

Fauna Assessment Nyidinghu Iron Ore Project



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22nd January 2012

Executive summary

Background

Fortescue Metals Group Limited (Fortescue) proposes to develop the Nyidinghu Iron Ore Project on Exploration Tenements E47/2390 and E47/1320, and Mining Tenement M47/1461. As part of the Environmental Impact Assessment for the project, Bamford Consulting Ecologists (BCE) and Ecoscape Australia were engaged to conduct a Level 2 Fauna Assessment of the vertebrate fauna within the project area, in accordance with Environment Protection Authority (EPA, Western Australia) Guidance Statement No. 56 (EPA 2004) and EPA Technical Guide – Terrestrial Vertebrate Fauna Surveys for Environmental Impact Assessment (Hyder *et al.* 2010). The key objectives of fauna assessment are listed below:

- conduct a desktop review to identify the vertebrate fauna assemblage that may occur within the project area and review this with respect to fauna habitats present;
- investigate the likelihood of conservation significant species being present, and locate and record evidence of these;
- identify and describe fauna habitats present, particularly those that are significant or fragile;
- identify general patterns of biodiversity within the project area;
- identify any ecological processes within the project area upon which fauna may depend and with which the proposal may interact;
- identify potential impacts upon fauna; and
- provide management recommendations to minimise impacts.

Study area

The project area of *ca.* 5000 ha is located between the Hamersley Range and the Fortescue Marsh, on Exploration Tenements E47/2390 and E47/1320, and Mining Tenement M47/1461, *ca.* 100 km north-west of Newman and 1100 km north-east of Perth.

Fauna assessment

The fauna assessment included a desktop review and a two phase field survey of the project area. The desktop review involved accessing databases including the Department of Environment and Conservation's (DEC) Naturemap (incorporating the Western Australian Museum's FaunaBase and the DEC Threatened and Priority Fauna Database), Birds Australia's (BA) Atlas Database,

the EPBC Protected Matters Search Tool and the BCE database. An initial field survey (Phase 1) was conducted from 7-17 of April 2011 and involved pitfall, funnel, Elliott and camera (Motion-sensitive cameras) trapping, bird censusing, ultrasonic bat detection (Anabat surveys), head-torching, spotlighting and opportunistic observations. Sampling was carried out at five sites, with one in each of the five main land systems within the project area:

- Divide Land System
- River Land System
- Boolgeeda Land System
- Urandy Land System
- Fan Land System

A second targeted survey (Phase 2) was conducted from 16-24 of June and involved targeted searches for conservation significant fauna. This comprised Elliott, cage and camera trapping for the Northern Quoll; ultrasonic bat detection (Anabat surveys) for Ghost and Pilbara Leaf-nosed Bats; transect searching (on foot) for species such as Bilby and mulgara; and head-torching and spotlighting for any fauna. The trapping component was conducted at three sites within habitats deemed suitable for the Northern Quoll.

Vegetation and substrate associations (VSAs)

Five major VSAs were identified in the project area:

- Shrubs and spinifex on red longitudinal sand-dunes in the west of project area. This VSA occurs within the Divide Land System.
- Open woodland of eucalypts over buffel grass on brown rocky loam bordering the Weeli Wolli Creek. The creekline supports gallery forest of eucalypts over gravel river bed and areas of buffel grass on gravelly loam. This VSA occurs within the River Land System.
- Open low shrubland of mixed acacia over Spinifex on rocky/gravelly lower slopes of hills. This VSA occurs within the Boolgeeda Land System.
- Open low shrubland of mixed acacia over spinifex on red sandy loam plain. This VSA occurs within the Urandy Land System.
- Mulga over buffel grass on red clayey-loam. This VSA occurs within the Fan Land System.

Within the region, these Land Systems are broadly represented and have all experienced similar land-use history of broad-scale pastoralism, with the attendant degradation caused by feral herbivores, and localised mining interests. Most mining has focussed upon the Banded Ironstone Formations (BIF) that comprise the ridges and hills such as the Newman Land System of the Hamersley Ranges. Some Land Systems are recognised as having significant fauna values such as the Fortescue Marsh and surrounds, and deep red sand plains and dune fields of the Divide Land System.

Vertebrate fauna assemblage

The vertebrate fauna assemblage of the project area is expected to be composed of up to 316 species, including: three fish, five amphibian, 104 reptile, 158 bird, 38 native mammal and eight introduced species. The initial field survey recorded 103 species in the project area. This consisted of two fish, two amphibian, 43 reptile, four mammal and 56 bird species. An additional five species (two reptiles and three mammals) were recorded during the second phase of sampling.

Conservation significant species

Twenty-eight species of conservation significance may occur in the project area. Of these, 19 species are listed under state or federal legislation (Conservation Significance level 1; CS1), while nine are listed as Priority (Conservation Significance level 2; CS2) by the Western Australian Department of Environment and Conservation. Six conservation significant species were recorded during the surveys (Pilbara Olive Python (reported by Marillana Station personnel), Fork-tailed Swift, Eastern Great Egret, Peregrine Falcon and Rainbow Bee-eater, all CS1; and Australian Bustard, CS2), but several additional species may be regularly present or resident.

Patterns of distribution and abundance

Trapping and census data at the systematic sampling sites provide measures of abundance with which to compare the fauna habitat types. The vertebrate community structure of each site, however, was found to be unique within the study area by principal components analysis. Species richness and terrestrial biodiversity were lowest at Site 3 (Boolgeeda Land System), probably as a result of low habitat complexity. Site 2 (River Land System) offers some unique habitats for terrestrial vertebrates along the creekline. Similarly, Site 1 (Divide Land System) supports a unique deep sandy soil.

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1 Introduction

1.1 Background

Fortescue Metals Group Limited (Fortescue) proposes to develop the Nyidinghu Iron Ore Project on Exploration Tenements E47/2390 and E47/1320, and Mining Tenement M47/1461. As part of the Environmental Impact Assessment for the project, Bamford Consulting Ecologists (BCE) and Ecoscape Australia were engaged to conduct a Level 2 Fauna Assessment of the vertebrate fauna within the project area, in accordance with Environment Protection Authority (EPA, Western Australia) Guidance Statement No. 56 (EPA 2004) and EPA Technical Guide – Terrestrial Vertebrate Fauna Surveys for Environmental Impact Assessment (Hyder *et al.* 2010). This level of assessment involves a desktop literature study and field surveys to assess the fauna values in the region. This report presents the results of the desktop assessment and field surveys undertaken in April and June 2011 (Phase 1 and Phase 2, respectively). It is intended to provide government agencies with the information needed to assess the significance of impacts under state and government legislation.

Whichever level of investigation is carried out, the impact assessment process effectively has at least two components:

- 1) Values - The identification of fauna values of the site. These include the range of fauna habitats present, the composition of the fauna assemblage including the presence of significant species, and the distribution of that fauna assemblage across the landscape;
- 2) Impacts - The identification of ecological processes that maintain the fauna assemblage and how these processes may interact with the proposed development, and therefore what impact the proposed development may have on the fauna; and

1.2 Study Objectives

The objectives of the fauna studies are based around these stages. The key objectives of the vertebrate fauna assessment are listed below:

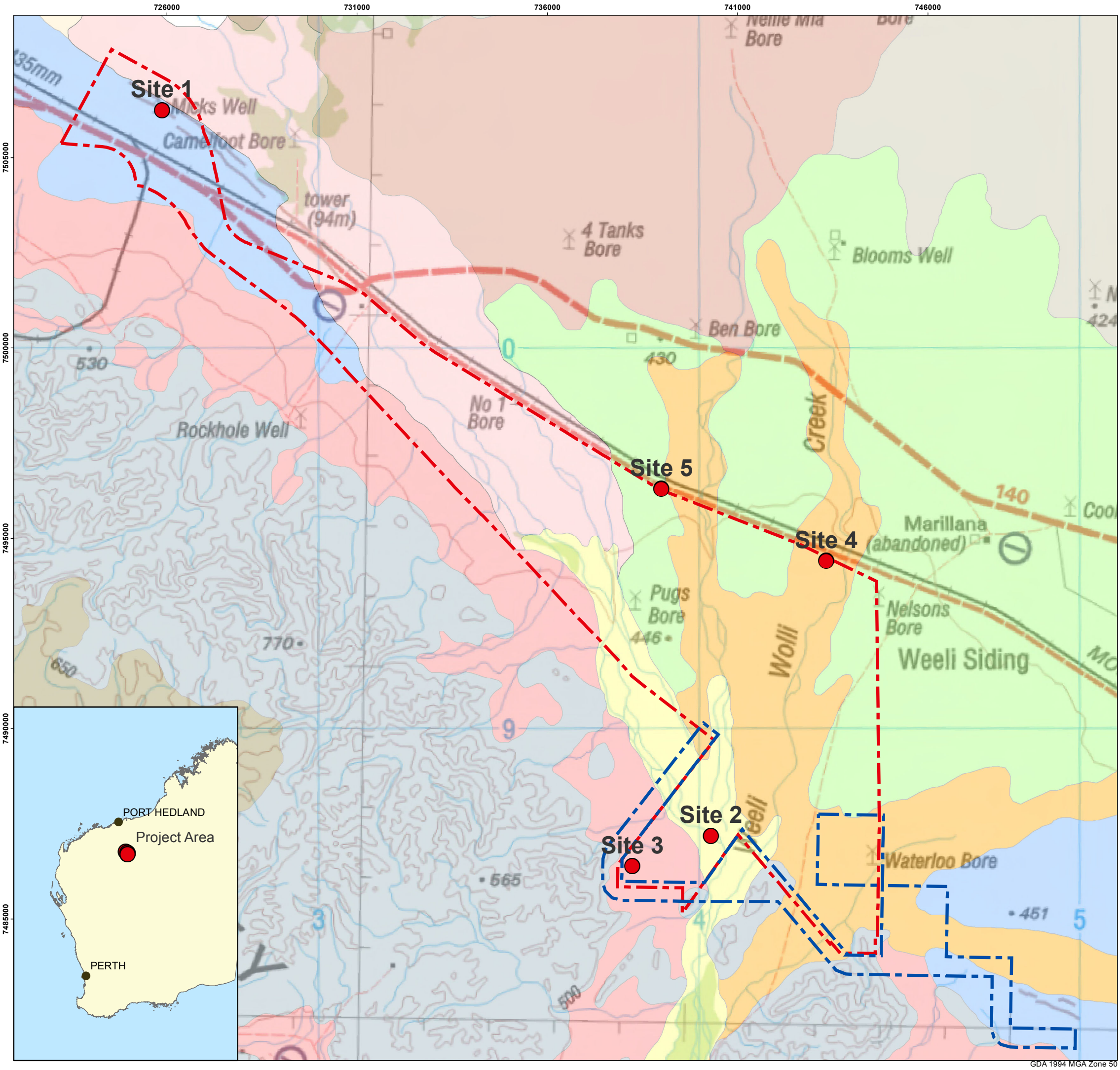
- conduct a desktop review to identify the vertebrate fauna assemblage that may occur within the project area and review this with respect to fauna habitats present;
- investigate the likelihood of conservation significant species being present, and locate and record evidence of these;
- identify, describe and map fauna habitats present, particularly those that are significant, fragile or support conservation significant species;
- identify general patterns of biodiversity within the project area;

- identify any ecological processes within the project area upon which fauna may depend and with which the proposal may interact; and
- identify potential impacts upon fauna.

