawa study areas is similar to other regional sites.

6.2.2 Conservation Significant Species

The occurrence of conservation significant species at the Cundaline and Callawa study areas is discussed in Section 5.3.

As stated in Section 5.3.1, BHPBIO referred the planned Callawa and Cundaline mining operations to the DEWHA under the EPBC Act in order to confirm whether the planned activities were considered to constitute a controlled action on matters of National Environmental Significance (including the EPBC Act listed Northern Quoll and Pilbara Leaf-nosed Bat). The DEHWA evaluated the referral and notified BHPBIO that the proposal was not a controlled action.

The likely impacts of the planned Cundaline and Callawa mining operations on conservation significant species are as follows:

- **Northern Quoll –** The Northern Quoll has been recorded at multiple locations on the Callawa Ridge (Section 5.3.1). A low-localised impact on the Northern Quoll is possible given that potential habitat for this species would be removed or modified, however, it is likely that any impacts would be limited in extent given the large extent of potential habitat remaining.
- **Pilbara Leaf-nosed Bat** - It is unlikely that the planned mining operations at the Cundaline and Callawa deposits would result in a significant impact on the Pilbara Leaf-nosed Bat, as:
    - the species record at the Cundaline study area is within the planned disturbance area, is likely to represent an individual passing through the area (rather than a substantial cave or maternity roost);
    - the specific management measures implemented for the Goldsworthy Operations (as outlined in the Bat Management Plan) have shown to be effective as ENV (2007) has reported that the Pilbara Leaf-nosed Bat community using the nearby caves is stable; and
    - a low-localised impact on the Pilbara Leaf-nosed Bat is possible as the proposed mining will involve the removal of some potential habitat for this species, however any impacts are likely to be limited in extent.
- **Peregrine Falcon** – This species is wide ranging and although it was recorded flying across the study area (*ecologia*, 2005a) only marginal habitat for this species occurs within the study area and this species is not likely to be dependant on the habitat. The ANRA (2007) discusses the need to clarify the distributions of this species.

- **Pilbara Olive Python** – This species is likely to be a resident in the gorge habitat of the study area. This habitat is considered to provide refuge for individuals of this species. The Pilbara Olive Python is a widespread species in the Pilbara and therefore while the development would result in the loss of habitat for this species in the development footprint, the species and its habitat occurs in the wider area. This species would not be significantly impacted by the planned Cundaline and Callawa mining operations.

- **Mulgara** – This species has been previously recorded near the Cattle Gorge mining area (approximately 6 km north-east of the planned Cundaline mining operations). The main distribution of this species is in the Great Sandy Desert to the east. As such, it is unlikely that this species would be significantly impacted by the planned Cundaline and Callawa mining operations.

- **Western Pebble-mound Mouse** – Evidence of this mouse has been repeatedly recorded within the study area (Section 5.3.2), as such it is likely that a local population of Western Pebble-mound Mouse utilise the habitat within the study areas. This species is widely distributed in the Pilbara, and therefore, while the development would result in the loss of habitat for this species in the development footprint, the species and its habitat occurs in the wider area. This species would not be significantly impacted by the planned Cundaline and Callawa mining operations.

- **Ghost Bat** – This species was recorded at the Callawa study area in 2005 (*ecologia,* 2005b), near Yarrie in 2006 and 1992 (DEC, 2008; Dames and Moore, 1992). The Ghost Bat is presently, patchily distributed over northern Australia occupying a wide variety of diverse habitats including the arid Pilbara to the rainforests of North Queensland (Van Dyck and Strahan, 2008). A low-localised impact on the Ghost Bat is possible as the proposed mining will involve the removal potential habitat for this species, however any impacts are likely to be limited in extent.

- **Australian Bustard** – This species was recorded by *ecologia* in 2005 (*ecologia,* 2005a). The Australian Bustard is a wide-ranging species and its potential habitat is common (i.e. open grassland and open woodland [Johnstone and Storr, 1998]). This species would not be significantly impacted by the planned Cundaline and Callawa mining operations.

- **Long-tailed Dunnart** – This species has not been recorded in the study areas. This Dunnart is widely distributed in low densities in the Pilbara, Murchinson, north-eastern Goldfields, Ashburton and Gibson Desert regions of Western Australia, and is also found in the Northern Territory. Therefore, while the development would result in the loss of habitat for this species in the development footprint, the species and it habitat occurs in the wider area. This species would not be significantly impacted by the planned Cundaline and Callawa mining operations.

- **Lakeland Downs Mouse** – This species was recorded at Yarrie in 1998 (DEC, 2008). This species occupies a wide range of habitats that are found throughout the Pilbara region and therefore its considered it would not be significantly impacted by the planned Cundaline and Callawa ,mining operations.

- **Bush Stone-curlew** – The Bush Stone-curlew has been recorded at a number of different locations around the study areas. This species occupies a wide range of woodland habitats that are found throughout the Pilbara region and therefore it would not be significantly impacted by the planned Cundaline and Callawa mining operations.

- **Grey Falcon** – The listed species was recorded at Meentheena approximately 80 km south-east of the study areas (DEC, 2008). While this species has not been recorded in the study area it may potentially utilise habitat within the study area as it is wide ranging. This species would not be significantly impacted by the planned Cundaline and Callawa mining operations.

- **Star Finch** – The Star Finch was recorded at Cattle Gorge mining area approximately 6 km north-east of the planned Cundaline mining operations (*ecologia*, 2005e). It is mostly associated with permanent water courses and as this habitat is not represented within the study areas, it is unlikely that it will be impacted by the planned Cundaline and Callawa mining operations.

- **Pictorella Mannikin** – The Pictorella Mannikin was recorded at Cattle Gorge mining area approximately 6 km north-east of the planned Cundaline mining operations (*ecologia*, 2005e). The species is known to inhabit lightly wooded grasslands with short grass and Spinifex over red soils (Johnstone and Storr, 2004). As this habitat is well represented outside of the study area, it is unlikely this species will be impacted by the planned Cundaline and Callawa mininig operations.

- **Rainbow Bee-eater and other migratory species** – Migratory bird species are unlikely to be dependant on the specific habitat within the study areas.

Considering the management measures outlined in the previous Goldsworthy Environmental Management Plan (particularly the Significant Species Management Plan), it is considered that the continuation of those measures for the planned Cundaline and Callawa mining operations would reduce the potential impacts on conservation significant fauna.

6.2.3 Fauna and Noise

The development of the planned Cundaline and Callawa mining operations is likely to generate constant noise due to machinery, heavy and light vehicles and the general presence of people. The affects of noise on wildlife have been well studied, although responses vary depending on the species and on the age and sex of the individual animal (see Radle, 2007 for a comprehensive summary).

General responses to noise across a wide variety of animal species range from interruptions in feeding and resting behavior to complete abandonment of an area. Noise may lead to reduced population densities in small mammals, nest failure in birds and reduced hunting efficiency in bats due to disturbance of their echolocation system. Constant levels of noise also interfere with species communication. Species which may be especially at risk of disturbed communication are those that use calls to communicate over larger distances.

6.2.4 Fauna and Light

The planned Cundaline and Callawa mining operations are likely to result in an increase in exposure of fauna to artificial light. Artificial light from the mine-site may have detrimental effects on resident bird, mammal and reptile species, as it may interfere with biological and behavioural activities that are governed by the length of day or photoperiod, including reproduction, dormancy, foraging and migration (Bradshaw and Holzapfel, 2007; Corre *et al.*, 2002). Bird *et al.* (2004) found that nocturnal mice exposed to artificial light exploited fewer food patches compared to mice exposed to areas of less light, while nocturnal frogs exposed to artificial light have been known to suspend normal feeding and reproductive behaviour (Harder, 2002).

6.2.5 Fauna and Introduced Flora

Environmental weeds may be brought in by mobile mining equipment. These may have a negative impact on fauna species as vegetation communities become simplified and out-competed. It is therefore important to check for weeds during mining operations. Considering the weed management measures outlined in the previous Goldsworthy Environmental Management Plan (particularly the Weed Management Plan), it is considered that the continuation of those measures for the planned Cundaline and Callawa mining operations would reduce the potential impacts from introduced flora.

6.2.6 Introduced Fauna

Twelve introduced fauna species have been recorded in the study areas or within the Chichester subregion (ANRA, 2007), including the House Mouse, Black Rat, Dingo (or dingo dog hybrids), Cat, Red fox, European Rabbit, Pig, Donkey, Horse, Camel, sheep and European Cattle.

While the European Cattle and sheep are domesticated within the study area, the other species are considered to be feral animals.

Predation by the Feral Cat is listed as key threatening processes under the EPBC Act, although both the Cat and Dingo have the potential to prey on native fauna species.

Expansion of the mine site may attract more individuals of the feral animals previously recorded, and attract additional feral animal species that have not been previously recorded

Considering the measures to manage potential impacts outlined in the previous Goldsworthy Environmental Management Plan, it is considered that the continuation of those measures for the

planned Cundaline and Callawa mining operations would be adequate for the prevention and control of increased feral species and attraction of new feral species.

7.0 CONCLUSION

Short-range Endemics

There were no known SRE invertebrate species identified as a result of the survey within the Cundaline and Callawa Ridges. However, habitat that is currently considered to potentially support SRE invertebrates was identified along both ridges. This habitat is the south-west-facing and south-east-facing ridges and gorges which provide a sheltered mesic environment capable of supporting relictual species such as SREs. The south-west-facing and south-east-facing ridges make up a relatively small proportion of the overall study areas; however sections of these ridges lie within the proposed disturbance footprints of the Cundaline and Callawa mining operations.

Vertebrate Fauna

Eight conservation significant vertebrate fauna species have been recorded at Callawa and Cundaline, across two separate surveys conducted in 2005: Northern Quoll, Pilbara Leaf-nosed Bat, Ghost Bat, Western Pebble-mound Mouse, Peregrine Falcon, Australian Bustard, Rainbow Bee-eater and; Pilbara Olive Python.

