Panorama Project Mine Site and Haul Road Corridor Targeted Fauna Survey

Contents

Appendix 1

Licence to Take Fauna

Appendix 2

Genetic Distance table for individuals of *Rhagada*

Appendix 3

DEH Search Tool Results

Tables

Figures

Plates

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1.0 Summary

1.1 Background

CBH Resources plan to develop a copper-zinc mine at the Panorama Project in the north-eastern Pilbara region of Western Australia. The project comprises the mine site and associated infrastructure areas, as well as a haul road.

The original proposal has been altered to accommodate changes to the haul road corridor, initiating a requirement for:

- a Level 1 targeted fauna survey of the Plains Access Road between the Port Hedland-Marble Bar Road and the Gorge Ranges following agreement with the DEC Karratha;
- a Level 2 terrestrial fauna survey of the Valley Access Road through a valley in the Gorge Range; and
- a survey targeting possible Short-range endemic (SRE) fauna within the mine site study area.

Biota Environmental Sciences was commissioned to carry out the surveys of the above areas on behalf of CBH Resources in 2006.

1.2 Methodology

The study was conducted over an eight-day period between the 29th of August and 5th of September 2006.

The central component of this study comprised three parts, each of which are treated separately for the purposes of this report:

1.2.1 Level 1 Fauna Survey along the Plains Access Road

Targeted searches for rare fauna species (in particular the Bilby, Mulgara and Spectacled Hare Wallaby) or their traces, and to identify fauna habitat, were conducted along the Plains Access Road. Searches incorporated locating areas of preferred habitat for each species and traversing the area or access road on foot, recording signs of the species (burrows, scats, diggings or tracks) by day, or spotlighting by night. Additionally, one cage-trapping grid targeting the Spectacled Hare-wallaby *Lagorchestes conspicillatus* was installed along the Plains Access Road. Additional records of targeted species were also obtained by night spotting from a vehicle, or opportunistically while traversing the study area.

1.2.2 Level 2 Fauna Sampling of the Valley Access Road

The central component of this Level 2 survey comprised six pit-trapping grids, three Elliott-trapping grids and six harp traps, all installed within defined habitats. Trapping effort at each location was adapted to the habitat in which the grid was installed. Pit-trap grids comprised up to ten traps, a mixture of 20 litre buckets and PVC tubes (150mm diameter x 700mm depth), connected by a suitable length of 30cm high flywire drift fence. Elliott trapping grids totalling 100 traps were placed on rock walls located on either side of the Valley Access Road to target the Northern Quoll *Dasyurus hallucatus*.

Avifauna censuses were conducted during a foot traverse of the entire Valley Access Road on four successive mornings. Opportunistic records were also obtained during vehicular and foot traverses of the study area.

Bats were directly sampled using harp traps erected adjacent to the Valley Access Road. Opportunistic records were also obtained during night-spotting traverses of the study area in a vehicle.

1.2.3 Short Range Endemic Survey of the Mine Site

The survey of the mine area utilised hand foraging techniques to search for potential Short Range Endemic (SRE) invertebrate taxa including:

- Pulmonata (land snails);
- Diplopoda (millipedes);
- Pseudoscorpionida (pseudoscorpions); and
- Mygalomorph (Trapdoor) spiders.

Land snails were searched for under large *Triodia* hummocks found on sandy to loamy soils and in small drainage lines, which is also where mygalomorph spiders commonly occur. Pseudoscorpions were collected from under bark on trees as well as from under rocks in the extraction/infrastructure area. Millipedes were searched for under leaf litter and rocks.

1.3 Results

1.3.1 Level 1 Survey of the Plains Access Road

The survey yielded a single Schedule taxon, the Mulgara *Dasycercus cristicauda,* and four Priority listed taxa comprising the Spectacled Hare Wallaby *Lagorchestes conspicillatus*, Ghost Bat *Macroderma gigas*, Australian Bustard *Ardeotis australis* and Bush Stone-curlew *Burhinus grallarius* (Table 1.1). The Plains Access Road also intersects habitat suitable for a further three Schedule listed species (the Bilby, Peregrine Falcon and Woma Python), although none of these species were recorded during the current survey. In addition, the Plains Access Road passes within 100 m of a known roost for the Schedule 1 Orange Leaf-nosed Bat *Rhinonicteris aurantius*.

Table 1.1: Schedule and Priority species recorded from the Plains Access Road.

Species	Conservation Status (State Level)	Record	Co-ordinates
Dasycercus cristicauda	Schedule 1	Numerous diggings	741682mE, 7701908mN
Lagorchestes conspicillatus	Priority 3	Single animal and tracks Tracks Tracks Tracks	739514mE, 7677880mN 733366mE, 7668060mN 738091mE, 7673377mN 739904mE, 7692919mN
Macroderma gigas	Priority 4	Numerous observations	Vicinity of Lalla Rookh Mine
Ardeotis australis	Priority 4	2 2 2	739458mE, 7678003mN 727063mE, 7665410mN 739514mE, 7677880mN
Burhinus grallarius	Priority 4	Call	727026mE, 7665461mN

The survey also recorded invertebrate taxa from groups known, or thought, to support SRE taxa including land snails (represented only by shells) and pseudoscorpions (Table 1.2).

Table 1.2: Locations from which land snails and pseudoscorpions were collected from along the Plains Access Road.

Site	Land Snails	Pseudoscorpions			
	Rhagada	Olpiidae	Chernetidae	Garypidae	Other Pseudoscorpions
SPEC 01	Shells only		*Haplochernes* sp.	*Synsphyronus* sp.	?Genera
SPEC 04			*Haplochernes* sp.		
SUMU 01		?Genera		*Synsphyronus* sp.	

No Threatened Ecological Community (TEC) types were identified along the Plains Access Road nor are there any Communities at Risk as defined by Kendrick and McKenzie (2001).

1.3.2 Level 2 Survey of the Valley Access Road

1.3.2.1 Fauna Habitats

Two primary fauna habitats were identified in the Valley Access Road study area:

- a narrowly incised valley supported mid-dense to dense riparian vegetation in the central portion of the Valley Access Road. The valley floor in this section comprised extensive areas of bare bedrock interspersed with alluvial sand sheets. This portion of the Valley Access Road was also characterised by numerous small to medium sized pools of standing or slowly running water; and
- low stony hills, vegetated with *Triodia* hummock grasslands, within a broad valley floor at the eastern and western extremities of the valley.

1.3.2.2 Vertebrate Fauna

The Level 2 terrestrial fauna survey of the Valley Access Road study area yielded a total of 73 species, representing 35 families (Table 1.3).

Table 1.3: Vertebrate fauna species recorded from the Valley Access Road in the Panorama study area.

Fauna Group	Number of Species
Avifauna	41
Native Mammals	8
Introduced Mammals	2
Bats	2
Reptiles	18
Frogs	2
Total	73

Censuses of the Valley Access Road study area, in combination with opportunistic records, yielded a total of 41 avifauna species. The total comprised 19 species of non-passerines and 22 species of passerines, from 21 families.

The survey yielded 12 mammal species of which ten are native and two are introduced. The native species included three carnivorous marsupials (Dasyuridae), one kangaroo (Macropodidae), four native rodents (Muridae) and two bats (Hipposideridae and Vespertilionidae). The introduced taxa comprised one species each from the Bovidae (Cattle) and Muridae (rodents).

Twenty herpetofauna species, representing eight families, were recorded from the Valley Access Road. The total included two frogs (Hylidae and Myobatrachidae), one dragon (Agamidae), one front-fanged snake (Elapidae), five geckos (Gekkonidae), one legless lizard (Pygopodidae), eight skinks (Scincidae), and two monitors (Varanidae).

1.3.2.3 Invertebrate Fauna

Rhagada shells were collected from flood debris at SU03, although no live specimens were recorded. Several barychelid mygalomorph spiders were recorded from dry pits at the main trapping sites including SU02 (n=3), SU03 (n=1) and SU04 (n=2). All specimens appear to represent the one species.

1.3.3 SRE Taxa

A total of 67 live individuals from one morphotype of *Rhagada* (referred to as *Rhagada* sp. 'Sulphur Springs' throughout this report) were collected from eight sampling locations during the survey (see Table 1.4). Shells of the pupillid genus *Pupoides*, likely to belong to *P.* aff. *beltianus* were also collected from beneath *Triodia* hummocks in a small drainage at SUSS04.

Table 1.4: Number of live *Rhagada* sp. 'Sulphur Springs' collected during the survey.

Site	No. of Live Adults	No. of Live Sub-Adults	No. of Live Juveniles
SUSS01	10	1	5
SUSS02	0	1	0
SUSS03	1	0	1
SUSS04	10	1	5
SUSS05	0	0	2
SUSS06	12	2	2
SUSS07	5	0	2
SUSS08	5	0	2
	43	5	19

Five pseudoscorpion taxa were collected during the survey of the mine site, including *Feaella* sp 'Sulphur Springs', a *Synsphyronus* sp., a Chernetidae (probably *Haplochernes* sp.), an olpiid (possibly more than one species), and another taxon of uncertain affinities which is awaiting review by Dr. Mark Harvey of the WA Museum (Table 1.5).

Table 1.5: Details of sites from which pseudoscorpions were collected during the Panorama Survey.

Site	Feaellidae	Garypidae	Chernetidae	Olpiidae	Uncertain
SUSS 07		*Synsphyronus* sp.	*Haplochernes* sp.	? Genera	
SUSS 09		*Synsphyronus sp.*			
SUSS 10		*Synsphyronus* sp.			
SUSS 11	*Feaella* sp.			? Genera	
SUSS 12		*Synsphyronus sp.*			
SUSS 13		*Synsphyronus* sp.			
SUS Mine		*Synsphyronus* sp.			
SPEC 01		*Synsphyronus* sp.	*Haplochernes* sp.		Uncertain
SPEC 04			*Haplochernes* sp.		
SUMU 01		*Synsphyronus* sp.		? Genera	

1.4 Schedule and Priority Fauna and Other Species of Conservation Interest

Two Schedule 1 species, one Priority 3 species and four Priority 4 listed species were recorded from the Plains Access Road and Valley Access Road survey areas (

1.5 Habitat Conservation Significance

There are no Threatened Ecological Communities within the current project area nor do any occur in the Chichester subregion. There are similarly no "ecosystems at risk" in the study area, although Kendrick and McKenzie (2001) identify numerous such ecosystems for the Chichester subregion.

The majority of the habitat types are considered to be of neutral conservation significance, representing units that are likely to be more widely distributed and relatively well represented in the Panorama area of the Chichester subregion.

Table 1.6). The Northern Quoll is Federally listed as "Endangered". A further four Schedule and two Priority listed species have either been recorded from or may occur in the region (as determined by a search of the DEC Rare Fauna Database).

1.6 Habitat Conservation Significance

There are no Threatened Ecological Communities within the current project area nor do any occur in the Chichester subregion. There are similarly no "ecosystems at risk" in the study area,

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Table 1.6: Fauna species of conservation significance recorded from, or expected to occur in, the Panorama Project study area.

Species	Conservation Status		Taxon Recorded at Panormama	Number of Records	Location†	Co-ordinates
	State Level	Federal Level				
Northern Quoll *Dasyurus hallucatus*		Endangered	✓	2	CAR	727798mE, 7663587mN
Mulgara *Dasycercus cristicauda*	Schedule 1	Vulnerable	✓	1	PAR	741682mE, 7701908mN
Orange Leaf-nosed Bat *Rhinonicteris aurantius*	Schedule 1	Vulnerable	✓	8	CAR	727850mE, 7663830mN
Pilbara Olive Python *Liasis olivaceus barroni*	Schedule 1	Vulnerable				
Bilby *Macrotis lagotis*	Schedule 1					
Woma *Aspidites ramsayi*	Schedule 4					
Peregrine Falcon *Falco peregrinus*	Schedule 4					
Spectacled Hare Wallaby *Lagorchestes conspicillatus*	Priority 3		✓	5	PAR PAR PAR PAR PAR	739514mE, 7677880mN 739514mE, 7677880mN* 733366mE, 7668060mN* 738091mE, 7673377mN* 739904mE, 7692919mN*
Australian Bustard *Ardeotis australis*	Priority 4		✓	3	PAR PAR PAR	739514mE, 7677880mN 739458mE, 7678003mN 727063mE, 7665410mN
Bush Stone-curlew *Burhinus grallarius*	Priority 4		✓	1	PAR	727026mE, 7665461mN
Lakeland Downs Mouse *Leggadina lakedownensis*	Priority 4					
Ghost Bat *Macroderma gigas*	Priority 4		✓		PAR	Vicinity of Lalla Rookh mine
Western Pebble-mound Mouse *Pseudomys chapmani*	Priority 4		✓	2	CAR CAR	727339mE, 7664938mN 727335mE, 7664958mN*
Long-tailed Dunnart *Sminthopsis longicaudata*	Priority 4					

† CAR = Valley Access Road; PAR = Plains Access Road.

- indicates records obtained from secondary evidence only (diggings, tracks, calls and pebble-mounds respectively for the four species).

Moderate Conservation Significance

This value is ascribed to parcels of land for which there are contributing attributes that elevate the conservation ranking above neutral and that may require particular management.

Areas of moderate conservation significance comprise:

- Areas of sandplain habitat along the Plains Access Road that constitute suitable habitat for Mulgaras.
- Drainage features within the mine area.

High Conservation Significance

This value is ascribed to parcels of land with contributing attributes elevating the conservation status above Moderate and requiring particular management, often determined by legislative requirements at both a State and Federal Level.

Three key habitats are areas are considered to have high conservation significance:

- The valley area;
- The locations from which Spectacled Hare Wallabies were recorded; and
- The location from which *Feaella* sp. 'Sulphur Springs' (a pseudoscorpion) was recorded.

1.7 Potential Impacts, Conclusions and Recommendations

The following generic management measures are proposed to minimise or better understand potential impacts to the fauna and fauna habitats of the Panorama project area:

1. Disturbance to habitats of high conservation significance should be avoided if possible, or otherwise minimised, by relocating all non-essential infrastructure to other areas and/or minimising clearing in these areas. Disturbance to habitats of moderate significance should likewise be minimised. Vegetation clearing in general should be kept to the minimum necessary for safe construction and operation of the Sulphur Springs mine.
2. Wherever possible, disturbance to surface drainage features should be avoided during mine planning. Modifications to the local surface hydrology will be needed for this project and natural drainage patterns should be re-established at the completion of mining activities in the locality.
3. A Fire Management Plan should be prepared and implemented to minimise the risk of unplanned fires in the project area.
4. Weed control measures should be developed and implemented to prevent the introduction or spread of weeds in the project area. This is particularly the case for aggressive environmental weeds such as buffel grass *Cenchrus ciliaris,* that can replace native *Triodia* species thereby modifying habitat for native fauna (eg land snails). A Weed Hygiene and Management Plan should be prepared in consultation with the DEC prior to construction commencing.
5. A Topsoil Management and Rehabilitation Plan should be prepared for all non-permanent cleared areas in liaison with the DEC prior to the commencement of construction activities. This plan should include use of provenance collected native seed, characterisation and management of areas of topsoil, and the respreading of cleared vegetative material. Recovery monitoring should also be carried out, with any rehabilitation failure subject to additional treatment to a suitable standard.
6. A Feral Species Management and Mitigation program should be developed for the proposed project. This program should target species such as the European fox, feral cat and wild dogs where these are readily distinguishable from dingoes.

In addition, several specific recommendation made in relation to specific fauna are also made.

In respect of Mulgaras, it is recommended:

- that a pre-clearing survey (2-3 days prior to clearing activities) be undertaken within suitable habitat coinciding with the transport corridor to determine whether the area encompasses any active burrows; and
- should any such burrows be located, these should be excavated and any animals encountered held in captivity until after the clearing has taken place, then released into adjacent areas where it is likely they will have additional burrows.

In respect of the Orange Leaf-nosed Bat, it is recommended that the following studies are undertaken:

- Desktop Review
  A desktop review should be undertaken to evaluate the likely occurrence of comparable valley habitat (to that at Panorama) within a similar distance from the known Orange Leaf-nosed Bat colony at Lalla Rookh (as this is potentially a source of the bats at Panorama). The desktop review should use available aerial photography, topography and other cadastral features to identify comparable valley features. It is proposed that apparently suitable valleys then be ground-truthed (where access permits) to establish whether they support bats. The main aim of this work is to determine whether there is additional foraging habitat available to

bats that might be using Lalla Rookh as a roost and then undertaking nightly foraging forays to Panorama and the surrounds.

- Site Visit
  A six day (five night) site visit should be undertaken to ground-truth any additional suitable habitat identified from the desktop studies described above. An additional attempt to locate roost sites within the valley through which the access road is to be constructed is also recommended. It is noted that a preliminary though cursory search did not locate suitable caves. Additional Orange Leaf-nosed Bat surveys might also be undertaken in the Valley Access Road study area to determine if the bats regularly utilise the area.

In respect of the Spectacled Hare Wallaby, the following are recommended:

- To further clarify the occurrence of this species along the corridor and within the general location, a survey should be undertaken using rapid assessment techniques, which involve utilizing secondary signs to establish presence and in some cases relative density estimates. It is proposed that a suitably qualified and experience person in identifying species from tracks be involved, and that during the survey DEC staff be invited to participate so that they can also learn techniques for recording this species from tracks.
- CBH should conduct environmental awareness training that will identify significant habitat/s and the appropriate management actions will be implemented eg. slowing vehicle speed through areas recognised as being of environmental significance.
- Large old spinifex hummocks (favoured habitat) should be avoided where practicable during construction.
- A fire management plan for the vicinity of the Spectacled Hare Wallaby population should be developed in consultation with the DEC.

In respect of the pseudoscorpion *Feaella* sp. 'Sulphur Springs', the following is recommended:

- Additional survey work be undertaken to better delineate distribution and habitat.
- Additional taxonomic work be undertaken to resolve the identity of the specimens.

2.0 Introduction

2.1 Project Background and Study Area Location

CBH Resources plan to develop a copper-zinc mine on a deposit identified at Panorama in the north-eastern Pilbara region of Western Australia. The project comprises the mine site and associated infrastructure areas, as well as a haul road (Figure 2.1).

The project has been the subject of a previous Level 2 (in accordance with the Environmental Protection Authority (EPA) Guideline No. 56) terrestrial fauna survey (Bamford and Wilcox 2001). However, the original proposal was subsequently altered to accommodate two modifications to the haul road corridor. The existing access road from the Port Hedland-Marble Bar Road is to be widened by an estimated four to five metres, where required, for a distance of approximately 40 kilometres to the south, after which it then deviates from the original proposal to enter the Gorge Ranges through a narrow valley[1].

In addition, the EPA required that a targeted SRE survey be carried out in the proposed mine area, as this was not undertaken during the original survey by Bamford and Wilcox (2001).

2.2 Study Objectives and Scope

Biota Environmental Sciences (Biota) was commissioned by CBH Resources to conduct a multi-level fauna survey of the revised haul road corridor and mine site at Sulphur Springs. The survey was planned and implemented in accordance with EPA Guidance Statement No. 3 "Terrestrial Biological Surveys as an element of Biodiversity Protection" (EPA 2002) and Guidance Statement No. 56 "Terrestrial Fauna Surveys for Environmental Impact Assessment in Western Australia" (EPA 2004).

The scope of the fauna survey was to undertake:

- a Level 1 targeted fauna survey of the Plains Access Road between the Port Hedland-Marble Bar Road and the Gorge Ranges as agreed with DEC, Karratha;
- a Level 2 terrestrial fauna survey of the Valley Access Road through a valley in the Gorge Range; and
- a survey targeting possible Short Range Endemic (SRE) fauna within the mine site study area.

2.3 Purpose of this Report

This report describes the methodology used to conduct the various fauna surveys associated with the Panorama project. It documents the results of the survey and provides recommendations to mitigate impacts of the development on the fauna habitats and assemblages occurring in the study area. Its intended use is as a supporting document for environmental assessment of the project. Both the survey and this report are subject to limitations including, but not necessarily restricted to, those discussed in Section 3.5.

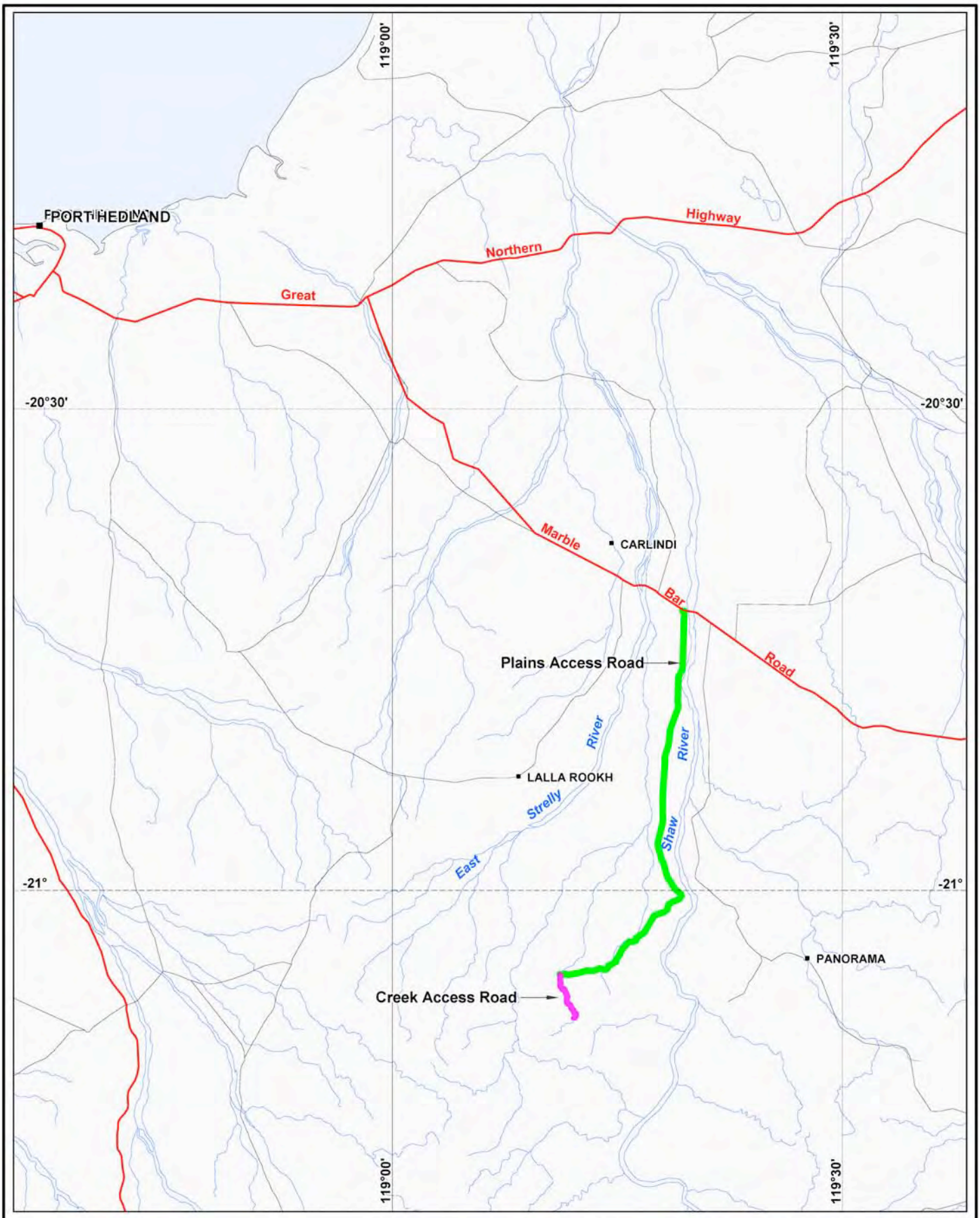
2.4 Geological and Physiographic Context of the Study Area

2.4.1 Major Physiographic Units

Beard (1975) recognised four major physiographic units within the Fortescue Botanical District:

- Abydos Plain – extending from Cape Preston east to Pardoo Creek and south to the

[1] To maintain consistency with the previous report on the site (Bamford and Wilcox 2001), the haul road corridor between the Port Hedland-Marble Bar Road and the entrance to the valley will be referred to as the 'Plains Access Road' and that through the valley itself will be referred to as the 'Valley Access Road'.



Location Map

Map Area

PERTH

KALGOORLIE

Legend

Level 1 Assessment

Level 2 Assessment

N

W E

S

0 10 20

kilometres

BIOTA

Fig 2.1 Panorama Project - Location Plan

Author: P Runham	Date: 30/01/2007
Drawn: P Sawers	Revised:
Job No.: 370	WS No.:
Projection: GDA94	Scale: 1 : 550,000

Chichester Range: it includes alluvial plains, low stony hills and granite outcrops comprising largely granitic soils with alluvial soils in coastal regions;

- Chichester Plateau – a predominantly basaltic plateau of siltstones, mudstones, dolomite and jaspilite: it forms a watershed between drainage lines flowing north through the Abydos Plain and south through the Fortescue Valley;
- Fortescue Valley – occupies a trough between the Chichester and Hamersley Plateaux, with the eastern portion draining into the Fortescue Marshes; and
- Hamersley Plateau – rounded hills and ranges comprised largely of dolomite and jaspilite, with some shale, siltstone and volcanics.

The Panorama study area lies toward the mid-eastern area of the Abydos Plain and incorporates a small portion of the Gorge Range, which is within the Nullagine Hills sub-region of Payne (2004).

2.4.2 Geological Units

The Geological Survey of Western Australia 1:500,000 scale mapsheet (Thorne and Trendall 2001) shows a number of geological types intersected by the study area, comprising:

- Qx (Undivided Quaternary deposits; includes colluvium, reworked alluvium, eolian sand, and clay): the greater proportion of the Plains Access Road between the Port Hedland-Marble Bar Road and the lower slopes of the Gorge Ranges;
- Qa (Alluvium – unconsolidated silt, sand and gravel; in river channels): small sections of the Plains Access Road between the Port Hedland-Marble Bar Road and the lower slopes of the Gorge Ranges;
- Ab (Basaltic and andesite flows, and associated volcaniclastic rocks; metamorphosed): the section of the Plains Access Road running north-east to south-west along the lower slopes of the Gorge Ranges; and
- As (Sedimentary rock, undivided; includes oligomictic and polymictic conglomerate, pebbly sandstone, mudstone, siltstone, and chert; metamorphosed): occurring along the Valley Access Road and in the mine site area.

2.4.3 Land Systems of the Study Area

Land Systems (Rangelands) mapping covering the study area has been prepared by the Western Australian Department of Agriculture (van Vreeswyk et al. 2004). Land Systems are comprised of repeating patterns of topography, soils, and vegetation (Christian and Stewart 1953) (ie. a series of "land units" that occur on characteristic physiographic types within the Land System).

A total of 107 Land Systems occur in the Pilbara bioregion. [This information was obtained by combining the Land System mapping for the Pilbara (van Vreeswyk et al. 2004) and Ashburton (Payne et al. 1988), and intersecting this with the Pilbara bioregion (Environment Australia 2000) in ArcView 3.2.].

Six of these Land Systems occur in the Panorama study area (Figure 3.1 and Figure 3.2):

1. Uaroo (RGEUAR) — Broad sandy plains supporting shrubby hard and soft spinifex grasslands; occurring along the northern half of the Plains Access Road;
2. Macroy (RGEMAC) — Stony plains and occasional tor fields based on granite supporting hard and soft spinifex grasslands; a small area in the central portion of the Plains Access Road;
3. Satirist (RGESAT) — Stony plains and low rises supporting hard spinifex grasslands, and gilgai plains supporting tussock grasslands; a small area in the central portion of the Plains Access Road;

4. Rocklea (RGEROC) — Basalt hills, plateaux, lower slopes and minor stony plains supporting hard spinifex (and occasionally soft spinifex) grasslands; the southern-most portion of the Plains Access Road adjacent to rocky hills, as well as a section of the infrastructure area;
5. Boolgeeda (RGEBGD) — Stony plains adjacent to hills, hard spinifex or mulga short grass forb pastures in good to excellent condition; a very small area adjacent to the entry to the Valley Access Road; and
6. Capricorn (RGECPN) — Rugged sandstone hills and ridges; hard spinifex or stony short grass forb pasture in fair to good condition; dominating the Valley Access Road and majority of the mine site and infrastructure area.

Less than 0.01% of the total mapped area for the Pilbara bioregion for each Land System lies within the Panorama study area. All but one of the Land Systems in the study area are in the six most abundant occurring in the Pilbara Bioregion (ranked 102nd or above). The Satirist Land System, with an area of 43,483 ha and ranking of 49th out of 107 Land Systems, is restricted in its distribution and size.

Table 2.1: Distribution of Land Systems in the study area and wider Pilbara bioregion (data from Payne et al. 1988 and van Vreeswyk et al. 2004).

Land System	Total Area in the Pilbara Bioregion (Rank*)	Number of Mapping Polygons in the Pilbara Bioregion	General Distribution through the Pilbara Bioregion	Amount of Land System in the current study area	
				Hectares	% of Total in Pilbara Bioregion
Uaroo	987,066 ha (104th)	100	Reasonably extensive in the north and far west of the bioregion; the study area lies at the southern extremity of the northern portion of the land system .	512.20	<0.01
Macroy	1,331,614 ha (105th)	166	Extensively distributed through the northeastern quarter of the Pilbara bioregion; study area lies in the central western area of the distribution	113.42	<0.01
Satirist	43,483 ha (49th)	25	Very small areas in the central northern half of the bioregion; study area intersects a small block to the west of Marble Bar	100.29	<0.01
Rocklea	2,881,199 ha (107th)	385	Very extensively distributed across most of the bioregion; the study area lies toward the central northern limit of the distribution	239.88	<0.01
Boolgeeda	961,634 ha (103rd)	588	Widespread through the Pilbara with a large number of occurrences, particularly through the Hamersley subregion; study area is toward the north-eastern extremity of the distribution of this Land System	24.60	<0.01
Capricorn	698,531ha (102nd)	252	Widespread through the bioregion, particularly the southern Abydos Plain and adjacent Nullagine hills; study area lies toward the central portion of this Land System's distribution	115.06	<0.01
Pilbara Total	17,800,478ha	5,636		1172.59	<0.01

- Land System rankings in terms of area out of the 107 occurring in the Pilbara bioregion; ranked from least (1) to most abundant (107).

2.5 Biological Context of the Study Area

2.5.1 IBRA Bioregion

The Interim Biogeographic Regionalisation for Australia (IBRA) currently recognises 85 bioregions in Australia. The Panorama study area lies in the Pilbara bioregion and specifically in the Chichester subregion.

The Pilbara bioregion has been nominated as one of fifteen national biodiversity "hotspots" by the Minister for Environment and Heritage (go to www.deh.gov.au/minister/env/2003/mr03oct03.html). This high diversity appears in part to be related to the Pilbara's position as a transitional zone between the Eyrean (central desert) and southern Torresian (tropical) bioclimatic regions. Consequently, it contains elements of the flora and fauna found in both of these regions.

The limited representation of the Pilbara in conservation reserves has resulted in land purchases in the area being listed as medium priority for funding under the National Reserves System Co-operative Program. Portions of numerous pastoral leases in the Pilbara have been nominated for exclusion for public purposes, when the leases are due for renewal in 2015, by the Department of Environment and Conservation (DEC). The aim is to add these areas to the existing conservation estate, thereby providing a comprehensive, adequate and representative reserve system. None of these proposed exclusions relate to the current study area.

2.5.2 Conservation Reserves in the Locality

There are no formally gazetted conservation reserves in the vicinity of Panorama.

2.5.3 Beard's Vegetation Mapping

Beard (1975) mapped the vegetation of the Pilbara at a scale of 1:1,000,000. The study area lies entirely within the Fortescue Botanical District of the Eremaean Botanical Province as defined by Beard. The vegetation of this province is typically open and frequently dominated by spinifex, wattles and occasional eucalypts.

The current study area intersects two of Beard's physiographic units, the Abydos Plain and the Gorge Ranges. Beard (1975) describes the vegetation of the Abydos Plain as:

(i) Shrub steppe. The predominant community of the granite plain is shrub steppe of the *Acacia pyrifolia - Triodia pungens*[2] association, in which there is a general cover of hummock grasses dotted with rather widely spaced shrubs.

(ii) Dwarf-shrub steppe. On the seaward margin of the granite plain are extensive sandplains covered by dwarf-shrub steppe in which there is a general cover of the hummock-grass *Triodia pungens* interspersed by very numerous low spreading shrubs of *Acacia translucens*[3].

(iii) The grass plains. Where finer-grained alluvia have been deposited, particularly those derived from the weathering of basic rocks, there are open plains of tussock grass or mixed grass and spinifex. Nearer the coast, clay plains of tussock grass only occur. On the Lower de Grey, the soil material is more mixed so treeless plains are uncommon. Patches of *Acacia pyrifolia-Triodia pungens* shrub steppe occur mixed with patches of grass savanna, or the grass and spinifex occur mixed together.

(iv) The coastal complex. The Abydos Plain slopes so gently to the sea that there is a 5-10 km wide belt of tidal lagoons with samphire flats and mangroves.

The vegetation of the Gorge Ranges is described by Beard (1975) as:

(ii) The high steep parts of the Gorge Ranges with rocky substrates are covered with sparse tree steppe (Snappy gum *Eucalyptus brevifolia*[4] - low, only 6-8m or less), over hummock grasses (*Triodia pungens* and *T. brizoides*, at least in the north. In the south *T. brizoides* appears to be replaced by *T. wiseana* var. *brevifolia*[5]). This is replaced by shrub steppe in the valleys (*Acacia pyrifolia* and *Triodia pungens*) and lower slopes (*Acacia bivenosa* and *Triodia*

2 *Acacia pyrifolia* is probably more likely to refer to *A. inaequilatera;* references to *Triodia pungens* should also incorporate *T. epactia.*

3 Now *Acacia stellaticeps.*

4 Now *Eucalyptus leucophloia* subsp. *leucophloia.*

5 This variety not currently recognised.

pungens). On higher ground the eucalypts may be absent altogether, or joined by *Ficus* and *Terminalia*.

Given the coarse mapping scale utilised by Beard (1975), these units represent the vegetation types within the study area only in broad terms.

2.6 Previous Fauna Studies in the Area

Two fauna surveys have previously been conducted in the vicinity of the Panorama study area:

- Panorama Project Area: Baseline Fauna Study as Part of the Sulphur Springs Feasibility Study (Bamford and Wilcox 2001); and
- a biological survey of the Abydos-Woodstock Reserve by the Western Australian Museum (1991).

In addition, a portion of the Hope Downs Rail Corridor (Biota 2004a) that traversed areas of the Chichester Ranges, and contained habitats similar to those found in the Panorama study area, has been used as a comparative reference for the current study.

3.0 Survey Methodology

3.1 Database Searches

A search of the Threatened Fauna Database managed by the DEC was commissioned for threatened fauna records in the vicinity of the Panorama study area. Similarly, the Western Australian Museum Faunabase was also searched for records of fauna specimens vouchered from the vicinity of the current study area. The bounding coordinates used for these searches were:

- 20.6265 ºS, 119.718315 ºE; and
- 21.6150 ºS, 118.700761 ºE.

3.2 Survey Timing and Weather

The study was conducted over an eight-day period between the 29th of August 2006 and the 5th of September 2006.

During this period, maximum temperatures ranged from 33.7°C to 35.6°C (Table 3.1), with the mean temperature for the study period exceeding the long-term average for September (Table 3.2). Conversely, the minimum temperature range, which fell between 12.1°C and 15.5°C, yielded a study period average of 14.2°C (Table 3.1), 2.5°C below the long-term September average (Table 3.2).

No rainfall events were recorded during the study period, or in the four months preceding it.

Table 3.1: Daily meteorological observations for Marble Bar for the duration of the Panorama survey period (data provided by the Western Australian Bureau of Meteorology).

Date	Minimum Temperature (ºC)	Maximum Temperature (ºC)	Rainfall 24 hrs to 9am (mm)
29-08-2006	14.8	35.6	0
30-08-2006	15.5	34.6	0
31-08-2006	14.9	34.6	0
01-09-2006	13.2	33.7	0
02-09-2006	12.1	34.5	0
03-09-2006	13.8	34.9	0
04-09-2006	14.5	34.8	0
05-09-2006	14.6	34.7	0
Mean	14.2	34.7	

Table 3.2: Climatological summary for Marble bar incorporating data from 1895 to 2004, compared to values for 2006 (data supplied by the Western Australian Bureau of meteorology).

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Mean Daily Maximum (ºC)	41.0	39.8	39.0	36.0	30.7	27.1	26.8	29.6	33.9	37.5	40.5	41.6
Mean Daily Minimum (ºC)	26.1	25.6	24.7	21.3	16.6	13.1	11.8	13.3	16.7	20.3	23.6	25.5
Mean Total Monthly Rain (mm)	76.2	87.8	56.6	21.1	23.3	23.3	12.0	6.6	0.9	3.9	9.2	39.1
Mean Daily Maximum 2006 (ºC)	37.4	36.2	36.5	33.1	30.0	26.3	26.5	32.0	35.5			
Mean Daily Minimum 2006 (ºC)	26.3	25.1	25.2	21.3	16.0	12.1	10.1	12.9	17.0			
Total Monthly Rain 2006 (mm)	168.2	147.4	106.2	113.6	0.0	0.0	0.0	0.0	53.6			

3.3 Fauna Survey Team

Vertebrate fauna sampling for this study was conducted under DEC "Licence to take fauna for scientific purposes" No. SF005532 issued to Dr P. Runham (Appendix 1). Ethics approval for handing of vertebrate fauna was provided under the W.A. Museum application to the DEC Animal Ethics Committee, and covered Mr Roy Teale as a research associate of the W.A. Museum.

The team conducting the survey comprised Mr Roy Teale, Dr Phil Runham and Mr Mike Greenham (all of Biota). The study team completed field identifications of all vertebrate and invertebrate fauna collected using field experience and current fauna guides.

Field identifications were confirmed, where necessary, with the help of staff from the WA Museum. Ms Norah Cooper and Mr Brad Maryan are acknowledged for assistance with mammal and herpetofauna identifications respectively. Dr Mark Harvey and Ms Julianne Waldock were also of assistance where confirmation of invertebrate identifications was required.

3.4 Fauna Sampling

The current study had three main components, each of which will be treated separately for the purposes of this report:

- a Level 1 fauna survey along the Plains Access Road targeting threatened (Schedule or Priority listed) fauna or evidence thereof;
- a Level 2 fauna survey, with sampling centred on trapping grids installed along the Valley Access Road in habitats considered to represent the range of elements available; and
- non-systematic searches of specific habitats in the mine site and infrastructure area for invertebrate taxa potentially containing Short Range Endemics (SREs). Collections were also made outside of this area for contextual information.

3.4.1 Level 1 Survey of the Plains Access Road

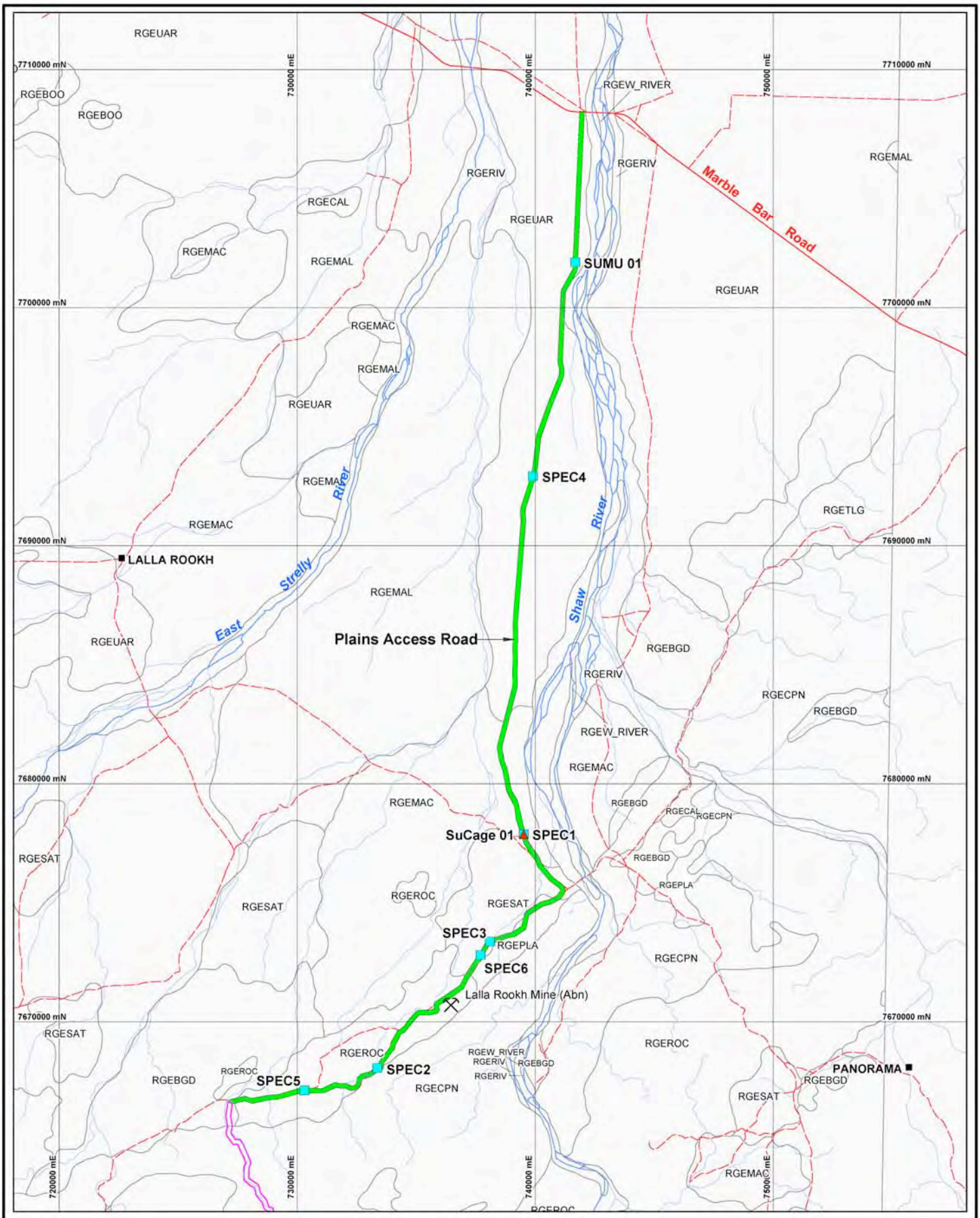
A Level 1 survey was conducted along the Plains Access Road, which in addition to describing fauna habitat was also required to search for the Bilby *Macrotis lagotis* and Spectacled Hare Wallaby *Lagorchestes conspicillatus* (Table 3.3, Figure 3.1) (Ms. Hayley Valentine, DEC Karratha, pers comm. 2006).

Targeted searches for species (in particular the Bilby and Spectacled Hare Wallaby) were conducted along the Plains Access Road by spotlighting and investigation of burrows/tracks. Spotlighting was conducted on four occasions (31/8/06, 2/9/06, 3/9/06 and 5/9/06) and involved driving a vehicle at 40km/hr along the existing vehicle access road from dusk through to approximately 22:00 hrs.

Table 3.3: Details of the cage trapping grid and foot traverses used to target the Mulgara, Bilby and Spectacled Hare Wallaby along the Plains Access Road at Panorama.

Site	Location	Sample Type	Vegetation Alliance*	Date Opened	Date Closed	Nights Open	Trap Effort
SuCage 01	739514 mE; 7677880 mN	Cage Traps (10 traps)	VA42	01/09/2006	05/09/2006	4	40
SPEC1	739514 mE; 7677880 mN	Foot traverse	VA42	-	-	-	-
SPEC2	733366 mE; 7668060 mN	Foot traverse	VA45	-	-	-	-
SPEC3	738091 mE; 7673377 mN	Foot traverse	VA45	-	-	-	-
SPEC4	739904 mE; 7692919 mN	Foot traverse	VA27	-	-	-	-
SPEC5	730300mE; 7667125mN	Foot traverse	VA14	-	-	-	-
SPEC6	737700mE; 7672810mN	Foot traverse	VA42	-	-	-	-
SUMU 01	741682mE; 7701908mN	Foot traverse	VA37	-	-	-	-

*From Trudgen (2006): VA42 = *Triodia epactia* hummock grasslands on the plains and lower slopes;
VA45 = (Scattered tall shrubs over) *Triodia* sp. '*Panorama*' hummock grassland;
VA27 = *Grevillea wickhamii* high open shrubland to shrubland;
VA14 = *Corymbia hamersleyana* scattered low trees over scattered tall shrubs to high open shrubland over *Triodia epactia* hommock grasslands on valley floor and lower slopes.
VA37 = *Acacia stellaticeps* low shrubland to low open heath.



Location Map

Map Area

PERTH

KALGOORLIE

Legend

Level 1 Assessment

Level 2 Assessment

Foot traverse

Cage traps

N

W E

S

0 2.5 5

kilometres

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Fig 3.1 Panorama Project - Plains Access Road Level 1 Assessment Survey Area

Author: P Runham	Date: 25/01/2007
Drawn: P Sawers	Revised:
Job No.: 370	WS No.:
Projection: GDA94	Scale: 1 : 200,000

Foot traverses were conducted at 6 locations to search for evidence of Bilbies, Mulgaras and Spectacled Hare Wallabies. Searches consisted of locating areas of preferred habitat for each species and traversing the area on foot, or walking transects of the access road itself and recording signs of the species (burrows, scats, diggings or tracks).

Additionally, one cage-trapping grid targeting the Spectacled Hare Wallaby *Lagorchestes conspicillatus* was installed along the Plains Access Road at SuCage 01 (where an individual was sighted). This grid comprised two rows of five traps set on opposite sides of the track, with individual traps set approximately 10 m apart. Details of the trapping grid are shown in Table 3.3.

3.4.2 Level 2 Survey of the Valley Access Road

A level 2 fauna survey was conducted along the 6 km long Valley Access Road, which provides access to the mine area.

3.4.2.1 Selection and Location of Sampling Sites

The central component of this Level 2 survey was the establishment of systematic trapping grids. A range of different trapping techniques were employed: six trapping grids utilised only pit traps, three utilised only medium-sized Elliott traps and six utilised harp traps. Each trapping site was installed within a defined habitat, and was selected such that equal weight was given to accessibility in terms of regular inspection of pit-fall, Elliott and harp traps.

Trapping grid composition and locations are presented in Figure 3.2 and Table 3.4. Photos of selected survey sites are presented in Plates 3.1 to 3.4.

3.4.2.2 Systematic Terrestrial Fauna Sampling

Trapping effort at each location (see Table 3.4) was adapted to the habitat in which the grid was installed. Pit-trap grids comprised up to 10 traps, utilising a mixture of 20 litre buckets and PVC tubes (150mm diameter x 700mm depth) connected by a suitable length of 30cm high flywire drift fence.

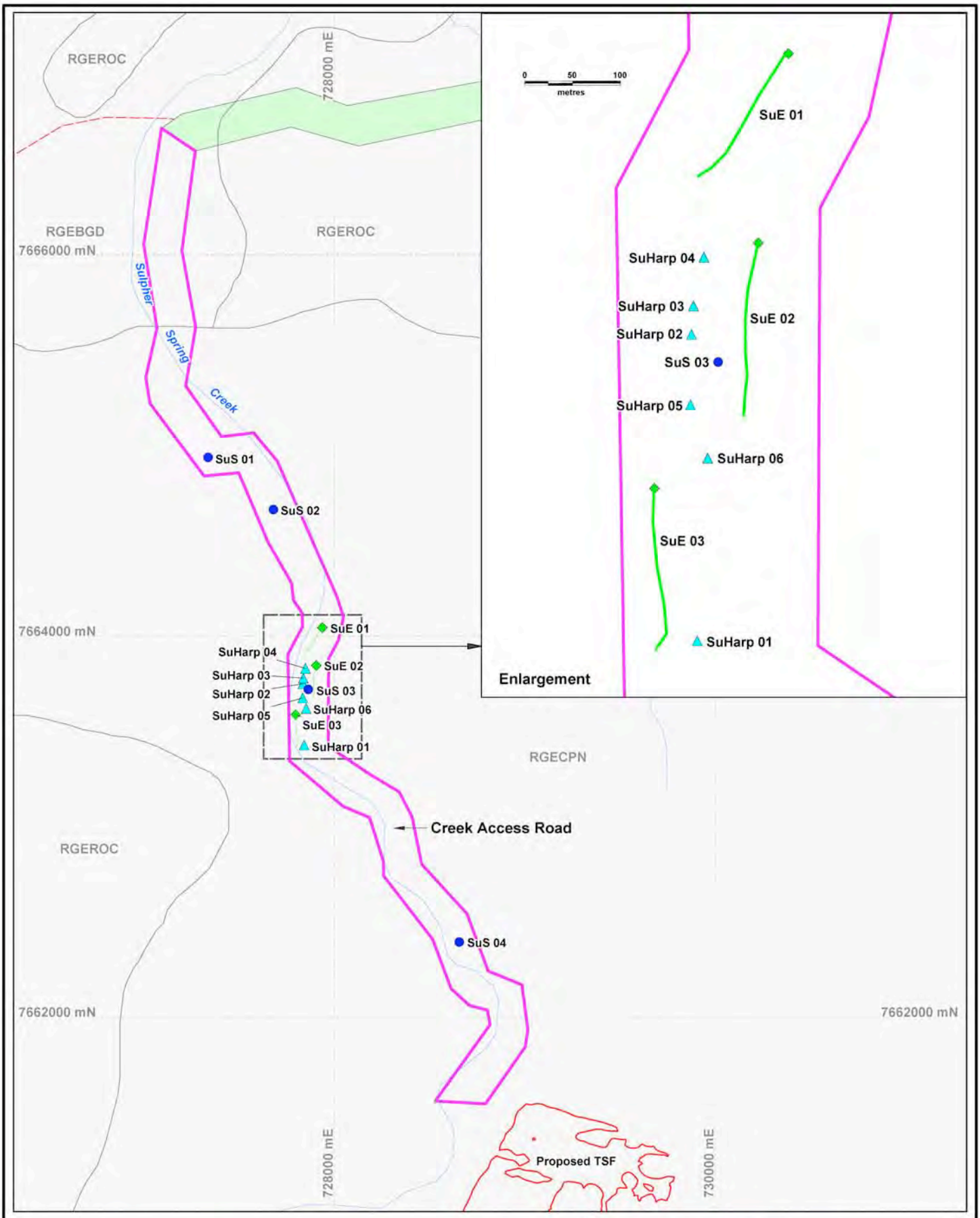
Three Elliott trapping grids totalling 100 traps were placed on rock walls located on either side of the Valley Access Road to target the Northern Quoll *Dasyurus hallucatus*. Individual traps were separated by a distance of approximately 10 m.

Table 3.4: Trapping details for the Valley Access Road survey.

Site	Location	Trap Type	Trap Number	Date Opened	Date Closed	Nights Open	Trap Effort
SuS 01	727339 mE; 7664938 mN	Pit	10	31/08/2006	05/09/2006	5	50
SuS 02	727682 mE; 7664664 mN	Pit	8	31/08/2006	05/09/2006	5	40
SuS 03	727865 mE; 7663720 mN	Pit	6	31/08/2006	05/09/2006	5	30
SuS 04	728658 mE; 7662393 mN	Pit	7	31/08/2006	05/09/2006	5	35
SuE 01	727939 mE; 7664044 mN	Elliott	25	01/09/2006	04/09/2006	3	75
SuE 02	727907 mE; 7663845 mN	Elliott	50	01/09/2006	04/09/2006	3	150
SuE 03	727798 mE; 7663587 mN	Elliott	25	01/09/2006	04/09/2006	3	75
SuHarp 01	727843 mE; 7663427 mN	Harp	1	31/08/2006	04/09/2006	4	4
SuHarp 02	727837 mE; 7663749 mN	Harp	1	31/08/2006	04/09/2006	4	4
SuHarp 03	727839 mE; 7663779 mN	Harp	1	31/08/2006	03/09/2006	4	4
SuHarp 04	727850 mE; 7663830 mN	Harp	1	31/08/2006	03/09/2006	4	4
SuHarp 05	727836 mE; 7663675 mN	Harp	1	03/09/2006	04/09/2006	1	1
SuHarp 06	727854 mE; 7663619 mN	Harp	1	03/09/2006	04/09/2006	1	1
				Total Pit-trap Nights			155
				Total Elliott Trap Nights			300
				Total Harp Trap Nights			18
				Total Trap Nights			473

3.4.2.3 Avifauna Sampling

Avifauna censuses were conducted during a foot traverse of the entire Valley Access Road on four successive mornings. Due to the linear nature and limited size of the study area, it was not



Location Map

Map Area

PERTH

KALGOORLIE

Legend

Level 2 Assessment

Level 1 Assessment

Trapping type

Pit

Harp

Elliott

0 500 1,000

metres

N

W E

S

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Fig 3.2 Panorama Project - Creek Access Road
Level 2 Assessment Survey Area

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Drawn: P Sawers	Revised:
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Projection: GDA94	Scale: 1 : 25,000

possible to restrict censuses to discrete habitats. However, the point at which low stony hills vegetated with *Triodia* gave way to riparian vegetation at each end of the valley was noted, and avifauna recorded for each area. Details of each census are presented in Table 3.5.

Table 3.5: Avifauna censuses conducted during the Valley Access Road survey.

Date	Start – Finish Times	Census Time (mins)
01/09/2006	07:00 – 09:00	120
02/09/2006	07:15 – 09:20	125
03/09/2006	06:05 – 08:55	170
04/09/2006	06:35 – 08:20	105
	Total Census Time	520

Plate 3.1. SuS04

Plate 3.2. SuS 03

Plate 3.3. SU Harp 02

Plate 3.4. SuE 01

3.4.2.4 Bat Sampling

Bats were directly sampled using harp traps erected adjacent to the Valley Access Road. Traps were placed in six locations (Table 3.4) and were set up in potential flyways, typically over water amongst riparian vegetation.

3.4.2.5 Non-systematic Invertebrate and Vertebrate Sampling

Additional records of targeted species were also obtained by night spotting from a vehicle, being driven at approximately 40km/h along the access road, using a spotlight. Any fauna observed opportunistically while traversing the study area were also recorded.

3.4.2.6 Short Range Endemic Sampling

Hand foraging techniques were used to search for potential SRE invertebrate taxa in the Valley Access Road corridor, including:

- Pulmonata (land snails);

- Diplopoda (millipedes);
- Pseudoscorpionida (pseudoscorpions); and
- Mygalomorph spiders.

Techniques used and the locations searched are described further under Section 3.4.3.

3.4.3 Short Range Endemic Survey of the Mine Site

The previous survey of the mine area (Bamford and Wilcox 2001) had not involved specific searches for species with naturally small distributions; so called Short Range Endemics (SREs). Although vertebrates can also have small distributions, survey work for SREs principally focuses on invertebrate taxa.

In addition to collecting within the mine site area, sampling was also undertaken outside of this area (including along the Valley Access Road; Section •) to provide additional distributional information.

Hand foraging techniques were used to search the mine area for potential SRE invertebrate taxa including:

- Pulmonata (land snails);
- Diplopoda (millipedes);
- Pseudoscorpionida (pseudoscorpions); and
- Mygalomorph spiders.

Land snails were searched for under large *Triodia* hummocks found on sandy to loamy soils and in small drainage lines, which is also where mygalomorph spiders commonly occur. Pseudoscorpions were collected from under bark on trees, as well as from under rocks. Millipedes were searched for under leaf litter and rocks. Search locations for SRE taxa are shown in Table 3.6, Figure 3.3 and Figure 3.4.

3.4.4 Phylogenetic Investigations of *Rhagada* Land Snails

Whilst most specimens considered to represent SRE taxa were submitted to the WA Museum for identification (typically to morphotype), the *Rhagada* specimens were included into a broader genetic study examining the phylogeography of this land snail genus, which is currently being coordinated by Biota in collaboration with the University of Western Australia.

3.4.4.1 DNA Extraction

DNA was extracted from a total of 51 *Rhagada* specimens using a simple digestion method (Schenk 1996). These specimens included 26 individuals from eight sampling locations from the current survey. DNA was then purified using an "Ultra Clean PCR Clean-Up DNA Purification kit" (MO BIO Laboratories Inc.) following manufacturer's instructions.

3.4.4.2 Polymerase Chain Reaction (PCR)

Polymerase Chain Reaction (PCR) was used to amplify the cytochrome oxidase c subunit one (COI) mitochondrial gene. This gene was chosen because of the known useful levels of variability of this region in many other phylogenetic investigations, and the reliability of this gene for inferring phylogenetic information (Biota 2006a, 2006b; Bond 2004; Hart and Podolsky 2004; Hebert et al. 2004; Paquin and Hedin 2004; Steinke et al. 2004; Bond and Sierwald 2003; Hebert et al. 2003; Holland and Hadfield 2002; Stothard et al. 2002; Farrell 2001; and Kojima et al. 1995). The gene has also been found to be reliable for 'DNA barcoding' (Hebert et al. 2003).

Primers used to attempt amplification of this region were COI L and COI H from Folmer et al. (1994) (see Table 3.7). PCRs were 25µl in total volume and contained 5µl of each primer (2mM),

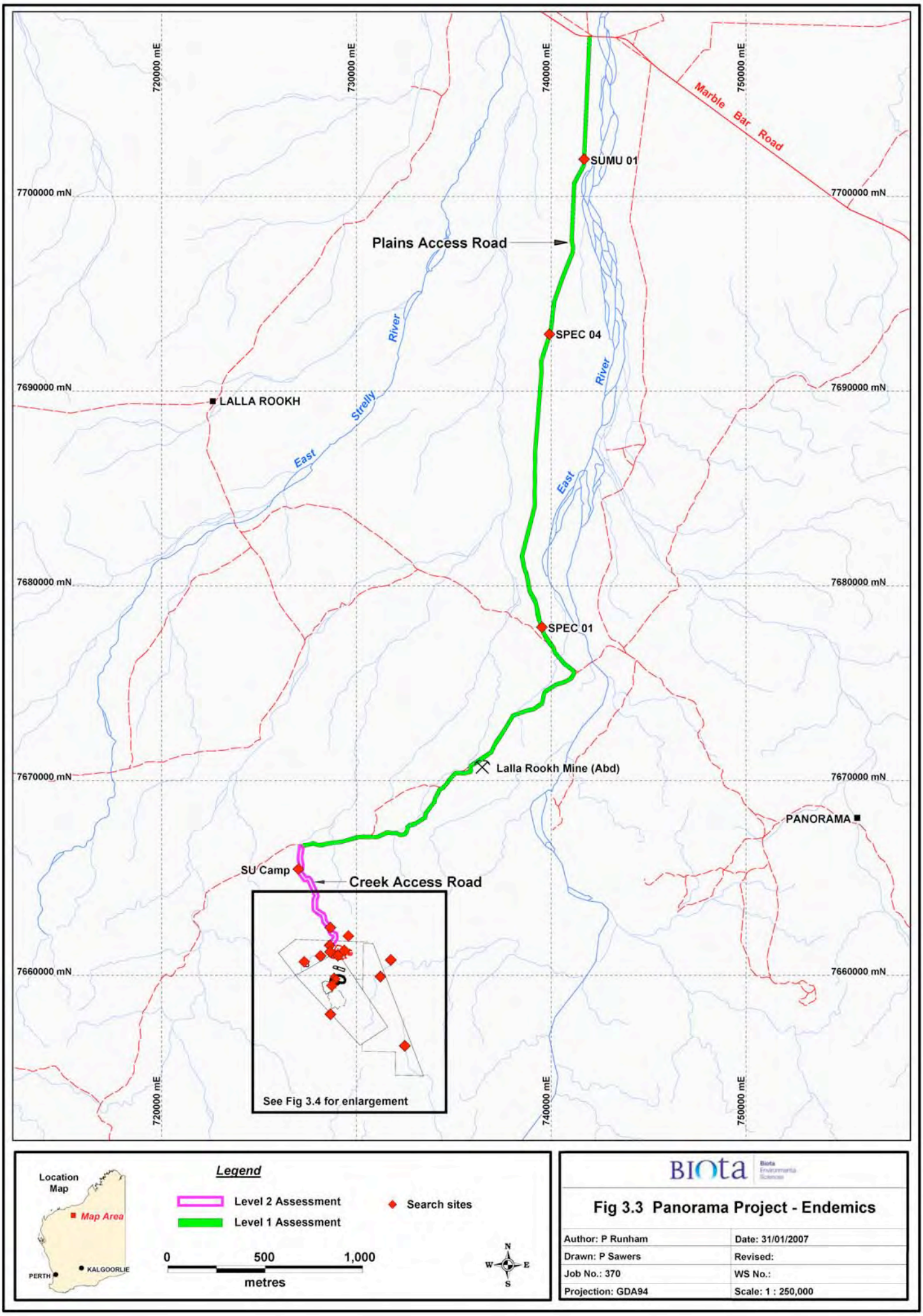

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Fig 3.3 Panorama Project - Endemics

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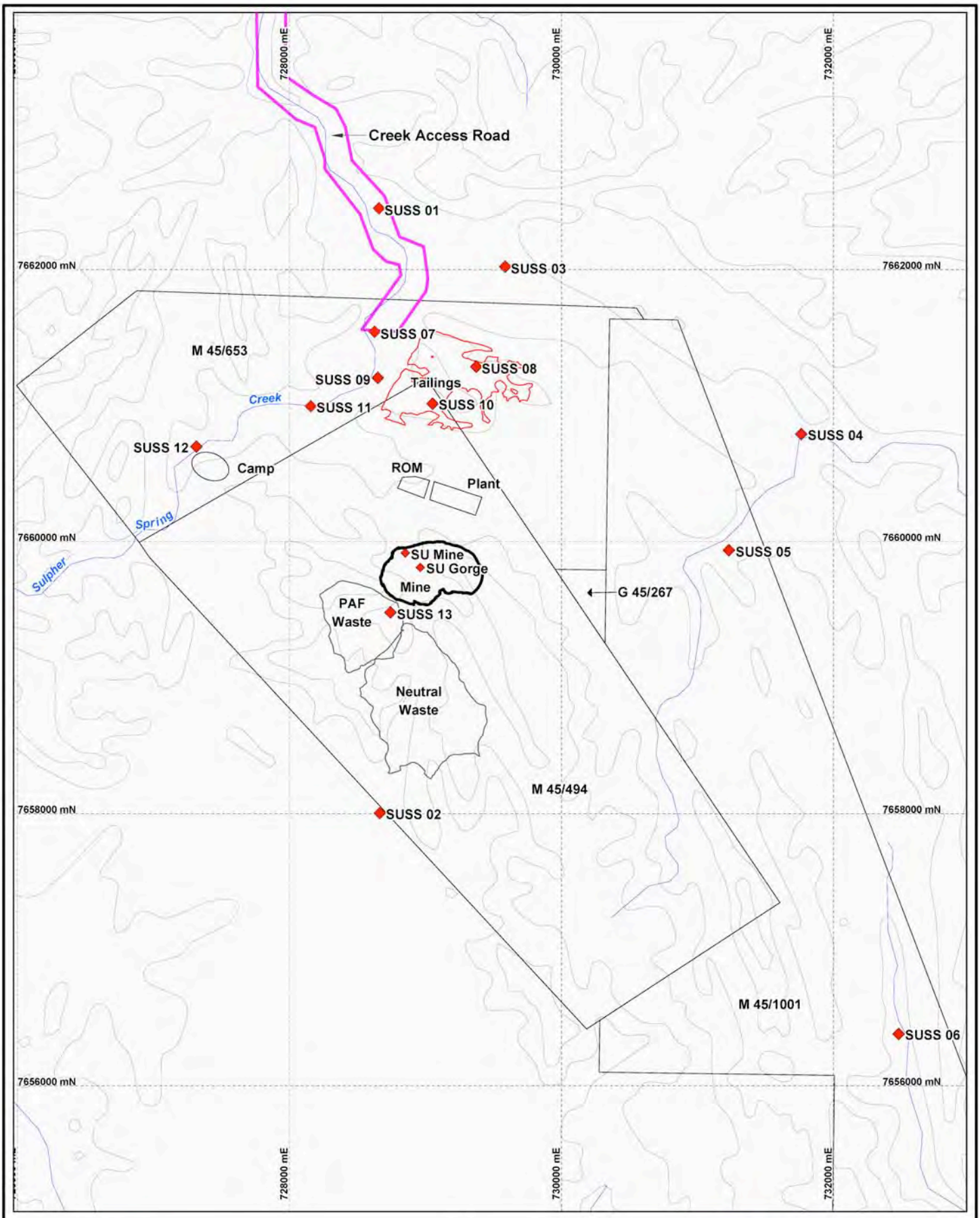
Job No.: 370	WS No.:
Projection: GDA94	Scale: 1 : 250,000



Location Map

Map Area

PERTH

KALGOORLIE

Legend

Level 2 Assessment

Search sites

N W E S

0 500 1,000

metres

Note: Contour interval 50m

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Fig 3.4 Panorama Project - Endemics

Author: P Runham	Date: 31/01/2007
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Projection: GDA94	Scale: 1 : 35,000

0.75µl MgCl2 (50mM), 2.5µl 10 x Taq buffer, 2.5µl dNTPs (2mM), 0.2µl Taq polymerase, 6.05µl dH20 and 3µl of DNA template.

Table 3.6: Locations of non-systematic searches for targeted invertebrate fauna at the Panorama study site.

Site	Location (UTM, zone 50, WGS84)	Target Taxa
SUSS 01	728658 mE; 7662451 mN	Pulmonata
SUSS 02	728664 mE; 7658004 mN	Pulmonata / Pseudoscorpionida
SUSS 03	729586 mE; 7662022 mN	Pulmonata / Pseudoscorpionida
SUSS 04	731762 mE; 7660791 mN	Pulmonata / Pseudoscorpionida
SUSS 05	731231 mE; 7659937 mN	Pulmonata
SUSS 06	732479 mE; 7656381 mN	Pulmonata
SUSS 07	728626 mE; 7661543 mN	Pulmonata / Pseudoscorpionida
SUSS 08	729373 mE; 7661286 mN	Pulmonata
SUSS 09	728650 mE; 7661204 mN	Pulmonata / Pseudoscorpionida
SUSS 10	729052 mE; 7661014 mN	Pulmonata / Pseudoscorpionida
SUSS 11	728157 mE; 7660995 mN	Pulmonata / Pseudoscorpionida
SUSS 12	727316 mE; 7660699 mN	Pulmonata / Pseudoscorpionida
SUSS 13	728742 mE; 7659480 mN	Pulmonata
SUS Mine	728851 mE; 7659917 mN	Pseudoscorpionida
SUS Valley	728962 mE; 7659811 mN	Pseudoscorpionida
SPEC 01	739514 mE; 7677880 mN	Pseudoscorpionida
SPEC 04	739904 mE; 7692919 mN	Pseudoscorpionida
SUMU 01	741682 mE; 7701908 mN	Pseudoscorpionida

Methodology of PCR has been detailed in previous reports (see Biota 2006a, 2006b, 2006c and 2006d).

Table 3.7: Primers used in this study.

Primer	Gene	Sequence (5' – 3')	Reference
COI L	CO1	GGTCAACAAATCATAAAGATATTGG	Folmer et al. 1994
COI H	CO1	TAAACTTCAGGGTGACCAAAAAATCA	Folmer et al. 1994

3.4.4.3 DNA Sequencing

PCR products were sequenced using the ABI BigDye chemistry by the Macrogen Inc. facility.

3.4.4.4 Sequence Editing and Analysis

Sequences were checked and edited and chromatograms were visualised using Sequencher software (GENECODES). Sequences were then aligned using ClustalW, and gaps were adjusted by eye.

Phylogenetic and molecular evolutionary analyses were conducted using MEGA version 3.1 (Kumar et al. 2004). Analyses were conducted on the Burrup *Rhagada* COI sequences, and then on all *Rhagada* COI sequences to date in order to make comparisons between species.

Kimura's 2-parameter model of genetic distance was used to generate a distance matrix in MEGA version 3.1 (Kumar et al. 2004). Kimura's model of genetic distance (Kimura 1980) accounts for the difference in the ratio of transitions to transversions. A transition is the substitution of a purine for another purine or the substitution of a pyrimidine for another pyrimidine. Transversions are all other types of nucleotide substitutions. In most DNA segments, transitional nucleotide substitutions are known to occur more frequently than transversions (Forstner et al. 1995; Nei and Kumar 2000).

A Neighbour joining tree was constructed using all individuals in MEGA version 3.1 (Kumar et al. 2004). A Bootstrap routine with 100 pseudoreplicates was performed to determine the internal support for the individual nodes.

3.5 Limitations of this Study

The survey incorporated only a single survey phase and, whilst the Level 2 study area was small and fauna sampling incorporated a substantial range of the available habitats, it is possible that a seasonal phase may yield additional fauna taxa.

Sampling for bats was carried out using harp traps, as this method provides voucher specimens that can be definitively identified, which is not always possible using alternative methods such as recording echolocation calls. However, harp-traps limit sampling to specific roost sites or flyways, and do not exhaustively sample all bat species, such as high flying taxa, that may be present.

The Level 1 survey of the Plains Access road targeted vertebrate taxa of elevated conservation significance (see Section 3.4.1), many of which are typically uncommon and highly mobile. Their presence in the study area was recorded predominantly from traces such as scats, tracks and diggings, which may only be apparent for short periods of time and difficult to detect where the substrate is hard or stony. Sampling of these fauna taxa is consequently usually restricted to areas where traces may be readily observed.

4.0 Results

4.1 Level 1 Survey of the Plains Access Road

The primary focus of this survey was to identify any attributes (species, communities or habitats) of elevated conservation value along the Plains Access Road (as delineated in Figure 3.1). In particular, the survey focussed on searching for the Spectacled Hare Wallaby *Lagorchestes conspicillatus* and Bilby *Macrotis lagotis* in accordance with a specific request from the Karratha branch of the DEC (see Section 3.4.1).

The survey yielded a single Schedule taxon, the Mulgara *Dasycercus cristicauda,* as well as four Priority listed taxa comprising the Spectacled Hare Wallaby *Lagorchestes conspicillatus*, Ghost Bat *Macroderma gigas*, Australian Bustard *Ardeotis australis* and Bush Stone-curlew *Burhinus grallarius*. In addition, the Plains Access Road passes within 100 m of a known roost for the Orange Leaf-nosed Bat *Rhinonicteris aurantius,* and although not recorded during the current study, this species is considered in discussions below.

The survey also recorded invertebrate taxa from groups known to (or with the potential to) support SRE taxa.

4.1.1 Fauna Habitats

Two primary habitat types were identified along the Plains Access Road on the basis of the predominant substrate type. Numerous small creek lines traverse the plain, which is adjacent to the Shaw River, but these did not represent significantly different faunal habitats. Vegetation assemblages also varied throughout the length of the study area (Trudgen 2006) but at too fine a level to result in recognisably different faunal habitats.

The initial 25 km of the Plains Access Road (from the Marble Bar Road) intersects the Uaroo Land System, and predominantly the "sandy/loamy plains" land unit of this Land System. This land unit corresponds with the *Acacia stellaticeps* and *A. inaequilatera* scattered shrubs to open shrubland and scattered low *Corymbia* spp over *Triodia* spp. hummock grassland vegetation alliances of Trudgen (2006). Several areas along the Plains Access Road showed evidence of fire scarring, resulting in a range of *Triodia* hummock grassland habitats, from those with small, scattered hummocks to those with dense grasslands of large hummocks.

The final 16 km portion of the Plains Access Road aligned in a north-south orientation intersects the "sandy plains" land unit of the Macroy Land System. This corresponds to the various vegetation types comprising shrublands of *Acacia* spp. over hummock grasslands of *Triodia* spp. as defined by Trudgen (2006).

The portion of the Plains Access Road oriented east-west intersects three land systems: Satirist, Rocklea and Boolgeeda. All of these contain land units comprising red, loamy earths with pebbled to stony mantles, which are vegetated with *Triodia* spp. hummock grasslands and scattered *Acacia* spp. as detailed by Trudgen (2006).

There are no Threatened Ecological Communities along the Plains Access Road nor are there any Communities at Risk as defined by Kendrick and McKenzie (2001).