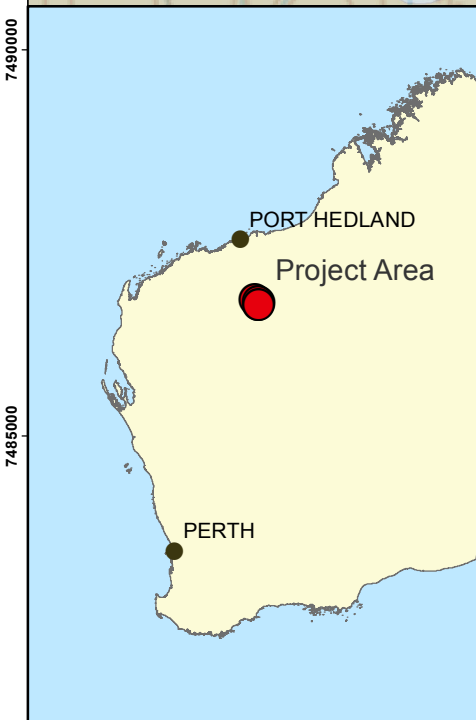
1.3 Location

The project area of *ca.* 5000 ha is located between the Hamersley Range and the Fortescue Marsh, on Exploration Tenements E47/2390 and E47/1320, and Mining Tenement M47/1461, *ca.* 100 km north-west of Newman and 1100 km north-east of Perth. The exploration leases are composed of one largely east-west oriented lease to the north of the Hamersley Range, and one narrow, north-south oriented lease that extends into the Fortescue Marsh (Figure 1).

The desktop review examined databases for fauna records within 40 km of the centre point of these tenements (see Section 2.2.1), and field investigations were carried out in sites across and adjacent to the project area (see Section 2.3). In this report, the entire proposed project area comprising the two exploration leases and the mining lease is referred to as “the project area”; the locations at which field investigations were carried out within and adjacent to the project area are referred to as “survey sites”; the locations at which pitfall traps were operated are referred to as “trapping sites”.



- Legend**
- Site_Locations_Export_Output
 - ▭ Study Boundary
 - ▭ Additional_Investigation_Area_region
- Land Systems**
- Boolgeeda Land System (VSA 3)
 - Calcrete Land System
 - Coolibah Land System
 - Cowra Land System
 - Divide Land System (VSA 1)
 - Fan Land System (VSA 5)
 - Fortescue Land System
 - Jamindie Land System
 - Marillana Land System
 - Newman Land System
 - Platform Land System
 - River Land System (VSA 2)
 - Turee Land System
 - Urandy Land System (VSA 4)



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 DATE: 01-2012 PROJECT NO: 2620-11

**Nyidinghu Terrestrial Vertebrate
 Fauna Survey**
 Fortescue Metals Group Ltd

**Figure 1. Nyidinghu Project
 Area and Major Land Systems**



GDA 1994 MGA Zone 50

1.4 Project Description

In August 2010 Fortescue discovered the Nyidinghu iron ore deposit beneath the thick alluvial cover of Weeli Wolli Creek. It is located about 280 km south of Port Hedland, 35 km south of Fortescue's existing Cloudbreak operations. Fortescue is currently studying the expansion of its Pilbara operations, including development of the Nyidinghu Project.

The Nyidinghu Project scope includes the mining area, processing plant and supporting minesite infrastructure.

1.5 Regional Description

The project area lies within the Fortescue Plains (PIL2) subregion of the Pilbara Bioregion (Figure 2). The regions are described by the Interim Biogeographical Regionalisation for Australia (IBRA) classification system (McKenzie *et al.* 2003; see Figure 2). The Pilbara Bioregion falls within the Bioregion Group 2 classification (EPA 2004). Bioregions within Group 2 have been described as areas of “native vegetation that is largely contiguous but is used for commercial grazing”.

The general features of the Fortescue Plains subregion are summarised by (Kendrick 2001). The subregion has an area of *ca.* 2 041 914 ha, consisting largely of alluvial plains and river frontage, with extensive salt marsh, mulga-bunch grass, and short grass communities. There is a deeply incised gorge system in the western (lower) part of the Fortescue River drainage. The climate of the region is semi-desert tropical, with average rainfall of 300 mm, falling mainly in summer cyclonic events. An extensive calcrete aquifer feeds numerous permanent springs supporting large permanent wetlands with extensive stands of river gum and cadjeput *Melaleuca* woodlands. The dominant land uses in this subregion broad-scale rangelands pastoralism and mining with fewer areas of rural residential, road easements and urban land use.

Kendrick (2001) provides a detailed description of special values and features of the Fortescue Plains subregion with respect to fauna and environments, including endemism, refugia, significant species and important wetlands. All rare features are associated with the Fortescue River, including Millstream Wetlands and Millstream Aquifer and the Fortescue Marsh. Little is known in the subregion concerning short-range endemism (Kendrick 2001), but these sites are almost certainly hotspots of the phenomenon. The region is also known to support primary populations of Bilby (*Macrotis lagotis*), Night Parrot (*Pezoporus occidentalis*) and Pilbara (Orange) Leaf-nosed Bat (*Rhinionictis aurantia*).

Kendrick (2001) notes that 7.75% of the Pilbara IBRA Region is under some form of conservation tenure (reservation class 3). Within the bioregion, PIL2 (Fortescue Plains Subregion) has 0.79% of the land area under conservation management, which is the lowest in the Pilbara. There are two national parks within the Pilbara, Millstream–Chichester National Park and Karijini National Park. Only small portions of the northern margins of Karijini

National Park are within the Fortescue Plains subregion, but the Millstream wetlands of Millstream-Chichester National Park fall within the Fortescue Plains subregion.

As an example of the climate in the vicinity of the proposed Nyidinghu Project, the mean maximum temperature and mean rainfall are presented below for Newman (data from the Australian Bureau of Meteorology).

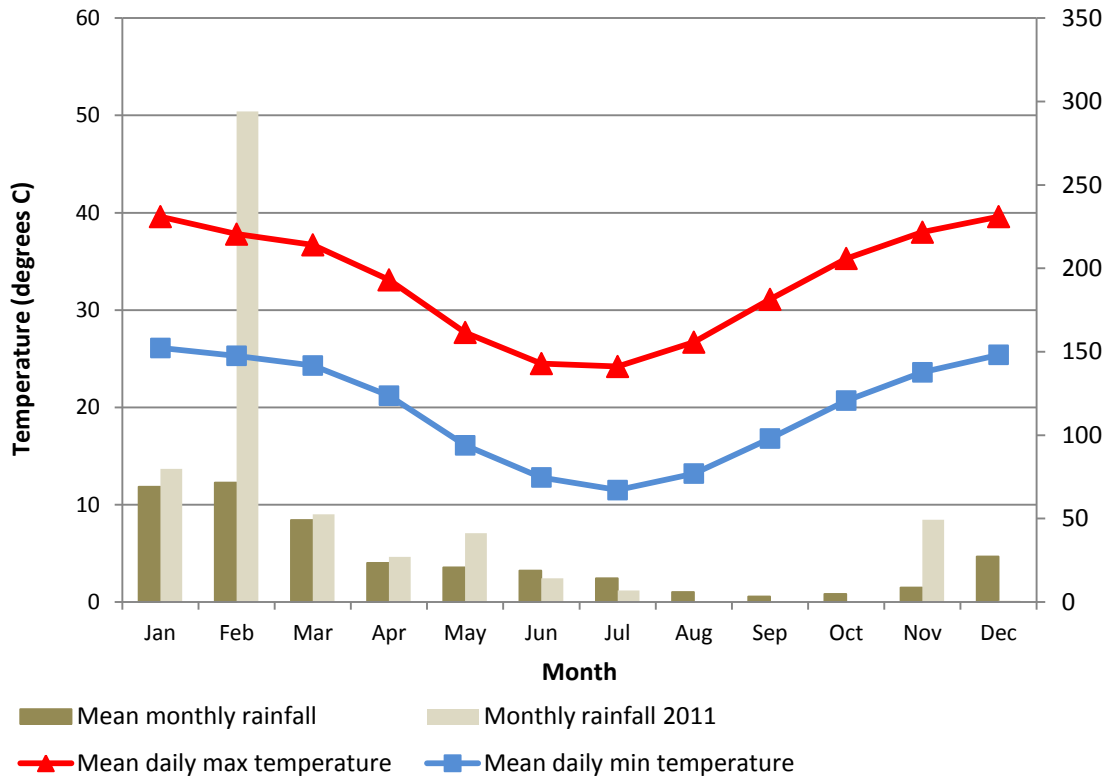




Figure 2. IBRA Subregions in Western Australia.

The project area lies in PIL2: Fortescue.