All habitats present over the study area are widely represented throughout the region, and the vertebrate fauna assemblage recorded is similar to other regional sites.

Considering the measures to manage potential impacts outlined in the previous Goldsworthy Environmental Management Plan, it is considered that the continuation of those measures for the planned Cundaline and Callawa mining operations would minimise potential impacts on vertebrate fauna.

8.0 SURVEY TEAM

The Cundaline and Callawa April/May 2008 Short-Range Endemic Survey was conducted by E. Guarino and S. Doody Validus, contracted to ENV.

The Cundaline and Callawa July 2008 Short-Range Endemic Survey was conducted by:

Mr Paul Bolton	B.Sc (Hons)	Outback Ecology
Ms Carly Weston	B.Sc (Hons)	Outback Ecology
Mr Jarrad Donald	B.Sc (Hons)	Outback Ecology

Invertebrate identification was undertaken by the following specialists:

Dr Mark Harvey	Museum of Western Australia
Dr Shirley Slack-Smith	Museum of Western Australia

The Cundaline and Callawa July 2008 survey was conducted under the following licence issued by DEC:

- Licence to Take Fauna for Scientific Purposes No. SF006429
  - Date of issue: 03/07/2008
  - Valid from: 01/07/2008
  - Date of expiry: 30/06/2009

A copy of this licence is provided in **Appendix F**.

9.0 REFERENCES

Abbott, I. (1994) Distribution of the Native Earthworm Fauna of Australia: a Continent-wide Perspective. *Aust. J. Soil Res.* 32*:* 117-126.

Allen, G.R., Midgley, S.H. and Allen, M. (2002) *Field Guide to the Freshwater Fishes of Australia*. Western Australian Museum, Perth.

Australian Museum (2008a) *Australian Museum Online*.
Website: http://www.amonline.net.au/factsheets/scorpions.htm
Date Accessed: July 2008.

Australian Museum (2008b) *The Australian Museum database*. The bounding coordinates used were: S20 35 51.1 E120 15 13.3 with a 200 km Buffer.

Australian Museum and Rio Tinto (2008) *BioMaps - Map Locater Homepage*.
Website: http://www.biomaps.net.au/biomaps/
Date Accessed: July 2008.

Australian Natural Resource Atlas (2007) *Biodiversity Assessment Pilbara*.. Department of the Environment, Water, Heritage and the Arts. Canberra, ACT, Australia.

BHP Billiton Iron Ore (2005) *Goldsworthy Extension Project Environmental Protection Statement*.

Bird, B., Branch, L. and Miller, D. (2004) Effects of coastal lighting on foraging behaviour of beach mice. *Conservation Biology* 18(5): 1435-1439.

Birds Australia (2008) *The Birds Australia database Pilbara*. The boundary co-ordinates used were: S20 35 51.1 E120 15 13.3 with a 200 km Buffer.

Bradshaw, W. and Holzapfel, C. (2007) Evolution of Animal Photoperiodism. *Annual Review of Ecology, Evolution and Systematics* 38: 1-25.

Brennan, K.E.C., Majer, J.D., and Moir, M, L. (2005) Refining Sampling Protocoals for Inventorying Invertebrate Biodiversity: Influence of Drift-Fence Length and Pitfall Trap Diameter on Spiders. *The Journal of Arachnology* 33: 681-702.

Brunet, B. (1994) *The Silken Web – A Natural History of Australian Spiders*. Reed Books, Australia.

Brunet, B. (1996) *Spider watch: A Guide to Australian Spiders*. Reed New Holland Book, New Holland Publishers Pty Ltd, Sydney.

Burbidge, A., McKenzie, N. and Fuller, P. (1995) *Long-tailed Dunnart*. In: Strahan, R. (Ed.) *Mammals of Australia*. Australian Museum, Sydney, pp 146-147.

Bureau of Meteorology (2008) *Climate Statistics for Australian Locations*.
Website. http://www.bom.gov.au
Date Accessed: 25 August 2008

Chevron Australia (2007) *Gorgon Project: Terrestrial and Subterranean Environment Summary of Baseline Ecological Information*.

Cogger, H.G. (2000) *Reptiles and Amphibians of Australia*, *6th edition*.

Commonwealth Scientific and Industrial Research Organisation (1970) *The Insects of Australia*. Melbourne University Press.

Corre, M., Ollivier, A., Ribes, S. and Jouventin, P. (2002) Light-induced mortality of petrels: a 4-year study from Reunion Island (Indian Ocean). *Biological Conservation* 105: 93-102.

Dames and Moore Pty Ltd (1992) *Goldsworthy Extension Project Phase II – Consultative Environmental Review*. Report prepared for BHP Billiton Ore Pty Ltd.

Dell, J. (2007) *Short Range Endemics*: *The DEC/EPA Perspective*. Terrestrial Ecosystem Branch Strategic Policy Division. Department of Environment and Conservation. Presentation at the Short Range Endemics Symposium, August 2007.

Department of the Environment and Conservation (2008) *Threatened and Priority Fauna Database held by the Department of Environment and Conservation.* Search coordinates used: S 20 35 51.1 E 120 15 13.3 (WGS 84) with a 100 km Buffer.

Department of the Environment and Heritage (2006) *Online Guide. Australian Faunal Directory. Australian Biological Resources Study*.
Website: www.deh.gov.au/cgi-bin/abrs/fauna

Department of the Environment, Water, Heritage and Arts (2008) *Biodiversity Analysis Tool.*
Website: http://www.environment.gov.au/biodiversity/abif/bat/index.html
Date Accessed: July 2008.

Department of Environment and Water Resources - SPRAT (2007) *The Protected Matters and Environmental Reporting Tools of the Australian Government.* Search coordinates used: S 20 35 51.1 and E 120 15 13.3 (WGS 84) with a 100 km Buffer.

ecologia (1999) *Yarrie Biological and Soil Survey.* Report prepared for BHP Iron Ore Pty Ltd.

ecologia (2004) *Yarrie Cattle Gorge Biological Survey*. Report prepared for BHP Iron Ore Pty Ltd.

ecologia (2005a) *Cundaline Biological Assessment Survey*. Report prepared for BHP Iron Ore Pty Ltd.

ecologia (2005b) *Callawa Biological Assessment Survey.* Report prepared for BHP Billiton Pty Ltd.

ecologia (2005c) Goldsworthy Bat Monitoring Programme December 2005. Unpublished report commissioned by BHP Billiton Iron Ore Pty Ltd.

ecologia (2005d) *Pilbara Leaf-nosed Bat, (Rhinonicteris aurantis) and Ghost Bat, (Macroderma gigas) Monitoring Survey at Nimingarra and Cattle Gorge*. Report prepared for BHP Billiton Iron Ore Pty Ltd.

ecologia (2005e) *Goldsworthy Extension Project Biological Assessment Survey*. Unpublished report for BHP Billiton Iron Ore Pty Ltd.

ecologia (2006a) *Goldworthy Bat Monitoring Programme February 2006*. Unpublished report commissioned by BHP Billiton Iron Ore Pty Ltd.

ecologia (2006b) *Goldsworthy Bat Monitoring Programme June 2006*. Unpublished report commissioned by BHP Billiton Iron Ore Pty Ltd.

ecologia (2006c) *Goldsworthy Bat Monitoring Programme August 2006*. Unpublished report commissioned by BHP Billiton Iron Ore Pty Ltd.

Edgecombe, G. and Barrow, L. (2007) A new genus of scutigerid centipedes (Chilopoda) from Western Australia, with new characters for morphological phylogenitics of Scutigeromorpha. *Zootaxa* 1409: 23-50.

ENV Australia (2007a) *Goldsworthy Bat Monitoring March 2007*. Unpublished report commissioned by BHP Billiton Iron Ore Pty Ltd.

ENV Australia (2007b) *Goldsworthy Bat Monitoring July 2007*. Unpublished report commissioned by BHP Billiton Iron Ore Pty Ltd.

ENV Australia (2008) *Short-range Endemic Study: Pseudoscorpions (chelicerata:arachnidia)*. Report prepared for MPD JV Asset Development Projects.

Environment Australia (2000) *Revision of the Interim Biogeographic Regionalisation of Australia (IBRA) and the Development of Version 5.1. – Summary Report*. Department of Environment and Heritage, Canberra.

Environmental Protection Authority (2002) *Terrestrial Biological Surveys as an Element of Biodiversity Protection*. Position Statement No 3. March, 2003.

Environmental Protection Authority (2004) *Guidance for the Assessment of Environmental Factors: Terrestrial Fauna Surveys for Environmental Impact Assessment in Western Australia*. No 56. June, 2004.

Environmental Protection Authority (2006) *Mt Gibson Iron Ore Mine and Infrastructure Project*.

FaunaBase (2008) *Records of the Western Australian Museum, Incorporating specimen records from the Queensland Museum and the Museum and Art Gallery of the Northern Territory*. Website: http://www.museum.wa.gov.au/faunabase/prod/index.htm Date Accessed: 1 July 2008

Framenau, V.W. and Yoo, J-S. (2006) Systematics of the new Australian wolf spider genus *Tuberculosa* (Araneae: Lycosidae). *Invertebrate Systematics* 20*:* 185-202.

Garnett, S. T. and Crowley, G. M. (2000) *The Action Plan for Australian Birds*. National Heritage Trust, Environment Australia.

Gibson, L. and McKenzie, N. (2005) *Species Composition of Small Ground Dwelling Mammals in the Pilbara Region of Western Australia*. Abstract for the Australian Mammal Society, 2005 Scientific Meeting. Albany, Western Australia.

Harder, B. (2002) The unnatural ecology of artificial light at night. *Science News* 161(16): 242.