4.1.2 Schedule Fauna

The survey recorded one Schedule 1 listed species, the Mulgara *Dasycercus cristicauda*. This species was recorded from its characteristic diggings, burrows, scats and tracks near the commencement of the Plains Access Road where it intersects with the Marble Bar Road (Table 4.1; Figure 4.1). Mulgaras have previously been recorded from a number of locations along the Marble Bar Road (Roy Teale, pers. obs.) and across the eastern Pilbara in general. A more

detailed account of this species, its broader distribution and current conservation status is provided in Section 5.2.2.

Habitat suitable for the Bilby was present along parts of the first 25 km of the Plains Access Road, however no evidence of this species was located. The Bilby is known from the general vicinity, with records from Nimingarra and Abydos-Woodstock (see Section 5.2.5).

The Plains Access Road intersects habitat suitable for a further two Schedule listed species, the Woma Python and Peregrine Falcon (see Sections 5.2.6 and 5.2.7), though neither was recorded during the current survey.

The Plains Access Road also passes within 100 m of the abandoned Lalla Rookh mine, which is a known roost for the Schedule 1 Orange Leaf-nosed Bat *Rhinonicteris aurantius* (see Section 5.2.3). This species was recorded from the Valley Access Road and may fly between the two locations. This species is known to be susceptible to collision with vehicles (Churchill 1994), as it tends to forage low over the ground.

4.1.3 Priority Fauna

Four Priority listed fauna were recorded from along the Plains Access Road including the Spectacled Hare Wallaby *Lagorchestes conspicillatus*, Ghost Bat *Macroderma gigas*, Australian Bustard *Ardeotis australis* and Bush Stone-curlew *Burhinus grallarius*(Table 4.1 and Figure 4.1). Each of these species is discussed in greater detail in Section 5.2.

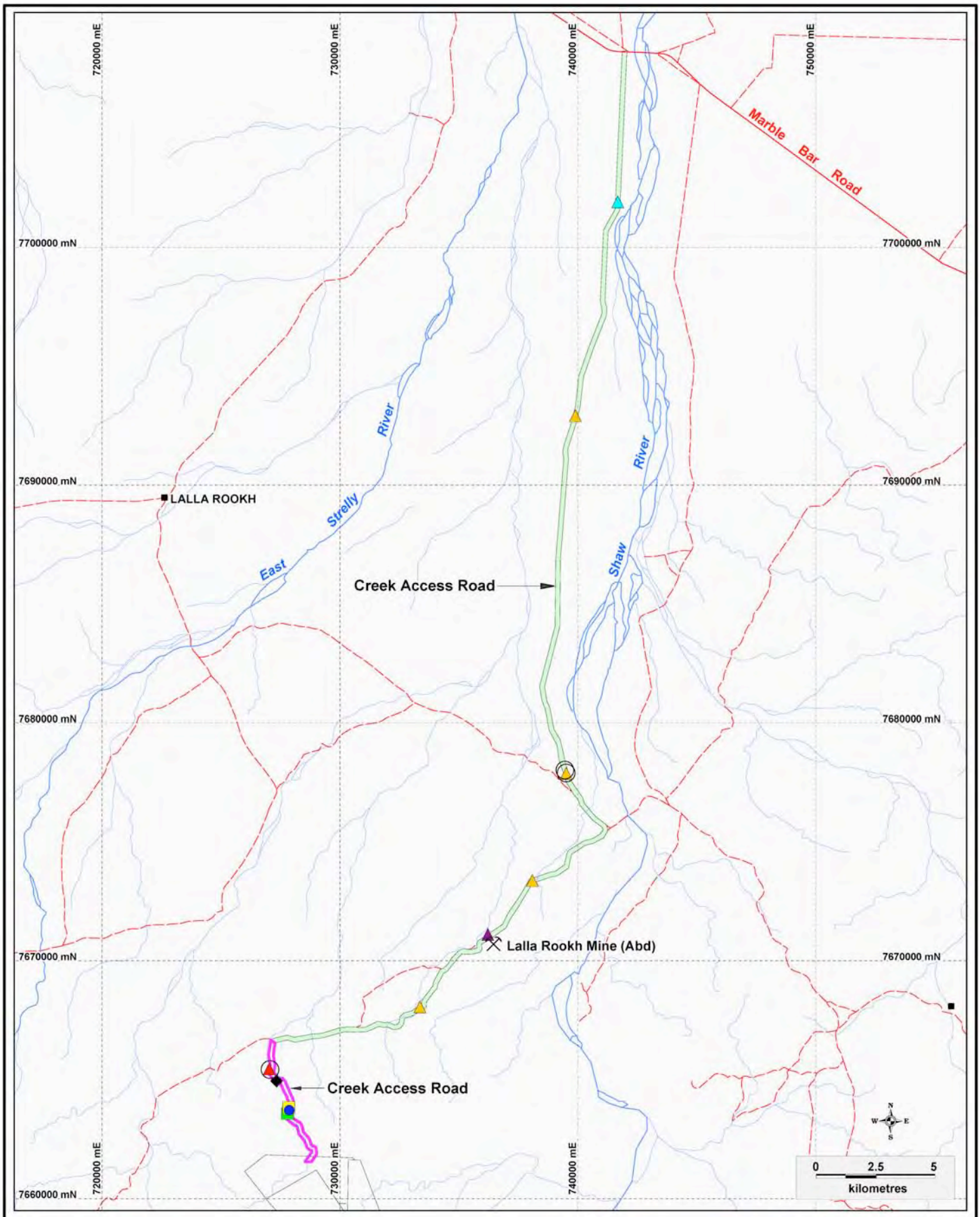
A single sighting of the Spectacled Hare Wallaby was made along the Plains Access Road at 739514mE, 7677880mN on the 31/8/2006. Tracks were subsequently located at four separate locations, including that at which the sighting was made (Table 4.1). In addition, Malcolm Trudgen provided a description of a small macropod that was most probably this species, which was recorded from 737162 mE, 7672416 mN and 739289 mE, 7690704mN in 2002 (Malcolm Trudgen, ME Trudgen and Associates, pers comm. 2006). The species was known from the area between Wodgina Mine and Pilgangoora Mine (Dr Peter Kendrick, DEC Karratha, pers. comm. 2006).

Numerous Ghost Bats were seen flying above the track during the night-time traverses, particularly adjacent to the Lalla Rookh mine, which is a known roost for this species.
Three sightings of two Australian Bustards were made on three separate days from the Plains Haul Road (Table 4.1), and may have represented the same individuals.

Calls of the Bush Stone-curlew were heard from the camp-site on a number of evenings (Table 4.1).

Table 4.1: Schedule and Priority species recorded from the Plains Access Road.

Species	State Level	Record	Co-ordinates
Dasycercus cristicauda	Schedule 1	Numerous diggings	741682 mE, 7701908 mN
Lagorchestes conspicillatus	Priority 3	Single animal, and tracks Tracks Tracks Tracks	739514 mE, 7677880 mN 733366 mE, 7668060 mN 738091 mE, 7673377 mN 739904 mE, 7692919 mN
Macroderma gigas	Priority 4	Numerous observations	Vicinity of Lalla Rookh Mine
Ardeotis australis	Priority 4	2 individuals 2 individuals 2 individuals	739514 mE, 7677880 mN 739458 mE, 7678003 mN 727063 mE, 7665410 mN
Burhinus grallarius	Priority 4	Calls	727026mE, 7665461mN



Location Map

Legend

- *Dasycercus cristicauda*
- *Lagorchestes conspicillatus*
- *Macroderma gigas*
- *Ardeotis australis*
- *Burhinus grallarius*
- *Dasyurus hallucatus*
- *Rhinonicteris aurantius*
- *Sminthopsis longicaudata*
- *Pseudomys chapmani*
- Level 1 Assessment
- Level 2 Assessment

BIOTA Biota Environmental Sciences

Fig 4.1 Panorama Project - Threatened Species

Author: P Runham	Date: 05/01/2007
Drawn: P Sawers	Revised:
Job No.: 370	WS No.:
Projection: GDA94	Scale: 1 : 200,000

4.1.4 Short Range Endemic Taxa

4.1.4.1 Land Snails

Numerous *Rhagada* shells were noted at 739514mE, 7677880mN (see Table 4.2), however despite targeted searches at a number of locations (see Table 3.6), no live individuals were collected from the Plains Access Road (nor from the Valley Access Road).

4.1.4.2 Pseudoscorpions

Pseudoscorpions were collected from three locations along the Plains Access Road (Table 4.2): all specimens have been lodged with Dr Mark Harvey of the WA Museum.

Table 4.2: Locations from which land snails and pseudoscorpions were collected from along the Plains Access Road.

Site	Land Snails	Pseudoscorpions			
	Rhagada	Olpiidae	Chernetidae	Garypidae	Other Pseudoscorpions
SPEC 01	Shells only		*Haplochernes* sp.	*Synsphyronus* sp	?Genera
SPEC 04			*Haplochernes* sp.		
SUMU 01		?Genera		*Synsphyronus* sp	

4.2 Level 2 Survey of the Valley Access Road

4.2.1 Fauna Habitats

The Valley Access Road study area contained two primary fauna habitats associated with the two land units found in the Capricorn Land System:

- a narrowly incised valley with exposed bedrock floor and sandy alluvial banks supporting moderately dense to dense *Eucalyptus* spp., *Melaleuca* and tall mixed shrubland over *Triodia* and sedges along the central portion of the Valley Access Road. At the time of the current survey, this section of the Valley Access Road was also characterised by numerous small to medium sized pools of standing or slowly running water associated with an ephemeral stream; and
- the "ridges, hills and upper slopes" land unit with cobbled and stony substrates (with some bedrock exposures), vegetated primarily with *Triodia* hummock grasslands and scattered *Corymbia hamersleyana* (Trudgen 2006), formed a broad valley floor at the northern and southern extremities of the valley.
- the "stony plains" land unit with cobbled and stony mantles over shallow red loamy substrates, vegetated primarily with *Triodia* hummock grasslands and scattered *Acacia* (Trudgen 2006), formed a broad valley floor at the northern and southern extremities of the valley.

4.2.2 The Assemblage

The Level 2 terrestrial fauna survey of the Valley Access Road study area yielded a total of 73 vertebrate species, as summarised in Table 4.3.

Table 4.3: Vertebrate fauna species recorded from the Valley Access Road in the Panorama study area.

Fauna Group	Number of Species
Avifauna	41
Native Mammals	8
Introduced Mammals	2
Bats	2
Reptiles	18
Frogs	2
Total	73

4.2.3 Avifauna

4.2.3.1 The Assemblage

Censuses of the Valley Access Road study area, in combination with opportunistic records, yielded a total of 41 avifauna species (see Table 4.4). The total comprised 19 species of non-passerines and 22 species of passerines, from 21 families.

Eight species were noticeably more abundant than the remainder, with the Budgerigar *Melopsittacus undulatus* (129 records), Painted Finch *Emblema pictum* (103 records), Brown Honeyeater *Lichmera indistincta* (98 records), Diamond Dove *Geopelia cuneata* (93 records), Zebra Finch *Taeniopygia guttata* (92 records), Grey-headed Honeyeater *Lichenostomus keartlandi* (89 records), Masked Woodswallow *Artamus personatus* (80 records) and White-plumed Honeyeater (63 records) comprising 72.52% of the total of 1,030 individuals recorded.

The Meliphagidae was the most speciose and abundant family, with six species yielding 292 records or 28.35% of the total. Despite being represented by only two species, the Passeridae were also abundant, with 195 records providing 18.93% of the total individuals recorded. The Columbidae family was also relatively speciose, with four species being documented.

4.2.3.2 Discussion

The 41 avifauna species recorded during the current Level 2 survey represents a subset of the 80 species recorded for the entire Panorama study site by Bamford and Wilcox (2001) and also of the 104 taxa documented for the Abydos-Woodstock Reserve to the west (WA Museum 1991). Nonetheless, the assemblage is typical for creekline / valley habitat in the Pilbara bioregion of Western Australia, with additional records reflecting the predominantly *Triodia* vegetated northern and southern extremities of the Valley Access Road.

The lower yield by the current survey is due primarily to the restricted number of habitats associated with the small study site encompassed by the valley, as well as a lesser number of survey periods. The original survey (Bamford and Wilcox 2001) incorporated five sites, each censused over two seasons and distributed over habitats incorporating rocky hills, gorges, creeklines and plains vegetated with *Triodia*, *Grevillea* and other shrubs. Whilst the Abydos-Woodstock survey area was dominated by undulating *Triodia* vegetated plains, it also contained creekline eucalypt habitat, and was surveyed a total of nine times over three years.

Although these factors explain the majority of the differences between the avifauna inventories, other differences may be the result of the biology of the species. The single survey conducted for this report included very few of the water birds recorded by Bamford and Wilcox (2001) at Honeyeater Creek and Strelley Pool, presumably because of the lack of significant permanent water bodies in the current study area. Of further relevance is the relatively large proportion of avifauna species (67.5%) recorded opportunistically by Bamford and Wilcox (2001). These species typically comprise infrequent visitors or species that occur in low numbers. Censuses during the present survey yielded 63.5% of the total avifauna taxa recorded, and it is likely that further survey stages would result in a greater number of opportunistic records for species comprising the birds of prey, rarely or uncommonly documented species such as the Striated Grasswren and Western Gerygone, and transient taxa.

4.2.3.3 Breeding Records

Breeding records from the Valley Access Road were obtained for three species:

- a nesting burrow of the Rainbow Bee-eater *Merops ornatus* was recorded near a fauna-trapping grid (SUS 02);
- Budgerigars were observed tending nestlings throughout the valley area; and
- a single young White-plumed Honeyeater was observed being fed by adults.

Table 4.4: Avifauna recorded from the Valley Access Road area of the Panorama study site.

Family Name	Species Name	Common Name	Number of Individuals
Ardeidae	*Ardea novaehollandiae*	White-faced Heron	2
	Nycticorax caledonicus	Rufous Night Heron	1
Accipitridae	*Accipiter fasciatus*	Brown Goshawk	1
	Aquila audax	Wedge-tailed Eagle	2
Falconidae	*Falco berigora*	Brown Falcon	1
Columbidae	*Phaps chalcoptera*	Common Bronzewing	2
	Ocyphaps lophotes	Crested Pigeon	4
	Geophaps plumifera	Spinifex Pigeon	34
	Geopelia cuneata	Diamond Dove	93
Psittacidae	*Cacatua roseicapilla*	Galah	1
	Nymphicus hollandicus	Cockatiel	2
	Melopsittacus undulatus	Budgerigar	129
Cuculidae	*Cuculus pallidus*	Pallid Cuckoo	2
	Chrysococcyx basalis	Horsfield's Bronze Cuckoo	3
Centropodidae	*Centropus phasianinus highami*	Pheasant Coucal	9
Podargidae	*Podargus strigoides*	Tawny Frogmouth	1
Halcyonidae	*Dacelo leachii*	Blue-winged Kookaburra	1
	Todiramphus pyrrhopygia	Red-backed Kingfisher	4
Meropidae	*Merops ornatus*	Rainbow Bee-eater	5
Maluridae	*Malurus lamberti*	Variegated Fairy-wren	22
Pardalotidae	*Pardalotus rubricatus*	Red-browed Pardalote	3
Meliphagidae	*Lichmera indistincta*	Brown Honeyeater	98
	Lichenostomus virescens	Singing Honeyeater	3
	Lichenostomus keartlandi	Grey-headed Honeyeater	89
	Lichenostomus penicillatus	White-plumed Honeyeater	63
	Melithreptus gularis	Black-chinned Honeyeater	21
	Manorina flavigula	Yellow-throated Miner	18
Pachycephalidae	*Colluricincla harmonica*	Grey Shrike-thrush	23
Dicruridae	*Rhipidura leucophrys*	Willie Wagtail	15
	Grallina cyanoleuca	Magpie-lark	28
Campephagidae	*Coracina novaehollandiae*	Black-faced Cuckoo-shrike	28
	Lalage tricolor	White-winged Triller	30
Artamidae	*Artamus personatus*	Masked Woodswallow	80
	Artamus cinereus	Black-faced Woodswallow	2
	Artamus minor	Little Woodswallow	1
Cracticidae	*Cracticus nigrogularis*	Pied Butcherbird	3
	Cracticus tibicen	Australian Magpie	1
Corvidae	*Corvus orru*	Torresian Crow	2
Ptilonorhynchidae	*Ptilonorhynchus maculatus*	Western Bowerbird	8
Passeridae	*Taeniopygia guttata*	Zebra Finch	92
	Emblema pictum	Painted Finch	103
		Total Individuals	1,030
		Total Species	41

4.2.3.4 Regional Endemism and Restricted Taxa

One taxon, the Pheasant Coucal *Centropus phasianinus highami,* considered to be endemic to the Pilbara was recorded. This species was once considered moderately common, but has become uncommon (Johnstone and Storr 1998). Occurring singly or in pairs, it inhabits rank herbage and thickets along major watercourses, long grasses and rushes between the De Grey and Ashburton rivers, and occurs up to a couple of hundred kilometres inland along the Pilbara coast.

Two additional taxa considered endemic or near-endemic to the Pilbara bioregion were not recorded, but may occur in the study area:

- The endemic Striated Grasswren *Amytornis striatus whitei* is widespread and common in the bioregion in suitable habitat, which usually consists of *Triodia* growing on scree slopes, mesa tops and, particularly, the edges of hilltops (Johnstone and Storr 2004). It appears to favour areas where there are some patches of bare, exposed rocks, and occurs primarily on banded ironstone (Roy Teale, pers. obs.); and

- The near endemic Black-tailed Treecreeper *Climacteris melanura wellsi* typically occurs in eucalypt woodland, either along minor watercourses or in more open woodlands on scree slopes and mesa tops.

4.2.3.5 Avifauna Of Conservation Significance

No avifauna species of conservation significance were recorded during the present study of the Valley Access Road.

4.2.4 Non-volant Mammals

4.2.4.1 The Assemblage

The survey of the Valley Access Road at Panorama yielded 10 non-volant mammal species, of which eight are native and two are introduced (Table 4.5). The native species included three carnivorous marsupials (Dasyuridae), one kangaroo (Macropodidae) and four native rodents (Muridae). The introduced taxa comprised one species each from the Bovidae (Cattle) and Muridae (rodents). Two bat species were also recorded (see Section 4.2.5).

The most abundant species recorded was the Common Rock Rat *Zyzomys argurus*, with 26 individuals providing 31 capture records. Two further species, the house mouse *Mus musculus* and the Sandy Inland Mouse *Pseudomys hermannsburgensis* represented in excess of 10% of all mammal records.

The most speciose group was the Muridae (rodents), which comprised half of the ten species recorded. The Dasyuridae (carnivorous marsupials) also yielded three species while the remaining families, the Macropodidae (kangaroos) and the Bovidae (cattle) were represented by a single species each.

4.2.4.2 Discussion

The current survey of the Valley Access Road yielded relatively few species (when compared with broad regional surveys), however, the survey did add to the tally of species recorded from the valley by Bamford and Wilcox (1991). The relatively low number of species can be attributable to a significantly reduced diversity of habitats. As an example, there is no suitable habitat for species such as *Notomys alexis* and *P. delicatulus*, both of which inhabit sandy to loamy substrates often vegetated with *Triodia*. Additionally, although mammalian taxa including *Pseudantechinus roryi* would be expected to occur in habitats such as those found along the Valley Access Road, these species are typically recorded only infrequently.

4.2.4.3 Breeding Records

A single breeding record was obtained, of a female Northern Quoll *Dasyurus hallucatus* carrying pouch young.

4.2.4.4 Regional Endemism and Restricted Taxa

No species endemic to the Pilbara bioregion were recorded, however *Ningaui timealeyi* is considered a “near endemic”. It is widespread and common across a range of substrate types vegetated with *Triodia* spp. including *T. angusta*, *T. basedowii*, *T. brizoides*, *T. epactia*, *T. lanigera*, *T. longiceps*, *T. pungens* and *T. wiseana* (source: Biota database). Also recorded was *Pseudomys chapmani*, from the presence of mounds and a single specimen trapped at SuS01. This species occurs across much of the eastern and central Pilbara bioregion and is largely confined to this bioregion.

Other regional endemics or near endemics that may occur in the project area but were not recorded during the current survey include *Dasykaluta rosamondae*, *Planigale* sp. 'T', *Planigale* sp. 'K' and *Petrogale rothschildi*.

4.2.4.5 Non-volant Mammals of Conservation Significance

Two species of conservation significance were recorded during this component of the survey. The Northern Quoll *Dasyurus hallucatus*, was caught in an Elliott trap along the valley wall in the Valley Access Road study area (see Section 5.2.1). This recorded supplements the captures made by Bamford and Wilcox (1991). A single individual of the Pebble-mound Mouse *Pseudomys chapmani* was trapped at SuS 01 and an active mound was found at the same site.

4.2.5 Bats

Two species of bats were recorded during the current survey of the Valley Access Road: *Rhinonicteris aurantius* (Hipposideridae) and *Scotorepens greyii* (Vespertilionidae) (Table 4.6). *R. aurantius* is a Schedule 1 fauna species (see Section 5.2.3).

The relatively low yield of the current survey is probably a result of sampling exclusively with harp traps. While this method typically will not sample all species in a given area, it is specific to those species which fly at relatively low heights and might therefore be impacted by vehicular traffic associated with the proposed haul road. Moreover, it eliminates issues of tentative identification of calls using electronic equipment, and permits the collection of material necessary for resolving current taxonomic uncertainties of various bat taxa.

4.2.5.1 Bats of Conservation Significance

A single bat species *Rhinonicteris aurantius* of conservation significance was recorded from the Valley Access Road.

4.2.6 Herpetofauna

4.2.6.1 The Assemblage

Twenty herpetofauna species, representing eight families, were recorded during the Level 2 survey of the Valley Access Road (Table 4.7). The total included two frogs (Hylidae and Myobatrachidae), one dragon (Agamidae), one front-fanged snake (Elapidae), five geckos (Gekkonidae), one legless lizard (Pygopodidae), eight skinks (Scincidae), and two monitors (Varanidae).

None of the herpetofauna species documented during the survey were particularly abundant. The most common was the Tree Dtella *Gehyra variegata*, with eight records comprising 16.3% of all records. The skink *Lerista muelleri* and dragon *Ctenophorus caudicinctus* were also relatively common with seven (14.3%) and six (12.2%) records respectively.

The most speciose family was the Scincidae, with eight species comprising 40% of the total species number, although the geckoes also yielded five species (25% of the tally). Amongst the remaining families, only the varanids (with 10% of the species captured) were represented by more than one species.

4.2.6.2 Discussion

A relatively small number of species was recorded from the survey area, reflecting the scale of the project area and limited array of available habitats. The assemblage is a typical sub-set of that recorded from other survey sites in the Pilbara (with the notable exception of *V. snelli*), and is typical of creekline / gorge habitats.

Table 4.5: Non-volant mammal species recorded from the Valley Access Road at Panorama.

Family *Species*	SuS 01	SuS 02	SuS 03	SuS 04	SuE 01	SuE 02	SuE 03	SuCage 01	Opport. Valley Access Road	Total Individuals
Dasyuridae										
Dasyurus hallucatus							1			1
Ningaui timealeyi				1						1
Sminthopsis macroura		1								1
Macropodidae										
Macropus robustus									2	2
Muridae										
Mus musculus		2	4	1						7
Pseudomys chapmani	2(1)*									2(1)*
Pseudomys desertor			1							1
Pseudomys hermannsburgensis	2	2	5							9
Zyzomys argurus					4	25	2			31[#]
Bovidae										
Bos taurus									2(2)*	2(2)*

*Numbers in parentheses indicate the number of records from traces such as tracks, scats or burrows.

[#] Total individuals includes six recaptures.

Number of Individuals	57
Number of Species	10

Table 4.6: Bat species caught during the Level 2 survey of the Valley Access Road at Panorama.

Species (Family)	SUHARP 01	SUHARP 02	SUHARP 04	SUHARP 06	Total
Rhinonicteris aurantius (Hipposideridae)	3	2	4		9
Scotorepens greyii (Vespertilionidae)			1	1	2

The Western Australian Museum survey of the Abydos-Woodstock Reserve (WA Museum 1991) yielded a total of 73 herpetofauna species, whilst the earlier study of the Panorama site (Bamford and Wilcox 2001) yielded 31 species. Whilst the larger species numbers recorded during these surveys can in part be attributed to the greater trapping effort and larger study areas, the most significant factor likely to account for lower species numbers recorded during the current survey is the habitat types available.

The Abydos-Woodstock Reserve survey area incorporated large expanses of sandy-loam soils vegetated with *Triodia*, a combination known to support rich herpetofauna assemblages and which was absent in the Valley Access Road study area. Whilst this system at Abydos-Woodstock was juxtaposed with isolated rockpiles and braided drainage lines, the study site at Panorama presented only the last of these habitats. Hence, the species inventories compiled by both the earlier survey of Bamford and Wilcox (2001) and the current work would be expected to be considerably less rich than those of the WA Museum (1991).

4.2.6.3 Breeding Records

No breeding records were recorded for herpetofauna during the Level 2 survey of the Valley Access Road.

4.2.6.4 Regional Endemism and Restricted Taxa

Four species recorded during the current survey are considered to be endemic or near endemic to the Pilbara bioregion:

- the endemic elapid snake *Vermicella snelli* is also of interest as it is rarely recorded and represented by less than 20 specimens in the State collection;
- the geckos *Diplodactylus savagei* and *D. wombeyi* are considered endemic; and
- the skink *Morethia ruficauda exquisita* is considered a near endemic.

In addition, there are a number of other species endemic, or nearly endemic, to the Pilbara that may occur in the Valley Access Road study area on the basis of available habitat, including:

- the elapid *Acanthophis wellsi*;
- the gecko *Nephrurus wheeleri cinctus;*
- the pygopod *Delma elegans*; and
- the skinks *Ctenotus rubicundus*, *C. rutilans* and *C. nigrilineatus*.

4.2.6.5 Unresolved Species Complexes

Several of the taxa either recorded from, or potentially occurring within the project area, are thought to belong to species complexes. Distribution and conservation significance of putative taxa within these complexes is difficult to ascertain. Examples of taxa thought to represent complexes of species include:

- The *Diplodactylus stenodactylus* species complex is currently under review, with possibly six new species occurring in the Pilbara bioregion (Mr. Laurie Smith, WA Museum, pers. comm. 2004). The conservation status of those specimens recorded by Biota during the Panorama survey is uncertain.
- *Diplodactylus savagei* recorded during the survey also has a range of morphologies within its distribution and may represent a species complex.
- Many of the taxa within the genus *Gehyra* are undoubtedly species complexes.
- *Lerista muelleri* is known to comprise a number of distinct taxa.

4.2.6.6 Species of Conservation Significance

No species of conservation significance were recorded, though habitat within the Valley Access Road study area is suitable for the Pilbara Olive Python *Liasis olivaceus barroni*, which is included

on Schedule 1 of the *Wildlife Conservation (Specially Protected Fauna) Notice 2006(2)* (see Section 5.2.4).

Table 4.7: Herpetofauna recorded from along the Valley Access Road at Panorama.

Family *Species Name*	SUS 01	SUS 02	SUS 03	SUS 04	SUE 01	SUE 03	Total Number
Hylidae							
Litoria rubella			2				2
Myobatrachidae							
Uperoleia russelli			4				4
Agamidae							
Ctenophorus caudicinctus caudicinctus	6						6
Elapidae							
Vermicella snelli				1			1
Gekkonidae							
Diplodactylus savagei				1			1
Diplodactylus stenodactylus		3					3
Diplodactylus wombeyi	1						1
Gehyra variegata	2		6				8
Strophurus elderi				2			2
Pygopodidae							
Delma pax			1				1
Scincidae							
Carlia munda		1	2				3
Ctenotus duricola	1						1
Ctenotus saxatilis	1					1	2
Cyclodomorphus melanops melanops				1			1
Egernia formosa					1		1
Lerista muelleri			7				7
Morethia ruficauda exquisita			2				2
Notoscincus ornatus ornatus				1			1
Varanidae							
Varanus eremius		1					1
Varanus tristis tristis			1				1
						Total Individuals	49
						Total Species	20

4.2.7 Potential Short Range Endemic Taxa

Banded *Rhagada* shells were collected from SUS03 and appeared to be similar to those collected from the mine area (see Section 4.3.1). All shells were recovered from flood debris and it was not clear whether they had been washed downstream to that location, or whether they genuinely inhabit areas of suitable habitat with the valley. No live specimens were recorded. It is assumed that they represent the same taxon as those collected from the mine area and elsewhere in the vicinity (see Section 4.3.1).

Several barychelid mygalomorph spiders were recorded from dry pits at the main trapping sites including SUS02 (n=3), SUS03 (n=1) and SUS04 (n=2). All specimens appear to represent the one species.

4.3 Short Range Endemic Survey of the Mine Area

Taxonomic groups of invertebrates with naturally small distributions are described as Short Range Endemics (SREs) and are in part characterised by poor dispersal capabilities, confinement to disjunct habitats and low fecundity (Harvey 2002, Ponder and Colgan 2002). Given the

importance of short-range endemism to the conservation of biodiversity, the assessment of such invertebrate taxa is a potentially important component of this assessment.

Examples of taxonomic groups that show high levels of short-range endemism in this respect include mygalomorph spiders, millipedes, pseudoscorpions and freshwater and terrestrial molluscs.

All invertebrates with the exception of land snails have now been sorted to morphotype and lodged with the WA Museum. The land snails have been stored in an ultrafreezer at the University of Western Australia for molecular analyses.

4.3.1 *Rhagada* Land Snails

Live individuals from one morphotype of *Rhagada* (referred to as *Rhagada* sp. 'Sulphur Springs' throughout this report; see Plate 4.1) were collected from eight sampling locations (Figure 3.3 and Figure 3.4). A total of 67 live individuals were collected during the survey (Table 4.8).

Table 4.8: Number of live *Rhagada* sp. 'Sulphur Springs' collected during the survey.

Site	No. of Live Adults	No. of Live Sub-Adults	No. of Live Juveniles
SUSS01	10	1	5
SUSS02	0	1	0
SUSS03	1	0	1
SUSS04	10	1	5
SUSS05	0	0	2
SUSS06	12	2	2
SUSS07	5	0	2
SUSS08	5	0	2
	43	5	19

Plate 4.1: *Rhagada* sp. 'Sulphur Springs' (photo: Roy Teale).

4.3.1.1 Sequencing and Sequence Variation

In this study, 589 base pairs (bp) of the COI region of the mitochondrial genome were sequenced from 51 *Rhagada* individuals, including 26 individuals from eight sites from the Panorama study area (the remaining individuals came from additional sampling sites across the Pilbara, Souurce: Biota database). Overall, 31 haplotypes (unique mitochondrial sequences) were recovered from

the 51 individuals of *Rhagada* that were sequenced. These haplotypes contained 152 variable sites and 129 parsim-informative sites. No stop codons were observed within the protein coding COI gene, indicating that sequences did not derive from nuclear paralogues (insertions of mitochondrial DNA copies into the nuclear genome).

The Blastn search in GenBank of the *Rhagada* COI sequences from this study confirmed that the correct segment of mtDNA was amplified and sequenced. There were 180 blast hits on the sequence of the cytochrome oxidase subunit (COI) region of the mitochondrial genome. The most homologous sequence belonged to a clausiliid land snail, *Albinaria discolor discolor*, with 83% homology.

4.3.1.2 Phylogenetic Relationships

Sequence Divergence

Kimura's two-parameter genetic distances between all individuals of *Rhagada* indicated a relatively substantial range of genetic distances (discussed here as percent sequence divergence) (see Appendix 2). There was a total of 31 haplotypes from the 51 individuals of *Rhagada* sequenced. Within the Panorama survey area there were 13 haplotypes shared by 17 individuals. All other individuals (n=8) had unique haplotypes.

Of the 13 haplotypes identified within the Panorama survey area, one was shared by seven individuals across four sampling locations. Eight individuals of *Rhagada* from the survey area possessed unique haplotypes. Within populations of *Rhagada* from Panorama there was 0.0% - 4.3% sequence divergence between sampling locations/individuals of *Rhagada*.

Sequence divergence between *Rhagada* from Panorama and *Rhagada richardsonii* from Port Hedland ranged from 11.5% to 14.3%. Divergence within the Port Hedland *R. richardsonii* was between 0.8% and 2.3%. Sequence divergence within two other described species was 0.4% - 3.5% for *R. angulata* (from the Burrup Peninsula), and 0.0% - 7.2% for *R. convicta* (from a number of sites between Cossack and Munda Station).

Sequence divergence between the described *Rhagada* species ranged from:

- 19.7 to 22.3% for *R. angulata* and *R. convicta*;
- 19.1% to 23.5% for *R. angulata* and *R. richardsonii*; and
- 13.1% to 16.5% for *R. convicta* and *R. richardsonii*.

4.3.1.3 Evolutionary Relationships

There are two aspects of a phylogenetic tree that are of interest: the branching pattern and the length of the branches. In the case of the *Rhagada* studied here, the point of interest is whether haplotypes group according to a discernible geographic or spatial pattern (i.e. locality, drainage, valley etc.).

The horizontal branch length that separates each haplotype or group of haplotypes is also of interest for identifying biological entities with long-separate evolutionary histories; longer branches are an identification of greater genetic divergence, and therefore a longer time since individuals shared a common ancestor (Berry 2005). The scale bar at the bottom left of the tree provides a measure of this divergence.

The neighbour-joining tree (Figure 4.2) had strong internal support for the branches defining the major clades. High bootstrap values also supported the majority of the branches within each clade. The statistical support for these groupings is measured by bootstrap values, which are the numbers above or below internal branches in the tree. These represent the level of support for the adjacent "node" (ie. branching pattern to the right of the number). Bootstrap values greater than 75% are considered well supported (Hillis et al. 1996). Bootstrap support less than 50% is not considered reliable. Nodes on the tree without bootstrap values indicate that bootstrap support was less than 50%.

The neighbour-joining tree shows structuring within samples of *Rhagada* examined in this study. Most obvious are the distinct clades of *Rhagada angulata*, *R. convicta* and *R. richardsonii*, with extremely high support (100%, 79% and 100% respectively) (Figure 4.2). The remaining *Rhagada* individuals are grouped into the clade that represents the *Rhagada* sp. 'Sulphur Springs' morphotype (see Figure 4.2). Within the *Rhagada* sp. 'Sulphur Springs' clade haplotypes are shared across sampling locations suggesting that a single species is involved.

4.3.1.4 Rate of Divergence

By investigating the amount of sequence divergence between haplotypes it is also possible to estimate the time since divergence from a common ancestor. Estimating the divergence times allows processes to be inferred with comparison to historical and geological data. These times since divergence are estimated with the use of a molecular clock (Zamudio and Greene 1997). The controversial hypothesis of the molecular clock is a consequence of the neutral theory of evolution (Rodriguez-Robles and De Jesús-Escobar 1999). It holds that in any given DNA sequence, mutations accumulate at an approximately constant rate as long as the DNA sequence retains its original functions. The difference between the sequences of a DNA segment in two species could then be proportional to the time since the species diverged from a common ancestor (coalescence time). Estimation of divergence times remains problematic, largely due to heterogeneity in rates of sequence change among taxa over time, and because fossils provide only minimum dates (Rest et al. 2003). The mechanisms of DNA damage, and its repair, may also vary among different groups of organisms (Nei and Kumar 2000). The molecular clock hypothesis asserts that the rate of amino acid or nucleotide substitution is approximately constant over evolutionary time, although the actual number of substitutions is subject to stochastic errors (Rodriguez-Robles and De Jesús-Escobar 1999).

Rates of molecular evolution can vary between lineages and there is therefore no universal molecular clock (Bromham and Woolfit 2004). Studies of the rate of mitochondrial sequence divergence in snails (Murray et al. 1999, Collins et al. 1996) and in other invertebrates (Brown et al. 1979, Brower 1994, Trewick and Wallis 2001) suggest that pairwise divergence occurs at a rate of approximately 1.5 - 2.5% per million years.

This range of rates of mitochondrial divergence can be used to estimate a range of historic isolation times between populations of *Rhagada*. For example, the maximum sequence divergence level of 22.3% between the described species *Rhagada angulata* and *R. convicta* suggest that these species have been isolated from each other for 8.92 to 14.86 million years. On a smaller scale, when examining sequence divergence of *Rhagada convicta* between West Intercourse Island and the Burrup Peninsula (3.3%), the 'molecular clock' suggests that these populations have been isolated for 1.32 to 2.2 million years.

Estimating time since separation can in some cases be of great use when attributing these separations to major geographical features such as rises in sea level resulting in the creation of islands. However, there are also a number of competing explanations, such as the possibility of an accelerated rate of mitochondrial divergence. Rapid mitochondrial evolution has been found in other terrestrial snails (Chiba 1999, Ross 1999, Thacker and Hadfield 2000, Thomaz et al. 1996) and in at least one slug species (Pinceel et al. 2005) (see Thomaz et al. 1996 for further possible explanations). Resolution between competing explanations requires analysis of additional *Rhagada* samples and comparison to the known geographic history of the Pilbara.

4.3.1.5 Discussion

According to Solem (1997), the Panorama project area sits midway between the distributional boundaries of *Rhagada radleyi* and *R. richardsonii*. Given that no mainland species have been found in sympatry and that distribution represents a key 'attribute' in resolving species identity (see step 17 in the key to *Rhagada* species of Solem 1997), the taxonomic affinities of the Panorama specimens are difficult to resolve. The molecular work suggests that the specimens share a closer affinity with *R. ?radleyi* from Dawson Creek (Millstream) than to *R ?richardsonii* from Port Hedland or Oakover River.

Levels of sequence divergence between individuals of *Rhagada* from the survey area give no indication of the presence of more than one taxon. Sequence divergence within the morphotype *Rhagada* sp. 'Sulphur Springs' is between 0% and 4.3%, with no clear consistent phylogeographic pattern; instead it appears that there are a number of haplotypes shared between geographical separate sampling locations. However, unique haplotypes (haplotypes not shared by any other individuals) were found in individuals from sampling locations SUSS01, SUSS02, SUSS05, SUSS06, and SUSS07, none of which occur in the mine impact area.

The *Rhagada* were collected from point samples on drainage features and it is likely that snails would occur along the length of these drainages where suitable cover exists. Any permanent impact to the catchment of the various drainage lines may also impact on the long-term viability of snail populations downstream.

4.3.2 Pupillid Land Snails

Shells of the pupillid genus *Pupoides* were collected from beneath *Triodia* hummocks in a small drainage at SUSS04. It is likely that these dextral coiling shells belong to *P.* aff. *beltianus,* a species with an apparently wide distribution (Solem 1986).

4.3.3 Freshwater Snails

An unknown freshwater snail species was collected from SUSS06 and has been lodged with the WA Museum.

4.3.4 Pseudoscorpions

The current survey recorded five pseudoscorpion taxa including *Feaella* sp 'Sulphur Springs', a *Synsphyronus* sp., a Chernetidae (probably *Haplochernes* sp.), an olpiid (possibly more than one species) and one of uncertain affinities (awaiting review by Dr. Mark Harvey of the WA Museum) (Table 4.9).

Currently *Feaella* sp 'Sulphur Springs' has not been identified to species level, though it is likely to represent a new taxon. The specimens were collected from one location in the project area (SUSS11) and given that the Australian distribution of the genus was previously thought to be confined to the Kimberley region (Harvey 1989; Dr. Mark Harvey, WA Museum, pers. comm. 2006), the outlying population of *Feaella* sp 'Sulphur Springs' may well have a small distribution. Additional work would be required to establish the broader distribution of this taxon. Specimens were collected from beneath slate like rock on the south face of a low cliff adjacent to a narrowly incised ephemeral drainage line. Specimens may occur on the many gabbro rock piles across the study area.

The *Synsphyronus* sp. from the mine area (also collected from along the Plains Access Road) shares affinities with the *Synsphyronus paradoxus* species group, and similar specimens have been collected from a number of locations across the Pilbara (eg *S. heptatrichus* from Yandicoogina; Biota database). All specimens were collected from beneath flaking bark of *Corymbia* species, principally *C. hamersleyana*, where they were found in association with *Haplochernes* sp. (see below). As habitat supporting *C. hamersleyana* is widespread in the region and broadly contiguous, it is considered likely that the *Synsphyronus* also has a broader distribution.

The Chernetidae specimens collected from the survey area appear to belong to the genus *Haplochernes* (Dr. Mark Harvey, WA Museum, pers. comm. 2006). Specimens were again collected from beneath flaking bark of *Corymbia* species, principally *C. hamersleyana*. As discussed above for *Synsphyronus* sp., given that habitat supporting *C. hamersleyana* is widespread in the region and broadly contiguous, it is considered unlikely that the *Haplochernes* sp. has a restricted distribution.

The olpiids were collected from beneath rocks at three locations and may represent more than one taxon. Specimens from all three localities have been lodged with the WA Museum.

Table 4.9: Details of sites from which pseudoscorpions were collected during the Panorama survey.

Site	Feaellidae	Garypidae	Chernetidae	Olpiidae	Uncertain
SUSS 07		*Synsphyronus* sp.	*Haplochernes* sp.	? Genera	
SUSS 09		*Synsphyronus sp.*			
SUSS 10		*Synsphyronus* sp.			
SUSS 11	*Feaella* sp.			? Genera	
SUSS 12		*Synsphyronus sp.*			
SUSS 13		*Synsphyronus* sp.			
SUS Mine		*Synsphyronus* sp.			
SPEC 01		*Synsphyronus* sp.	*Haplochernes* sp.		Uncertain
SPEC 04			*Haplochernes* sp.		
SUMU 01		*Synsphyronus* sp.		? Genera	

4.3.4.1 Discussion

The presence or otherwise of restricted habitat types is particularly important in the context of assessing the potential for SRE invertebrate taxa. Of the pseudoscorpion species recorded, the genus *Synsphyronus* is known to support SRE taxa. The bark-inhabiting *Synsphyronus* collected from the study area occupies the same habitat as *S. heptatrichus* collected from Yandicoogina (Biota Database), which is also known from the Roper River in the Northern Territory (Dr. Mark Harvey, WA Museum, pers. comm. 2004). It is the rock-inhabiting species belonging to this genera that appear most restricted (Dr. Mark Harvey, WA Museum, pers. comm. 2004), particularly where rocky habitat is discontinuous (eg. granite outcrops in the Wheatbelt region).

Two other bark-inhabiting pseudoscorpion species were recorded from the study area. There is virtually no data on the extent of distribution of the bark-inhabiting pseudoscorpions in the Pilbara. Elsewhere in Australia a bark-inhabiting pseudoscorpion (*Synsphyronus paradoxus*) is known to have a distribution that coincides with the Murray-Darling catchment (Dr. Mark Harvey, WA. Museum, pers. comm. 2004). Discussions with Dr. Mark Harvey suggest that it is likewise plausible that the distribution of pseudoscorpions collected from the current project area may also have distributions confined to individual catchments, though a broader distribution is not implausible (eg. *Synsphyronus heptatrichus*). There is currently little information on the habitat preferences of the pseudoscorpion species collected during the survey, other than to say that specimens were collected from beneath bark and rocks.

Figure 4.2: Neighbour-joining tree for individuals of *Rhagada*.

5.0 Fauna Conservation Significance

5.1 Threatened Fauna Statutory Framework

Native fauna species that are rare, threatened with extinction, or have high conservation value are specially protected by law under the Western Australian *Wildlife Conservation Act 1950-1979*. In addition, many of these species are listed under the Federal *Environment Protection and Biodiversity Conservation (EPBC) Act 1999*.

5.1.1 *EPBC Act 1999*

Fauna species of national conservation significance are listed under the *EPBC Act 1999*, and may be classified as 'critically endangered', 'endangered', 'vulnerable' or 'conservation dependent' (consistent with IUCN categories (go to http://www.wcmc.org.uk/species/animals/categories.html for more information)). Migratory wader species are also protected under the *EPBC Act 1999*. The national List of Migratory Species consists of those species listed under the following International Conventions:

- Japan-Australia Migratory Bird Agreement (JAMBA);
- China-Australia Migratory Bird Agreement (CAMBA); and
- Convention on the Conservation of Migratory Species of Wild Animals (Bonn Convention).

A list of the species yielded using the DEH Protected Matters Search Tool (using coordinates 20° 48' 00'S; 119° 12' 03'E with a 50km buffer) are given in Appendix 3. From this list those species recorded by the current survey or considered likely to occur are shown in Table 5.1 and discussed in greater detail in Section 5.2.

5.1.2 *Wildlife Conservation Act 1950-1979*

Classification of rare and endangered fauna under the *Wildlife Conservation (Specially Protected Fauna) Notice 2006(2)* recognises four distinct schedules of taxa:

1. Schedule 1 taxa are fauna which are rare or likely to become extinct and are declared to be fauna in need of special protection;
2. Schedule 2 taxa are fauna which are presumed to be extinct and are declared to be fauna in need of special protection;
3. Schedule 3 taxa are birds which 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, which are declared to be fauna in need of special protection; and
4. Schedule 4 taxa are fauna that are in need of special protection, otherwise than for the reasons mentioned in paragraphs (1), (2) and (3).

In addition to the above, fauna are also classified under five different Priority codes:

Priority One — Taxa with few, poorly known populations on threatened lands.
Taxa which are known from a few specimens or sight records from one or a few localities on lands not managed for conservation. 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, or taxa with several, poorly known populations not on conservation lands.
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. 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.

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.
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. Taxa which are declining significantly but are not yet threatened.

Priority Five — Taxa in need of monitoring
Taxa which are not considered threatened but are subject to a specific conservation program, the cessation of which would result in the species becoming threatened within five years.

5.2 Threatened Fauna from the Panorama Study Area

Two Schedule 1 species, one Priority 3 species and four Priority 4 listed species were recorded from the Level 1 (Plains Access Road) and Level 2 (Valley Access Road) survey areas (Table 5.1 and Figure 4.1). While not listed for Western Australia, the Northern Quoll is Federally listed as "Endangered". A further four Schedule and two Priority listed species have either been recorded from or may occur in the region (as determined by a search of the DEC Rare Fauna Database). These Threatened fauna species are listed in Table 5.1 and discussed individually below.

5.2.1 Northern Quoll *Dasyurus hallucatus* ('Endangered')

Distribution: The Northern Quoll was originally recorded across northern Australia from the North-west Cape of Western Australia to south-east Queensland, but has declined in recent years. Its distribution is now restricted to six main areas: the north and western top end of the Northern Territory, north of Cape York, the Atherton-Cairns area, the Carnarvon Range-Bowen area of Queensland (Menkhorst and Knight 2001), and the northwest Kimberley and Pilbara regions of Western Australia (Braithwaite and Griffiths 1994). It also occurs on numerous islands off the Australian coast (Abbott and Burbidge 1995, Burbidge and McKenzie 1978).

The listing of the Northern Quoll as a threatened taxon by the Australian Government in 2004 was predicated on the dramatic decline of populations of the species across northern Australia associated with the spread of the Cane Toad. To date, the species remains widely distributed and relatively common throughout the Kimberley, although this is likely to change with the arrival of the Cane Toad in the next few years.

The Northern Quoll is also distributed widely through the Pilbara of Western Australia, based on specimen records held in the WA Museum, but the status of resident populations has not been studied in any detail. This observation is in contrast with The Action Plan for Australian Marsupials and Monotremes, which suggests that there has been a "....*substantial decline in the Pilbara....*" and cites Braithwaite and Griffiths (1994) as the source. This statement is paraphrased on the Department of Environment and Heritage (DEH) website for the Northern Quoll (go to http://www.deh.gov.au/biodiversity/threatened/species/dasyurushallucatus.html#conservation). However, Braithwaite and Griffiths (1994) make no statement about a decline in Pilbara populations specifically, other than to say "*Owl deposits reveal that it was formerly common throughout the Pilbara well into the arid zone"* and in turn cite Morton and Baynes (1985). There is no comment in the Braithwaite and Griffiths (1994) paper to suggest a "*substantial decline*". Significantly, Morton and Baynes (1985) make no mention of historical abundance of the Northern Quoll based on the evidence from owl deposits; rather, the theme of their paper addresses changes in overall species richness of rodents and polyprotodont marsupials since European

Table 5.1: Fauna species of conservation significance recorded from, or expected to occur in, the Panorama study area.

Species	Conservation Status		Taxon Recorded at Panorama	Number of Records	Location	Co-ordinates
	State Level	Federal Level				
Northern Quoll *Dasyurus hallucatus*		Endangered	✓	2	Valley Access Road	727798 mE, 7663587 mN
Mulgara *Dasycercus cristicauda*	Schedule 1	Vulnerable	✓	1	Plains Access Road	741682 mE, 7701908 mN*
Orange Leaf-nosed Bat *Rhinonicteris aurantius*	Schedule 1	Vulnerable	✓	8	Valley Access Road	727850 mE, 7663830 mN
Pilbara Olive Python *Liasis olivaceus barroni*	Schedule 1	Vulnerable				
Bilby *Macrotis lagotis*	Schedule 1	Vulnerable				
Woma *Aspidites ramsayi*	Schedule 4					
Peregrine Falcon *Falco peregrinus*	Schedule 4					
Spectacled Hare Wallaby *Lagorchestes conspicillatus*	Priority 3		✓	5 (1 sighting, remainder from tracks)	Plains Access Road Plains Access Road Plains Access Road Plains Access Road Plains Access Road	739514 mE, 7677880 mN 739514 mE, 7677880 mN* 733366 mE, 7668060 mN* 738091 mE, 7673377 mN* 739904 mE, 7692919 mN*
Australian Bustard *Ardeotis australis*	Priority 4		✓	3	Plains Access Road Plains Access Road Plains Access Road	739514 mE, 7677880 mN 739458 mE, 7678003 mN 727063 mE, 7665410 mN
Bush Stone-curlew *Burhinus grallarius*	Priority 4		✓	1	Plains Access Road	727026mE, 7665461mN
Lakeland Downs Mouse *Leggadina lakedownensis*	Priority 4					
Ghost Bat *Macroderma gigas*	Priority 4		✓		Plains Access Road	Vicinity of Lalla Rookh mine
Western Pebble-mound Mouse *Pseudomys chapmani*	Priority 4		✓	2	Valley Access Road Valley Access Road	727339 mE, 7664938 mN 727335 mE, 7664958 mN*
Long-tailed Dunnart *Sminthopsis longicaudata*	Priority 4			5 (including active nest)	Valley Access Road	727865 mE; 7663720 mN
Rainbow Bee-eater *Merops ornatus*		Migratory species	✓			

* indicates a record based on secondary evidence only (diggings, tracks, calls or pebble-mounds respectively for the four species).

settlement. Morton and Baynes (1985) do state that *"…. analysis, of skeletal remains from the surfaces of cave deposits at 15 sites in the western arid zone shows that species richness of rodents and polyprotodont marsupials has declined to 44% and 41% of the pre-European numbers."* Furthermore, it is considered highly improbable that any measure of abundance for any mammal could be derived from reviewing the contents of owl deposits. In summary, there appears to be little, if any, support for the statement regarding the decline of the Northern Quoll in the Pilbara which is made by the Action Plan and paraphrased on the DEH website. Rather, it seems to have been derived from a series of misinterpretations, commencing with Braithwaite and Griffiths (1994) misinterpretation of the Morton and Baynes (1985) data. A more appropriate listing for the Pilbara region would be "data deficient".

Ecology: The Northern Quoll is classed as a medium-sized marsupial, with adult weight ranging from 300 g up to 1,200 g. It is considered a partially arboreal and aggressive carnivore, preying on a varied diet of small invertebrates and vertebrates, including lizards, birds, snakes, small mammals and frogs (Oakwood 1997). It is also known to feed on fleshy fruit. The Northern Quoll is mostly nocturnal, although crepuscular (dusk and dawn) activity is common. Many records from the Pilbara bioregion have come from breakaway features abutting large creeks (Roy Teale, Biota, pers. obs.) and from boulder tors of the Abydos-Woodstock Plain (How et al. 1991).

The Northern Quoll is a short-lived mammal, with both sexes maturing at 11 months. Females reproduce only once each year, and all males die shortly after reproducing (Dickman and Braithwaite 1992, Oakwood 2000). The discrete male cohorts that arise within populations make quolls vulnerable to extinction: if no juvenile male quolls survive to adulthood, there will be no males available for mating the following year, and the local population will rapidly go extinct (Braithwaite and Griffiths 1994, Oakwood 2000). Therefore, any factor that results in significant increases in mortality rates of female and juvenile quolls could cause local extinction of quoll populations.

Likelihood of Occurrence: Bamford and Wilcox (2001) recorded 18 capture events across three sites over two seasons within the main mine area of the Panorama study area. During the current survey, several scats were noted along the screes and cliffs through the valley, and a single female carrying pouch young was captured in an Elliott trap (Table 5.2). The WA Museum Faunabase has numerous records of this species in the Pilbara, collected between 1950 and 1999 (Figure 5.1).

Table 5.2: Location in the study area from which the Northern Quoll *Dasyurus hallucatus* was trapped.

Species	Number	Location
Dasyurus hallucatus	Female and pouch young	727798 mE, 7663587 mN

Potential Impacts: Potential impacts are discussed under each of the major headings identified below, which relate to the key EPA objectives.

A Decline in Abundance

Mortality events will likely occur as a consequence of several factors, including loss of potential foraging habitat, loss of potential dens and interactions with vehicles. It is understood that the cliff face and scree slopes on either side of the proposed haul road will be left undisturbed, as will most of the older vegetation components (eg. tall trees), thereby reducing these impacts. The number of mortalities and the effect of these on the local abundance over the life of mine are extremely difficult to establish, especially given the natural population variations recorded for this species (Schmitt et al. 1987, Kenneally et al. 2002). Though individual mortality events along the haulage road could be ascribed to operations (eg. road kills), it is extremely doubtful that any trapping program could ascribe changes in abundance (even at a local level within the valley) to haulage related activities with any statistical rigour.

Equally difficult to gauge is the cumulative effect of habitat loss across the Pilbara bioregion, of which this project forms a part. Northern Quolls appear to be tolerant of human habitation in the Pilbara and are regularly seen foraging around camps and homesteads. By way of example, Bamford and Wilcox (2001) noted that this species "….was also caught around the Panorama

Camp, where they were living among and underneath buildings." Significant threats to the Northern Quoll are related to landscape level effects such as the spread of the Cane Toad, spread of infectious diseases and inappropriate burning regimes, rather than the localised and generally small scale impacts (such as clearing and occasional collisions with vehicles) associated with mining operations. Clearly mining operations can contribute to some of these landscape level factors, for example by encouraging feral animals around camps or initiating uncontrolled fires, and such issues need to be managed as part of general environmental commitments.

It is considered unlikely that the development of the haulage road will cause the localised extinction of the Northern Quoll within the valley, and it is unlikely that any effect on abundance would be detectable over natural population fluctuations.

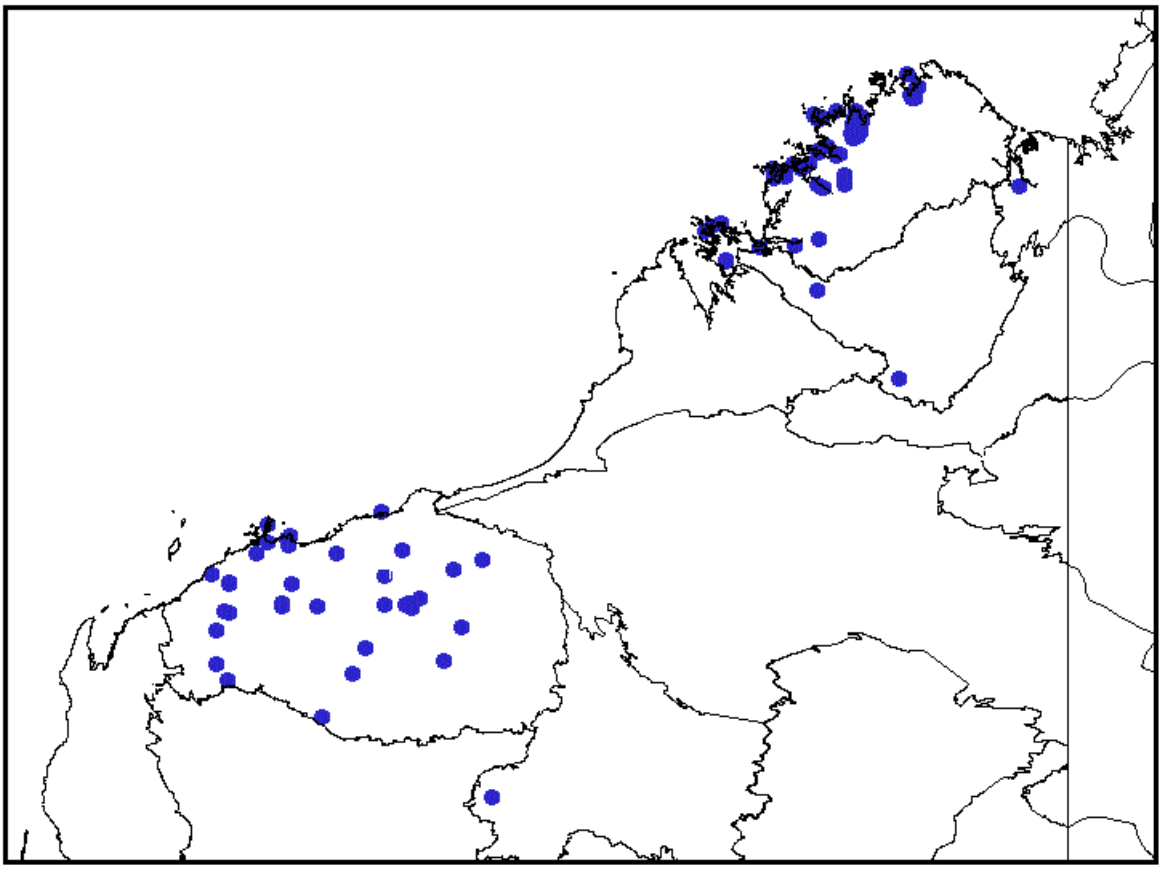


Figure 5.1: Distribution of WA Museum specimens of the Northern Quoll *Dasyurus hallucatus* from Western Australia.

A Reduction in Geographic Spread

Though there has been a considerable contraction in range across Queensland and the Northern Territory, this does not appear to be the case for the Kimberley region of WA (How and Hamilton 2005), though this may change with the imminent arrival of the Cane Toad *Bufo marinus*. The status of populations in the Pilbara is less clear and is poorly understood. However, the taxon is not currently listed by DEC under the *Wildlife Conservation (Specially Protected Fauna) Notice 2006(2)*, nor is it listed as a Priority species (though this is likely to change; Dr. Peter Mawson, DEC, pers comm. 2006).

It is considered highly unlikely that the current proposal will cause a reduction in the geographic spread of the Northern Quoll in Western Australia.

Increase in the Conservation Status

It is considered unlikely that the current proposal will increase the conservation status of this species in Western Australia (based on the IUCN criteria for an Endangered classification). The primary threat to this species appears to be the spread of the Cane Toad, rather than small scale

clearing associated with mining proposals (such as the haul road through the valley) in the Pilbara bioregion.

Summary: There is no reason to suspect that the Pilbara population of the Northern Quoll is declining or has declined (see above), particularly given that the Cane Toad is largely implicated in the Quoll's decline across north-eastern Australia. However, there is a need for clarification on the distributional extent and status of the Pilbara population.

Under the *EPBC Act 1999*, an action requires referral to the Federal Environment Minister if it is deemed likely to have a significant impact on a matter of national environmental significance (eg. a listed threatened species such as the Northern Quoll *Dasyurus hallucatus*). Given the apparently broad distribution of the Northern Quoll in the Pilbara bioregion, it is considered that the action will not result in a significant impact.

5.2.2 Mulgara *Dasycercus cristicauda* (Schedule 1, 'Vulnerable')

Distribution: The Mulgara is a medium-sized (60-120 g) carnivorous marsupial exhibiting a patchy distribution throughout arid Queensland, the Northern Territory and Western Australia.

Ecology: This species is listed as Vulnerable under the *EPBC Act 1999* and as Schedule 1 under the *Wildlife Conservation (Specially Protected Fauna) Notice 2006(2).* Maxwell et al. (1996) indicate that the preferred habitat comprises largely immature hummock grasslands, and that larger colonies coincide with better watered areas such as paleo-drainage channels or drainage lines in sandplain or sand-dune habitats.

Goldfields
An assessment of the status of the Mulgara on parts of Mt Keith, Albion Downs, Tarmoola, Weebo and Yeelirrie Pastoral Leases found that the Spinifex Sandplain land unit of the Bullimore Land System (Pringle et al. 1994) comprised the primary habitat for the Mulgara (Halpern Glick Maunsell 2000; Roy Teale, Biota, pers. obs.). Vegetation typically comprised sparse eucalypts and/or *Acacia* spp over open *Triodia basedowii*. The Bullimore LS occurs widely throughout the Goldfields region, with an estimated 3 million ha across the region encompassed by the Sandstone, Youanmi, Sir Samuel, Duketon, Leonora, Laverton, Menzies and Edjudina 1:250,000 maps.

Pilbara
A survey encompassing an area bounded by the Chichester Range in the south, Port Hedland in the north, the Great Northern Highway to the west and the Marble Bar Road to the east was undertaken in winter 2001 (Biota 2002c). Evidence of Mulgaras coincided with *Triodia* dominated sandy or sandy clay plains. In some areas, such as on the granitic sands of the Abydos-Woodstock area, activity was concentrated in the first order drainage rills. These tended to be sandier than the adjacent areas, which were often clayey and more densely vegetated. The species of *Triodia* did not seem to be critical, as Mulgaras were recorded from sites supporting *T. epactia*, *T. lanigera*, *T. longiceps*, *T. schinzii* and *T. secunda*.

Habitats included land units associated with the Macroy, River and Uaroo Land Systems (see van Vreeswyk et al. 2004). In particular these included the sandy surfaced plains and large sand hummocks amongst saline scalds of the near coastal areas and further inland, together with extensive sandy/loamy plains, and the flood plains and lower terraces of the riverine systems.

Likelihood of Occurrence: The Mulgara was recorded during the current study from *Triodia* vegetated sandplain in the Uaroo Land System at the northern end of the Plains Access Road (Table 5.3). This species is well known from the Abydos Plain (Biota database) and from along the Marble Bar Road where it intersects suitable habitat (Biota database).

Table 5.3: Location in the study area from which Mulgara *Dasycercus cristicauda* was recorded.

Species	Number	Location
Dasycercus cristicauda	Numerous diggings and burrows	741682 mE, 7701908 mN

Potential Impacts: Potential impacts are discussed under each of the major headings identified below, which relate to the key EPA objectives.

A Decline in Abundance
The area of suitable habitat impacted by the proposed development encompasses 512.20 hectares, representing less than 0.01% of the Uaroo Land System, which occupies 7,681km^2 of the Pilbara bioregion (data from Payne et al. 1988 and van Vreeswyk et al. 2004). Eighty-two percent (82%) of this Land System comprises the "sandy/loamy plains" land unit, which represents the main habitat for Mulgaras, however suitable habitat would largely coincide with the following ecological units: plain hard spinifex grassland, plain soft spinifex grassland, sandplain hard spinifex grassland and sandplain soft spinifex grassland. The proportional representation of these ecological types within the "sandy/loamy plains" land unit is not given by the above references. In addition, suitable habitat varies temporally and areas that currently do not support Mulgaras may do so in the future, particularly under different burning regimes.

Clearing of the proposed area of Uaroo Land System would result in some loss of habitat and perhaps the direct loss of one or two individuals (depending on whether the area was being occupied by Mulgaras at the time). However, it would not be expected to contribute to a detectable decline in abundance over levels of natural variation. This species is more acutely threatened by broad landscape level management concerns (eg. burning regimes and predation from introduced predators) than localised small-scale clearing activities.

A Reduction in Geographic Spread
The project area is located well within the current known range of this species and there is no reason to suspect that clearing of the area of Uaroo Land System in question would result in a reduction in geographic spread.

The following extract is taken from the draft Recovery Plan for Mulgaras prepared for the Mulgara Recovery Committee by Masters (2005):

> *The species appears to be relatively secure within its present range however a clarification of the distribution in Western Australia is required for an accurate estimate of the national distribution and area of occupancy, and population size. Although changes in fire regimes, increased predation by dingos, foxes and cats, and habitat change through the impact of introduced herbivores, particularly domestic stock and rabbits, are likely factors causing the original decline, there is no clear evidence that the species has declined in distribution in recent years.*

Increase in the Conservation Status
It is considered that the current proposal will not increase the conservation status of this species in Western Australia (based on the IUCN criteria for a Vulnerable classification).

The current recovery plan focuses on the clarification of status of the Mulgara based on findings since the 1996 recovery plan. Its long-term aims are as follows:

1. To clarify the extent of occurrence and area of occupancy of the Mulgara, providing good baseline information for future assessments.
2. To re-assess the status of the species in light of updated information and to consider the possibility of downlisting the species based on the IUCN criteria of population trends, extent of occurrence and area of occupancy.
3. To maintain the gains that have been made to date.

Summary: The points discussed above suggest that the Mulgara is not declining in Western Australia, and further clarification of its area of occupancy is required. The Mulgara is now known from numerous locations within Western Australia (see Biota 2006e), with most records coming from environmental surveys for the mining sector. This would suggest that a concerted targeted survey would demonstrate a broad occurrence of this species and result in a downlisting of the species conservation status.

Under the *EPBC Act 1999*, an action requires referral to the Federal Environment Minister if it is deemed likely to have a significant impact on a matter of national environmental significance (such as the listed threatened species, the Mulgara *Dasycercus cristicauda*). Given the broader distribution of the Mulgara in the Pilbara bioregion and across the State (see references summarized in Biota 2006e), and the proposed change to the conservation ranking of the species, it is considered that the current action will not result in a significant impact. Nevertheless, it is recommended that, should any clearing be required of the area from which Mulgara evidence was recorded, the action be referred under the *EPBC Act 1999* with the following management recommendations:

- that a pre-clearing survey (2-3 days prior to clearing activities) be undertaken within suitable habitat coinciding with the transport corridor to determine whether the area encompasses any active burrows; and
- should any such burrows be located, these should be excavated and any animals encountered held in captivity until after the clearing has taken place, then released into adjacent areas where it is likely they will have additional burrows.

5.2.3 Orange Leaf-nosed Bat *Rhinonicteris aurantius* (Schedule 1, 'Vulnerable')

Distribution: *Rhinonicteris* is a relictual monotypic genus of the Hipposideridae and occupies a disjunct distribution across the north of the Australian continent. Populations found in the extreme northwest of Queensland are considered to be contiguous with those in the Northern Territory and the Kimberley region of Western Australia. Populations occurring further south in the Pilbara bioregion of Western Australia are considered to be isolated from northern populations by the Great Sandy Desert.

Over the past 15 years prior to 2005, colonies of *Rhinonicteris* had been recorded at nine sites in the eastern Pilbara, including the disused Klondyke Queen and Comet mines, near Marble Bar (Armstrong 2001, Churchill et al. 1987), and the disused Lalla Rookh mine (Dr. Kyle Armstrong, pers. comm.), approximately 20 km to the north of the Panorama study site. Recent surveys by the DEC have yielded records of the species from 14 sites, all associated with range country (Dr. Norm McKenzie, DEC, pers. comm. 2006). These records are complemented by further records of the species from west of Pannawonica at Mesa K (Biota Database), as well as at Cattle Gorge near Yarrie (Ecologia 2005), together with the recent records from the Panorama study area.

The listing of the Orange Leaf-nosed Bat is based on a decline in the population, and the recovery outlines listed under *The Action Plan for Australian Bats* (Environment Australia 1999) specifies protection of known colonies and identification and protection of natural roost sites in the Pilbara as primary recovery objectives.

Ecology: *R. aurantius* exhibit a strict dependence on roost micro-climates which fall within a narrow range of 28C to 32C and 85% to 100% relative humidity, particularly during the dry season, a factor that has been implicated in their low numbers (Churchill 1991). Armstrong (2001) has suggested that the species exhibits seasonal movement patterns through roost sites in the East Pilbara, and greater dependence on deep and complex roost sites in the summer months. Roost caves have yielded colonies estimated to number 21,000 animals, but single animals have also been observed at rest. Populations have been known to abandon a roost site when disturbed.

An insectivorous species, *Rhinonicteris* has been observed to commence foraging within 30 minutes of sunset, and continue for several hours (Churchill et al 1987), with many animals returning to the roost as late as after sunrise the following morning. Bats were seen to forage over spinifex grasslands, thick scrub and amongst taller open woodlands along creeklines. Within woodland, such as that found at the Panorama study site, the bats have often being observed flying at heights of less than two metres, a behavioural trait that has been implicated in a perceived susceptibility to vehicle traffic. The species is known to be a prey item for the Ghost bat *Macroderma gigas* and is also probably preyed on by snakes.

Mating occurs in July, with females giving birth to solitary young in late December or early January. Young grow rapidly until weaning in February, with females becoming sexually mature in their first year at about seven months, although males do not mature until their second year.

Likelihood of Occurrence: The species has been recorded during both surveys completed in the study area. Bamford and Wilcox (2001) reported three unconfirmed sightings of *Rhinonicteris* from the vicinity of the Panorama, including a site near Kangaroo Caves and the disused Lalla Rookh mine. The current survey yielded nine individual animals in the Valley Access Road area, all caught in harp traps over a period of three nights. It should be noted that these records were of animals in flight or caught in harp traps and that potential roost sites were not located, although a colony is known to inhabit the abandoned Lalla Rookh mine to the north.

Potential Impacts: Potential impacts are discussed under each of the major headings identified below, which relate to the key EPA objectives.

A Decline in Abundance

The presence of foraging animals over several nights indicates that the Valley Access Road site represents a regular foraging area for the species, although the number of animals frequenting the valley is unknown. Irrespective of this, increased human activity in the valley is likely to result in increased mortality rates for the species due to factors including loss of foraging habitat and motor vehicle impacts. No caves representing potential roost sites were located within the valley, although a more comprehensive survey is required to confirm this initial observation.

Mortalities associated with increases in human activity in the valley will obviously reduce the abundance of the species in the local area. However, the currently available data are insufficient to determine the value of the valley as a foraging area, and the location and size of the colony from which the trapped bats originated is not known. Hence, the significance of such a reduction cannot be determined without ascertaining the value of the valley as a foraging area, locating the roost site(s) being utilised by the animals and estimating population size in the area.

Nonetheless, the geographic distribution and number of relatively recent records of *Rhinonicteris*, (Armstrong 2001; Churchill 1991; Dr. Norm McKenzie, DEC, pers. comm. 2006) indicate that the species is widespread throughout the Pilbara in association with range country. The proposed development is therefore unlikely to pose a risk to the abundance of the species on a bioregional basis.

A Reduction in Geographic Spread

On the basis of reports that the species is in decline, it would appear that this has occurred throughout the known range. However, there is no evidence that the species historically occupied a larger area in the north of Australia than that currently known (Churchill et al 1987). Moreover, recent records of *Rhinonicteris* span the Pilbara bioregion, (see above) and those from the Panorama survey area are within this range.

The proposed development at Panorama is therefore considered unlikely to result in a reduction in the species' geographic extent.

Increase in the Conservation Status

Consideration of the possible impacts on the local population of *Rhinonicteris* at Panorama against the recent records of this species from numerous locations across the Pilbara, it is considered improbable that the proposed development will result in an elevation of the species' conservation status (based on the IUCN criteria for a Vulnerable classification). However, further evaluation of the Panorama site is required to confirm this, and to clarify the level of impact.

Summary: Historically, individual *Rhinonicteris* have been recorded from a range of locations across the Pilbara since 1925. Perceptions that the species had declined were subsequently founded on the reduction in animal numbers at two mine sites previously known to contain roosting populations (Environment Australia 1999). However, widespread recent records of foraging animals and individuals caught in traps indicate that the species may not have declined

but persists across its 'former' range. Significantly, uncertainty remains over the importance of artificial (man-made) versus natural roost sites.