Personnel

Field work was conducted by:

Phase 1 (Level 2 Vertebrate Fauna Assessment) – 7-17 April 2011

- Dr Mike Bamford (B.Sc. Hons. Ph.D.);
- Dr John Scanlon (B.Sc. Hons. Ph.D.);
- Sarah Smith (B.Sc.);
- Robert Browne-Cooper (B.Sc.);
- Peter Smith (Dip. Ag.);
- Bruce Turner (B.Sc. Hons.);
- Brenden Metcalf (B.Sc. Hons.);
- Simon Cherriman (B.Sc. Hons.); and
- Natalie Randell (B.Sc. Hons.).

Phase 2 (Northern Quoll and other Significant Fauna Targeted Survey) – 16-24 June 2011

- Dr Mike Bamford (B.Sc. Hons. Ph.D.);
- Dr John Scanlon (B.Sc. Hons. Ph.D.);
- Bruce Turner (B.Sc. Hons.);
- Richard Daniel (B.Sc.);
- Brenden Metcalf (B.Sc. Hons.); and
- Claudia McHarrie (B.Sc. Hons.).

This document was prepared by Dr Mike Bamford, Dr Sean Tomlinson (BCE) and Claudia McHarrie (Ecoscape). The report was edited by Jeff Turpin, Dr Mike Bamford and Dr Wes Bancroft (BCE), and Bruce Turner (Ecoscape).

2 Approach and methods

2.1 Overview

The environmental impact assessment process requires the identification of the fauna values of a site, the identification of ecological processes that maintain these values and a discussion of how the proposed development might affect those processes (and therefore impact upon the fauna). The aim is to identify impacts and then develop management recommendations that will mitigate and minimise the deleterious impacts of development upon the fauna within and surrounding the development footprint.

BCE undertook the fauna impact assessment within the guidelines and recommendations set out by the Western Australian EPA on fauna surveys and environmental protection (EPA 2002, 2004). The level of assessment required by the EPA is determined by the size and location of the proposed disturbance, the sensitivity of the surrounding environment in which the disturbance is planned, and the availability of pre-existing data. The Nyidinghu Iron Ore Project area lies within the Fortescue subregion of the Pilbara Bioregion. In this bioregion, for a project of this scale and nature, a Level 2 fauna assessment (reconnaissance and detailed field investigations; EPA 2004) is recommended. Although considerable pre-existing data (from databases and previous surveys) were available, a level 2 assessment was conducted.

The following approach and methods is divided into three groupings that relate to the stages and the objectives of impact assessment:

- Desktop assessment. The purpose of the desktop review is to produce a species list that can be considered to represent the vertebrate fauna assemblage of the project area based on unpublished and published data using a precautionary approach.
- Field investigations. The purpose of the field investigations is to gather information on this assemblage: confirm the presence of as many species as possible (with an emphasis on species of conservation significance), place the list generated by the desktop review into the context of the environment of the project area, collect information on the distribution and abundance of this assemblage in relation to environments present, assess the fauna habitats themselves, and develop an understanding of the project area's ecological processes that maintain the fauna.
- Impact assessment. Determine how the fauna assemblage may be affected by the proposed development based on the interaction of the project with a suite of ecological and threatening processes.

2.2 Desktop assessment

2.2.1 Sources of information

Information on the fauna assemblage of the project area was drawn from a wide range of sources. These included state and federal government databases, the local BCE database and results of regional studies. Databases accessed were the Department of Environment and Conservation's (DEC) Naturemap (incorporating the Western Australian Museum's (WAM) FaunaBase and the DEC Threatened and Priority Fauna Database), Birds Australia's (BA) Atlas Database, the EPBC Protected Matters Search Tool and the BCE database (Table 1). Results were also available from previous fauna surveys in the general area (BCE 2005, 2010, Biota Environmental Science 2005, 2009, 2010, 2011, ecologia 2009, 2010, Ninnox Wildlife Consulting 2009, Western Wildlife 2009).

Information from the above sources was supplemented with species expected in the area based on general patterns of distribution. Sources of information used for these general patterns were: Allen *et al.* (2002) - freshwater fish; Tyler & Doughty (2009) - frogs; Storr *et al.* (1983, 1990, 1999, 2002) and Wilson & Swan (2008) - reptiles; Blakers *et al.* (1984); Johnstone and Storr (1998, 2004) and Barrett *et al.* (2003) - birds; and Strahan (1995, 2004); Menkhorst & Knight (2001); Churchill (2008); and Van Dyck and Strahan (2008) - mammals.

Table 1. Types of records held on database, areas searched and their source location.

Database	Type of records held on database	Area searched
NatureMap (DEC 2011)	Records in the WAM and DEC databases. Includes historical data and records on Threatened and Priority species in WA.	22.76S,119.46E 22.37S,119.13E
Birds Australia Atlas Database	Records of bird observations in Australia, 1998-2010.	One degree square containing 22.58 S, 119.73E
EPBC Protected Matters Search Tool	Records on matters protected under the EPBC Act, including threatened species and conservation estate.	22.76S,119.46E 22.37S,119.13E
Bamford Consulting Ecologists	Records from a range of other surveys in the region.	Records over radius of <i>ca.</i> 50 km interpreted on the basis of landforms and vegetation type

2.2.2 Nomenclature and taxonomy

As per the recommendations of EPA (2004), the nomenclature and taxonomic order presented in this report are based on the Western Australian Museum's *Checklist of the Vertebrates of Western Australia 2010*. The authorities used for each vertebrate group were: amphibians (Doughty and Maryan 2010a), reptiles (Doughty and Maryan 2010b), birds (Christidis and Boles 2008), and mammals (How *et al.* 2009). English names of species, where available, are used throughout the text; Latin species names are presented with corresponding English names in tables in the appendices.

2.2.3 Interpretation of species lists

Species lists generated from the review of sources of information are generous as they include records drawn from a large region and possibly from environments not represented in the project area. Therefore, some species that were returned by one or more of the data searches have been excluded because their ecology, or the environment within the project area, meant that it was

highly unlikely that these species would be present. In general, however, species returned by the desktop review process are considered to be expected in the project area whether or not they were recorded during field surveys; field surveys can only confirm the presence of a proportion of species, and provide information on distribution and abundance. This is because fauna are highly mobile, often seasonal and frequently cryptic. This is particularly important for significant species that are often rare and hard to find.

Interpretation of species lists generated through the desktop review included assigning an expected status within the project area to species of conservation significance. This is particularly important for birds that may naturally be migratory or nomadic, and for some mammals that can also be mobile or irruptive. The status categories used are:

- Resident: species with a population permanently present in the project area;
- Regular migrant or visitor: species that occur within the project area regularly in at least moderate numbers, such as part of annual cycle;
- Irregular Visitor: species that occur within the project area irregularly such as nomadic and irruptive species. The length of time between visitations could be decades but when the species is present, it uses the project area in at least moderate numbers and for some time;
- Vagrant: species that occur within the project area unpredictably, in small numbers and/or for very brief periods. Therefore, the project area is unlikely to be of important for the species; and
- Locally extinct: species that has not been recently recorded in the local area and therefore is almost certainly no longer present in the project area.

2.2.4 Definition of conservation significance

The conservation status of fauna species in Australia is assessed under Commonwealth and State Acts such as the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) and the *Western Australian Wildlife Conservation Act 1950* (Wildlife Conservation Act). In addition, the Western Australian DEC recognises priority levels, while local populations of some species may be significant even if the species as a whole has no formal recognition. Therefore, three broad levels of conservation significance can be recognised and are used for the purposes of this report. A full description of the conservation significance categories, schedules and priority levels mentioned below is provided in Appendix 2. These levels are:

Conservation Significance (CS) 1: Species listed under State or Commonwealth Acts.

Species listed under the EPBC Act are assigned to categories recommended by the International Union for the Conservation of Nature and Natural Resources (IUCN) and reviewed by Mace and Stuart (1994), or are listed as migratory. Migratory species are recognised under international

treaties such as the China Australia Migratory Bird Agreement (CAMBA), the Japan Australia Migratory Bird Agreement (JAMBA), the Republic of South Korea Australia Migratory Bird Agreement (ROKAMBA), and/or the Bonn Convention (The Convention on the Conservation of Migratory Species of Wild Animals). The Wildlife Conservation Act uses a series of Schedules to classify status, but also recognizes the IUCN categories.

Conservation Significance (CS) 2: Species listed as Priority by the DEC but not listed under State or Commonwealth Acts.

In Western Australia, the DEC has produced a supplementary list of Priority Fauna, being species that are not considered threatened under the Wildlife Conservation Act but for which the DEC feels there is cause for concern. Some Priority species are also assigned to the Conservation Dependent category of the IUCN.

Conservation Significance (CS) 3: Species not listed under Acts or in publications, but considered of at least local significance because of their pattern of distribution.

This level of significance has no legislative or published recognition and is based on interpretation of distribution information, but is used here as it may have links to preserving biodiversity at the genetic level (EPA 2002). If a population is isolated but a subset of a widespread (common) species, then it may not be recognised as threatened, but may have unique genetic characteristics. Conservation significance is applied to allow for the preservation of genetic richness at a population level, and not just at a species level. Species on the edge of their range, or that are sensitive to impacts such as habitat fragmentation, may also be classed as CS3, as may colonies of waterbirds. The Western Australian Department of Environmental Protection, now DEC (2000), used this sort of interpretation to identify significant bird species in the Perth metropolitan area as part of the Perth Bushplan.

In addition to these conservation levels, species that have been introduced (INT) are indicated throughout the report. Introduced species may be important to the native fauna assemblage through effects by predation and/or competition.