Harvey, M.S. (1998) Pseudoscorpion Groups with Bipolar Distributions: A New Genus from Tasmania Related to the Holarctic *Syarinus* (Arachnida, Pseudoscorpiones, Syarinidae). *The Journal of Arachnology* 26: 429-441.

Harvey, M.S. (2002) Short range endemism in the Australian fauna: some examples from non-marine environments. *Invertebrate systematics* 16: 555-570.

Harvey, M.S (2008a) *The Short-Range Endemic Invertebrate Fauna from Cundaline/Callawa, Western Australia*. Unpublished report by the Western Australian Museum for Outback Ecology Services.

Harvey, M.S. (2008b) *The Short-Range Endemic Invertebrate Fauna from Spinifex Ridge, Western Australia*. Unpublished report by the Western Australian Museum for Outback Ecology Services.

Harvey, M.S. and Yen, A.L. (1989) *Worms to Wasps: An Illustrated Guide to Australia's Terrestrial Invertebrates*. Oxford University Press, Melbourne.

Heatwole (1987) *Major Components and Distribution of the Terrestrial Fauna*. P 101-135. In Dyne, G.R. and Walton, D.W. (Eds). *Fauna of Australia, General Articles*. Canberra, Australian Government Publishing Service, Volume 1a.

Higgins, P.J. (Ed.) (1999) *Handbook of Australian, New Zealand, and Antarctic Birds*. *Volume 4, Parrots to Dollarbird*. Birds Australia, Oxford University Press.

Higgins, P.J., Peter, J.M. and Steele, W.K. (Eds.) (2001) *Handbook of Australian, New Zealand, and Antarctic Birds*. *Volume 5, Tyrant-flycatchers to Chats*. Birds Australia, Oxford University Press.

Hope Downs Management Services (2000) *Hope Downs Iron Ore Project Public Environmental Review*.

Johnson, M.S., Hamilton, Z.R., Murphy, C.E., MacLeay, C.A., Roberts, B. and Kendrick, P.G. (2004) Evolutionary genetics of island and mainland species of *Rhagada* (Gastropoda: Pulmonata) in the Pilbara Region, Western Australia. *Australian Journal of Zoology* 52(4): 341-355.

Johnstone, R.E. and Storr, G.M. (1998) *Handbook of Western Australian Birds. Volume I – Non-passerines (Emu to Dollarbird)*. W.A. Museum, Perth.

Johnstone, R.E. and Storr, G.M. (2004) *Handbook of Western Australian Birds. Volume 2 – Passerines (Blue-winged Pitta to Goldfinch)*. W.A. Museum, Perth.

Kendrick, P. and McKenzie, N. (2001) *A Biodiversity Audit of Western Australia's 53 Biogeographical Subregions in 2002. Pilbara 1 (PIL1 – Chichester synopsis)*. Department of Conservation and Land Management.

Larson, H.K. (2001) A revision of the gobiid fish genus *Mugilogobius* (Teleostei: Gobioidei), and its systematic placement. *Records of the Western Australian Museum, Supplement* 62: 1-233.

Main, B.Y. (1976) *Spiders*. The Australian Naturalist Library, Williams Collins Pty Ltd, Sydney

Main, B.Y. (1982) *Adaptations to arid habitats by mygalomorph spiders*. In Barker, W.R. and Greenslade, P.J.M. (Eds.) (1982) *Evolution of the Flora and Fauna of Arid Australia*. Published by Peacock Publications, Frewville, South Australia.

Main, B.Y. (1999) *Biological anachronisms among trapdoor spiders reflect Australia's environmental changes since the Mesozoic*. In Ponder, W. and Lunney, D. (Eds.) (1999) *The Other 99%. The Conservation and Biodiversity of Vertebrates*. Transactions of the Royal Zoological Society of New South Wales.

Main, B.Y. (2002) *Survey of Trapdoor Spiders Occurring in Avon Location 1881, Lots 11 & 14, including an Area for Proposed Relocation of the Voyager Quarry*.

Main, B.Y. (2005) *The Mygalomorph Spiders from the Mt Gibson Region, Western Australia, Including Species Apparently Endemic to the Area.* Report prepared for ATA Environmental.

Menkhorst, P. and Knight, F. (2004) *A Field Guide to the Mammals of Australia*. 2nd Edition. Oxford University Press, South Melbourne, Australia.

Miller, A.C., Ponder, W.F. and Clark, S.A. (1999) Freshwater snails of the genera *Fluvidona* and *Austropyrgus* (Gastropoda: Hydrobiidae) from northern New South Wales and southern Queensland. *Invertebrate Taxonomy* 13: 461-489.

Morcombe, M. (2003) *Field Guide to Australian Birds.* Second Edition. Steve Parish Publishing Pty Ltd, Archerfield, Australia.

Morton, S.R., Short, J. and Barker, R.D. with an Appendix by Griffin, G.F. and Pearce, G. (1995) *Refugia for biological diversity in Arid and Semi-arid Australia*. A report to the Biodiversity Unit of the Department of Environment, Sport and Territories. CSIRO Australia, Canberra.

Outback Ecology Services (2006) *Spinifex Ridge Molybdenum Project: Short-range Endemic Invertebrate Fauna Survey*. Unpublished report for Moly Mines Ltd.

Outback Ecology Services (2008a) *Spinifex Ridge Molybdenum Project: Invertebrate Short-range Endemic Fauna Assessment*. Unpublished report for Moly Mines Ltd.

Outback Ecology Services (2008b) *Area C Revision 4: Invertebrate Short-range Endemic Assessment*. Unpublished report for BHP Billiton Iron Ore.

Outback Ecology Services (2008c) *Orebody 24/25 Upgrade: Invertebrate Short-range Endemic Assessment*. Unpublished report for BHP Billiton Iron Ore.

Pavey, C. (2006) *National Recovery Plan for the Greater Bilby Macrotis lagotis*. Northern Territory Department of Natural Resources, Environment and the Arts.

Pearson, D. (2003) Giant Pythons of the Pilbara. *Landscope* 19(1): 32-39.

Pearson, D., P. Davies, Carnegie, N. and Ward, J (2001) The Great Desert Skink *(Egernia kintorei*) in Western Australia: distribution, reproduction and ethno-zoological observations. *Herpetofauna* 31. 64-68.

Pizzey, G. and Knight, F. (2007) *Field Guide to the Birds of Australia*. Harper Collins, Sydney.

Ponder, W.F. and Colgan, D.J. (2002) What makes a narrow range taxon? Insights from Australian freshwater snails. *Invertebrate systematics* 16: 571-582.

Ponder, W.F., Clark, G.A., Miller, A.C. and Toluzzi, A. (1993) On a major radiation of freshwater snails in Tasmania and eastern Victoria: a preliminary overview of the *Beddomeia* group (Mollusca: Gastropodia: Hydrobiidae). *Invertebrate Taxonomy* 7: 501-750.

Radle, A.L. (2007) *The Effect of Noise on Wildlife: A Literature Review*. Website: http://interact.uoregon.edu/MediaLit/wfae/library/articles/radle_effect_noise_wildlife.pdf Date Accessed: October 2008

Raven, R.J., Baehr, B.C. and Harvey, M.S. (2002) *Spiders of Australia. Interactive identification to subfamily*. CSIRO publishing, Collingwood.

Shear, W.A. and Mesibov, R. (1997) Australian chordeumatidan millipedes. III. A review of the millipede family Metopiotrichidae Attems in Australia (Diplopoda: Chordeimatida). *Invertebrate Taxonomy* 11: 141-178.

Sierwald, P. and Bond, J.E. (2007) Current Status of the Myriapod Class Diplopoda (Millipedes): Taxonomic Diversity and Phylogeny. *Annu. Rev. Entomol* 52: 401-420.

Slack-Smith, S.M. (2002) *Report to BGC Quarries on a Survey of Invertebrates (Terrestrial Molluscs) of Areas within and Adjacent to a Proposed Expansion of the Voyager Quarry, WA*.

Slater. P., Slater. P. and Slater, R. (2007) *Slater's Field Guide to Australian Birds*. New Holland Publishers.

Specialised Zoological (2008a) Goldsworthy Bat Monitoring, December 2007. *Unpublished report prepared for ENV Australia and BHP Billiton Iron Ore Pty Ltd.*

Specialised Zoological (2008b) Goldsworthy Bat Monitoring, February 2008. *Unpublished report prepared for ENV Australia and BHP Billiton Iron Ore Pty Ltd.*

Strahan, R. (2002) *The Mammals of Australia* (revised edition) 6th edition. Reed Books, Chatswood, NSW.

Storr, G.M., Smith, L.A. and Johnstone, R.E. (1983) *Lizards of Western Australia. II. Dragons and Monitors*. W.A. Museum, Perth.

Storr, G.M., Smith, L.A. and Johnstone, R.E. (1990) *Lizards of Western Australia. III. Geckos and Pygopods*. W.A. Museum, Perth.

Storr, G.M., Smith, L.A. and Johnstone, R.E. (1999) *Lizards of Western Australia. I. Skinks*. W.A. Museum, Perth.

Storr, G.M., Smith, L.A. and Johnstone, R.E. (2002) *Snakes of Western Australia*. W.A. Museum, Perth.

Thackway, R. and Cresswell, I.D. (Eds.) (1995) *An Interim Biogeographical Regionalisation of Australia.* Australian Nature Conservation Agency (now DEH), Canberra.

Tyler, M.J., Smith, L.A. and Johnstone, R.E. (2000) *Frogs of Western Australia.* Revised Edition. W.A. Museum, Perth.

Van Dyck. S. and Strahan. R. (2008) *The Mammals of Australia*. Third Edition. Queensland Museum, Reed New Holland Sydney.