Under the *EPBC Act 1999*, an action requires referral to the Federal Environment Minister if it is deemed likely to have a significant impact on a matter of national environmental significance (such as the listed threatened species, the Orange Leaf-nosed Bat *Rhinonicteris aurantius*). Without additional evaluation of the population in the valley and the importance of this location as foraging habitat (perhaps for bats from Lalla Rookh), it is difficult to establish the significance or otherwise of the potential impact. In view of this, the following recommendations are made in respect of Orange Leaf-nosed Bats:

- Desktop Review
  A desktop review should be undertaken to evaluate the likely occurrence of comparable Valley habitat (to that at Panorama) within a similar distance from the known Orange Leaf-nosed Bat colony at Lalla Rookh (as this is potentially a source of the bats at Panorama). The desktop review should use available aerial photography, topography and other cadastral features to identify comparable valley features. It is proposed that apparently suitable valleys then be ground-truthed (where access permits) to establish whether they support bats. The main aim of this work is to determine whether there is additional foraging habitat available to bats that might be using Lalla Rookh as a roost and then undertaking nightly foraging forays to Panorama and the surrounds.
- Site Visit
  A six day (five night) site visit should be undertaken to ground-truth any additional suitable habitat and attempt to locate roost sites within the valley. Additional surveys might also be undertaken in the Valley Access Road study area.

5.2.4 Pilbara Olive Python *Liasis olivaceus barroni* (Schedule 1, 'Vulnerable')

Distribution: Regarded as a Pilbara endemic, this subspecies has a known distribution that coincides roughly with the Pilbara bioregion (Environment Australia 2000).

Ecology: The Pilbara Olive Python shows a preference for rocky habitats near water, particularly rock pools. It may shelter in deep rock crevices, with a diet that includes birds, reptiles, and mammals as large as rock wallabies.

Likelihood of occurrence: Suitable habitat for this species occurs within the project area, and it is considered likely to occur.

Potential Impacts: Some potential habitat loss; possible direct mortality associated with construction of access roads, particularly in the valley area. The conservation status and distribution of this species is unlikely to be affected by the proposal.

5.2.5 Bilby *Macrotis lagotis* (Schedule 1)

Distribution: The former range of the Bilby included most of the semi-arid areas of mainland Australia, however, it is now confined to *Triodia* hummock grassland and Acacia scrub across parts of northern Australia.

Ecology: The Bilby *Macrotis lagotis* is a medium-sized ground mammal, ranging in weight from 1.0 - 2.5 kg. The species is apparently strictly nocturnal and constructs a substantial burrow system, which may be up to 3 m in length (Strahan 2004). Similar to the Mulgara, the species has been documented as holding temporary home ranges and showing relatively rapid changes in distribution in response to variation in habitat resources (Johnson 1995). Whilst fox and cat predation and the effect of rabbits and stock are thought to be the principal factors in the decline of this species, fire has also been suggested as an important factor in maintaining habitat diversity for this species (Johnson 1995).

Likelihood of occurrence: The species is considered may occur in the Plains access Road portion of the study area where suitable habitat, which includes Acacia Shrublands on sandplain, is found.

Potential Impacts: The current proposal is unlikely to affect the conservation status of the Bilby.

5.2.6 Woma *Aspidites ramsayi* (Schedule 4)

Distribution: Occurs as four potentially disjunct populations in Western Australia (Storr et al. 2002). The arid north-western population occurs between Eighty Mile Beach in the east and Mundabullangana Station in the west. The population in the south of Western Australia is the one considered to be under threat (Cogger et al. 1993), with the northern and inland population considered to be stable (Dr. Dave Pearson, DEC, pers. comm.). The Schedule fauna listing does not currently distinguish between these populations.

Ecology: The north-western populations apparently prefer the coastal sands.

Likelihood of Occurrence: Not recorded during the current survey. However, there were two records in May 2001 from the BHP Billiton rail access track, from comparable habitat to that occurring along part of the Plains Access Road; one from approximately 10 km south of Port Hedland, and the other from 35 km south of Port Hedland (Biota 2002b). The species is also well known from the Great Northern Highway between Port Hedland and Broome.

5.2.7 Peregrine Falcon *Falco peregrinus* (Schedule 4)

Distribution: The Peregrine Falcon has an almost cosmopolitan distribution. The only subspecies in Australia (*macropus*) is widespread throughout Australia and Tasmania (Marchant and Higgins 1993). The Australian population has been estimated at 3,000 to 5,000 pairs (Cade 1982). Whilst its status is difficult to determine in the Pilbara, it is certainly more common than its Priority 4 listed cogener *Falco hypoleucos*.

Ecology: This species inhabits a wide range of habitats including forest, woodlands, wetlands and open country. The availability of prey is apparently more important than habitat in determining its distribution. Home ranges are probably defended year round and are variable in size, though not typically less than 480 ha (Marchant and Higgins 1993).

This species typically nests on cliffs (81% of nests Australia-wide) but also on stick nests (11%) and in tree hollows (8%). Breeding typically occurs from August to November (Johnstone and Storr 1998). Food is almost exclusively birds such as pigeons, parrots and passerines, which are captured in flight (Johnstone and Storr 1998). Mammals such as possums and rabbits have been recorded as rare prey items (Marchant and Higgins 1993).

Likelihood of Occurrence: Not recorded during the current survey. This species is likely to be resident along the Strelley River area, as suitable prey species (such as parrots) are common. It may also occur in the valley area and along some of the large drainage features adjacent to the proposed mine.

Potential Impacts: Some loss of potential nesting and foraging habitat. The conservation status of this species is unlikely to be affected by the proposal.

5.2.8 Spectacled Hare Wallaby *Lagorchestes conspicillatus* (Priority 3)

Distribution: The distribution of the Spectacled Hare Wallaby is shown as an arc across much of northern Australia (Strahan 2004), with a sub-species also occurring on Barrow Island. The Western Australian populations appear to have declined drastically (Dr. Dave Pearson, DEC, pers comm. 2006) and this species is now considered extinct in the Great Sandy and Gibson Deserts (Strahan 2004). Whilst the Barrow Island subspecies is listed as Vulnerable under the *EPBC Act 1999,* the WA

mainland population is considered to be only Priority 4 despite localised extinctions and apparent substantial decline.

Ecology: Within the Pilbara, this species appears to require large spinifex hummocks for shelter, and the species' decline has been attributed to the absence of these hummocks, possibly as a result of increased frequency in burning and extensive grazing by cattle.

Likelihood of Occurrence: During the current survey a single individual was sighted and tracks were located along the access road at 739514 mE, 7677880 mN, and tracks were also recorded from three further locations (see Table 5.4). In addition, Malcolm Trudgen provided a description of a small macropod that was most probably this species from 737162 mE, 7672416 mN and 739289 mE, 7690704 mN (Malcolm Trudgen, ME Trudgen and Associates, pers. comm. 2006). This species was known from the area between Wodgina Mine and Pilgangoora Mine (Dr Peter Kendrick, DEC Karratha, pers. comm. 2006).

Table 5.4: Locations within the study area from which the Spectacled Hare Wallaby *Lagorchestes conspicillatus* was recorded.

Site (Vegetation Alliance*)	Location (AMG)	Observation
SPEC1 (VA42)	739514 mE, 7677880 mN	Single animal, and tracks
SPEC2 (VA45)	733366 mE, 7668060 mN	Tracks
SPEC3 (VA45)	738091 mE, 7673377 mN	Tracks
SPEC4 (VA27)	739904 mE, 7692919 mN	Tracks

From Trudgen (2006): VA42 = *Triodia epactia* hummock grasslands on the plains and lower slopes;
VA45 = (Scattered tall shrubs over) *Triodia* sp. 'Panorama' hummock grassland;
VA27 = *Grevillea wickhamii* high open shrubland to shrubland

Potential Impacts: The core habitat and area of occupancy for this species is less well known than for either the Mulgara or Northern Quoll and would need resolving before convincing statements about potential impacts can be made. However, the current records of this species came from *Triodia* dominated vegetation types along the Plains Access Road north of Lalla Rookh Mine.

The proponent is proposing to widen the road by 12-15 m to allow for heavy haulage vehicles. Haulage units will average 6 cycles per day (i.e. 2-3 trucks twice per day). There will be occasional personnel light vehicle and employee transport intermittently.

Potential impacts are discussed under each of the major headings identified below which relate to the key EPA objectives.

A Decline in Abundance

Some habitat will clearly be lost with the additional clearing associated with the proposed widening of the Plains Access Road. However, the extent of habitat intersected by the widening is not clear as insufficient information is available as to the area of occupancy and distribution of habitat.

Mortality events arising from vehicle collisions may cause a decline in local abundance, which may be of significance at a bioregional level if the study area remains as the primary Pilbara population. However, insufficient information is available on the size and extent of the local population or the broader Pilbara population.

Any increase in fire frequency also clearly poses a threat to the long-term persistence of the population in the area. Given the capacity for fire to impact at a landscape level, this is seen as the main potential risk arising from the project.

A Reduction in Geographic Spread

There is insufficient information to establish whether the identified and relevant impacts arising from the project would cause a reduction in geographic spread.

Increase in the Conservation Status

There is insufficient information to establish whether the identified and relevant impacts arising from the project would cause a change of conservation status. However, it is suggested that the current conservation ranking (as Priority 3) does not reflect the true conservation status of this taxon.

Summary: Although this species is listed by DEC as a Priority 3 species, it is our impression and that of many others (eg Dr. Peter Kendrick, Dr. Peter Mawson and Dr. Dave Pearson, all of DEC) that it should probably be considered equivalent to a Schedule 1 fauna. One of the primary concerns is the lack of current data to support the general belief that this species has undergone a dramatic decline in the Pilbara and WA as a whole. According to Dr. Peter Mawson, the record from the study area represents the first confirmed live record of this species in five years. Until additional information is gathered on the abundance and extent of the population along the Plains Access Road and placed in regional context, it is difficult to clearly identify whether likely impacts are manageable. In view of this, it is recommended that:

- To further clarify the occurrence of Spectacled Hare Wallaby along the corridor and within the general location, a survey should be undertaken using rapid assessment techniques, which involve utilizing secondary signs to establish presence and in some cases relative density estimates. It is proposed that Ric Southgate (Private consultant), who has considerable experience in identifying species from tracks, be involved and that during the survey DEC staff be invited to participate so that they can also learn techniques for recording this species from tracks.

In addition, the following general recommendations are made in respect of this species:

- Low speed limits should be enforced through the section of road where Spectacled Hare Wallaby habitat is present;
- Large old spinifex hummocks (favoured habitat) should be avoided during construction; and
- A fire management plan for the vicinity of the Spectacled Hare Wallaby population should be developed in consultation with the DEC.

5.2.9 Australian Bustard *Ardeotis australis* (Priority 4)

Distribution: The Australian Bustard occurs over much of Western Australia, with the exception of the more heavily wooded southern portions of the state (Johnstone and Storr 1998). Its wider distribution includes eastern Australia and New Guinea.

Ecology: This species prefers open or lightly wooded grassland including *Triodia* sandplains (Johnstone and Storr 1998) and is considered scarce to common depending on season and habitat. It has an omnivorous diet and occurs in a relatively broad range of habitats, but appears to have some preference for grasshoppers and is often attracted to recently burnt areas (Marchant and Higgins 1993). This species breeds from March to September and the eggs are laid on bare, preferably stony, ground (Johnstone and Storr 1998).

Likelihood of Occurrence: Three sightings of two birds were made along the Plains Haul Road (Table 5.5) on three separate days and may represent the same individuals.

Table 5.5: Locations in the study area from which the Australian Bustard *Ardeotis australis* was recorded.

Site	Location (AMG)	Number of Individuals	Date
Plains Haul Road	739514 mE, 7677880 mN	2	1/09/2006
Plains Haul Road	739458 mE, 7678003 mN	2	2/09/2006
Plains Haul Road	727063 mE, 7665410 mN	2	3/09/2006

Potential Impacts: Some habitat loss. Risk of increased mortality through collision with vehicles along the proposed transport corridor. The conservation status of this species would not be impacted by the proposed development at either the Pilbara bioregion or Hamersley subregion level.

5.2.10 Bush Stone-curlew *Burhinus grallarius* (Priority 4)

Distribution: This species is widespread in Australia and southern New Guinea. It remains common in tropical Australia but has declined alarmingly in temperate Australia and has disappeared from many regions (Marchant and Higgins 1993). Populations are apparently secure in the Pilbara (Ron Johnstone, WA Museum, pers. comm. 2003). The Australian population has been estimated at c. 15,000 individuals. This species was once found throughout most of the south-west of Western Australia, but has disappeared from many areas.

Ecology: Bush Stone-curlews inhabit sparsely grassed, lightly timbered forest or woodland. In southern Australia, they persist most often where there is a well-structured litter layer and fallen timber debris. Individuals have an estimated home range of about 250 ha (Johnson and Baker-Gabb 1993). This species breeds from July to January. The eggs are either laid directly on the ground or in a small scrape (Johnstone and Storr 1998). This species is a terrestrial feeder and is quite wide-ranging in its diet. It feeds primarily on invertebrates, particularly beetles, but also eats small lizards, frogs, snakes, vegetation and seeds (Marchant and Higgins 1993). Foxes are usually considered to be the primary cause for their decline, hence their relative abundance in the tropics, but habitat clearance has also been identified as a threatening process (Garnett and Crowley 2000).

Likelihood of Occurrence: This species was heard calling from areas immediately adjacent to the Plains Access Road on most nights. Bamford and Wilcox (2001) also noted several sightings of this species from a number of localities during surveys in 2001.

Potential Impacts: The conservation status of this species would not be impacted by the proposed development at either the bioregion or subregion level.

5.2.11 Lakeland Downs Mouse *Leggadina lakedownensis* (Priority 4)

Distribution: Since 1997, the number of records of this species has increased substantially such that it has now been recorded from over 20 locations (Roy Teale, Biota, Pers. comm.). A recent taxonomic revision of *Leggadina* (Cooper et al. 2003) found that despite morphological variation, *L. lakedownensis* are genetically similar across their range and the variation is insufficient to warrant subspecific status for any regional populations. In Western Australia the distribution of this species includes the Pilbara and Kimberley regions. Biota has recorded the Lakeland Downs Mouse on cracking clay communities from Cape Preston in the west to the northern flanks of the Fortescue Marshes in the east.

Ecology: Regional records suggest that the primary mainland habitat comprises areas of cracking clay and adjacent habitats, although this species has also been recorded from hill tops (Dr Peter Kendrick, DEC Karratha, pers. comm. 2003) and sandy coastal areas near Onslow (Biota unpublished data). At Cape Preston, this species was recorded from *Acacia xiphophylla* open shrubland over a mosaic of *Triodia wiseana* and *Eragrostis xerophila* mixed hummock and tussock grassland (Halpern Glick Maunsell and Biota 2000). At the Southern Plains study site (near Tom Price), numerous individuals were recorded from *Acacia xiphophylla* shrubland over *Triodia longiceps* and annual grasses (Biota 2002). Along the proposed Hope Downs rail alignment, it was recorded from *Astrebla pectinata* tussock grassland. During the Fortescue Metals Group Stage A survey (Biota 2004b), this species was recorded from *Astrebla pectinata*, *Aristida latifolia* tussock grassland on the self-mulching clays within the Chichester Range.

Likelihood of Occurrence: This species was not recorded during the current survey and core habitat (cracking clay communities) is absent from the project area. It is unlikely to occur in the project area.

Potential Impacts: The proposed is not expected to affect the distribution or the conservation status of this species.

5.2.12 Ghost Bat *Macroderma gigas* (Priority 4)

Distribution: The distribution of Ghost Bats is fragmented across northern Australia, with each population showing some genetic differentiation (Armstrong and Wilmer 2004, Biota 2002a; Biota 2004a). Populations in the Pilbara bioregion appear to be isolated from those in the Kimberley and Northern Territory.

Ecology: Ghost Bats are efficient predators of small birds, mammals and reptiles, and large insects, and have highly developed echolocation, visual and hearing systems. Vocalisations audible to humans are used in their complex social interactions. Scat material from *M. gigas* is quite distinctive and can be used to identify temporary roosts or feeding sites. Fairy Martin (*Hirundo ariel*) nests within culverts provide a roosting substrate for *M. gigas* and the culverts may function either as a night or feeding roost or (probably less commonly) as a temporary day roost. This is an example of where man-made habitat has benefited bats (Biota 2002a).

Likelihood of Occurrence: Numbers of individuals were sighted flying over flat, *Triodia* vegetated plains during night spotting from a vehicle (Roy Teale, Phil Runham, Mike Greenham, Biota, pers. obs.) in the vicinity of the abandoned Lalla Rookh mine, which is a known roost site for the species.

Potential Impacts: Widening of this portion of the Plains Access Road will not affect the roost site at Lalla Rookh, however increased traffic along the road is likely to result in higher mortality rates. Fencing of the roost site will prevent adverse impacts on the colony by human visitation. These factors are unlikely to adversely affect the conservation status of the species.

5.2.13 Western Pebble-mound Mouse *Pseudomys chapmani* (Priority 4)

Distribution: This species is common to very common in suitable habitat within the Hamersley and Chichester subregions of the Pilbara bioregion. Records from areas where it is considered locally extinct (eg. the Burrup Peninsula) are of interest.

Ecology: Well known for its behaviour of constructing extensive mounds of small stones, covering areas from 0.5 to 9.0 square metres (Strahan 2004). This mound formation is most common on spurs and gentle slopes with stones of a suitable size class.

Likelihood of Occurrence: One individual was caught at SU01, and an active mound was located nearby (Table 5.6).

Potential Impacts: The conservation status of this species would not be impacted by the proposed development at either the bioregion or subregion level.

Table 5.6: Location within the study area from which *Pseudomys chapmani* was recorded.

Site	Location (AMG)	Number of Captures
SU01	727339 mE, 7664938 mN	1 adult male
Mound near SU01	727335 mE, 7664958 mN	Active mound

5.2.14 Long-tailed Dunnart *Sminthopsis longicaudata* (Priority 4)

Distribution: Inhabits rocky, rugged habitat from the Pilbara and adjacent upper Gascoyne region east to the central Northern Territory and South Australia.

Ecology: Records have come from plateaus near breakaways, and screes and rugged boulder strewn screes. Biota has only recorded three individuals from the Pilbara; the first from the bank of Caves Creek (near Mt Brockman) adjacent to a rugged scree; the second from calcareous soil on a low hill near Mt Brockman; and the third during the Fortescue Metals Group Stage B survey, from spinifex hummock grassland on a low stony hillslope near Mt Joel (Biota 2005). It is understood that this species has been recorded on a number of occasions from invertebrate pit traps established during the CALM Pilbara Biological Survey.

Likelihood of occurrence: Not recorded during the current survey but likely to occur in the study areas.

Potential Impacts: Potential habitat loss. The proposed development is unlikely to alter the distribution or the conservation status of this species, should it occur in the project area.

5.3 Short Range Endemic Taxa

The conservation status of invertebrate SRE taxa is difficult to establish as key information such as taxonomy and distributional data is lacking. At the level of the project area, the most restricted taxon appears to be the pseudoscorpion *Feaella* sp 'Sulphur Springs' (see Section 4.3.4). Additional survey work is required to resolve the broader distribution and taxonomic affinities of this taxon.

6.0 Habitat Conservation Significance

Fauna habitats may be of conservation significance because they are uncommon, support unique vegetation or faunal assemblages, support fauna (or flora) of special conservation significance, or any combination of these three factors. They may also be important because they maintain local ecosystem processes (nitrogen fixation, nutrient turnover etc), or are important to regional ecosystem function (transfer of energy and matter through the abiotic and biotic components of the ecosystem). An example of the latter might be broad catchment areas servicing a significant drainage feature. With current data and practicable survey methods, we are some way off being able to resolve the latter in most cases.

A serious limitation of any habitat classification system is that it does not cover all habitats available to the entire assemblage of invertebrate and vertebrate fauna, as this would be difficult to resolve and logistically impracticable to sample. Rather, the classifications provide a convenient framework within which to summarise species occurrence (with a strong bias towards vertebrates) and are often determined by the observers experience. To increase objectivity, we have used a three-tiered classification system that makes use of existing published descriptions for Land System mapping: the three tiers comprise Land System, Land Unit and Habitat. However, the relatively recent emergence of Short Range Endemics (particularly invertebrates) as an important component of the faunal assessment process (in terms of identifying conservation imperatives) challenges the usefulness of broad habitat categories, and it may be that a functional perspective that considers the evolutionary driving forces which have shaped current patterns of phylogeography will be more appropriate for this group of fauna.

6.1 Assessment Based on Land Systems

The study area encompasses six Land Systems, which were found to encompass a broad range of vegetation types, and the vegetation mapping is presented in detail in Trudgen (2006).

The area of each Land System within the Pilbara is given in Table 2.1, and their distribution can be appreciated by examining van Vreeswyk et al. (2004). However, there is no equivalent mapping of Land Units; rather these are represented by their proportional contribution to the Land System in which they occur (see van Vreeswyk et al. 2004). There is similarly no regional mapping of the habitat units ("site types" of van Vreeswyk et al. 2004), neither is there an estimate of their proportional contribution to the encompassing Land Unit. Unfortunately, therefore, there is little opportunity to determine regional context at the most useful tier in terms of classifying fauna habitats (ie. the Land Unit or perhaps the habitat unit itself). In the absence of such regional datasets, we have made use of the area calculations for each Land System and individual experience to provide a relative summary of conservation significance.

The most restricted Land System intersected by the study area is Satirist, which comprises less than 0.25% of the Pilbara bioregion. The project area intersects a small area of this Land System to the west of the Marble Bar Road. All other Land Systems within the study area are widespread throughout the Pilbara bioregion.

6.2 Assessment Based on Vegetation Types

None of the vegetation types occurring within the Bungaroo study area are listed as Threatened Ecological Communities (TECs) by DEC, hence there are similarly no TECs listed under the Federal *Environment Protection and Biodiversity Conservation Act 1999* within the area.

However, "all major ephemeral water courses" (which may correspond to vegetation type EcCv within the permanently wet areas) are considered to be ecosystems at risk, principally from grazing and trampling by stock, weed invasion and large fires (see Kendrick 2003).

6.3 Assessment Based on Fauna

6.3.1 Species of Elevated Conservation Status

Eight species with an elevated conservation status were recorded from the survey area and the occurrence of these species may impart a comparable level of significance to the habitat from which they were recorded.

Significantly, none of the recorded species are restricted to habitats within the project area and many are in fact wide ranging species (especially the birds). However, for two of these species, the habitat encompassed by the project area does appear important. In the case of the Orange Leaf-nosed Bat, the close proximity of suitable foraging sites (such as those along the Valley Access Road) to documented large colonies (ie. at Lalla Rookh) may be uncommon in the Pilbara: as such, the valley habitat is considered to have high conservation value. The other species of importance is the Spectacled Hare Wallaby. Most recent evidence suggests that the loss of suitable habitat is the primary cause of the decline of this species in the Pilbara. As such, the habitats at the locations from which this species was recorded are considered to have high conservation value. (There is insufficient information regarding use of habitats along the remainder of the Plains Access Road by this species to ascribe any conservation value beyond these immediate areas.)

Two of the remaining species are Federally protected and the conservation value of their preferred habitat warrants additional discussion. It was argued in Section 5.2.1 that the status of the Northern Quoll in the Pilbara is best described as "Data Deficient", and that there is no support for the comment that the species has undergone a dramatic decline. However, given that the species is Federally listed with no recognition for different populations, the valley area should be considered to have an elevated conservation value, as it constitutes the primary habitat for this species within the project area. (The valley is already considered to have high conservation value in any case given the presence of Orange Leaf-nosed Bats.) The only other Federally protected species recorded from the study area was the Mulgara, which was recorded from the sandplain habitats along the Plains Access Road. Utilisation of this habitat by Mulgaras is dependent on fire history. Given that the conservation status of this species is likely to be reviewed downwards, it is considered that this habitat has a moderate conservation ranking.

6.3.2 Bioregional Endemics

Seven taxa considered endemic (or nearly so) to the Pilbara bioregion were recorded during the survey comprising Pheasant Coucal *Centropus phasianus highami*, *Ningaui timealeyi, Pseudomys chapmani, Diplodactylus savagei, D. wombeyi, Morethia ruficauda exquisita* and *Vermicella snelli*. Most are widespread across the bioregion and common in suitable habitat, however *Vermicella snelli* is rarely encountered. The Pheasant Coucal was recorded numerous times from Vegetation alliances 2 and 5 of Trudgen (2006) in the Valley, comprising *Eucalyptus camaldulensis*, *Melaleuca argentea*, *Eucalyptus victrix* open forest over scattered tall shrubs and *Schoenus falcatus*, *Cyprerus vaginatus*, *Triodia longiceps* sedgelands/grasslands and *Eucalyptus victrix* scattered trees to open woodland over *Melaleuca glomerata*, *Melaleuca linophylla* open to closed scrub respectively. *Pseudomys chapmani* and *Diplodactylus wombeyi* were recorded from Vegetation Alliance 14 of Trudgen (2006), comprising *Corymbia hamersleyana* scattered low trees over shrubs and *Triodia epactia* hummock grassland on the lower slopes of the Capricorn Land System. The *Morethia* was recorded from adjacent to a cliff face at SU02. *Diplodactylus savagei* and *Vermicella snelli* were recorded from Vegetation Alliance 15; *Corymbia hamersleyana* over *Triodia wiseana* hummock grassland (Trudgen 2006). The conservation status of these fauna taxa should not be adversely affected by the proposed development as the vegetation alliances correspond to broad habitat types which are widespread throughout the region.

6.3.3 Short Range Endemics

The current survey recorded several taxa that may be SRE taxa including *Feaella* sp. 'Sulphur

Springs', a barychelid mygalomorph spider and *Rhagada* sp. 'Sulphur Springs'.

At the scale of the project area, only one of these is considered to be at risk and hence the location has an elevated conservation ranking:

- The *Feaella* sp. 'Sulphur Springs' has not been identified to species level, however it is likely to represent a new taxon. It is known from only one location in the project area (SUSS 11) and additional work is required to establish the likely distribution and habitat requirements of this taxon. The location from which it was recorded is considered to have high conservation significance.

6.4 Assessment Based on Landscape

6.4.1 Ecological Refugia

This concept follows that outlined by Morton et al. (1995), who recognised areas in which a suite of species persists over short periods when surrounding habitat becomes unsuitable due to adverse climatic or ecological conditions. The primary difference between the use by Morton et al. (1995) and the application here is one of scale: the review by Morton et al. (1995) was on a continental scale with resolution down to bioregions ,whereas the current analysis is at a local scale and is related to the size of the project area. The valley along the proposed Valley Access Road would be considered an ecological refugia: this habitat already has a high conservation ranking (see Section 6.3).

6.4.2 Relictual Refugia

Relictual refugia are those refugia that have allowed species or suites of species to persist during periods (in evolutionary terms) when most of the original geographic range has become uninhabitable due to changes in climate. In some respects (and for some taxa) this classification overlaps with Short Range Endemics (Section 6.3.3). Relictual refugia can be either geological features such as rockpiles, or landscape features such as hilltops or gorges.

The global distribution of *Feaella* suggests that it is a relictual Gondwanan species, and its persistence at Panorama may suggest that parts of the project area have acted as relictual refugia. However, in the absence of additional information about the broader occurrence of *Feaella* at Panorama, this supposition is difficult to test. Nonetheless the location from which this taxon was recorded is considered to have a high conservation value.

6.4.3 Landscape Processes

As noted previously, the *Rhagada* were collected from point samples on drainage features and it is likely that snails would occur along the length of these drainages where suitable cover exists. Any permanent impact to the catchment of the various drainage lines or to the drainage lines themselves may also impact on the long-term viability of snail populations downstream. A similar argument can be made for any species or community dependent on ephemeral streams and creeks in the project area. For this reason, such areas have moderate conservation value.

6.5 Summary and Rankings

6.5.1 Neutral Conservation Significance

This includes habitat with no recognized environmentally significant attributes that require particular or special management strategies (given our current understanding). However, normal company management policies with regards to clearing and rehabilitation etc still apply.

The majority of the habitat types are considered to be of neutral conservation significance, representing units that are likely to be more widely distributed and relatively well represented in the Panorama area of the Chichester subregion.

6.5.2 Moderate Conservation Significance

This value is ascribed to parcels of land for which there are contributing attributes that elevate the conservation ranking above neutral and that may require particular management.

Areas of moderate conservation significance comprise:

- Areas of sandplain habitat along the Plains Access Road that constitute suitable habitat for Mulgaras.
- Drainage features within the mine area.

6.5.3 High Conservation Significance

This value is ascribed to parcels of land with contributing attributes elevating the conservation status above Moderate and requiring particular management, often determined by legislative requirements at both a State and Federal Level.

Three key habitats are areas are considered to have high conservation significance:

- The valley area;
- The locations from which Spectacled Hare Wallabies were recorded; and
- The location from which *Feaella* sp. 'Sulphur Springs' was recorded.

6.6 Management Recommendations

The following generic management measures are proposed to minimise or better understand potential impacts to the fauna and fauna habitats of the Panorama project area:

1. Disturbance to habitats of high conservation significance should be avoided if possible, or otherwise minimised, by relocating all non-essential infrastructure to other areas and/or minimising clearing in these areas. Disturbance to habitats of moderate significance should likewise be minimised. Vegetation clearing in general should be kept to the minimum necessary for safe construction and operation of the Sulphur Springs mine.
2. Wherever possible, disturbance to surface drainage features should be avoided during mine planning. Modifications to the local surface hydrology will be needed for this project and natural drainage patterns should be re-established at the completion of mining activities in the locality.
3. A Fire Management Plan should be prepared and implemented to minimise the risk of unplanned fires in the project area.
4. Weed control measures should be developed and implemented to prevent the introduction or spread of weeds in the project area. This is particularly the case for aggressive environmental weeds such as buffel grass *Cenchrus ciliaris,* that can replace native *Triodia* species thereby modifying habitat for native fauna (eg land snails). A Weed Hygiene and Management Plan should be prepared in consultation with the DEC prior to construction commencing.
5. A Topsoil Management and Rehabilitation Plan should be prepared for all non-permanent cleared areas in liaison with the DEC prior to the commencement of construction activities. This plan should include use of provenance collected native seed, characterisation and management of areas topsoil, and the respreading of cleared vegetative material. Recovery monitoring should also be carried out, with any rehabilitation failure subject to additional treatment to a suitable standard.

6. A Feral Species Management and Mitigation program should be developed for the proposed project. This program should target species such as the European fox, feral cat and wild dogs where these are readily distinguishable from dingoes..

In addition, several specific recommendation made in relation to specific fauna are also made.

In respect of Mulgaras, it is recommended:

- that a pre-clearing survey (2-3 days prior to clearing activities) be undertaken within suitable habitat coinciding with the transport corridor to determine whether the area encompasses any active burrows; and
- should any such burrows be located, these should be excavated and any animals encountered held in captivity until after the clearing has taken place, then released into adjacent areas where it is likely they will have additional burrows.

In respect of the Orange Leaf-nosed Bat, it is recommended that the following studies are undertaken:

- Desktop Review
  A desktop review should be undertaken to evaluate the likely occurrence of comparable Valley habitat (to that at Panorama) within a similar distance from the known Orange Leaf-nosed Bat colony at Lalla Rookh (as this is potentially a source of the bats at Panorama). The desktop review should use available aerial photography, topography and other cadastral features to identify comparable valley features. It is proposed that apparently suitable valleys then be ground-truthed (where access permits) to establish whether they support bats. The main aim of this work is to determine whether there is additional foraging habitat available to bats that might be using Lalla Rookh as a roost and then undertaking nightly foraging forays to Panorama and the surrounds.
- Site Visit
  A six day (five night) site visit should be undertaken to ground-truth any additional suitable habitat identified from the desktop studies described above. An additional attempt to locate roost sites within the valley through which the access road is to be constructed is also recommended. It is noted that a preliminary though cursory search did not locate suitable caves. Additional Orange Leaf-nosed Bat surveys might also be undertaken in the Valley Access Road study area to determine if the bats regularly utilise the area.

In respect of the Spectacled Hare Wallaby, the following are recommended:

- To further clarify the occurrence of this species along the corridor and within the general location, a survey should be undertaken using rapid assessment techniques, which involve utilizing secondary signs to establish presence and in some cases relative density estimates. It is proposed that a suitably qualified and experience person in identifying species from tracks be involved, and that during the survey DEC staff be invited to participate so that they can also learn techniques for recording this species from tracks.
- CBH should conduct environmental awareness training that will identify significant habitat/s and the appropriate management actions will be implemented eg. slowing vehicle speed through areas recognised as being of environmental significance.
- Large old spinifex hummocks (favoured habitat) should be avoided where practicable during construction.
- A fire management plan for the vicinity of the Spectacled Hare Wallaby population should be developed in consultation with the DEC.

In respect of the pseudoscorpion *Feaella* sp. 'Sulphur Springs', the following is recommended:

- Additional survey work be undertaken to better delineate distribution and habitat.
- Additional taxonomic work be undertaken to resolve the identity of the specimens.

7.0 References

Abbott, I. and Burbidge, A. A. 1995. The occurrence of mammal species on the islands of Australia: a summary of existing knowledge. *CALM Science* 1: 259-324.

Armstrong (2001) The distribution and roost habitat of the orange leaf-nosed bat, *Rhinonicteris aurantius*, in the Pilbara region of Western Australia. Wildlife Research 28: 95-104.

Armstrong, K.N and Worthington Wilmer, J. (2004). The importance of determining genetic population structure for the management of Ghost Bats, *Macroderma gigas*, in the Pilbara region of Western Australia. Proceedings of the 11th Australasian Bat Society Conference, Toowoomba, Queensland, 12-14 April 2004. See *The Australasian Bat Society Newsletter* 22: 37-38.

Bamford M.J. and Wilcox J.A. (2001). Panorama Project Area: Baseline Fauna Study as Part of the Sulphur Springs Feasibility Study. Unpublished report for Astron Environmental.

Beard, J.S. (1975). Vegetation Survey of Western Australia. 1:1,000,000 Vegetation Series Map Sheet 5 – Pilbara and Explanatory Notes.

Berry, O. (2005). The molecular systematics of troglofauna from the Pilbara, Western Australia. Unpublished report for Pilbara Iron.

Biota Environmental Sciences (2002a). Proposed Hope Downs Rail Corridor from Weeli Wolli Siding to Port Hedland – Vertebrate Fauna Study. Unpublished Consultants Report.

Biota Environmental Sciences (2002b). Southern Plains and Southern Detritals Fauna and Vegetation Monitoring 2001. Unpublished Consultants Report.

Biota Environmental Sciences (2002c). An assessment of the distribution of the Mulgara *Dasycercus cristicauda* and Bilby *Macrotis lagotis* along and adjacent to the proposed Hope Downs to Port Hedland rail corridor. Biota, Perth. Unpublished Report.

Biota Environmental Sciences (2004a). Hope Downs Additional Rail Corridor – Chichester Range. Vertebrate fauna Survey. Unpublished Consultants Report.

Biota Environmental Sciences (2004b). Fauna Habitats and Fauna Assemblages of the Proposed FMG Stage A Rail Corridor. Unpublished Consultants Report.

Biota Environmental Sciences (2005) Fauna Habitats and Fauna Assemblage of the Proposed FMG Stage B Rail Corridor and Mindy Mindy, Christmas Creek, Mt Lewin and Mt Nicholas Mine Areas. Unpublished Consultants Report.

Biota Environmental Sciences (2006a). The molecular systematics of *Bothriembryon* from the Pilbara, Western Australia. Land Snail Report. Unpublished report prepared for Pilbara iron.

Biota Environmental Sciences (2006b). Molecular studies on *Rhagada* sp "Mt Brockman". Unpublished report for Pilbara Iron.

Biota Environmental Sciences (2006c). Burrup land and Freshwater Snails – Sites A and E. Unpublished report for Woodside.

Biota Environmental Sciences (2006d). Burrup land and Freshwater Snails – Site B. Unpublished report for Woodside.

Biota (2006e). Northern Nickel Projects (Dasycercus cristicauda) Survey and Management Plan.

Bond, JE. (2004). Systematics of the Californian euctenizine spider genus *Apomastus* (Araneae: Mygalomorphae: Cyrtaucheniidae): the relationship between molecular and morphological taxonomy. *Invertebrate Systematics* 18: 361-376.

Bond, JE. and Sierwald, P. (2003). Molecular taxonomy of the *Anadenobolus excisus* (Diplopoda: Spirobolida: Rhinocricidae) species-group on the Caribbean island of Jamaica. *Invertebrate Systematics* 17: 515-528.

Braithwaite R.W. and Griffiths A. (1994) Demographic variation and range contraction in the Northern Quoll *Dasyurus hallucatus* (Marsupialia: Dasyuridae). *Wildlife Research* 21: 203-217.

Bromham, L. and Woolfit, M. (2004). Explosive radiations of molecular clocks: island endemic radiations as a test case. *Systematic Biology* 53(5); 758-766.

Brower, AVZ. (1994). Rapid morphological radiation and convergence among races of the butterfly *Heliconius erato* inferred from patterns of mitochondrial DNA evolution. *Proceedings of the National Academy of Science. USA*. 91: 6491-6495.

Burbidge A. A. and McKenzie, N. L. Eds. 1978. *The Islands of the North-west Kimberley*. Wildlife Research Bulletin of Western Australia. No 7.

Cade T.J. (1982). *The Falcons of the World*. Collins, London.

Chiba, S. (1999). Accelerated evolution of land snails *Mandarina* in the oceanic Bonin island: evidence from mitochondrial DNA sequences. *Evolution* 53:460-471.

Christian C.S. and G.A. Stewart (1953). General report on Survey of Katherine-Darwin region 1946. CSIRO Australian Land Research Series 1. cited in Environmental Protection Authority (2002). *Position Statement No. 3: Terrestrial Biological Surveys as an Element of Biodiversity Protection.* Environmental Protection Authority, March 2002.

Churchill, S.K. (1991) Distribution, Abundance and Roost Selection of the Orange Horseshoe-bat, Rhinonycteris aurantius, a Tropical Cave-dweller. Wildlife Research 18: 343-53.

Churchill, S.K. (1994) Diet, prey selection and foraging behaviour of the Orange Horse-shoe Bat, *Rhinonicteris aurantius*. *Wildlife Research* 21:115-130.

Churchill, S.K., Helman, P.M. and Hall, L.S. (1987) Distribution, Populations and Status of the Orange Horseshoe Bat, *Rhinonicteris aurantius* (Chiroptera: Hipposideridae). Australian Mammalogy 11: 27-33.

Cogger, H., Cameron E.E., Sadlier, R.A. and Eggler, P. (1993) The Action Plan for Australian Reptiles. Australian Nature Conservation Agency.

Collins, TM., Frazer, K., Palmer, AR., Vermeij, GJ. and Brown, WM. (1996). Evolutionary history of northern hemisphere *Nucella* (Gastropoda, Muricidae): molecular, morphological, ecological and paleontological evidence. *Evolution* 50: 2287-2304.

Cooper N.K, M. Adams, C. Anthony and L.H. Schmitt (2003). Morphological and genetic variation in *Leggadina* (Thomas, 1910) with special reference to western Australian populations. *Records of the Western Australian Museum* 21: 333-351

Dickman C.R. and Braithwaite (1992) Post-mating mortality of males in the Dasyurid Marsupials *Dasyurus* and *Parantechinus*. *Journal of Mammalogy.* 73(1): 143-147.

Ecologia Environmental Consultants (2005) *Goldsworthy Extension Project Biological Assessment Survey.* Unpublished report for BHP Billiton Ore Pty Ltd.

Environment Australia 1999 The Action Plan for Australian Bats. Department of Environment and Heritage.

Environment Australia (2000). Revision of the Interim Biogeographic Regionalisation for Australia (IBRA) and Development of Version 5.1, Summary Report. Environment Australia, November 2000.

Environmental Protection Authority (2002) 'Terrestrial Biological Surveys as an Element of Biodiversity Protection: Position Statement No. 3.' Environmental Protection Authority, Perth.

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

Farrell, BD. (2001). Evolutionary assembly of the milkweed fauna: cytochrome oxidase I and the age of *Tetraopes* beetles. *Molecular Phylogenetics and Evolution* 18: 467-478.

Folmer O., Black M., Hoeh W., Lutz R., Vrijenhoek R. (1994). DNA primers for amplification of mitochondrial cytochrome c oxidase subunit I from diverse metazoan invertebrates. *Molecular Marine Biology and Biotechnology*, 3: 294-299.

Forstner, MRJ., Davis, SK. and Arévalo, E. (1995). Support for the hypothesis of anguimorph ancestry for the suborder Serpentes from phylogenetic analysis of mitochondrial DNA sequences. *Molecular Phylogenetics and Evolution* 4(1): 93-102.

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

Halpern Glick Maunsell (2000). Lease Wide Mulgara *Dasycercus cristicauda* Survey. An unpublished report prepared for WMC Leinster Nickel Operations.

Halpern Glick Maunsell and Biota Environmental Sciences (2000). Austeel Biological Survey, Cape Preston. Unpublished report prepared for Austeel, Perth.

Hart, MW., and Podolsky, RD. (2004). Mitochondrial DNA phylogeny and rates of larval evolution in *Macrophiothrix* brittlestars. *Molecular Phylogenetics and Evolution* 34: 438-447.

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

Hebert, PDN., Cywinska, A., Ball, SL. and deWaard J.R. (2003). Biological identifications through DNA barcodes. *Proceedings of the Royal Society of London. Series B.* 270: 313-321.

Hebert, PDN., Stoeckle, MY., Zemlak, TS. and Francis, CM. (2004). Identification of Birds through DNA Barcodes. *PloS Biology*. Volume 2, Issue 10.

Hillis, DM., Mable, BK., and Moritz, C. (1996). Applications of molecular systematics: the state of the field and a look to the future. In: *Molecular Systematics*, by Hillis, DM, Mable, BK., and Moritz., C. Editors. Sinauer Associates: Sunderland, MA. pp. 515-543.

Holland, BS. and Hadfield, MG. (2002). Islands within an island: phylogeography and conservation genetics of the endangered Hawaiian tree snail *Achatinella musteline*. *Molecular Ecology 11*: 365-375.

How, R.A., Dell, J and Cooper, N.K. 1991. Vertebrate fauna of the Abydos-Woodstock Reserve, northeast Pilbara. *Records of the Western Australian Museum Supplement* 37: 78-125.

How R. and Hamilton Z.R. (2005). Northern Quoll, *Dasyurus hallucatus*, populations of the Robe River valley. Unpublished report for Robe River Mining.

Johnson G. and D.J. Baker-Gabb (1993). *Bush Thick-knee in Northern Victoria (Part 1): Conservation and Management.* Arthur Rylah Institute of Environmental Research Technical Report 129(A).

Johnstone R.E. and G.M. Storr (1998). *Handbook of Western Australian Birds. Volume 1 - Non-passerines (Emu to Dollarbird).* Western Australian Museum, Perth WA.

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

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

Kenneally, K., Edinger, D., Coate, K., Hyland, B., How, R., Schmitt, L., Cowan, M., Willing, T. and Done, C. 2003. *The Last Great Wilderness – Exploration of the Mitchell Plateau 2002*. LANDSCOPE Expedition Report No. 49, CALM, Perth, WA. 32pp.

Kimura, M. (1980). A simple method for estimating evolutionary rate of base substitutions through comparative studies of nucleotide sequences. *Journal of Molecular Biology and Evolution* 16: 111-120.

Kojima, S., Kobayashi, T., Hashimoto, J., and Ohta, S. (1995). RFLP analysis of a mitochondrial gene, cytochrome oxidase I (COI) of three species of the genus *Calyptogena* around Japan. *Journal of Oceanography* 51: 257-259.

Kumar, S., Tamura, K. and Nei, M. (2004). MEGA3: Integrated software for Molecular Evolutionary Genetics Analysis and sequence alignment. *Briefings in Bioinformatics* 5: 150- 163.

Marchant S. and P.J. Higgins (1993). *Handbook of Australian, New Zealand & Antarctic Birds Volume 2: Raptors to Lapwings.* Oxford University Press, South Melbourne.

Masters P. (2005). Draft Mulgara Recovery Plan *Dasycercus cristicauda*: 2005-2009.

Maxwell, S., A. A. Burbidge, and K. Morris (1996). The 1996 Action Plan for Australian marsupials and monotremes. Wildlife Australia, Canberra.

Menkhorst PW (2001). A Field Guide to the Mammals of Australia. Oxford University Press, Melbourne, Australia.

Morton, S. R., and Baynes, A. (1985). Small mammal assemblages in arid Australia: a reappraisal. *Australian Mammalogy* 8, 159-69.

MortonS.R., Short, J. and Barker, R.D. (1995) Ecological Refugia for Biological Diversity in Arid and Semi-arid Australia. Deprtment of the Environment, Sport and Territories. Canberra, Australia.

Murray, J., Stine, OC. and Johnson, MS. (1999). The evolution of mitochondrial DNA in *Partula*. *Heredity* 66: 93-104.

Nei, M. and Kumar, S. (2000). *Molecular Evolution and Phylogenetics*. Oxford University Press, New York.

Oakwood M. (1997). The ecology of the northern quoll, *Dasyurus hallucatus*. PhD thesis, Australian National University.

Oakwood, M. 2000. Reproduction and demography of the northern quoll, *Dasyurus hallucatus*, in the lowland savanna of northern Australia. *Australian Journal of Zoology* 48: 519-539.

Paquin, P. and Hedin, M. (2004). The power and perils of 'molecular taxonomy': a case study of eyeless and endangered *Cicurina* (Araneae: Dictynidae) from Texas caves. *Molecular Ecology* 13: 3239-3255.

Payne, A.L. (2004). Geomorphology. *In*: van Vreeswyk, A.M.E., A.L. Payne, K.A. Leighton and P. Hennig (2004). *An inventory and condition survey of the Pilbara region, Western Australia.* Department of Agriculture Technical Bulletin No. 92, December 2004.

Payne P.L., A.A. Mitchell and W.F. Holman (1988). An inventory and condition survey of the rangelands in the Ashburton River catchment, Western Australia. Technical Bulletin No. 62. Western Australian Department of Agriculture.

Pinceel, J., Jordaens, K. and Backeljau, T. (2005). Extreme mitochondrial divergence in a terrestrial slug (Gastropoda, Pulmonata, Arionidae): accelerated evolution, allopatric divergence and secondary contact. *Journal of Evolutionary Biology* 18: 1264-1280.

Ponder, WF. and Colgan, DJ. (2002). What makes a narrow-range taxon? Insights from Australian fresh-water snails. *Invertebrate Systematics* 16: 571-582.

Pringle H.J.R., Van Vreeswyk A.M.E. and Gilligan S.A. (1994) An inventory and condition survey of the north-eastern goldfields, Western Australia. Technical Bulletin No. 87. Department of Agriculture, Western Australia.

Rest, JS., Ast, JC., Austin, CC., Waddell, PJ., Tibbetts, EE., Hay, JM., and Mindell, DP. (2003). Molecular Systematics of primary reptilian lineages and the tuatara mitochondrial genome. *Molecular Phylogenetics and Evolution.*

Rodriguez-Robles, JA. and De Jesús-Escobar, JM. (1999). Molecular systematics of New World lampropeltinine snakes (Colubridae): implications for biogeography and evolution of food habitat. *Biological Journal of the Linnean Society* 68: 335-385.

Ross, TK. (1999). Phylogeography and conservation genetics of the Iowa Pleistocene snail. *Molecular Ecology* 8: 1363-1373.

Schenk K. (1996). Evolutionary genetics of *Daphnia* species complex, hybridism in syntopy. Publication 2231, Netherlands Institute of Ecology, Centre for Limnology, Neuwersluis, The Netherlands.

Schmitt, L.H., Bradley, A.J., Kemper, C.M., Kitchener, D.J., Humphreys, W.F. and How, R.A. 1989. Ecology and physiology of the Northern Quoll, *Dasyurus hallucatus*, (Marsupialia: Dasyuridae) at Mitchell Plateau, Kimberley, Western Australia. *Journal of Zoology*, *London* 217: 539-558.

Solem, A. (1986). Pupilloid Land Snails from the South and Mid-west Coasts of Australia. *J. Malac. Soc. Aust.* 7(3-4): 95-124.

Solem, A. (1997). Camaenid land snails from Western and Central Australia (Mollusca: Pulmonata: Camaenidae). VII Taxa from Dampierland through the Nullarbor. *Records of the Western Australian Museum, Supplement No* 50: 1461-1906.

Steinke, D., Albrecht, C., and Pfenniger, M. (2004). Molecular phylogeny and character evolution in the Western Palaearctic Helicidae s.l. (Gastropoda: Stylommatophora). *Molecular Phylogenetics and Evolution.* 32(3): 724-34.

Storr G.M., Smith L.A. and Johnstone R.E. (2002). Snakes of Western Australia. Revised Edition. Western Australian Museum Publishing, Perth, Western Australia.

Stothard, JR., Llewellyn-Hughes, J., Griffin, CE., Hubbard, SJ., Kristensen, TK., and Rollinson, D. (2002). Identification of snails within the *Bulinus africanus* group from East Africa by Multiplex SnaPshotä Analysis of Sindle Nucleotide Polymorphisms within the Cytochrome Oxidase Subunit I. Memorias do Instituto Oswaldo Cruz. 97(Suppl.): 31-36.

Strahan R. (2004). *The Mammals of Australia.* Reed Books, Chatswood.

Thacker, RW. and Hadfield, GM. (2000). Mitochondrial phylogeny of extant Hawaiian tree snails (Achatinellinae). *Molecular Phylogenetics and Evolution* 16: 263-270.

Thomaz, D., Guiller, A. and Clarke, B. (1996). Extreme divergence of mitochondrial DNA within species of pulmonate land snails. *Proceedings of the Royal Society of London. Series B.* 263: 363-368.

Thorne A.M. and A.F. Trendall (2001). *Geology of the Fortescue Group, Pilbara Craton, Western Australia.* Geological Survey of Western Australia, Bulletin 144.

Trewick, SA. and Wallis, GP. (2001). Bridging the "beech-gap": New Zealand invertebrate phylogeography implicates Pleistocene glaciation and Pliocene isolation. *Evolution* 55: 2170- 2180.

Trudgen, M.E. (2006) Rare flora searches of a proposed campsite, tailings dam and waste dumps for the Panorama project. Unpublished Consultants Report.

van Vreeswyk, A.M.E., A.L. Payne, K.A. Leighton and P. Hennig (2004). *An inventory and condition survey of the Pilbara region, Western Australia.* Department of Agriculture Technical Bulletin No. 92, December 2004.

Western Australian Museum (1991). Ecological Survey of the Adydos – Woodstock Reserve, Western Australia. Records of the Western Australian Museum Supplement No. 37.

Zamudio, KR. and Greene, HW. (1997). Phylogeography of the bushmaster (*Lachesis muta*: Viperidae): implications for neotropical biogeography, systematics and conservation. *Biological Journal of the Linnean Society*. 62: 421-442.

8.0 Glossary

Base	The DNA is a chain of nucleotide units; each unit consists of a backbone made of a sugar and a phosphate group, with a nitrogenous base attached. The base unit is one of adenine (A), guanine (G), cytosine (C), or thymine (T). In RNA, uracil (U) is used instead of thymine. A and G belong to the chemical class called purines; C, T, and U are pyrimidines.
Coalescence	The evolutionary process viewed backward through time, so that allelic diversity is traced back through mutations to ancestral alleles. Coalescent theory can be used to make predictions about effective population sizes, ages and frequencies of alleles, selection, rates of mutation, or time to common ancestry of a set of alleles.
Cryptic	Tending to conceal or camouflage.
Endemic	Native to or confined to a certain region.
Fecundity	The capacity for producing offspring, especially in abundance.
Haplotype	A group of alleles of different genes on a single chromosome that are closely enough linked to be inherited usually as a unit.
Lineage	Direct descent from a particular ancestor; ancestry. The descendants of a common ancestor considered to be the founder of the line.
Molecular Clock	A measure of evolutionary change over time at the molecular level that is based on the theory that specific DNA sequences or the proteins they encode spontaneously mutate at constant rates. This is used chiefly for estimating how long ago two related organisms diverged from a common ancestor.
Nonparametric Bootstrapping	A statistical method based on repeated random sampling with replacement from an original sample to provide a collection of new pseudoreplicate samples, from which sampling variance can be estimated.
Nucleotide	Unit building block of DNA and RNA; a nucleotide consists of a sugar and phosphate backbone with a base attached.
Oligonucleotide	A short chain of nucleotides, often produced in the laboratory.
Parametric Bootstrapping	A method for producing independent pseudoreplicates of a data set by estimating parameters from the observed data, using the estimates to produce a model, and using the model to simulate replicate data sets.
Phylogenetic	Relating to or based on evolutionary development or history.
Phylogeny	The historical relationships among lineages of organisms or their parts (eg. genes).
Primers	Oligonucleotides used to initiate synthesis of DNA by a DNA polymerase or reverse transcriptase. A primer anneals to a complementary sequence in a single-stranded DNA or RNA template, and the polymerase then extends the complementary sequence from the primer.
Pseudogene	A sequence of nucleotides in the DNA that resembles a gene but is non-functional for some reason.
Purine	A kind of base; in the DNA, adenine (A) and guanine (G) are purines.
Putative	Thought, assumed, or alleged to be such or to exist.
Pyrimidine	A kind of base; in the DNA, cytosine (C) and thymine (T), and in RNA, cytosine (C) and uracil (U) are pyrimidines.
Reproductive Isolation	Two populations, or individuals of opposite sex, are reproductively isolated from one another if they cannot together produce fertile offspring.
Short Range Endemic (SRE)	A species that has a naturally small distribution and is often characterised by having poor dispersal capabilities, confinement to disjunct habitats and low fecundity.
Stop Codon	Any of three codons (UAA, UAG, or UGA) that signal the termination of

	the synthesis of a protein. Also called "chain termination codon".
Sympatry	The occurrence of organisms in overlapping geographical areas, but without interbreeding.
Systematics	A near synonym of taxonomy.
Taxonomy	Theory and practice of biological classification.
Transition	The substitution of a purine for another purine, or the substitution of a pyrimidine for another pyrimidine.
Transversion	The substitution of all types of nucleotide substitutions other than transitions.
Variance	A measure of the variability within a set of numbers. The more variable the numbers, the higher the variance.

Appendix 1

Licence to Take Fauna for Scientific Purposes

DEPARTMENT OF CONSERVATION AND LAND MANAGEMENT

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

Job # 370

DATE OF ISSUE 23/08/2006
DATE OF EXPIRY 07/09/2006
VALID FROM 29/08/2006

DPStehan
LICENSING OFFICER

LICENSEE: DR PB RUNHAM (PHILIP BERNARD)
ADDRESS BIOTA ENVIRONMENTAL SCIENCES
P.O. BOX 155
LEEDERVILLE
W.A. 6903

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DEPARTMENT OF CONSERVATION AND LAND MANAGEMENT

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

NO. SF005532

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.

EXECUTIVE DIRECTOR

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 EXECUTIVE DIRECTOR, 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 EXECUTIVE DIRECTOR. 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 EXECUTIVE DIRECTOR, 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 DEPARTMENT OF THE ENVIRONMENT AND HERITAGE, 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 CALM'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 EXECUTIVE DIRECTOR OF C.A.L.M.

9 FURTHER CONDITIONS (NUMBERED (TO 10) ARE ATTACHED.

PURPOSE FAUNA SURVEY SULFUR SPRINGS ALONG PROPOSED ACCESS ROAD BETWEEN THE MARBLE BAR ROAD AND LALLA ROOKH IN THE EAST PILBARA.

AUTHORISED PERSONS ROY TEALE

WILDLIFE CONSERVATION ACT 1950
WILDLIFE CONSERVATION REGULATIONS

Regulation 17:- Licence to Take Fauna for Scientific Purposes

FURTHER CONDITIONS (OF LICENCE NUMBER SF 5532)

1. The licensee shall ensure that all due care is taken in the capture and handling of fauna to prevent injury or mortality resulting from that capture or handling. Where traps or other mechanical means or devices are used to capture fauna these shall be inspected at regular intervals throughout each day of their use. At the conclusion of research all markers etc and signs erected by the licensee and all traps shall be removed, all pitfalls shall be refilled or capped and the study area returned to the condition it was in prior to the research/capture program. During any break in research, cage traps should be removed and pitfalls either removed, capped or filled with sand.

2. No collecting is to be undertaken in areas where it would impinge on pre-existing scientific research programs.

3. Any form of colour marking of birds or bats to be coordinated by the Australian Bird and Bat Banding Schemes.

4. Any inadvertently captured specimens of fauna which is declared as likely to become extinct, rare or otherwise in need of special protection is to be released immediately at the point of capture. Where such a specimen is injured or deceased, the licensee shall contact Department of Environment and Conservation licensing staff at Kensington (08 9334 0434) for advice on disposal. Records are to be kept of any fauna so captured and details included in the report required under further condition 6 below.

5. Prior to any renewal of this research licence the licensee shall submit a summary report outlining work conducted under this licence and work proposed for the next research period.

6. Within one month of the expiration of this licence (or at such other time or times as the Director General may determine) the holder shall furnish to the Director General [ATTENTION: WILDLIFE CLERK] a return setting out in full detail the number of each species of fauna taken during the currency of the licence, the localities where the species was/were taken and the method of handling of such fauna and disposal of specimens. A copy of any paper or report resulting from this research should be lodged in due course with the Director General. In the case of consultants, a list of the fauna handled, the localities involved and a copy of the interpretive data prepared should be lodged.

7. As a general rule not more than ten specimens of any one protected species shall be permanently taken from any location less than 20km apart. Where exceptional circumstances make it necessary to take large series in order to obtain adequate statistical data the collector will proceed with circumspection and justify their actions to the Director General in advance.

8. No fauna, whether dead or alive, may be taken out of Western Australia without the necessary export permit issued under the *Wildlife Conservation Act 1950.* It should be noted that the permit will not be issued unless the State to which the fauna is going has approved that fauna entering that State. In addition to the requirements of the Australian States, the Commonwealth controls exports overseas through Commonwealth legislation administered by the Australian Nature Conservation Agency.

9. All holotypes and syntypes and a half share of paratypes of species or subspecies permitted to be permanently taken under this licence shall be donated to the Western Australian Museum. Duplicates (one pair in each case) of any species collected which represents a significant extension of geographic range shall be donated on request to the Western Australian Museum.

10. To prevent any unnecessary collecting in this state, all specimens and material collected under the authority of this license shall, on request, be loaned to the Western Australian Museum. Also, the unused portion or portions of any specimen collected under the authority of this license shall be offered for donation to the Western Australian Museum or made available to other scientific workers if so required.

Appendix 2

Genetic Distance Table for Individuals of *Rhagada*

		R. convicta Cossack	*R. convicta* Cossack	*R. convicta* Cossack	SUSS01	SUSS01	SUSS03	SUSS08	SUSS06	*R. convicta* Southern Burrup	*R. angulata* Northern Burrup	*R. angulata* Northern Burrup	*R. angulata* Northern Burrup	*R. convicta* West Intercourse island	*R. convicta* Nickol Bay	*R. convicta* Nickol Bay	*R. convicta* Nickol Bay	*R. convicta* West Intercourse island	*R. convicta* West Intercourse island	*R. convicta* West Intercourse island	SUSS05	SUSS06	SUSS06	SUSS06	SUSS08	SUSS07	SUSS07	SUSS08	SUSS08
		R512	R508	R509	R457	R460	R463	R486	R476	R367	R287	R311	R312	R387	R430	R426	R427	R389	R314	R350	R470	R473	R474	R475	R485	R477	R480	R484	R482
R. convicta Cossack	R512																												
R. convicta Cossack	R508	0.0000																											
R. convicta Cossack	R509	0.0000	0.0000																										
SUSS01	R457	0.0930	0.0930	0.0930																									
SUSS01	R460	0.1060	0.1060	0.1060	0.0110																								
SUSS03	R463	0.0940	0.0940	0.0940	0.0150	0.0190																							
SUSS08	R486	0.0980	0.0980	0.0980	0.0190	0.0190	0.0040																						
SUSS06	R476	0.1070	0.1070	0.1070	0.0310	0.0270	0.0190	0.0190																					
R. convicta Southern Burrup	R367	0.0640	0.0640	0.0640	0.1060	0.1110	0.0980	0.0970	0.1020																				
R. angulata Northern Burrup	R287	0.1870	0.1870	0.1870	0.1960	0.2060	0.1960	0.1910	0.1960	0.2180																			
R. angulata Northern Burrup	R311	0.1920	0.1920	0.1920	0.2010	0.2110	0.2010	0.1970	0.2010	0.2130	0.0190																		
R. angulata Northern Burrup	R312	0.1920	0.1920	0.1920	0.2060	0.2160	0.2120	0.2070	0.1960	0.2130	0.0350	0.0310																	
R. convicta West Intercourse Island	R387	0.0680	0.0680	0.0680	0.1070	0.1110	0.0980	0.0980	0.1020	0.0110	0.2180	0.2120	0.2010																
R. convicta Nickol Bay	R430	0.0640	0.0640	0.0640	0.1020	0.1060	0.0940	0.0930	0.0980	0.0270	0.2030	0.2080	0.1970	0.0310															
R. convicta Nickol Bay	R426	0.0640	0.0640	0.0640	0.1020	0.1060	0.0940	0.0930	0.0980	0.0270	0.2030	0.2080	0.1970	0.0310	0.0000														
R. convicta Nickol Bay	R427	0.0600	0.0600	0.0600	0.1020	0.1060	0.0940	0.0930	0.0980	0.0310	0.1970	0.2030	0.1920	0.0350	0.0040	0.0040													
R. convicta West Intercourse Island	R389	0.0720	0.0720	0.0720	0.1110	0.1160	0.1030	0.1020	0.1070	0.0150	0.2230	0.2180	0.2070	0.0040	0.0350	0.0350	0.0390												
R. convicta West Intercourse Island	R314	0.0680	0.0680	0.0680	0.1070	0.1110	0.0980	0.0980	0.1020	0.0110	0.2180	0.2120	0.2010	0.0000	0.0310	0.0310	0.0350	0.0040											
R. convicta West Intercourse Island	R350	0.0680	0.0680	0.0680	0.1070	0.1110	0.0980	0.0980	0.1020	0.0110	0.2180	0.2120	0.2010	0.0000	0.0310	0.0310	0.0350	0.0040	0.0000										
SUSS05	R470	0.1060	0.1060	0.1060	0.0310	0.0310	0.0190	0.0190	0.0040	0.1060	0.1960	0.2010	0.1960	0.1060	0.1020	0.1020	0.1020	0.1110	0.1060	0.1060									
SUSS06	R473	0.1030	0.1030	0.1030	0.0310	0.0270	0.0150	0.0150	0.0040	0.0980	0.1910	0.1960	0.1960	0.0980	0.0940	0.0940	0.0940	0.1030	0.0980	0.0980	0.0080								
SUSS06	R474	0.1070	0.1070	0.1070	0.0350	0.0310	0.0190	0.0190	0.0080	0.1020	0.1960	0.2010	0.2010	0.1030	0.0980	0.0980	0.0980	0.1070	0.1030	0.1030	0.0110	0.0040							
SUSS06	R475	0.1030	0.1030	0.1030	0.0310	0.0270	0.0150	0.0150	0.0040	0.0980	0.1910	0.1960	0.1960	0.0980	0.0940	0.0940	0.0940	0.1030	0.0980	0.0980	0.0080	0.0000	0.0040						
SUSS08	R485	0.0940	0.0940	0.0940	0.0150	0.0190	0.0000	0.0040	0.0190	0.0980	0.1960	0.2010	0.2120	0.0980	0.0940	0.0940	0.0940	0.1030	0.0980	0.0980	0.0190	0.0150	0.0190	0.0150					
SUSS07	R477	0.0940	0.0940	0.0940	0.0150	0.0190	0.0000	0.0040	0.0190	0.0980	0.1960	0.2010	0.2120	0.0980	0.0940	0.0940	0.0940	0.1030	0.0980	0.0980	0.0190	0.0150	0.0190	0.0150	0.0000				
SUSS07	R480	0.0980	0.0980	0.0980	0.0190	0.0190	0.0040	0.0000	0.0190	0.0970	0.1910	0.1970	0.2070	0.0980	0.0930	0.0930	0.0930	0.1020	0.0980	0.0980	0.0190	0.0150	0.0190	0.0150	0.0040	0.0040			
SUSS08	R484	0.0940	0.0940	0.0940	0.0150	0.0190	0.0000	0.0040	0.0190	0.0980	0.1960	0.2010	0.2120	0.0980	0.0940	0.0940	0.0940	0.1030	0.0980	0.0980	0.0190	0.0150	0.0190	0.0150	0.0000	0.0000	0.0040		
SUSS08	R482	0.0940	0.0940	0.0940	0.0150	0.0190	0.0000	0.0040	0.0190	0.0980	0.1960	0.2010	0.2120	0.0980	0.0940	0.0940	0.0940	0.1030	0.0980	0.0980	0.0190	0.0150	0.0190	0.0150	0.0000	0.0000	0.0040	0.0000	
SUSS07	R478	0.0930	0.0930	0.0930	0.0080	0.0190	0.0230	0.0270	0.0390	0.1060	0.2060	0.2110	0.2170	0.1070	0.1020	0.1020	0.1020	0.1110	0.1070	0.1070	0.0390	0.0390	0.0430	0.0390	0.0230	0.0230	0.0270	0.0230	0.0230
R. richardsonii Port Hedland	R490	0.1410	0.1410	0.1410	0.1340	0.1430	0.1200	0.1240	0.1240	0.1500	0.2290	0.2240	0.2240	0.1500	0.1460	0.1460	0.1410	0.1550	0.1500	0.1500	0.1240	0.1200	0.1250	0.1200	0.1200	0.1200	0.1240	0.1200	0.1200
R. richardsonii Port Hedland	R487	0.1510	0.1510	0.1510	0.1430	0.1530	0.1290	0.1340	0.1340	0.1600	0.2410	0.2350	0.2350	0.1600	0.1560	0.1560	0.1510	0.1650	0.1600	0.1600	0.1330	0.1290	0.1340	0.1290	0.1290	0.1290	0.1340	0.1290	0.1290
R. richardsonii Port Hedland	R489	0.1360	0.1360	0.1360	0.1290	0.1380	0.1150	0.1200	0.1200	0.1450	0.2070	0.2020	0.2020	0.1450	0.1310	0.1310	0.1260	0.1500	0.1450	0.1450	0.1190	0.1150	0.1200	0.1150	0.1150	0.1150	0.1200	0.1150	0.1150
SUSS04	R469	0.1020	0.1020	0.1020	0.0190	0.0190	0.0080	0.0040	0.0190	0.1020	0.1970	0.2020	0.2020	0.1020	0.0980	0.0980	0.0980	0.1070	0.1020	0.1020	0.0190	0.0190	0.0230	0.0190	0.0080	0.0080	0.0040	0.0080	0.0080
SUSS04	R468	0.0940	0.0940	0.0940	0.0150	0.0190	0.0000	0.0040	0.0190	0.0980	0.1960	0.2010	0.2120	0.0980	0.0940	0.0940	0.0940	0.1030	0.0980	0.0980	0.0190	0.0150	0.0190	0.0150	0.0000	0.0000	0.0040	0.0000	0.0000
SUSS07	R479	0.0930	0.0930	0.0930	0.0000	0.0110	0.0150	0.0190	0.0310	0.1060	0.1960	0.2010	0.2060	0.1070	0.1020	0.1020	0.1020	0.1110	0.1070	0.1070	0.0310	0.0310	0.0350	0.0310	0.0150	0.0150	0.0190	0.0150	0.0150
SUSS05	R471	0.1020	0.1020	0.1020	0.0350	0.0310	0.0230	0.0230	0.0040	0.0970	0.2010	0.2060	0.2010	0.0980	0.0930	0.0930	0.0930	0.1020	0.0980	0.0980	0.0080	0.0080	0.0110	0.0080	0.0230	0.0230	0.0230	0.0230	0.0230
SUSS06	R472	0.1070	0.1070	0.1070	0.0310	0.0270	0.0190	0.0190	0.0000	0.1020	0.1960	0.2010	0.1960	0.1020	0.0980	0.0980	0.0980	0.1070	0.1020	0.1020	0.0040	0.0040	0.0080	0.0040	0.0190	0.0190	0.0190	0.0190	0.0190
SUSS04	R467	0.1020	0.1020	0.1020	0.0230	0.0230	0.0080	0.0040	0.0230	0.1020	0.1960	0.2010	0.2120	0.1020	0.0970	0.0970	0.0970	0.1060	0.1020	0.1020	0.0230	0.0190	0.0230	0.0190	0.0080	0.0080	0.0040	0.0080	0.0080
SUSS01	R458	0.0980	0.0980	0.0980	0.0190	0.0190	0.0040	0.0000	0.0190	0.0970	0.1910	0.1970	0.2070	0.0980	0.0930	0.0930	0.0930	0.1020	0.0980	0.0980	0.0190	0.0150	0.0190	0.0150	0.0040	0.0040	0.0000	0.0040	0.0040
SUSS02	R462	0.0940	0.0940	0.0940	0.0190	0.0230	0.0040	0.0080	0.0230	0.0980	0.1960	0.2010	0.2120	0.0980	0.0940	0.0940	0.0940	0.1030	0.0980	0.0980	0.0230	0.0190	0.0230	0.0190	0.0040	0.0040	0.0080	0.0040	0.0040
SUSS03	R464	0.0940	0.0940	0.0940	0.0150	0.0190	0.0000	0.0040	0.0190	0.0980	0.1960	0.2010	0.2120	0.0980	0.0940	0.0940	0.0940	0.1030	0.0980	0.0980	0.0190	0.0150	0.0190	0.0150	0.0000	0.0000	0.0040	0.0000	0.0000
SUSS04	R465	0.0980	0.0980	0.0980	0.0190	0.0190	0.0040	0.0000	0.0190	0.0970	0.1910	0.1970	0.2070	0.0980	0.0930	0.0930	0.0930	0.1020	0.0980	0.0980	0.0190	0.0150	0.0190	0.0150	0.0040	0.0040	0.0000	0.0040	0.0040
SUSS04	R466	0.1020	0.1020	0.1020	0.0230	0.0230	0.0080	0.0040	0.0230	0.1020	0.1960	0.2010	0.2120	0.1020	0.0970	0.0970	0.0970	0.1060	0.1020	0.1020	0.0230	0.0190	0.0230	0.0190	0.0080	0.0080	0.0040	0.0080	0.0080
R. convicta Mund	R15	0.0430	0.0430	0.0430	0.0800	0.0930	0.0720	0.0760	0.0840	0.0550	0.2070	0.2020	0.2020	0.0590	0.0600	0.0600	0.0550	0.0630	0.0590	0.0590	0.0840	0.0800	0.0840	0.0800	0.0720	0.0720	0.0760	0.0720	0.0720
R. convicta Munda	R16	0.0510	0.0510	0.0510	0.0800	0.0840	0.0630	0.0670	0.0750	0.0720	0.2180	0.2230	0.2230	0.0760	0.0680	0.0680	0.0640	0.0800	0.0760	0.0760	0.0750	0.0710	0.0760	0.0710	0.0630	0.0630	0.0670	0.0630	0.0630
R. convicta Southern Burrup	R258	0.0640	0.0640	0.0640	0.1060	0.1110	0.0980	0.0970	0.1020	0.0000	0.2180	0.2130	0.2130	0.0110	0.0270	0.0270	0.0310	0.0150	0.0110	0.0110	0.1060	0.0980	0.1020	0.0980	0.0980	0.0980	0.0970	0.0980	0.0980
R. angulata Northern Burrup	R275	0.1870	0.1870	0.1870	0.1960	0.2060	0.1960	0.1910	0.1960	0.2070	0.0190	0.0150	0.0310	0.2180	0.2030	0.2030	0.1970	0.2230	0.2180	0.2180	0.1960	0.1910	0.1960	0.1910	0.1960	0.1960	0.1910	0.1960	0.1960
R. angulata Northern Burrup	R273	0.1970	0.1970	0.1970	0.2060	0.2160	0.2070	0.2020	0.2060	0.2180	0.0230	0.0040	0.0350	0.2180	0.2130	0.2130	0.2080	0.2230	0.2180	0.2180	0.2070	0.2010	0.2070	0.2010	0.2070	0.2070	0.2020	0.2070	0.2070
R. angulata Northern Burrup	R274	0.1920	0.1920	0.1920	0.2010	0.2110	0.2010	0.1970	0.2010	0.2130	0.0230	0.0190	0.0350	0.2230	0.2080	0.2080	0.2030	0.2290	0.2230	0.2230	0.2010	0.1960	0.2010	0.1960	0.2010	0.2010	0.1970	0.2010	0.2010
R. convicta Southern Burrup	R254	0.0640	0.0640	0.0640	0.0930	0.0970	0.0850	0.0840	0.0890	0.0270	0.2030	0.1970	0.1970	0.0310	0.0310	0.0310	0.0350	0.0350	0.0310	0.0310	0.0930	0.0850	0.0890	0.0850	0.0850	0.0850	0.0840	0.0850	0.0850
R. convicta Southern Burrup	R256	0.0640	0.0640	0.0640	0.1060	0.1110	0.0980	0.0970	0.1020	0.0000	0.2180	0.2130	0.2130	0.0110	0.0270	0.0270	0.0310	0.0150	0.0110	0.0110	0.1060	0.0980	0.1020	0.0980	0.0980	0.0980	0.0970	0.0980	0.0980

		SUSS07	*R. richardsonii* Port Hedland	*R. richardsonii* Port Hedland	*R. richardsonii* Port Hedland	SUSS04	SUSS04	SUSS07	SUSS05	SUSS06	SUSS04	SUSS01	SUSS02	SUSS03	SUSS04	SUSS04	*R. convicta* Munda	*R. convicta* Munda	*R. convicta* Southern Burrup	*R. angulata* Northern Burrup	*R. angulata* Northern Burrup	*R. angulata* Northern Burrup	*R. convicta* Southern Burrup	*R. convicta* Southern Burrup
		R478	R490	R487	R489	R469	R468	R479	R471	R472	R467	R458	R462	R464	R465	R466	R15	R16	R258	R275	R273	R274	R254	R256
R. convicta Cossack	R512																							
R. convicta Cossack	R508																							
R. convicta Cossack	R509																							
SUSS01	R457																							
SUSS01	R460																							
SUSS03	R463																							
SUSS08	R486																							
SUSS06	R476																							
R. convicta Southern Burrup	R367																							
R. angulata Northern Burrup	R287																							
R. angulata Northern Burrup	R311																							
R. angulata Northern Burrup	R312																							
R. convicta West Intercourse Island	R387																							
R. convicta Nickol Bay	R430																							
R. convicta Nickol Bay	R426																							
R. convicta Nickol Bay	R427																							
R. convicta West Intercourse Island	R389																							
R. convicta West Intercourse Island	R314																							
R. convicta West Intercourse Island	R350																							
SUSS05	R470																							
SUSS06	R473																							
SUSS06	R474																							
SUSS06	R475																							
SUSS08	R485																							
SUSS07	R477																							
SUSS07	R480																							
SUSS08	R484																							
SUSS08	R482																							
SUSS07	R478																							
R. richardsonii Port Hedland	R490	0.1340																						
R. richardsonii Port Hedland	R487	0.1430	0.0080																					
R. richardsonii Port Hedland	R489	0.1290	0.0150	0.0230																				
SUSS04	R469	0.0270	0.1290	0.1380	0.1240																			
SUSS04	R468	0.0230	0.1200	0.1290	0.1150	0.0080																		
SUSS07	R479	0.0080	0.1340	0.1430	0.1290	0.0190	0.0150																	
SUSS05	R471	0.0350	0.1200	0.1290	0.1150	0.0230	0.0230	0.0350																
SUSS06	R472	0.0390	0.1240	0.1340	0.1200	0.0190	0.0190	0.0310	0.0040															
SUSS04	R467	0.0310	0.1290	0.1380	0.1240	0.0080	0.0080	0.0230	0.0270	0.0230														
SUSS01	R458	0.0270	0.1240	0.1340	0.1200	0.0040	0.0040	0.0190	0.0230	0.0190	0.0040													
SUSS02	R462	0.0270	0.1200	0.1290	0.1150	0.0110	0.0040	0.0190	0.0270	0.0230	0.0110	0.0080												
SUSS03	R464	0.0230	0.1200	0.1290	0.1150	0.0080	0.0000	0.0150	0.0230	0.0190	0.0080	0.0040	0.0040											
SUSS04	R465	0.0270	0.1240	0.1340	0.1200	0.0040	0.0040	0.0190	0.0230	0.0190	0.0040	0.0000	0.0080	0.0040										
SUSS04	R466	0.0310	0.1290	0.1380	0.1240	0.0080	0.0080	0.0230	0.0270	0.0230	0.0000	0.0040	0.0110	0.0080	0.0040									
R. convicta Munda	R15	0.0800	0.1260	0.1350	0.1210	0.0800	0.0720	0.0800	0.0800	0.0840	0.0800	0.0760	0.0720	0.0720	0.0760	0.0800								
R. convicta Munda	R16	0.0800	0.1210	0.1300	0.1160	0.0710	0.0630	0.0800	0.0710	0.0750	0.0710	0.0670	0.0630	0.0630	0.0670	0.0710	0.0150							
R. convicta Southern Burrup	R258	0.1060	0.1500	0.1600	0.1450	0.1020	0.0980	0.1060	0.0970	0.1020	0.1020	0.0970	0.0980	0.0980	0.0970	0.1020	0.0550	0.0720						
R. angulata Northern Burrup	R275	0.2060	0.2180	0.2290	0.1970	0.1970	0.1960	0.1960	0.2010	0.1960	0.1960	0.1910	0.1960	0.1960	0.1910	0.1960	0.1970	0.2180	0.2070					
R. angulata Northern Burrup	R273	0.2170	0.2180	0.2290	0.1970	0.2070	0.2070	0.2060	0.2110	0.2060	0.2070	0.2020	0.2070	0.2070	0.2020	0.2070	0.2020	0.2230	0.2180	0.0190				
R. angulata Northern Burrup	R274	0.2110	0.2130	0.2240	0.1910	0.2020	0.2010	0.2010	0.2060	0.2010	0.2010	0.1970	0.2010	0.2010	0.1970	0.2010	0.2020	0.2230	0.2130	0.0040	0.0230			
R. convicta Southern Burrup	R254	0.0930	0.1310	0.1410	0.1260	0.0890	0.0850	0.0930	0.0840	0.0890	0.0890	0.0840	0.0850	0.0850	0.0840	0.0890	0.0430	0.0590	0.0270	0.1920	0.2030	0.1970		
R. convicta Southern Burrup	R256	0.1060	0.1500	0.1600	0.1450	0.1020	0.0980	0.1060	0.0970	0.1020	0.1020	0.0970	0.0980	0.0980	0.0970	0.1020	0.0550	0.0720	0.0000	0.2070	0.2180	0.2130	0.0270	

Appendix 3

DEH Search Tool Results

Details 20° 48' 00"; 119° 12' 03" with a 50km buffer around this central point.