2.2.5 Definition of vegetation and substrate associations

Vegetation and Substrate Associations (VSAs) were assessed during the desktop and as part of the field investigations. VSAs combine broad vegetation types, the soils or other substrate with which they are associated, and the landform. This information is supplemented for the Pilbara by a Land Systems Analysis (van Vreeswyk *et al.* 2004) that provides information on the regional distribution, abundance and management of these VSAs. In the context of fauna assessment, VSAs are the environments that provide habitats for fauna. The term habitat is

widely used in this context, but by definition an animal's habitat is the environment that it utilises (Calver *et al.* 2009), not the environment as a whole. Habitat is a function of the animal and its ecology, rather than being a function of the environment. For example, a species may occur in eucalypt canopy or in leaf-litter on sand, and that habitat may be found in only one or in several VSAs. VSAs are not the same as vegetation types since these may not incorporate soil and landform, and recognise floristics to a degree that VSAs do not. Vegetation types may also not recognise minor but often significant (for fauna) structural differences in the environment. VSAs also do not necessarily correspond with soil types, but may reflect some of these elements.

2.3 Field surveys

Sampling for vertebrate fauna was conducted over two field surveys:

- Phase 1: an initial Level 2 vertebrate fauna assessment (April 2011)
- Phase 2: Northern Quoll and other significant fauna targeted survey (June 2011).

2.3.1 Approach to field surveys

The timing of field surveys was determined by Guidance Statement 56 (EPA 2004). Guidance Statement 56 states:

“fauna and faunal assemblage surveys conducted for baseline information should be multiple surveys conducted in each season appropriate to the bioregion and the faunal group. The most important seasonal activity times for many faunal groups are related to rainfall and temperature. Thus, a survey in the season that follows the time of maximum rainfall is generally the most productive and important survey time. However, in some cases there may also be a need to time surveys according to the seasonal activity patterns of particularly important species (such as Specially Protected Fauna or Priority species) or particular assemblages (e.g. amphibians [and migratory birds])”.

2.3.2 General survey (Phase 1)

The project area was visited from the 7-17 of April 2011. This period is considered a suitable time for maximising trap captures in the north-west of Western Australia (Hyder *et al.*, 2010). Fauna survey techniques are described in the following sections. The main sampling techniques used during the survey were:

- Pitfall traps (assisted with drift-fences);
- Elliott traps;
- Funnel traps;

- Bird censusing;
- Harp traps and ultra-sonic (Anabat) recording for bats;
- Headtorching and spotlighting;
- Motion-sensitive cameras;
- Searching for evidence of conservation significant species; and
- Opportunistic observations and searching.

Locations where sampling was carried out during the Phase 1 field trip are shown on Figure 3.

2.3.2.1 Systematic fauna trapping

Five survey sites were established to sample fauna in locations that were representative of the Land Systems and VSAs within the proposed disturbance area. Coordinates and descriptions of survey sites (and other sampling locations) appear in Appendix 3 and site locations are indicated on Figures 1 and 3. Details of vegetation and soils and photographs at each survey site are given in Section 4.1. General characteristics of each sampling site were:

Site 1 - Shrubs and Spinifex on red longitudinal sand-dunes in west of project area.

Site 2 - Open woodland of eucalypts over buffel grass on brown rocky loam bordering the Weeli Wolli Creek.

Site 3 – Open low shrubland of mixed acacia over Spinifex on rocky/gravelly lower slopes of hills.

Site 4 - Open low shrubland of mixed acacia over spinifex on red sandy loam plain.

Site 5 - Mulga over buffel grass on red clayey-loam.

At each survey site, trapping for small vertebrates involved the following:

- Twenty pitfall traps, each trap consisting of a 20 L bucket, 40 cm deep and with a diameter of 28 cm, with three, one to two metre drift-fences placed in a Y-shape around the trap. The pitfalls were placed at intervals of *ca.* 50 m in either one transect (therefore *ca.* 1 km long) or in two independent transects (therefore each about 500 m long). Pitfall traps were opened for seven consecutive nights in each sampling period. A total of 100 pitfall traps was used giving a total of 700 trap-nights;
- A single funnel trap associated with one drift-fence arm of each pitfall; and
- A single Elliott box trap associated with one drift-fence arm of each pitfall.

2.3.2.2 Bird censusing

Bird censusing was carried out at each survey site by counting all birds within *ca.* 25 m of the line of pitfall traps on each morning when these were checked. Thus, an area of *ca.* 5 ha was surveyed for birds seven times at each of the five survey sites, with each bird survey visit lasting about 45 minutes.

2.3.2.3 Headtorching and spotlighting

Spotlighting from vehicles took place whenever night travel occurred, including when returning from sites after sunset. Spotlighting also took place through Priority areas 2a and 3 on the evening of 13 April (Figure 3). When spotlighting, vehicle speeds were kept low (<20kph) and personnel relied on the headlights as well as hand-held spotlights. Head-torching (two or three personnel on each occasion) took place at Weeli Wolli Creek (8 and 14 April), in gorges near Site 3 (11 April), in Priority area 2b (13 April) and at the Yandi Road crossing of Weeli Wolli Creek (15 April). Approximately 20 person-hours were spent head-torching.

2.3.2.4 Motion-sensitive cameras

Camera trapping was conducted using motion-sensitive cameras (Bushnell Trophycam) that were set as follows (total of 22 camera-nights):

- Site 1. One camera 11-14 April (on a burrow).
- Site 3. Four cameras in gorges 11-14 April. (In areas likely to be used by Northern Quoll. These cameras were baited with universal bait in an attempt to lure Northern Quoll into view).
- Site 5. One camera set on waterhole 14-17 April.
- Weeli Wolli crossing near Site 3. One camera 8-16 April (set on waterhole).
- Yandi Road crossing of Weeli Wolli Creek. One camera 15-16 April.
- Culvert under railway. One camera 13-17 April.

2.3.2.5 Opportunistic surveys

Throughout the survey, observations of fauna were noted when they contributed to the accumulation of information on the fauna of the site. These included such casual observations as birds or reptiles seen while travelling through the site. Opportunistic searching for fauna, such as raking through leaf-litter and turning over logs, was carried out throughout the project area. In addition, significant fauna species identified during the desktop assessment include several that can be found by searching for evidence of their activities (e.g. scats, tracks, diggings, burrows),

and opportunistic observations of these were recorded throughout the survey. More systematic, targeted surveys for significant species were undertaken in the Phase 2 field trip.

Opportunistic surveys included an aerial (helicopter) flight over part of the Fortescue Marshes (focussed on the project area across Marshes as illustrated in Figure 1) on 17 April, during which some waterbird observations were made.

2.3.2.6 Bat surveys

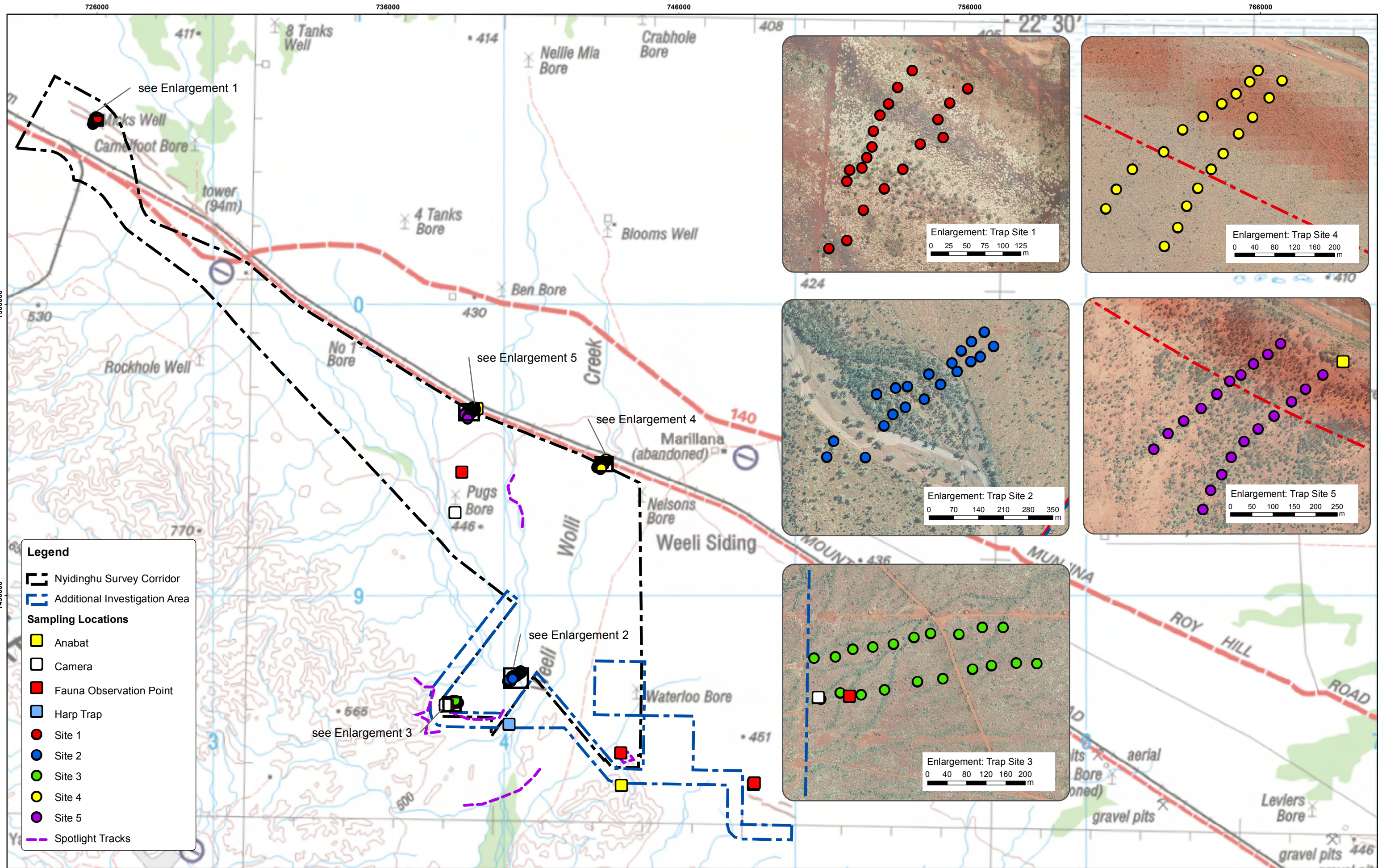
Bats were surveyed during the April field survey using a harp trap and remotely by the recording of echolocation calls. A two-tier harp trap was set from 8-11 April at Weeli Wolli Creek crossing near Site 3 and was checked before sunrise each morning because of husbandry concerns with Pilbara Leaf-nosed Bats being held into daylight. The recording of echo-location calls were made using ANABAT SD series (Titley Electronics, Ballina, NSW) detectors, set to divide by 16 or 32, in conjunction with a Professional PCM Recorder (LS series, Olympus, Japan). Recording units were set at:

Weeli Wolli Creek crossing near Site 3.	One unit each night 8-11 April, 14 April.
Site 5.	One unit on night of 14 April.
The Yandi Road crossing of Weeli Wolli Creek.	Two units on night of 15 April.