Van Vreeswyk, A.M.E., Payne, A.L., Leighton, K.A. and Hennig, P. (2004) *An Inventory and Condition Survey of the Pilbara Region, Western Australia*. Technical Bulletin No. 92. Department of Agriculture, Perth

Western Australian Museum (2008) *The Western Australian Museum Database.* The bounding co-ordinates used were: S20 35 51.1 E120 15 13.3 with a 200 km Buffer.

Wilson, S. and Swan, G. (2003) *A Complete Guide to the Reptiles of Australia*. Reed New Holland, Sydney.

Wilson, S. and Swan, G. (2008) *A Complete Guide to the Reptiles of Australia*. Reed New Holland, Sydney.

Appendix A

Western Australian Museum Guidelines: Preservation and Lodgement Arachnid and Myriapod Specimens

Western Australian Museum
Preservation and Lodgement of Specimens
Arachnids and Myriapods

Preservation

All specimens are to be fixed in ethanol as rapidly as possible after collection.

Small specimens (e.g. pseudoscorpions, schizomids) preferably to be fixed in 100% ethanol. Otherwise 75% ethanol is fine.

Large specimens (e.g. scorpions, trap-door spiders):

- Remove third left leg at point of specimen death using clean, small scissors (wash the scissors in water, and dry with clean paper towel between each specimen).
- Place leg in 100% ethanol in 2 ml Cryotube with screw cap (available from Interpath Service Pty Ltd, Melbourne).
- Preserve remainder of specimen in tube or jar (see below).
- Include Cryotube in same jar as specimen.

Each container should contain a unique coded identifier that we can quote when supplying identifications.

Each container should contain a small printed label specifying the concentration of the ethanol (e.g. "100% ETOH" or "75% ETOH").

Storage

Specimens should be stored in suitable glass containers. Plastic is not suitable as they deteriorate over time.

- Smaller specimens should be stored in SAMCO "Specimen Tubes Soda Glass Poly Stopper" vials, Size Code G050/26.
- Other vial sizes of SAMCO vials are available for different sized animals.
- Larger specimens should be in small glass jars.

Keep specimens in cool place, ideally in a refrigerator.

Labels

Each vial should contain a small, neatly trimmed printed label with the following specifications:

- Arial 4.5 font
- Use Latitudes and Longitudes (DD°MM'SS") not UTMs or decimal degrees.
- Specify the datum.
- Dates with month spelled out, not as a numeral.

> W.A.: Mesa Y-09, ca. 64 km SSW. of Pannawonica
> 25°18'23"S, 117°51'03"E (WGS 84)
> 14 Dec. 2007-5 Jan. 2008
> J.A. Brown, T.R. Smith (Eco-company site 667-898A)
> Troglofauna trap, 10 metres

If the vial is suspected of containing multiple species, ensure that sufficient labels are included so that when we transfer specimens to new vials, we have enough labels.

Labels should be printed on "Tablex System Board, 250 GSM" cut to A4 sheets (210 x 297mm). Available from Spicers Stationery, Bassendean (ph: 9279 6860). The labels should be printed on a laser printer and baked in an oven @100°C for 20-30 minutes to fix the printing onto the card.

Delivery

- Specimens should be delivered to the Western Australian Museum after an appointment is made with staff members.
- A printed copy of the relevant locality data should be supplied with the specimens, along with the name, address, telephone and email address of the company representative. An electronic copy of the spreadsheet containing the relevant data should be emailed to the Museum.

Prepared by Mark Harvey and Julianne Waldock
May 2008

Appendix B

Report by Dr Mark Harvey on the Short-range Endemic Invertebrate Fauna Collected by Outback Ecology July 2008 from the Callawa and Cundaline Study Areas

The Short-Range Endemic Invertebrate Fauna from Cundaline/Callawa, Western Australia

Report to Outback Ecology

August 2008

Mark S. Harvey

Department of Terrestrial Invertebrates, Western Australian Museum,
Locked Bag 49, Welshpool DC, Western Australia 6986, Australia

Short-Range Endemism

The terrestrial invertebrate fauna of inland Australia contains a plethora of species, with the arthropods alone recently estimated to consist of more than 250,000 species (Yeates *et al.* 2004). The vast majority of these are found within the Insecta and Arachnida, although significant numbers of millipedes are anticipated to be represented as well.

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

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

The Western Australian fauna contains a number of SRE taxa, including millipedes, land snails, trap-door spiders, some pseudoscorpions, slaters, and onychophorans.

The Cundaline/Callawa region

The short-range endemic fauna of the region was assessed by examination of pseudoscorpions and scorpions collected by staff from Outback Ecology, preserved in ethanol and submitted to the Western Australian Museum for identification. The specimens were examined using a Leica dissecting microscope (MZ16) and an Olympus compound microscope (BH-2).

SPIDERS

Family Ctenizidae

***Conothele* sp.**

Members of the genus *Conothele* are found across much of arid and semi-arid Western Australia, where they generally dig burrows in soil which are sealed with a tight-fitting lid that is usually very difficult to find.

The taxonomic status of the Western Australian fauna is very uncertain, with the entire fauna representing unnamed species. However, the precise distributions of each species is unknown, and much taxonomic work on this genus is required before the status of individual populations can be ascertained. The taxonomy of the genus is based upon adult male specimens which have modifications of the first leg and pedipalp that can be used to separate individual species.

The Cundaline/Callawa survey collected several immature specimens which are unidentifiable.

Superfamily Amaurobioidea

A single male specimen of amaurobioid spider was collected. It has not been possible to identify the specimen, as the taxonomy of the group in the Pilbara is uncertain. It is unlikely to represent a short-range endemic species.

PSEUDOSCORPIONS

The Western Australian pseudoscorpion fauna is fairly diverse with representatives of 17 different families. They are found in a variety of biotopes, but can be most commonly collected from the bark of trees, from the underside of rocks, or from leaf litter habitats. The pseudoscorpion fauna of the Cundaline/Callawa area was found to consist of three species of Olpiidae (Appendix 1).

Family Olpiidae

Austrohorus sp. (family Olpiidae)

This small species was collected at a number of sites throughout the survey (Appendix 1), and appears to be very similar to other samples of *Austrohorus* collected elsewhere in the Pilbara. Based on our current levels of knowledge, it is not possible to state whether this species is a short-range endemic species.

Euryolpium sp. (family Olpiidae)

Species of *Euryolpium* are commonly found under bark and under rocks throughout northern Australia. They can be locally abundant, and at least one species is quite widespread across northern Australia. Based on our current levels of knowledge, it appears that this species is not a short-range endemic species.

Indolpium sp. (family Olpiidae)

Several specimens of this pseudoscorpion species were collected at a number of sites throughout the study area (Appendix 1). The specimens comprise a single species and extremely similar specimens have been collected from other regions of Western Australia, suggesting that only a single species is involved. Based on our current levels of knowledge, it appears that this species is not a short-range endemic species.

SCORPIONS

Family Buthidae

***Lychas* sp.**

Several specimens of a species of *Lychas* were collected during the survey. The identity of these specimens is currently uncertain, but I am confident that they do not represent a short-range endemic species.

Family Urodacidae

***Urodacus* sp.**

Two specimens of *Urodacus* were collected during the survey. The identity of these specimens is currently uncertain due to our lack of knowledge of the taxonomy of urodacids in northern Western Australia. It is unlikely to represent a short-range endemic species.

CENTIPEDES

Order Geophilida

Family Schendylidae

Geophilid centipedes are very difficult to identify and their taxonomy is very poorly known. The status of the sample from Cundaline is uncertain. It is possible that some geophilid species in Western Australian represent short-range endemic species, but this can only be determined after a full full taxonomic treatment is undertaken.

Order Scutigerida

Family Scutigeridae

Pilbarascutigera incola

Pilbarascutigera incola is widely distributed throughout the Pilbara region and elsewhere in Western Australia (Edgecombe and Barrow 2007) and is not a short-range endemic species.

Order Scolopendrida

Family Cryptopidae

***Cryptops* sp.**

The taxonomy of the Australian cryptopid fauna is very poorly known, and the status of the sample from Callawa in uncertain. It is possible that some species of *Cryptops* in Western Australian represent short-range endemic species, but a full taxonomic analysis is necessary.

Family Scolopendridae

Cormocephalus strigosus

Cormocephalus strigosus is widely distributed throughout mainland Australia (Koch 1983a) and is not a short-range endemic species.

Ethmostigmus curtipes

Ethmostigmus curtipes is widely distributed throughout mainland Australia (Koch 1983b) and is not a short-range endemic species.

Scolopendra morsitans

Scolopendra morsitans is widely distributed throughout mainland Australia (Koch 1983c) and is not a short-range endemic species.

REFERENCES

Edgecombe, G. and Barrow, L. (2007). A new genus of scutigerid centipedes (Chilopoda) from Western Australia, with new characters for morphological phylogenetics of Scutigeromorpha. *Zootaxa* **1409**: 23-50.

Harvey, M.S. (2002). Short-range endemism in the Australian fauna: some examples from non-marine environments. *Invertebrate Systematics* **16**: 555-570.

Koch, L.E. (1983a). Revision of the Australian centipedes of the genus *Cormocephalus* Newport (Chilopoda: Scolopendridae: Scolopendrinae). *Australian Journal of Zoology* **31**: 799-833.

Koch, L.E. (1983b). A taxonomic study of the centipede genus *Ethmostigmus* Pocock (Chilopoda: Scolopendridae: Otostigminae) in Australia. *Australian Journal of Zoology* **31**: 835-849.

Koch, L.E. (1983c). Morphological characters of the Australian scolopendrid centipedes, and the taxonomy and distribution of *Scolopendra morsitans* L. (Chilopoda: Scolopendridae: Scolopendrinae). *Australian Journal of Zoology* **31**: 79-91.

Yeates, D.K., Harvey, M.S. and Austin, A.D. (2004). New estimates for terrestrial arthropod species-richness in Australia. *Records of the South Australian Museum, Monograph Series* **7**: 231-241.