Matters of National Environmental Significance

Threatened Species	Status	Type of Presence
Birds		
Rostratula australis Australian Painted Snipe	Vulnerable	Species or species habitat may occur within area
Mammals		
Dasycercus cristicauda Mulgara	Vulnerable	Species or species habitat likely to occur within area
Dasyurus hallucatus Northern Quoll	Endangered	Species or species habitat may occur within area
Rhinonicteris aurantius (Pilbara form) Pilbara Leaf-nosed Bat	Vulnerable	Community likely to occur within area
Reptiles		
Morelia olivacea barroni Olive Python (Pilbara subspecies)	Vulnerable	Species or species habitat may occur within area

Migratory Species	Status	Type of Presence
Birds		
Haliaeetus leucogaster White-bellied Sea-Eagle	Migratory	Species or species habitat likely to occur within area
Hirundo rustica Barn Swallow	Migratory	Species or species habitat may occur within area
Merops ornatus Rainbow Bee-eater	Migratory	Species or species habitat may occur within area
Migratory Wetland Species		
Birds		
Charadrius veredus Oriental Plover, Oriental Dotterel	Migratory	Species or species habitat may occur within area
Glareola maldivarum Oriental Pratincole	Migratory	Species or species habitat may occur within area
Numenius minutes Little Curlew, Little Whimbrel	Migratory	Species or species habitat may occur within area
Rostratula benghalensis s. lat. Painted Snipe	Migratory	Species or species habitat may occur within area

Other Matters Protected by the EPBC Act

Listed Marine Species	Status	Type of Presence
Birds		
Apus pacificus Fork-tailed Swift	Listed - overfly marine area	Species or species habitat may occur within area
Ardea alba Great Egret, White Egret	Listed - overfly marine area	Species or species habitat may occur within area
Ardea ibis Cattle Egret	Listed - overfly marine area	Species or species habitat may occur within area
Charadrius veredus Oriental Plover, Oriental Dotterel	Listed - overfly marine area	Species or species habitat may occur within area
Glareola maldivarum Oriental Pratincole	Listed - overfly marine area	Species or species habitat may occur within area
Haliaeetus leucogaster White-bellied Sea-Eagle	Listed	Species or species habitat likely to occur within area

Hirundo rustica Barn Swallow	Listed - overfly marine area	Species or species habitat may occur within area
Merops ornatus Rainbow Bee-eater	Listed - overfly marine area	Species or species habitat may occur within area
Numenius minutes Little Curlew, Little Whimbrel	Listed - overfly marine area	Species or species habitat may occur within area
Rostratula benghalensis s. lat. Painted Snipe	Listed - overfly marine area	Species or species habitat may occur within area

Field survey for conservation significant bats near Sulphur Springs, Pilbara

Type:	Field survey and management advice
Client:	CBH Resources Ltd
Prepared by:	MOLHAR Pty Ltd
Date:	13 July 2007

MOLHAR PTY LTD
Applying DNA technology

Job012 Document revision history

Date	Type
29 June 2007	First draft for comment by CBH Resources Ltd / URS
13 July 2007	Final draft to CBH Resources / URS

Front page: hidden, deep, steep-sided gullies like this are a favourite foraging habitat for Pilbara leaf-nosed bats.

MOLHAR PTY LTD ABN 46 117 824 629 Established January 2006

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Contents Page

EXECUTIVE SUMMARY

CBH Resources Ltd plans a zinc – copper mine (the 'Panorama Project') at Sulphur Springs, south-east of Port Hedland. Commissioning of the Project is scheduled for the end of 2008 and first production in 2009. This report provided specialist advice on two conservation-significant bat species - Pilbara leaf-nosed bat *Rhinonicteris aurantia* (listed under the *Environment Protection and Biodiversity Conservation Act 1999*) and the ghost bat *Macroderma gigas* (listed as 'Priority 4' under the Western Australian Department of Environment and Conservation's *Priority Fauna List*). There are several separate issues that involve these species, but particularly the Pilbara leaf-nosed bat:

1. Night traffic (haulage trucks and light vehicles) passing close to a roosting colony in the Lalla Rookh mine (along the 'Plains Access Road') and along an upgraded road that will traverse the Sulphur Springs valley (the 'Sulphur Springs Valley Road') might cause a significant number of bat roadkills;
2. Dewatering for the mine pit and water extraction from bores adjacent to the Lalla Rookh mine might reduce water levels in the Lalla Rookh workings to the point where humid microclimates suitable for the bats are unable to be maintained;
3. Earthworks for mine infrastructure might result in the removal or disturbance of natural roosts of these species;
4. Noise and vibration from traffic, as well as human visitation resulting from the close proximity of the Plains Access Road to the Lalla Rookh mine might result in disturbance to the bat colony.

A field survey and literature reviews were conducted to:

1. Determine the presence of the Pilbara leaf-nosed bat over the plain north from the Lalla Rookh mine, in the context of the position of the miscellaneous lease for the Plains Access Road.
2. Determine the presence of the Pilbara leaf-nosed bat foraging at night in areas within 20 km of the Lalla Rookh mine.
3. Survey areas for cave roosts in close proximity to the Sulphur Springs Valley Road, and in the wider area.
4. Assess the potential effect of water drawdown on water levels and roost habitat suitability based on historical drawings of the underground structure of the Lalla Rookh mine; and assess possible responses to reducing bat roadkills by seeking background information on previous occurrences.

The main conclusions from the study were:

1. Pilbara leaf-nosed bats forage at least 750 m over the flat plain north of the Lalla Rookh mine, and beyond the northern extent of the miscellaneous lease in the vicinity of this roost.
2. The species also forages in five deep gullies examined in the area, and they can be found as far east as the North Pole mining centre, and west to Strelley Gorge.
3. The survey did not identify diurnal roost sites in the most prospective gullies in the area. Given that no other roost sites are currently known from near the project area, and the general lack of deep caves, it was concluded that bats foraging in the ranges adjacent to the proposed Panorama Project area would roost in the Lalla Rookh mine. Therefore, the Pilbara leaf-nosed bat might be capable of nightly foraging bouts of a significant distance – up to 32 km round trip commuting distance, given that Strelley Gorge is 16 km from Lalla Rookh.
4. Dewatering by up to 15 m near the Lalla Rookh mine might still allow for humid microclimates suitable for bat habitation to be maintained.

Specific recommendations made to reduce the likelihood of significant impacts from the project included (*further details in section 6.0*):

1. **Bat roadkill – management.** Measures should be taken to limit the amount of night traffic along the Plains Access Road and Sulphur Springs Valley Road, especially between dusk and midnight for haul trucks, and speed limits should be posted at 60 km/hr.
2. **Bat roadkill – mitigation.** CBH might consider helping to develop an acoustic deterrent device to be attached to vehicles travelling at night to further reduce the risk of roadkills.
3. **Pumping for water at the Lalla Rookh mining area**. Decreasing the water level below 43 m from the surface in the vicinity of the North Reef workings from the combined effects of pit dewatering and bore extraction should be avoided.
4. **Access to the Lalla Rookh mining area.** Access to the this area should be restricted to workers with a reason to enter the area; the stope containing the bat colony should be signposted, and the fence improved; and site safety inductions should inform that the site is off-limits.
5. **Use of barbed wire.** Barbed wire should not be used in the project area given the recognised threat to ghost bat entanglement and mortality over their wide foraging range.

Fences that have a requirement for barbed wire under Australian Standards, such as those around electrical substations, should have metal plates wired between the top two strands to increase their visibility to bats.

6. **Future monitoring of bat presence.** Monitoring the continued presence of both the Pilbara leaf-nosed bat and the ghost bat would be required to demonstrate that they maintain their presence, though it could be limited to simple qualitative assessments, such as simple presence/absence and an estimation of activity ('high', 'low') given the constraints on collecting useful data.

1.0 INTRODUCTION AND SCOPE

1.1 THE PROPOSED DEVELOPMENT

CBH Resources Ltd (CBH) plans a zinc – copper mine (the 'Panorama Project') at Sulphur Springs, south-east of Port Hedland (Figure 1). The resource is a shallow-dipping massive sulphide system. The company plans an open cut mine and ore processing plant to produce 80,000 tonnes per annum of copper concentrates (25% Cu) and 90,000 tonnes per annum of zinc concentrates (53% Zn). With its partner Sipa Resources, CBH continues an active and extensive programme of exploration in the area, and drilling has identified further potential resources at several other localities nearby including Kangaroo Caves and Bernts. Commissioning of the Project is scheduled for the end of 2008 and first production in 2009. This report provides specialist advice on bats and was sought by CBH as part of the environmental approval process.

The Sulphur Springs deposit is located on Panorama Station, west of the Shaw River and just south of a series of Archean ridges that overlook the flat plains that extend to the coast. Numerous gullies and gorges dissect this range, including a watercourse that emanates from Sulphur Springs itself. The water from this spring is relatively acidic, since the water percolates through the sulphide system. A track connects the project area to the Port Hedland – Marble Bar Road (53.6 km S of the North West Coastal Highway turnoff). This track provides access to pastoral leases, and eventually leads to the Sulphur Springs valley. On the way, it passes close (within 600 m) to a series of old underground workings at 'Lalla Rookh'. These are currently abandoned, but Haoma Mining NL has an interest in the remaining gold resources in this area. The road is to be upgraded for haulage of ore by trailer trucks to a concentrate loading facility at Port Hedland.

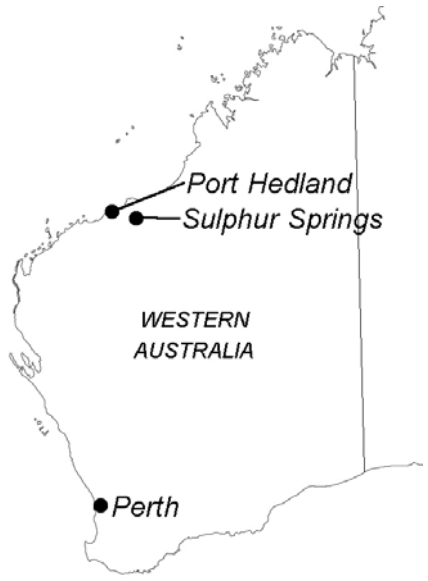

FIGURE 1. Approximate location of Sulphur Springs, south-east of Port Hedland.

1.2 BACKGROUND INFORMATION ON SPECIES OF SIGNIFICANCE

Two species of bat with an elevated conservation status are present adjacent to the project area – the orange leaf-nosed bat *Rhinonicteris aurantia* (Pilbara 'form'; also called the 'Pilbara leaf-nosed bat', which is the nomenclature used in this report), and ghost bat *Macroderma gigas*. Of these, the occurrence of the Pilbara leaf-nosed bat is of greater concern. Background information on the two species, their conservation status and the implications of their occurrence near the project area are given below.

Pilbara leaf-nosed bat *Rhinonicteris aurantia*

The Pilbara leaf-nosed bat is isolated from populations in the Kimberley, the Top End of the Northern Territory, and north-west Queensland by the Great Sandy Desert (Churchill et al. 1988; Churchill 1998; Figure 2). There is evidence from their cranial morphology, ultrasonic echolocation calls and from genetic markers that this population is divergent below the species level, which reflected their long period of isolation in the Pilbara environment (Armstrong 2002; 2006; Armstrong and Coles 2007). While these differences have not yet resulted in a formal taxonomic reclassification, the distinctness of the Pilbara population qualified it for recognition as a separate 'form' pending the collection of further data, and also for separate protection in a Threatened category under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (*EPBC Act 1999*; *see section 1.3 Conservation Status*).

FIGURE 2. General distribution of the orange leaf-nosed bat *Rhinonicteris aurantia* (adapted from Churchill 1998; Armstrong 2007).

In the Pilbara, the species is restricted to caves and mine workings with stable, warm and humid microclimates because of their poor ability to thermoregulate and retain water (Kulzer et al. 1970; Churchill et al. 1988; Jolly 1988; Churchill 1991; Baudinette et al. 2000; Armstrong 2001). Extensive surveys for roost sites conducted over several years by Armstrong (2001, 2003) and also subsequently (K.N. Armstrong unpublished data) established that while the

species was distributed widely in the region, there were few opportunities for roosting in much of the terrain, and most importantly that the majority of the known population roosted in five locations in the eastern Pilbara in disused underground mines, or adjacent to active open cut mines.

While rare, Pilbara leaf-nosed bats can be detected relatively easily if present in an area. The echolocation call is distinctive and can be used for unambiguous identification. They emit a 'CF-FM' (constant frequency – frequency modulated) type call with a CF component of c. 120 kHz (Armstrong and Coles 2007). They forage relatively low (<3 m) over vegetation, particularly in gorge habitats (Armstrong 2001; K.N. Armstrong unpublished observations), and display a peculiar curiosity for light sources, which appears unrelated to foraging for insects (K.N. Armstrong unpublished observations). This characteristic can be exploited during field surveys if transects are conducted at night, with light from headtorches bringing bats within the effective range of electronic devices capable of recording their ultrasonic calls ('bat detectors'). It has also resulted in numerous reported roadkills after bats were attracted to the headlights of vehicles (Table 1). In the Pilbara, there have been five recorded instances, and in the Kimberley / Northern Territory, there have been eight. No other Australian bat is represented in a museum by so many roadkills.

TABLE 1. Recorded instances of roadkills of the Pilbara leaf-nosed bat from the Western Australian Museum and other unpublished sources.

Pilbara	Kimberley / Northern Territory
Millstream-Chichester National Park—1985	Ivanhoe—1964
Karratha—1985	Timber Creek—1980
Fortescue Roadhouse—1990	Kununurra—1978, 1980, 1993
Tom Price—1995	Yampi Sound—1995
Yarrie—2005	Adelaide River town—2007
	Tipperary Station—2007

Ghost bat *Macroderma gigas*

The ghost bat is one of Australia's most remarkable and iconic mammals, especially because of its large size and carnivorous diet that includes small birds, reptiles, mammals and large insects (Churchill 1998; Richards et al. 2007). Like the orange leaf-nosed bat, it is endemic to Australia, and is distributed across the north of the continent (Figure 3 – *next page*), though it once had a much wider distribution (Molnar et al. 1984; Churchill and Helman 1990). It often shares cave or mine roosts with the Pilbara leaf-nosed bat, especially in the largest and deepest structures (Armstrong and Anstee 2000). While it has a preference for the same warm, humid microclimates, it is somewhat tolerant of less stringent conditions. Thus, it can

sometimes be found in relatively shallow caves, though usually only one or a few individuals will be present. Relatively few large colonies are known and most occur in deep mines in the eastern Pilbara, or in ironstone adits in the Hamersley Range. Both population size and the number of known roosts supporting large colonies is greater than the Pilbara leaf-nosed bat, but it is similarly sensitive to disturbance in its roost and is particularly vulnerable to entanglement in barbed wire fences (Armstrong and Anstee 2000).

FIGURE 3. General distribution of the ghost bat *Macroderma gigas* (points indicate fossil and subfossil records; adapted from Churchill 1998, Richards et al. 2007).

1.3 CONSERVATION STATUS

The conservation status of the two bats is listed as follows:

Orange leaf-nosed bat *Rhinonicteris aurantia* (Pilbara 'form'; Pilbara leaf-nosed bat)

- 'Vulnerable' under the *EPBC Act 1999;*
- Schedule 1 ("fauna that is rare or is likely to become extinct") of the Western Australian *Wildlife Conservation (Specially Protected Fauna) Notice 2006*;
- 'Vulnerable' on the WA Department of Environment and Conservation *Priority Fauna List*.
- 'Vulnerable A1c' by the IUCN in 'The Global Status Survey and Conservation Action Plan for Microchiropteran Bats' (Hutson et al. 2001).
- The Pilbara 'form' was also listed in the 'Action Plan for Australian Bats' as 'Vulnerable' A1c, B1, B2c' (McKenzie et al. 1999)

Ghost bat *Macroderma gigas*

- 'Vulnerable A2c' by the IUCN in 'The Global Status Survey and Conservation Action Plan for Microchiropteran Bats' (Hutson et al. 2001).
- Priority 4 ("taxa in need of monitoring") under the Western Australian Department of Environment and Conservation *Priority Fauna List*.

1.4 IMPLICATIONS FOR BATS

The old workings at Lalla Rookh are of significance to the Panorama Project, since colonies of both species of bat listed in categories of conservation significance are known to occupy one stoped shaft in the Lalla Rookh area. These colonies were first discovered by Bamford and Wilcox (2001; ghost bat) and Armstrong (2004; Pilbara leaf-nosed bat).

In addition, during biological surveys in mid 2006 conducted by Biota Environmental Sciences Pty Ltd, a significant number of Pilbara leaf-nosed bats (nine) were captured in passive-capture type traps (harp traps) over three nights along the Sulphur Springs watercourse. This constituted a new record of the species.

There are several separate issues that involve both bat species, but particularly the Pilbara leaf-nosed bat in the context of this proposal. Those most likely to have the greatest impact include:

1. Night traffic (haulage trucks and light vehicles) passing close to the roosting colony in the Lalla Rookh mine (along the '**Plains Access Road**') might cause a significant number of bat roadkills;
2. Night traffic has the potential to result in a significant number of bat roadkills along an upgraded road that will traverse the Sulphur Springs valley (the '**Sulphur Springs Valley Road**');
3. Dewatering for the mine pit, and water extraction from bores adjacent to the Lalla Rookh mine, might reduce water levels in the old Lalla Rookh workings to the point where humid microclimates suitable for the bats are unable to be maintained;
4. Earthworks for mine infrastructure might result in the removal or disturbance of natural roosts of these species.
5. Noise and vibration from traffic, as well as human visitation resulting from the close proximity of the Plains Access Road to the Lalla Rookh mine, might result in disturbance to the bat colony.

The location of the roads, and other main features mentioned in this report are given in Figure 4.

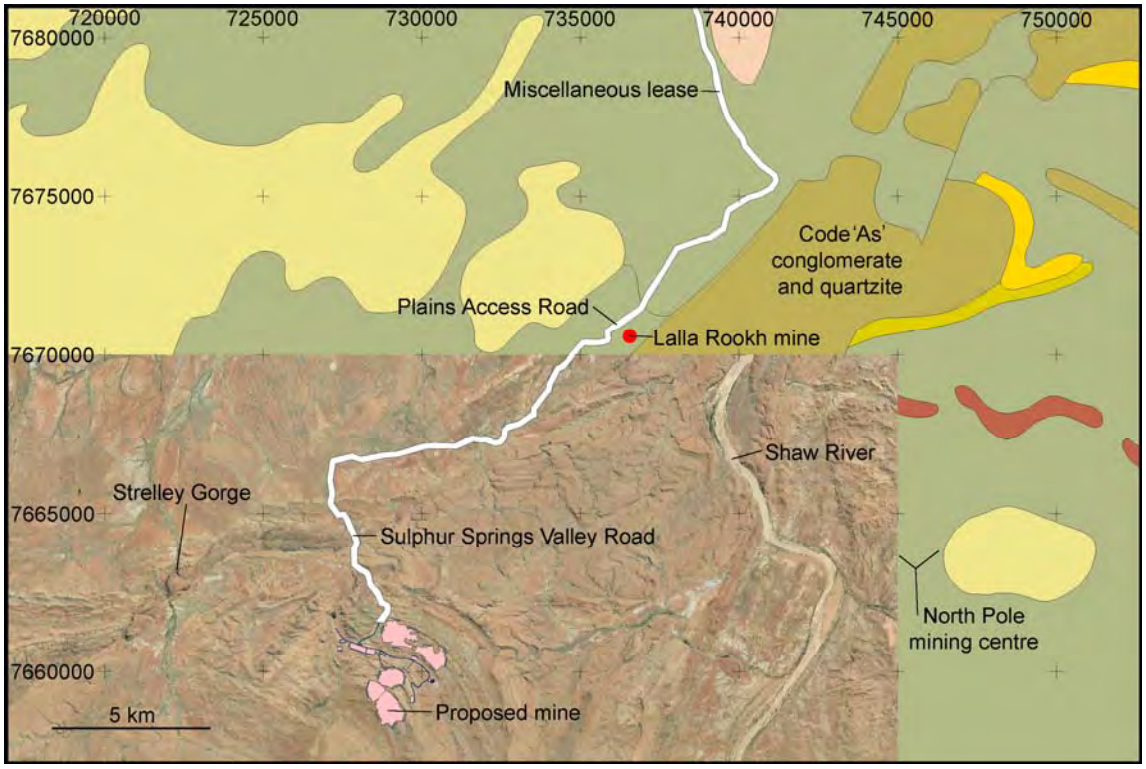

FIGURE 4. Main features in the Panorama Project area relevant to this survey (AMG85 Zone 50, Datum WGS84). The geology of the main unit (from GSWA 1996) to the east of the proposed mine is indicated, since it contains many deep gullies (*see section 5.3 for further details*).

The issues listed above should be considered realistic threats to the Pilbara leaf-nosed bat in particular for several reasons:

1. Their foraging height and curiosity for light sources brings them into contact with vehicles. A significant number of specimens of the Pilbara leaf-nosed bat (and their counterparts in the Kimberley and Northern Territory) lodged in the Western Australian Museum are derived from vehicle collisions (Table 1). Obviously, it is not possible to manage collisions of bats and vehicles on a regional scale, but placement of a road carrying regular traffic at night close to a significantly-sized colony will increase greatly the potential for vehicle-related mortality of bats. The species is thought to forage away from their roost mainly in gorge habitats (Armstrong 2001), but they do swarm near their roost entrance for several hours after dusk (K.N. Armstrong unpublished observations). To address this issue, it is relevant to consider the distance at which bats move out from their roost towards the existing access track (the planned Plains Access Road will follow this), and also Information on the situation in which the roadkills have occurred in the past, especially information on vehicle speed at the time of collision.

2. The Lalla Rookh mine is one of the most important roosts for Pilbara leaf-nosed bats in the Pilbara. The Pilbara leaf-nosed bat is listed as 'Vulnerable' under the *EPBC Act 1999* in recognition of its distinctness from the northern populations of *R. aurantia*, and also because most of its known population is restricted to five localities in the eastern Pilbara. 'Significant colonies' are known from four underground mines in the eastern Pilbara — Lalla Rookh mine, Bamboo Creek mine, Klondyke Queen mine, Copper Hills mine; and cave roosts occur in the Yarrie – Nimingarra area (exact locations remain undiscovered). The only other significant group known occurs in Barlee Range Nature Reserve (western Pilbara). The remaining records in the region are of <5 individuals observed while in flight. Recently, 32 individuals of the Pilbara Leaf-nosed bat were captured and released at the Lalla Rookh mine as part of a population genetic study, and it was observed that the colony numbered many more (K.N. Armstrong unpublished observations, August 2006). Of the five important colonies in the eastern Pilbara listed above, only the Lalla Rookh mine and Bamboo Creek mine are known to support around or at least 100 individuals, with the Lalla Rookh colony representing probably a fifth of their known regional population.

In addition to the issue of vehicle collisions (*see Point 1 above*), the implications for the Panorama Project include water drawdown as a result of dewatering for the pit and from water extraction from bores nearby the old Lalla Rookh workings. If the water level in the Lalla Rookh mine decreases below a certain level, it is possible that a concomitant decrease in the humidity of the roost microclimate would occur, which would render the habitat unsuitable. In this case, the result would be a decrease in the area of occupancy of the two bat species, which should be avoided. To address this issue, information on the structure of the Lalla Rookh mine is required in order to be able to assess the effect on projected drawdown from hydrological models.

3. The capture of nine Pilbara leaf-nosed bats in the Sulphur Springs valley suggests that it is an important foraging area. Habitat in the Sulphur Springs valley is typical of those where they have been observed foraging in the region (Armstrong 2001, K.N. Armstrong unpublished observations). They have been observed foraging in similar habitats at Cattle Gorge near Yarrie, Geode Creek near Paraburdoo-Channar, a small gorge at Soansville and Goodaman Creek in Barlee Range Nature Reserve. Such habitats are reasonably common in the region, but are presumably only used by Pilbara leaf-nosed bats if they occur near suitable roost sites (natural caves or disused underground mine workings of suitable structure), since their presence is first limited by the occurrence of a suitable roost.

The Pilbara Leaf-nosed bat is an acrobatic flier, and is difficult to capture in flight away from its roost, since they are able to detect nets and similar structures with their echolocation. The capture total at Sulphur Springs by Biota Environmental Sciences in a passive trapping setup, and over several nights is unprecedented, and suggested that a large number of the species use this gully for foraging. Furthermore, the aggregation of significant numbers of foraging individuals might be suggestive of limited foraging opportunity elsewhere in the local area. Alternatively, since they are known to swarm after dusk near their roost site and in the vicinity of other underground structures, a roost site might be close by.

The presence of the Pilbara leaf-nosed bat in the Sulphur Springs valley constitutes an issue for the planned Sulphur Springs Valley Road for the same reason as the Plains Access Road, in that collisions with vehicles have the potential to cause bat mortality. The location of their roost site is highly relevant to this situation. If the roost site is located nearby (i.e. within the same valley, or in a valley nearby), then the haul road would bring vehicles in close proximity to an entire colony. If the roost site was actually in the Lalla Rookh mine, then it is relevant to consider whether the Sulphur Springs valley is their only foraging area. If a wider search of similar habitats in the area revealed the presence of Pilbara leaf-nosed bats, it could be assumed that the planned Sulphur Springs road would not be affecting the entire Lalla Rookh colony at once.

4. A roost site is not known from the Sulphur Springs area. A previous GIS study of the distribution of suitable habitat for the Pilbara leaf-nosed bat based on geology, topography and knowledge of roost site locations identified their potential area of occupancy in the region (Armstrong 2001, 2003). Some geological formations comprising the greenstone terrain had limited representation in the resulting distribution model, and were only included because of the presence of underground gold and copper mines. The ability of greenstone and chert to proliferate deep caves suitable for maintaining warm, humid microclimates was considered to be low. Thus, the most obvious site for a roost of those detected in the Sulphur Springs valley is the Lalla Rookh mine. However, the potential still exists for natural caves to support a colony of the Pilbara Leaf-nosed bat nearby. Preliminary observations of aerial photographs of this valley suggested that the terrain was not of the type with good cave-forming propensity, though areas of bluffs still have the potential to contain relatively deep caves preferred by this species.

2.0 AIMS and LIMITATIONS

The aims of the field survey were to:

1. Determine the presence of the Pilbara leaf-nosed bat over the plain north from the Lalla Rookh mine, in the context of the position of the miscellaneous lease for the Plains Access Road.
2. Determine the presence of the Pilbara leaf-nosed bat foraging at night in areas within 20 km of the Lalla Rookh mine.
3. Survey areas for cave roosts in close proximity to the Sulphur Springs Valley Road, and in the wider area.
4. Upon returning from the field visit, locate plans of the underground structure of the Lalla Rookh mine in order to assess the potential effect of water drawdown on mine water levels and habitat suitability. Locate further information on bat roadkill occurrences.

Limitations to the field survey included:

1. Without a comprehensive field programme involving marking, capture and radiotracking, it was not possible to determine the origin of foraging bats in the Sulphur Springs valley.

2. Areas that may contain roosts within the nightly foraging range of bats observed in the Sulphur Springs valley are unable to surveyed completely, however it was feasible to determine whether there are roosts in close proximity to the Sulphur Springs Valley Road.

3. Recommendations for reducing the likelihood of bat mortality from vehicle collisions will be limited by economic feasibility, especially recommendations to move the roads.

4. Surveying for this species is difficult for many reasons, including the scale of the landscape, and the fact that it is difficult to assess occupancy in natural caves because the species prefers to roost deep into the structure, and often beyond the point at which an investigator can access. Thus, even if a potentially suitable roost is found, assessment of occupancy must be made at the time of dusk emergence.

3.0 METHODS

The field survey was conducted between 11 – 16 June 2007.

3.1 PLAINS ACCESS ROAD – ASSESSING FORAGING DISTANCE NORTH OF LALLA ROOKH

Foraging distance over the flat plains north of the Lalla Rookh mine was assessed using electronic bat call detectors. These contain microphones sensitive to the ultrasonic echolocation calls of bats, and allow recording for later analysis or output for real-time identification. The Pilbara leaf-nosed bat produces an echolocation call of c. 120 kHz, which can be identified unambiguously either by computer analysis of the recorded signal, or simply by an experienced person listening to the real-time heterodyne output of a bat detector. Two Anabat II detectors each connected to a CF-ZCAIM unit (Titley Electronics, NSW) were placed at several distances from the Lalla Rookh mine over several nights. These units recorded signals onto a CF card for later computer analysis. In addition, nightly monitoring for varying periods (minimum 2 hours) between 8:00 pm and midnight was conducted with a D240x unit (Pettersson Elektronik AB, Sweden) set to heterodyne mode. The maximum survey distance from the Lalla Rookh was c. 760 m, which was beyond the northern edge of the CBH miscellaneous lease (lease boundary indicated in Figure 4), and coincided with a dry sandy watercourse. Detector surveys (real-time identification with the heterodyne detector) were conducted both with headtorch lights on, and lights off on different nights.

3.2 SULPHUR SPRINGS ROAD – BROAD-SCALE PRESENCE OF FORAGING BATS

Topographic maps (1:100 000 scale) and aerial photographs were used to identify potential foraging habitat in the Sulphur Springs area prior to the field visit. Several relatively deep gullies and gorges were identified for ground searches. In addition, historical mining areas with underground workings to the east of the Shaw River were included in the search itinerary.

Ground searches involved walking transects in gullies from dusk with hand-held electronic bat detectors. The curiosity of the Pilbara leaf-nosed bat for light sources was an advantage during night transects, since attraction to headtorch-light brings the bats within range of the bat detectors (within c. 5 m for a 120 kHz call in dry air). The D240x detector was set to 120 kHz in heterodyne mode, and calls were recorded in time expansion mode (10x) onto a Microtrack 24/96 Professional 2-channel digital recorder (M-Audio, USA), and saved in Wave format (44.1 kHz resolution, 16 bit) for later verification. Wave files were visualised in Cool Edit 2000 software (Syntrillium Corp.).

3.3 ROOST SITE SURVEYS

Armstrong (2001) suggested that deep gorges and gullies were the landscape units most likely to contain caves suitable for the Pilbara leaf-nosed bat. Daytime transects were made in search of cave roosts in the deepest and most likely gullies. Some of these were also traversed at night to assess foraging activity of bats. Caves were not to be entered, but checked for emergence of bats at dusk with bat detectors if, from their external appearance, they appeared large and deep enough to support a colony.

4.0 RESULTS

4.1 PLAINS ACCESS ROAD – ASSESSING FORAGING DISTANCE NORTH OF LALLA ROOKH

- Pilbara leaf-nosed bats were heard on each of the five survey nights foraging along a dry sandy watercourse 760 m north of the Lalla Rookh mine. This watercourse was slightly north of the miscellaneous lease (Figure 5). The species was also detected regularly flying over vegetation between the watercourse and the old mine, with both the heterodyne D240x detector and the Anabat detectors.

- Pilbara leaf-nosed bats were present in this area regardless of whether headtorches were turned on or off. Areas between the road and the dry watercourse were traversed without lights, and the species was always present, particularly along the dry sandy watercourse. Their presence was recorded soon after dusk and as late as 1.00 am (and possibly later).

- Areas north of this watercourse were not surveyed for Pilbara leaf-nosed bats, since it was outside the miscellaneous lease.

- One individual was almost hit by our vehicle at c. 9.30 pm along the Plains Access Road 2130 m from the Lalla Rookh mine (Figure 5). It swooped into the lights and almost hit the windscreen. Vehicle speed was c. 50 km/hr. The habitat was open plain, and the location was 940 m from the nearest range, and at least 2500 m from the nearest significantly-sized gully.

4.2 SULPHUR SPRINGS ROAD – BROAD-SCALE PRESENCE OF FORAGING BATS

- Five transects were made at night in gully habitats (Gullies A – E; Figure 6). Orange bats were detected on all transects (reference calls illustrated in Figure 7). The location of most bat passes in front of the bat detector is shown by the position of an orange dot in Figure 6. In two gullies (B, D), bat activity appeared relatively high and passes were recorded along almost the entire length of the transect. Two ghost bats were observed in the Sulphur Springs valley, which flew away when approached.

- In all cases, the time of first detection was between 6.30 – 6.45 pm, which corresponds to 62 mins after sunset (5.28 pm) and 38 mins after civil twilight end (5.52 pm). Thus, given that Pilbara leaf-nosed bats emerge from their diurnal roost when it is almost fully dark (around civil twilight end; K.N. Armstrong personal observations), they appear at their gully foraging sites around 40 mins later. It is certainly possible that the bats arrived earlier than they were detected.

- While the Pilbara leaf-nosed bat was present in all gully habitats surveyed, suggesting that they prefer this habitat, the presence of a 'collision near miss' also indicates that foraging / commuting takes place in open habitats at least 2 km from the roost or gully habitat.

4.3 ROOST SITE SURVEYS

- Two underground workings (an adit and a vertical shaft) at the North Pole mining centre did not contain the Pilbara leaf-nosed bat, though the adit contained two ghost bats. However, we recorded several passes of two individuals of the Pilbara leaf-nosed bat over a small (5 m long) pool of water in a gully adjacent to a drill track and 960 m from the nearest working. While the habitat was much more open than other gullies where this species was observed, they were only recorded in the watercourse. Discussion with caretakers at the Normay mining centre nearby revealed that further small underground workings are present nearby at Mickey's Find, some apparently containing water, however there was insufficient time to survey these. The distance between North Pole and Lalla Rookh is c. 10.5 km. It is possible that the bats observed over the pool at North Pole came from Lalla Rookh or nearby from somewhere such as Mickey's Find.

- In addition to the daytime transects to locate underground mines, three other daytime transects were undertaken in the most prospective gullies for caves (Gullies B – E; Figure 6). This included areas adjacent to the Sulphur Springs valley. No caves deemed suitable for the Pilbara leaf-nosed bat or the ghost bat were observed. A small

cave near the proposed camp did not appear suitable, but was not assessed for bat emergence.

- One small cave in Gully D (Figure 6) was observed that appeared suitable as a night roost. It was within the watercourse, and below a small ephemeral waterfall (Plate 1). It was fronted by a pool and appeared to be c. 3 m deep, and contained elevated humidity. The cave was not entered, but a small amount of bat guano of around the correct size for Pilbara leaf-nosed bats was noted at the entrance. The structure was very similar to a deeper night roost in Barlee Range that is visited nightly by significant numbers of Pilbara leaf-nosed bats (60+; Armstrong 2001).

4.4 LITERATURE SEARCHES AND CONTACT REPORTS

- Historical information on the structure of the Lalla Rookh mine was sought in the Bewick Moreing reports held in the public library of the WA Department of Industry and Resources. Descriptions of the workings at Lalla Rookh revealed that there were two main underground systems – the 'North Reef' and 'South Reef'. The deepest parts of these mines were 140 feet [42.7 m] and 150 feet [45.7 m] respectively. It was noted that the waterlevel in the North Reef stood at 100 feet [30.5 m] below the surface and that Underwood's winze (a continuation of the Duncan shaft, which extends 55 feet [16.8 m] below the 89 foot [27.1 m] horizontal drift level) was under water (Finucane 1936).

- Permission was also obtained from Haoma Mining NL to access historical plans for the Lalla Rookh that are held by the Department of Consumer and Employment Protection. The plans show extensive mulit-level workings below ground in both the North and South Reef systems, with drifts, shafts ending in sumps, winzes, cross-cuts and large stoped sections (Figures 8 and 9). The opening that Pilbara leaf-nosed bats and ghost bats exit from appears to be either the Duncan Shaft (No. 2) or Shaft No. 3 of the North Reef workings, considering its location relative to the main shaft (over which is a large headframe). All shafts in the North Reef are connected to the underground system, which comprises two drifts at 89 feet [27.1 m] and 140 feet [42.7 m].

- Further information was sought on the nature of bat roadkills from people who had donated the most recent specimens. Of particular relevance was the speed at which vehicles were travelling at the time. Extracts from their communications are provided below:

- Employees of Ecologia Environment Pty Ltd were travelling at c. 40 km/hr along a gravel road in the Yarrie – Goldsworthy area in 2005. A Pilbara leaf-nosed bat flew into the windscreen, and the carcass was submitted to the Western Australia Museum (M. Ladyman pers. comm.).

- Two individuals of the orange leaf-nosed bat were hit by a vehicle in the Northern Territory between 1.00 – 2.00 am in April 2007. The first was hit along Dorat Rd near the town of Adelaide River, in savannah habitat and near a large escarpment. The second individual was hit along the access road to Tipperary Station. On both occasions, the vehicle was travelling between 100 – 110 km/hr. Several individuals were observed foraging at heights of <3 m, and the habitat was open (G. Madani pers. comm.). The specimens will be submitted to the Western Australian Museum.

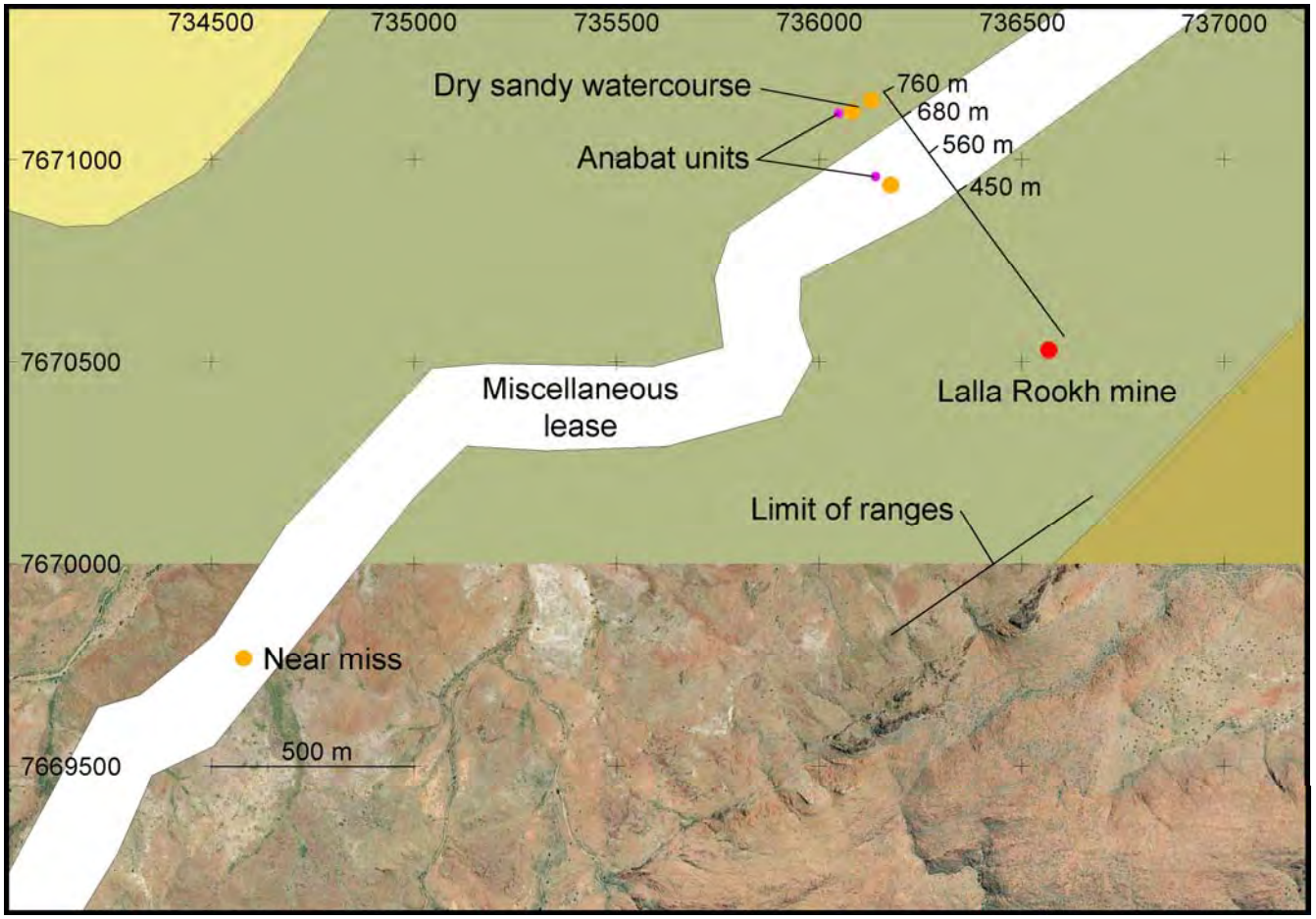

FIGURE 5. Area near the Lalla Rookh mine showing proximity of the existing road (centre line of the miscellaneous lease) to the old workings (red dot). Pilbara leaf-nosed bats were recorded along the entire length of the distance indicated between the Lalla Rookh mine and the dry sandy watercourse. Anabat detector placement is indicated (purple dots), as well as the location where our vehicle almost collided with a Pilbara leaf-nosed bat. Coloured polygons indicate geological terrain (GSWA 1996).

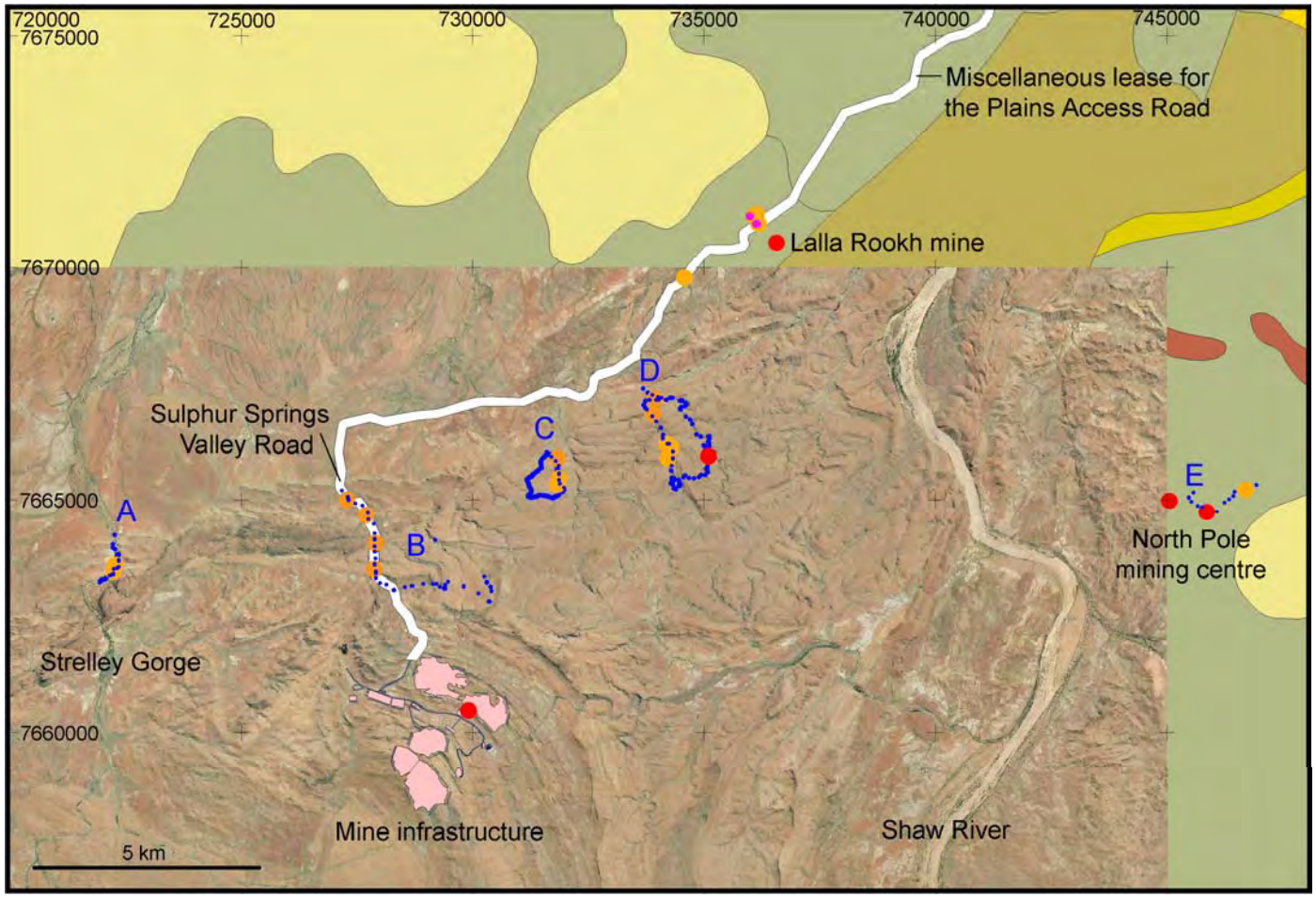

FIGURE 6. Overview of the survey area. Points A – E indicate the starting points of the five day and night transects, with blue dots approximating the route taken. Orange dots represent locations where Pilbara leaf-nosed bats were heard on electronic bat detectors. Red dots indicate potential diurnal or nocturnal roosts of the species, with the only confirmed roost being the Lalla Rookh mine. The miscellaneous lease for the road is indicated in white, other coloured polygons indicate geological terrain boundaries (GSWA 1996).

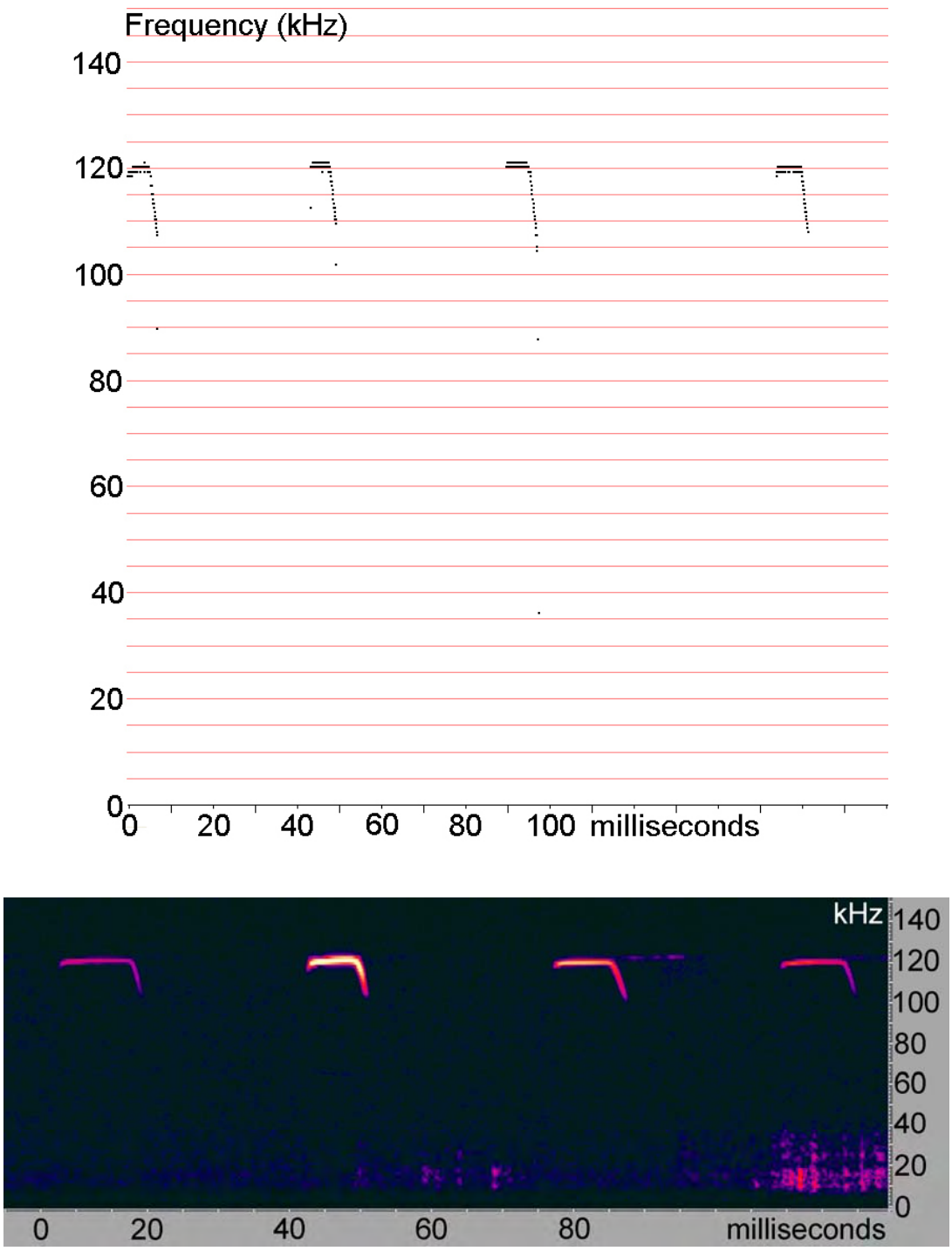

FIGURE 7. Example reference calls from the Anabat frequency division detector (top) and Pettersson D240x time expansion detector (bottom). Time between pulses has not been compressed. Both sequences illustrate pulses with a constant frequency – frequency modulated structure and a characteristic frequency of c. 120 kHz.

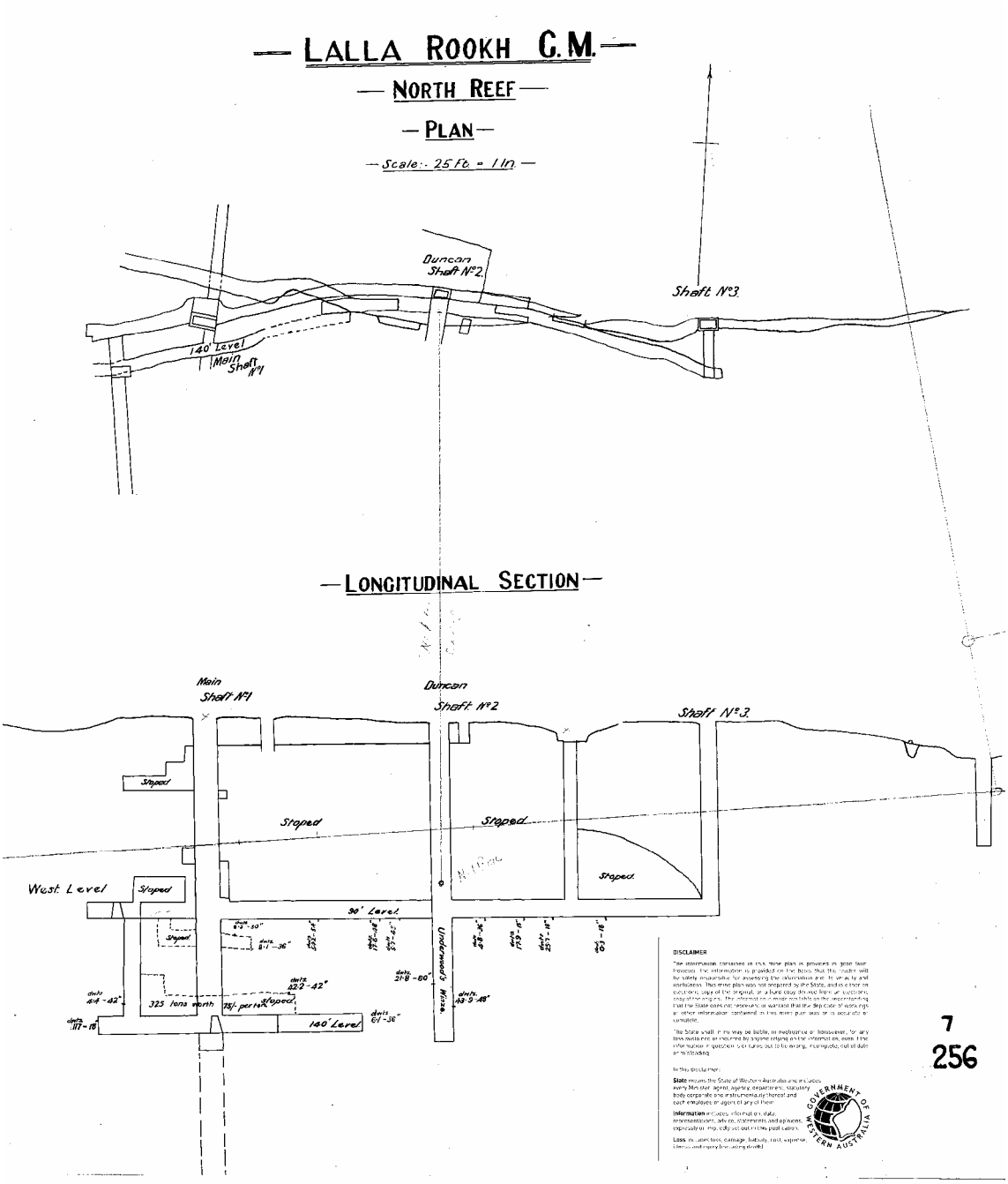

FIGURE 8. Plan of underground workings at the North Reef (Anon. c. 1930's, a). Pilbara leaf-nosed bats and ghost bats are thought to occupy this structure.

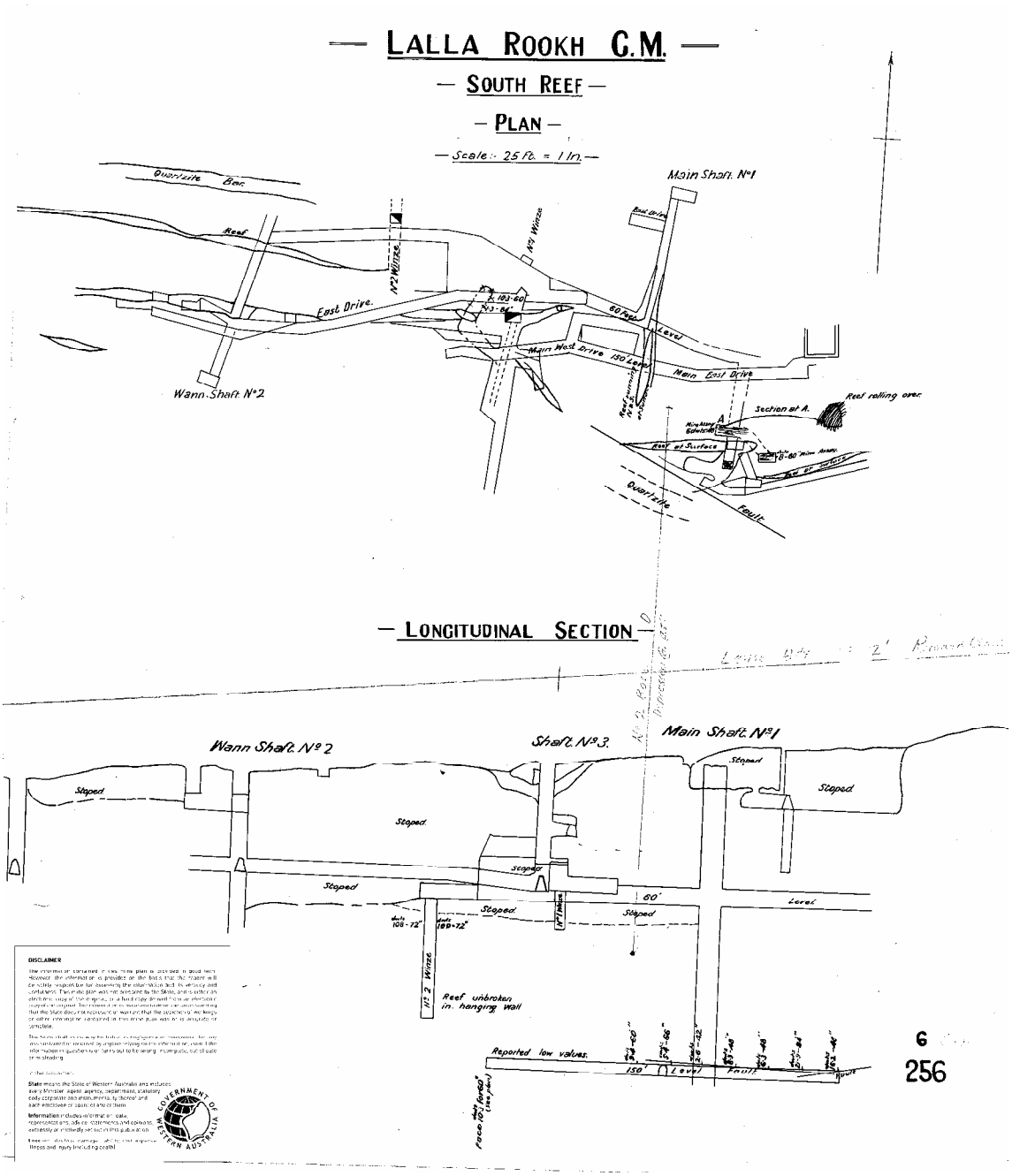

FIGURE 9. Plan of underground workings at the South Reef (Anon. c. 1930's, b). It is not known whether Pilbara leaf-nosed bats and ghost bats occupy this structure.

PLATE 1. Possible night roost of the Pilbara leaf-nosed bat in Gully D (indicated with a red dot in Figure 6). The entrance to the cave is c. 50 cm high.

5.0 DISCUSSION

5.1 SUMMARY OF OBSERVATIONS

There were three main conclusions that arose from the field survey:

1. Pilbara leaf-nosed bats forage at least 750 m over the flat plain north of the Lalla Rookh mine, and beyond the northern extent of the miscellaneous lease in the vicinity of this roost.

2. The species also forages in all (five) deep gullies examined in the area, and they can be found as far east as the North Pole mining centre, and west to Strelley Gorge.

3. The survey did not identify diurnal roost sites in the most prospective gullies in the area. Given that no other roost sites are currently known from the Shaw River area, it may be assumed that bats foraging in the ranges adjacent to the proposed Sulphur Springs area roost in the Lalla Rookh mine. Thus, this species might be capable of nightly foraging bouts of a significant distance – up to 32 km round trip commuting distance, given that Strelley Gorge is 16 km from Lalla Rookh.

5.2 FORAGING DISTANCE FROM THE LALLA ROOKH

From this survey, it is apparent that the Pilbara leaf-nosed bat forages widely at the foot of the ranges and within the numerous gullies in the area. The Lalla Rookh mine has been identified previously as a significant roost for the species, and is also the most likely origin for the majority of Pilbara leaf-nosed bats in the Shaw River area. The nightly foraging range of the Pilbara leaf-nosed bat is not known, however it is not an unreasonable assumption that the distance between the Lalla Rookh mine and the Sulphur Springs valley is within their capability. Similar-sized bats from New Zealand (long-tailed bats *Chalinolobus tuberculatus*) moved frequently and rapidly within their range (790 ± 471 SD m/15 mins; average range length 3.3 – 10 km; maximum 19 km) every night (O'Donnell 2001). The Pilbara leaf-nosed bat has a similar aspect ratio and wing loading, as well as "usual foraging strategy" and "usual foraging microhabitat" to the two Australian species of wattled bats *Chalinolobus gouldii* and *C. morio* (Bullen and McKenzie 2002), so nightly range capability is likely to be similar.

Without a comprehensive field programme involving marking, capture and radiotracking, it would not be possible to determine the origin of foraging bats in the Sulphur Springs valley. However, this knowledge would not help resolve the issues involving the species in the context of this project. This survey established that the Sulphur Springs valley was not the

only foraging locality of the species in the area, and therefore, assuming that most bats roost in the Lalla Rookh, only part of the colony would be exposed to traffic along the proposed Sulphur Springs Valley Road. Given the relatively high capture rate by Biota Environmental Sciences, and the high number of passes detected by bat detectors on the present survey in the Sulphur Springs valley, this is still likely to be a significant number of individuals.

The observation of a possible 'night roost' in Gully D (Figure 6) might support the suggestion that Pilbara leaf-nosed bats travel over 10 km from their diurnal roost. The cave had a similar structure and microclimate to a night roost of this species identified in Barlee Range (Armstrong 2001). Such caves might be used transiently on a nightly basis for resting between bouts of foraging, especially if the diurnal roost is relatively distant. While these structures are unsuitable as daytime refuges, they might be very important for allowing members of larger-sized colonies to find suitable foraging habitat a significant distance away from their roost and thus avoid intra-specific competition.

5.3 ROOST SEARCHES

A colony occurring in a natural cave would be highly significant, since it would not be subject to the threats typically imposed on colonies roosting in disused mines (collapse, further mining, flooding; McKenzie et al. 1999). No roost was located in areas planned for development within or adjacent to the Sulphur Springs valley, on this survey or the 2006 survey conducted by Biota Environmental Sciences.

Initial inspections of maps and aerial photographs of the area revealed a small number of prospective deep gullies. The steep escarpment is composed of conglomerates, pebbly sandstone, mudstone, siltstone, and chert (code 'As'; GSWA 1996), as well as quartzites (a compact metamorphosed sandstone that comprises quartz grains cemented with silica) (Finucane 1936). The likelihood of natural roosts was considered to be low, although sedimentary formations have some degree of cave-forming propensity, unlike the nearby greenstones. Field inspections revealed that the structure of the formation was similar in some ways to the sedimentary formations at Barlee Range, especially their degree of folding (which encourages cave formation between weaknesses). However, the layers were much thinner than the massive silcretes of the Kiangi Creek Formation at Barlee Range, and often oriented vertically rather than horizontally (usually what appeared to be chert), which did not encourage cave formation. The small potential night roost in Gully D was an exception. These observations of geology and the general lack of caves was further evidence that the Lalla Rookh mine supports the largest, if not the only colony within 10 km of the Sulphur Springs project. It is acknowledged that the entire local area was not searched, however it is

difficult to imagine that a deep natural cave containing more than a few Pilbara leaf-nosed bats is present in this area.

Regardless of the fact that the Lalla Rookh mine is an artificial habitat, it should be considered highly important both locally and regionally, and encroachment of Project infrastructure on this roost would be significant.

5.4 POTENTIAL MITIGATION MEASURES TO PREVENT BAT ROADKILL

The baseline fauna study conducted by Bamford and Wilcox (2001) drew attention to the close proximity (300 m) of the Plains Access Road to colonies of bats in the Lalla Rookh mine. The mine is actually a little further from the existing road than the 300 m quoted by Bamford and Wilcox (2001: p 17; it is actually 560 m). Although they did not make a confirmed observation of the Pilbara leaf-nosed bat in this mine at the time (for lack of appropriate specialised equipment), their comments and recommendations are still relevant. These comments were based mainly on the perceived threat of noise and vibration to the colony of ghost bats. They recommended that a buffer zone of at least 1 km be maintained between the road and the mine, which would involve realigning the road by several hundred metres. There is no available information on the effects of noise and vibration from roads on these or similar bat species, and it is assumed that the recommended buffer zone size was considered adequate for avoiding these anticipated effects. However, they recognised this would not be an ideal solution because the shift would involve crossing several watercourses, which would increase other environmental impacts. In addition, the potential effects of noise and vibration from daytime traffic on this road might be considered relatively minor in comparison to other disturbances such as casual visitation of old workings and the increased mortality from roadkill.

There are several possible solutions for reducing the likelihood of bat roadkill from the Plains Access Road. The most obvious is to remove the source of the threat, which would involve relocating the Plains Access Road. A potential route would be from where the Shaw River crosses the Marble Bar Road in a relatively straight line to the mouth of the Sulphur Springs valley. The terrain is relatively flat, but contains numerous small watercourses. However, the construction of this road, in addition to its high cost, would involve a significant amount of vegetation clearing. It appears that there would be many negative implications in realigning this road.

Re-routing the Sulphur Springs Valley Road was also considered. An alternative route that was considered by CBH earlier crossed hilly terrain west of the Sulphur Springs valley.

While it would avoid Pilbara leaf-nosed bats foraging in this valley, the present survey demonstrated that the species forages widely over the general area of the ranges, including in gullies that would be intersected by this earlier alternative route. It is understood that there would also be cost and safety issues for heavily-laden haul trucks on steep grades. Thus, there seems to be no alternative but to construct the mine access and haul road through the Sulphur Springs valley.

If the roadway cannot be moved, then attention is drawn to the traffic that will travel on this road. Haulage of ore by trailer trucks is planned over a 24 hour period. While Pilbara leaf-nosed bats forage throughout the night, activity near the roost appears greatest in the few hours following dusk. Scheduling of the haul trucks to avoid travel in the period between dusk and (nominally) midnight is an obvious solution. Limiting light vehicle travel at night along the access road might be easier to accommodate. Maintaining a relatively low speed limit along the access road is also likely to reduce the probability of collisions with bats. The collision of a bat near Yarrie demonstrates that even relatively slow speeds can result in mortality, however it is suggested that a reduction in speed reduces the probability of collision. The combination of reducing night traffic and enforcing a low speed limit along the access road appears to represent the only feasible solution to this issue.

In response to this situation, it was also relevant to consider more novel ways to exclude bats from the roadway. Ideas included permanent lights (with bulbs that do not attract insects) along the 'high-risk' sections of road (all bat species stay outside well-lit areas, but some may venture to the edge to capture insects), visual barriers to prevent the bats seeing headlights, and an acoustic deterrent. Of all of these, the acoustic deterrent is considered to have the highest chance of success, as well as being the more cost effective. While the success of this approach cannot be guaranteed, it might reduce the likelihood of bat collisions even further. Further notes are given in the recommendations.