Thus, there were eight unit-nights of recording across three locations. Analysis of recordings was conducted by Mr Bob Bullen of Bat Calls Australia. Methodology was consistent with that suggested by the Australasian Bat Society (2006).

2.3.2.7 Licences

The field surveys were conducted under DEC Regulation 17 licence number SF7962, held in the name of Dr. Mike Bamford.



Nyidinghu Terrestrial Vertebrate Fauna Survey - Phase 1
Figure 3. Vertebrate Trap Sites, Trail Camera, Anabat and Search Locations

Imagery supplied by FMG and base map sourced from Geoscience Australia 1:250,000 digital topographic series

Jan 2012

prepared for Fortescue Metals Group Ltd

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Project No. 2620-11



GDA 1994 MGA Zone 50

2.3.3 Northern Quoll and other significant fauna targeted survey (Phase 2)

2.3.3.1 Northern Quoll

Suitable habitat for the EPBC listed Northern Quoll was identified during the initial phase (Phase 1) of sampling. Therefore, a field survey specifically designed to determine the status of the Northern Quoll within the project area was conducted from 16-24 June 2011.

The Northern Quoll survey was designed in accordance with Commonwealth Northern Quoll survey guidelines (DSEWPaC 2011a, b). Three trap sites were established across the survey area in locations identified as potential Northern Quoll habitat during the Phase 1 survey. Twenty-five cage traps and 55 Elliott traps were installed across the three sites and checked daily, over seven trap-nights.

Trap Site No.	Easting	Northing	Cage Traps	Elliott Traps
1	744519	7484273	6	14
2	741313	7485030	12	27
3	737449	7486434	7	14
Total			25	55
Trap nights (x7)			175	385

Additionally, one motion-sensitive camera was set up at each of Site 1 and Site 2, and two motion cameras were set up at Site 3 (see Figure 4). These were operated for two nights.

2.3.3.2 Other significant fauna

Anabat bat detectors were placed at Sites 1 and 3 for two nights to target Ghost Bats and Pilbara Leaf-nosed Bats.

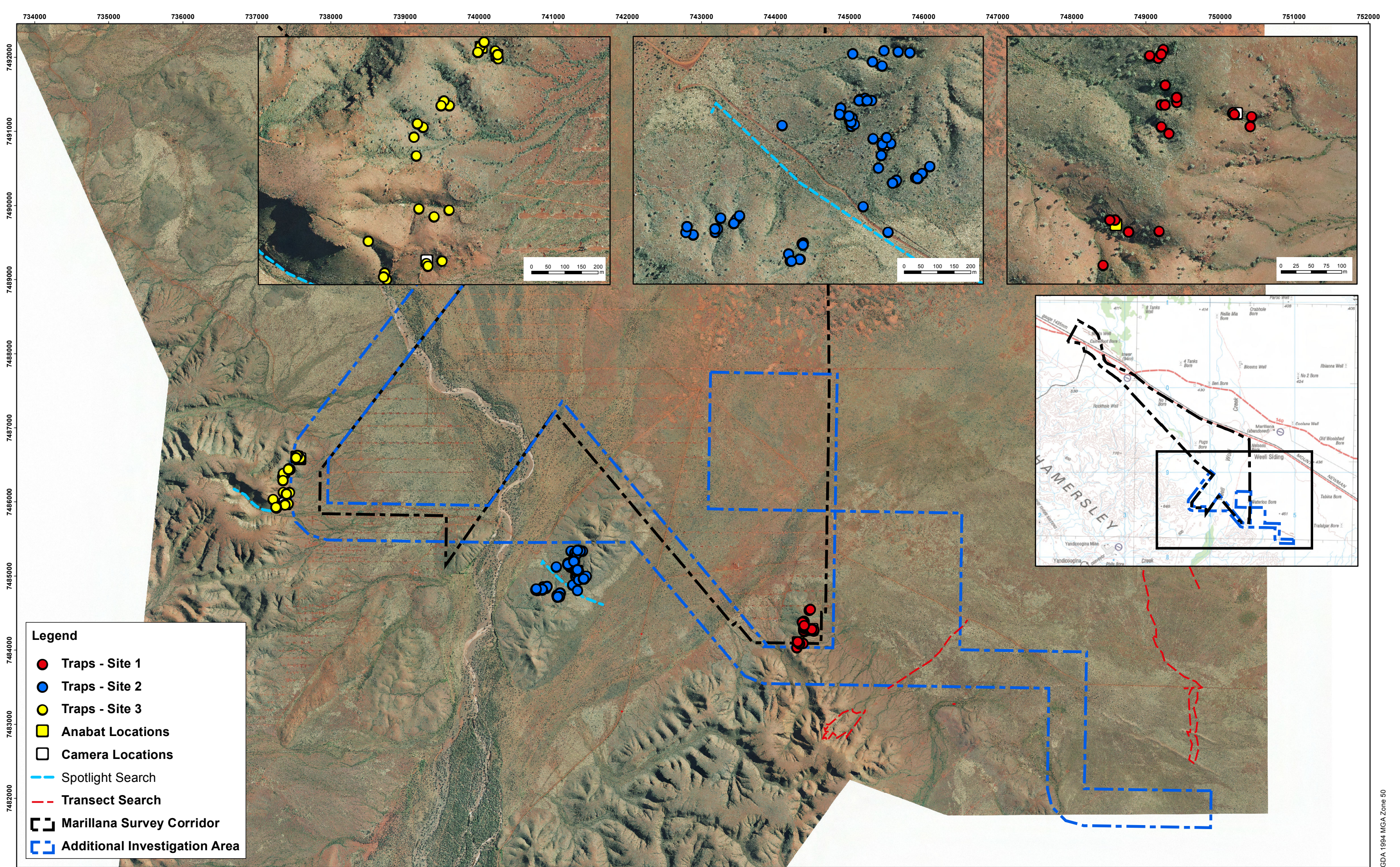
Two transect searches for evidence of conservation significant species (such as burrows/tracks of Bilby and mulgara) were conducted within sand dune and sand plain habitat (see Figure 4). These involved three people spaced approximately 50 m apart for a total length of *ca.* 5 km. Any evidence of conservation significant species was photographed and co-ordinates were recorded.

Searches at night using spotlights were carried out by three personnel on two nights (see Figure 3). Approximately 30 person-hours were spent searching and spotlighting.

2.3.4 Summary of survey effort from survey Phase 1 and 2

Overall survey effort can be summarised as follows:

Survey Method	Effort		
	Phase 1	Phase 2	Total
Pitfall traps	700 trap-nights	-	700 trap-nights
Funnel traps	700 trap-nights	-	700 trap-nights
Elliott traps	700 trap-nights	385 trap-nights	1085 trap-nights
Cage traps	-	175 trap-nights	175 trap-nights
Bird censusing	35 area (5 ha) surveys	-	35 transect surveys
Head-torching	20 person-hours	30 person-hours	50 person-hours
Spotlighting	several evenings	-	several evenings
Motion-sensitive cameras	22 camera-nights	8 camera-nights	30 camera-nights
Anabat recording	8 unit-nights	4 unit-nights	12 unit-nights
Transect searching (on foot)	-	68 ha	68 ha
Opportunistic observations	at all times	at all times	at all times



Legend

- Traps - Site 1
- Traps - Site 2
- Traps - Site 3
- Anabat Locations
- Camera Locations
- Spotlight Search
- Transect Search
- Marillana Survey Corridor
- Additional Investigation Area

Nyidinghu Terrestrial Vertebrate Fauna Survey - Phase 2
Figure 4. Vertebrate Trap Sites, Trail Camera, Photo, Anabat and Search Locations

2.4 Impact Assessment

Impact assessment requires the interpretation of the fauna values of the project area and how they may be impacted by the proposed development. Therefore, the impact assessment process can be examined under the following headings:

- the assessment of fauna values; and
- processes that impact these values.

2.4.1 Fauna values

Vegetation and soil associations

The definition of VSAs is given in Section 2.2.5 and VSAs in the project area are described in Section 3.1. Impacts may be significant if the VSA is rare, a large proportion of the VSA is affected and/or the VSA supports significant fauna. The disturbance of even small amounts of habitat in a localised area can have significant impacts to fauna if rare or unusual habitats are disturbed. Such disturbances include the clearance of large hollow bearing trees, disturbances to caves, rocky ridges and changes to local hydrology.

Fauna assemblage and distribution

Fauna assemblage and distribution describe the number of species within the project area, their abundance and how they are distributed across the landscape. It includes general fauna and conservation significant fauna. Generally, the fauna assemblage is not distributed evenly across the landscape or even within one vegetation/landform type. There may be zones of high biodiversity such as particular habitats or ecotones (transitions between VSAs). Impacts may be significant if a wide range of species is affected even if most of those species are not significant per se. While some impacts upon fauna are unavoidable and/or are only of a short-term and localised nature, long-term deleterious impacts upon biodiversity are of concern. Information on fauna assemblage and distribution comes from the desktop and field investigations.

Conservation significant fauna

Impacts of the project may be significant if species of conservation significance, or habitat important for such species, are affected. Impacts to populations of conservation significant fauna that already occur at low densities may be significant. Categories of conservation significance are outlined in Section 2.2.4.

Ecological processes

Ecological processes affect and maintain fauna populations in an area and may be very complex; for example, populations are maintained through the dynamic of mortality, survival and recruitment being more or less in balance, and these are affected by a myriad of factors. The dynamics of fauna populations in a project area may be affected by processes such as fire

regime, landscape patterns (such as fragmentation and/or linkage), the presence of feral species and hydrology. Impacts may be significant if processes are altered such that fauna populations are adversely affected, resulting in declines and even localised loss of species.