Appendix 1. Location data for samples from Cundaline/Callawa.

REGNO	CLASS	ORDER	FAMILY	GENUS	SPECIES	SITE
T92057	Arachnida	Araneae	Amaurobioidea			Cundaline area, site 1-1M
T92053	Arachnida	Araneae	Ctenizidae	*Conothele*	`indet.`	Cundaline area, site 3-3L
T92054	Arachnida	Araneae	Ctenizidae	*Conothele*	`indet.`	Cundaline area, site 3-3O
T92055	Arachnida	Araneae	Ctenizidae	*Conothele*	`indet.`	Cundaline area, site 4-4B
T92056	Arachnida	Araneae	Ctenizidae	*Conothele*	`indet.`	Cundaline area, site 4-4E
T92051	Arachnida	Araneae	Ctenizidae	*Conothele*	`indet.`	Cundaline area, site 3-3A
T92052	Arachnida	Araneae	Ctenizidae	*Conothele*	`indet.`	Cundaline area, site 3-3C
T92050	Arachnida	Pseudoscorpiones	Olpiidae	*Austrohorus*		Callawa area, site 8-8F
T92045	Arachnida	Pseudoscorpiones	Olpiidae	*Austrohorus*		Cundaline area, site 3-3N
T92046	Arachnida	Pseudoscorpiones	Olpiidae	*Austrohorus*		Cundaline area, site 4-4G
T92040	Arachnida	Pseudoscorpiones	Olpiidae	*Austrohorus*		Cundaline area, site 2-2C
T92041	Arachnida	Pseudoscorpiones	Olpiidae	*Austrohorus*		Cundaline area, site 2-2D
T92042	Arachnida	Pseudoscorpiones	Olpiidae	*Austrohorus*		Cundaline area, site 2-2E
T92043	Arachnida	Pseudoscorpiones	Olpiidae	*Austrohorus*		Cundaline area, site 2-2F
T92044	Arachnida	Pseudoscorpiones	Olpiidae	*Austrohorus*		Cundaline area, site 3-3K
T92039	Arachnida	Pseudoscorpiones	Olpiidae	*Euryolpium*		Cundaline area, site 2-2B
T92037	Arachnida	Pseudoscorpiones	Olpiidae	*Euryolpium*		Cundaline area, site 1-1O
T92038	Arachnida	Pseudoscorpiones	Olpiidae	*Euryolpium*		Cundaline area, site 1-1P
T92032	Arachnida	Pseudoscorpiones	Olpiidae	*Euryolpium*		Cundaline area, site 1-1I
T92033	Arachnida	Pseudoscorpiones	Olpiidae	*Euryolpium*		Cundaline area, site 1-1J
T92034	Arachnida	Pseudoscorpiones	Olpiidae	*Euryolpium*		Cundaline area, site 1-1K
T92035	Arachnida	Pseudoscorpiones	Olpiidae	*Euryolpium*		Cundaline area, site 1-1L
T92036	Arachnida	Pseudoscorpiones	Olpiidae	*Euryolpium*		Cundaline area, site 1-1N
T92047	Arachnida	Pseudoscorpiones	Olpiidae	*Euryolpium*		Callawa area, site 6-6J
T92049	Arachnida	Pseudoscorpiones	Olpiidae	*Euryolpium?*		Callawa area, site 7-7C
T92048	Arachnida	Pseudoscorpiones	Olpiidae	*Indolpium*		Callawa area, site 6-6L
T92058	Arachnida	Scorpiones	Buthidae	*Lychas*		Cundaline area, site 1-1A
T92059	Arachnida	Scorpiones	Buthidae	*Lychas*		Cundaline area, site 1-1B

T92060	Arachnida	Scorpiones	Buthidae	*Lychas*		Cundaline area, site 1-1G
T92061	Arachnida	Scorpiones	Buthidae	*Lychas*		Cundaline area, site 2-2A
T92062	Arachnida	Scorpiones	Buthidae	*Lychas*		Cundaline area, site 3-3E
T92063	Arachnida	Scorpiones	Buthidae	*Lychas*		Cundaline area, site 5-5A
T92064	Arachnida	Scorpiones	Buthidae	*Lychas*		Callawa area, site 6-6C
T92065	Arachnida	Scorpiones	Buthidae	*Lychas*		Callawa area, site 6-6F
T92066	Arachnida	Scorpiones	Buthidae	*Lychas*		Callawa area, site 6-6I
T92067	Arachnida	Scorpiones	Urodacidae	*Urodacus*		Callawa area, site 6-6K
T92068	Arachnida	Scorpiones	Urodacidae	*Urodacus*		Callawa area, site 7-7C
T92031	Chilopoda	Geophilida	Schendylidae			Cundaline area, site 3-3J
T92030	Chilopoda	Scutigerida	Scutigeridae	*Pilbarascutigera*	*incola*	Cundaline area, site 3-3I
T92029	Chilopoda	Scolopendrida	Scolopendridae	*Scolopendra*	*morsitans*	Callawa area, site 8-8C, D
T92020	Chilopoda	Scolopendrida	Cryptopidae	*Cryptops*		Callawa area, site 6-6B
T92023	Chilopoda	Scolopendrida	Scolopendridae	*Cormocephalus*	*strigosus*	Callawa area, site 6-6E
T92021	Chilopoda	Scolopendrida	Scolopendridae	*Ethmostigmus*	*curtipes*	Callawa area, site 6-6A
T92022	Chilopoda	Scolopendrida	Scolopendridae	*Ethmostigmus*	*curtipes*	Callawa area, site 6-6H
T92027	Chilopoda	Scolopendrida	Scolopendridae	*Scolopendra*	*morsitans*	Cundaline area, site 5-5C, D, E, F
T92028	Chilopoda	Scolopendrida	Scolopendridae	*Scolopendra*	*morsitans*	Callawa area, site 6-6G
T92024	Chilopoda	Scolopendrida	Scolopendridae	*Scolopendra*	*morsitans*	Cundaline area, site 1-1F
T92025	Chilopoda	Scolopendrida	Scolopendridae	*Scolopendra*	*morsitans*	Cundaline area, site 3-3F, G, H
T92026	Chilopoda	Scolopendrida	Scolopendridae	*Scolopendra*	*morsitans*	Cundaline area, site 4-4A

Appendix C

Report by Dr Shirley Slack-Smith on the Non-marine Molluscan Specimens Collected by Outback Ecology July 2008 from the Callawa and Cundaline Study Areas

The Land Snails of the Callawa and Cundaline Areas of the Pilbara Region of Western Australia

Report to *Outback Ecology*

S. Slack-Smith and C. Whisson,
Western Australian Museum
September 2008

Background

In considering the question of the conservation of the biota native to Western Australia the question of short-range endemicity is regarded as being of great importance. Such a degree of endemicity is best illustrated by organisms that are limited to specific habitats and that cannot easily spread to other appropriate habitats.

As a group, native species of land snails are considered to be among the most appropriate organisms in this regard, especially those taxa that are confined to particular habitats that tend to be patchy in their distribution. Many such habitats and the taxa associated with them are relics of once widespread environments that existed in less rigorous climatic conditions.

Knowledge of the land snail fauna of Western Australia has been limited largely by the paucity of workers in this field. In this large State, collecting has been largely limited to areas with easy access and so the fauna of huge areas of the State have not been even cursorily collected, let alone surveyed. This has resulted in a lack of information and even of relevant comparative material related to many of the land snail populations currently being encountered during surveys of areas proposed for mining and other development.

Surveys of the Callawa and Cundaline areas

The faunal survey of these areas was carried out by the environmental consultancy company *Outback Ecology* between the 2nd and the 12th of July, 2008. Information on the location of each of the 5 survey sites (3 in the Cundaline area and 2 in the Callawa area) and the collecting methods employed were provided by that company and included in Table 1.

From this survey, snail specimens of only the family Camaenidae were presented for identification and comment. These specimens, both alive and dead-taken, were

examined under a Wild dissecting microscope (M3C) and compared with specimens in the Western Australian Museum's mollusc collections and with data accompanying those specimens, in the Museum's database and in relevant scientific literature.

Results

Comments on the identity of the snail specimens are included in Table 1, together with details of the location of the collecting sites, the modes of collecting and the numbers of the specimens collected

Discussion

All of the submitted camaenid specimens from this survey appear to be conspecific.

A search on the WA Museum's molluscan database did not indicate any records of the family Camaenidae from the area defined by 20°32'S, 120°09'E/20°38'S; 120°18'E through to that defined by 20°20'S, 119°55E/20°50'S, 120°30'E.

The closest locality from which records of similar camaenid snails were collected is the Spinifex Ridge area, which lies to the SSW of the Cundaline-Callawa area. The specimens from the Callawa and Cundaline sites appear to be similar to but not conspecific with those from the Spinifex Ridge area or with some more recently collected in two areas further to the south and west.

In the report on the Spinifex Ridge molluscan survey (Slack-Smith & Whisson 2008), the camaenid specimens from that area were regarded as most closely resembling a few dead-taken and eroded shells that had been determined by Solem (1997) as belonging to an un-named genus and species. Those dead-taken and eroded specimens had been collected in 1976 from an area to the south-south-east of Spinifex Ridge and north of Skull Springs within the catchment area of the Oakover River.

Although the specimens from Callawa and Cundaline also do not appear to be conspecific with the Skull Springs specimens they do resemble them more closely than do the Spinifex Ridge and other apparently congeneric specimens in:-

shell shape,
mean adult size, whorl count,
diameter of the umbilicus,
degree of overlap of the umbilicus by the columellar lip,
angle of the descending body whorl above the aperture
colouration of the shell and its periostracum.

The establishment of the degree of relationship between these two "populations" and with those in the areas of Spinifex Ridge and Skull Springs will also depend on future in-filling of collecting gaps. This also applies to the investigation of the possible relationship postulated for the Skull Springs specimens by Solem (1997) with members of the South Australian fauna.