5.5 BARBED WIRE AND MONITORING

Both the Pilbara leaf-nosed bat and the ghost bat face some similar issues from the Panorama Project (the potential effect of changed microclimates in the Lalla Rookh mine from water extraction; the potential effect of noise and vibration from the road), however others pertain only to one species (e.g. night traffic along the access roads is considered relevant to the Pilbara leaf-nosed bat; barbed wire and human visitation of the Lalla Rookh mine are considered more relevant to the ghost bat). Thus, addressing the issues for one species does not completely consider the other.

The recommendation of Bamford and Wilcox (2001) that barbed wire should be avoided and removed where present near the Lalla Rookh mine is very relevant. Armstrong and Anstee (2000) highlighted the issue of ghost bat mortality from entanglement in barbed wire fences in the Pilbara, and summarised known occurrences at that time. There have been several entanglements reported since in several localities (N.L. McKenzie pers. comm.). Placement of barbed wire around a roost of this species is likely to cause a massive decline. Use of barbed wire further away in the project area might also cause mortality. Ghost bats forage in the Sulphur Springs valley, and presumably widely in the area. They are strong fliers, and may cover distances even greater than that of the Pilbara leaf-nosed bat. Previous records of entanglements in the region (Armstrong and Anstee 2000) demonstrated that entanglements can remove a large proportion of a local colony, despite being situated away from the roost entrance and in the wider area used for foraging.

Bamford and Wilcox (2001) also recommended fencing around the Lalla Rookh mine to restrict casual human visitation, and implementation of monitoring to assess numbers and seasonal usage of the mine by ghost bats. Ghost bats are relatively simple to count, since most individuals leave the roost at dusk, and do not re-enter until some time later. They are also large and pale, and so easily counted when they exit. The potential effects of noise and vibration from the nearby road could be assessed through these simple counts, however there are two major limitations to the usefulness of such data. Firstly, there is no available information on the degree of usage of this roost by ghost bats in the absence of disturbances, which introduces a confounding factor. Secondly, a disturbance at other nearby roosts containing large colonies might affect colony size at the Lalla Rookh. As an example of this effect, the number of ghost bats in the Klondyke Queen mine near Marble Bar varied between 107 – 336 individuals over a 5-day period (Biota 2001), and it was suggested that a disturbance at a nearby roost was the cause. In addition, if the proximity of the planned road caused a decline in numbers, a monitoring programme would simply be documenting this, and the same issues would remain. Despite these limitations, monitoring would be required, however a programme could be designed in a cost effective way to ensure that resources available for environmental mitigation are allocated to the most useful solutions.

It is not possible to gain accurate counts of the Pilbara leaf-nosed bat because they swarm near the entrance of their roosts at dusk. A bat detector such as the Anabat system can be used to collect echolocation calls over a full night automatically with virtually no disturbance to the colony. While quantifying activity levels as assessed with bat detectors is possible, it will not allow for a meaningful comparison among surveys, since many factors can affect how many calls are recorded on the detector (apart from impacts from the mining project, variation

might result from natural fluctuations in numbers, atmospheric conditions and the orientation of the microphone). The effects of these factors cannot be separated. Furthermore, while the large size of this colony allows for a qualitative assessment based on activity levels (i.e. 'many bats present', 'few bats present'), a gradual decline in numbers from roadkill for example would not be detected. Therefore monitoring will only allow for simple qualitative assessments, and simple presence/absence. Counts of the ghost bat will not allow an estimation of the effect of project infrastructure on the Pilbara leaf-nosed bat, and the various confounding factors will remain.

5.6 Mine Pit Dewatering Zone, and Water Extraction from Adjacent the Lalla Rookh

Plans of the underground structure of the Lalla Rookh mine were sought in order to determine whether dewatering would result in complete drying of the structure. It is assumed that if the water level in the mine falls below the extent of the workings, the humidity would not be maintained, and the roost microclimate would become unsuitable for both the Pilbara leaf-nosed bat and the ghost bat. The intention was to provide a maximum drawdown level, rather than an assessment of the effect of various hydrological models and test pumping results.

Examination of the plans suggested that the 'North Reef' workings are occupied by the two species. A previous visit in 2004 established that the slightly-inclined stope east of the headframe (possibly the Duncan shaft or shaft 3; at 50K 736567 7670527, WGS84) was the only opening from which ghost bats exited (K.N. Armstrong pers. obs. April 2004). The Pilbara leaf-nosed bat also exits in significant numbers from this opening (K.N. Armstrong pers. obs. August 2006), though it is certainly possible that this species uses other entrances in the local area. It has been noted before that these two species prefer underground workings with an adit or inclined opening, rather than a steeply vertical shaft.

Within this mine are two main horizontal levels ('drifts') at 89 feet [27.1 m] and 140 feet [42.7 m], and that the water level could be around 100 feet [30.5 m] below the surface (Finucane 1936). Bats would be most likely to roost in the 89 foot drift or one of the stopes (Figure 8). The water level could drop by 50 feet [15.2 m], which would presumably allow access of bats to the lower drift. Further lowering might reduce the humidity in the mine. Given its depth, and the fact that air would not be flushed easily from the mine (it is only accessed by vertical or near-vertical openings), humidity would probably be maintained despite dewatering below the 140 foot [42.7 m] level. However, if possible, complete dewatering of the Lalla Rookh should be avoided.

6.0 RECOMMENDATIONS

1. **Bat roadkill – management.** The potential for a significant decline in the local abundance of the Pilbara Leaf-nosed bat from repeated mortality from roadkill is high. Given that it appears to be a major and costly exercise to relocate the Plains Access Road away from the Lalla Rookh roost, measures should be taken to limit the amount of night traffic along this road, especially between dusk and midnight for haul trucks. The likelihood of a collision between a vehicle and a bat will also be reduced at lower speeds. Therefore, night traffic on the Sulphur Springs Valley Road, and the stretch of the Plains Access Road between the gully and the point at which it turns north to follow the Shaw River, should be limited to 60 km/hr.

2. **Bat roadkill – mitigation.** CBH might consider helping to develop a measure to deter bats from vehicles travelling at night to further reduce the risk of roadkills. The solution with the highest likelihood of success appears to be an acoustic deterrent device, which would be attached to a vehicle. While we do not yet know which type of signal would cause bats to move away from vehicles (in contrast to attracting them), it would be possible to conduct a carefully designed experiment in the Sulphur Springs valley to test an electronic set-up developed through discussion between a Zoologist and an acoustic engineer. The project could be completed within a reasonable budget that would represent far less than the cost of re-aligning the road, and might have wide-ranging benefits in the context of other issues, including wind farms. It is suggested that as a first step, CBH commission a literature review on the past success of other acoustic deterrents for wildlife (e.g. for kangaroos), and design an experimental set-up that would allow collection of unambiguous results. The resulting device might also be designed to deter other Threatened fauna in the area.

3. **Pumping for water at the Lalla Rookh mining area**. The combined effects of pit dewatering and bore extraction should avoid decreasing the water level below 45 m from the surface in the vicinity of the North Reef workings.

4. **Access to the Lalla Rookh mining area.** Access to the Lalla Rookh mining area should be restricted to workers with a reason to enter the area, such as for servicing the pumps. The stope containing the bat colony should be signposted, and the fence improved (*see Recommendation 5 below regarding barbed wire*). Site safety inductions should inform that the site is off-limits, and should specifically warn of repercussions for those entering the fenced area and throwing rocks into the structure.

5. **Use of barbed wire.** Barbed wire should not be used in the project area given the recognised threat to ghost bat entanglement and mortality over their wide foraging range. Improvement of the fence around the Lalla Rookh mine should obviously not incorporate barbed wire, and strands on the fence should not be excessively tight or close together. If cattle must be excluded from certain operations for safety reasons, barbed wire can be used on lower strands, but the top strand should be plain. Other fences, such as those around electrical substations that have a requirement for barbed wire under Australian Standards, should have metal plates (at least 10 cm x 10 cm) wired between the top two strands, at intervals of no greater than 2 m.

6. **Future monitoring of bat presence.** Monitoring the continued presence of both species would be required to demonstrate that both the Pilbara leaf-nosed bat and the ghost bat maintain their presence. Given the many limitations on collecting useful data, this monitoring programme would not need to be excessively comprehensive or costly, and could be limited to short visits to make qualitative assessments, such as simple presence/absence and an estimation of activity ('high', 'low').

7.0 ACKNOWLEDGEMENTS

Thank you to Paul Webala (Murdoch University) for assistance in the field; to Piers Higgs (Gaia Resources Pty Ltd) for advice with mapping.

8.0 REFERENCES

Anon. (circa 1930's, a). Lalla Rookh G. M. [Gold Mine], North Reef. Location 256, map 7, held at Department of Consumer and Employment Protection, Perth.

Anon. (circa 1930's, b). Lalla Rookh G. M. [Gold Mine], South Reef. Location 256, map 6, held at Department of Consumer and Employment Protection, Perth.

Armstrong, K.N. (2001). The roost habitat and distribution of the orange leaf-nosed bat, *Rhinonicteris aurantius*, in the Pilbara region of Western Australia. Wildlife Research 28: 95–104.

Armstrong, K.N. (2002). Morphometric divergence among populations of *Rhinonicteris aurantius* (Chiroptera: Hipposideridae) in northern Australia. Australian Journal of Zoology 50: 649–669.

Armstrong, K.N. (2003). The bats that time forgot: the Orange Leaf-nosed Bat *Rhinonicteris aurantius* (Gray, 1845) (Microchiroptera: Hipposideridae) in the Pilbara region of Western Australia. PhD thesis, Department of Animal Biology, The University of Western Australia.

Armstrong (2004). Genetic structure of the ghost bat in the Pilbara: Alternative approaches for determining roost importance. Interim report for Phases 1 and 2. Unpublished report by Biota Environmental Sciences Pty Ltd for Robe River Mining Co. Pty Ltd and Hamersley Iron Pty Ltd, September 2004.

Armstrong, K.N. (2006). Phylogeographic structure in *Rhinonicteris aurantia* (Chiroptera: Hipposideridae): implications for conservation. Acta Chiropterologica 8: 63–81.

Armstrong, K.N. (2007). Pilbara Leaf-nosed Bat *Rhinonicteris aurantia*. pp. 470–471 In: Mammals of Australia 3rd edition (ed. S. Van Dyck). Australian Museum. In press.

Armstrong, K.N. and Anstee, S.D. (2000). The ghost bat in the Pilbara: 100 years on. Australian Mammalogy 22: 93–101.

Armstrong, K.N. and Coles, R.B. (2007). Echolocation call frequency differences between geographic isolates of *Rhinonicteris aurantia* (Chiroptera: Hipposideridae): implications of nasal chamber size. Journal of Mammalogy 88: 94–104. .

Bamford, M.J. and Wilcox, J.A. (2001). Panorama Project Area: Baseline fauna study as part of the Sulphur Springs feasibility study. Unpublished report by M.J. and A.R. Bamford Consulting Ecologists Pty Ltd for Astron Environmental Pty Ltd, November 2001.

Biota (2001). Managing threatened bats during the Klondyke Queen drilling program, Marble Bar. Unpublished report by Biota Environmental Sciences Pty Ltd for Cardinal Minerals Ltd and Lynas Corporation, May-July 2001.

Baudinette, R.V., Churchill, S.K., Christian, K.A., Nelson, J.E., and Hudson, P.J. (2000). Energy, water balance and the roost microenvironment in three Australian cave-dwelling bats (Microchiroptera). Journal of Comparative Physiology B 170: 439–446.

Bullen, R.D. and McKenzie, N.L. (2002). Scaling bat wingbeat frequency and amplitude. Journal of Experimental Biology 205: 2615–2626.

Churchill, S.K. (1991). Distribution, abundance and roost selection of the Orange Horseshoe-bat, *Rhinonycteris aurantius*, a tropical cave dweller. Wildlife Research 18: 343–353.

Churchill, S.K. (1998). Australian bats. Reed New Holland: Frenchs Forest, NSW.

Churchill, S.K., Helman, P.M. and Hall, L.S. (1988). Distribution, populations and status of the Orange Horseshoe Bat, *Rhinonicteris aurantius* (Chiroptera: Hipposideridae). Australian Mammalogy 11: 27–33. [incorrectly marked as 1987]

Churchill, S.K. and Helman, P.M. (1990). Distribution of the Ghost Bat, *Macroderma gigas*, (Chiroptera: Megadermatidae) in central and south Australia. Australian Mammalogy 13: 149–156.

Finucane, K.J. (1936). Lalla Rookh Mining Centre. The aerial, geological and geophysical survey of northern Australia. Pages 35-47, File 19 in the Bewick Moreing reports, held at the Department of Industry and Resources, Perth.

GSWA (1996). Bulletin 144 Plate 1B Geology of the Fortescue Group – East, Pilbara Craton (1:500 000). Geological Survey of Western Australia: Perth, Western Australia.

Hutson, A.M., Mickleburgh, S.P. and Racey, P.A. (comp.) (2001). Microchiropteran Bats: Global Status Survey and Conservation Action Plan. IUCN/SSC Chiroptera Specialist Group. IUCN, Gland, Switzerland, and Cambridge, UK.

Jolly, S. (1988). Five colonies of the Orange Horseshoe Bat, *Rhinonycteris aurantius* (Chiroptera: Hipposideridae), in the Northern Territory. Australian Wildlife Research 15: 41–49.

Kulzer E., Nelson J.E., McKean J.L. and Möhres F.P. (1970). Untersuchungen über die Temperaturregulation australischer Fledermäuse (Microchiroptera). Zeitschrift fuer Vergleichende Physiologie 69: 426–438.

McKenzie, N., Armstrong, K. and Kendrick P. (1999). Pilbara leaf-nosed bat. pp. 36–38, in The Action Plan for Australian Bats. (A. Duncan, G.B. Baker and N. Montgomery eds.) Environment Australia, Canberra.

Molnar, R.E., Hall, L.S. and Mahoney, J.H. (1984). New fossil localities for *Macroderma* Miller, 1906 (Chiroptera: Megadermatidae) in New South Wales and its past and present distribution in Australia. Australian Mammalogy 7: 63–73.

O'Donnell, C.F.J. (2001). Home range and use of space by *Chalinolobus tuberculatus*, a temperate rainforest bat from New Zealand. Journal of Zoology 253: 253–264.

Richards, G.C., Hand, S., Armstrong, K.N. and Hall, L.S. (2007). Ghost Bat *Macroderma gigas*. pp. 449–450 In: Mammals of Australia 3rd edition (ed. S. Van Dyck). Australian Museum. In press.

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APPENDIX 4: LEVEL 1 TERRESTRIAL FAUNA SURVEY (OUTBACK ECOLOGY 2012A)

Pilbara Copper-Zinc Project

Level 1 Terrestrial Fauna Survey

November 2012

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Pilbara Copper-Zinc Project: Level 1Terrestrial Fauna Survey

Distribution:

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Document Control for Job Number: VPX-FS-0611

Document Status	Author	Reviewer	Signature	Date of Issue
Draft Report	B. Parsons, T. Lee-Steere	D.Jasper		3 May 2011
Final Report	B. Parsons, P. Bolton	T. File		19 September 2011
Final Report v2	B. Parsons, P. Bolton, T. Derham			30 October 2012
Final Report v3	T. Derham			15 November 2012

Executive Summary

Venturex Resources Limited (Venturex) commissioned Outback Ecology to undertake a terrestrial fauna desktop study and subsequent reconnaissance survey of the Pilbara Copper-Zinc Project (the Study area). The Study area is situated 80 km south-east of Port Hedland encompassing an area of 7,623 hectares, of which approximately 178 ha will be disturbed by the Project. Venturex proposes to develop an underground copper-zinc mine with a production rate of approximately 700,000 - 850,000 tonnes per annum. Works will incorporate an underground mine with twin decline access ramps, processing plant topsoil stockpiles, laydown/hardstand area, workshops and associated facilities, water treatment facility and associated evaporation ponds, cemented backfill batch plant, accommodation camp, access tracks and haul roads to Marble Bar Road. A temporary waste rock landform is proposed to house waste for a period of 1-3 years prior to all waste being returned underground as backfill.

The specific objectives of the terrestrial fauna desktop study were to:

- develop an inventory of terrestrial vertebrate fauna species and invertebrate short-range endemic (SRE) species identified within or likely to be present within the Study area;
- provide a description of vertebrate fauna habitat, sensitive habitat and terrestrial SRE invertebrate fauna habitat expected to occur within the Study area;
- assess desktop findings in the regional context by comparisons with available data from other localities within the bioregion; and
- identify knowledge gaps pertaining to terrestrial fauna within the Study area and recommend further investigations required to address these gaps in accordance with regulatory guidelines.

The specific objectives of the reconnaissance survey were to:

- ground truth the occurrence of fauna habitat within the Study area, specifically focused on Northern Quoll habitat, habitat for conservation significant bats (*Rhinonicteris aurantia* and *Macroderma gigas*) and habitat for SRE invertebrate species; and
- provide advice on any requirement for further fauna surveys.

Conclusions contained within this report are based on a desktop study and reconnaissance survey only (i.e. no sampling of fauna was conducted as part of this study). A general assessment was made as to the likelihood of particular species of conservation significance occurring within the Study area, given the broad habitat types likely to occur, and specific habitat features occurring therein. This report does not include an impact assessment, for which a separate report will be forthcoming following refinement of the Project footprint.

Six broad terrestrial fauna habitats were recorded within the Study area, comprising Spinifex Stony Plains, Rocky Foothills, Scree Slope, Spinifex Sandplains, Drainage Line and Rocky Ridges and Gorges. An additional two significant fauna habitats of limited extent were identified: Rubble Piles and Ficus Groves.

Based on database search findings and a review of relevant literature within the surrounding region, it is possible that a total of 392 terrestrial vertebrate fauna species may potentially occur within the Study area, comprised of 53 mammals (44 native), 211 birds, 116 reptiles, five fish and seven amphibian species.

Based on a more specific review of previous surveys within the Study area (Bamford Consulting Ecologists 2001, Biota 2007), it is possible that a total of 151 terrestrial vertebrate fauna species may potentially occur within the Study area, comprised of 27 mammals (22 native), 83 birds, 34 reptiles, five fish and two amphibian species.

A total of 23 conservation significant fauna species could potentially occur within the Study area, comprising:

- Eight species listed under the *Environment Protection and Biodiversity Act 1999* (EPBC Act) and the *Wildlife Conservation Act 1950* (WC Act): Northern Quoll, Mulgara, Greater Bilby, Pilbara Leaf-nosed Bat, Night Parrot, Pilbara Olive Python, Peregrine Falcon and Woma;
- Ten species listed as Priority 4 Fauna by the Department of Environment and Conservation (DEC): Ghost Bat, Spectacled Hare-wallaby, Western Pebble-mound Mouse, Long-tailed Dunnart, Lakeland Downs Mouse, Australian Bustard, Bush Stone-curlew, Grey Falcon, Star Finch, and *Ramphotyphlops ganei* (a blind snake); and
- Five species listed as Migratory under the EPBC Act: Fork-tailed Swift, Cattle Egret, Oriental Plover, Rainbow Bee-eater and Night Parrot.

Potential SRE invertebrate fauna habitat within the Study area is most likely to include Rocky Ridges and Gorges, and Drainage Lines habitat. Additionally, Rubble Piles and the Ficus Groves represent habitat isolates that may support SRE species. The remaining landscape within the Study area appears relatively uniform and does not correspond to typical SRE habitat; i.e. these habitat types were widespread, well connected and extensive throughout the surrounding landscape.

Three potential SRE species are known to occur in the region surrounding the Study area. Based on the broad habitats which occur, there is potential for all three of these species to occur within the Study area. The millipede *Antichiropus* 'abydos' has been collected 6.5km west of the Study area and the mygalomorph spider *Kwonkan* 'MYG200' has been collected 37 km south of the Study area. The pseudoscorpion *Feaella sp.* 'Sulphur Springs' is known from a single specimen collected from the Study area in 2007.

Previous survey effort within the Study area has provided a sound baseline and combined with existing data in the literature and from fauna databases, has adequately documented the faunal assemblages likely to be present.

On-ground reconnaissance suggests that much of the habitat within the Study area is of marginal quality for the conservation significant Pilbara Leaf-nosed Bats and Ghost Bats. Rocky Ridge and Gorge habitat is the habitat type most likely to support these species; however, deep, substantial caves required by these

species for breeding appear to be largely absent within this habitat type. In particular, there is little habitat considered of high quality for these species within proposed impact footprints (i.e. habitat containing deep, substantial caves). Should these species be making use of any minor caves within these areas, it is likely that they would be used as foraging or night roosts only. Despite this, disturbance to Rocky Ridge and Gorge habitat should be minimised, particularly within the valley and gorge system surrounding Sulphur Springs itself.

Northern Quolls are known to occur within the Study area with preferred habitat consisting of Rocky Ridge and Gorge habitat and Drainage Line habitat. A substantial portion of high quality Drainage Line habitat coincides with the proposed impact footprints, and is likely to impact upon Northern Quoll populations at a localised scale. The majority of Rocky Ridge and Gorge habitat lacks deep, substantial caves, crevices and outcropping required by this species as denning habitat, with the exception of the valley and gorge system surrounding Sulphur Springs itself. Disturbance to the high quality Drainage Line habitat and above mentioned valley and gorge should be minimised.

With consideration to the scale of the proposed project, the level of potential impacts and current knowledge of terrestrial fauna in the Study area, it is recommended that a Northern Quoll monitoring program be established for the Pilbara Copper-Zinc Project, consistent with EPBC guidelines for the species. The primary objectives of this monitoring program would be to:

- design and conduct a baseline population survey to provide quantitative data on Northern Quoll demographics and distribution in the Study area;
- provide pre-disturbance baseline population data that can be used to monitor the impacts of the Project on localised Northern Quoll populations; and
- develop future monitoring and management recommendations for the Northern Quoll within the Study area.

The pseudoscorpion *Feaella sp.* 'Sulphur Springs' is only known from one location, which may coincide with proposed impact footprint of the Project. Additionally, *Feaella sp.* 'Sulphur Springs' may occur in association with Drainage Line habitat; of which a considerable portion occurs within the proposed haulage route footprint in the northwest of the Study area. Subsequently a targeted terrestrial invertebrate SRE survey for *Feaella sp.* 'Sulphur Springs' is recommended with the aim of gaining a better understanding the species distribution outside of the proposed impact footprints. In addition, potential habitat for *Feaella sp.* 'Sulphur Springs' should be mapped and assessed outside proposed impact areas.

Database searches were also conducted for the Whim Creek Copper Project study area and surrounds. The search of the Western Australian Museum SRE Database provided a nil return for this Whim Creek Copper Project study area and is therefore not considered further in this assessment.

TABLE OF CONTENTS

TABLES

FIGURES

ATTACHMENTS

1. INTRODUCTION

1.1 Project Background and Location

The Study area is situated approximately 80 km south-east of Port Hedland (**Figure 1**) encompassing an area of 7,623 hectares. A map of the conceptual layout of the project is shown in (**Figure 2**).

Outback Ecology understands that Venturex Resources Limited (Venturex) proposes to develop an underground mine with a production rate of approximately 700,000 - 850,000 tonnes per annum at the Pilbara Copper-Zinc Project (the Project). The Project will comprise the underground development of the Sulphur Springs deposit, processing of ore at an on site concentrate plant and haulage of concentrate from the Project to Port Hedland via road train for export. The initial project life will be approximately nine years.

Primarily, the following facilities will be developed as part of the proposed underground mine:

- 1.3 – 1.5 million tonnes per annum (tpa) capacity processing plant;
- twin decline access;
- ventilation rises;
- a waste rock stockpile (with intention for waste rock to be re-deposited underground);
- a 50 man camp;
- airstrip (possibly all weather);
- local site roads;
- ROM trucking pad;
- haulage road directly north to the Marble Bar road;
- associated workshops and offices;
- clearing footprint of approximately 178 hectares (ha);
- waters supply – for potable water and dust suppression; and
- water treatment plant, with a small, lined sludge drying pond.

The original project proposal was assessed as a PER under Part IV of the Environmental Protection Act (EP Act) in 2007. The PER was assessed under the bilateral agreement between the Commonwealth and WA government. The draft PER was “placed on hold” due to the EPA’s concerns regarding the design, long-term operations and closure of the TSF.

The environmental impacts for the proposed single underground operation at the Project would be expected to be significantly reduced in comparison to those outlined in the 2007 draft PER. The significant reductions in impacts are associated with the:

- reduction in physical disturbance area of the area described in the 2007 draft PER (590 ha) to approximately 178 ha;
- significant reduction in acid generation from waste rock and tailings due to the removal of an open pit and the underground storage of waste rock and tailings;

- reduced water demand – water use will be limited to camp facility requirements and dust suppression (in and at the mine and on haul road); and
- reduction in emissions of light, noise, atmospheric emissions and risk of leaks and spills.

1.2 Report Scope and Objectives

This desktop study was designed and conducted as far as practicable in accordance with:

- Western Australian Environmental Protection Authority's (EPA) Position Statement No. 3 *Terrestrial Biological Surveys as an Element of Biodiversity Protection* (Environmental Protection Authority 2002);
- EPA Guidance Statement No. 56 *Terrestrial Fauna Surveys for Environmental Impact Assessment in Western Australia* (Environmental Protection Authority 2004);
- *Technical Guide - Terrestrial Vertebrate Fauna Surveys for Environmental Impact Assessment* (Environmental Protection Authority and Department of Environment and Conservation 2010); and
- Guidance Statement No. 20 *Sampling of Short Range Endemic Invertebrate Fauna for Environmental Impact Assessment in Western Australia* (Environmental Protection Authority 2009).

The specific objectives of the terrestrial fauna desktop study were to:

- Develop an inventory of terrestrial vertebrate fauna species and terrestrial short-range endemic (SRE) invertebrate fauna species that have been recorded or likely to occur within the Study area;
- Provide a description of vertebrate fauna habitat, sensitive habitat and terrestrial SRE invertebrate fauna habitat expected to occur within the Study area;
- Assess desktop findings in the regional context by comparisons with available data from other localities within the bioregion; and
- Identify knowledge gaps pertaining to terrestrial fauna within the Study area and recommend further investigations required to address these gaps in accordance with regulatory guidelines.

The specific objectives of the reconnaissance survey were to:

- ground truth the occurrence of fauna habitat within the Study area, specifically focused on Northern Quoll habitat, habitat for conservation significant bats (*Rhinonicteris aurantia* and *Macroderma gigas*) and habitat for SRE invertebrate species; and
- to provide advice on any requirement for further fauna surveys.

In addition to these objectives, a search of relevant databases for vertebrate and SRE invertebrate fauna within the Whim Creek area and surrounds has been included as an attachment for use in future approvals documentation.

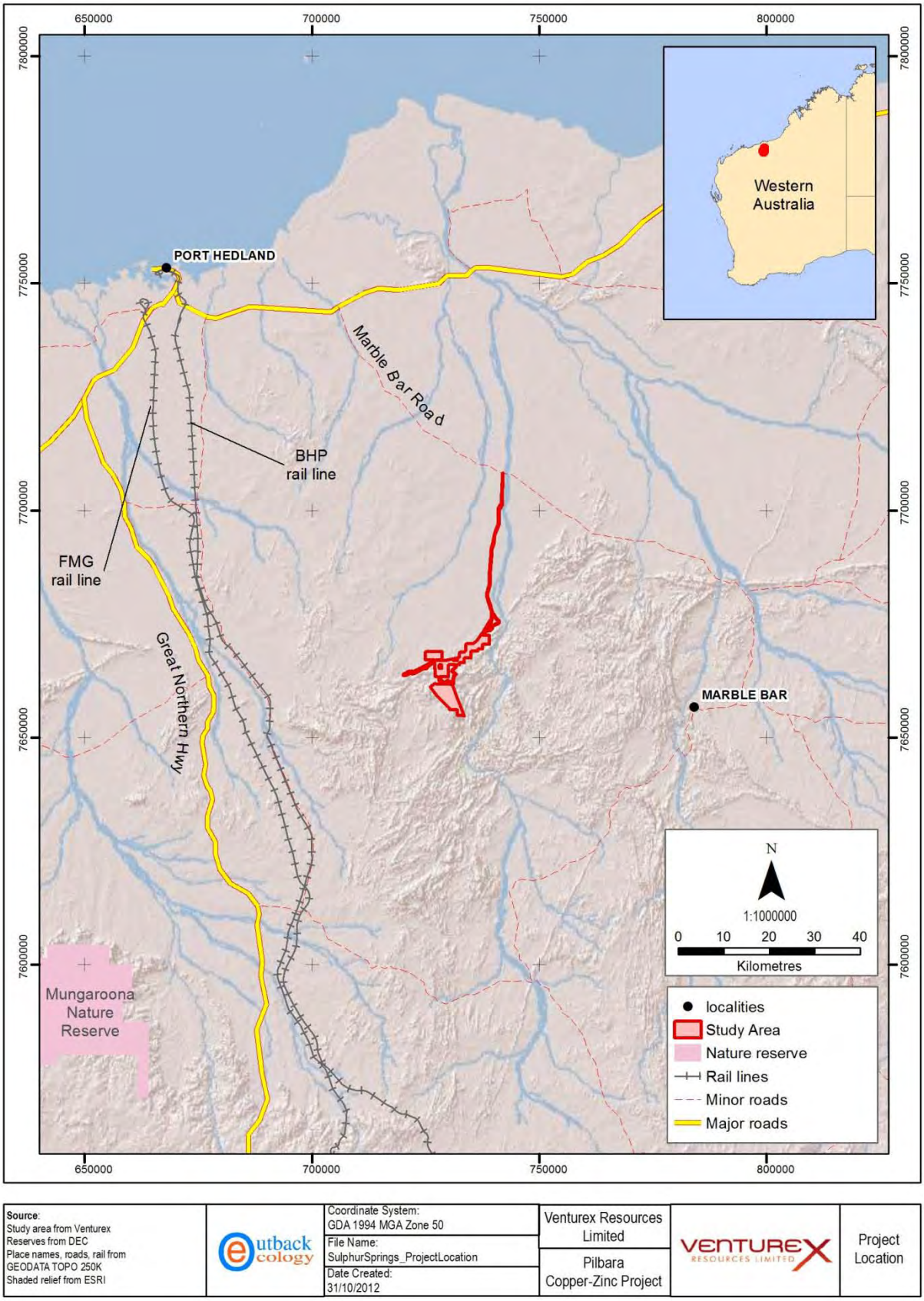

Figure 1: Regional location of the Study area

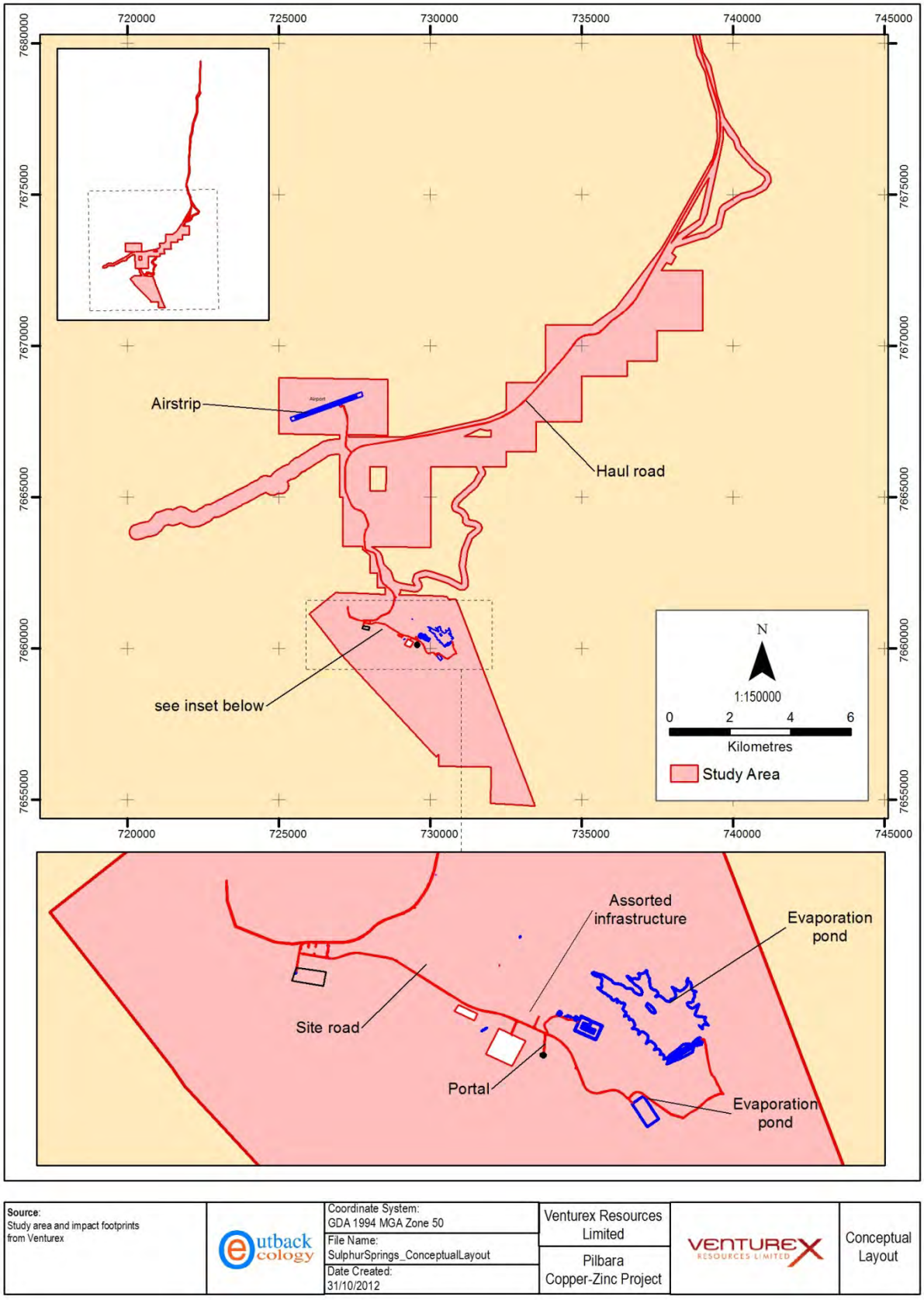

Figure 2: The Study area and conceptual project layout.

2. EXISTING ENVIRONMENT

2.1 Biogeographic Region

The Study area occurs within the Pilbara bioregion which encompasses approximately 178,500 km^2 (McKenzie *et al.* 2009). The Pilbara bioregion has a semi-arid to arid tropical climate, with active drainage in the Fortescue, De Grey and Ashburton river systems (McKenzie *et al.* 2003). The Pilbara has a high level of fauna biodiversity and species endemism. However, a combination of invasive weeds, altered fire regimes, feral predators and grazing by introduced herbivores is causing ecosystem degradation and consequently a loss of vegetation and of native species, in particular mammals within the critical weight range of 35 – 5,500 g body mass (McKenzie *et al.* 2003).

The Pilbara bioregion is further classified into the Chichester, Roebourne, Fortescue Plains, and Hamersley sub-bioregions using the Interim IBRA classification system (McKenzie *et al.* 2003). The Study area falls largely within the Chichester sub-bioregion with a small portion of the Haul Road falling within the Roebourne sub-bioregion (**Figure 3**).

The Chichester sub-bioregion is the largest sub-bioregion encompassing 47% (83,700 km^2) of the Pilbara region (McKenzie *et al.* 2009). It is characterised by undulating Archaean granite and basalt plains with significant areas of basalt ranges (Kendrick and McKenzie 2001). The basalt plains host a shrub steppe of *Acacia inaequilatera* over *Triodia* spp. hummock grasslands, while tree steppes of *Eucalyptus leucophloia* occur on the ranges (Kendrick and McKenzie 2001). The northern part of the Chichester sub-bioregion is relatively flat and undulating, being dominated by large alluvial floodplains associated with the De Grey River system and its tributaries (McKenzie *et al.* 2009). The Chichester sub-bioregion lies predominantly inland from the coast (**Figure 3**).

The Roebourne sub-bioregion is situated on the Pilbara's north-western fringe and covers an area of 18,910km^2 (McKenzie *et al.* 2009). The uplands of the Roebourne sub-bioregion, which are of relevance to the Study area, are dominated by *Triodia* hummock grasslands. Ephemeral drainage lines support *Eucalyptus victrix* or *Corymbia hamersleyana* woodlands. Resistant linear ranges of basalts occur across the coastal plains, with minor exposures of granite (Kendrick and Stanley 2001).

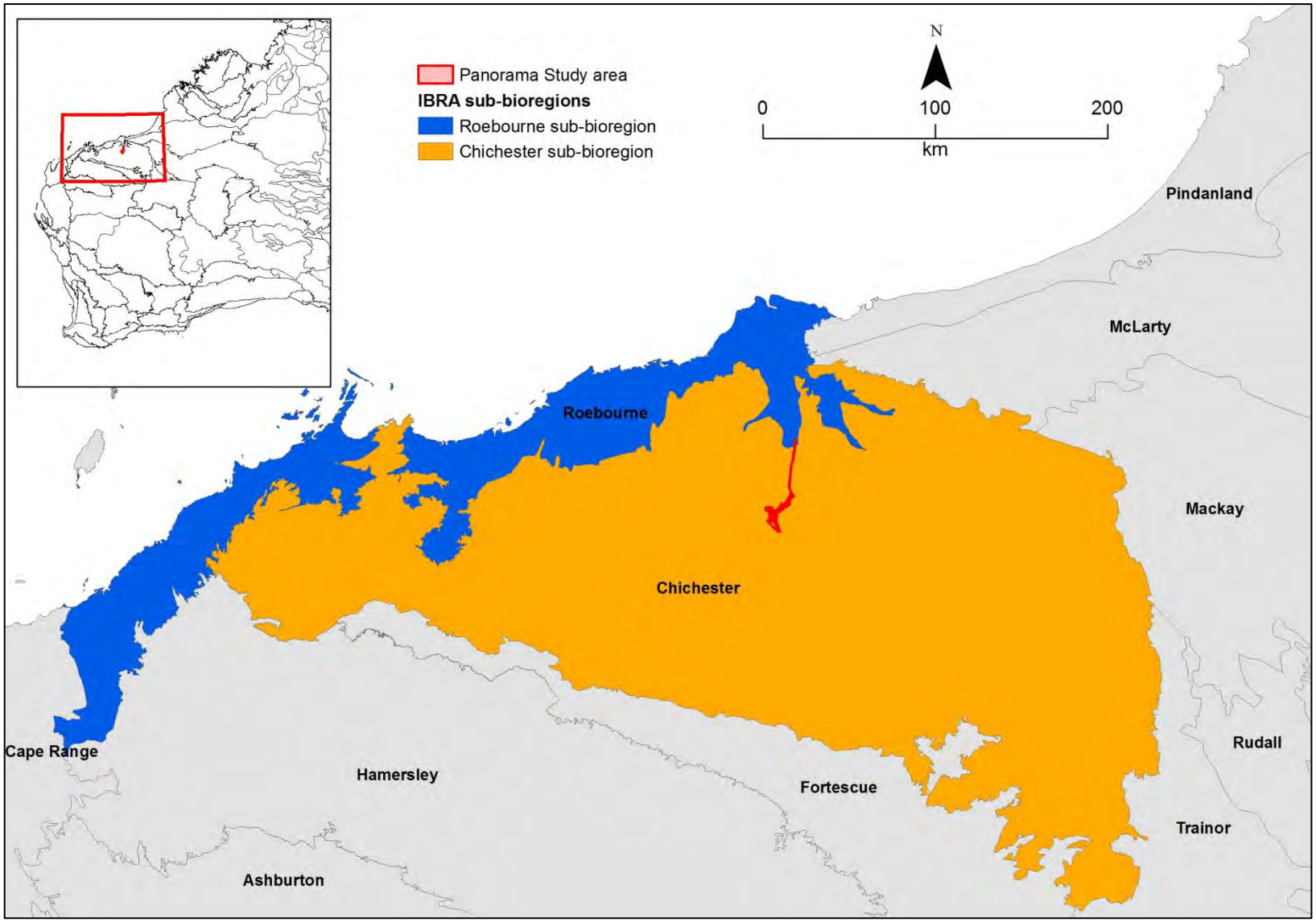

Figure 3: The location of the Study area with respect to IBRA sub-bioregions

2.2 Climate

The study area is located within the northern section of the Pilbara bioregion, which experiences a semi-arid to arid-tropical climate that is characterised by hot summers and relatively warm, dry winters (Bureau of Meteorology 2011). Tropical cyclones can occur between the months of January to April, bringing sporadic drenching rainfall events (How *et al.* 1991).

The nearest Bureau of Meteorology (BOM) weather station to the Project is located at Marble Bar, approximately 55 km to the east of the Study area. Weather data collected from the Marble Bar Meteorological Station indicates rainfall occurs mainly in the first half of the year with a mean average rainfall of approximately 360mm (Bureau of Meteorology 2011) (**Figure 4**). Rainfall within the Study area can be highly localised and unpredictable with substantial fluctuations occurring from year to year (Bureau of Meteorology 2011, Leighton 2004). This variability is illustrated in **Figure 5**.

Marble Bar typically experiences a very hot summer with the mean maximum temperature reaching 40.1°C and a mean minimum temperature of 25.7°C (**Figure 4**). Over the whole year, Marble Bar averages 98 days above 40° (Leighton 2004). Winter occurs from June to August when the mean maximum temperature for Marble Bar is 28°C and the mean minimum temperature is 12.8°C (**Figure 4**).

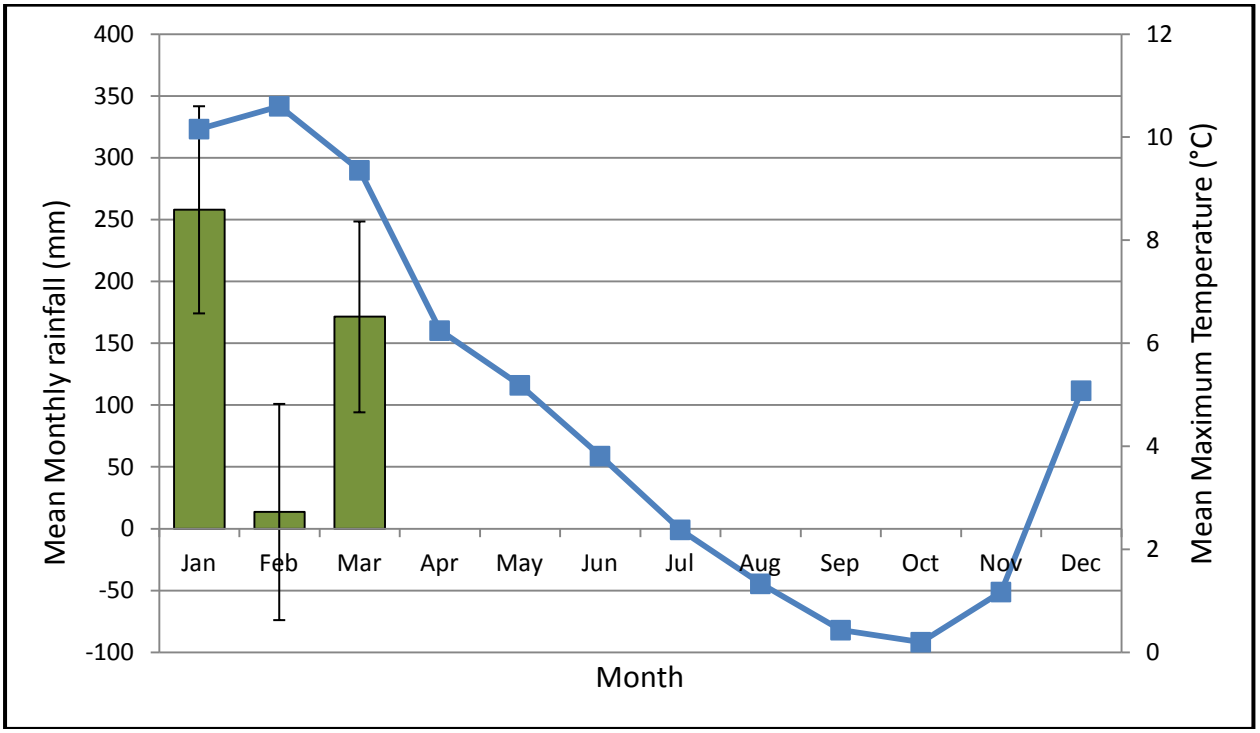

Figure 4: Mean rainfall and temperature for Marble Bar Weather Station (1895 – 2010) (BOM 2011)

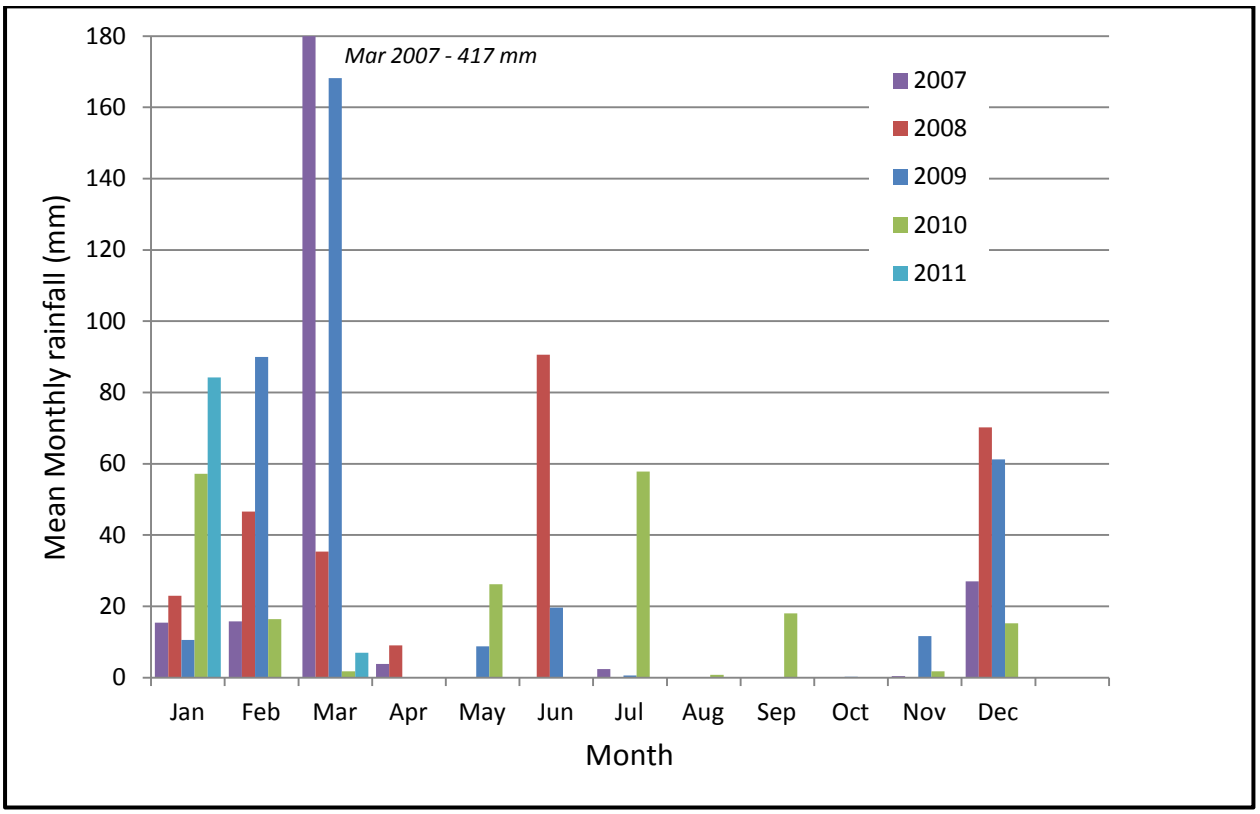

Figure 5: Monthly rainfall for Marble Bar 2007- March 2011 (BOM, 2011)

2.3 Land Systems of the Study Area

A regional survey was undertaken in the Pilbara between 1995 and 1999 by the Department of Agriculture (now the Department of Agriculture and Food) and the Department of Land Administration (now Landgate) to develop a comprehensive description of the biophysical resources and the vegetation composition and soil condition within the region. This information was used by van Vreeswyk *et al*. (2004) to classify and map the land systems of the Pilbara region based on landform, soil, vegetation, geology and geomorphology. An assessment of land systems provides an indication of the occurrence and distribution of fauna habitats within and surrounding the Study area.

The Study area contains eight land systems: Capricorn, Rocklea, Boolgeeda, Uaroo, Satirist, Platform, Macroy and River. The characteristics and extent of these land systems are summarised in **Table 1** and are mapped in **Figure 6**. Of these eight land systems, the Capricorn and Rocklea land systems are likely to be of particular significance to conservation significant fauna occurring within the Study area. These land systems, which consists of hills and ridges of volcanic and other rocks supporting hard Spinifex, is likely to support Northern Quoll (*Dasyurus hallucatus*), Pilbara Leaf-nosed Bat (*Rhinonicteris aurantia*), Ghost Bat (*Macroderma gigas*) and Rothschild's Rock-wallaby (*Petrogale rothschildi*), with Pebble-mound Mouse (*Pseudomys chapmani*) likely to be present on stony slopes. Finer scale mapping of specific fauna habitats is presented in **Section 4.1**.

Table 1: Land systems occurring within the Study area

Land System	Brief Description	Total area (ha) within Study area	Proportion of Study area (%)
Capricorn Land System	Hills and ridges of sandstone and dolomite supporting low shrublands or shrubby spinifex grasslands.	3,656	48.0
Rocklea Land System	Basalt hills, plateaux, lower slopes and minor stony plains supporting hard spinifex (and occasionally soft spinifex) grasslands.	1,932	25.3
Boolgeeda Land System	Stony lower slopes and plains below hill systems supporting hard and soft spinifex grasslands or mulga shrublands.	904	11.9
Uaroo Land System	Broad sandy plains supporting shrubby hard and soft spinifex grasslands.	525	6.9
Satirist Land System	Stony plains and low rises supporting hard spinifex grasslands, and gilgai plains supporting tussock grasslands.	293	3.8
Platform Land System	Dissected slopes and raised plains supporting hard spinifex grasslands.	163	2.1
Macroy Land System	Stony plains and occasional tor fields based on granite supporting hard and soft spinifex grasslands.	124	1.6
River Land System	Active flood plains, major rivers and banks supporting grassy eucalypt woodlands, tussock grasslands and soft spinifex grasslands.	26	0.3

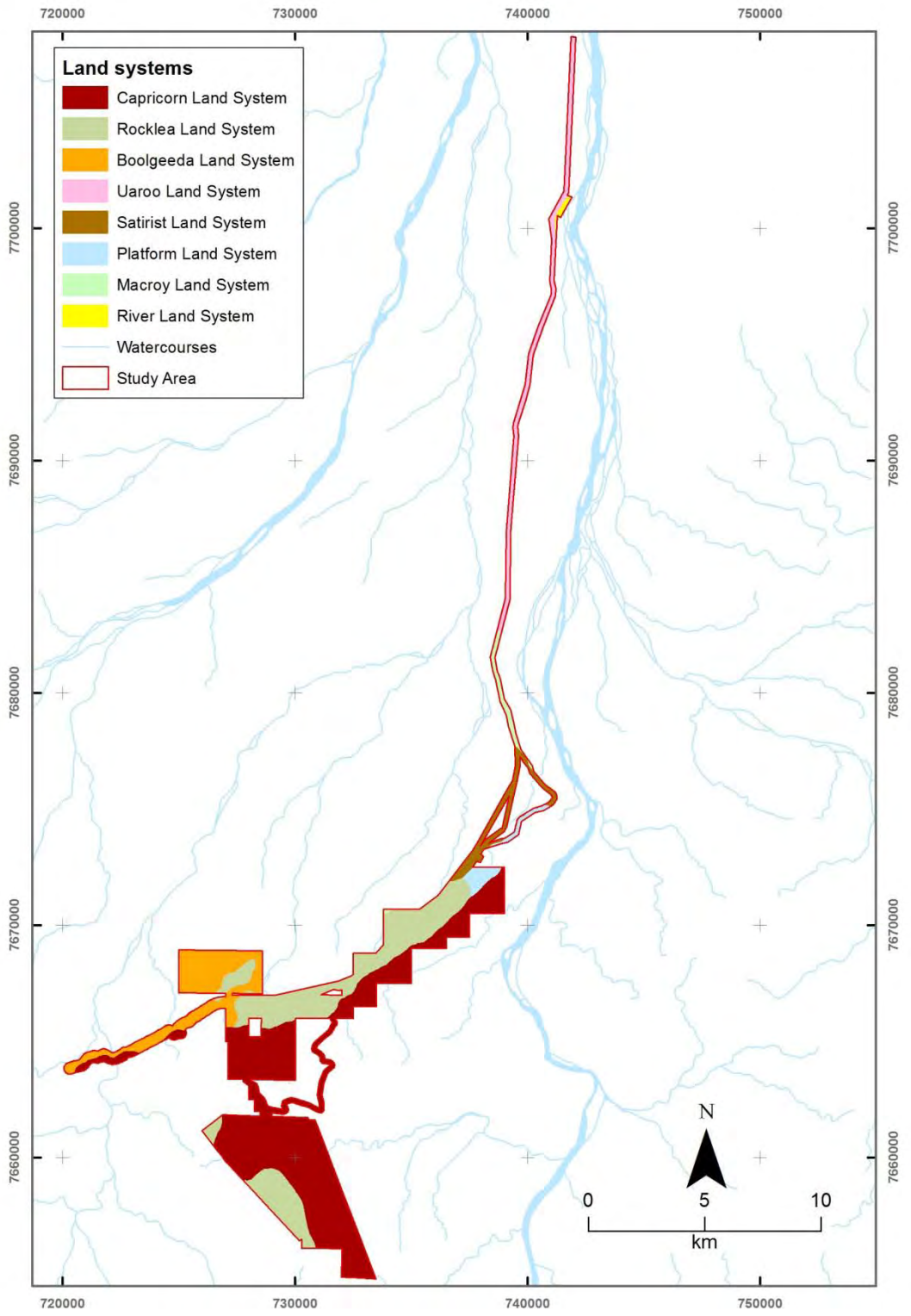

Figure 6: Land systems occurring within and surrounding the Study area

2.4 Land Use

Land tenure in the Pilbara consists primarily of pastoral leases, with other crown reserves such as Aboriginal reserves and leasehold reserves also forming a large proportion. National parks and reserves and unallocated crown land are the other major land use categories present in the region. The first mining exploration in the Pilbara commenced in the early 1800s and currently this area provides the majority of Western Australia's petroleum, gas and iron ore exports, while gold mining is also an important industry (Australian Natural Resources Atlas 2007).

In the Chichester subregion, the dominant land uses are pastoralism (i.e. grazing of native pasture by cattle), Aboriginal lands and reserves, unallocated crown land (UCL) and crown reserves, conservation, and mining (Kendrick and McKenzie 2001). The Chichester subregion has 6.56% of its land surface reserved under some form of conservation. The subregion contains Millstream-Chichester National Park, Mungaroona Range Nature Reserve and Meentheena ex-pastoral lease (Kendrick and McKenzie 2001).

Mungaroona Range Nature Reserve is the only substantial nature reserve that exists near the Study area (**Figure 1**). Knowledge of the fauna of this nature reserve is limited (Department of Environment and Conservation 2007). It is proposed that all of the Mungaroona Range Nature Reserve will be gazetted as 'wilderness' under the *Conservation and Land Management Act 1984*. The Department of Environment and Conservation (DEC) considers the Mungaroona Range Nature Reserve warrants gazettal as a wilderness area based on the following criteria:

- The reserve more than exceeds the minimum size criterion of 20 000 hectares;
- There is currently no vehicle access into the reserve, no built infrastructure and visitation to the reserve is exceptionally low; and
- Given the reserve's considerable remoteness and lack of impacts from modern technological society, much of the area's biodiversity and natural systems are likely to be intact.

In relation to land tenure, the Project is located within mining tenements M45/494, M45/1001 and M45/653 and spans both pastoral lease and unallocated crown land and lies on the Njamal Native Title Claim area. Land use across the study area includes exploration activities and cattle grazing (**Figure 7**).

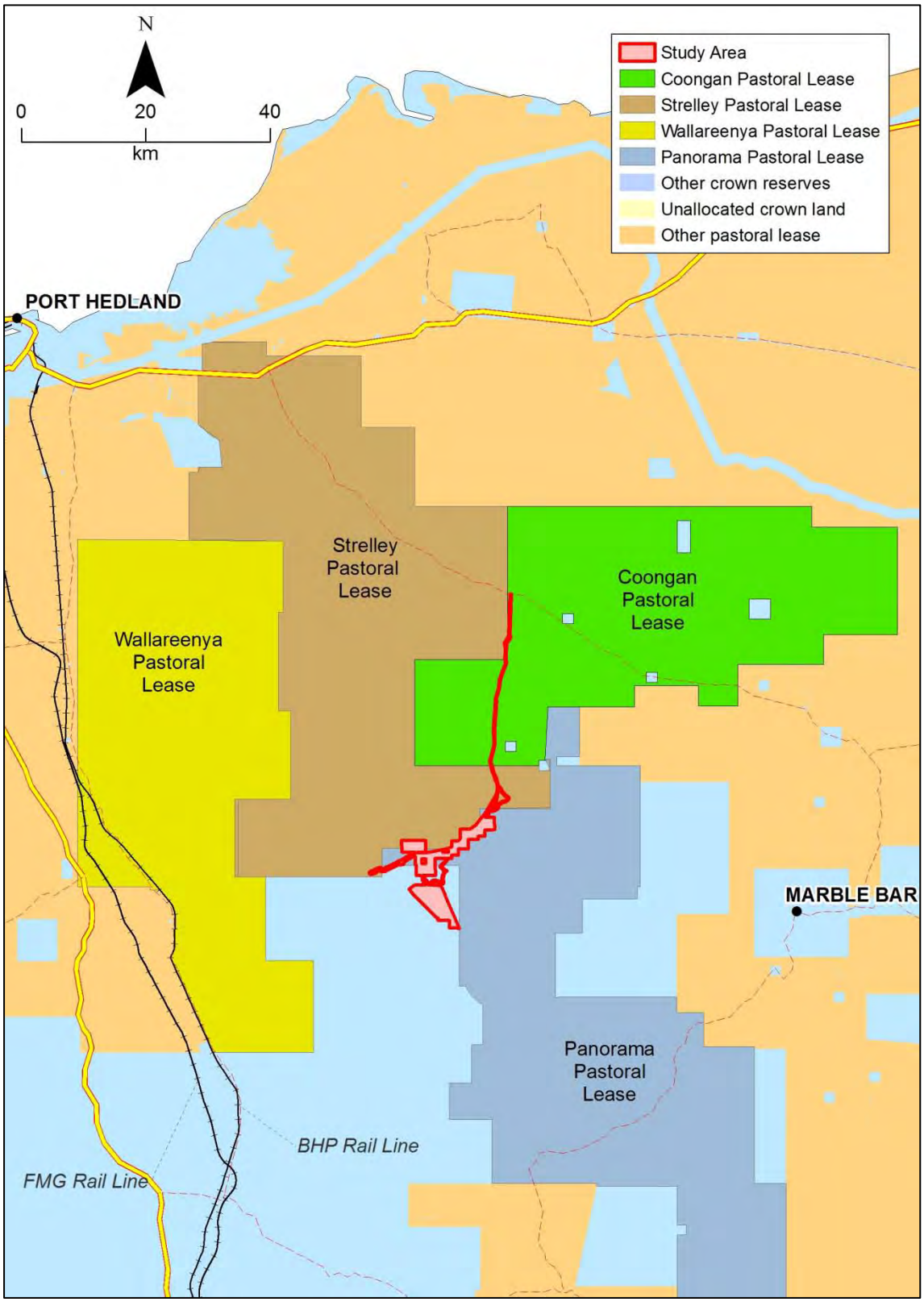

Figure 7: Land use within and surrounding the Study area

3. SURVEY ASSESSMENT AND METHODOLOGY

The methods used to assess the potential occurrence of terrestrial vertebrate fauna and SRE invertebrate fauna within the Study area include database searches (Section 3.1), a literature review (Section 3.2) and a reconnaissance survey (Section 3.3).

3.1 Database Searches

Database searches were undertaken to provide a list of mammals, reptiles, amphibians, bird species and SRE invertebrate fauna species that have previously been recorded or have the potential to occur within the Study area. The search area consisted of a 75 kilometre buffer around the Study area. Database searches of these areas were made using the following databases and internet tools:

- DEC's NatureMap database (Department of Environment and Conservation 2010a).
- Threatened and Priority Fauna Database held by the DEC (Department of Environment and Conservation 2010b).
- The Birds Australia New Atlas 1998 – 2010 database (Birds Australia 2010).
- The Environmental Reporting Tool (Department of Sustainability Environment Water Population and Communities 2010a).
- Western Australian Museum SRE Database – arachnids and millipedes (Western Australian Museum 2010).

The above searches were also conducted for the Whim Creek Study area and surrounds and have been included as an attachment for use in future approvals documentation. The search of the Western Australian Museum SRE Database provided a nil return for the Whim Creek Study area and is therefore, not considered further.

Presence of fauna species recorded in regional summary documents was also considered in this report. Documents included:

- Birds of the Pilbara Region, Western Australia (Storr 1984);
- A Biodiversity Audit of Western Australian's 53 Biogeographical Subregions (Kendrick and McKenzie 2001);
- The Australian Natural Resources Atlas (Australian Natural Resources Atlas 2007) of the National Land and Water Resources Audit;
- An introduction to the Pilbara Biological Survey 2002-2007 (McKenzie *et al.* 2009);
- Pilbara Biological Survey 2002-2007: Environmental Associations of small ground-dwelling mammals in the Pilbara region, Western Australia (Gibson and McKenzie 2009);
- Pilbara Biological Survey 2002-2007: Birds in a vast arid upland: avian biogeographical patterns in the Pilbara region of Western Australia (Burbidge *et al.* 2010); and
- Pilbara Biological Survey 2002-2007: The echolocation calls, habitat relationships, foraging niches and communities of Pilbara microbats (McKenzie and Bullen 2009).

3.2 Literature Review

A literature review was undertaken to provide a list of mammals, birds, reptiles, amphibians, fish and invertebrate SRE fauna species that have been previously recorded within the vicinity of the Study area. The following two sections distinguish between those surveys that were conducted within the Study area or its immediate surrounds and those that were conducted near the Study area. These surveys are described below and the location of each Study area (where available) is shown in **Figure 8**. A key detailing the surveys examined within the literature review is provided in **Table 2**. A detailed inventory of the vertebrate fauna recorded in each of these surveys is provided in **Attachment A.**

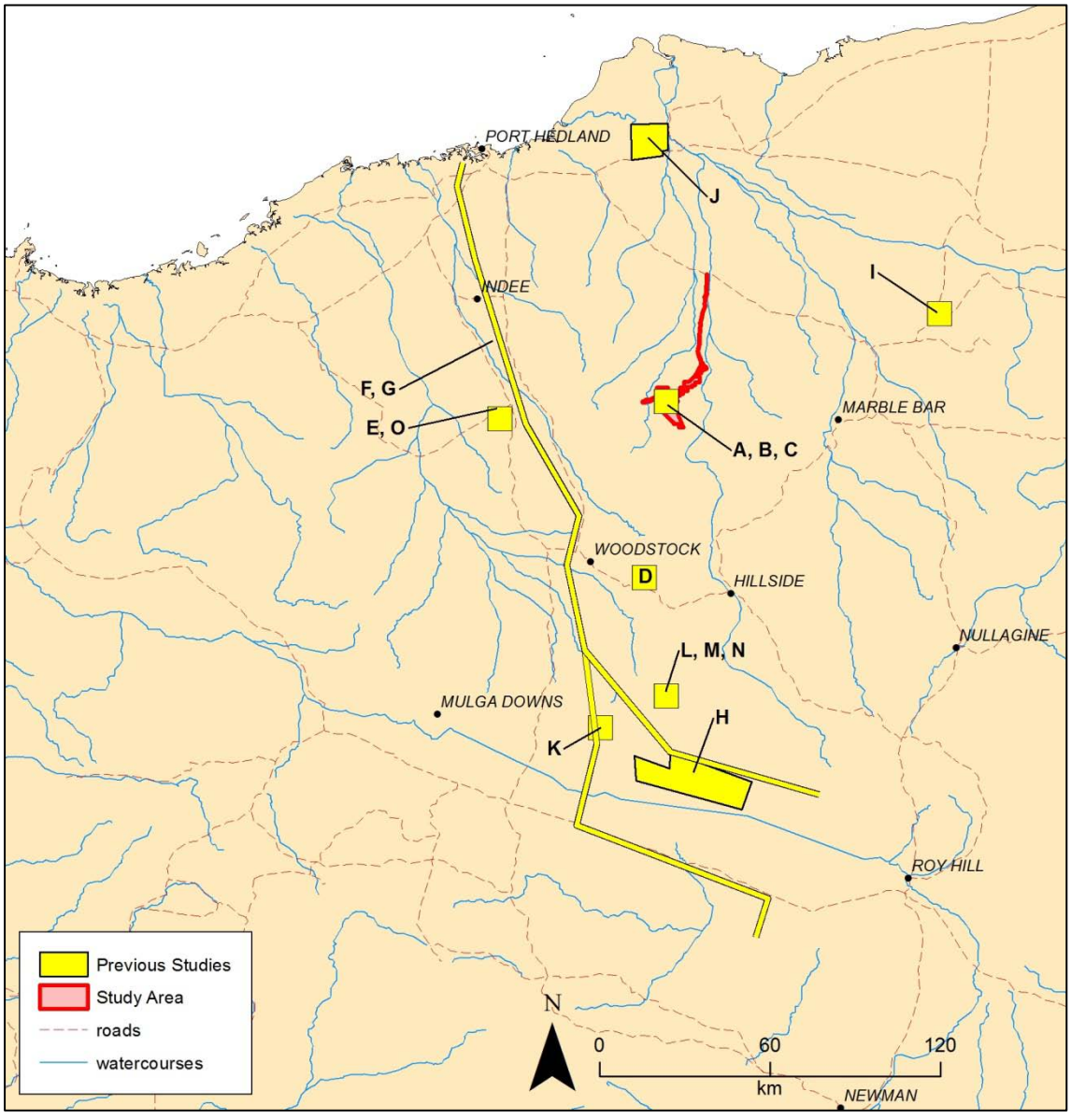

Figure 8: Location of previous fauna surveys within the surrounding region

Table 2: Key to map of location of previous fauna surveys within the surrounding region

Map Label	Reference
Fauna surveys in/near the Study area	
A	Bamford Consulting Ecologists. (2001) Sulphur Springs Project Area: Baseline Fauna Study as Part of the Sulphur Springs Feasibility Study, Prepared for Astron Environmental.
B	Biota. (2007) Sulphur Springs Project: Mine Site and Haul Road Corridor Targeted Fauna Survey, Prepared for CBH Resources Ltd.
C	MOLHAR Pty Ltd. (2007) Field Survey for conservation significant bats near Sulphur Springs, Pilbara: field survey and management advice, Prepared for CBH Resources Ltd.
Fauna surveys in the region	
D	How, R. A., Dell, J. and Cooper, N. K. (1991) Ecological Survey of Abydos-Woodstock Reserve, Western Australia: Vertebrate Fauna. Records of the Western Australian Museum Supplement 37: 78-125.
E	Mattiske Consulting Pty Ltd. (2000) Flora, Vegetation and Vertebrate Fauna of the Proposed Expansion at Wodgina, Prepared for Sons of Gwalia Ltd.
F	Biota. (2002) Proposed Hope Downs Rail Corridor From Weeli Wolli Siding to Port Hedland - Vertebrate Fauna Survey, Hope Downs Management Services Vertebrate Fauna Survey.
G	Biota. (2004) Fauna Habitats and Fauna Assemblage of the Proposed FMG Stage A Rail Corridor, Fortescue Metals Group Fauna Habitat and Fauna Assemblage Report.
H	Bamford Consulting Ecologists. (2005) Fauna Survey of Proposed Iron Ore Mine, Cloud Break, Prepared for Fortescue Metals Group Ltd.
I	Outback Ecology Services. (2006) Spinifex Ridge Molybdenum Project: Terrestrial Vertebrate Fauna Baseline Surveys (2005-2006), Unpublished report prepared for Atlas Iron Limited.
J	Bamford Consulting Ecologists. (2007) Fauna Assessment of the Pardoo Direct Shipping Ore Project Atlas Iron Limited, Prepared for Enesar Consulting Pty Ltd.
K	ecologia. (2008) RGP 5 Level 2 Fauna Survey: Chichester Deviation, A report commissioned by BHP Billiton Iron Ore Pty Ltd.
L	Ninox Wildlife Consulting. (2009) A Fauna Survey of the Proposed Hope Downs 4 Mining Area Near Newman, Western Australia, Prepared for Mattiske Consulting Pty Ltd on behalf of Pilbara Iron Company (Services) Pty Ltd.
M	Ninox Wildlife Consulting. (2009) A Vertebrate Fauna Survey of the Proposed Hope Downs 4 Infrastructure Corridor: Option 1 Near Newman, Western Australia, Prepared for Mattiske Consulting Pty Ltd on behalf of Pilbara Iron Company (Services) Pty Ltd.
N	Ninox Wildlife Consulting. (2009) A Vertebrate Fauna Survey of the Proposed Hope Downs 4 Option 6 Infrastructure Corridor Near Newman, Western Australia, Prepared for Mattiske Consulting Pty Ltd on behalf of Pilbara Iron Company (Services) Pty Ltd.
O	Outback Ecology. (2009) Wodgina DSO Project: Terrestrial Vertebrate Fauna Assessment, Prepared for Atlas Iron Limited.

3.2.1 Fauna Surveys in the Study Area

Four terrestrial vertebrate fauna surveys have been conducted within or in areas adjacent to the Study area. A brief synopsis of these surveys is presented in chronological order below.

Bamford Consulting Ecologists (2001) Sulphur Springs Project Area: Baseline Fauna Study as Part of the Sulphur Springs Feasibility Study

This comprehensive fauna assessment was conducted over two periods: June and September 2001. Survey methods included: systematic trapping for amphibians, reptiles and mammals; census for birds; spotlighting for nocturnal reptiles, birds and mammals; mist-netting, harp trapping and ultra-sonic detecting for bats; and active searches.

The Sulphur Springs study area was considered a locally significant example of a Pilbara landscape possessing rocky hills, small gorges and undulating plains. Rocky hills, gorges and cliff-lines were identified as important habitat for mammals, reptiles and birds, including Ghost Bats (*Macroderma gigas*) and Peregrine Falcons (*Falco peregrinus*). Although limited in extent, watercourses and riparian vegetation were also considered highly significant fauna habitats.

A total of 137 species were recorded during the surveys, comprising 22 mammals, 80 birds, 29 reptiles, two amphibians and four fish species.

Conservation significant fauna recorded during this survey included:

- Northern Quoll (*Dasyurus hallucatus*) (EPBC Act - Endangered; WC Act – Schedule 1);
- Mulgara (*Dasycercus cristicauda*) burrows (EPBC Act – Endangered; WC Act – Schedule 1);
- Pilbara Leaf-nosed Bat (*Rhinonicteris aurantia*) (EPBC Act - Vulnerable; WC Act – Schedule 1);
- Spectacled Hare-wallaby (*Lagorchestes conspicillatus leichardti*) (DEC - Priority 3);
- Four species listed as Priority 4 under the DEC Priority List: Western Pebble-mound Mouse (*Pseudomys chapmani*), Ghost Bat (*Macroderma gigas*), Australian Bustard (*Ardeotis australis*), and Bush Stone-curlew (*Burhinus grallarius*).

The Study concluded that future developments of the area should endeavour to minimise impacts on the surrounding habitats, particularly given the watercourse on which the proposed mine area and existing access road are located is one of the most distinctive environmental features of the project area. The watercourse provides important habitat for many of the identified fauna species and permanent pools along the Strelley and Shaw River systems were found to be used by waterbirds and freshwater fish and may support significant fauna such as the Olive Python.