2.4.2 Threatening processes

Overview

Potential impacts of proposed developments upon fauna values can be related to threatening processes. This is recognised in the literature and under the EPBC Act, in which threatening processes are listed (see Appendix 2). Processes that may impact fauna values with respect to mining are discussed below. Processes specific to the project are discussed in Sections 4 and 5. Rather than being independent of one another, processes are complex and often interrelated. They are the mechanisms by which fauna can be affected by development. Impacts may be significant if large numbers of species or large proportions of populations are affected. Impacting processes are outlined below.

Increased mortality

Increased mortality can occur during project operations; for example from roadkill, animals striking infrastructure and entrapment in trenches. Roadkill has been documented as a cause of population decline for some species (e.g. Dufty 1989, Jones 2000). Increased mortality due to roadkill is often more prevalent in habitats that have been fragmented (Scheick & Jones 1999; Clevenger & Waltho 2000; Jackson & Griffin 2000).

Increased mortality of some common species during development is unavoidable and may not be significant for a population. However, the cumulative impacts of increased mortality of conservation significant species or species that already occur at low densities may have a significant impact on the population.

Loss of habitat affecting population survival

Clearing for a development can lead to habitat loss for a species with a consequent decline in population size. This may be significant if the smaller population has reduced viability. Conservation significant species or species that already occur at low densities may be particularly sensitive to habitat loss affecting population survival.

Loss of habitat leading to population fragmentation

Loss of habitat can affect population movements by limiting movement of individuals throughout the landscape as a result of fragmentation. Obstructions associated with the development, such as roads, pipes and drainage channels, may also affect movement of small,

terrestrial species. Fragmented populations may not be sustainable and may be sensitive to effects such as reduced gene flow.

Species interactions, including predation and competition

Changes in species interactions often occur with development. Introduced species, including the feral Cat, Red Fox and Rabbit have adverse impacts upon native species and development can alter their abundance. In particular, some mammal species are very sensitive to introduced predators and the decline of many mammals in Australia has been linked to predation by the Red Fox, and to a lesser extent the feral Cat (Burbidge & McKenzie 1989). Introduced grazing species, such as the Rabbit, Goat, Camel and domestic livestock, can also degrade habitats and deplete vegetation that may be a food source for other species.

Changes in the abundance of some native species at the expense of others, due to the provision of fresh watering points, can also be a concern. (Harrington 2002) found the presence of artificial fresh water-points in the semi-arid mallee rangelands to influence the abundance and distribution of certain bird species. Common, water-dependent birds were found to out-compete some less common, water-independent species. Over-abundant native herbivores, such as kangaroos, can also adversely affect less abundant native species through competition and displacement.

Hydroecology

Interruptions of hydroecological processes can have major effects because they underpin primary production in ecosystems and there are specific, generally rare habitats that are hydrology-dependent. Fauna may be impacted by potential changes to groundwater level and chemistry and altered flow regime. These changes may alter vegetation across large areas and may lead to habitat degradation or loss. Impacts upon fauna can be widespread and major.

Changes to flow regime across the landscape may alter vegetation and may lead to habitat degradation or loss, affecting fauna. For example, Mulga has a shallow root system and relies on surface sheet flow during flood events. If surface sheet flow is impeded, Mulga can die (Kofoed 1998), which may impact on a range of fauna associated with this vegetation type.

Fire

The role of fire in the Australian environment and its importance to vertebrate fauna has been widely acknowledged (e.g. Gill et al. 1981; Fox 1982; Letnic et al. 2004). Fire is a natural feature of the environment but frequent, extensive fires may adversely impact some fauna, particularly mammals and short-range endemic species. Changes in fire regime, whether to more frequent or less frequent fires, may be significant to some fauna. Impacts of severe fire may be devastating to species already occurring at low densities or to species requiring long unburnt habitats to survive.

Dust, light, noise and vibration

Impacts of dust, light, noise and vibration upon fauna are difficult to predict. Some studies have demonstrated the impact of artificial night lighting on fauna, with lighting affecting fauna behaviour more than noise ((Rich & Longcore 2006)). Effects can include impacts on predator-prey interactions, changes to mating and nesting behaviour, and increased competition and predation within and between invertebrates, frogs, birds and mammals.

Artificial night lighting may also lead to disorientation of migratory birds. Aquatic habitats and open habitats such as grasslands and dunes may be vulnerable to light spill.

2.4.3 Criteria for impact assessment

The severity of impacts on the fauna assemblage and conservation significant fauna can be quantified on the basis of predicted population change (Table 2). Population change can be the result of direct habitat loss and/or impacts upon ecological processes as discussed above.

Table 2. Assessment criteria of impacts upon fauna.

Impact Category	Observed Impact
Negligible	No population decline
Minor	Short-term population decline (recovery after end of project) within project area, no change in viability of conservation status of population
Moderate	Permanent population decline, no change in viability of conservation status of population
Major	Permanent population decline resulting in change in viability or conservation status of population
Critical	Taxon extinction

2.4.4 Limitations of investigations

Guidance Statement 56 (EPA 2004) outlines a number of limitations that may arise during surveying. These survey limitations are discussed in the context of the BCE fauna survey at the project area in Table 3.

Table 3. Survey limitations as outlined by EPA (2004).

EPA Limitation	BCE Comment
Level of survey.	Level 2 (reconnaissance survey, detailed survey and targeted survey). Survey intensity was deemed adequate to identify significant fauna and habitats occurring in the project area.
Competency/experience of the consultant(s) carrying out the survey.	The consultants have had extensive experience in conducting fauna assessments throughout Western Australia, including the Pilbara region.
Scope. (What faunal groups were sampled and were some sampling methods not able to be employed because of constraints?)	Birds, mammals (including bats), reptiles and frogs sampled. No constraints limited sampling.
Proportion of fauna identified, recorded and/or collected.	All vertebrate fauna observed were identified.
Sources of information e.g. previously available information (whether historic or recent) as distinct from new data.	Sources include previous reports on the fauna of the region (BCE); databases (Naturemap, BA, DEC and EPBC).
The proportion of the task achieved and further work which might be needed.	Level 2 Survey complete.
Timing/weather/season/cycle.	Detailed field survey conducted 7-17 of April 2011, and again from 16-24 June 2011. Conditions were generally dry, which may have affected the presence and/or abundance of some species.
Disturbances (e.g. fire, flood, accidental human intervention etc.), which affected results of survey.	No disturbances affected the survey.
Intensity. (In retrospect, was the intensity adequate?)	Survey intensity adequate to record conservation significant fauna and habitats.
Completeness (e.g. was relevant area fully surveyed).	Field survey complete but as noted above, some species not recorded may be present under different conditions. The habitat assessment allows such species to be considered.
Resources (e.g. degree of expertise available in animal identification to taxon level).	All vertebrate species identified to species (and subspecies, where applicable) level. All staff are trained and deemed competent to conduct animal identification to taxon level.
Remoteness and/or access problems.	Vegetation communities surrounding the Fortescue Marsh are remote and difficult to access from the ground, but are at the extreme edge of the proposed disturbance footprint.
Availability of contextual (e.g. biogeographic) information on the region.	Extensive regional information was available and was consulted.

3 Results

3.1 Vegetation and Soil Associations

Five major VSAs were identified during field investigations and were specifically targeted for fauna assessment by establishing survey sites within each during survey Phase 1. The VSAs correspond with the Land Systems as on Figure 3. VSAs and corresponding Land Systems are:

- Shrubs and spinifex on red longitudinal sand-dunes in west of project area (Divide Land System);
- Open woodland of eucalypts over Buffel Grass on brown rocky loam bordering the Weeli Wolli Creek (River Land System);
- Open low shrubland of mixed acacias over spinifex on rocky/gravelly lower slopes of hills (Boolgeeda Land System);
- Open low shrubland of mixed acacia over spinifex on red sandy loam plain (Urandy Land System); and
- Mulga over Buffel Grass on red clayey-loam (Fan Land System).

Descriptions and photographs of each follow (survey site numbers in parenthesis; locations in Figure 3).

Shrubs and spinifex on red longitudinal sand-dunes in west of project area. The site is characterised by the Divide Land System (sandplains and occasional dunes supporting shrubby hard Spinifex grasslands; van Vreeswyk *et al.* 2004). To the north it grades into the Fortescue Land System and the Fortescue Marsh, and to the south it grades into the Boolgeeda and Newman Land Systems of the Hamersley Ranges (Site 1, see Plate 1).



Plate 1. The Divide Land System (Site 1).

Open woodland of eucalypts over Buffel Grass on brown rocky loam bordering the Weeli Wollie Creek. The creekline supports a forest of eucalypts over a gravel river bed and areas of Buffel Grass on gravelly loam. The site is characterised by the River Land System (active flood plains and major rivers supporting grassy eucalypt woodlands, tussock grasslands and soft spinifex grasslands; van Vreeswyk *et al.* 2004). To the east it grades into the Urandy Land System, and to the west it grades into the Boolgeeda and Newman Land Systems of the Hamersley Ranges (Site 2, see Plate 2).



Plate 2. The River Land System (Site 2).

Open low shrubland of mixed acacias over spinifex on rocky/gravelly lower slopes of hills. The site is characterised by the Boolgeeda Land System (stony lower slopes and plains below hill systems supporting hard and soft spinifex grasslands and mulga shrublands; van Vreeswyk *et al.* 2004). To the east it grades into the River Land System of Weeli Wolli Creek, and to the west it grades into the Newman Land System of the Hamersley Ranges (Site 3, see Plate 3).



Plate 3. The Boolgeeda Land System (Site 3).

Open low shrubland of mixed acacia over spinifex on red sandy loam plain. The site is characterised by the Urandy Land System (stony plains, alluvial plains and drainage lines supporting shrubby soft spinifex grasslands; van Vreeswyk *et al.* 2004). It is surrounded by a mosaic of Urandy and Fan Land Systems (Site 4, see Plate 4).