Conclusion

The camaenid landsnails collected during the biological survey of the Callawa and Cundaline leases appear to belong to a single un-named species of a currently un-named genus.

References

Slack-Smith, S. & Whisson, C., 2008, Report to *Outback Ecology Services* - Molluscs from the area of Spinifex Ridge and Meentheena Conservation Park, Western Australia, collected by *Outback Ecology Services* during March and April, 2008. Unpublished Report, 9 pp.

Solem, A., 1997, Camaenid land snails from Western and central Australia (Mollusca: Pulmonata: Camaenidae) VII Taxa from Dampierland through the Nullarbor. *Rec. W. Aust. Mus* Suppl. 50: 1461-1906.

Table 1. - Camaenid specimens collected during the biological survey of the Callawa and Cundaline BHP Billiton Holdings

Study area	Specimen numbers/condition	Co-ordinates	Collecting Notes	Identification
Cundaline Site 1	1D -1 to19 (all dead-taken)	20°32' 34.6"S, 120°09'13.5 E	Active searching	Family Camaenidae, **Gen. & sp. indet.** (see Solem 1997 & Slack-Smith & Whisson 2008)
"	1H -1-9 (1 live-taken, 8 dead-taken)	"	Active searching	"
Cundaline Site 5	5B -1 to 3 (all dead-taken)	20°34'37.7"S 120°12'19.9"E	leaf litter	"
"	5G -1 to 2 (1 live-taken, 1 dead-taken)	"	Soil sieving	"
Callawa Site 6	6D -1 to 8 (4 live-taken, 4 dead-taken)	20°38'51.6"S 120°18'18.2"E	Soil sieving	"
"	6M -1 to 3 (all dead-taken)	"	Soil sieving	"
Callawa Site 7	7A -1 to3 (all dead-taken)	20°38'56.5"S 120°18'12.3"E	Soil sieving	"
Callawa Site 8	8A -1 to 8 (3 live-taken, 5 dead-taken)	20°38'33.0"S 120°18'25.9"E	Whilst digging pit traps	"
"	8E -1 to 11 (1 live-taken, 10 dead-taken)	"	Soil sieving	"
"	8G -1 to 12 (all dead-taken)	"	Soil sieving	"

Appendix D

Vertebrate Fauna Recorded at Cundaline, Callawa or the Surrounds

Reptile and Amphibian species observed at each site of the Goldsworthy Extension Project Area.

CGHR = Cattle Gorge Haul Road, CGOB = Cattle Gorge Ore Body, SH = Sunrise Hill, NIM = Nimingarra, YAR = Yarrie, CUN = Cundaline, CAL = Callawa (*ecologia,* 2005b)

Family	Species	Common Name	SH	NIM	CG	YAR	CUN	CAL
AMPHIBIA								
HYLIDAE								
	Cyclorana maini	Main's Frog				x		
	Litoria rubella	Desert Tree Frog	x	x	x	x	x	x
MYOBATRACHIDAE								
	Limnodynastes spenceri	Spencer's Frog			x	x		
	Uperoleia glandulosa	Glandular Toadlet	x		x			
TOTAL AMPHIBIAN SPECIES			**2**	**1**	**3**	**3**	**1**	**1**
REPTILIA								
CHELUIDAE								
	Chelodina steindachneri	Plate-shelled Turtle		x				
GEKKONIDAE								
	Crenadactylus ocellatus 'horni'	Clawless Gecko	x					
	Diplodactylus conspicillatus	Fat-tailed Gecko	x	x	x	x		
	Diplodactylus savagei		x	x	x		x	x
	Diplodactylus stenodactylus	Sand-plain Gecko		x	x			
	Diplodactylus wombeyi			x	x		x	
	Gehyra ?punctata		x					
	Gehyra punctata		x	x	x	x	x	x
	Gehyra purparescens					x		
	Gehyra variegata	Varied Dtella	x	x	x			x
	Heteronotia binoei	Bynoe's Gecko			x	x		
	Heteronotia spelea	Desert Cave Gecko	x	x	x	x	x	
	Nephrurus levis pilbarensis	Smooth Knob-tailed Gecko	x	x				

Family	Species	Common Name	SH	NIM	CG	YAR	CUN	CAL
	Rhynchoedura ornata	Beaked Gecko	x					
	Strophurus ciliaris abberans	Northern Spiny-tailed Gecko	x	x				
PYGOPODIDAE								
	Delma elegans			x				x
	Delma nasuta							x
	Delma tincta			x	x			
	Delma pax (desert pax)		x					x
	Lialis burtonis	Burton's Legless Lizard	x			x		
AGAMIDAE								
	Ctenophorus caudicinctus	Ring-tailed Rock Dragon	x	x	x	x	x	x
	Ctenophorus isolepis	Military Dragon				x		
	Ctenophorus nuchalis	Central Netted Dragon	x		x			
	Diporiphora winneckei	Canegrass Dragon		x				
	Lophognathus longirostris	Long-nosed Water Dragon			x	x		
	Pogona mitchelli	Dwarf Bearded Dragon			x			x
VARANIDAE								
	Varanus acanthurus	Ridge-tailed Monitor		x	x		x	
	Varanus caudolineatus	Stripe-tailed Monitor		x				
	Varanus eremius	Pygmy Desert Monitor		x				
	Varanus giganteus	Perentie	x	x	x		x	
	Varanus gouldii	Gould's Monitor	x					
	Varanus panoptes	Yellow-spotted Monitor		x		x		
	Varanus pilbarensis	Pilbara Rock Monitor	x			x	x	x
	Varanus tristis	Black-headed Monitor	x		x			
SCINCIDAE								
	Carlia munda		x	x	x	x	x	x

Family	Species	Common Name	SH	NIM	CG	YAR	CUN	CAL
	Carlia triacantha		×		×			
	Cryptoblepharus plagiocephalus	Fence Skink				×	×	×
	Ctenotus helenae			×				
	Ctenotus pantherinus	Leopard Skink				×		
	Ctenotus piankai				×			
	Ctenotus rubicundus		×	×				
	Ctenotus rubicundus			×				
	Ctenotus rutilans						×	×
	Ctenotus saxatilis	Rock Ctenotus	×	×	×	×	×	×
	Cyclodomorphus melanops	Spinifex Slender Blue-tongue				×		×
	Egernia depressa	Pygmy Spiny-tailed Skink	×	×		×	×	×
	Eremiascincus sp.			×				
	Lerista bipes		×	×	×	×		
	Lerista muelleri		×	×	×		×	×
	Lerista vermicularis					×		
	Menetia greyii			×				
	Menetia surda surda							×
	Morethia ruficauda					×		
TYPHLOPIDAE								
	Ramphotyphlops grypus	Beaked Blindsnake				×	×	
BOIDAE								
	Antaresia perthensis	Pygmy Python	×		×		×	
	Antaresia stimsoni	Stimson's Python	×	×	×			
	Liasis olivaceous barroni	Pilbara Olive Python			×		×	
ELAPIDAE								
	Acanthophis pyrrhus	Desert Death Adder			×			
	Brachyurophis approximans	North-western Shovel-nosed Snake		×				

Family	Species	Common Name	SH	NIM	CG	YAR	CUN	CAL
	Demansia psammophis	Yellow-faced Whipsnake	×	×		×		
	Demansia rufescens	Rufous Whipsnake	×					
	Furina ornata	Moon Snake		×		×		
	Pseudechis australis	Mulga Snake			×	×		×
	Pseudonaja modesta	Ringed Brown Snake	×					
	Pseudonaja nuchalis	Gwardar			×			
	Simoselaps anomalus	Desert Banded Snake		×				
	Suta fasciata	Rosen's Snake					×	×
TOTAL REPTILE SPECIES			**30**	**34**	**28**	**24**	**19 ***	**19**

* Please note that the number of reptile species present at the Cundaline study area is 18, not 19.

Bird species observed at each site of the Goldsworthy Extension Project Area.
CG = Cattle Gorge, SH = Sunrise Hill, NIM = Nimingarra, YAR = Yarrie, CUN = Cundaline, CAL = Callawa (*ecologia,* 2005b)

PHASIANIDAE								
	Coturnix ypsilophora	Brown Quail	x	x	x	x		
TURNICIDAE								
	Turnix velox	Little Button-quail		x		x		
PELECANIDAE								
	Pelecanus conspicillatus	Australian Pelican			x			
PHALACROCORACIDAE								
	Phalacrocorax melanoleucos	Little Pied Cormorant			x			
	Phalacrocorax sulcirostris	Little Black Cormorant						
ANATIDAE								
	Anas gracilis	Grey Teal			x			
	Anas superciliosa	Pacific Black Duck			x			
	Aythya australis	Hardhead			x			
RALLIDAE								
	Gallirallus philippensis	Buff-banded Rail			x			
	Porzana fluminea	Spotted Crake	x					
ARDEIDAE								
	Ardea alba	Great Egret			x			
	Ardea pacifica	White-necked Heron		x	x			
	Egretta novaehollandiae	White-faced Heron		x	x	x		

Family	Species	Common Name	SH	NIM	CG	YAR	CUN	CAL
THRESKIORNITHIDAE								
	Platalea flavipes	Yellow-billed Spoonbill			×			
	Platalea regia	Royal Spoonbill			×			
	Plegadis falcinellus	Glossy Ibis			×			
	Threskiornis spinicollis	Straw-necked Ibis			×			
CICONIIDAE								
	Ephippiorhynchus asiaticus	Black-necked Stork			×			
OTIDIDAE								
	Ardeotis australis	Australian Bustard			×		×	
SCOLOPACIDAE								
	Actitis hypoleucos	Common Sandpiper			×			
	Gallinago sp.	*Gallinago* Snipe sp.			×			
	Tringa glareola	Wood Sandpiper			×			
	Tringa nebularia	Common Greenshank			×			
	Tringa stagnatilis	Marsh Sandpiper		×	×			
BURHINIDAE								
	Burhinus grallarius	Bush Stone-curlew		×	×			
CHARADRIIDAE								
	Charadrius ruficapillus	Red-capped Plover			×			
	Elseyornis melanops	Black-fronted Dotterel			×	×		
	Erythrogonys cinctus	Red-kneed Dotterel			×			
ACCIPITRIDAE								
	Accipiter fasciatus	Brown Goshawk		×	×		×	