Biota (2007) Sulphur Springs Project: Mine Site and Haul Road Corridor Targeted Fauna Survey

This Level 2 survey was conducted to assess the haul road associated with the Sulphur Springs project in August-September 2006. The survey incorporated a variety of sampling techniques including pitfall trapping, Elliott traps, harp traps, avifauna census and opportunistic recording.

The study area encompassed two habitat types: a narrowly incised valley supporting mid-dense to dense riparian vegetation and small to medium sized pools of water; and low stony hills, vegetated with *Triodia* hummock grasslands.

The survey recorded a total of 73 vertebrate fauna species, comprising 12 mammals, 41 birds, 18 reptiles and two amphibians.

Conservation significant fauna recorded during the survey comprised:

- Northern Quoll (*Dasyurus hallucatus*) (EPBC Act - Endangered; WC Act – Schedule 1);
- Mulgara (*Dasycercus cristicauda*) burrows (EPBC Act – Endangered; WC Act – Schedule 1);
- Pilbara Leaf-nosed Bat (*Rhinonicteris aurantia*) (EPBC Act - Vulnerable; WC Act – Schedule 1);
- Spectacled Hare-wallaby (*Lagorchestes conspicillatus leichardti*) (DEC - Priority 3); and
- Four species listed as Priority 4 under the DEC Priority List: Western Pebble-mound Mouse (*Pseudomys chapmani*), Ghost Bat (*Macroderma gigas*), Australian Bustard (*Ardeotis australis*), and Bush Stone-curlew (*Burhinus grallarius*).

Invertebrate taxa prone to short-range endemism collected during the survey included terrestrial snails, mygalomorph spiders and pseudoscorpions. The only species collected during the survey that was identified as representing a potential SRE species was the pseudoscorpion *Feaella sp* 'Sulphur Springs' represented by a single specimen (728157 mE; 7660995 mN; UTM, zone 50, WGS84). The specimen was collected beneath slate like rock on the south face of a low cliff adjacent to a narrowly incised ephemeral drainage line. Biota (2007) speculated that specimens may also occur on the gabbro rock piles across the study area.

Biota (2007) recommend that additional survey work be undertaken to delineate distribution and habitat of *Feaella sp* 'Sulphur Springs' and that additional taxonomic work should be undertaken to resolve the identity of the specimen. As a result, additional survey work was undertaken with the assistance of Dr Mark Harvey from the WA Museum in October 2007 (M. Harvey pers. comm. September 2011). The survey was unsuccessful in collecting additional specimens of *Feaella sp* 'Sulphur Springs'.

MOLHAR (2007) Sulphur Springs Project: Field Survey for Conservation Significant Bats near Sulphur Springs, Pilbara

This targeted bat survey was conducted to determine the presence of the Pilbara Leaf-nosed Bat over the plain north from the Lalla Rookh mine, focussing on the area pertaining to the Plains Access Road lease, as well as to determine the areas where foraging occurred within 20 km of the mine site. Surveys were also carried out to determine the presence of cave roosts in close proximity to the Sulphur Springs Valley Road, and in the wider area.

Surveys helped to assess the potential effect of water drawdown and roost habitat suitability based on historical drawings of the underground structure of the Lalla Rookh mine; and assess possible responses to reducing bat roadkills by seeking background information on previous occurrences.

Several conclusions could be drawn from the survey results. Pilbara Leaf-nosed Bats were found to forage at least 750 m over the flat plain north of the Lalla Rookh mine, and beyond the northern extent of the miscellaneous lease in the vicinity of this roost. The species also forages in five deep gullies examined in the area, and they can be found as far east as the North Pole Mining Centre, and west to Strelley Gorge, however the survey did not identify diurnal roost sites in the most prospective gullies in the area.
Given that no other roost sites are currently known from near the project area, and the general lack of deep caves, it was concluded that bats foraging in the ranges adjacent to the proposed Project area would roost in the Lalla Rookh mine. Therefore, the Pilbara leaf-nosed bat might be capable of nightly foraging bouts of a significant distance, up to 32 km round trip commuting distance, given that Strelley Gorge is 16 km from Lalla Rookh. It was also concluded that dewatering by up to 15 m near the Lalla Rookh Mine might still allow for humid microclimates suitable for bat habitation to be maintained.

3.2.2 Fauna Surveys in the Region

The following 13 surveys have been conducted in the Study area surrounds. A brief synopsis of these surveys is presented in chronological order below.

How et al. (1991) Ecological Survey of Abydos-Woodstock Reserve, Western Australia

This publication represented the first major survey of the region and was conducted by the Western Australian Museum (WAM) from 1988 to 1990. The survey sought to determine the richness and diversity of vertebrate fauna and identify unique fauna communities of conservation value within the Abydos-Woodstock Reserve, located approximately 60 km to the south of the Study area (**Figure 8**).

Sampling of vertebrate fauna was conducted over nine sessions during a two and a half year period. Sampling techniques included pitfall and Elliott traps, mist nets, active searches and avifauna censuses.
A total of 179 vertebrate fauna species were recorded, comprising 14 mammals, 92 birds, 68 reptiles and five amphibian species. Fauna abundance remained reasonably consistent across different habitats and

seasons, although species composition varied significantly. Further, species richness was seen to decrease substantially after fire, particularly for mammals.

The Abydos-Woodstock Reserve was found to be depauperate in avifauna, due largely to the lack of free-standing water and mulga plains, which are known to support a greater diversity in the southern Pilbara. Rocky slope, ridge, plateau and rockpile habitats were deemed of particular importance to mammal and reptile assemblages.

Thirteen conservation significant fauna species were recorded during the survey, comprising:

- Northern Quoll (*Dasyurus hallucatus*) (EPBC Act - Endangered; WC Act – Schedule 1);
- Mulgara (*Dasycercus cristicauda*) burrows (EPBC Act – Endangered; WC Act – Schedule 1);
- Pilbara Olive Python (*Liasis olivaceus barroni)* (EPBC Act – Vulnerable; WC Act – Schedule 1);
- Common Slender Blue-tongue (*Cyclodomorphus branchialis*) (WC Act -Schedule 1);
- *Ctenotus nigrilineatus* (DEC - Priority 1);
- Spectacled Hare-wallaby (*Lagorchestes conspicillatus leichardti*) (DEC - Priority 3);
- Four species listed as Priority 4 under the DEC Priority List: Western Pebble-mound Mouse (*Pseudomys chapmani*), Ghost Bat (*Macroderma gigas*), Bush Stone-curlew (*Burhinus grallarius*), and Australian Bustard (*Ardeotis australis*); and
- Three migratory species listed under the EPBC Act, Common Greenshank (*Tringa nebularia*), Fork-tailed Swift (*Apus pacificus*), and Rainbow Bee-Eater (*Merops ornatus*).

Mattiske Consulting. (2000) Flora, Vegetation and Vertebrate Fauna of the Proposed Expansion at Wodgina

This Level 1 fauna assessment reviewed the terrestrial fauna potentially occurring at the Wodgina Tantalum Mine, which is situated approximately 55 km west of the Study area (**Figure 8**). One objective of this assessment was to identify the potential impacts of the proposed expansion of the Wodgina Tantalum Mine on local fauna assemblages and habitat. However the emphasis of this report was on the flora and vegetation of the area and consequently only provided a cursory discussion of potential fauna.

Five key fauna habitats were described, including Eucalyptus woodlands, Acacia shrublands, hummock grasslands, adits and caves, and water bodies.

Four conservation significant fauna species were identified as possibly occurring in the area, comprising:

- Pilbara Olive Python (*Liasis olivaceus barroni)* (EPBC Act – Vulnerable; WC Act – Schedule 1);
- Two species listed as Schedule 4 under the WC Act, the Peregrine Falcon (*Falco peregrinus*) and Woma (*Aspidites ramsayi*); and
- Grey Falcon (*Falco hypoleucos*)- Priority 4.

Biota (2002b) Proposed Hope Downs Rail Corridor From Weeli Wolli Siding to Port Hedland - Vertebrate Fauna Survey

This Level 2 fauna survey was conducted on the Hope Downs Rail Corridor from Port Hedland to Weeli Wolli siding in April and June 2001. The study area assessed for this proposed railway corridor consists of a long, linear corridor that passes 45 km to the west of the Sulphur Springs Study area (**Figure 8**). This fauna assessment incorporated a variety of sampling techniques including pitfall traps, Elliott traps, funnel traps, and cage traps, systematic hand searching, targeted searching, AnaBat echolocation recording, harp trapping for bats and avifauna census.

Six habitats were identified during this assessment comprising of sand dune, Fortescue basin flats, cracking clay, major drainage lines, granite rock piles, and mangrove and mudflats.

A total of 243 vertebrate fauna species were recorded, comprising 39 mammals, 125 birds, 73 reptiles and six amphibians.

Twelve conservation significant vertebrate fauna species were recorded from this survey, comprising:

- Two species listed as Endangered under the EPBC Act and Schedule 1 under the WC Act, the Northern Quoll (*Dasyurus hallucatus*) and Mulgara (*Dasycercus cristicauda*) (burrows, diggings and tracks only);
- One species listed as Vulnerable under the EPBC Act and Schedule 1 under the WC Act, the Bilby (*Macrotis lagotis* – burrows only);
- Two species listed as Schedule 4 under the WC Act, the Peregrine Falcon (*Falco peregrinus*) and Woma (*Aspidites ramsayi*); and
- Seven species listed as Priority 4 on the DEC Priority Species List, the Ghost Bat (*Macroderma gigas*); Lakeland Downs Mouse (*Leggadina lakedownensis*); Pebble-mound Mouse (*Pseudomys chapmani*); Australian Bustard (*Ardeotis australis*); Bush Stone-curlew (*Burhinus grallarius*); Eastern Curlew (*Numenius madagascariensis*); and *Ctenotus nigrilineatus*.

Biota (2002a) An Assessment of the Distribution of the Mulgara (Dasycercus cristicauda) and Bilby (Macrotis lagotis) along and adjacent to the Proposed Hope Downs to Port Hedland Rail Corridor

This Level 1 targeted fauna assessment surveyed areas where evidence of Bilby and Mulgara had been recorded during a previous survey of the proposed rail corridor study area. Thirty separate locations comprising of over 200 individual data points corresponding to Mulgara activity were recorded. Field investigations confirmed that the primary habitat for the Mulgara in this study area comprised sandy or sandy clay plains dominated by *Triodia*. Two additional Bilby diggings were recorded from the same locality as previously recorded in Spinifex hummock grassland.

Biota (2004) Fauna Habitats and Fauna Assemblage of the Proposed FMG Stage A Rail Corridor

This Level 2 fauna survey was undertaken over the FMG Stage A Rail Corridor between March and April 2004. The FMG rail corridor study area passes 45 km to the west of the Sulphur Springs Study area (**Figure 8**). This fauna assessment incorporated a variety of sampling techniques including pitfall traps, Elliott traps, funnel traps, cage traps, hand searching and avifauna census.

Thirteen vegetation types occurred within the study area, comprising Littoral Vegetation – shrub dominated; Sandy Plain Vegetation – Spinifex dominated; Sandy Plain Vegetation – Tree/shrub dominated; Stony Plain and Hill Vegetation – Spinifex dominated; Drainage and Sandy Plain Vegetation – Tree/shrub dominated; Minor Creeklines, Drainage Areas and Floodplains; Granite Outcrop Vegetation; Granite Ridge Vegetation; Quartz Ridge Vegetation; Dolerite Dyke Vegetation; Cracking Clay Vegetation; Vegetation of Clayey/Sandy Plains; and Sand Dune Vegetation.

A total of 176 vertebrate species were recorded, comprising 25 mammals, 84 birds, 58 reptiles, six amphibians and three fish.

Six conservation significant vertebrate fauna species were recorded from this survey, comprising:

- Mulgara (*Dasycercus cristicauda*) (EPBC Act – Endangered; WC Act – Schedule 1);
- Peregrine Falcon (*Falco peregrinus*) (WC Act - Schedule 4); and
- Four species listed as Priority 4 under the DEC Priority List: Lakeland Downs Mouse (*Leggadina lakedownensis*); Australian Bustard (*Ardeotis australis*); Bush Stone-curlew (*Burhinus grallarius*); and Grey Falcon (*Falco hypoleucos*).

Bamford Consulting Ecologists (2005) Fauna Survey of the Proposed Cloud Break Iron Ore Mine

This Level 2 fauna survey was conducted between April and May 2005. The Cloud Break study area assessed during this survey is located 120 km south of the Sulphur Springs Study area (**Figure 8**). This survey incorporated a variety of sampling techniques including systematic trapping, active searching, bird surveys and AnaBat echolocation recordings.

Six fauna habitat types occurred within the Cloud Break Study area including Spinifex plains, samphire flats, woodlands, ridges, gullies and drainage lines.

A total of 152 vertebrate species were recorded, comprising of 25 mammals, 98 birds, 28 reptiles and one amphibian.

Four conservation significance fauna species were recorded during this survey:

- Night Parrot (*Pezoporus occidentalis*) (EPBC Act – Endangered; WC Act – Schedule 1)
- Peregrine Falcon (*Falco peregrinus*) (WC Act – Schedule 4); and

- Two species listed as Priority 4 under the DEC Priority List, Australian Bustard (*Ardeotis australis*) and Star Finch (*Neochmia ruficauda subclarescens*).

Outback Ecology Services (2006) Spinifex Ridge Molybdenum Project: Terrestrial Vertebrate Fauna Baseline Surveys 2005-2006

Outback Ecology conducted this Level 2 fauna survey between July and August 2005. The study area is situated approximately 90 km east of the Sulphur Springs Study area (**Figure 8**). This fauna assessment incorporated a variety of sampling techniques including pitfall traps, Elliott traps, funnel and cage traps, systematic hand searching, targeted searching, spotlighting, AnaBat echolocation recording and avifauna censusing.

Six fauna habitat types occurred within the study area including Spinifex plains, riverine Eucalypts, basalt ridge, rocky lower to mid slope, rock gullies and minor drainage lines.

A total of 119 vertebrate species were recorded, comprising of 26 mammals, 63 birds, 26 reptiles and four amphibians.

Three conservation significance fauna species were recorded in the study area;

- Northern Quoll (*Dasyurus hallucatus*) (EPBC Act - Endangered; WC Act – Schedule 1);
- Pilbara Leaf-nosed Bat (*Rhinonicteris aurantia*) (EPBC Act - Vulnerable; WC Act – Schedule 1);and
- Rainbow Bee-eater (*Merops ornatus*) (EPBC Act – Migratory).

Bamford Consulting Ecologists (2007) Pardoo Direct Shipping Ore Project Fauna Assessment

Bamford Consulting conducted this fauna survey in April 2007. The Pardoo study area is located approximately 85km north of the Sulphur Springs Study area (**Figure 8**). This fauna assessment consisted of a literature review and an extended site inspection with the key objectives of documenting the vertebrate fauna and habitats present within the study area, assessing their conservation significance, and identifying potential impacts from the proposed operations.

Five fauna habitat types occurred within the Study area including Spinifex plains, major watercourses, ephemeral drainage lines, rocky hills and gorges and gullies.

A total of 89 vertebrate species were recorded, comprising of 12 mammals, 51 birds, 21 reptiles, four amphibians and one fish.

Five conservation significance fauna species were recorded in the study area;

- Northern Quoll (*Dasyurus hallucatus*) (EPBC Act - Endangered; WC Act – Schedule 1);
- Mulgara (*Dasycercus cristicauda*) burrows (EPBC Act – Endangered; WC Act – Schedule 1);
- Pilbara Olive Python (*Liasis olivaceus barroni)* (EPBC Act – Vulnerable; WC Act – Schedule 1);

- Peregrine Falcon (*Falco peregrinus)* (WC Act - Schedule 4); and
- Pebble-mound Mouse (*Pseudomys chapmani*) (DEC - Priority 4).

ecologia (2008) RGP 5 Level 2 Fauna Survey: Chichester Deviation

This Level 2 survey of the Chichester Deviation of the BHP Billiton rail corridor was conducted in October 2007 and April 2008. The study area was located approximately 110 km south of the Sulphur Springs Study area (**Figure 8**). Fauna sampling techniques implemented during the survey included: pitfall traps, Elliott traps, funnel traps, and cage traps; systematic hand searching; targeted searching; spotlighting; AnaBat echolocation recording for bats; and avifauna census.

Six broad fauna habitats were identified during this survey comprising Mulga woodland over spinifex hummocks; Open woodland over dense grass hummocks; Rocky hill slope regenerating after fire; Open woodland over dense understorey on rocky ground; Rocky hill side with dense spinifex hummocks; and burnt mulga woodland, open canopy with regenerating spinifex.

Three conservation significant fauna species were recorded during this survey, comprising:

- Ghost Bat (*Macroderma gigas*) (DEC -Priority 4);
- Lakeland Downs Mouse (*Leggadina lakedownensis*) (DEC -Priority 4); and
- Western Pebble-mouse (*Pseudomys chapmani*) (DEC -Priority 4).

Ninox Wildlife Consulting (2009a) A Fauna Survey of the Proposed Hope Downs 4 Mining Area Near Newman, Western Australia

Two detailed surveys were conducted as part of this assessment, in May and September 2008. The study area for this survey is located approximately 95 km south of the Sulphur Springs Study area (**Figure 8**). The surveys incorporated a variety of sampling techniques including: pitfall, Elliott, funnel and cage traps; harp trap and AnaBat echolocation recordings for bats; targeted searching; and avifauna census.

Four broad habitat types were identified from vegetation associations comprising Spinifex with Eucalypts, Ridges and Ranges (two categories), and Mulga Groves.

A total of 71 vertebrate fauna species were recorded during the May survey, comprising six mammals, 19 reptiles and 46 birds. A total of 84 fauna species were recorded in the September 2008 survey, comprising seven mammals, 22 reptiles and 55 birds.

Three species of conservation significance were recorded during the 2008 surveys, comprising:

- Two species listed as Priority 4 under the DEC Priority List: Western Pebble-mound Mouse (*Pseudomys chapmani*) and Australian Bustard (*Ardeotis australis*) (DEC- Priority 4); and
- Rainbow Bee-eater (*Merops ornatus*) (EPBC Act - Migratory).

Ninox Wildlife Consulting (2009b) A Vertebrate Fauna Survey of the Proposed Hope Downs 4 Infrastructure Corridor: Option 1 Near Newman, Western Australia

A detailed Level 2 fauna survey was undertaken over the Hope Downs Infrastructure Corridor Option 1 study area in May 2008. The study area was located approximately 95 km south of the Sulphur Springs Study area (**Figure 8**). Fauna sampling techniques included pitfall traps, Elliott traps, AnaBat echolocation recording for bats, opportunistic records and avifauna census.

Four major plant communities were defined in this survey: grassland with emergent mulga on cracking clays; low open mulga woodland on sandy loam and plains; Triodia hummock grassland on gravely soils; and open Eucalypt woodland on major creeklines.

A total of 71 species were recorded during this survey comprising 11 mammal, 37 bird and 23 reptile species.

Two species of conservation significance were recorded:

- Western Pebble-mound Mouse (*Pseudomys chapmani*) (DEC - Priority 4); and
- Australian Bustard (*Ardeotis australis*) (DEC - Priority 4).

Ninox Wildlife Consulting (Ninox Wildlife Consulting 2009c) A Vertebrate Fauna Survey of the Proposed Hope Downs 4 Option 6 Infrastructure Corridor Near Newman, Western Australia

Two detailed Level 2 fauna surveys were conducted as part of this assessment; a spring survey in September 2008 and an autumn survey in April 2009. The study area assessed for the proposed Hope Downs 4 Option 6 infrastructure corridor is located approximately 95 km south of the Sulphur Springs Study area (**Figure 8**). The surveys incorporated a variety of sampling techniques including: pitfall, Elliott, funnel and cage traps; AnaBat echolocation recordings for bats; targeted searching; and avifauna census.

Three significant fauna habitats were identified within the study area including riverine woodlands, spinifex grasslands and Mulga woodlands.

A total of 105 vertebrate fauna species were recorded during these surveys, comprising 19 mammal, 62 bird, 23 reptiles and one amphibian species. Thirty-two species of reptile were recorded during this September 2008 survey and 41 species in April 2009.

Two fauna species of conservation significance were recorded in the study area:

- the Australian Bustard (*Ardeotis australis*) (DEC – Priority 4); and
- the Western Pebble-mound Mouse (*Pseudomys chapmani*) (DEC – Priority 4).

Outback Ecology (2009) Wodgina DSO Project: Terrestrial Vertebrate Fauna Assessment

A detailed Level 2 survey was conducted over the Wodgina DSO Project study area in April 2009. This study area is located approximately 55 km west of the Sulphur Springs Study area (**Figure 8**). This survey incorporated a variety of sampling techniques including pitfall traps, Elliott traps, funnel traps, and cage traps, systematic hand searching, targeted searching, spotlighting, AnaBat echolocation recording and avifauna census.

A total of 90 vertebrate fauna species were recorded, comprising 18 mammals, 45 birds, 25 reptiles and two amphibians.

Six conservation significant fauna species were recorded within this study area, comprising:

- Northern Quoll (*Dasyurus hallucatus*) (EPBC Act - Endangered; WC Act – Schedule 1);
- Pilbara Leaf-nosed Bat (*Rhinonicteris aurantia*) (EPBC Act - Vulnerable; WC Act – Schedule 1);
- Three species listed as Priority 4 under the DEC Priority List: Western Pebble-mound Mouse (*Pseudomys chapmani*); Ghost Bat (*Macroderma gigas*); and Long-tailed Dunnart (*Sminthopsis longicaudata*); and
- Rainbow Bee-eater (*Merops ornatus*) (EPBC Act – Migratory).

Fourteen Ghost Bat roost locations were recorded within the study area of which four were considered significant roost sites supporting large numbers of Ghost Bats. The four significant roost sites all occurred outside of the Wodgina DSO Stage 1 Project disturbance area.

3.3 Reconnaissance Survey

The objective of the reconnaissance survey was to ground truth the occurrence of fauna habitat within the Study area, specifically focused on Northern Quoll (*Dasyurus hallucatus*) habitat, habitat for conservation significant bats (*Rhinonicteris aurantia* and *Macroderma gigas*) and habitat for SRE invertebrate species. Several methods were used to address this objective including targeted searching and opportunistic recording.

3.3.1 Targeted Searching

Targeted searches were conducted in habitats with the potential to support the Northern Quoll (*Dasyurus hallucatus*), Pilbara Leaf-nosed Bat (*Rhinonicteris aurantia*) and Ghost Bat (*Macroderma gigas*) within the Study area (**Figure 9**). This involved searching caves, crevices, gorges and ridge lines for any evidence of these species, including scats, individuals, bones and carcasses. Time spent conducting targeted searches totalled four person hours during the reconnaissance survey.

3.3.2 Opportunistic Sampling

The presence of conservation significant species was recorded wherever and whenever possible within the Study area during the reconnaissance survey. The location of any conservation significant species recorded opportunistically was taken by GPS.

3.3.3 Habitat Assessment

Definitions of fauna habitat used in this survey are consistent with classifications used elsewhere in biodiversity assessments. Identification and mapping of broad fauna habitats within the Study area, and those of particular relevance to conservation significant fauna, provides a useful framework within which to discuss species occurrence. Prior to the reconnaissance survey, broad habitat types present within the Study area were identified from analysis of aerial imagery and topographical mapping.

Representative areas were selected within selected major habitat types to conduct habitat assessments. Each representative area was given a rating of excellent, very good, good, moderate, degraded or completely degraded based on the overall condition of the habitat for fauna. Existing disturbance at each site was characterised and the potential for the habitat to support species of conservation significance was assessed.

3.4 Taxonomy and Nomenclature

Nomenclature and taxonomy of all vertebrate fauna species follows that of the Western Australian Museum (WAM) provided in the *Checklist of the Vertebrates of Western Australia* for amphibians, reptiles and mammals (Western Australian Museum 2010), and for the *Bird's Australia Checklist of Australian Birds*, based on Christidis and Boles (2008). Relevant texts from which information on general patterns of distribution were obtained included:

- Mammals (non-volant) - Van Dyck and Strahan (2008) and Menkhort and Knight (2004);
- Bats - Churchill (2008);
- Birds - Johnstone and Storr (1998, 2004), Pizzey and Knight (2007) and Morcombe (2003);
- Reptiles - Storr *et al.* (1999, 2002), Cogger (2000) and Wilson and Swan (2008);
- Amphibians - Cogger (2000).

3.5 Limitations and Constraints

Conclusions contained within this report are based on a desktop study and reconnaissance survey only (i.e. no sampling of fauna was conducted as part of this study). The reconnaissance survey comprised habitat assessment and ground-truthing and targeted searches of selected habitats (Rocky Ridge and Gorge, Drainage Line). A general assessment was made as to the likelihood of particular species of conservation significance occurring within the Study area, given the broad habitat types likely to occur, and specific habitat features occurring therein.

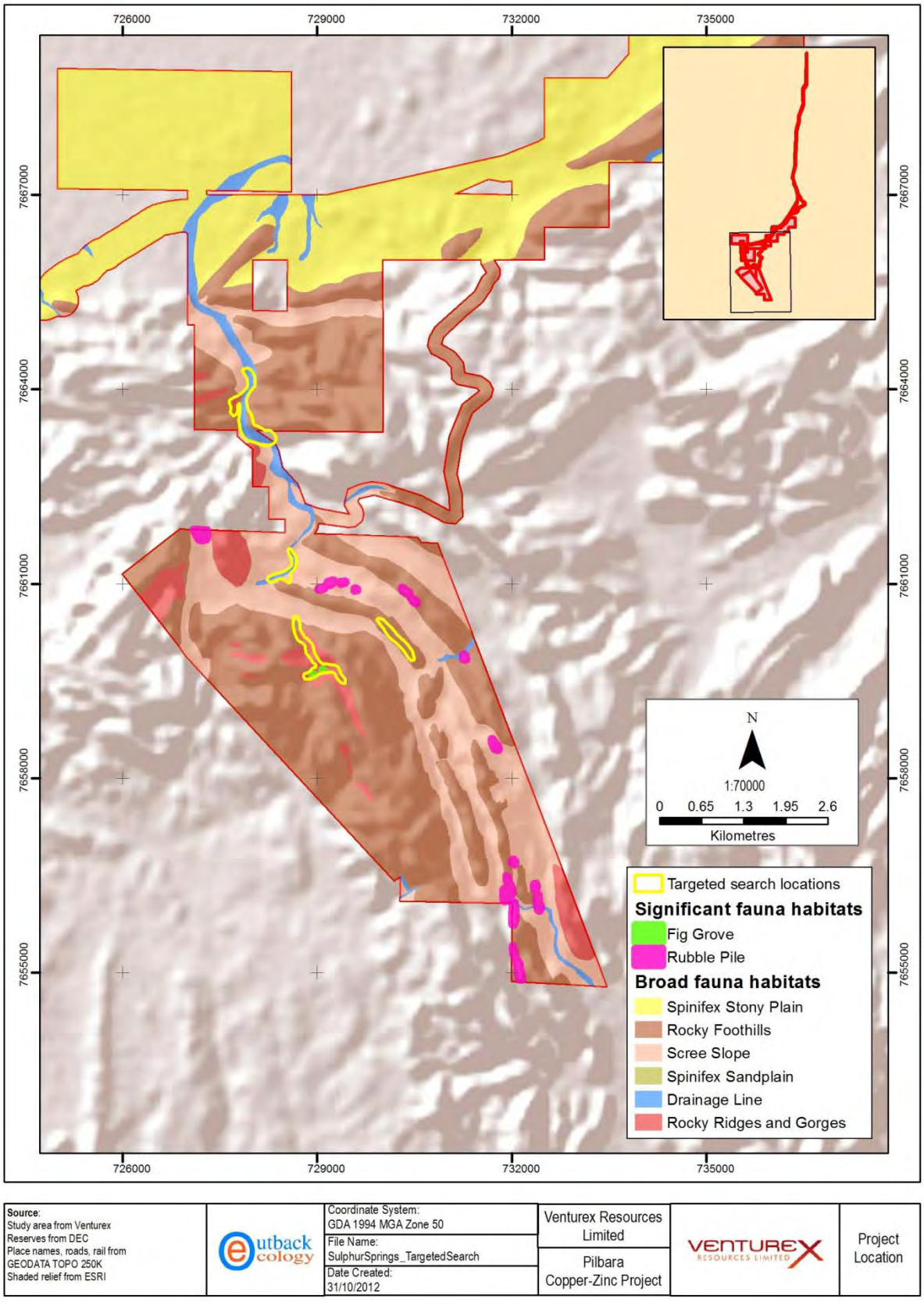

Figure 9: Location of targeted searches conducted within the study area

4. RESULTS AND DISCUSSION

4.1 Fauna Habitats Present within the Study area

The Study area consists of two main areas: the main infrastructure area; and the haul road corridor, which extends to the north. The combined extent of these study areas totals 7,623 ha. Of the range of habitats encompassed, some are considered widespread and typical of the Pilbara bioregion and some are considered uncommon and of limited extent.

A total of six broad fauna habitats were identified in the Study area (**Table 3**; **Figure 10**) on the basis of location, landform, substrate, vegetation community, degree of disturbance (e.g. mining, fire) and the fauna habitat which they offer:

- Spinifex Stony Plains;
- Rocky Foothills;
- Scree Slope;
- Spinifex Sandplains;
- Drainage Line; and
- Rocky Ridges and Gorges.

An additional two significant fauna habitats of limited extent were identified:

- Rubble Piles; and
- Ficus Groves.

A brief description of each habitat identified, with a focus on the complexity and the quality that each provides for the local fauna assemblages and specific suitability for conservation significant species, is provided below in order of extent of its occurrence within the Study area.

Table 3: Habitat summary

Broad Fauna Habitat	Hectares in Study area (ha)	Proportion of habitat within Study area (%)
Spinifex Stony Plains	2,689	35.3
Rocky Foothills	2,487	32.6
Scree Slope	1,416	18.6
Spinifex Sandplains	590	7.7
Drainage Line	215	2.8
Rocky Ridges and Gorges	211	2.8
Rubble Piles	13.1	0.2
Ficus Groves	0.1	< 0.01
Total	**7,623**	**100.0**

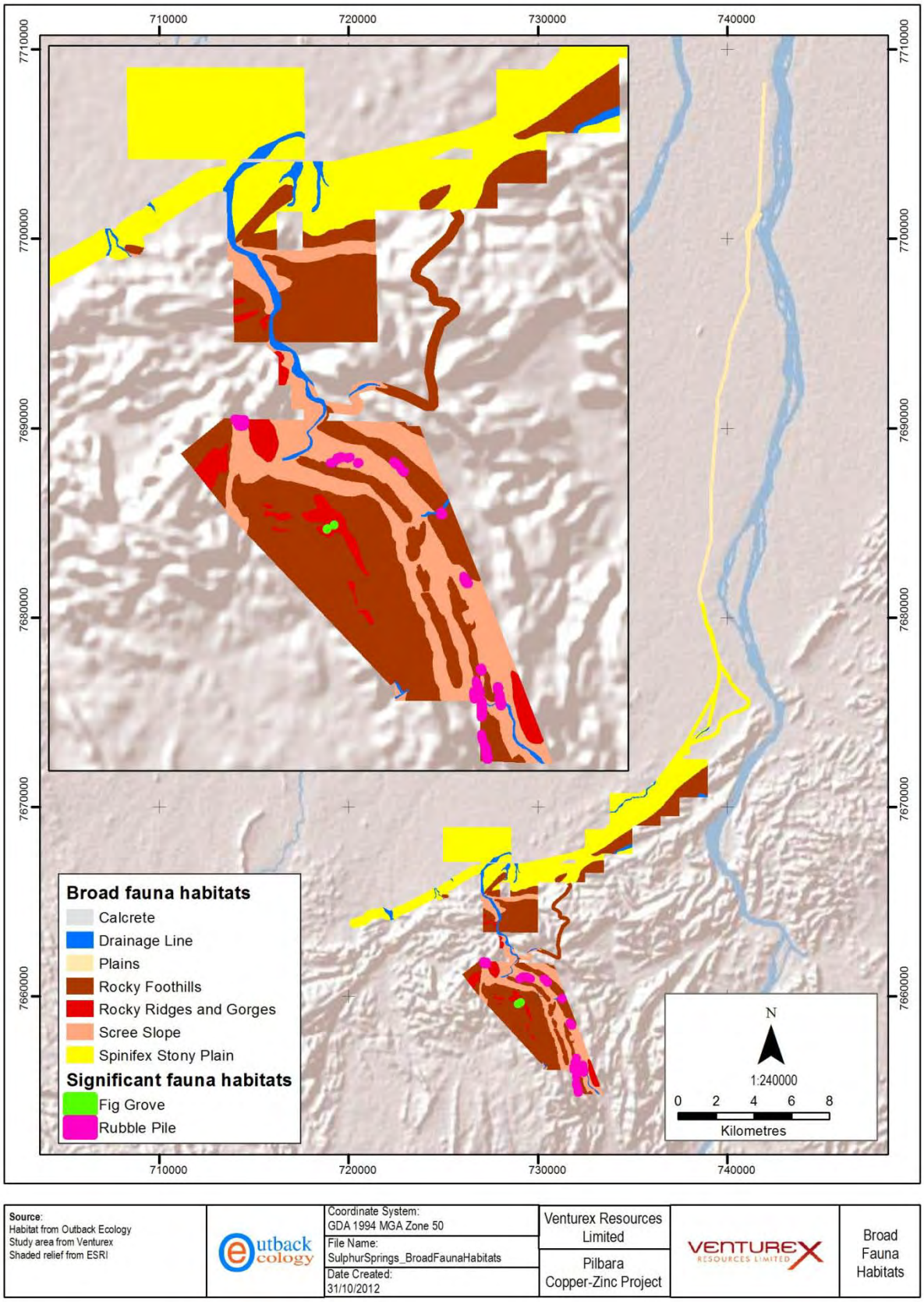

Figure 10: Habitat mapping for the Study area

4.1.1 Spinifex Stony Plains

Approximately 35% of the Study area consists of Spinifex Stony Plains habitat with the majority of this habitat type occurring in the central portion of the Study area (**Figure 10**). Some of the Haul Road consists of this habitat type, which is widespread throughout the surrounding landscape (e.g. Macroy, Satirist land system, **Table 1**; **Figure 6**).

The value of Plains habitat (both Spinifex Sandplain and Stony Plain) in supporting fauna assemblages is often closely related to its fire history, with areas retaining a mosaic of fire ages often providing the best habitat (Parr and Andersen 2006, Southgate *et al.* 2007, Woinarski 1999). Newly burnt habitat may be used for foraging, where as long unburnt areas may be used for shelter and breeding. It is common for large swathes of sandplain habitat to be burnt on a frequent basis (Burrows *et al.* 2006) as part of pastoral operations in order to promote new palatable growth and prevent regrowth of non-palatable Acacia species (Van Vreeswyk *et al.* 2004, Wright and Clarke 2007). In contrast, Stony Plains are of marginal value to pastoral operations as they do not support the same diversity of palatable grasses as sandplains; however, are also subject to frequent burning (Van Vreeswyk *et al.* 2004).

The conservation significant Spectacled Hare-wallaby (Priority 3 Fauna) and Brush-tailed Mulgara (Priority 4 Fauna) are commonly recorded within this habitat in areas where large, long unburnt hummocks of Spinifex exist (e.g. (Biota 2002b, 2004)). These are considered important habitat elements for these species (Menkhorst and Knight 2004). Additional conservation significant species that may occur in this habitat included the Australian Bustard (*Ardeotis australis*), Bush Stone-curlew (*Burhinus grallarius*) and the Rainbow Bee-eater (*Merops ornatus*). Mounds of the Western Pebble-mound Mouse (*Pseudomys chapmani*) may be recorded where stony pebbles and gravel occur. Spinifex Stony Plain habitat is known to support populations of this species as it possesses the small even sized pebbles required to construct mounds (Menkhorst and Knight 2004, Van Dyck and Strahan 2008).

SRE invertebrate species are unlikely to occur in the Spinifex Stony Plains as this habitat is widespread and well connected in the surrounding landscape.

4.1.2 Rocky Foothills

Approximately 33 % of the Study area consists of Rocky Foothills habitat with the majority of this habitat type occurring in the southern portions of the Study area (**Figure 10**). The habitat consists of those hills that do not commonly feature ridges, caves and gorges, and hence do not tend to possess microclimates that are favourable to fauna species. This habitat type also corresponds with the Capricorn land system, which is well represented throughout the surrounding landscape (**Table 1**; **Figure 6**).

Conservation significant species that may occur within this habitat type include the Australian Bustard (*Ardeotis australis*), Bush Stone-Curlew (*Burhinus grallarius*) and the Western Pebble-mound Mouse (*Pseudomys chapmani*).

SRE invertebrate fauna are unlikely to occur in the Rocky Foothills as this habitat is exposed and extensive in the surrounding landscape.

4.1.3 Scree Slope

Scree Slope habitat comprises approximately 19 % of the overall Study area, occurring mostly in the southern portion of the Study area (**Figure 10**). This fauna habitat forms part of the Capricorn land system, which is not typically utilised for pastoralism, resulting in much of this habitat remaining in good condition (Van Vreeswyk *et al.* 2004). Scree Slopes also represent a transition between Plains habitat and the more rugged Rocky Foothills and Rocky Ridges and Gorges.

The conservation significant Western Pebble-mound Mouse (*Pseudomys chapmani*) is commonly detected in this habitat via its characteristic mounds (How *et al.* 1991, Outback Ecology 2011). Other conservation significant species likely to occur within this habitat include the Australian Bustard (*Ardeotis australis*) and Rainbow Bee-eater (*Merops ornatus*).

SRE invertebrate fauna are unlikely to occur in the Scree Slopes as this habitat is largely exposed and extensive.

4.1.4 Spinifex Sandplain

Approximately 8% of the study area consists of Spinifex Sandplain with the majority of this habitat type occurring in the Haul Road portion of the Study area (**Figure 10**). Spinifex Sandplain is widespread throughout the surrounding landscape (e.g. Uaroo land system, **Table 1**; **Figure 6**).

The conservation significant Spectacled Hare-wallaby (Priority 3 Fauna) may occur within this habitat where large, long unburnt hummocks of Spinifex exist. These are considered important habitat elements for this species (Menkhorst and Knight 2004). Additional conservation significant species likely to occur in this habitat include the Australian Bustard (*Ardeotis australis*), Bush Stone-curlew (*Burhinus grallarius*) and the Rainbow Bee-eater (*Merops ornatus*).

SRE invertebrate fauna are unlikely to occur in the Spinifex Sandplain habitat, as this habitat is extensive and well connected to similar habitats in the surrounding landscape.

4.1.5 Drainage Line

Drainage Line habitat consists of rivers, creeks and minor watercourses and forms approximately 2.6 % of the overall Study area. This habitat type, which is subject to regular flooding, is typically less than 20 m in width and often supports a thin band of Eucalypt and Acacia species as well as isolated groups of Melaleuca trees and sedges. Drainage Line habitat may support soft spinifex and buffel grass (*Cenchrus*

ciliaris – an introduced weed), which is considered palatable to livestock, often leading to degradation from grazing (Van Vreeswyk *et al.* 2004).

Drainage Line habitat represents important habitat for fauna as it provides a range of microhabitats and a stable source of resources (How *et al.* 1991). More specifically, nectarivorous avifauna benefit from the flowering plants that line the banks of drainage lines (Burbidge *et al.* 2010) and mammal and reptile fauna may congregate around permanent water pools (How *et al.* 1991). In particular, amphibian species would be most likely to occur within this habitat type. Their linear arrangement provides linkages between other more permanent sources of food and water (How *et al.* 1991) and are therefore important for allowing fauna to move throughout the landscape. For example, migratory bird species are also known to use Drainage Line habitat as a conduit for movement (Bamford *et al.* 2008, Storr 1984).

Conservation significant species that may occur within this habitat type include the Northern Quoll (*Dasyurus hallucatus*), Australian Bustard (*Ardeotis australis*) and Bush Stone-Curlew (*Burhinus grallarius*).

There is potential for SRE invertebrate fauna to occur within the Drainage Line habitat as this habitat has sheltered areas of dense vegetation that are uncommon in the surrounding landscape. Although this habitat is not extensive in the landscape, it is relatively well connected along its length.

4.1.6 Rocky Ridges and Gorges

Approximately three percent of the Study area consists of this habitat type, consisting of isolated occurrences throughout the southern and central portions of the Study area (**Figure 10**). Rocky Ridges and Gorges is relatively uncommon habitat within the broader landscape as they are comprised specifically of those hills featuring outcropping ironstone, fallen boulders, caves, overhangs and crevices. This habitat type is considered important for fauna and may support a number of species of conservation significance (Bamford Consulting Ecologists 2008, How *et al.* 1991). Gorges provide shelter and water sources for habitat specific species such as the Pilbara Olive Python (*Liasis olivaceus barroni*). Deep, humid caves provide roost habitats for conservation significant bat species, the Pilbara Leaf-nosed Bat (*Rhinonicteris aurantia*) and Ghost Bat (*Macroderma gigas*). Ridge habitats provide important breeding habitat, and nursery dens for the Northern Quoll (*Dasyurus hallucatus*) (Van Dyck and Strahan, 2008).

There is potential for SRE invertebrate fauna to occur within the Rocky Ridges and Gorges as this habitat consists of sheltered areas with cooler more moist microclimates that are uncommon in the landscape. Additionally, this habitat tends to be isolated from other similar habitats in the landscape.

4.1.7 Rubble Piles

Rubble Piles comprise approximately 0.2 % of the overall Study area, occurring mostly in the southern portion (**Figure 10**). The Rubble Piles consist of large blocky boulders of dark gabbro which generally lack vegetation, however occasionally larger trees of *Ficus* or *Terminalia* may occur. This habitat is uncommon

in the Study area and uncommon in the surrounds. This habitat is also relatively unique and isolated in comparison to other habitats in the landscape. As a result, there is potential for this habitat to support invertebrate species with restricted distributions.

4.1.8 Ficus Groves

The Ficus Groves comprise less than 0.01 % of the overall Study area and occur in close association with the Rocky Ridges and Gorges habitat (**Figure 10**). The Ficus Groves are made up of large trees of *Ficus brachypoda* which grow in sheltered and rocky areas. The often deep decaying leaf litter and shelter provided by the trees creates a moist sheltered environment that is uncommon and isolated from similar habitat in the surrounding landscape. As a result, this habitat has the potential to support invertebrate species with restricted distributions.

4.2 Vertebrate Fauna of the Study Area

Based on database search findings and a review of relevant literature within the surrounding region, it is possible that a total of 392 terrestrial vertebrate fauna species may potentially occur within the Study area, comprised of 53 mammals (44 native), 211 birds, 116 reptiles, five fish and seven amphibian species.

Based on a more specific review of previous surveys within the Study area (Bamford Consulting Ecologists 2001, Biota 2007), it is possible that a total of 151 terrestrial vertebrate fauna species may potentially occur within the Study area, comprised of 27 mammals (22 native), 83 birds, 34 reptiles, five fish and two amphibian species.

A complete list of vertebrate fauna species previously recorded and/or expected to occur within the Study area and surrounds is presented in **Appendix A**.

4.2.1 Mammals

Based on the data from the review of database searches and previous surveys in the region, a total of 44 native mammal species have the potential to utilise the Study area; 22 of which have been recorded within or in close proximity to the Study area (Bamford Consulting Ecologists 2001, Biota 2007) (**Attachment A**). Fourteen bat species have the potential to utilise the Study area, six of which have been recorded within the Study area; two of these are of conservation significance (the Pilbara Leaf-nosed Bat and the Ghost Bat). Seven non-volant conservation significant mammals have the potential to utilise the Study area, comprising the Northern Quoll, Mulgara, Greater Bilby, Spectacled Hare-wallaby, Western Pebble-mound Mouse, Long-tailed Dunnart and Lakeland Downs Mouse.

4.2.2 Birds

Based on the data from the review of database searches and previous surveys in the region, a total of 211 bird species have the potential to utilise the Study area; 83 of which have been recorded within or in close proximity to the Study area (Bamford Consulting Ecologists 2001, Biota 2007) (**Attachment A**). Eight

conservation significant birds have the potential to utilise the Study area, comprising the Night Parrot, Peregrine Falcon, Australian Bustard, Bush Stone-curlew, Grey Falcon, Star Finch, Eastern Curlew and Flock Bronzewing. An additional four migratory species have the potential to utilise the Study area, comprising the Fork-tailed Swift, Cattle Egret, Oriental Plover and Rainbow Bee-eater, although the Cattle Egret and Oriental Plover would only be present irregularly, either as nomads or migrants occurring during particular climatic conditions.

4.2.3 Reptiles

Based on the data from the review of database searches and previous surveys in the region, a total of 116 reptile species have the potential to utilise the Study area; 34 of which have been recorded within the Study area (Bamford Consulting Ecologists 2001, Biota 2007) (**Attachment A**). Five conservation significant reptiles have the potential to utilise the Study area, comprising the Pilbara Olive Python, Woma, *Ramphotyphlops ganei* (a blind snake), the Spotted Ctenotus and Pin-striped Finesnout Ctenotus.

4.2.4 Amphibians

Based on the data from the review of database searches and previous surveys in the region, seven amphibian species have the potential to utilise the Study area; two of which have been recorded within the Study area (Bamford Consulting Ecologists 2001, Biota 2007) (**Attachment A**). None of these amphibians are of conservation significance.

4.2.5 Fish

Based on the data from the review of database searches and previous surveys in the region, five fish species have the potential to occur within water bodies in the Study area; all of which have been recorded within the Study area (Bamford Consulting Ecologists 2001, Biota 2007) (**Attachment A**). None of these fish species are of conservation significance.

4.2.6 Introduced and Declared Fauna Species

Previous fauna surveys and database searches have revealed that ten introduced species have the potential to occur within the Study area. These include: European Cattle, Dromedary, Dingo, Fox, Donkey, Horse, Feral Cat, European Rabbit, House Mouse and Rock Dove (**Attachment A)**.

4.3 Conservation Significant Vertebrate Fauna Species

The conservation significance of terrestrial vertebrate fauna potentially occurring within the Study area is described in the following sections, including:

- Threatened fauna species listed under the EPBC Act and specially protected fauna listed under the WC Act (Section 4.3.1);
- Priority fauna recognised by DEC (Section 4. 3.2);
- 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 4.3.3).

In the following sections, the likelihood of conservation significant fauna occurring within the Study area has been ranked using the following definitions:

Confirmed - presence in Study area recorded unambiguously during the last ten years (i.e. recent surveys of Study area or via database searches).

Very Likely – Study area lies within the species' known distribution and contains suitable habitat(s), plus the species generally occurs in suitable habitat and has been recorded nearby in the last 20 years.

Likely – Study area lies within the species' known distribution and the species has been recorded nearby in the last 20 years; however, either:
a) contains habitat that is marginally suitable, or only a small area of suitable habitat;
b) the species is generally rare and patchily distributed in suitable habitat.

Possible - Outside chance of occurrence based on:
a) Study area is just outside the known distribution; however, contains suitable and sufficient habitat (species may be common, rare, or patchy); or
b) Study area lies within the known distribution but species is very rare and/or patchily distributed; or
c) Study area lies on the edge or within the known distribution and has suitable habitat, but the species has not been recorded in the area for over 20 years.

Unlikely – Study area lies outside the species known distribution, does not contain suitable habitat and the species has not been recorded in the area for over 20 years.

4.3.1 Threatened Species

Legislation has been developed at a Commonwealth and State level to protect fauna species that have been formally recognized as rare, threatened with extinction, or as having high conservation value. At the national level, fauna are protected under the EPBC Act. Within Western Australia, fauna can be listed under various Schedules within the WC Act. Definitions of conservation significance are presented in **Attachment B**.

There are eight threatened fauna species that have the potential to occur within the Study area: Night Parrot (*Pezoporous occidentalis*), Northern Quoll (*Dasyurus hallucatus*), Mulgara (*Dasycercus cristicauda/blythi*), Greater Bilby (*Macrotis lagotis*), Pilbara Leaf-nosed Bat (*Rhinonicteris aurantia*), Pilbara

Olive Python (*Liasis olivaceus barroni*), Peregrine Falcon (*Falco peregrinus*) and Woma (*Aspidites ramsayi*) (**Table 4**).

Table 4: Threatened fauna species potentially occurring within the Study area

Common name (*Scientific name*)	Likelihood	Conservation Status		No of previous surveys recorded	No. of database searches recorded	Reason for likelihood
		EPBC Act[1]	WC Act[2, 3]			
Mammals						
Northern Quoll (*Dasyurus hallucatus*)	Confirmed	EN	S1	9	3	recorded within the Study area during previous surveys
Mulgara[#] (*Dasycercus cristicauda/blythi*)	Confirmed	VU	S1	6	2	recorded within the Study area during previous survey
Greater Bilby (*Macrotis lagotis*)	Possible	VU	S1	2	1	presence of suitable habitat, recent records within surrounding region
Pilbara Leaf-nosed Bat (*Rhinonicteris aurantia*)	Confirmed	VU	S1	5	3	recorded within the Study area during previous surveys
Birds						
Night Parrot (*Pezoporus occidentalis*)	Possible	EN	S1	1	-	presence of suitable habitat, recent records adjacent to Study area
Peregrine Falcon (*Falco peregrinus*)	Likely	-	S4	6	2	presence of suitable habitat, recent records adjacent to Study area, patchily distributed
Reptiles						
Pilbara Olive Python (*Liasis olivaceus barroni*)	Very Likely	VU	S1	4	2	presence of suitable habitat, recent records adjacent to Study area
Woma (*Aspidites ramsayi*)	Possible	-	S4	1	-	presence of suitable habitat, recent records in surrounding region, patchily distributed species

[1]EPBC Act: E Endangered, VU Vulnerable
[2]WC Act: Schedule 1, S4
[3] DEC Priority Species List: Priority 1, P2, P3, P4
[#] – *Dasycercus cristicauda* and *D. blythi* are treated as one species within this report as taxonomic uncertainty exists for previous records of this species within Study area and surrounds

Northern Quoll (*Dasyurus hallucatus*)

The Northern Quoll is listed as Endangered under the EPBC Act and listed as Schedule 1 under the WC Act. Optimal habitat for the Northern Quoll consists of dissected rocky escarpments which provide shelter such as rock crevices and caves and support higher densities of Northern Quolls than habitats such as *Eucalyptus* woodlands and human settlements (Van Dyck and Strahan 2008). Adult male home ranges are over 100 hectares and overlap with female home range (King 1989).

Northern Quolls breed once a year and the majority of adult males die off after mating at approximately one year of age (Van Dyck and Strahan 2008). Northern Quoll abundance is highly cyclical, with annual reproduction that is highly synchronised within a population. Breeding seasons may vary by a few weeks between nearby populations (Schmitt *et al.* 1989). Females have a short life span with the oldest female recorded in the wild being three years of age.

The population of Northern Quolls in the Pilbara is at its lowest after the mating season which occurs in the winter months, as a significant proportion of males have died off and young have not yet begun to forage independently. Therefore the population density is expected to be highest in the summer months, prior to the mating season and when juveniles are foraging independently.

Several threatening processes have contributed to decline in Northern Quoll populations across Australia, such as inappropriate fire regimes, predation, and poisoning as a result of ingesting cane toads (Department of Environment Water Heritage and the Arts 2010). The Pilbara is considered to be one of the remaining strong holds of Northern Quolls as the cane toad is encroaching the Kimberley region and populations in the Northern Territory are known to have been decimated and become locally extinct within a year of contact with cane toads (Van Dyck and Strahan 2008).

DEC threatened and priority fauna database records indicate that the Northern Quoll has been recorded from Wodgina, Poondano and Marble Bar (Department of Environment and Conservation 2010b). Northern Quolls were considered “clearly abundant” within the Study area during a survey in 2001, although the species was limited to Rocky Ridge habitat. It is very likely that the Northern Quoll occurs within Drainage Line habitat within the study area, as it possesses a reliable and semi-permanent water source and is situated adjacent to high quality Rocky Ridge habitat also.

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

The Mulgara prefers spinifex grasslands on sandy soils, constructing burrows on the flats between sand dunes (Van Dyck and Strahan, 2008). Introduced grazers namely cattle and rabbits, altered fire regimes and predation by cats and foxes have contributed to the population decline of this species (Maxwell *et al.* 1996, Van Dyck and Strahan 2008).

DEC threatened and priority fauna database records indicate that the Mulgara has been recorded from Kangan and Port Hedland, with the most recent record being in 2009 (Department of Environment and Conservation 2010b). During a Level 1 fauna survey within the Sulphur Springs Study area, numerous diggings for Mulgara were recorded around the Plains Access Road, with the species also captured along the Valley Access Road (Biota 2007).

- **Bilby (*Macrotis lagotis*)**

The Bilby (Vulnerable – EPBC Act, Schedule 1 – WC Act) was formerly associated with a variety of inland habitats including desert sandplains and dune fields with hummock grasslands and massive red earths and *Acacia* shrubland (Maxwell *et al.* 1996). Bilbies dig large burrows in the sandy substrates that can reach up to three metres long and 1.8 metres deep (Van Dyck and Strahan 2008). They are not reliant on surface water and receive most of their water requirements from food sources. Their diet consists of insects, larvae, seeds, bulbs, fruit and fungi (Van Dyck and Strahan 2008). The Bilby has undergone a widespread population decline as a result of altered fire regimes, predation by the European Red Fox (*Vulpes vulp*es) and feral cats and grazing pressure from introduced herbivores and livestock.

Bilby diggings have been recorded near the Study area at Kangan in 2001 and from Marble Bar in 2006 (Department of Environment and Conservation 2010b). It has also been recorded from the southern portion of the proposed Hope Downs rail corridor (Biota 2002b) and from a survey of the Cloudbreak Project (Bamford Consulting Ecologists 2005). It is possible that the species could occur within the Study area where sandy habitat supporting mature hummock grasslands exists (e.g. within the Haul Road corridor) although it was not recorded during previous surveys of the study area (Bamford Consulting Ecologists 2001, Biota 2007).

- **Pilbara Leaf-nosed Bat (*Rhinonicteris aurantia)***

The Pilbara Leaf-nosed Bat is classified as Vulnerable under the EPBC Act. This species is subject to several threatening processes including flooding and human impacts such as mining (Department of Environment Water Heritage and the Arts 2010). The Pilbara Leaf-nosed Bat has specific habitat requirements occupying warm, very humid roost sites in caves and mines (MOLHAR Pty Ltd 2007, Van Dyck and Strahan 2008). This enables the species to persist in arid temperatures by limiting water loss and energy expenditure. The Pilbara Leaf-nosed Bat is sensitive to human disturbance and the best method of detection is through recording echolocation calls while it flies from roost sites or forages within gorges (Van Dyck and Strahan 2008).

DEC records indicate that the Pilbara Leaf-nosed Bat has been recorded from Sulphur Springs and Poondano, near Port Hedland in 2009 (Department of Environment and Conservation 2010b). Positive AnaBat echolocation recordings for this species were recorded by previous surveys within the Study area (Bamford Consulting Ecologists 2001, Biota 2007) although sightings of the species were unconfirmed. Habitat within proposed impact areas assessed as part of the 2011 habitat assessment were deemed

unlikely to possess breeding roosts for the species as the rocky ridges did not appear to possess deep caves or crevices required by the species. In the absence of these habitat features, the presence of the species within this habitat is likely to be transitory.

- **Night Parrot (*Pezoporous occidentalis*)**

The Night Parrot is listed as Critically Endangered under the EPBC Act and as Schedule 1 under the WC Act. There have been very few confirmed records of the Night Parrot, with only 24 specimens in museum collections. The Night Parrot inhabits arid and semi-arid areas that are characterised by having dense, low vegetation. Based on accepted records, the habitat of the Night Parrot consists of *Triodia* grasslands in stony or sandy environments (Department of Sustainability Environment Water Population and Communities 2010b). In 2005 the presence of a single Night Parrot was recorded within the Fortescue Metals Group Cloud Break site, south east of the Study area (Bamford Consulting Ecologists 2005).

It is possible that the Night Parrot could occur within the Study area, although any estimate of likelihood of occurrence is putative, owing to the paucity of data for the species.

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

The Peregrine Falcon is listed as Schedule 4 under the WC Act 1950. It is a nomadic species that utilises a wide range of habitats across Australia, including rocky escarpments and gorges, cliffs, tree lined watercourses, open woodland and *Acacia* shrublands (Pizzey and Knight 2007). This species has a home range of approximately 20 – 30 km throughout the year.

The Peregrine Falcon was not recorded by previous surveys within the Study area (Bamford Consulting Ecologists 2001, Biota 2007); however, it has been recorded from a range of projects in the surrounding region, including surveys of the Hope Downs and FMG railway corridor projects (Biota 2002b, 2004) and the WA Museum survey of the Abydos-Woodstock Reserve (How *et al.* 1991). The species is found in most habitats but prefers inland cliffs and open woodlands near water for nesting (Pizzey and Knight 2007). Consequently, the species may favour Rocky Ridge habitat as it may provide more secure nesting sites than the other habitats within the study area. It is likely that this species would utilise the study area intermittently; however, it is unlikely to be dependent on the habitat within it given its mobility and the availability of suitable habitat within the region.

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

The Pilbara Olive Python is ranked as Vulnerable under the EPBC Act and listed as Schedule 1 and ranked as Vulnerable under the WC Act. This species inhabits rocky escarpments, deep gullies and gorges within the Pilbara region and is often recorded near water holes and riverine habitats (Wilson and Swan 2008). Radiotelemetry has found that the Pilbara Olive Python occupies a distinct home range. However males travel long distances during their breeding season from June to July to locate females (Department of Environment Water Heritage and the Arts 2010).

The Pilbara Olive Python was not recorded by previous surveys within the Study area (Bamford Consulting Ecologists 2001, Biota 2007); however, it has been recorded from a range of projects in the surrounding region, including the WA Museum survey of the Abydos-Woodstock Reserve (How *et al.* 1991). Given that Rocky Ridges and Gorges habitat is present within the Study area it is very likely that the Pilbara Olive Python could occur.

- **Woma or Ramsay's Python (*Aspidites ramsayi*)**

The Woma Python is listed under Schedule 4 of the WC Act. This species occurs in arid zones of Western Australia in woodland habitats, heathland and shrubland habitats often containing spinifex. The south-west Wheatbelt population appears to be threatened as opposed to the northern populations (Storr *et al.* 2002).

This species was not recorded within the study area during previous surveys (Bamford Consulting Ecologists 2001, Biota 2007); however, the Woma has been recorded during the survey of the southern section of the Hope Downs railway corridor (Biota 2002b). Consequently, it is possible that the Woma could occur within the Study area.

4.3.2 Priority Species

DEC recognises species not listed under the WC Act but for which there is some concern, and subsequently has produced a supplementary list of 'Priority' fauna. Definitions of Priority fauna are listed in **Appendix B**.

Fifteen listed Priority species have the potential to occur within the Study area and are listed in **Table 5** and **Appendix A**, and discussed below. Five of these species were recorded within the Study area during previous surveys: Ghost Bat (*Macroderma gigas*), Spectacled Hare-wallaby (*Lagorchestes conspicillatus subsp. leichardti),* Western Pebble-mound Mouse (*Pseudomys chapmani*), Australian Bustard (*Ardeotis australis*) and Bush Stone-curlew (*Burhinus grallarius*).

Table 5: Priority species recorded or with the potential to occur within the Study area

Common name (*Scientific name*)	Likelihood	Conservation Status		No of previous surveys recorded	No. of database searches recorded	Reason for likelihood
		EPBC Act	WC Act[1]			
Mammals						
Ghost Bat (*Macroderma gigas*)	Confirmed	-	P4	8	2	recorded within the Study area during previous survey
Spectacled Hare-wallaby (*Lagorchestes conspicillatus leichardti*)	Confirmed		P3	3	2	recorded within the Study area during previous survey
Western Pebble-mound Mouse (*Pseudomys chapmani*)	Confirmed	-	P4	11	2	recorded within the Study area during previous surveys
Long Tailed Dunnart (*Sminthopsis longicaudata*)	Possible	-	P4	1	-	presence of suitable habitat, recent records in surrounding region, patchily distributed species
Lakeland Downs Mouse (*Leggadina lakedownensis*)	Likely	-	P4	3	1	presence of suitable habitat, recent records in surrounding region, patchily distributed species
Mangrove Freetail-bat *(Mormopterus cobourgiana)*	Unlikely	-	P1	1	-	no suitable habitat within study area
Birds						
Australian Bustard (*Ardeotis australis*)	Confirmed	-	P4	10	3	recorded within the Study area during previous survey
Bush Stone-curlew (*Burhinus grallarius*)	Confirmed	-	P4	8	3	recorded within the Study area during previous survey
Grey Falcon (*Falco hypoleucos)*	Possible	-	P4	3	2	presence of suitable habitat, recent records in surrounding region, patchily distributed species
Star Finch (*Neochima ruficauda*)	Possible	-	P4	3	-	presence of suitable habitat, recent records in surrounding region
Eastern Curlew (*Numenius madagascariensis*)	Unlikely	-	P4	1	1	no suitable habitat within the Study area
Flock Bronzewing (*Phaps histrionica*)	Unlikely	-	P4	-	1	presence of suitable habitat, towards periphery of species range, patchily distributed species

Common name (*Scientific name*)	Likelihood	Conservation Status		No of previous surveys recorded	No. of database searches recorded	Reason for likelihood
		EPBC Act	WC Act[1]			
Reptiles						
Ramphotyphlops ganei	Possible	-	P1	1	1	presence of suitable habitat, recent records in surrounding region, ecology and habitat preferences poorly known
Spotted Ctenotus *(Ctenotus uber johnstonei)*	Unknown	-	P2	4	-	few records for this species, ecology and habitat preferences poorly known
Pin-striped Finesnout Ctenotus *(Ctenotus nigrilineatus)*	Unknown	-	P2	1	1	few records for this species, ecology and habitat preferences poorly known

[1] DEC Priority Species List: Priority 1, P2, P3, P4

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

The Ghost Bat is listed as Priority 4 by the DEC. The Ghost Bat is Australia's only carnivorous bat and is known to feed on a variety of vertebrate species including large insects, frogs, lizards, small mammals and other bats (Van Dyck and Strahan, 2008). Ghost bats occupy a variety of habitats from the arid Pilbara to the rainforests of Northern Queensland (Van Dyck and Strahan 2008). Ghost Bats roost in undisturbed caves usually with several entrances, in deep fissures or abandoned mine shafts (Menkhort and Knight 2004).

Ghost Bats mate between July and August with females bearing a single young around September. Mothers form nursery colonies and genetic testing has shown that the entire species is centralised upon regional maternity sites, of which approximately ten are known to exist (Van Dyck and Strahan, 2008). In the Pilbara, a number of natural formations are used by the Ghost Bat intermittently as short-term transient roosts and for feeding activity by an individual or small numbers of individuals, whilst others are used by maternity colonies (Armstrong and Anstee 2000).

The structure of a roost site is largely indicative of its use. The transient day roosts or feeding sites of Ghost Bats are often shallow overhangs and crevices with microclimates similar to ambient conditions, whereas roosts for breeding activity have a relative humidity of above 80% (Armstrong and Anstee 2000). Domed ceilings which create humid microclimates are often present in, but not exclusive to maternity caves. Deep, humid and complex mine shafts and deep humid caves with several chambers and dome ceilings are associated with permanent Ghost Bat occupancy and maternity roosts (Hall *et al.* 1997).

Roost sites have been identified in the surrounds during a fauna assessment of the Wodgina DSO study area, located 55 km to the west of the study area (Outback Ecology, 2009). Two sites were considered to be regionally significant and were found to contain large aggregations of between 40 – 70 bats (Outback Ecology, 2009).

The Ghost Bat was recorded by a previous survey within the Study area (Bamford Consulting Ecologists 2001).

- **Spectacled Hare-Wallaby (*Lagorchestes conspicillatus*)**

The Spectacled Hare-Wallaby is listed as Priority 3 by the DEC. This species inhabits *Triodia* hummock grasslands and *Acacia* shrublands and has declined dramatically within the Pilbara region, possibly due to fox predation and altered fire regimes which have prevented the development of large tussock grasslands required for adequate shelter (Van Dyck and Strahan 2008). The Spectacled Hare-Wallaby has been recorded near the Study area at Pilgangoora in 1994 (Department of Environment and Conservation 2010b).

Unconfirmed records of the Spectacled Hare-Wallaby were detailed in a survey by Bamford (2001), and so it is very likely that this species could occur in the northern portion of the Study area.

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

The Western Pebble-mound Mouse is listed as Priority 4 species by the DEC. This mouse constructs mounds out of small pebbles that can cover 0.5 to 9.0 m² (Van Dyck and Strahan 2008). Breeding for this species can occur throughout the year. Females may produce several litter per year of up to four young (Van Dyck and Strahan 2008).

Suitable habitat for the species is patchy but populations are widespread throughout the ranges of the central and southern Pilbara (Van Dyck and Strahan 2008). Furthermore, evidence of the mouse has been has been frequently recorded within the region surrounding the Study area (Bamford Consulting Ecologists 2001, 2007, 2008, Biota 2004, How and Cooper 2002, How *et al.* 1991). The Western Pebble-mound Mouse was recorded during previous surveys of the study area (Bamford Consulting Ecologists 2001, Biota 2007).

It should be noted that the prevalence of mounds within the study area and surrounds is not a reliable indicator of abundance or even presence as mounds are often used by successive generations (Van Dyck and Strahan 2008) and persist in the landscape for many years. All of the mounds recorded recently may represent signs of a population that has declined substantially in recent times.

- **Long-tailed Dunnart (*Sminthopsis longicaudata*)**

The Long-tailed Dunnart is classified as Priority 4 under the WC Act 1950. This species lives in arid rocky areas and has been recorded from flat topped hills, plateaus, granite outcrops and rocky scree slopes. In the winter, the Long-tailed Dunnart feeds entirely on arthropods and under cold conditions this species may utilise torpor as a strategy to conserve energy (Van Dyck and Strahan 2008).

Although suitable rocky habitat for this species occurs within the Study area and wider region, the species is only represented by a single record in this area; namely, from Wodgina, which is located 30 km to the south (Outback Ecology Services 2009).

- **Lakeland Downs Mouse (*Leggadina lakedownensis*)**

The Lakeland Downs Mouse is classified as Priority 4 by the DEC and utilises a variety of different habitats including spinifex and tussock grasslands, samphire and sedgelands, *Acacia* shrublands, tropical *Eucalyptus* woodlands and stony ranges. Most of these habitats are seasonally inundated on red or white sandy-clay soils (Van Dyck and Strahan 2008). Previous records of the Lakeland Downs Mouse were recorded during both the proposed Hope Downs and FMG railway corridor surveys (Biota 2002b, 2004). Records also occur from Chichester and Marble Bar in 2001 (Department of Environment and Conservation 2010b).

This species was not recorded during previous surveys (Bamford Consulting Ecologists 2001, Biota 2007); however, it is considered likely to occur as suitable habitat for this species does occur within the study area.

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

The Australian Bustard is listed as Priority 4 by DEC and has a wide distribution across Australia. The Australian Bustard inhabits open dry woodlands of Mulga, arid scrublands and Spinifex tussock grasslands (Johnstone and Storr 1998, Morcombe 2003). The DEC priority and threatened fauna database shows that this species has previously been recorded near Kangan, Marble Bar and Boodarie and Port Hedland with the most recent recording being from 2008 (Department of Environment and Conservation 2010b). It has also been recorded from a number of previous surveys nearby and in the wider region (**Attachment A**). The Australian Bustard was recorded within the Study area during a previous survey (Bamford Consulting Ecologists 2001).

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

The Bush Stone-curlew is classified as Priority 4 by the DEC and is found in open woodland and forest particularly near water courses or swampy areas (Geering *et al.* 2007). The Bush Stone-curlew was recorded during a previous survey within the Study area (Bamford Consulting Ecologists 2001) and has been frequently recorded in the surrounding area (**Attachment A**).

- **Grey Falcon (*Falco hypoleucos)***

The Grey Falcon is listed as Priority 4 by the DEC. This species mainly occurs around inland ephemeral and permanent drainage systems where annual rainfall is less than 500mm (Garnett and Crowley 2000). The Grey Falcon inhabits lightly wooded countryside especially stony plains and *Acacia* scrublands (Morcombe 2003). This species can be rare, resident or nomadic to most of the semi-arid interior of Western Australia.

The species was recorded during a survey of the FMG rail corridor (Biota 2004) and records for the species exist within databases (Birds Australia 2010, Department of Environment and Conservation 2010b). It is possible that this species may occur within the Study area as suitable habitat is present although this species is patchily distributed and so its presence may be intermittent.

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

The western race of the Star Finch is classified as Priority 4 by the DEC. This species occurs in lush, green woodland vegetation along temporary or permanent water courses, the margins of swamps or in green crops (Morcombe 2003). The Star Finch can be seen in pairs or in small flocks of up to 20 birds feeding on seed heads in low vegetation or on the ground (Morcombe 2003). This species is susceptible to changes that impact on riparian ecosystems (Bamford Consulting Ecologists 2008).

The Star Finch has been recorded from the WA Museum survey of the Abydos-Woodstock Reserve (How *et al.* 1991), the fauna survey of the Cloudbreak area (Bamford Consulting Ecologists 2005) and from the fauna survey of the BHP RGP5 Chichester railway deviation (ecologia 2008) (**Attachment A**). The Star Finch has not previously been recorded within the Study area; however, this species could intermittently occur in woodland vegetation and temporary water pools, especially after significant rainfall events.

- **Unnamed Blind Snake *(Ramphotypholops ganei*)**

Ramphotyphlops ganei is listed as Priority 1 and is endemic to the Pilbara region. There is a lack of data pertaining to this species' habitat requirements as few specimens have been recorded (Department of Environment and Conservation 2010b). *Ramphotypholops ganei* is thought to be associated with moist gorge and gully habitats.

Suitable habitat for this species within the study area is present (i.e. Rocky Ridge habitat) although it was not recorded during previous surveys (Bamford Consulting Ecologists 2001, Biota 2007). Therefore it may possibly occur in the study area but any estimate of likelihood of occurrence is putative, owing to the paucity of data for the species.

- **Pin-striped Finesnout *Ctenotus* (*Ctenotus nigrilineatus*)**

Ctenotus nigrilineatus is classified as Priority 2 by the DEC. The species is known from *Triodia pungens* hummock grassland at the base of granite outcrops near Woodstock in the hilly interior of the Pilbara (Wilson and Swan 2008). Previous records of *C*. *nigrilineatus* exist for Marble Bar in 1990 and the Abydos Plain in 2001 (Department of Environment and Conservation 2010b, How *et al.* 1991).

Suitable habitat for this species within the study area is limited (i.e. occurrences of granite) and it was not recorded during previous surveys (Bamford Consulting Ecologists 2001, Biota 2007). Therefore it may possibly occur in the study area but any estimate of likelihood of occurrence is putative, owing to the paucity of data for the species.

- **Spotted *Ctenotus* (*Ctenotus uber johnstonei*)**

Ctenotus uber johnstonei is classified as Priority 2 by the DEC and is known from hard reddish soils from interior Western Australia (Wilson and Swan 2008). Previous records of *C*. *uber johnstonei* are scant although it has been recorded from both the northern and southern portions of the FMG rail corridor (Biota 2004). The species may possibly occur in the study area but any estimate of likelihood of occurrence is putative, owing to the scarcity of data for the species.

Species recorded from previous surveys within the region and / or recorded form database searches that are considered unlikely to occur within the Study area are briefly discussed below.

- **Mangrove Freetail Bat (*Mormopterus cobourgiana*)**

This species occurs in Western Australian coastal areas from the Exmouth Gulf to Broome and is restricted to mangrove forests and other dense vegetation associated with coastal waterways (Churchill, 2008). As there is no suitable habitat present within the study area, this species is unlikely to occur.

- **Eastern Curlew (*Numenius phaeopus*)**

The Eastern Curlew is a migratory species that breeds in damp bogs and marshes in Siberia and Mongolia. The majority of the species migrates south to Australia with a major stronghold in southeast Queensland (Geering *et al.* 2007). Within Western Australia, Roebuck Bay and Eighty Mile Beach are considered sites of international importance to the species (Bamford *et al.* 2008). Although the study area is within the range of the species, there is no suitable habitat present and so the species is unlikely to occur.