Plate 4. The Urandy Land System (Site 4).

Mulga over Buffel Grass on red clayey-loam. The site is characterised by the Fan Land System (washplains and gilgai plains supporting groved mulga shrublands and minor tussock grasslands; van Vreeswyk *et al.* 2004). It is surrounded by a mosaic of Urandy and Fan Land Systems (Site 5, see Plate 5).



Plate 5. The Fan Land System (Site 5).

Within the region, all these land systems are broadly represented and have all experienced similar land use history of broad-scale pastoralism, with the attendant degradation caused by feral herbivores, and localised mining interests. Most mining has focussed upon the Banded Ironstone Formations (BIF) that comprise the ridges and hills such as the Newman Land System of the Hamersley Ranges. Some Land Systems are recognised as having significant fauna values, however, such as the Fortescue Marsh and surrounds, consisting of extensive lakes and marshlands that may be of international conservation significance for migratory birds and the Night Parrot, and deep red sand plains and dune fields of the Divide Land System, which provide refuge habitats for some conservation significant fauna. Regionally it must be considered that mining has had the most severe cumulative impacts to the BIF hills and ridges, and that these may also constitute a growing conservation and management issue.

3.2 Threatened Ecological Communities

No threatened ecological communities (TECs) were identified within the vicinity of the project area during the desktop review.

At least four DEC priority ecological communities (PECs) occur in the vicinity of the project area:

- Weeli Wolli Spring community (Priority 1);
- Freshwater claypans of the Fortescue Valley (Priority 1);
- Fortescue Marsh (Marsh Land System) (Priority 1); and
- Fortescue Valley Sand Dunes (Priority 3).

3.3 Fauna Assemblage

The composition of vertebrate fauna expected to occur in the region and recorded within the project area is outlined in Table 4. The vertebrate fauna assemblage is expected to be composed of 316 species, including: three fish, five frogs, 104 reptile, 158 bird and 38 native mammal, and eight introduced mammal species. Vertebrate fauna species expected to occur in the region based upon the desktop review and those recorded during field investigations are presented in Appendix 4. Species that were returned from databases but which are unlikely to occur in the project area (including local extinctions) and therefore excluded from the expected species lists are given in Appendix 5. These excluded species are not discussed in this report.

Overall, the assemblage of vertebrate fauna expected to occur reflects the community structure of the Pilbara Region of Western Australia. These include a number of terrestrial fauna that are unique to the region such as the Pilbara Leaf-nosed Bat (*Rhinionicteris aurantia* Pilbara form), the Pilbara Olive Python (*Liasis olivaceus barroni*), *Ramphotyphlops ganei* (a blind snake), and some representatives of northern and arid Australia. As a result, a diverse fauna assemblage is expected to occur across the project area where ranges of species with predominantly Torresian (tropical Australian) and Eyreaen (Inland Australian) distributions overlap.

Twenty-eight species of conservation significance are expected to occur in the region. Of these, 14 bird, four mammal and one reptile species are listed under legislation (conservation significance level CS1), while four bird, four mammal and one reptile species are listed as Priority (CS2) by the DEC. Summary information on conservation significant species is presented in Table 5, with details of conservation significance categories in Appendix 1.

Table 4. Composition of vertebrate fauna expected to occur within the project area and recorded during the survey.

Taxon	Number of species expected	Number recorded	Significant fauna expected	Significant Fauna recorded
Fish	3	2	-	-
Frogs	5	2	0	0
Reptiles	104	52	2	1
Birds	158	86	18	5
Native Mammals	38	17	8	0
Introduced Mammals	8	3	0	0
Total	316	162	28	6

Table 5. Conservation listing of significant fauna species expected to occur in the project area.

Conservation significance categories are defined in Appendix 1. Status categories as defined in Section 2.2.3.

Species	EPBC Act 1999	WA Wildlife Conservation Act 1950-1979	DEC Priority	IUCN
Conservation Significance level 1				
Pilbara Olive Python	<i>Liasis olivaceus barroni</i>	Vulnerable	Schedule 1	
Peregrine Falcon	<i>Falco peregrinus</i>		Schedule 4	
Night Parrot	<i>Pezoporus occidentalis</i>	Endangered	Schedule 1	
Fork-tailed Swift	<i>Apus pacificus</i>	Migratory	Schedule 3	
Rainbow Bee-eater	<i>Merops ornatus</i>	Migratory	Schedule 3	
Migratory waterbirds	10 species (see Appendix 4)	Migratory	Schedule 3	
Northern Quoll	<i>Dasyurus hallucatus</i>	Endangered	Schedule 3	
Crest-tailed Mulgara ¹	<i>Dasyercus cristicauda</i>	Vulnerable	Schedule 1	
Bilby	<i>Macrotis lagotis</i>	Vulnerable	Schedule 1	VU C2a
Pilbara Leaf-nosed Bat	<i>Rhinonictis aurantia</i>	Vulnerable		
Conservation Significance level 2				
blind snake	<i>Ramphotyphlops ganei</i>		Priority 1	
Australian Bustard	<i>Ardeotis australis</i>		Priority 4	
Bush Stone-curlew	<i>Burhinus grallarius</i>		Priority 4	
Grey Falcon	<i>Falco hypoleucos</i>		Priority 4	
Star Finch	<i>Neochmia ruficauda subclaescens</i>		Priority 4	
Western Pebble-mound Mouse	<i>Pseudomys chapmani</i>		Priority 4	
Lakeland Downs Mouse	<i>Leggadina lakedownensis</i>		Priority 4	
Long-tailed Dunnart	<i>Sminthopsis longicaudata</i>		Priority 4	
Ghost Bat	<i>Macroderma gigas</i>		Priority 4	

¹ Note that while two mulgara species are recognised under WA legislation (the Crest-tailed Mulgara and the Brush-tailed Mulgara *Dasyercus blythi*), only the Crest-tailed Mulgara is recognised by SEWPaC and therefore by default, any Mulgara recorded will be considered under the EPBC Act as the Crest-tailed Mulgara.

3.4 Results of Field Investigations

3.4.1 Observations on the recorded vertebrate assemblage

The field investigations in April and June 2011 recorded 162 vertebrate species: two fish, two frogs, 52 reptiles, 86 birds and 20 mammals (including three introduced mammals). A list of the species recorded (by all methods) during the surveys is provided in Appendix 4.

The results of systematic sampling are presented and discussed in Section 3.4.2, and observations on significant species in Section 3.4.3. General observations on the species recorded within each major vertebrate taxon are discussed briefly below:

Freshwater fish

Two species recorded (see Appendix 4), with both present in pools along Weeli Wolli Creek just south of the project area. Weeli Wolli Creek flows through the project area. Both species (and the third species expected but not recorded) are widespread across the Pilbara.

Frogs

Two species (see Appendix 4) were recorded around pools along Weeli Wolli Creek, with *Cyclorana mainii* also caught at some of the trapping sites (Table 6). The three remaining expected frog species are widespread in the Pilbara and, in most cases, across arid and semi-arid Australia.

None of the frog species recorded is of conservation significance.

Reptiles

The total of 52 reptile species recorded (see Appendix 4) in the Phase 1 field survey is among the highest known from surveys conducted by BCE. This appeared to be due to a high numbers of juvenile lizard captures; reflecting a very successful breeding season. The 52 expected species that were not recorded during the Phase 1 survey include many that are associated with rocky landscapes in the Pilbara. This habitat is minimally represented within the project area.

Identification of some reptile specimens was difficult, particularly with small juveniles. Of interest was the presence of two members of the *Lerista bipes* complex (*L. bipes* and *L. labialis*), and three members of the *Lerista muelleri* complex (*L. muelleri*, *L. jacksoni* and *L. amicorum*). It is unusual to catch such a range of these species within the one survey. Identification and separation of these species was based on close examination of key diagnostic features with reference to recent relevant publications (e.g. Smith and Adams 2007).

One conservation significant species, the Pilbara Olive Python (CS1), was anecdotally reported by Marillana Station personnel. The description provided was consistent for the species and this is accepted as a genuine record.

Birds

Birds were abundant in the Phase 1 survey because of favourable seasonal conditions. The total of 86 species recorded is high for a single survey and does not include most of the waterbirds observed on the Fortescue Marshes at too great a distance to be identified. Granivorous birds (pigeons, doves, parrots, finches and button-quails) were very well-represented, while species not recorded include those that may be irregular visitors to the area.

Five species of conservation significance were recorded: Fork-tailed Swift, Eastern Great Egret, Peregrine Falcon, Rainbow Bee-eater (all CS1) and Australian Bustard (CS2).

Mammals

Twenty mammal species were recorded, including three introduced species.

Inactive mounds of one species of conservation significance, the Western Pebble-mound Mouse (CS2), were recorded. The targeted surveys (Phase 2) failed to detect conservation significant mammals such as Northern Quoll, Bilby, mulgara, Ghost Bat and Pilbara Leaf-nosed Bat, but see discussion on these species in section 3.4.3.

3.4.2 Patterns of distribution and abundance

Results of trapping and bird censuses are presented in Tables 6, 7 and 8, and Appendix 6. Trapping and census data at the systematic sampling sites used in the Phase 1 survey provide measures of abundance with which to compare the fauna assemblages of the VSAs.

Site biodiversity and community composition

Table 9 shows a summary of the biodiversity of each trapping site and a summary of the major groups of terrestrial vertebrates trapped there. Three indices of biodiversity are provided: species richness, the Shannon diversity index and the Shannon equitability index (see Krebs 1999 for discussion of these indices). Biodiversity was lowest at Site 3 (Boolgeeda land system), where only 11 taxa (10 reptiles and one mammal, see Table 6) were trapped. This may be due to low habitat complexity, where the gravelly substrate offers little chance of burrows, and the sparse vegetation doesn't offer much auxiliary cover. All other sites supported a similar biodiversity of terrestrial vertebrates.