Family	Species	Common Name	SH	NIM	CG	YAR	CUN	CAL
	Accipiter cirrhocephalus	Collared Sparrowhawk					x	
	Aquila audax	Wedge-tailed Eagle	x				x	x
	Circus assimilis	Spotted Harrier	x	x	x		x	x
	Elanus axillaris	Black-shouldered Kite		x		x		
	Haliastur sphenurus	Whistling Kite	x	x	x		x	
	Hieraaetus morphnoides	Little Eagle	x		x		x	x
	Lophoictinia isura	Square-tailed Kite					x	x
	Pandion haliaetus	Osprey			x			
FALCONIDAE								
	Falco berigora	Brown Falcon	x	x	x	x	x	
	Falco cenchroides	Australian Kestrel	x	x	x	x	x	x
	Falco longipennis	Australian Hobby	x		x		x	
	Falco peregrinus	Peregrine Falcon					x	
COLUMBIDAE								
	Geopelia cuneata	Diamond Dove	x	x	x	x	x	x
	Geopelia striata	Peaceful Dove		x	x			
	Geophaps plumifera	Spinifex Pigeon	x	x	x	x	x	x
	Ocyphaps lophotes	Crested Pigeon	x	x	x	x		
	Phaps chalcoptera	Common Bronzewing	x	x				x
CACATUIDAE								
	Cacatua roseicapilla	Galah	x	x	x	x	x	
	Cacatua sanguinea	Little Corella	x	x	x	x	x	x
PSITTACIDAE								
	Barnardius zonarius	Australian Ringneck				x		
	Nymphicus hollandicus	Cockatiel					x	x

Family	Species	Common Name	SH	NIM	CG	YAR	CUN	CAL
CUCULIDAE								
	Chrysococcyx basalis	Horsfield's Bronze-Cuckoo		×	×	×	×	
	Cuculus pallidus	Pallid Cuckoo					×	
CENTROPODIDAE								
	Centropus phasianinus	Pheasant Coucal	×	×	×			
STRIGIDAE								
	Ninox boobook	Southern Boobook			×		×	×
AEGOTHELIDAE								
	Aegotheles cristatus	Owlet Nightjar	×	×				
CAPRIMULGIDAE								
	Eurostopodus argus	Spotted Nightjar	×	×	×	×		×
HALCYONIDAE								
	Dacelo leachii	Blue-winged Kookaburra	×	×	×			
	Todiramphus pyrrhopygia	Red-backed Kingfisher	×	×	×	×		
	Todiramphus sanctus	Sacred Kingfisher		×	×			
MEROPIDAE								
	Merops ornatus	Rainbow Bee-eater	×	×	×	×	×	×
MALURIDAE								
	Amytornis striatus	Striated Grasswren	×	×	×	×	×	×
	Malurus lamberti	Variegated Fairy-wren		×	×	×		×
	Malurus leucopterus	White-winged Fairy-wren	×					

Family	Species	Common Name	SH	NIM	CG	YAR	CUN	CAL
PARDALOTIDAE								
	Pardalotus rubricatus	Red-browed Pardalote	×	×	×			×
	Pardalotus striatus	Striated Pardalote				×		×
MELIPHAGIDAE								
	Epthianura tricolor	Crimson Chat					×	×
	Lichenostomus keartlandi	Grey-headed Honeyeater	×	×	×	×	×	×
	Lichenostomus ornatus	Yellow-plumed Honeyeater			×			
	Lichenostomus penicillatus	White-plumed Honeyeater	×	×	×	×		
	Lichenostomus plumulus	Grey-fronted Honeyeater				×	×	
	Lichenostomus virescens	Singing Honeyeater	×	×	×	×		
	Lichmera indistincta	Brown Honeyeater	×	×	×	×	×	×
	Manorina flavigula	Yellow-throated Miner	×		×	×	×	×
	Melithreptus gularis	Black-chinned Honeyeater	×	×	×	×		×
	Phylidonyris albifrons	White-fronted Honeyeater						×
POMATOSTOMIDAE								
	Pomatostomus temporalis	Grey-crowned Babbler			×			
PACHYCEPHALIDAE								
	Colluricincla harmonica	Grey Shrike-thrush	×	×	×	×	×	×
	Pachycephala rufiventris	Rufous Whistler				×	×	×
DICRURIDAE								
	Grallina cyanoleuca	Magpie Lark	×	×	×	×		×
	Rhipidura leucophrys	Willie Wagtail	×	×	×	×	×	×
PTILONORHYNCHIDAE								

Family	Species	Common Name	SH	NIM	CG	YAR	CUN	CAL
	Chlamydera guttata	Western Bowerbird	×	×	×	×		×
CAMPEPHAGIDAE								
	Coracina novaehollandiae	Black-faced Cuckoo-Shrike	×	×	×	×	×	×
	Lalage tricolor	White-winged Triller	×	×	×		×	×
ARTAMIDAE								
	Artamus cinereus	Black-faced Woodswallow	×	×	×	×		×
	Artamus minor	Little Woodswallow	×	×	×	×	×	×
	Artamus personatus	Masked Woodswallow					×	×
	Cracticus nigrogularis	Pied Butcherbird	×	×	×	×	×	×
	Gymnorhina tibiciens	Australian Magpie						×
CORVIDAE								
	Corvus bennetti	Little Crow						×
	Corvus orru	Torresian Crow	×	×	×	×	×	×
HIRUNDINIDAE								
	Hirundo ariel	Fairy Martin	×	×	×	×	×	
	Hirundo nigricans	Tree Martin		×				
MOTACILLIDAE								
	Anthus novaeseelandiae	Australian Pipit	×		×	×	×	×
ALAUDIDAE								
	Cincloramphus cruralis	Brown Songlark		×				×
	Cincloramphus mathewsi	Rufous Songlark			×		×	
	Mirafra javanica	Singing Bushlark		×	×			

Family	Species	Common Name	SH	NIM	CG	YAR	CUN	CAL
SYLVIIDAE								
	Eremiornis carteri	Spinifexbird	x	x	x	x		x
ESTRILDIDAE								
	Emblema pictum	Painted Firetail	x	x	x	x	x	x
	Heteromunia pectoralis	Pictorella Mannikin			x			
	Neochmia ruficauda	Star Finch			x			
	Taeniopygia guttata	Zebra Finch	x	x	x	x	x	x
DICAEIDAE								
	Dicaeum hirundinaceum	Mistletoe Bird				x		x
Total Bird Species			**45**	**52**	**77**	**43**	**41**	**43**

Mammal species observed at each site of the Goldsworthy Extension Project Area.
CGHR = Cattle Gorge Haul Road, CGOB = Cattle Gorge Ore Body, SH = Sunrise Hill, NIM = Nimingarra, YAR = Yarrie, CUN = Cundaline, CAL = Callawa (*ecologia,* 2005b)

Family	Species	Common Name	SH	NIM	CG	YAR	CUN	CAL
TACHYGLOSSIDAE								
	Tachyglossus aculeatus	Echidna				×		
DASYURIDAE								
	Dasycercus cristicauda	Mulgara			×			
	Dasykaluta rosamondae	Kaluta				×		
	Dasyurus hallucatus	Northern Quoll	×	×	×	×		×
	Ningaui timealeyi	Pilbara Ningaui				×		
	Planigale sp.		×	×				
	Sminthopsis youngsoni	Lesser Hairy-footed Dunnart				×		
	Sminthopsis macroura	Stripe-faced Dunnart		×				
MACROPODIDAE								
	Macropus robustus	Euro	×	×	×	×	×	×
	Macropus rufus	Red Kangaroo			×	×		×
	Petrogale rothschildi	Rothschild's Rock Wallaby	×	×			×	×
MEGADERMATIDAE								
	Macroderma gigas	Ghost Bat					×	×
EMBALLONURIDAE								
	Saccolaimus flaviventris	Yellow-bellied Sheathtail Bat		×				
	Taphozous georgianus	Common Sheathtail Bat	×	×	×		×	×
	Taphozous hilli	Hill's Sheathtail Bat				×		
HIPPOSIDERIDAE								
	Rhinonicteris aurantius	Pilbara Leaf-nosed Bat		×	×		×	×

Family	Species	Common Name	SH	NIM	CG	YAR	CUN	CAL
VESPERTILIONIDAE								
	Chalinolobus gouldii	Gould's Wattled Bat	x	x	x		x	x
	Nyctophilus geoffroyi	Lesser Long-eared Bat		x	x		x	x
	Scotorepens greyii	Little Broad-nosed Bat	x	x	x		x	
	Vespadelus baverstocki	Inland Forest Bat	x					
	Vespadelus finlaysoni	Inland Cave Bat	x	x	x		x	x
MOLOSSIDAE								
	Chaerophon jobensis	Northern Freetail Bat			x			
MURIDAE								
	Leggadina lakedownensis	Lakeland Downs Mouse				x		
	**Mus musculus*	House Mouse		x	x	x		
	Pseudomys chapmani	Western Pebble-mound Mouse				x		
	Pseudomys delicatulus	Delicate Mouse		x		x		
	Pseudomys desertor	Desert Mouse			x	x		
	Pseudomys hermannsburgensis	Sandy Inland Mouse			x	x		
	Zyzomys argurus	Common Rock Rat	x	x	x	x	x	x
CANIDAE								
	**Canis lupus dingo*	Dingo		x			x	x
FELIDAE								
	**Felis catus*	Cat	x			x		
BOVIDAE								
	**Bos Taurus*	Cow	x	x		x		
TOTAL MAMMAL SPECIES			**12**	**17**	**15**	**17**	**11**	**12**