- **Flock Bronzewing (*Phaps histrionica*)**

This species is patchy and nomadic across its range, which extends from central NSW and Queensland across to the north-western coast of Western Australia (Pizzey, 2007). Its preferred habitat is treeless grassy plains, saltbush, Spinifex and mulga. Although habitat within the Study area may be suitable, there are very few records existing for the species within the surrounding region. A record for the species exists

some 55 km to the east of the Study area; however, this record is dates back to 1957 (Department of Environment and Conservation, 2010). It is unlikely this species occurs in the study area.

4.3.3 Migratory Bird Species

Migratory species are listed under the EPBC Act and international agreements including 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).

The database searches and literature review identified 27 migratory species that have the potential to occur within the Study area (**Table 6**). Of these, 22 were considered unlikely to occur within the Study area and are excluded from further consideration. The remaining five species are discussed briefly below.

Table 6: Migratory species recorded or with the potential to occur within the Study area

Common name (*Scientific name*)	Likelihood	Conservation Status		No of previous surveys recorded	No. of database searches recorded	Reason for likelihood
		EPBC Act[1]	WC Act[2]			
Australian Reed-Warbler (*Acrocephalus australis*)	Unlikely	M	S3	2	2	no suitable habitat within the Study area
Common Sandpiper (*Actitis hypoleucos*)	Unlikely	M	S3	1	1	no suitable habitat within the Study area
Fork-tailed Swift (*Apus pacificus*)	Likely	M	S3	3	2	Aerial species, may occur within Study area
Cattle Egret (*Ardea ibis*)	Possible	M	S3	-	2	marginal habitat within the Study area
Ruddy Turnstone (Arenaria interpres)	Unlikely	M	S3	-	1	no suitable habitat within the Study area
Curlew Sandpiper (*Calidris ferruginea*)	Unlikely	M	S3	-	1	no suitable habitat within the Study area
Red-necked Stint (*Calidris ruficollis*)	Unlikely	M	S3	-	1	no suitable habitat within the Study area
Long-toed Stint (*Calidris subminuta*)	Unlikely	M	S3	-	1	no suitable habitat within the Study area
Greater Sand Plover (*Charadrius leschenaultii*)	Unlikely	M	S3	-	1	no suitable habitat within the Study area
Oriental Plover (*Charadrius veredus*)	Possible	M	S3	-	2	suitable habitat present within the Study area
White-winged Black Tern (*Chlidonias leucopterus*)	Unlikely	M	S3	-	1	no suitable habitat within the Study area

Common name (*Scientific name*)	Likelihood	Conservation Status		No of previous surveys recorded	No. of database searches recorded	Reason for likelihood
		EPBC Act[1]	WC Act[2]			
Eastern Reef Egret (*Egretta sacra*)	Unlikely	M	S3	-	1	no suitable habitat within the Study area
Oriental Pratincole (*Glareola maldivareum)*	Unlikely	M	S3	-	2	no suitable habitat within the Study area
White-Bellied Sea Eagle (*Haliaeetus leucogaster*)	Unlikely	M	S3	-	2	no suitable habitat within the Study area
Barn Swallow (*Hirundo rustica*)	Unlikely	M	S3	-	1	no suitable habitat within the Study area
Caspian Tern (*Hydroprogne caspia*)	Unlikely	M	S3	1	1	no suitable habitat within the Study area
Rainbow Bee-eater (*Merops ornatus*)	Confirmed	M	S3	12	3	recorded during previous surveys of the Study area
Eastern Curlew (*Numenius madagascariensis*)	Unlikely	M	S3	1	1	no suitable habitat within the Study area
Whimbrel (*Numenius phaeopus*)	Unlikely	M	S3	2	1	no suitable habitat within the Study area
Night Parrot (*Pezoporus occidentalis*)	Possible	M	S3	1	-	presence of suitable habitat, recent records adjacent to Study area
Glossy Ibis (*Plegadis falcinellus*)	Unlikely	M	S3	-	1	no suitable habitat within the Study area
Pacific Golden Plover (*Pluvialis fulva*)	Unlikely	M	S3	-	1	no suitable habitat within the Study area
Lesser Crested Tern (*Thalasseus bengalensis*)	Unlikely	M	S3	-	1	no suitable habitat within the Study area
Grey-tailed Tattler (*Tringa brevipes*)	Unlikely	M	S3	1	1	no suitable habitat within the Study area
Wood Sandpiper (*Tringa glareola*)	Unlikely	M	S3	1	1	no suitable habitat within the Study area
Common Greenshank (*Tringa nebularia*)	Unlikely	M	S3	1	1	no suitable habitat within the Study area
Marsh Sandpiper (*Tringa stagnatilis*)	Unlikely	M	S3	-	1	no suitable habitat within the Study area

[1] EPBC Act, M = Migratory species
2 WC Act, S3 = Schedule 3

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

The Fork-tailed Swift is a nomadic species that may be seen before and after storm fronts or tropical cyclonic events that are associated with an increase in insect activity which the species feeds on (Johnstone and Storr 2004). This species may fly over the study area without specifically utilising the habitats present. The Fork-tailed Swift was recorded during several studies within the surrounding region (Biota 2005, ecologia 2008, How *et al.* 1991). It is likely to occur within the Study area.

- **Cattle Egret (*Ardea ibis*)**

This species is associated with inland rivers and lakes that contain surface water. The Cattle Egret is highly mobile and can be found throughout most of the western fringes of the State in coastal areas and towards the semi-arid interior (Johnstone and Storr 1998).

Although this species has not been recorded during previous studies of the region, it is possible that it could occur within the Study area intermittently, when standing water is present after rainfall.

- **Oriental Plover (*Charadrius veredus*)**

The Oriental Plover breeds in northern China and Mongolia and the bulk of the population spends the non-breeding period in northern Australia (Bamford *et al.* 2008). All important sites in the non-breeding period are in northern Australia (Bamford *et al.* 2008). This species favours dry grasslands, particularly shorter grassland areas or recently burnt areas, rarely feeding in wet habitats but may occupy mudflats or beaches to roost when warm conditions prevail (Geering *et al.* 2007).

Although this species has not been recorded during previous studies of the region, it may occur within the study area intermittently, when standing water is present after rainfall.

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

The Rainbow Bee-eater occupies numerous habitats including open woodlands, sandpits, riverbanks, road cuttings, beaches, cliffs, mangroves and rain forests (Pizzey and Knight 2007). The Rainbow Bee-eater can occur as a resident, breeding visitor, passage migrant or winter visitor (Pizzey and Knight 2007).

This species is insectivorous, with bees and flies representing the bulk of its diet. The Rainbow Bee-eater nests in burrows dug at a slight angle in flat ground and sandy banks (Johnstone and Storr 1998). It is also known to nest in sandy embankments and cuttings and often perches on man-made structures such as power lines and fences (Johnstone and Storr 1998). As a consequence, it is commonly seen in areas occupied by humans such as mining camps and urban areas.

The Rainbow Bee-eater was recorded during previous surveys of the Study area (Bamford Consulting Ecologists 2001, Biota 2007) and is common in the surrounding region (**Attachment A**).

- **Night Parrot (*Pezoporus occidentalis*)**

This species is discussed in Section 4.3.1.

4.4 Terrestrial SRE Invertebrate Fauna Species

4.4.1 Short-range Endemism in Arid and Semi-arid Western Australia

Endemism refers to the restriction of a species to a particular area, at a continental, national or local scale (Allen *et al.* 2002). Short-range endemic species have naturally restricted ranges of less than approximately 10,000 square kilometres (Harvey 2002). A combination of intrinsic and extrinsic factors, such as dispersal capabilities or opportunities, habitat preferences, life history attributes, physiological attributes, habitat availability, biotic and abiotic interactions and historical factors, determine not only the geographic distribution of a taxon, but its propensity for population differentiation and speciation (Ponder and Colgan 2002).

In Western Australia, many terrestrial SRE invertebrate species have Gondwanan origins and are relics of previously widespread species common to the continents of the southern hemisphere during the mesic climates of the Miocene. The subsequent aridification of Australia during the Miocene through to Pleistocene resulted in the fragmentation and contraction of once common mesic habitats. Consequently, populations dependent on these mesic habitats were also fragmented, resulting in the evolution of SRE invertebrate fauna.

Taxa prone to short-range endemism tend to share several ecological and life-history characteristics, such as poor powers of dispersal, confinement to discontinuous habitats, highly seasonal activity patterns and low fecundity (Harvey 2002). The main invertebrate groups with these traits in the Pilbara region of WA include:

- Mygalomorph spiders;
- Scorpions;
- Pseudoscorpions;
- Millipedes;
- Slaters; and
- Snails.

Terrestrial invertebrate groups prone to short-range endemism and that potentially occur within the Study area are discussed below.

Mygalomorph spiders

Class: Arachnida Order: Araneae Sub-order: Mygalomorphae

Represented by some ten families and 241 named species, Mygalomorphae is a primitive group of spiders which constitute approximately 13% of Australia's described spider species (Brunet 1996, Main 2005). Mygalomorphs have several distinctive morphological features that differentiate them from modern araneomorph spiders including: parallel fangs, two pairs of book-lungs and the presence of four (sometimes six) spinnerets (ABRS 2010, Brunet 1996).

Unlike araneomorphs, mygalomorphs generally do not construct a web for capturing prey but instead build a burrow in which they wait for prey (Main 1982). Some species can spend their entire life in a single burrow (Main 1982). Burrow morphology is highly variable and a burrow may be up to 60 cm deep depending on the species and terrain (Brunet 1996). Females rarely venture from the burrow and it is usually the males which are observed above ground when they are wandering in search of females (Main 1982).

Harvey (2002) indicates that Mygalomorphae is likely to have SRE taxa, at least partly due to the group's limited powers of dispersal and low fecundity. The cryptic lifestyle and highly seasonal variation in above ground abundance makes collecting mygalomorphs problematic. The use of pitfall traps during the wetter parts of the year generally yield wandering males, whereas both sexes can be dug from the burrow at anytime. Mature male specimens are usually required for definitive species identifications based on morphology.

Pseudoscorpions

Class: Arachnida Order: Pseudoscorpionida

It is estimated that there are more than 700 species of pseudoscorpion in Australia; however, currently only 150 species are described with many specimens awaiting description. Pseudoscorpions are found in virtually all terrestrial habitats, most commonly amongst leaf litter and beneath rocks and bark (Harvey and Yen 1989). Pseudoscorpions are usually no more than several millimetres long and have a pair of pincer-like pedipalps which they use to subdue small invertebrate prey (Harvey and Yen 1989). Very few terrestrial pseudoscorpions are considered to be SRE (Environmental Protection Authority 2009). Hand collection, soil sieving, the processing of leaf litter in Tullgren funnels and wet pitfall trapping can be used to collect pseudoscorpions. Mature male specimens are usually required for definitive species identifications based on morphology.

Scorpions

Class: Arachnida Order: Scorpionida

Current classifications of the scorpions usually recognise five superfamilies, but only members of the Scorpionoidea and Buthoidea are present in Australia (ABRS 2010). Scorpions are nocturnal, solitary,

predatory arachnids that have a pair of pincer-like pedipalps and an elongate metasoma (tail) tipped with a sting. Australian scorpions may reach up to 12 cm in length (Harvey and Yen 1989). Some species construct spiral burrows that can extend up to 70 cm below ground.

Currently, many Australian scorpions belong to species-complexes in which a number of 'species' are grouped. With future taxonomic revision, the number of SRE species is likely to increase. Mature male specimens are usually required for definitive species identifications based on morphology. Males are generally active above ground on warm or humid nights, when they can be located using a UV spotlight under which they fluoresce. Scorpions can also be dug from their burrows and wandering males can be collected using pitfall traps.

Millipedes

Class: Diplopoda Orders: eg. Polydesmida, Chordeumatida, Polyzoniida, Spirostreptida

There are nine millipede orders present in Australia, represented by some 250 described species (ABRS 2010). Millipedes are elongate; generally detritivorous arthropods that usually have two legs per body segment. Little is known of the biology and ecology of Australian millipedes. The orders Polydesmidae and Chordeumatida either have, or are likely to have, representatives which are SREs. The propensity for short-range endemism in other millipede orders is unknown but considered low.

Millipedes are typically collected from mesic habitats and microhabitats and are commonly found among leaf litter and beneath rocks and bark in sheltered locations. Hand collection, soil sieving, the processing of leaf litter in Tullgren funnels and wet pitfall trapping are used to collect millipedes. Mature males which are generally present during the wetter parts of the year are usually required for definitive species identifications based on morphology.

Slaters

Class: Malacostraca Order: Isopoda

Slaters are terrestrial isopods that belong to the crustacean suborder Oniscoidea. They are generally detritivorous arthropods that usually do not exceed 15 mm in length. Seven families of slaters are known from Australia and nearly all species are undescribed (ABRS 2010). Slaters are found in tropical to arid climates, where they inhabit moist and sheltered locations such as those beneath rocks, logs and bark. Slaters can be collected by hand or by using wet pitfall traps. Slaters are likely to contain species which are SREs (Environmental Protection Authority 2009). Species identification based on morphology generally requires adult male specimens.

Snails

Class: Gastropoda Order: Eupulmonata

The Eupulmonata includes almost all terrestrial snails and slugs. There is approximately 1,000 species of slugs and snails in Australia. Snails tend to be either herbivorous or detritivorous. Snails prefer moist habitats and microhabitats and can be found in leaf litter, under rocks and logs and in crevices. In dryer areas snails may aestivate for an extended period up to 50 cm below ground. The best methods of collecting snails are by hand and by sieving leaf litter and soil. Many terrestrial snails have extremely restricted ranges and numerous species are known to be SREs, indeed some families consist entirely of SRE species (Environmental Protection Authority 2009, Harvey 2002). Mature live specimens are usually required for definitive species identifications based on morphology.

4.4.2 Potential Terrestrial Invertebrate SRE Fauna Habitat

SRE invertebrate fauna of arid and semi-arid Western Australia is typically associated with sheltered and mesic microhabitats, such as the south-west facing aspect of slopes, trees, boulders and rock piles, as well drainage systems, deep gorges, natural springs and fire refuges (Environmental Protection Authority 2009). SRE invertebrate fauna also tends to occur in isolated habitats such as outcrops and mesas (Environmental Protection Authority 2009).

Potential SRE habitat within the Study area is most likely to occur within Rocky Ridges and Gorges habitat and Drainage Lines habitat. The extent of these habitats is somewhat limited and in the case of Rocky Ridges and Gorges, it does not appear to be well connected within the wider landscape (**Figure 10**). Consequently, there may be some potential for SRE species to reside within this habitat type.

Additionally, two fauna habitats of limited extent have the potential to support SRE species, the Rubble Piles and the Ficus Groves Both the Rubble Piles and the Ficus Groves represent habitat isolates and have the potential to support SRE species (**Figure 10**).

The remaining landscape within the Study area appears relatively uniform and does not correspond to typical SRE habitat. All other habitat types were widespread, well connected and extensive throughout the surrounding landscape.

4.4.3 Terrestrial Invertebrate SRE Species Recorded Within or Near the Study area

A search of the Western Australian Museum SRE invertebrate collection yielded five records for three potential SRE species occurring within or in the region surrounding the Study area. The distribution of these species with respect to rangeland land systems is summarised below in **Table 7** and **Figure 11**. The complete set of database search results is included in **Attachment C**.

Table 7: Potential SRE species recorded within the surrounding region

SRE Group	Scientific name	Land systems in which species has been recorded	Closest record to Study area
Millipede	*Antichiropus* 'abydos'	Capricorn	6.5 west
Pseudoscorpion	*Feaella sp.* 'Sulphur Springs'	Capricorn	within Study area
Mygalomorph Spider	*Kwonkan* 'MYG200'	Talga	37 km south

Of the two SRE species not recorded within the Study area, there is potential for *Antichiropus* 'abydos to occur within the Study area as it has been recorded within the Capricorn land system, which forms 49% of the Study area. This land system is well represented within the surrounding region and so it likely that these species would also be represented elsewhere within the region. In contrast, *Kwonkan* 'MYG200' was only found in the Talga land system, which does not occur in the Study area, although this does not preclude this species from occurring within the Study area.

Feaella sp. 'Sulphur Springs' was recorded within the Study area (Biota 2007) and represents the only known record for this species (**Figure 12**). This species was collected from within the Drainage Line habitat and the distribution of this species may be closely associated with this habitat type. The Drainage Line habitat is a potential SRE habitat that it is relatively well connected along its length. This Drainage Line habitat coincides with a proposed haul road footprint for the Project.

Although the previous survey by Biota (2007) was undertaken prior to the release of EPA Guidance Statement 20 (EPA 2009), the methods used during the survey align with the Guidance Statement when considering the anticipated scale of the impact associated with an underground mining operation. The additional targeted survey conducted for *Feaella sp.* 'Sulphur Springs' completed in October 2007 was unsuccessful in locating specimens of this species and the distribution of this species remains unknown (M. Harvey, pers. comm. September 2011).

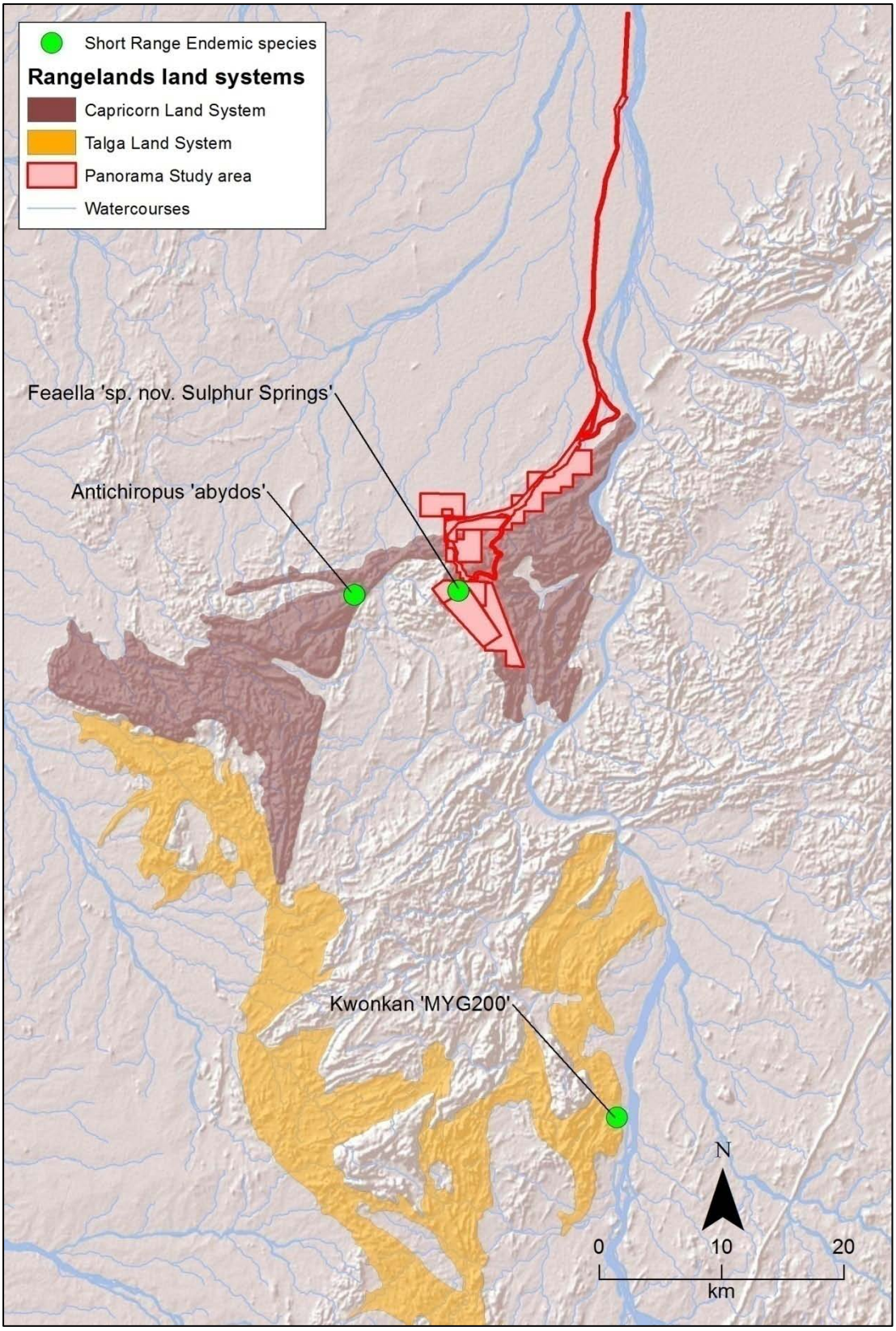

Figure 11: Location of potential SRE species recorded within the Study area and surrounding region

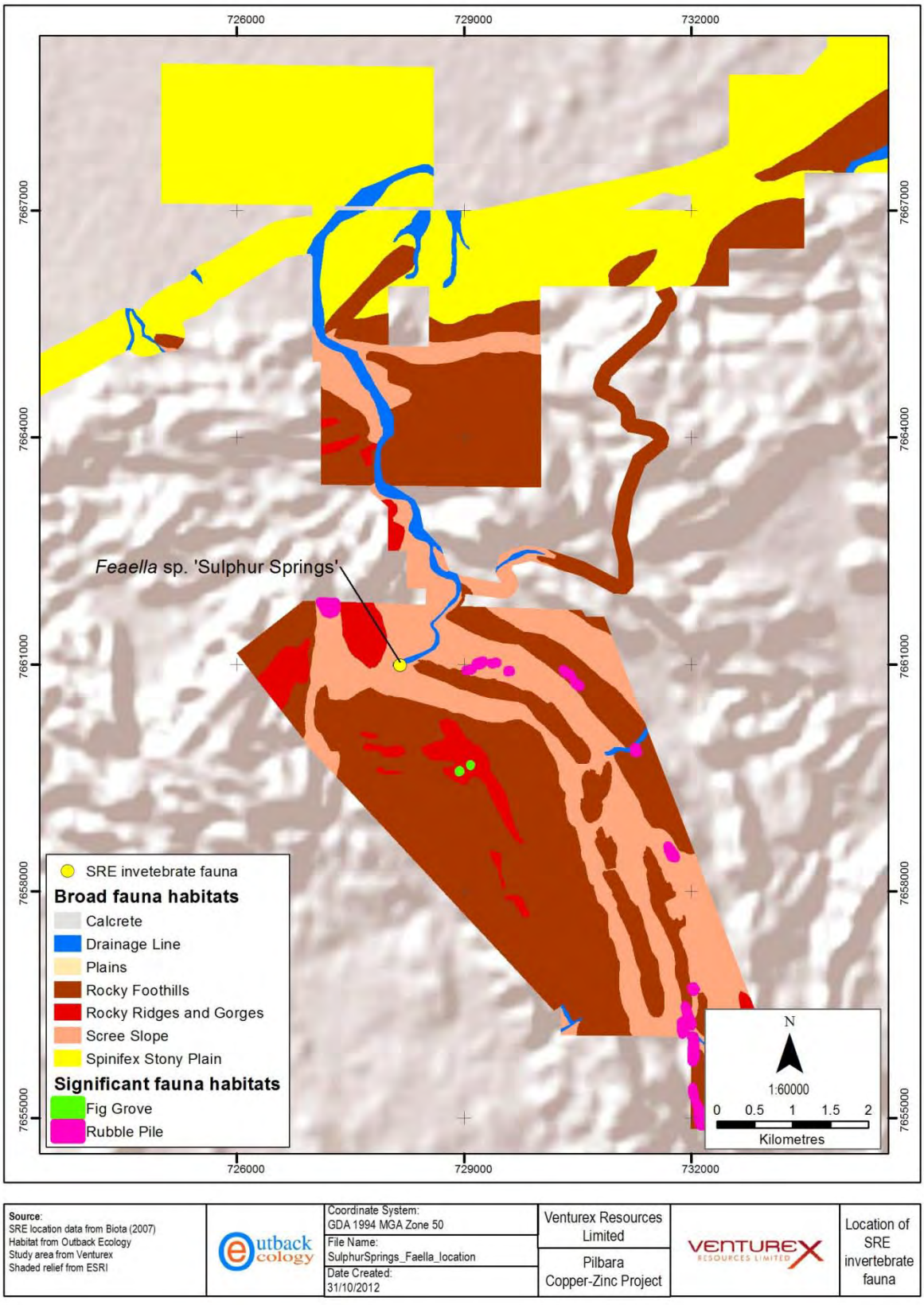

Figure 12: Location of the pseudoscorpion *Feaella* sp. 'Sulphur Springs' and habitats within the Study area

5. KNOWLEDGE GAPS AND RECOMMENDED ADDITIONAL STUDIES

Previous survey effort within the Study area has provided a sound baseline and combined with existing data in the literature and from fauna databases, has adequately documented the faunal assemblages likely to be present. However, some key knowledge gaps remain, which relate primarily to the distribution and abundance of the conservation significant Northern Quoll and also to the potential distribution of *Feaella* sp. 'Sulphur Springs' outside of areas likely to be impacted by the Project.

Two areas of habitat within the Study area consists of habitat that is likely to be critical to the survival of Northern Quoll

: 1) the substantial drainage line in the centre of the Study area (**Figure 10**); and 2) the Rocky Gorge/Gully surrounding Sulphur Springs itself (**Figure 10,** 729030S, 7659696E, UTM z50). Only the former is likely to be substantially affected by the Project as this habitat appears to coincide with a proposed haul route heading to the north.

Consistent with EPBC guidelines, it is recommended that a Northern Quoll monitoring program be conducted for the Pilbara Copper-Zinc Project, the primary objectives of which should be to:

- design and conduct a baseline population survey to provide quantitative data on Northern Quoll demographics and distribution in the Study area;
- provide pre-disturbance baseline population data that can be used to monitor the impacts of the Project on localised Northern Quoll populations; and

1. develop future monitoring and management recommendations for the Northern Quoll within the Study area.

The first survey conducted as part of this monitoring program should be undertaken pre-development and during the months of May to August to avoid any disturbance during the reproductive period.

As a minimum, a monitoring program should consider the following:

- the trapping program should be configured to address project impact and non-impact zones so that results are adequate to inform project siting and management options;
- trapping should be concentrated in habitat critical to the survival of the species with some consideration of non-rocky foraging and dispersal habitats;
- traps should be set for seven consecutive nights, unless two or more individuals are caught twice, in which case the traps should be closed after four nights of trapping;
- survey via trapping may be supplemented by one of several non-invasive survey techniques such as latrine searches in habitat critical to the survival of the species or use of motion sensitive cameras; however, these methods should be considered supplementary only.

The distribution of *Feaella* sp 'Sulphur Springs' may occur in association with Drainage Line habitat within and outside the Study area. Given that the project may impact upon the only recorded location of this species (728157 mE; 7660995 mN; UTM, zone 50, WGS84) and given that the Drainage Line habitat appears to coincide with a proposed haul route heading north, it is recommended that an additional targeted survey for this species be undertaken. The aim of this survey would be to determine if *Feaella* sp 'Sulphur Springs' has a distribution that extendes outside of proposed impact areas. Additionally, potential habitat for *Feaella sp.* 'Sulphur Springs' should be mapped and assessed both within and outside proposed impact areas.

Table 8 provides a summary of potential knowledge gaps identified from the desktop study and the action required to address each of these.

Table 8: Summary of desktop study knowledge gaps and actions required

Knowledge Gap	Action Required	Methods	Recommended Timing
Vertebrate Fauna			
Northern Quoll: Draft Commonwealth Survey and Monitoring Guidelines have been released. Populations and distribution of Northern Quolls in Rocky Ridge and Gorge and Drainage Line habitat that coincide with proposed impact footprints is not known.	As per DSEWPA draft guidelines, EPA Guidance Statement No 56 (EPA 2004) and Technical Guide (EPA 2010), a Level 2 targeted survey for Northern Quolls is recommended to: • assess the total population within Study area • assess the populations of Northern Quolls in impact and non-impact zones	Within suitable habitat, establish a standardised trapping layout to assess the Northern Quoll population (i.e. deployment of 20 Elliott traps per site for a total of up to seven nights). Where possible establish multiple sites within habitats to provide adequate replication.	Survey for Northern Quolls should be conducted between March and June so as to avoid the hottest parts of the year (increased risk of mortality) and breeding periods (disturbance to reproductive cycle).
SRE Invertebrate Fauna			
The distribution of *Feaella* sp 'Sulphur Springs' is only known from a single collection location. This location may coincide with proposed impact footprints.	Execute targeted SRE survey: • with the aim of extending the known distribution of *Feaella* sp 'Sulphur Springs' outside of proposed impact areas. • map and describe potential habitat for *Feaella* sp 'Sulphur Springs' outside of proposed impact areas. Undertake impact assessment on finalisation of disturbance footprint to determine risks to potential SRE species.	Targeted searching of sites in prospective habitats outside of proposed impact areas. Prospective habitats include: beneath slate like rock on the south face of low cliffs or areas adjacent to ephemeral drainage lines (Biota 2007). Map and describe potential habitat where *Feaella* sp 'Sulphur Springs' may occur within and outside proposed impact areas.	Although the only specimen of *Feaella* sp 'Sulphur Springs' was collected during September 2007, it is recommended that any follow up targeted surveys be conducted during or after the period of peak rainfall (EPA, 2009). For many invertebrates the period after peak rainfall coincides with peak activity and maturity. For the Study area, this coincides with January to April.

6. CONCLUSION

Six broad terrestrial fauna habitats occur within the Study area, comprising Spinifex Stony Plains, Rocky Foothills, Scree Slope, Spinifex Sandplain, Drainage Line and Rocky Ridges and Gorges. Additionally, two fauna habitats of limited extent were identified within the Study area: Rubble Piles and Ficus Groves.

Based on database search findings and a review of relevant literature within the surrounding region, it is possible that a total of 392 terrestrial vertebrate fauna species may potentially occur within the Study area, comprised of 53 mammals (44 native), 211 birds, 116 reptiles, five fish and seven amphibian species.

Based on a more specific review of previous surveys within the Study area (Bamford Consulting Ecologists 2001, Biota 2007), it is possible that a total of 151 terrestrial vertebrate fauna species may potentially occur within the Study area, comprised of 27 mammals (22 native), 83 birds, 34 reptiles, five fish and two amphibian species.

Overall, 23 conservation significant fauna species could potentially occur within the Study area, excluding those considered as unlikely:

- Eight species listed under the EPBC Act and WC Act: Northern Quoll, Mulgara, Greater Bilby, Pilbara Leaf-nosed Bat, Night Parrot, Pilbara Olive Python, Peregrine Falcon and Woma;
- Ten species listed as Priority 4 Fauna by the DEC: Ghost Bat, Spectacled Hare-wallaby, Western Pebble-mound Mouse, Long-tailed Dunnart, Lakeland Downs Mouse, Australian Bustard, Bush Stone-curlew, Grey Falcon, Star Finch, and *Ramphotyphlops ganei* (a blind snake); and
- Five species listed as Migratory under the EPBC Act: Fork-tailed Swift, Cattle Egret, Oriental Plover, Rainbow Bee-eater and Night Parrot.

Potential SRE habitat within the Study area is most likely to occur within Rocky Ridges and Gorges and Drainage Lines habitat. Additionally, the Rubble Piles and the Ficus Groves represent habitat isolates that may support SRE species. The remaining landscape within the Study area appears relatively uniform and does not correspond to typical SRE habitat; i.e. these habitat types were widespread, well connected and extensive throughout the surrounding landscape.

Three potential SRE species are known to occur in the region surrounding the Study area. Based on the broad habitats which occur, there is potential for all three of these species to occur within the Study area. The millipede *Antichiropus* 'abydos' has been collected 6.5 km west of the Study area and the mygalomorph spider *Kwonkan* 'MYG200' has been collected 37 km south of the Study area. The pseudoscorpion *Feaella sp. '*Sulphur Springs' is known from a single specimen collected from the Study area in 2007.

Previous survey effort within the Study area has provided a sound baseline and combined with existing data in the literature and from fauna databases, has adequately documented the faunal assemblages likely

to be present. A key remaining knowledge gap relates to the adequate assessment of Northern Quoll, particularly within Drainage Line and Rocky Ridge and Gorge habitat that coincides with proposed impact footprints. A further key knowledge gap relates to the only known record of the pseudoscorpion *Feaella sp.* 'Sulphur Springs' being recorded form within a potential impact area. Additionally, *Feaella sp.* 'Sulphur Springs' may occur in association with Drainage Line habitat; of which a considerable portion occurs within the proposed haulage route footprint in the northwest of the Study area.

With consideration to the scale of the proposed project, the level of potential impacts and current knowledge of terrestrial fauna in the Study area, it is recommended that a Northern Quoll monitoring program be established for the Pilbara Copper-Zinc Project, consistent with EPBC guidelines for the species. The primary objectives of this monitoring program would be to:

- design and conduct a baseline population survey to provide quantitative data on Northern Quoll demographics and distribution in the Study area;
- provide pre-disturbance baseline population data that can be used to monitor the impacts of the Project on localised Northern Quoll populations; and
- develop future monitoring and management recommendations for the Northern Quoll within the Study area.

A targeted terrestrial invertebrate SRE survey for *Feaella sp.* 'Sulphur Springs' is recommended with the aim of gaining a better understanding of the species distribution outside of the proposed impact footprint. In addition, potential habitat for *Feaella sp.* 'Sulphur Springs' should be mapped and assessed both within and outside proposed impact areas.

7. REFERENCES

ABRS. (2010) *Australian Biological Resources Study.* Department of Sustainability, Environment, Water, Population and Communities. Available online at. Accessed on.

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

Armstrong, K. N. and Anstee, D. (2000) The ghost bat in the Pilbara: 100 years on. *Australian Mammalogy* 22: 93-101.

Australian Natural Resources Atlas. (2007) *Rangelands overview - Pilbara.* Available online at http://www.anra.gov.au/topics/rangelands/overview/wa/ibra-pil.html. Accessed on 01/06/2010.

Bamford Consulting Ecologists. (2001) *Panorama Project Area: Baseline Fauna Study as Part of the Sulphur Springs Feasibility Study*, Prepared for Astron Environmental.

Bamford Consulting Ecologists. (2005) *Fauna Survey of Proposed Iron Ore Mine, Cloud Break*, Prepared for Fortescue Metals Group Ltd.

Bamford Consulting Ecologists. (2007) *Fauna Assessment of the Pardoo Direct Shipping Ore Project Atlas Iron Limited*, Prepared for Enesar Consulting Pty Ltd.

Bamford Consulting Ecologists. (2008) *Fauna Assessment of the Wodgina Tailings Storage Facility 3*, Prepared for Enviroworks Consulting.

Bamford, M., Watkins, D., Bancroft, W., Tischler, G. and Wahl, J. (2008) *Migratory Shorebirds of the East Asian - Australasian Flyway: Population Estimates and Internationally Important Sites.* Wetlands International - Oceania, Canberra, Australia.

Biota. (2002a) *An Assessment of the Distribution of the Mulgara Dasycercus cristicauda and Bilby Macrotis lagotis Along and Adjacent to the Proposed Hope Downs to Port Hedland Rail Corridor*, Hope Downs Management Services Survey Report.

Biota. (2002b) *Proposed Hope Downs Rail Corridor From Weeli Wolli Siding to Port Hedland - Vertebrate Fauna Survey*, Hope Downs Management Services Vertebrate Fauna Survey.

Biota. (2004) *Fauna Habitats and Fauna Assemblage of the Proposed FMG Stage A Rail Corridor*, Fortescue Metals Group Fauna Habitat and Fauna Assemblage Report.

Biota. (2005) *Fauna Habitats and Fauna Assemblage of the FMG Stage B Rail Corridor and Mindy Mindy, Christmas Creek, Mt Lewin and Mt Nicholas Mine Areas*, Report prepared for Fortescue Metals Pty Ltd.

Biota. (2007) *Panorama Project: Mine Site and Haul Road Corridor Targeted Fauna Survey*, Prepared for CBH Resources.

Birds Australia. (2010) *Birdata: Custom Atlas Bird Lists.* Available online at http://www.birdata.com.au/custom.vm. Accessed on 07/07/2010.

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

Burbidge, A. H., Johnstone, R. E. and Pearson, D. J. (2010) Birds in a vast arid upland: avian biogeographical patterns in the Pilbara region of Western Australia. *Records of the Western Australian Museum Supplement* 78: 247-270.

Bureau of Meteorology. (2011) *Climate Data Online.* Available online at http://www.bom.gov.au./climate/data/index.shtml. Accessed on 19/09/2011.

Burrows, N. D., Burbidge, A. A., Fuller, P. J. and Behn, G. (2006) Evidence of altered fire regimes in the Western Desert region of Australia. *Conservation Science Western Australia* 5(3): 272-284.

Department of Environment and Conservation. (2007) *Millstream-Chichester National Park and Mungaroona Range Nature Reserve: Draft Management Plan*, Produced by the Traditional Owners - Millstream Park Council, Department of Environment and Conservation and the Conservation Commission of Western Australia.

Department of Environment and Conservation. (2010a) *Naturemap: Mapping Western Australia's Biodiversity.* Available online at http://naturemap.dec.wa.gov.au./default.aspx. Accessed on 07/06/2010.

Department of Environment and Conservation (2010b) *Threatened and Priority Fauna Database*. Available online at https://secure.dec.wa.gov.au/apex/pls/fauna/f?p=faunasurveypublic.

Department of Environment Water Heritage and the Arts. (2010) *Species Profile and Threats Database.* Available online at http://www.environment.gov.au/cgi-bin/sprat/public/sprat.pl. Accessed on 06/07/2010.

Department of Sustainability Environment Water Population and Communities. (2010a) *Environmental Reporting Tool: Information for Decision Makers.* Available online at http://www.environment.gov.au/erin/ert/index.html. Accessed on 19/10/2010.

Department of Sustainability Environment Water Population and Communities. (2010b) *Pezoporus occidentalis — Night Parrot.* Available online at http://www.environment.gov.au/cgi-bin/sprat/public/publicspecies.pl?taxon_id=59350. Accessed on 01/08/2010.

Department of Sustainability Environment Water Population and Communities. (2011) *Environment Protection and Biodiversity Conservation Act 1999 referral guidelines for the endangered northern quoll, Dasyurus hallucatus*, EPBC Act Policy Statement 3.25.

ecologia. (2008) *RGP 5 Level 2 Fauna Survey: Chichester Deviation*, A report commissioned by BHP Billiton Iron Ore Pty Ltd.

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. (2009) *Guidance for the Assessment of Environmental Factors: Sampling of Short Range Endemic Invertebrate Fauna for Environmental Impact Assessment in Western Australia*, No 20. May, 2009.

Environmental Protection Authority and Department of Environment and Conservation. (2010) *Technical Guide - Terrestrial Vertebrate Fauna Surveys for Environmental Impact Assessment.* (eds. B.M. Hyder, J.Dell, M.A. Cowan) Perth, W.A.

Garnett, S. and Crowley, G. (2000) *The Action Plan for Australian Birds.* Environment Australia and the Royal Australia Ornithologists Union, Canberra, A.C.T.

Geering, A., Agnew, L. and Harding, S. (2007) *Shorebirds of Australia.* CSIRO Publishing, Collingwood, Vic.

Gibson, L. A. and McKenzie, N. L. (2009) Environmental Associations of small ground-dwelling mammals in the Pilbara region, Western Australia. *Records of the Western Australian Museum Supplement* 78: 91-122.

Hall, L., Richards, G., McKenzie, N. and Dunlop, N. (1997) The importance of abandoned mines as habitat for bats. In: P. Hale and D. Lamb (eds) *Conservation Outside Nature Reserves*. Centre for Conservation Biology, the University of Queensland, St Lucia, Queensland, pp 326-333

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. and Yen, A. L. (1989) *Worms to Wasps: An illustrated guide to Australia's terrestrial invertebrates.* Oxford University Press, Melbourne, Vic.

How, R. A. and Cooper, N. K. (2002) Terrestrial small mammals of the Abydos Plain in the north-eastern Pilbara, Western Australia. *Journal of the Royal Society of Western Australia* 85: 71-82.

How, R. A., Dell, J. and Cooper, N. K. (1991) Ecological Survey of Abydos-Woodstock Reserve, Western Australia: Vertebrate Fauna. *Records of the Western Australian Museum Supplement* 37: 78-125.

Johnstone, R. E. and Storr, G. M. (1998) *Handbook of Western Australian Birds. Vol 1. Non-passerines (Emu to Dollarbird).* Western Australian Museum, Perth, W.A.

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

Kendrick, P. and McKenzie, N. L. (2001) Pilbara 1 (PIL1 - Chichester subregion). In: *A Biodiversity Audit of Western Australia's 53 Biogeographical Subregions in 2002*. Department of Conservation and Land Management, Kensington, W.A., pp 547-558

Kendrick, P. and Stanley, F. (2001) Pilbara 1 (PIL4 - Roebourne subregion). In: *A Biodiversity Audit of Western Australia's 53 Biogeographical Subregions in 2002*. Department of Conservation and Land Management, Kensington, W.A., pp 581-593

King, D. (1989) An assessment of the hazard posed to northern quolls (*Dasyurus hallucatus*) by aerial baiting with 1080 to control dingoes. *Australian Wildlife Research* 16(5): 569-74.

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

Main, B. Y. (1982) *Adaptations to arid habitats by mygalomorph spiders.* Peacock Publications, Frewville, South Australia.

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

Mattiske Consulting. (2000) *Flora, vegetation and vertebrate fauna of the proposed expansion at Wodgina*, Prepared for Sons of Gwalia Ltd.

Maxwell, S., Burbidge, A. A. and Morris, K. (1996) *Action Plan for Australian Marsupials and Monotremes* Environment Australia, Canberra, A.C.T.

McKenzie, N. L. and Bullen, R. D. (2009) The echolocation calls, habitat relationships, foraging niches and communities of Pilbara microbats. *Records of the Western Australian Museum Supplement* 78: 123-155.

McKenzie, N. L., May, J. E. and McKenna, S. (2003) *Bioregional Summary of the 2002 Biodiversity Audit for Western Australia: A Contribution to the Development of Western Australia's Biodiversity Conservation Strategy.* Department of Conservation and Land Management, Kensington, W.A.

McKenzie, N. L., van Leeuwen, S. and Pinder, A. M. (2009) Introduction to the Pilbara Biodiversity Survey, 2002-2007. *Records of the Western Australian Museum Supplement* 78: 3-89.

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

MOLHAR Pty Ltd. (2007) *Field Survey for conservation significant bats near Sulphur Springs, Pilbara: field survey and management advice*, Prepared for CBH Resources Ltd.

Morcombe, M. (2003) *Field Guide to Australian Birds: Second Edition.* Oxford University Press, South Melbourne, Australia.

Ninox Wildlife Consulting. (2009a) *A Fauna Survey of the Proposed Hope Downs 4 Mining Area Near Newman, Western Australia*, Prepared for Mattiske Consulting Pty Ltd on behalf of Pilbara Iron Company (Services) Pty Ltd.

Ninox Wildlife Consulting. (2009b) *A Vertebrate Fauna Survey of the Proposed Hope Downs 4 Infrastructure Corridor: Option 1 Near Newman, Western Australia*, Prepared for Mattiske Consulting Pty Ltd on behalf of Pilbara Iron Company (Services) Pty Ltd.

Ninox Wildlife Consulting. (2009c) *A Vertebrate Fauna Survey of the Proposed Hope Downs 4 Option 6 Infrastructure Corridor Near Newman, Western Australia*, Prepared for Mattiske Consulting Pty Ltd on behalf of Pilbara Iron Company (Services) Pty Ltd.

Outback Ecology. (2006) *Spinifex Ridge Molybdenum Project: Terrestrial Vertebrate Fauna Baseline Surveys (2005-2006)*, Unpublished report prepared for Atlas Iron Limited.

Outback Ecology. (2011) *Mt Dove DSO Project Terrestrial Vertebrate Fauna Assessment 2011*, Prepared for Atlas Iron Ltd.

Outback Ecology Services. (2009) *Wodgina DSO Project: Terrestrial Vertebrate Fauna Assessment*, Prepared for Atlas Iron Limited.

Parr, C. L. and Andersen, A. N. (2006) Patch mosaic burning for biodiversity conservation: a critique of the pyrodiversity paradigm. *Conservation Biology* 20(6): 1610-1619.

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

Ponder, W. and Colgan, D. (2002) What makes a narrow-range taxon?-Insights from Australian freshwater snails. *Invertebrate Systematics* 16(4): 571-582.

Schmitt, L., Bradley, A., Kemper, C., Kitchener, D., Humphreys, W. and How, R. (1989) Ecology and physiology of the northern quoll, *Dasyurus hallucatus* (Marsupialia, Dasyuridae), at Mitchell Plateau, Kimberley, Western Australia. *Journal of Zoology* 217(4): 539-558.

Southgate, R., Paltridge, R., Masters, P. and Carthew, S. (2007) Bilby distribution and fire: a test of alternative models of habitat suitability in the Tanami Desert, Australia. *Ecography* 30(6): 759-776.

Storr, G. M. (1984) Birds of the Pilbara Region, Western Australia. *Records of the Western Australian Museum Supplement* 16.

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

Van Dyck, S. and Strahan, R. (2008) *The Mammals of Australia. Third edition* The Australian Museum Trust and Queensland Museum, Sydney, NSW.

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*, WA Department of Agriculture Technical Bulletin No. 92.

Western Australian Museum. (2010) *The Western Australian Museum Short Range Endemic Invetebrate Database.* Available online at. Accessed on 06/12/2010.

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

Woinarski, J. C. Z. (1999) Fire and Australian birds: a review. In: A. M. Gill, J. C. Z. Woinarski and A. York (eds) *Australia's biodiversity: responses to fire: plants, birds and invertebrates*. Environment Australia, Canberra, ACT, pp 55-111

Wright, B. R. and Clarke, P. J. (2007) Resprouting responses of Acacia shrubs in the Western Desert of Australia – fire severity, interval and season influence survival. *International Journal of Wildland Fire* 16(3): 317-323.

Attachment A

Vertebrate Species Recorded in Study Area and Surrounds

Attachment A– Vertebrate Species Recorded in Study Area and Surrounds

Legend

Abbreviations/Symbols

*	Introduced Species
EPBC Act	Commonwealth *Environmental Protection and Biodiversity Conservation Act 1999*: EN Endangered, VU Vulnerable M Migratory
WC Act	Western Australian Wildlife Conservation Act 1950 and Department of Environment and Conservation's Threatened and Priority Fauna Rankings: S1 Schedule 1 Rare or likely to become extinct, S3 Migratory birds protected under an international agreement, S4 In need of special protection P1 Priority 1 Fauna, P2, P3, P4, P5

Previous Surveys in Study area

A	Bamford Consulting Ecologists. (2001) Sulphur Springs Project Area: Baseline Fauna Study as Part of the Sulphur Springs Feasibility Study
B	Biota. (2007) Sulphur Springs Project: Mine Site and Haul Road Corridor Targeted Fauna Survey

Previous Surveys in surrounding region

D	How *et al*. (1991) Ecological Survey of Abydos-Woodstock Reserve, Western Australia: Vertebrate Fauna
F	Biota. (2002) Proposed Hope Downs Rail Corridor From Weeli Wolli Siding to Port Hedland - Vertebrate Fauna Survey
G	Biota. (2004) Fauna Habitats and Fauna Assemblage of the Proposed FMG Stage A Rail Corridor
H	Bamford Consulting Ecologists. (2005) Fauna Survey of Proposed Iron Ore Mine, Cloud Break
I	Outback Ecology Services. (2006) Spinifex Ridge Molybdenum Project: Terrestrial Vertebrate Fauna Baseline Surveys (2005-2006)
J	Bamford Consulting Ecologists. (2007) Fauna Assessment of the Pardoo Direct Shipping Ore Project Atlas Iron Limited
K	ecologia. (2008) RGP 5 Level 2 Fauna Survey: Chichester Deviation
L	Ninox Wildlife Consulting. (2009) A Fauna Survey of the Proposed Hope Downs Mining Area Near Newman, Western Australia
M	Ninox Wildlife Consulting. (2009) A Vertebrate Fauna Survey of the Proposed Hope Downs 4 Infrastructure Corridor: Option 1 Newman
N	Ninox Wildlife Consulting. (2009) A Vertebrate Fauna Survey of the Proposed Hope Downs 4 Option 6 Infrastructure Corridor Newman
O	Outback Ecology. (2009) Wodgina DSO Project: Terrestrial Vertebrate Fauna Assessment

Database Searches – centroid: 119.207784 E, -21.157591 S

Birds Aust.	Birds Australia Atlas Database Search (December 2010)
DEC TPFS	Department of Environment and Conservation's Threatened and Priority Fauna Database Search (December 2010)
ERT	Department of Sustainability, Environment, Water, Population and Communities database search (October 2010)
Nature Map	Department of Environment and Conservation's Nature Map Database (December 2010)

Scientific Name	Common Name	Conservation Status		Surveys in Study Area		Surveys in Surrounding Region											Database Seacrhes			
		EPBC Act	WC Act	A	B	D	F (sth)	F (nth)	G (nth)	G (sth)	H	I	J	K	L, M, N	O	Birds Aust.	DEC TPFS	ERT	Nature Map
Mammals																				
BOVIDAE																				
*Bos taurus**	European Cattle				*	*	*					*		*		*				
CAMELIDAE																				
*Camelus dromedarius**	Dromedary			*		*			*	*	*	*								
CANIDAE																				
*Canis lupus**	Dingo			*			*	*	*	*	*	*	*	*	*					
*Vulpes vulpes**	Fox						*						*						*	
DASYURIDAE																				
Dasycercus blythei	Brush-tailed Mulgara		P4															*		
Dasycercus cristicauda	Crest-tailed Mulgara	EN	S1	*		*	*	*	*	*			*					*	*	
Dasykaluta rosamondae	Kaluta			*		*	*	*	*	*	*	*		*	*					
Dasyurus hallucatus	Northern Quoll	EN	S1	*	*	*	*	*	*	*		*	*			*		*	*	*
Ningaui ridei	Wongai Ningaui								*	*										
Ningaui timealeyi	Pilbara Ningaui			*	*	*	*	*	*	*	*	*		*	*					*
Planigale ingrami	Long-tailed Planigale			*			*	*	*	*	*	*		*		*				*
Planigale maculata	Common Planigale					*									*					
Pseudantechinus macdonnellensis	Fat-tailed False Antechinus						*	*												
Pseudantechinus roryi	Tan False Antechinus			*		*														
Pseudantechinus woolleyae	Woolley's Pseudantechinus					*							*		*	*				
Sminthopsis longicaudata	Long-tailed Dunnart		P4															*		
Sminthopsis macroura	Stripe-faced Dunnart				*	*	*	*	*	*	*	*		*						
Sminthopsis ooldea	Ooldea Dunnart														*					
Sminthopsis youngsoni	Lesser hairy-footed Dunnart					*	*	*	*	*		*								
EMBALLONURIDAE																				
Saccolaimus flaviventris	Yellow-bellied Sheathtail-bat										*	*		*	*	*				
Taphozous georgianus	Common Sheathtail-bat			*		*	*	*			*	*	*	*	*	*				*
EQUIDAE																				
*Equus asinus**	Donkey					*	*	*	*	*	*									
*Equus caballus**	Horse										*									
FELIDAE																				
*Felis catus**	Cat			*		*	*	*	*	*	*	*	*	*		*			*	
HIPPOSIDERIDAE																				
Rhinonicteris aurantius (Pilbara form)	Pilbara Leaf-nosed Bat	VU	S1	*	*							*				*		*	*	*
LEPORIDAE																				
*Oryctolagus cuniculus**	Rabbit													*					*	
MACROPODIDAE																				
Lagorchestes conspicillatus leichardti	Spectacled Hare-wallaby (mainland)		P3	*		*												*		*
Macropus robustus	Common Wallaroo			*	*	*	*	*	*	*	*	*	*	*	*	*				*
Macropus rufus	Red Kangaroo						*	*			*				*					*
Petrogale rothschildi	Rothschild's Rock-wallaby			*		*	*	*	*	*		*				*				*

Scientific Name	Common Name	Conservation Status		Surveys in Study Area		Surveys in Surrounding Region											Database Seacrhes			
		EPBC Act	WC Act	A	B	D	F (sth)	F (nth)	G (nth)	G (sth)	H	I	J	K	L, M, N	O	Birds Aust.	DEC TPFS	ERT	Nature Map
MEGADERMATIDAE																				
Macroderma gigas	Ghost Bat		P4	*		*		*				*		*		*		*		*
MOLOSSIDAE																				
Austronomus australis	White-striped Freetail-bat			*			*	*			*				*	*				
Chaerephon jobensis	Northern Freetail-bat						*	*			*	*		*	*	*				
Mormopterus beccarii	Beccari's Freetail-bat											*		*						
Mormopterus loriae cobourgiana	Mangrove Freetail-bat		P1					*												
MURIDAE																				
Leggadina lakedownensis	Lakeland Downs Mouse		P4				*	*	*	*				*				*		
*Mus musculus**	House Mouse			*	*	*	*	*	*	*	*			*						*
Notomys alexis	Spinifex Hopping-mouse						*	*					*	*						
Pseudomys chapmani	Pebble-mound Mouse		P4	*	*	*	*				*	*	*	*	*	*		*		*
Pseudomys delicatulus	Delicate Mouse			*		*	*	*	*	*					*					*
Pseudomys desertor	Desert Mouse			*	*		*	*	*	*	*	*	*	*	*					*
Pseudomys hermannsburgensis	Sandy Inland Mouse			*	*	*	*	*	*	*		*		*	*					
Zyzomys argurus	Common Rock-rat			*	*	*	*	*	*	*	*	*		*	*	*				*
TACHYGLOSSIDAE																				
Tachyglossus aculeatus	Short-beaked Echidna			*		*	*	*	*	*	*		*							
THYLACOMYIDAE																				
Macrotis lagotis	Greater Bilby	VU	S1				*				*							*		
VESPERTILIONIDAE																				
Chalinolobus gouldii	Gould's Wattled Bat						*	*	*	*	*	*		*	*	*				
Chalinolobus morio	Chocolate Wattled Bat														*					
Nyctophilus arnhemensis	Arnhem Long-eared Bat							*												
Nyctophilus geoffroyi	Lesser Long-eared Bat										*	*		*						
Scotorepens greyii	Little Broad-nosed Bat				*	*	*	*	*	*	*	*		*	*	*				
Vespadelus finlaysoni	Inland Cave Bat			*		*	*	*		*	*	*		*	*	*				*
Birds																				
ACANTHIZIDAE																				
Acanthiza apicalis	Inland Thornbill						*							*	*					
Acanthiza robustirostris	Slaty-backed Thornbill						*		*	*	*			*						
Acanthiza uropygialis	Chestnut-rumped Thornbill						*		*	*	*			*	*					
Aphelocephala leucopsis	Southern Whiteface										*									
Aphelocephala nigricincta	Banded Whiteface											*								
Gerygone fusca	Western Gerygone			*		*	*				*	*		*	*		*			*
Gerygone levigaster	Mangrove Gerygone																			
Gerygone tenebrosa	Dusky Gerygone							*									*			
Pyrrholaemus brunneus	Redthroat														*					
Smicrornis brevirostris	Weebill			*		*	*	*	*	*	*	*		*	*		*			*
ACCIPITRIDAE																				
Accipiter cirrocephalus	Collared Sparrowhawk			*		*			*	*	*	*					*			*
Accipiter fasciatus	Brown Goshawk			*	*	*	*	*	*	*			*	*		*	*			*

Scientific Name	Common Name	Conservation Status		Surveys in Study Area		Surveys in Surrounding Region											Database Seacrhes			
		EPBC Act	WC Act	A	B	D	F (sth)	F (nth)	G (nth)	G (sth)	H	I	J	K	L, M, N	O	Birds Aust.	DEC TPFS	ERT	Nature Map
Aquila audax	Wedge-tailed Eagle			*	*	*	*	*	*	*	*	*	*	*	*		*			*
Circus approximans	Swamp Harrier								*	*							*			
Circus assimilis	Spotted Harrier			*		*		*	*	*	*		*	*			*			*
Elanus axillaris	Black-shouldered Kite			*		*	*	*	*	*			*	*			*			*
Haliaeetus leucogaster	White-bellied Sea-Eagle	M															*		*	
Haliastur indus	Brahminy Kite							*									*			
Haliastur sphenurus	Whistling Kite			*			*	*	*	*	*		*	*	*		*			*
Hamirostra melanosternon	Black-breasted Buzzard							*	*	*					*					
Hieraaetus morphnoides	Little Eagle			*		*		*	*	*	*	*	*	*	*		*			*
Lophoictinia isura	Square-tailed Kite								*	*				*	*		*			
Milvus migrans	Black Kite					*	*	*	*	*	*	*	*			*	*			*
Pandion cristatus	Eastern Osprey																*			
ACROCEPHALIDAE																				
Acrocephalus australis	Australian Reed-Warbler	M					*	*						*			*			*
AEGOTHELIDAE																				
Aegotheles cristatus	Australian Owlet-nightjar			*		*		*	*	*	*	*	*	*	*	*				*
ALAUDIDAE																				
Mirafra javanica	Horsfield's Bushlark						*	*	*	*	*		*	*			*			
ANATIDAE																				
Anas gracilis	Grey Teal					*		*			*						*			*
Anas rhynchotis	Australasian Shoveler																*			
Anas superciliosa	Pacific Black Duck			*		*	*	*	*	*	*			*			*			*
Aythya australis	Hardhead																*			
Chenonetta jubata	Australian Wood Duck							*									*			*
Cygnus atratus	Black Swan										*						*			
Dendrocygna eytoni	Plumed Whistling-Duck																*			
Malacorhynchus membranaceus	Pink-eared Duck										*						*			*
Tadorna tadornoides	Australian Shelduck										*									
ANHINGIDAE																				
Anhinga novaehollandiae	Australasian Darter			*		*		*	*	*							*			*
APODIDAE																				
Apus pacificus	Fork-tailed Swift	M				*			*	*				*			*		*	
ARDEIDAE																				
Ardea ibis	Cattle Egret	M															*		*	
Ardea intermedia	Intermediate Egret																*			
Ardea modesta	Eastern Great Egret			*				*					*				*		*	*
Ardea pacifica	White-necked Heron			*		*		*			*	*	*	*	*		*			*
Butorides striata	Striated Heron							*									*			
Egretta garzetta	Little Egret							*									*			
Egretta novaehollandiae	White-faced Heron			*	*	*	*		*	*	*	*		*			*			*
Egretta sacra	Eastern Reef Egret	M															*			
Ixobrychus flavicollis	Black Bittern																*			

Scientific Name	Common Name	Conservation Status		Surveys in Study Area		Surveys in Surrounding Region											Database Seacrhes			
		EPBC Act	WC Act	A	B	D	F (sth)	F (nth)	G (nth)	G (sth)	H	I	J	K	L, M, N	O	Birds Aust.	DEC TPFS	ERT	Nature Map
Nycticorax caledonicus	Nankeen Night Heron			*	*	*		*				*					*			*
ARTAMIDAE																				
Artamus cinereus	Black-faced Woodswallow			*	*	*	*	*	*	*	*	*	*	*	*	*	*			*
Artamus leucorynchus	White-breasted Woodswallow																*			
Artamus minor	Little Woodswallow			*	*	*	*	*					*	*	*	*	*			*
Artamus personatus	Masked Woodswallow				*	*	*		*	*					*		*			
Artamus superciliosus	White-browed Woodswallow							*												
Cracticus nigrogularis	Pied Butcherbird			*	*	*	*	*	*	*	*	*	*	*	*	*	*			*
Cracticus tibicen	Australian Magpie			*	*	*	*	*	*	*	*	*		*	*		*			*
Cracticus torquatus	Grey Butcherbird						*	*	*	*	*			*	*		*			
BURHINIDAE																				
Burhinus grallarius	Bush Stone-curlew		P4	*		*		*	*	*		*		*			*	*		*
CACATUIDAE																				
Cacatua sanguinea	Little Corella			*		*	*	*	*	*	*	*		*	*	*	*			*
Eolophus roseicapillus	Galah			*	*	*	*	*	*	*	*	*	*	*	*	*	*			*
Nymphicus hollandicus	Cockatiel			*	*	*	*	*	*	*	*		*	*		*	*			*
CAMPEPHAGIDAE																				
Coracina maxima	Ground Cuckoo-shrike										*			*	*		*			*
Coracina novaehollandiae	Black-faced Cuckoo-shrike			*	*	*	*	*	*	*	*	*	*	*	*	*	*			*
Lalage sueurii	White-winged Triller			*	*	*	*	*	*	*	*	*	*	*	*	*	*			*
CASUARIIDAE																				
Dromaius novaehollandiae	Emu					*	*	*	*	*	*			*			*			*
CHARADRIIDAE																				
Charadrius leschenaultii	Greater Sand Plover	M															*			
Charadrius ruficapillus	Red-capped Plover							*									*			
Charadrius veredus	Oriental Plover	M															*		*	
Elseyornis melanops	Black-fronted Dotterel			*		*	*	*	*	*	*	*	*	*		*	*			*
Erythrogonys cinctus	Red-kneed Dotterel										*						*			
Pluvialis fulva	Pacific Golden Plover	M															*			
Vanellus miles	Masked Lapwing																*			
Vanellus tricolor	Banded Lapwing																*			
CICONIIDAE																				
Ephippiorhynchus asiaticus	Black-necked Stork			*				*	*	*						*	*			*
CLIMACTERIDAE																				
Climacteris melanura	Black-tailed Treecreeper												*				*			
COLUMBIDAE																				
*Columba livia**	Rock Dove																*			
Geopelia cuneata	Diamond Dove			*	*	*	*	*	*	*	*	*	*	*	*	*	*			*
Geopelia humeralis	Bar-shouldered Dove							*									*			
Geopelia striata	Peaceful Dove			*		*		*				*	*	*			*			*
Geophaps plumifera	Spinifex Pigeon			*	*	*	*	*	*	*		*	*	*	*	*	*			*
Ocyphaps lophotes	Crested Pigeon			*	*	*	*	*	*	*	*			*	*		*			*

Scientific Name	Common Name	Conservation Status		Surveys in Study Area		Surveys in Surrounding Region											Database Seacrhes			
		EPBC Act	WC Act	A	B	D	F (sth)	F (nth)	G (nth)	G (sth)	H	I	J	K	L, M, N	O	Birds Aust.	DEC TPFS	ERT	Nature Map
Phaps chalcoptera	Common Bronzewing			*	*	*	*	*			*			*	*		*			*
Phaps histrionica	Flock Bronzewing		P4														*			
CORVIDAE																				
Corvus bennetti	Little Crow					*		*			*	*		*	*		*			*
Corvus orru	Torresian Crow			*	*	*	*	*	*	*	*	*	*	*	*	*	*			*
CUCULIDAE																				
Cacomantis pallidus	Pallid Cuckoo			*	*	*	*	*	*	*	*		*	*	*	*	*			*
Centropus phasianinus	Pheasant Coucal			*	*			*				*		*			*			*
Chalcites basalis	Horsfield's Bronze-Cuckoo			*	*		*	*	*	*	*	*	*	*	*		*			*
Chalcites osculans	Black-eared Cuckoo					*	*	*									*			
ESTRILDIDAE																				
Emblema pictum	Painted Finch			*	*	*	*	*	*	*	*	*	*	*	*	*	*			*
Neochmia ruficauda subclarescens	Star Finch (western)		P4			*					*			*			*			
Taeniopygia guttata	Zebra Finch			*	*	*	*	*	*	*	*	*	*	*	*	*	*			*
EUROSTOPODIDAE																				
Eurostopodus argus	Spotted Nightjar			*		*		*	*	*	*	*	*	*	*	*	*			*
FALCONIDAE																				
Falco berigora	Brown Falcon			*	*	*	*	*	*	*	*	*	*	*	*	*	*			*
Falco cenchroides	Nankeen Kestrel			*		*	*	*	*	*	*	*	*	*	*	*	*			*
Falco hypoleucos	Grey Falcon		P4						*	*	*			*			*	*		
Falco longipennis	Australian Hobby					*		*	*	*	*		*		*	*	*			*
Falco peregrinus	Peregrine Falcon		S4			*	*	*	*	*	*		*		*		*	*		
Falco subniger	Black Falcon															*	*			
GLAREOLIDAE																				
Glareola maldivarum	Oriental Pratincole	M															*		*	
Stiltia isabella	Australian Pratincole					*											*			
GRUIDAE																				
Grus rubicunda	Brolga																*			
HAEMATOPODIDAE																				
Haematopus fuliginosus	Sooty Oystercatcher																*			
Haematopus longirostris	Australian Pied Oystercatcher							*									*			
HALCYONIDAE																				
Dacelo leachii	Blue-winged Kookaburra			*	*	*		*	*	*	*	*	*	*	*		*			*
Todiramphus chloris	Collared Kingfisher																*			
Todiramphus pyrrhopygius	Red-backed Kingfisher			*	*	*	*	*	*	*	*	*	*	*	*		*			*
Todiramphus sanctus	Sacred Kingfisher			*		*	*	*	*	*		*	*	*	*	*	*			*
HIRUNDINIDAE																				
Cheramoeca leucosterna	White-backed Swallow																*			*
Hirundo neoxena	Welcome Swallow													*			*			
Hirundo rustica	Barn Swallow	M																	*	
Petrochelidon ariel	Fairy Martin					*	*	*	*	*	*	*		*		*	*			*

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Petrochelidon nigricans	Tree Martin			*		*	*	*	*	*			*	*	*	*	*			*
LARIDAE																				
Chlidonias hybrida	Whiskered Tern																*			
Chlidonias leucopterus	White-winged Black Tern	M															*			
Chroicocephalus novaehollandiae	Silver Gull							*									*			
Gelochelidon nilotica	Gull-billed Tern							*									*			
Hydroprogne caspia	Caspian Tern	M						*									*			
Sternula nereis	Fairy Tern																*			
Thalasseus bengalensis	Lesser Crested Tern	M															*			
Thalasseus bergii	Crested Tern							*									*			
MALURIDAE																				
Amytornis striatus	Striated Grasswren			*		*			*	*					*	*				*
Malurus lamberti	Variegated Fairy-wren			*	*	*	*	*	*	*	*	*		*	*	*	*			*
Malurus leucopterus	White-winged Fairy-wren					*	*	*	*	*	*	*	*	*	*		*			*
Malurus splendens	Splendid Fairy-wren														*					
Stipiturus ruficeps	Rufous-crowned Emu-wren			*		*	*	*			*				*		*			
MEGALURIDAE																				
Cincloramphus cruralis	Brown Songlark			*		*		*	*	*	*						*			*
Cincloramphus mathewsi	Rufous Songlark			*			*	*	*	*			*	*			*			*
Eremiornis carteri	Spinifexbird			*		*	*	*	*	*	*	*		*	*	*	*			*
MELIPHAGIDAE																				
Acanthagenys rufogularis	Spiny-cheeked Honeyeater					*	*	*	*	*	*	*		*	*		*			
Certhionyx variegatus	Pied Honeyeater			*		*			*	*						*	*			*
Conopophila whitei	Grey Honeyeater													*		*				
Epthianura aurifrons	Orange Chat										*									
Epthianura tricolor	Crimson Chat			*		*		*	*	*				*			*			*
Lichenostomus keartlandi	Grey-headed Honeyeater			*	*	*	*	*	*	*	*	*		*	*	*	*			*
Lichenostomus leucotis	White-eared 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			*	*				*	*	*	*		*	*		*			*
Purnella albifrons	White-fronted Honeyeater					*														
Sugomel niger	Black Honeyeater						*	*	*	*						*				
MEROPIDAE																				
Merops ornatus	Rainbow Bee-eater	M		*	*	*	*	*	*	*	*	*	*	*	*	*	*		*	*
MONARCHIDAE																				
Grallina cyanoleuca	Magpie-lark			*	*	*	*	*	*	*	*	*	*	*	*	*	*			*
MOTACILLIDAE																				

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Anthus novaeseelandiae	Australasian Pipit					*		*	*	*	*	*	*	*	*		*			*
NECTARINIIDAE																				
Dicaeum hirundinaceum	Mistletoebird			*		*	*	*	*	*	*				*		*			*
NEOSITTIDAE																				
Daphoenositta chrysoptera	Varied Sittella								*	*	*									
OTIDIDAE																				
Ardeotis australis	Australian Bustard		P4	*		*	*	*	*	*	*	*		*	*		*	*		*
PACHYCEPHALIDAE																				
Colluricincla harmonica	Grey Shrike-thrush			*	*	*	*		*	*	*	*		*	*	*	*			*
Oreoica gutturalis	Crested Bellbird			*		*	*	*	*	*	*			*	*		*			*
Pachycephala lanioides	White-breasted Whistler																*			
Pachycephala melanura	Mangrove Golden Whistler							*												
Pachycephala rufiventris	Rufous Whistler			*			*	*	*	*	*	*		*	*		*			*
PARDALOTIDAE																				
Pardalotus rubricatus	Red-browed Pardalote			*	*	*	*	*	*	*		*	*	*			*			
Pardalotus striatus	Striated Pardalote			*					*	*	*			*	*	*	*			*
PELECANIDAE																				
Pelecanus conspicillatus	Australian Pelican			*		*	*	*									*			*
PETROICIDAE																				
Melanodryas cucullata	Hooded Robin						*		*	*	*			*	*		*			
Peneonanthe pulverulenta	Mangrove Robin							*									*			
Petroica goodenovii	Red-capped Robin					*	*	*	*	*	*			*	*		*			*
PHALACROCORACIDAE																				
Microcarbo melanoleucos	Little Pied Cormorant			*				*				*					*			*
Phalacrocorax sulcirostris	Little Black Cormorant			*		*	*	*				*								*
Phalacrocorax varius	Pied Cormorant							*												
PHASIANIDAE																				
Coturnix pectoralis	Stubble Quail					*			*	*							*			
Coturnix ypsilophora	Brown Quail			*							*		*	*			*			*
PODARGIDAE																				
Podargus strigoides	Tawny Frogmouth			*	*	*		*	*	*	*	*		*			*			*
PODICIPEDIDAE																				
Podiceps cristatus	Great Crested Grebe																*			*
Poliocephalus poliocephalus	Hoary-headed Grebe																*			
Tachybaptus novaehollandiae	Australasian Grebe					*		*						*			*			*
POMATOSTOMIDAE																				
Pomatostomus superciliosus	White-browed Babbler						*		*	*	*			*	*					
Pomatostomus temporalis	Grey-crowned Babbler						*	*			*		*	*	*		*			*
PSITTACIDAE																				
Barnardius zonarius	Australian Ringneck			*		*	*	*	*	*	*	*		*	*		*			*
Melopsittacus undulatus	Budgerigar			*	*	*	*	*	*	*	*	*	*	*	*	*	*			*
Neopsephotus bourkii	Bourke's Parrot										*						*			