Appendix E

Summary Tables Describing Conservation Significance

IUCN categories also used under the Commonwealth EPBC Act and by DEC

Status	Code	Description
Extinct	(EX)	A taxon is Extinct when there is no reasonable doubt that the last individual has died.
Extinct in the Wild	(EW)	A taxon is Extinct in the Wild when it is known only to survive in cultivation, in captivity or as a naturalized population (or populations) well outside the past range.
Critically Endangered	(CR)	A taxon is Critically Endangered when the best available evidence indicates that it is considered to be facing an extremely high risk of extinction in the wild.
Endangered	(EN)	A taxon is Endangered when the best available evidence indicates that it is considered to be facing a very high risk of extinction in the wild.
Vulnerable	(VU)	A taxon is Vulnerable when the best available evidence indicates that it is considered to be facing a high risk of extinction in the wild.
Lower Risk	(LR)	A taxon is Lower Risk when it has been evaluated, does not satisfy the criteria for any of the categories Critically Endangered, Endangered or Vulnerable. Taxa included in the Lower Risk category can be separated into three subcategories: o Conservation Dependent (cd). Taxa which are the focus of a continuing taxon-specific or habitat-specific conservation program targeted towards the taxon in question, the cessation of which would result in the taxon qualifying for one of the threatened categories above within a period of five years. o Near Threatened (nt). Taxa which do not qualify for Conservation Dependent, but which are close to qualifying for Vulnerable. o Least Concern (lc). Taxa which do not qualify for Conservation Dependent or Near Threatened.
Data Deficient	(DD)	A taxon is Data Deficient when there is inadequate information to make a direct, or indirect, assessment of its risk of extinction based on its distribution and/or population status.
Not Evaluated	(NE)	A taxon is Not Evaluated when it is has not yet been evaluated against the criteria.

Schedules of the Western Australian Wildlife Conservation Act 1950: Wildlife Conservation (Specially Protected Fauna) Notice.

Status	Code	Description
Schedule 1	(S1)	Fauna that is rare or likely to become extinct, are declared to be fauna that is in need of special protection
Schedule 2	(S2)	Fauna that is presumed to be extinct, are declared to be fauna that is in need of special protection
Schedule 3	(S3)	Birds that are subject to an agreement between the governments of Australia and Japan relating to the protection of migratory birds and birds in danger of extinction, are declared to be faunathat is in need of special protection
Schedule 4	(S4)	Fauna that is in need of special protection, otherwise than for the reasons mentioned above

Priority Fauna Codes used by the Western Australian DEC

Status	Code	Description
Priority One Taxa with few, poorly known populations on threatened lands.	(P1)	Taxa which are known from few specimens or sight records from one or a few localities on lands not managed for conservation, e.g. agricultural or pastoral lands, urban areas, active mineral leases. The taxon needs urgent survey and evaluation of conservation status before consideration can be given to declaration as threatened fauna.
Priority Two Taxa with few, poorly known populations on conservation lands.	(P2)	Taxa which are known from few specimens or sight records from one or a few localities on lands not under immediate threat of habitat destruction or degradation, e.g. national parks, conservation parks, nature reserves, State forest, vacant Crown land, water reserves, etc. The taxon needs urgent survey and evaluation of conservation status before consideration can be given to declaration as threatened fauna.
Priority Three Taxa with several, poorly known populations, some on conservation lands.	(P3)	Taxa which are known from few specimens or sight records from several localities, some of which are on lands not under immediate threat of habitat destruction or degradation. The taxon needs urgent survey and evaluation of conservation status before consideration can be given to declaration as threatened fauna.
Priority Four Taxa in need of monitoring.	(P4)	Taxa which are considered to have been adequately surveyed, or for which sufficient knowledge is available, and which are considered not currently threatened or in need of special protection, but could be if present circumstances change. These taxa are usually represented on conservation lands.
Priority Five Taxa in need of monitoring.	(P5)	Taxa which are not considered threatened but are subject to a specific conservatin program, the cessation of which would result in the species becoming threatened within five years.

Appendix F

Licence to Take Fauna for Scientific Purposes No. SF006429

DEPARTMENT OF ENVIRONMENT AND CONSERVATION

Enquiries: 17 DICK PERRY AVE, KENSINGTON, WESTERN AUSTRALIA
Telephone: 08 9334 0333
Facsimile: 08 9334 0242

Correspondence: **Locked Bag 30**
Bentley Delivery Centre WA 6983

PAGE 1
NO. SF006429

RECEIPT NO.	AMOUNT
	$0.00

WILDLIFE CONSERVATION ACT 1950
REGULATION 17

LICENCE TO TAKE FAUNA FOR SCIENTIFIC PURPOSES

THE UNDERMENTIONED PERSON MAY TAKE FAUNA FOR RESEARCH OR OTHER SCIENTIFIC PURPOSES AND WHERE AUTHORISED, KEEP IT IN CAPTIVITY, SUBJECT TO THE FOLLOWING AND ATTACHED CONDITIONS, WHICH MAY BE ADDED TO, SUSPENDED OR OTHERWISE VARIED AS CONSIDERED FIT.

DIRECTOR GENERAL

CONDITIONS

1 THE LICENSEE SHALL COMPLY WITH THE PROVISIONS OF THE WILDLIFE CONSERVATION ACT AND REGULATIONS AND ANY NOTICES IN FORCE UNDER THIS ACT AND REGULATIONS.

2 UNLESS SPECIFICALLY AUTHORISED IN THE CONDITIONS OF THIS LICENCE OR OTHERWISE IN WRITING BY THE DIRECTOR GENERAL, SPECIES OF FAUNA DECLARED AS LIKELY TO BECOME EXTINCT, RARE OR OTHERWISE IN NEED OF SPECIAL PROTECTION SHALL NOT BE CAPTURED OR OTHERWISE TAKEN.

3 NO FAUNA SHALL BE TAKEN FROM ANY NATURE RESERVE, WILDLIFE SANCTUARY, NATIONAL PARK, MARINE PARK, TIMBER RESERVE OR STATE FOREST WITHOUT PRIOR WRITTEN APPROVAL OF THE DIRECTOR GENERAL. NO FAUNA SHALL BE TAKEN FROM ANY OTHER PUBLIC LAND WITHOUT THE WRITTEN APPROVAL OF THE GOVERNMENT AUTHORITY MANAGING THAT LAND.

4 NO ENTRY OR COLLECTION OF FAUNA TO BE UNDERTAKEN ON ANY PRIVATE PROPERTY OR PASTORAL LEASE WITHOUT THE CONSENT IN WRITING OF THE OWNER OR OCCUPIER, OR FROM ANY ABORIGINAL RESERVE WITHOUT THE WRITTEN APPROVAL OF THE DEPARTMENT OF INDIGENOUS AFFAIRS.

5 NO FAUNA OR THEIR PROGENY SHALL BE RELEASED IN ANY AREA WHERE IT DOES NOT NATURALLY OCCUR, NOR HANDED OVER TO ANY OTHER PERSON OR AUTHORITY UNLESS APPROVED BY THE DIRECTORGENERAL, NOR SHALL THE REMAINS OF SUCH FAUNA BE DISPOSED OF IN SUCH MANNER AS TO CONFUSE THE NATURAL OR PRESENT DAY DISTRIBUTION OF THE SPECIES.

6 THIS LICENCE AND THE WRITTEN PERMISSION REFERRED TO AT CONDITIONS 3 & 4 MUST BE CARRIED BY THE LICENSEE OR AUTHORISED AGENT AT ALL TIMES FOR THE PURPOSE OF PROVING THEIR AUTHORITY TO TAKE FAUNA WHEN QUESTIONED AS TO THEIR RIGHT TO DO SO BY A WILDLIFE OFFICER, ANY OTHER STATE OR LOCAL GOVERNMENT EMPLOYEE OR ANY MEMBER OF THE PUBLIC.

7 **********ANY INTERACTION INVOLVING GAZETTED THREATENED FAUNA THAT MAY BE HARMFUL AND/OR INVASIVE MAY REQUIRE APPROVAL FROM THE COMMONWEALTH DEPT OF THE ENVIRONMENT AND WATER RESOURCES, PHONE 02 6274 1900. INTERACTION WITH SUCH SPECIES IS CONTROLLED BY THE COMMONWEALTH GOVERNMENT'S "ENVIRONMENT PROTECTION AND BIODIVERSITY CONSERVATION ACT 1999" & "ENVIRONMENT PROTECTION AND BIODIVERSITY CONSERVATION REGULATIONS 2000" AS WELL AS DEC'S WILDLIFE CONSERVATION ACT & REGULATIONS.**********

8 NO BIOPROSPECTING INVOLVING THE REMOVAL OF SAMPLE AQUATIC AND TERRESTRIAL ORGANISMS (BOTH FLORA AND FAUNA) FOR CHEMICAL EXTRACTION AND BIOACTIVITY SCREENING IS PERMITTED TO BE CONDUCTED WITHOUT SPECIFIC WRITTEN APPROVAL BY THE DIRECTOR GENERAL OF DEC.

9 FURTHER CONDITIONS (NUMBERED TO) ARE ATTACHED.

PURPOSE	TO CARRY OUT A SHORT RANGE ENDEMIC (SRE) INVERTEBRATE FAUNA SURVEY WITHIN THE YARRIE PROJECT AREA AND SURROUNDS.
AUTHORISED PERSONS	CARLY WESTON JARRAD DONALD

DEPARTMENT OF ENVIRONMENT AND CONSERVATION

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