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Pezoporus occidentalis	Night Parrot	EN, M	S1								*									
Psephotus varius	Mulga Parrot							*												
Purpureicephalus spurius	Red-capped Parrot																			*
PSOPHODIDAE																				
Cinclosoma castaneothorax	Chestnut-breasted Quail-thrush								*	*										
PTILONORHYNCHIDAE																				
Ptilonorhynchus guttatus	Western Bowerbird			*	*		*	*						*	*	*	*			*
Ptilonorhynchus maculatus	Spotted Bowerbird					*						*								
RALLIDAE																				
Fulica atra	Eurasian Coot																*			*
Gallinula tenebrosa	Dusky Moorhen																			
Gallirallus philippensis	Buff-banded Rail																*			
Porphyrio porphyrio	Purple Swamphen																*			
Porzana tabuensis	Spotless Crake													*			*			*
Tribonyx ventralis	Black-tailed Native-hen										*						*			
RECURVIROSTRIDAE																				
Himantopus himantopus	Black-winged Stilt							*	*	*							*			*
Recurvirostra novaehollandiae	Red-necked Avocet																*			
RHIPIDURIDAE																				
Rhipidura albiscapa	Grey Fantail						*				*	*			*		*			
Rhipidura leucophrys	Willie Wagtail			*	*	*	*	*	*	*	*	*	*	*	*	*	*			*
Rhipidura phasiana	Mangrove Grey Fantail							*									*			
SCOLOPACIDAE																				
Actitis hypoleucos	Common Sandpiper	M						*									*			
Arenaria interpres	Ruddy Turnstone	M															*			
Calidris ferruginea	Curlew Sandpiper	M															*			
Calidris ruficollis	Red-necked Stint	M															*			
Calidris subminuta	Long-toed Stint	M															*			
Numenius madagascariensis	Eastern Curlew	M	P4					*									*			
Numenius phaeopus	Whimbrel	M						*									*			
Tringa brevipes	Grey-tailed Tattler	M						*									*			
Tringa glareola	Wood Sandpiper	M												*			*			
Tringa nebularia	Common Greenshank	M				*											*			
Tringa stagnatilis	Marsh Sandpiper	M															*			
STRIGIDAE																				
Ninox connivens	Barking Owl					*									*		*			
Ninox novaeseelandiae	Southern Boobook Owl			*		*		*	*	*	*	*		*	*		*			*
THRESKIORNITHIDAE																				
Platalea flavipes	Yellow-billed Spoonbill																*			
Platalea regia	Royal Spoonbill																*			
Plegadis falcinellus	Glossy Ibis	M															*			
Threskiornis molucca	Australian White Ibis							*									*			

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Threskiornis spinicollis	Straw-necked Ibis			*		*		*			*						*			*
TIMALIIDAE																				
Zosterops lateralis	Silvereye																			
Zosterops luteus	Yellow White-eye							*									*			
TURNICIDAE																				
Turnix velox	Little Button-quail			*		*	*	*	*	*	*	*	*	*	*	*	*			*
TYTONIDAE																				
Tyto javanica	Eastern Barn Owl					*					*			*			*			*
Reptiles																				
AGAMIDAE																				
Amphibolurus longirostris	Long-nosed Dragon			*		*	*	*	*	*	*	*	*	*	*	*				*
Caimanops amphiboluroides	Mulga Dragon						*		*	*				*	*					
Ctenophorus caudicinctus	Ring-tailed Dragon			*	*	*	*	*	*	*	*	*	*	*	*	*				*
Ctenophorus isolepis	Central Military Dragon					*	*	*	*	*		*	*	*						*
Ctenophorus nuchalis	Central Netted Dragon					*	*	*			*			*						*
Ctenophorus reticulatus	Western Netted Dragon						*				*			*	*					*
Ctenophorus rubens																				*
Ctenophorus scutulatus	Lozenge-marked Dragon																			*
Diporiphora valens	Pilbara Two-line Dragon						*	*												
Diporiphora winneckei	Canegrass Dragon					*														
Pogona minor minor	Dwarf Bearded Dragon					*	*	*				*		*	*					
Tympanocryptis cephalus	Pebble Dragon								*	*										
CHELIDAE																				
Chelodina steindachneri	Flat-shelled Turtle					*			*	*	*									*
ELAPIDAE																				
Acanthophis pyrrhus	Desert Death Adder					*							*							
Acanthophis wellsi	Pilbara Death Adder						*							*	*					
Brachyurophis approximans	North-western Shovel-nosed Snake					*			*	*				*						
Demansia psammophis	Yellow-faced Whip Snake					*	*	*	*	*			*	*	*					*
Demansia rufescens	Rufous Whipsnake			*					*	*				*		*				*
Furina ornata	Orange-naped Snake					*	*		*	*		*				*				*
Parasuta monachus	Monk Snake														*					
Pseudechis australis	King Brown Snake					*	*	*	*	*		*		*	*					
Pseudonaja modesta	Ringed Brown Snake					*								*		*				
Pseudonaja nuchalis	Western Brown Snake					*	*	*					*	*						*
Simoselaps anomalus	Desert Banded Snake						*	*												
Suta fasciata	Rosen's Snake						*		*	*					*					*
Suta punctata	Little Spotted Snake					*	*	*	*	*			*							
Vermicella snelli					*		*								*					*
GEKKONIDAE																				
Crenadactylus ocellatus	Clawless Gecko			*																
Diplodactylus conspicillatus	Fat-tailed Diplodactylus					*	*	*	*	*	*	*	*							*

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Diplodactylus pulcher	Fine-faced Gecko														*					
Diplodactylus savagei	Yellow-spotted Pilbara Gecko			*	*									*	*	*				*
Gehyra pilbara	Pilbara Dtella			*		*														
Gehyra punctata	Spotted Dtella			*		*	*	*					*	*	*					*
Gehyra purpurascens	Purplish Dtella																			
Gehyra variegata	Tree Dtella			*	*	*	*	*	*	*	*	*	*	*	*	*				*
Heteronotia binoei	Bynoe's Gecko			*		*	*	*	*	*	*	*	*	*	*	*				*
Heteronotia planiceps	Bynoe's Prickly Gecko															*				
Heteronotia spelea	Desert Cave Gecko						*				*			*		*				*
Lucasium stenodactylum	Crowned Gecko				*	*	*	*	*	*		*		*	*	*				
Lucasium wombeyi	Pilbara Ground Gecko				*				*	*				*						
Nephrurus levis	Three-lined Knob-tail					*			*	*										
Nephrurus wheeleri	Banded Knob-tail						*							*	*					
Oedura marmorata	Marbled Velvet Gecko					*	*							*						
Rhynchoedura ornata	Beaked Gecko					*	*							*	*					*
Strophurus ciliaris	Spiny-tailed Gecko						*	*				*								
Strophurus elderi	Jewelled Gecko			*	*	*	*	*	*	*				*						
Strophurus jeanae	Southern Phasmid Gecko					*			*	*										
Strophurus wellingtonae	Western Shield Spiny-tailed Gecko						*		*	*				*	*					
PYGOPODIDAE																				
Delma butleri	Unbanded Delma															*				*
Delma elegans	Pilbara Delma			*										*						*
Delma haroldi	Neck-barred Delma						*								*					
Delma nasuta	Sharp-snouted Delma			*			*	*	*	*		*		*	*	*				*
Delma pax	Peace Delma			*	*	*	*	*	*	*				*	*	*				*
Delma tincta	Excitable Delma					*	*	*	*	*		*	*	*	*					
Lialis burtonis	Burton's Snake-lizard			*		*	*	*	*	*	*	*	*	*	*					
Pygopus nigriceps	Hooded Scaly-foot						*	*						*	*					
PYTHONIDAE																				
Antaresia perthensis	Pygmy Python			*		*	*	*	*	*			*							*
Antaresia stimsoni	Stimson's Python					*	*	*	*	*		*	*	*		*				
Aspidites melanocephalus	Black-headed Python					*	*		*	*	*			*	*					
Aspidites ramsayi	Woma		S4				*													
Liasis olivaceus barroni	Olive Python (Pilbara)	VU	S1			*							*					*	*	
SCINCIDAE																				
Carlia munda	Shaded-litter Rainbow-skink			*	*	*	*	*	*	*	*			*	*	*				
Carlia triacantha	Desert Rainbow-skink						*	*	*	*					*	*				
Cryptoblepharus buchananii															*					
Cryptoblepharus plagiocephalus	Callose-palmed Shinning-skink			*		*	*				*			*						
Cryptoblepharus ustulatus															*					
Ctenotus ariadnae	Ariadna's Ctenotus								*	*										
Ctenotus duricola					*	*	*	*	*	*				*	*					*

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Ctenotus grandis	Grand Ctenotus					*	*	*	*	*		*		*						*
Ctenotus helenae	Clay-soil Ctenotus					*	*	*	*	*		*		*	*					*
Ctenotus nigrilineatus	Pin-striped Finesnout Ctenotus		P1			*												*		
Ctenotus pantherinus	Leopard Ctenotus					*	*	*	*	*	*		*	*	*					*
Ctenotus piankai	Coarse Sands Ctenotus											*								
Ctenotus robustus	Robust Ctenotus						*													*
Ctenotus rubicundus	Ruddy Ctenotus			*					*	*	*			*		*				*
Ctenotus rutilans	Rusty-shouldered Ctenotus														*					
Ctenotus saxatilis	Stony-soil Ctenotus			*	*	*	*	*	*	*	*	*	*	*	*	*				*
Ctenotus schomburgkii	Barred Wedgesnout Ctenotus					*			*	*					*					
Ctenotus serventyi	North-western Sandy-loam Ctenotus					*				*										*
Ctenotus uber johnstonei			P2				*		*	*				*	*					
Cyclodomorphus melanops	Spinifex Slender Blue-tongue			*	*	*	*	*	*	*	*			*	*	*				*
Egernia depressa	Pygmy Spiny-tailed Skink					*	*	*					*							*
Egernia formosa	Goldfields Crevice-skink			*	*	*														*
Egernia pilbarensis	Pilbara Crevice-skink																			
Eremiascincus fasciolatus	Narrow-banded Sand-swimmer																			
Eremiascincus richardsonii	Broad-banded Sand-swimmer					*	*	*												
Lerista bipes	North-western Sandslider					*	*	*	*	*		*								*
Lerista clara																				
Lerista desertorum	Central Deserts Robust Slider																			
Lerista jacksoni																				*
Lerista muelleri	Wood Mulch-slider			*	*	*	*	*	*	*	*			*	*	*				*
Lerista neander	Pilbara Robust Slider														*					
Lerista verhmens																				*
Lerista zietzi															*					
Liopholis striata	Nocturnal Desert-skink					*														
Menetia greyii	Common Dwarf Skink					*	*	*	*	*	*	*		*	*					
Menetia surda	Western Dwarf Skink			*								*			*					
Menetia surda surda																				*
Morethia ruficauda	Lined Firetail Skink			*	*	*	*	*	*	*	*	*		*	*	*				*
Notoscincus ornatus	Ornate Soil-crevice Skink			*	*	*			*	*										*
Proablepharus reginae	Western Soil-crevice Skink			*		*	*	*	*	*				*						*
Tiliqua multifasciata	Centralian Blue-tongue					*	*	*	*	*	*	*		*	*					
TYPHLOPIDAE																				
Ramphotyphlops ammodytes							*	*	*	*	*			*						*
Ramphotyphlops diversus	Northern Blind Snake					*														
Ramphotyphlops ganei			P1															*		
Ramphotyphlops grypus	Long-beaked Blind Snake					*	*	*	*	*	*			*	*	*				*
Ramphotyphlops hamatus	Pale-headed Blind Snake					*									*					
Ramphotyphlops pilbarensis																				

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Ramphotyphlops waitii	Beaked Blind Snake														*					
VARANIDAE																				
Varanus acanthurus	Ridge-tailed Monitor			*		*	*	*	*	*	*	*	*	*	*	*				*
Varanus brevicauda	Short-tailed Pygmy Monitor					*	*	*	*	*	*				*					*
Varanus bushi	Pilbara Mulga Monitor						*							*	*					
Varanus caudolineatus	Stripe-tailed Monitor					*					*			*						
Varanus eremius	Pygmy Desert Monitor				*	*	*	*	*	*				*						*
Varanus giganteus	Perentie			*		*	*	*				*				*				*
Varanus gouldii	Gould's Goanna					*	*	*	*	*										
Varanus panoptes	Yellow-spotted Monitor					*	*		*	*	*			*	*					
Varanus pilbarensis	Pilbara Rock Monitor					*							*							
Varanus tristis	Black-headed Monitor				*	*	*				*			*	*					
Amphibians																				
HYLIDAE																				
Cyclorana australis	Giant Frog						*	*	*	*			*							
Cyclorana maini	Main's Frog					*	*	*	*	*		*	*		*	*				*
Litoria rubella	Desert Tree Frog			*	*	*	*	*	*	*	*	*	*	*		*				*
LIMNODYNASTIDAE																				
Neobatrachus sutor	Shoemaker Frog																			
Notaden nichollsi	Desert Spadefoot Toad						*	*	*	*			*							*
Platyplectrum ornatus	Ornate Burrowing Frog																			*
Platyplectrum spenceri	Spencer's Burrowing Frog					*	*	*	*	*		*								*
MYOBATRACHIDAE																				
Uperoleia glandulosa	Glandular Toadlet					*														
Uperoleia russelli	Russell's Toadlet			*	*	*	*	*	*	*		*								*
Fish																				
CLUPEIDAE																				
Nematalosa erebi	Bony Bream			*																
DIODONTIDAE																				
Allomycterus pilatus	Australian Burrfish																			
MELANOTAENIIDAE																				
Melanotaenia australis	Western Rainbowfish			*																
PLOTOSIDAE																				
Neosilurus hyrtlii	Hyrtl's Catfish			*																
TERAPONTIDAE																				
Amniataba percoides	Barred Grunter			*									*							
Leiopotherapon unicolor	Spangled Perch			*																
				141	**73**	**190**	**182**	**201**	**176**	**178**	**147**	**119**	**89**	**177**	**153**	**91**	**181**	**17**	**15**	**174**

Attachment B
Definitions of Conservation Significance Status

Status	Code	Description
Categories used in EPBC Act Protected Matters Report		
Endangered	E	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	V	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.
Migratory	M	Species migrate to, over and within Australia and its external territories.
Schedules of the Western Australian Wildlife Conservation Act 1950		
Schedule 1	S1	Fauna that is rare or likely to become extinct.
Schedule 2	S2	Fauna that is presumed to be extinct.
Schedule 3	S3	Birds that are subject to an agreement between the governments of Australia and Japan relating to the protection of migratory birds.
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		
Priority 1 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 2 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 3 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 4 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 5 Taxa in need of monitoring	P5	Taxa which are not considered threatened but are subject to a specific conservation program, the cessation of which would result in the species becoming threatened within five years.

Attachment C
Short Range Endemic Invertebrate Database Search of the Western Australian Museum Collection, December 2010 for the Sulphur Springs Study Area

Short Range Endemic Invertebrate Database Search of the Western Australian Museum Collection, December 2010 for the Sulphur Springs Study Area

Family	Scientific Name	Notes	Latitude	Longitude
Diplopoda	Antichiropus 'abydos'	T107885 Paradoxosomatidae Antichiropus 'abydos' Abydos, ca. 64 km W. Marble Bar	-21.14222222	119.1150028
Diplopoda	Antichiropus 'abydos'	T107886 Paradoxosomatidae Antichiropus 'abydos' Abydos, ca. 64 km W. Marble Bar	-21.14222222	119.1150028
Araneae	Kwonkan 'MYG200'	T102701 Nemesiidae Kwonkan 'MYG200' Mt Webber	-21.52510556	119.3278111
Pseudoscorpiones	Feaella 'sp. nov. Sulphur Springs'	T78157 Feaellidae Feaella 'tealei' Sulphur Springs, site SUSS 11	-21.13805556	119.1969444
Pseudoscorpiones	Feaella 'sp. nov. Sulphur Springs'	T63963 Feaellidae Feaella 'tealei' Sulphur Springs, site SUSS 11	-21.13805556	119.1969444

Sulphur Springs Database Search: bounding coordinates

Top Left 20°42'23.1"S 118°43'52.3"E

Bottom Right 21°36'25.1"E 119°41'39"E

Whim Creek Database Search: bounding coordinates

Top Left 20°24'14.1"S 117°21'00.8"E

Bottom Right 21°18'23.1"S 118°18'29.3"E

NB –database search for the Whim Creek study area provided a NIL return.

Attachment D

Database Searches for Vertebrate Species Occurring Within the Whim Creek Study Area and Surrounds

Attachment D– Database Searches for Vertebrate Species Occurring Within the Whim Creek Study Area and Surrounds

Legend

Abbreviations/Symbols

*	Introduced Species
EPBC Act	Commonwealth *Environmental Protection and Biodiversity Conservation Act 1999*: EN Endangered, VU Vulnerable M Migratory
WC Act	Western Australian Wildlife Conservation Act 1950 and Department of Environment and Conservation's Threatened and Priority Fauna Rankings: S1 Schedule 1 Rare or likely to become extinct, S3 Migratory birds protected under an international agreement, S4 In need of special protection P1 Priority 1 Fauna, P2, P3, P4, P5

Database Searches – centroid: 117.827678° E, -20.854009° S

Birds Aust.	Birds Australia Atlas Database Search (December 2010)
DEC TPFS	Department of Environment and Conservation's Threatened and Priority Fauna Database Search (December 2010)
ERT	Department of Sustainability, Environment, Water, Population and Communities database search (October 2010)
Nature Map	Department of Environment and Conservation's Nature Map Database (December 2010)

Scientific Name	Common Name	Conservation Status		Database Searches			
		EPBC Act	WC Act	Birds Australia	DEC TPFS	ERT	Nature Map
Mammals							
CANIDAE							
*Vulpes vulpes**	Fox					*	
DASYURIDAE							
Dasycercus cristicauda	Crest-tailed Mulgara	VU	S1			*	
Dasyurus hallucatus	Northern Quoll	EN	S1		*	*	*
Ningaui timealeyi	Pilbara Ningaui						*
FELIDAE							
*Felis catus**	Cat					*	
HIPPOSIDERIDAE							
Rhinonicteris aurantius (Pilbara form)	Pilbara Leaf-nosed Bat	VU	S1			*	
LEPORIDAE							
*Oryctolagus cuniculus**	Rabbit					*	
MACROPODIDAE							
Lagorchestes conspicillatus leichardti	Spectacled Hare-wallaby (mainland)		P3				*
Petrogale lateralis lateralis	Black-flanked rock-wallaby	VU	S1		*		
MEGADERMATIDAE							
Macroderma gigas	Ghost Bat		P4		*		
MURIDAE							
Hydromys chrysogaster	Water-rat		P4		*		
Leggadina lakedownensis	Lakeland Downs Mouse		P4		*		
Pseudomys chapmani	Pebble-mound Mouse		P4		*		
VESPERTILIONIDAE							
Vespadelus finlaysoni	Inland Cave Bat						*
Birds							
ACANTHIZIDAE							
Gerygone fusca	Western Gerygone			*			
Gerygone tenebrosa	Dusky Gerygone			*			
Smicrornis brevirostris	Weebill			*			
ACCIPITRIDAE							
Accipiter cirrocephalus	Collared Sparrowhawk			*			*
Accipiter fasciatus	Brown Goshawk			*			*
Aquila audax	Wedge-tailed Eagle			*			*
Circus approximans	Swamp Harrier			*			
Circus assimilis	Spotted Harrier			*			*
Elanus axillaris	Black-shouldered Kite			*			*

Scientific Name	Common Name	Conservation Status		Database Searches			
		EPBC Act	WC Act	Birds Australia	DEC TPFS	ERT	Nature Map
Haliaeetus leucogaster	White-bellied Sea-Eagle	M		*		*	*
Haliastur indus	Brahminy Kite			*			
Haliastur sphenurus	Whistling Kite			*			*
Hieraaetus morphnoides	Little Eagle			*			*
Lophoictinia isura	Square-tailed Kite			*			
Milvus migrans	Black Kite			*			
Pandion cristatus	Eastern Osprey			*			
ACROCEPHALIDAE							
Acrocephalus australis	Australian Reed-Warbler	M		*			*
ALAUDIDAE							
Mirafra javanica	Horsfield's Bushlark			*			
ANATIDAE							
Anas gracilis	Grey Teal			*			*
Anas rhynchotis	Australasian Shoveler			*			
Anas superciliosa	Pacific Black Duck			*			*
Aythya australis	Hardhead			*			*
Chenonetta jubata	Australian Wood Duck			*			
Cygnus atratus	Black Swan			*			
Dendrocygna eytoni	Plumed Whistling-Duck			*			
Malacorhynchus membranaceus	Pink-eared Duck			*			
ANHINGIDAE							
Anhinga novaehollandiae	Australasian Darter			*			
APODIDAE							
Apus pacificus	Fork-tailed Swift	M		*		*	
ARDEIDAE							
Ardea ibis	Cattle Egret	M		*		*	
Ardea intermedia	Intermediate Egret			*			
Ardea modesta	Eastern Great Egret			*			*
Ardea pacifica	White-necked Heron			*			*
Butorides striata	Striated Heron			*			
Egretta garzetta	Little Egret			*			
Egretta novaehollandiae	White-faced Heron			*			*
Egretta sacra	Eastern Reef Egret	M		*			
Ixobrychus flavicollis	Black Bittern			*			
Nycticorax caledonicus	Nankeen Night Heron			*			*
ARTAMIDAE							
Artamus cinereus	Black-faced Woodswallow			*			*

Scientific Name	Common Name	Conservation Status		Database Searches			
		EPBC Act	WC Act	Birds Australia	DEC TPFS	ERT	Nature Map
Artamus leucorynchus	White-breasted Woodswallow			*			
Artamus minor	Little Woodswallow			*			*
Artamus personatus	Masked Woodswallow			*			*
Cracticus nigrogularis	Pied Butcherbird			*			*
Cracticus tibicen	Australian Magpie			*			*
Cracticus torquatus	Grey Butcherbird			*			
BURHINIDAE							
Burhinus grallarius	Bush Stone-curlew		P4	*	*		*
CACATUIDAE							
Cacatua sanguinea	Little Corella			*			*
Eolophus roseicapillus	Galah			*			*
Nymphicus hollandicus	Cockatiel			*			*
CAMPEPHAGIDAE							
Coracina maxima	Ground Cuckoo-shrike			*			
Coracina novaehollandiae	Black-faced Cuckoo-shrike			*			*
Lalage sueurii	White-winged Triller			*			*
CASUARIIDAE							
Dromaius novaehollandiae	Emu			*			
CHARADRIIDAE							
Charadrius leschenaultii	Greater Sand Plover	M		*			
Charadrius ruficapillus	Red-capped Plover			*			
Charadrius veredus	Oriental Plover	M		*		*	
Elseyornis melanops	Black-fronted Dotterel			*			*
Erythrogonys cinctus	Red-kneed Dotterel			*			
Pluvialis fulva	Pacific Golden Plover	M		*			
Vanellus miles	Masked Lapwing			*			
Vanellus tricolor	Banded Lapwing			*			
CICONIIDAE							
Ephippiorhynchus asiaticus	Black-necked Stork			*			
CLIMACTERIDAE							
Climacteris melanura	Black-tailed Treecreeper			*			*
COLUMBIDAE							
*Columba livia**	Rock Dove			*			
Geopelia cuneata	Diamond Dove			*			*
Geopelia humeralis	Bar-shouldered Dove			*			
Geopelia striata	Peaceful Dove			*			*

Scientific Name	Common Name	Conservation Status		Database Searches			
		EPBC Act	WC Act	Birds Australia	DEC TPFS	ERT	Nature Map
Geophaps plumifera	Spinifex Pigeon			*			*
Ocyphaps lophotes	Crested Pigeon			*			*
Phaps chalcoptera	Common Bronzewing			*			
Phaps histrionica	Flock Bronzewing		P4	*	*		
CORVIDAE							
Corvus bennetti	Little Crow			*			
Corvus orru	Torresian Crow			*			*
CUCULIDAE							
Cacomantis pallidus	Pallid Cuckoo			*			*
Centropus phasianinus	Pheasant Coucal			*			
Chalcites basalis	Horsfield's Bronze-Cuckoo			*			
Chalcites osculans	Black-eared Cuckoo			*			
ESTRILDIDAE							
Emblema pictum	Painted Finch			*			*
Neochmia ruficauda	Star Finch			*			
Taeniopygia guttata	Zebra Finch			*			*
EUROSTOPODIDAE							
Eurostopodus argus	Spotted Nightjar			*			
FALCONIDAE							
Falco berigora	Brown Falcon			*			*
Falco cenchroides	Nankeen Kestrel			*			*
Falco hypoleucos	Grey Falcon		P4	*	*		
Falco longipennis	Australian Hobby			*			
Falco peregrinus	Peregrine Falcon		S4	*	*		
Falco subniger	Black Falcon			*			
GLAREOLIDAE							
Glareola maldivarum	Oriental Pratincole	M		*		*	
Stiltia isabella	Australian Pratincole			*			
GRUIDAE							
Grus rubicunda	Brolga			*			
HAEMATOPODIDAE							
Haematopus fuliginosus	Sooty Oystercatcher			*			
Haematopus longirostris	Australian Pied Oystercatcher			*			
HALCYONIDAE							
Dacelo leachii	Blue-winged Kookaburra			*			*
Todiramphus chloris	Collared Kingfisher			*			
Todiramphus pyrrhopygius	Red-backed Kingfisher			*			*

Scientific Name	Common Name	Conservation Status		Database Searches			
		EPBC Act	WC Act	Birds Australia	DEC TPFS	ERT	Nature Map
Todiramphus sanctus	Sacred Kingfisher			*			*
HIRUNDINIDAE							
Cheramoeca leucosterna	White-backed Swallow			*			
Hirundo neoxena	Welcome Swallow			*			
Hirundo rustica	Barn Swallow	M				*	
Petrochelidon ariel	Fairy Martin			*			
Petrochelidon nigricans	Tree Martin			*			*
LARIDAE							
Chlidonias hybrida	Whiskered Tern			*			
Chlidonias leucopterus	White-winged Black Tern	M		*			
Chroicocephalus novaehollandiae	Silver Gull			*			
Gelochelidon nilotica	Gull-billed Tern			*			
Hydroprogne caspia	Caspian Tern	M		*			
Sternula nereis	Fairy Tern			*			
Thalasseus bengalensis	Lesser Crested Tern	M		*			
Thalasseus bergii	Crested Tern			*			
MALURIDAE							
Malurus lamberti	Variegated Fairy-wren			*			*
Malurus leucopterus	White-winged Fairy-wren			*			
Stipiturus ruficeps	Rufous-crowned Emu-wren			*			
MEGALURIDAE							
Cincloramphus cruralis	Brown Songlark			*			
Cincloramphus mathewsi	Rufous Songlark			*			*
Eremiornis carteri	Spinifexbird			*			
MELIPHAGIDAE							
Acanthagenys rufogularis	Spiny-cheeked Honeyeater			*			
Certhionyx variegatus	Pied Honeyeater			*			
Epthianura tricolor	Crimson Chat			*			
Lichenostomus keartlandi	Grey-headed Honeyeater			*			*
Lichenostomus penicillatus	White-plumed Honeyeater			*			*
Lichenostomus virescens	Singing Honeyeater			*			*
Lichmera indistincta	Brown Honeyeater			*			*
Manorina flavigula	Yellow-throated Miner			*			*
Melithreptus gularis	Black-chinned Honeyeater			*			

Scientific Name	Common Name	Conservation Status		Database Searches			
		EPBC Act	WC Act	Birds Australia	DEC TPFS	ERT	Nature Map
MEROPIDAE							
Merops ornatus	Rainbow Bee-eater	M		*		*	*
MONARCHIDAE							
Grallina cyanoleuca	Magpie-lark			*			*
MOTACILLIDAE							
Anthus novaeseelandiae	Australasian Pipit			*			*
NECTARINIIDAE							
Dicaeum hirundinaceum	Mistletoebird			*			*
OTIDIDAE							
Ardeotis australis	Australian Bustard		P4	*	*		*
PACHYCEPHALIDAE							
Colluricincla harmonica	Grey Shrike-thrush			*			*
Oreoica gutturalis	Crested Bellbird			*			*
Pachycephala lanioides	White-breasted Whistler			*			
Pachycephala rufiventris	Rufous Whistler			*			
PARDALOTIDAE							
Pardalotus rubricatus	Red-browed Pardalote			*			*
Pardalotus striatus	Striated Pardalote			*			*
PELECANIDAE							
Pelecanus conspicillatus	Australian Pelican			*			*
PETROICIDAE							
Melanodryas cucullata	Hooded Robin			*			
Peneonanthe pulverulenta	Mangrove Robin			*			
Petroica goodenovii	Red-capped Robin			*			
PHALACROCORACIDAE							
Microcarbo melanoleucos	Little Pied Cormorant			*			*
Phalacrocorax carbo	Great Cormorant						*
PHASIANIDAE							
Coturnix pectoralis	Stubble Quail			*			
Coturnix ypsilophora	Brown Quail			*			
PODARGIDAE							
Podargus strigoides	Tawny Frogmouth			*			
PODICIPEDIDAE							
Podiceps cristatus	Great Crested Grebe			*			
Poliocephalus poliocephalus	Hoary-headed Grebe			*			*
Tachybaptus novaehollandiae	Australasian Grebe			*			*
POMATOSTOMIDAE							

Scientific Name	Common Name	Conservation Status		Database Searches			
		EPBC Act	WC Act	Birds Australia	DEC TPFS	ERT	Nature Map
Pomatostomus temporalis	Grey-crowned Babbler			*			*
PSITTACIDAE							
Barnardius zonarius	Australian Ringneck			*			*
Melopsittacus undulatus	Budgerigar			*			*
Neopsephotus bourkii	Bourke's Parrot			*			
PTILONORHYNCHIDAE							
Ptilonorhynchus guttatus	Western Bowerbird			*			
RALLIDAE							
Fulica atra	Eurasian Coot			*			
Gallirallus philippensis	Buff-banded Rail			*			
Porphyrio porphyrio	Purple Swamphen			*			
Porzana tabuensis	Spotless Crake			*			
Tribonyx ventralis	Black-tailed Native-hen			*			
RECURVIROSTRIDAE							
Himantopus himantopus	Black-winged Stilt			*			
Recurvirostra novaehollandiae	Red-necked Avocet			*			
RHIPIDURIDAE							
Rhipidura albiscapa	Grey Fantail			*			
Rhipidura leucophrys	Willie Wagtail			*			*
Rhipidura phasiana	Mangrove Grey Fantail			*			
SCOLOPACIDAE							
Actitis hypoleucos	Common Sandpiper	M		*			
Arenaria interpres	Ruddy Turnstone	M		*			
Calidris ferruginea	Curlew Sandpiper	M		*			
Calidris ruficollis	Red-necked Stint	M		*			
Calidris subminuta	Long-toed Stint	M		*			
Numenius madagascariensis	Eastern Curlew	M	P4	*	*		
Numenius phaeopus	Whimbrel	M		*			
Tringa brevipes	Grey-tailed Tattler	M		*			
Tringa glareola	Wood Sandpiper	M		*			
Tringa nebularia	Common Greenshank	M		*			
Tringa stagnatilis	Marsh Sandpiper	M		*			
STRIGIDAE							
Ninox connivens	Barking Owl			*			*
Ninox novaeseelandiae	Southern Boobook Owl			*			*
THRESKIORNITHIDAE							
Platalea flavipes	Yellow-billed Spoonbill			*			
Platalea regia	Royal Spoonbill			*			

Scientific Name	Common Name	Conservation Status		Database Searches			
		EPBC Act	WC Act	Birds Australia	DEC TPFS	ERT	Nature Map
Plegadis falcinellus	Glossy Ibis	M		*			
Threskiornis molucca	Australian White Ibis			*			
Threskiornis spinicollis	Straw-necked Ibis			*			*
TIMALIIDAE							
Zosterops luteus	Yellow White-eye			*			
TURNICIDAE							
Turnix velox	Little Button-quail			*			
TYTONIDAE							
Tyto javanica	Eastern Barn Owl			*			
Reptiles							
AGAMIDAE							
Ctenophorus isolepis	Central Military Dragon						*
ELAPIDAE							
Demansia psammophis	Yellow-faced Whip Snake						*
GEKKONIDAE							
Gehyra punctata	Spotted Dtella						*
PYTHONIDAE							
Aspidites ramsayi	Woma		S4		*		
Liasis olivaceus barroni	Olive Python (Pilbara)	VU	S1			*	
SCINCIDAE							
Ctenotus pantherinus	Leopard Ctenotus						*
Cyclodomorphus melanops	Spinifex Slender Blue-tongue						*
Lerista nevinae			P1		*		
VARANIDAE							
Varanus acanthurus	Ridge-tailed Monitor						*
Varanus eremius	Pygmy Desert Monitor						*
Varanus gouldii	Gould's Goanna						*
Amphibians							
HYLIDAE							
Cyclorana maini	Main's Frog						*
				181	**14**	**14**	**84**

APPENDIX 5: TARGETED VERTEBRATE FAUNA IMPACT ASSESSMENT (OUTBACK ECOLOGY 2012B)

Venturex Resources Limited

Pilbara Copper-Zinc Project

Terrestrial Vertebrate Fauna Impact Assessment

November 2012

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Terrestrial Vertebrate Fauna Impact Assessment

Distribution:

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Document Control for Job Number: WHIM-SA-11002

Document Status	Author	Reviewer	Signature	Date of Issue
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Final Report	T. Derham			15 November 2012

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Executive Summary

Venturex Resources Limited (Venturex) is currently undertaking a defensible feasibility study in relation to the Pilbara Copper-Zinc Project (the Project). The Project is located approximately 57 kilometres (km) west of Marble Bar in the Pilbara region of Western Australia (WA).

The Project will comprise the underground development of the Sulphur Springs deposit, processing of ore at an on-site concentrate plant and haulage of concentrate from the Project to Port Hedland via road train for export. Development within the Project footprint will include a processing plant, tailings storage facility, evaporation pond, run of mine pad, access roads, workshops, borrow pit, offices, camp and air strip. The Project footprint is currently identified as 178.3 hectares and includes some pre-existing tracks and developed areas. Additional minor clearing may be required outside of the Project footprint for the construction of the infrastructure associated with the Project. Construction and use of the haul road (from the access road to the Marble Bar road) does not form part of this assessment

Venturex commissioned Outback Ecology to undertake a terrestrial fauna impact assessment of the Project, following a desktop study and reconnaissance survey. The area assessed (the Study area) was defined as an area of 7,623 hectares (ha) and incorporated tenements owned by Venturex plus neighbouring tenements.

This report comprises an assessment of potential impacts of the Project on terrestrial fauna and fauna habitat, particularly for species of conservation significance. This assessment is based on information from the aforementioned study and should be read in conjunction with that report. The impact assessment is based on a preliminary footprint and project description supplied on 28 August 2012.

Five broad fauna habitats relevant to vertebrates were identified in the Project footprint:

- Spinifex Stony Plains;
- Rocky Foothills;
- Scree Slope;
- Drainage Line; and
- Rocky Ridges and Gorges.

All habitat types are considered typical of the Pilbara bioregion. They are varied in their potential to support vertebrate assemblages and conservation significant species. Of the habitat types observed, Spinifex Stony Plains, Rocky Foothills and Scree Slope are considered widespread in the landscape. Although Drainage Line habitat is not extensive in the landscape, it is relatively well connected along its length. Rocky Ridges and Gorges is relatively uncommon habitat within the broader landscape and is patchily distributed.

Based on database search findings, a review of relevant literature within the surrounding region, and previous surveys in or near the Study area, it is possible that up to 392 terrestrial vertebrate fauna

species occur within the Project footprint, including 53 mammals (44 native), 211 birds, 116 reptiles, five fish and seven amphibian species (Outback Ecology 2012). Review of previous surveys conducted within the Study area suggests that it is possible that up to 151 terrestrial vertebrate fauna species occur within the Study area, including 27 mammals (22 native), 83 birds, 34 reptiles, five fish and two amphibian species.

Of the 392 species identified by database searches and literature review, and based on habitat preference or observed occurrence, there are 13 species of fauna of conservation significance that may occur in the Study area plus seven species that were confirmed in the Study area. These include eight threatened fauna species (as defined under the *Environment Protection and Biodiversity Conservation Act 1999* (Cth) (EPBC Act) or the *Wildlife Conservation Act 1950* (WA), ten Priority species as listed by the WA Department of Environment and Conservation and three species listed as Migratory under the EPBC Act and subject to international agreements. As the habitat is contiguous between the Project area and the Study area, since the vertebrate species identified are mobile on the scale of the Study area and using the precautionary principle, it is assumed that any species confirmed present in the Study area was also present in the Project footprint.

The primary impact to vertebrate fauna individuals, assemblages and habitat from the proposed activities associated with the Project is from removal and modification of habitat through land clearing. Impact to each of the habitat types is considered low on a regional scale, due either to the presence of extensive alternate habitat, being well-connected to adjacent similar habitat or a relatively small area being required to be cleared. Secondary to this impact is the potential impact from vehicle collisions.

At the local scale, assuming no actions are undertaken to mitigate risks, the likely impact on individual conservation significant species is negligible, minimal or low (the latter rating for the Northern Quoll – *Dasyurus hallucatus* - only). At the regional scale the impact on each species is either negligible or minimal.

Impacts to vertebrate fauna can be significantly mitigated and management recommendations are provided. Important recommendations include:

- preparation and implementation of a Significant Species Management Plan for fauna of conservation significance that are likely to be impacted by the Project;
- designing the project so as to minimise the footprint in significant habitat types (Drainage Line and Rocky Ridges and Gorges);
- clearing protocols, including progressive clearing to allow egress by mobile fauna and boundary checking to minimise accidental clearing;
- progressive rehabilitation to maximise rehabilitation success and minimise impacts associated with cleared areas; and
- management of traffic, especially reduced speed limits at night.

Table of Contents

TABLES

FIGURES

1. INTRODUCTION

1.1. Project Location And Description

Venturex Resources Limited (Venturex) is currently undertaking a definitive feasibility study of the Pilbara Copper-Zinc Project (the Project). The Project is located approximately 57 kilometres (km) west of Marble Bar in the Pilbara region of Western Australia (WA) (**Figure 1**). The Project will comprise the underground development of the Sulphur Springs deposit, processing of ore at an on site concentrate plant and haulage of concentrate from the Project to Port Hedland via road train for export. Construction and use of the haul road (from the access road to the Marble Bar road) does not form part of this assessment

The area of direct disturbance (i.e. the Project footprint) is defined as the processing plant, tailings storage facility (TSF), evaporation pond, run of mine pad, access roads, workshops, borrow pit, offices, camp and air strip (**Figure 2**). Additional minor clearing may be required outside of the Project footprint for the construction of the infrastructure associated with the Project.

For a summary of the existing environment, including biogeographic region, climate, land systems and land use, please refer to the previous fauna assessments of the Survey area:

- Pilbara Copper-Zinc Project: Level 1 Terrestrial Fauna Survey (Outback Ecology 2012);
- Panorama Project: Mine Site and Haul Road Corridor Targeted Fauna Survey (Biota 2007); and
- Panorama Project Area: Baseline Fauna Study as Part of the Sulphur Springs Feasibility Study (Bamford Consulting Ecologists 2001).

1.2. Assessment Scope And Objectives

The purpose of this terrestrial vertebrate fauna impact assessment is to assess the potential impacts of the Project on the terrestrial fauna assemblages and habitat in the Study area and more specifically, within the Project footprint. This document details project activities and threatening processes associated with the Project and impact on conservation significant fauna, terrestrial vertebrate fauna assemblages and fauna habitats within the Survey area.

This impact assessment for the Project includes an assessment of information presented within the following four biological surveys:

- Pilbara Copper-Zinc Project: Level 1 Terrestrial Fauna Survey (Outback Ecology 2012);
- Panorama Project: Mine Site and Haul Road Corridor Targeted Fauna Survey (Biota 2007);
- Field Survey for conservation significant bats near Sulphur Springs, Pilbara: field survey and management advice (MOLHAR Pty Ltd 2007); and
- Panorama Project Area: Baseline Fauna Study as Part of the Sulphur Springs Feasibility Study (Bamford Consulting Ecologists 2001).

The information from these surveys have been used in conjunction with a preliminary Project footprint and project description, supplied on 28 August 2012 (**Section 1.1**), to assess potential impacts on

terrestrial fauna and fauna habitat, particularly for species of conservation significance. This report should be read in conjunction with these previous survey reports.

The impact assessment has been aligned with:

- WA Environmental Protection Authority's (EPA's) Position Statement No. 3 *Terrestrial Biological Surveys as an Element of Biodiversity Protection* (EPA 2003);
- WA EPA Guidance Statement No. 56 *Terrestrial Fauna Surveys for Environmental Impact Assessment in Western Australia* (EPA 2004); and
- WA EPA and Department of Environment and Conservation (DEC) Technical Guide – *Terrestrial Vertebrate Fauna Surveys for Environmental Impact Assessment* (EPA and DEC 2010).

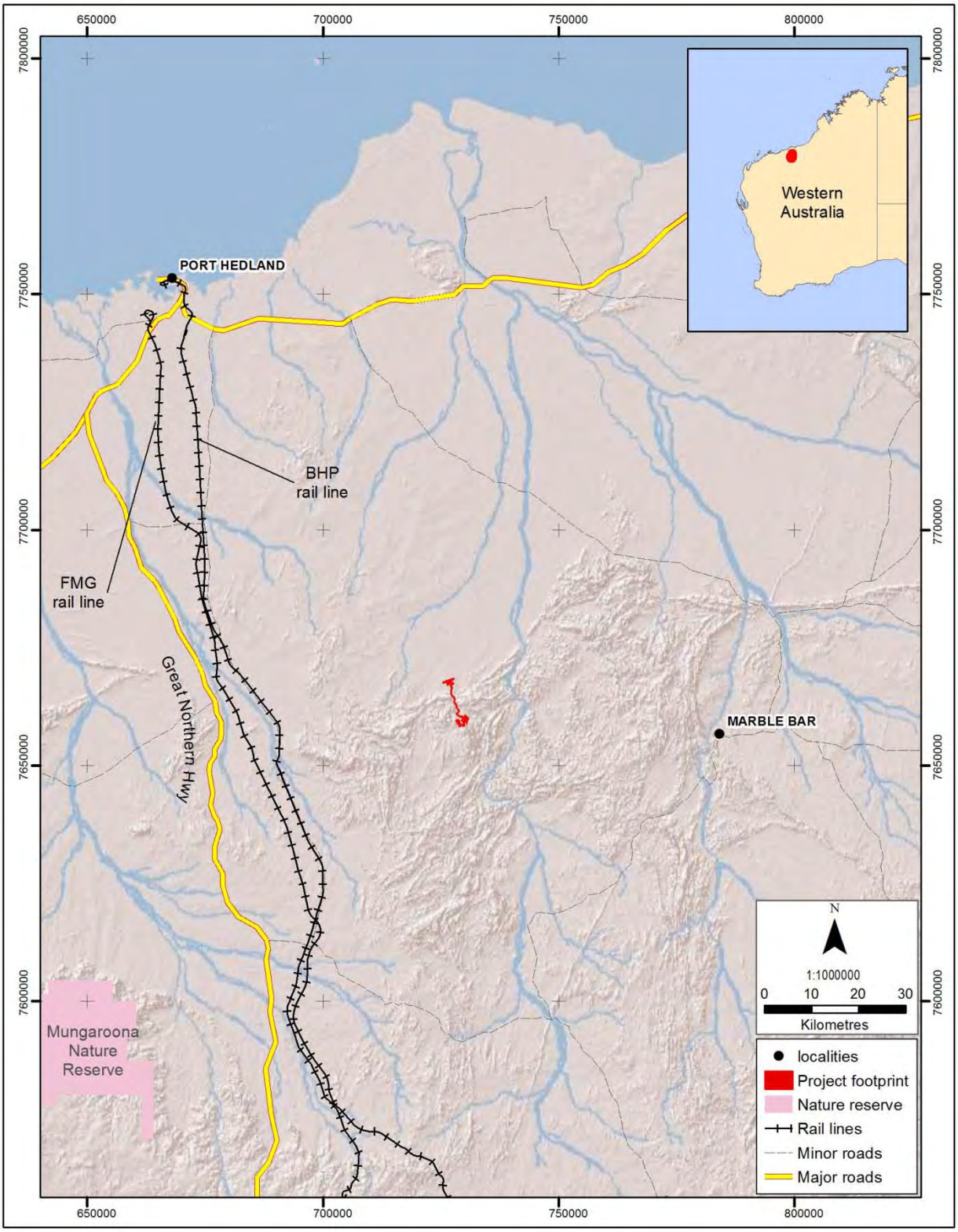

Figure 1: Regional location of the Project

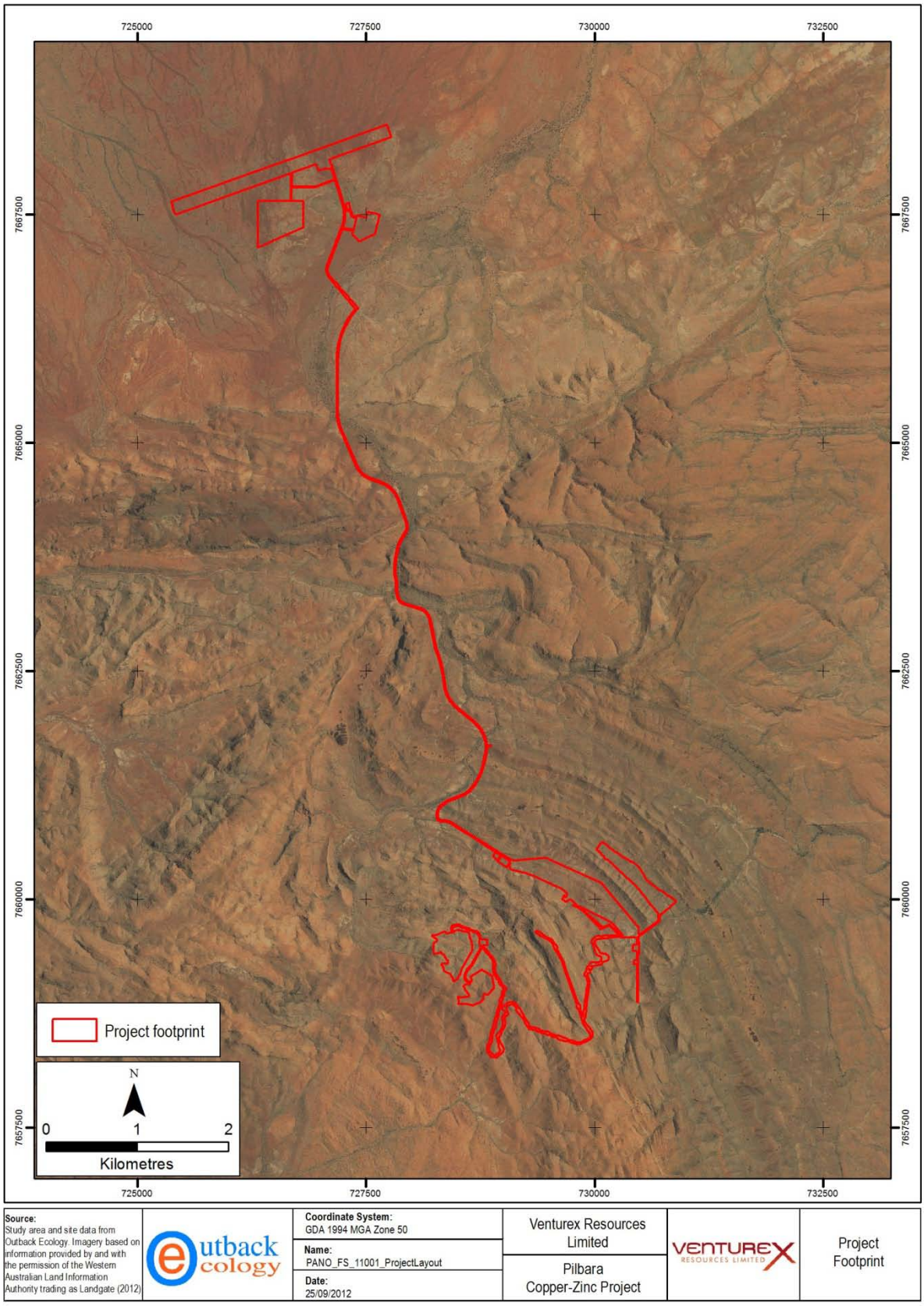

Figure 2: Project footprint

2. EXISTING ENVIRONMENT

2.1. Biogeographic Region

The Interim Biogeographic Regionalisation for Australia (IBRA) is a bioregional framework that divides Australia into 85 bioregions and 403 sub-bioregions on the basis of climate, geology, landforms, vegetation and fauna (McKenzie *et al.* 2003). The Project lies within the Pilbara bioregion (**Figure 3**). The Pilbara bioregion is further classified into the Chichester, Roebourne, Fortescue Plains, and Hamersley sub-bioregions (McKenzie *et al.* 2003). The Project footprint falls within the Chichester sub-bioregion (**Figure 3**). This subregion is described in detail in Outback Ecology (2012).

2.2. Climate

The Project is located within the northern section of the Pilbara bioregion, which experiences a semi-arid to arid-tropical climate characterised by hot summers and relatively warm, dry winters. Tropical cyclones can occur between January and April, bringing sporadic drenching rainfall events (Leighton 2004, McKenzie *et al.* 2003, McKenzie *et al.* 2009). For a detailed account of climate in the Pilbara, see Leighton (2004) and Outback Ecology (2012).

The closest locality with comprehensive climate data available is Marble Bar, approximately 60 km east of the Project, which was used as a proxy to describe climatic conditions.

2.3. Land Systems in the Project area

An assessment of land systems (Van Vreeswyk *et al.* 2004) provides an indication of the occurrence and distribution of fauna habitats within and surrounding the Project footprint. Land systems occurring within the Study area (**Table 1, Figure 4**) are discussed in detail by Outback Ecology (2012).

The Project footprint lies on three land systems. The Capricorn and Rocklea land systems are likely to be of particular significance to conservation significant fauna occurring within the Project footprint. These land systems, which consists of hills and ridges of volcanic and other rocks supporting hard spinifex, is likely to support Northern Quoll (*Dasyurus hallucatus*), Pilbara Leaf-nosed Bat (*Rhinonicteris aurantia*), Ghost Bat (*Macroderma gigas*) and Rothschild's Rock-wallaby (*Petrogale rothschildi*), with Pebble-mound Mouse (*Pseudomys chapmani*) likely to be present on stony slopes.

Table 1: Land Systems and their occurrence within the Project footprint (Van Vreeswyk et al. 2004)

Land System	Brief description	Area in Project Footprint	Extent in Study Area
Boolgeeda	Stony lower slopes and plains below hill systems supporting hard and soft spinifex grasslands or mulga shrublands	65.3 ha (36.6%)	904 ha
Capricorn	Hills and ridges of sandstone and dolomite supporting low shrublands or shrubby spinifex grasslands	84.5 ha (47.4%)	3,656 ha
Rocklea	Basalt hills, plateaux, lower slopes and minor stony plains supporting hard spinifex (and occasionally soft spinifex) grasslands	28.5 ha (16%)	1,932 ha

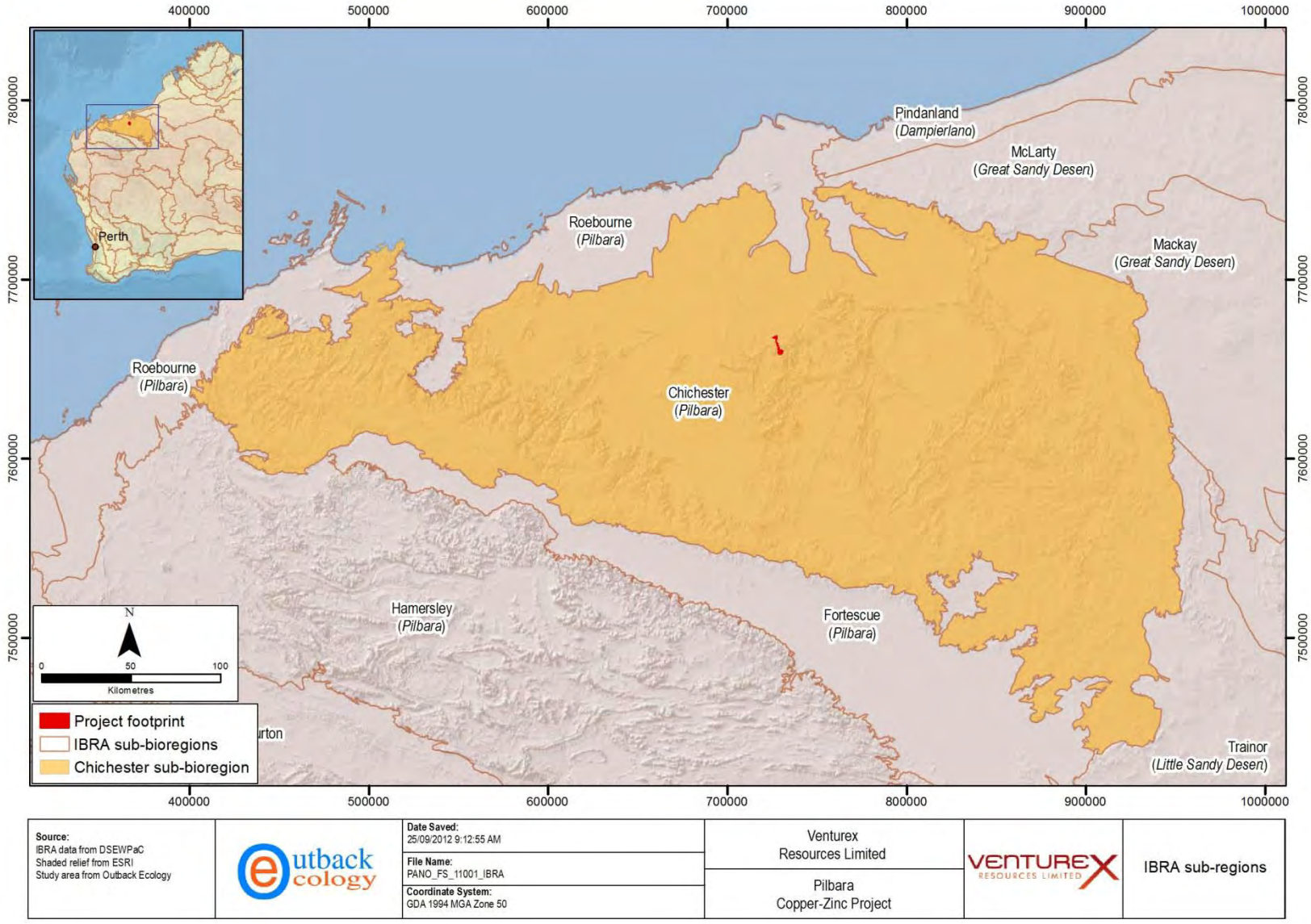

Figure 3: Location of Project with respect to the Pilbara bioregion and subregions

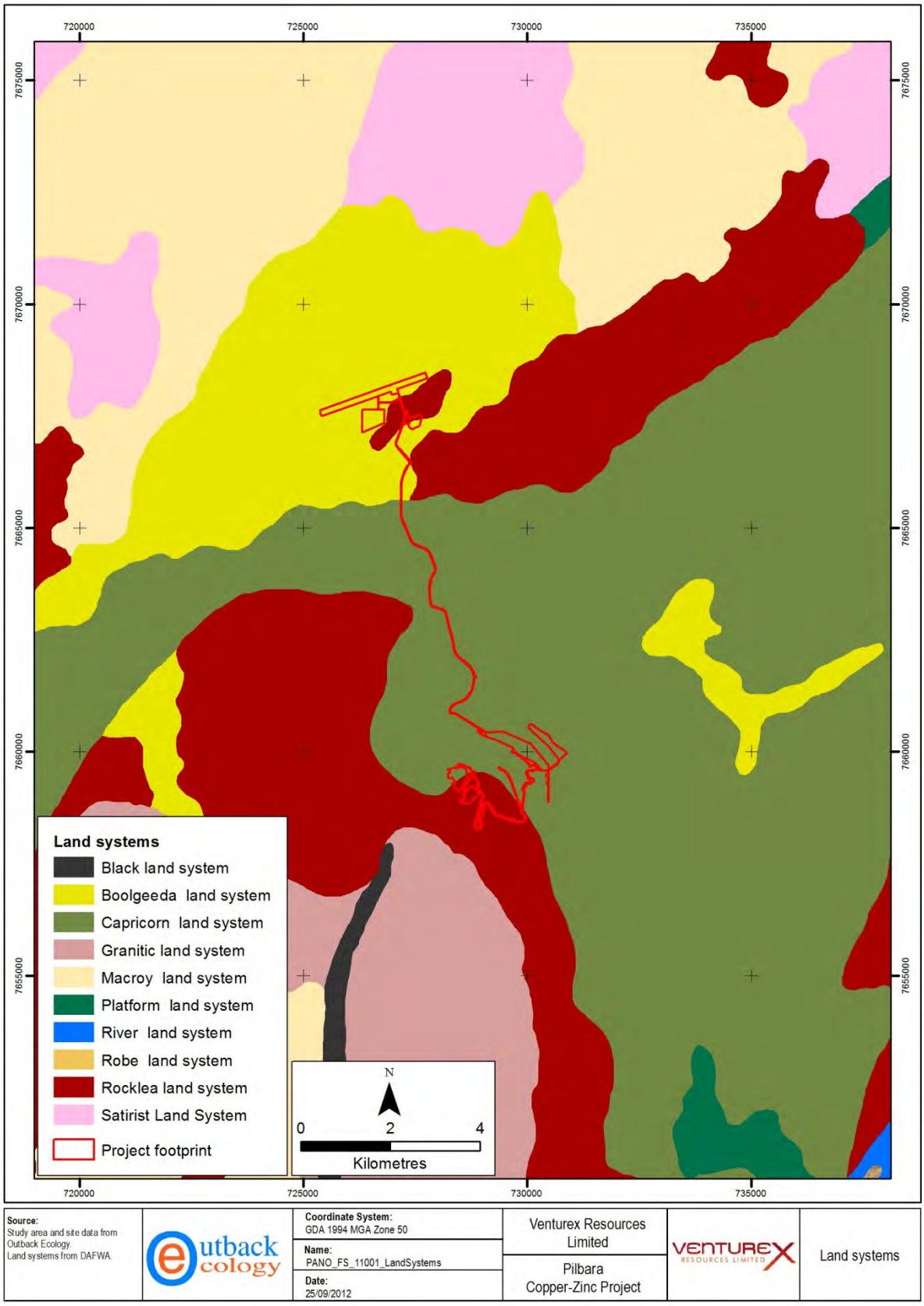

Figure 4: Land systems in and surrounding the Project footprint

2.4. Land Use in and surrounding the Project area

Land tenure in the Pilbara consists primarily of pastoral leases but Aboriginal reserves and leasehold reserves also occupy a large portion of the total land area. National parks and reserves, unallocated crown land (UCL) and mining are the other major land tenure categories.

In the Chichester sub-bioregion land tenure is dominated by pastoral leases (i.e. for grazing of native pasture by cattle), Aboriginal lands and reserves, UCL and crown reserves, conservation, and mining (Kendrick and McKenzie 2001). The Chichester sub-bioregion has 6.5% of its land surface reserved under some form of conservation, and includes a small portion of Western Australia's second-largest conservation area, Karijini National Park, which is located approximately 150 km south-west of the Project. Mungaroona Range Nature Reserve, approximately 100 km to the southwest, is the closest substantial nature reserve to the Project (**Figure 1**).

The Project footprint traverses the Panorama and Strelly pastoral leases and Njamal Native Title Claim area. Land use in the area includes mining and exploration activities and cattle grazing (**Figure 5**). Most of the Project lies on Unallocated Crown Land. The Project is to the east of both the Fortescue Metals Group and BHP Billiton Iron Ore railway corridors (**Figure 1**).

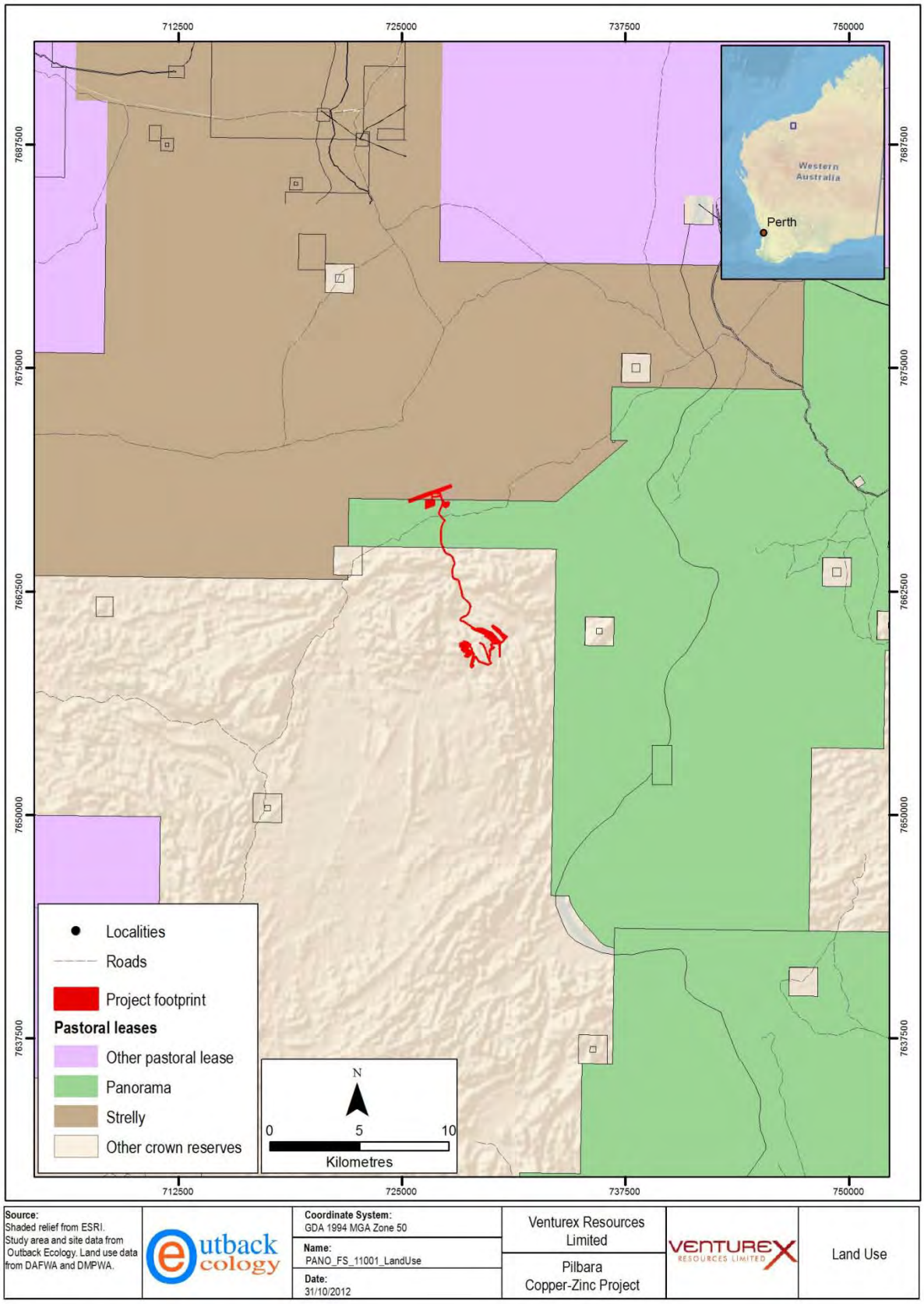

Figure 5: Land use in and surrounding the Project footprint

3. DESKTOP STUDY METHODOLOGY

3.1. Database Searches

Database searches were undertaken to provide a list of mammals, reptiles, amphibians and bird species that have previously been recorded or have the potential to occur within the Study area. The search area consisted of a 75 kilometre buffer around the Study area. Database searches are described in detail in Outback Ecology (2012).

3.2. Literature Review

Presence of fauna species recorded in regional summary documents was considered. A review was undertaken of four terrestrial vertebrate fauna surveys conducted within or adjacent to the Study area and 13 studies in the region surrounding the Project. These are described in detail in Outback Ecology (2012).

3.3. Reconnaissance Survey

A reconnaissance survey was undertaken to ground truth the occurrence of fauna habitat within the Study area, specifically focussing on habitat for the Northern Quoll (*Dasyurus hallucatus*) and habitat for conservation significant bats (*Rhinonicteris aurantia* and *Macroderma gigas*). Several methods were used to address this objective including targeted searching and opportunistic recording (Outback Ecology 2012).

4. RESULTS AND DISCUSSION

4.1. Fauna Habitats Present Within The Impact Area

Five broad fauna habitats relevant to vertebrates were identified in the Project footprint. Identification was based on location, landform, substrate, vegetation community, degree of disturbance (eg. mining, fire) and the fauna habitat which they offer (**Table 3, Figure 6**):

- Spinifex Stony Plains;
- Rocky Foothills;
- Scree Slope;
- Drainage Line; and
- Rocky Ridges and Gorges.

All habitat types are considered typical of the Pilbara bioregion. They are varied in their potential to support vertebrate assemblages and conservation significant species. Of the habitat types observed, Spinifex Stony Plains, Rocky Foothills and Scree Slope are considered widespread in the landscape. Although Drainage Line habitat is not extensive in the landscape, it is relatively well connected along its length. Rocky Ridges and Gorges is relatively uncommon habitat within the broader landscape as it is comprised specifically of those hills featuring outcropping ironstone, fallen boulders, caves, overhangs and crevices.

A brief description of each habitat identified, with a focus on the complexity and the quality that each provides for the local fauna assemblages and specific suitability for conservation significant species, is provided in **Section 5.2**.

4.2. Vertebrate Fauna

Database search findings, a review of relevant literature within the surrounding region, and previous surveys in or near the Study area indicated that it is possible that up to 392 terrestrial vertebrate fauna species occur within the Project footprint, including 53 mammals (44 native), 211 birds, 116 reptiles, five fish and seven amphibian species (Outback Ecology 2012). Review of previous surveys conducted within the Study area (Bamford Consulting Ecologists 2001, Biota 2007) suggests that it is possible that up to 151 terrestrial vertebrate fauna species occur within the Study area, including 27 mammals (22 native), 83 birds, 34 reptiles, five fish and two amphibian species.

Table 2: Extent of fauna habitats within the Project footprint and Study area

Broad fauna habitat type	Regional context	Conservation Significant Species that may be Supported	Area in Project Footprint	Extent in Study Area
Spinifex Stony Plain	Widespread throughout the surrounding landscape. Well represented in the region.	• Spectacled Hare-wallaby • Brush-tailed Mulgara • Australian Bustard • Bush Stone-curlew • Rainbow Bee-eater • Western Pebble-mound Mouse	69.5 ha (39.0%)	2,689 ha
Rocky Foothills	Widespread throughout the surrounding landscape. Well represented in the region.	• Australian Bustard • Bush Stone-curlew • Western Pebble-mound Mouse	56.9 ha (31.9%)	2,487 ha
Scree Slopes	Widespread throughout the surrounding landscape. Well represented in the region.	• Australian Bustard • Rainbow Bee-eater • Western Pebble-mound Mouse	48.9 ha (27.4%)	1,416 ha
Drainage Line	Limited in the surrounding landscape but well connected. Well represented in the region.	• Northern Quoll • Australian Bustard • Bush Stone-curlew	2.5 ha (1.4%)	215 ha
Rocky Ridges and Gorges	Limited in the surrounding landscape. Poorly connected. Well represented in the region.	• Northern Quoll • Pilbara Olive Python • Pilbara Leaf-nosed Bat • Ghost Bat	0.4 ha (0.25%)	211 ha

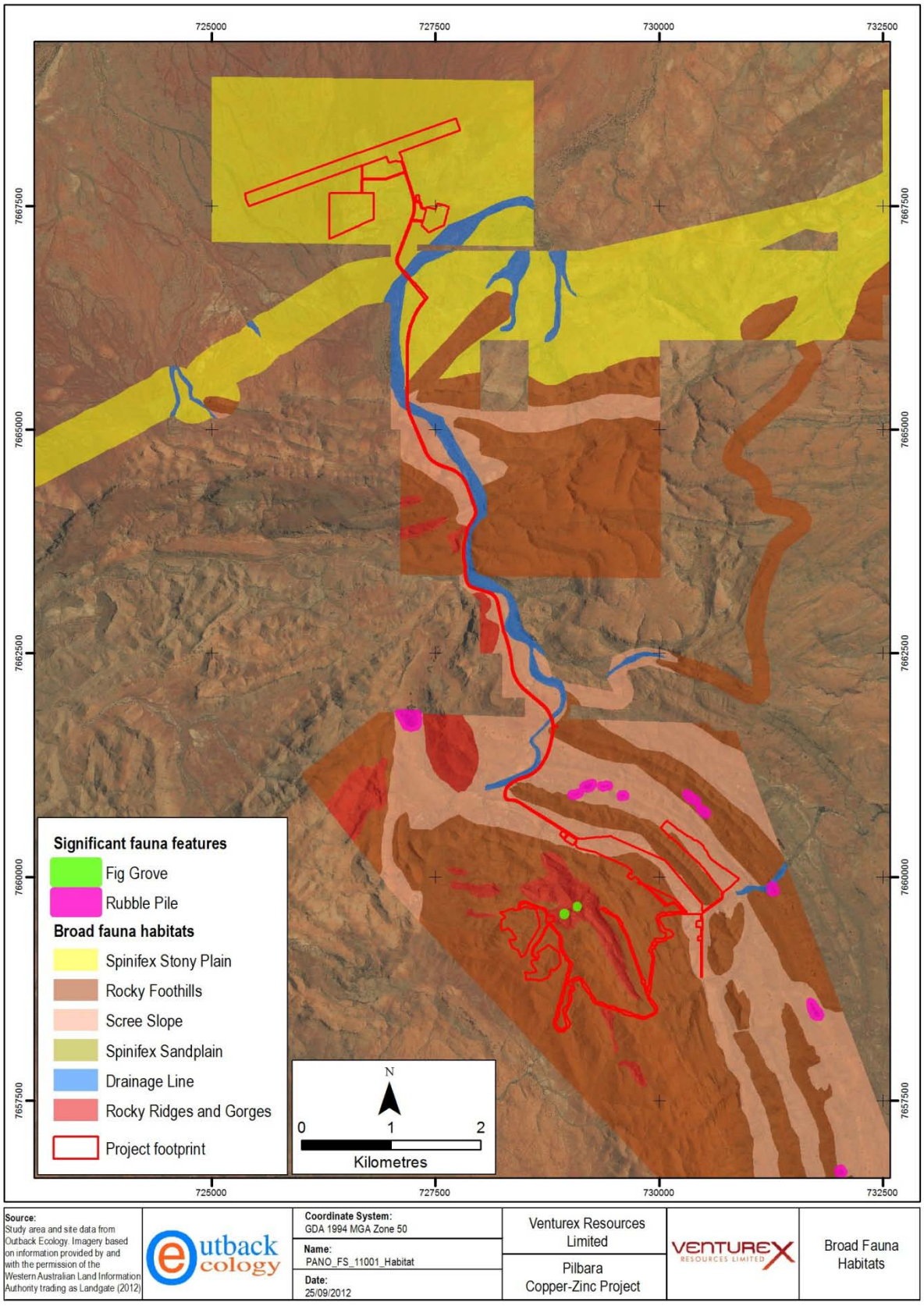

Figure 6: Habitat types present in the Project footprint and Outback Ecology (2012) Study area

4.3. Species Of Conservation Significance

The conservation significance of terrestrial vertebrate fauna potentially occurring within the Project footprint is described in the following sections, including:

- Threatened fauna species (as defined under the *Environment Protection and Biodiversity Conservation Act 1999 (Cth)* (EPBC Act) or the *Wildlife Conservation Act 1950 (WA)* (WC Act) (**Section 4.3.1**);
- Priority fauna recognised by WA Department of Environment and Conservation (DEC) (**Section 4.3.2**);
- 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 4.3.3**).

In the following sections, the likelihood of conservation significant fauna occurring within the Project footprint has been ranked using the following definitions:

Confirmed - presence in Study area recorded unambiguously during the last ten years (i.e. recent surveys of Project footprint or via database searches).

Very Likely – Project footprint lies within the species' known distribution and contains suitable habitat(s), plus the species generally occurs in suitable habitat and has been recorded nearby in the last 20 years.

Likely – Project footprint lies within the species' known distribution and the species has been recorded nearby in the last 20 years; however, either:

a) contains habitat that is marginally suitable, or only a small area of suitable habitat;

b) the species is generally rare and patchily distributed in suitable habitat.

Possible - Outside chance of occurrence based on:

a) Project footprint is just outside the known distribution; however, contains suitable and sufficient habitat (species may be common, rare, or patchy); or

b) Project footprint lies within the known distribution but species is very rare and/or patchily distributed; or

c) Project footprint lies on the edge or within the known distribution and has suitable habitat, but the species has not been recorded in the area for over 20 years.

Unlikely – Project footprint lies outside the species known distribution, does not contain suitable habitat and the species has not been recorded in the area for over 20 years.