Principle components analysis (PCA) was used to compare the community composition (i.e. species and their relative abundance) of the five Phase 1 trapping sites. The vertebrate community structure of each site was found to be unique. Only Sites 1 and 4 clustered together (i.e. were similar in their community composition) in

the PCA (Figure 5). The two principal components generated by this analysis account cumulatively for 73.3 % of the community variation between the trapping sites. Principal component 1 was strongly positively correlated with species richness (0.9607), gecko abundance (0.7040), and monitor abundance (0.9150), and strongly negatively correlated with rodent abundance (-0.8856). Principal component 2 was strongly positively correlated with skink abundance (0.7322), and dasyurid abundance (0.7324), and strongly negatively correlated with snake abundance (-0.7514). These components are apparent from examination of Table 6. For example, Site 1 had a high richness of skinks in the genus *Ctenotus*, whereas Site 2 had a high richness of geckoes and *Lerista* spp. In contrast, Site 3 had only one gecko species and no species of *Lerista*.

Bird surveys indicated similar patterns of diversity to the reptile surveys described above. Although Site 3 had the lowest bird species richness, it conversely rated as one of the most evenly diverse sites. This is probably an artefact of the consistent low number of individuals of all species seen at the site. Overall Site 3 should be regarded as the most depauperate of the study sites for birds, while Sites 1, 2 and 5 should be considered to support the most diverse bird communities. However, the high biodiversity at Sites 1 and 5 probably result from short-term high seeding by the grasses at the Sites. Site 2 may perennially support high diversity due to the complexity of the microhabitats at the Site, incorporating creeklines, tree canopies and several structural strata and flora communities for birds to exploit. Table 10 shows the summary species richness and biodiversity values of each census area, and a summary of the major avifaunal groups there.

The bird community structure of each site, however, was found to be unique within the study area by PCA (Figure 5). The two principal components generated by this analysis account cumulatively for 80.2 % of the community variation between the trapping sites. Principal component 1 was strongly positively correlated with parrot species abundance (0.8854), and strongly negatively correlated with biodiversity measures H' (-0.7589) and J' (-0.9310). The abundance of Budgerigars at some sites was probably a factor in this. Principal component 2 was strongly negatively correlated with quail abundance (-0.9053), and passerine abundance (-0.7579).

Fauna habitat and VSAs

Site 2 (River land system) offered some unique habitats for terrestrial vertebrates along the creekline, and this was the only site where tree frogs (*Litoria rubella*) were recorded. Similarly, Site 1 (Divide land system), with a distinctive deep sandy soil, was notable for the abundance of a number of frog and lizard species that burrow extensively.

Some species displayed a strong preference for one site, such as the gecko *Diplodactylus conspicillatus*, with 74 captures at Site 5, compared with just 24 captures at all other sites pooled.

A number of VSAs stand out as important for significant fauna. Important VSAs that are within the project area include the Open low shrubland of mixed acacias over spinifex on rocky/gravelly lower slopes of hills of the Boolgeeda Land System (Western Pebble-mound Mouse associated with gravelly lower slopes of hills), woodland of eucalypts bordering Weeli Wolli Creek (River Land System; several species) and Open low shrubland of mixed acacia over spinifex on red sandy loam plain (Urandy Land System; Bilby if present, Crest-tailed Mulgara).

Table 6. Numbers of terrestrial vertebrates caught at each trapping site (survey Phase 1).

Species	Site				
	1	2	3	4	5
<i>Cyclorana maini</i>	28			1	2
<i>Litoria rubella</i>		1			
<i>Diplodactylus conspicillatus</i>	18	1		3	74
<i>Gehyra purpurescens</i>		2		2	
<i>Gehyra variegata</i>	1	4		3	5
<i>Heteronotia binoei</i>	2	9			
<i>Lucasium stenodactylum</i>	3	4		2	8
<i>Rhynchodeura ornata</i>	12	1		3	11
<i>Strophurus elderi</i>		2		3	
<i>Strophurus jeanae</i>				1	
<i>Strophurus wellingtonae</i>			2		1
<i>Carlia munda</i>					1
<i>Ctenophorus caudicinctus</i>			1		2
<i>Ctenophorus isolepis</i>	18	1	11	41	6
<i>Ctenophorus nuchalis</i>	6		1		2
<i>Amphibolurus longirostris</i>	1	11			2
<i>Pogona minor mitchelli</i>				2	
<i>Ctenotus ariadnae</i>	5		5	6	
<i>Ctenotus duricola</i>			15	1	1
<i>Ctenotus grandis</i>	8			3	
<i>Ctenotus hanloni</i>	6	1	15	35	2
<i>Ctenotus leonhardii</i>	4				
<i>Ctenotus pantherinus</i>	7		1	3	
<i>Ctenotus rutilans</i>	3				5
<i>Ctenotus saxatilis</i>		7	19	8	3
<i>Cyclodomorpus melanops</i>	1				
<i>Eremiscincus richardsoni</i>		2			
<i>Lerista amicorum</i>		6			1
<i>Lerista bipes</i>	27	2			
<i>Lerista jacksoni</i>		1			
<i>Lerista labialis</i>		1			
<i>Lerista muelleri</i>		1			3
<i>Lerista timida</i>					2
<i>Menetia greyii</i>		2		2	4
<i>Varanus acanthurus</i>					1
<i>Varanus eremius</i>	2			3	1

Species	Site				
	1	2	3	4	5
<i>Varanus gouldii</i>				1	1
<i>Varanus panoptes</i>	1				
<i>Varanus tristis</i>		1			
<i>Antaresia perthensis</i>					1
<i>Demansia psammophis</i>					1
<i>Parasuta monachus</i>					2
<i>Pseudechis australis</i>				1	
Number of species	19	20	10	21	25
Number of individuals	153	60	70	124	142
<i>Pseudomys hermansbergensis</i>			2		
<i>Sminthopsis hirtipes</i>	1	1		3	1
<i>Ningauai timealeyi</i>	1				
<i>Dasykaluta rosamondae</i>	1				
Number of species	3	1	1	1	1
Number of individuals	3	1	2	3	1

Table 7. Total numbers of species recorded during daily bird surveys at each trapping site.

Species	Site				
	1	2	3	4	5
Little Button-quail	7	12	4	1	23
Black Kite	1	2			
Black-breasted Buzzard			1		
Brown Goshawk		1			
Collared Sparrowhawk	1	1			
Spotted Harrier		3			
Wedge-tailed Eagle		2			
Whistling Kite	1	2			
Australian Hobby		1		1	
Nankeen Kestrel		1			
Brown Falcon		1	2	1	5
Crested Pigeon	3		6	4	
Diamond Dove	8		6		9
Galah	32	23	2	7	8
Little Corella	1	16			
Cockatiel	145	25		11	78
Australian Ringneck		10			4
Budgerigar	575	366	24	107	172
Horsfield's Bronze-Cuckoo		2			
Pallid Cuckoo	2			3	1
Red-backed Kingfisher		2			
Rainbow Bee-eater		14			
Variegated Fairy-wren	6	6		2	8
White-winged Fairy-wren			3	16	
Chestnut-rumped Thornbill					6
Red-browed Pardalote	1	4	1		
Striated Pardolote		2			
Weebill		17			
Western Gerygone		2			
Black Honeyeater			3		
Brown Honeyeater	2		3		
Grey-headed Honeyeater			5		
Singing Honeyeater	14		1	9	26
White-plumed Honeyeater		25			6
Yellow-throated Miner	2	4			4
Crimson Chat				16	1

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Species	Site				
	1	2	3	4	5
Grey-crowned Babbler		17			
Hooded Robin					3
Red-capped Robin					1
Crested Bellbird				1	
Grey Shrike-thrush		2			
Rufous Whistler		5			19
Magpie Lark	4	6		1	3
Willy Wagtail	2	1		1	16
Black-faced Cuckoo-shrike		3			
White-winged Triller			2		29
Black-faced Woodswallow	9			7	80
Masked Woodswallow					80
Pied Butcherbird	1	3	1	2	5
Little Crow		1			
Torresian Crow		3	1		3
Tree Martin		2			
Singing Bushlark		3		1	4
Spinifexbird			3		
Zebra Finch	102		13	59	193
Mistletoebird		1			
Number of species	21	37	18	19	26
Number of individuals	919	591	81	250	787

Table 8. Numbers of terrestrial vertebrates caught at each trapping site (survey Phase 2).

Species	Site		
	1	2	3
Systematic Trapping			
<i>Pseudantechinus woolleyae</i>			1
<i>Pseudomys desertor</i>		2	1
<i>Zyzomys argus</i>		2	1
Opportunistic Records			
<i>Aspidites melanocephalus</i>	1		
<i>Lucasium wombeyi</i>			1

Table 9. Community structure parameters used for PCA comparison of the terrestrial vertebrate community. S is species richness, H' is the Shannon diversity index and J' is the Shannon equitability index.

Community Structure Parameter		Site				
		1	2	3	4	5
S		22	21	11	22	26
H'		2.54	2.66	1.90	2.21	2.09
J'		0.82	0.87	0.79	0.72	0.64
Frog	Species	1	1	0	1	1
	Individuals	28	1	0	1	2
Dragon	Species	3	2	3	1	4
	Individuals	25	12	13	43	12
Skink	Species	8	9	5	7	8
	Individuals	61	23	55	58	22
Gecko	Species	5	7	1	7	5
	Individuals	36	23	2	17	99
Snake	Species	0	0	0	1	3
	Individuals	0	0	0	1	4
Monitor	Species	2	2	0	2	2
	Individuals	3	1	0	4	3
Dasyurid	Species	3	1	0	1	1
	Individuals	3	1	0	3	1
Rodent	Species	0	0	1	0	0
	Individuals	0	0	2	0	0

Table 10. Community structure parameters used for PCA comparison of the bird community. S is species richness, H' is the Shannon diversity index and J' is the Shannon equitability index.

Community Structure Parameter		Site				
		1	2	3	4	5
S		21	37	18	19	26
H'		1.3063	1.8243	2.3938	1.8643	2.3303
J'		0.429	0.5052	0.8282	0.6331	0.7152
Raptors	Species	2	9	1	1	1
	Individuals	3	14	3	2	5
Quails	Species	1	1	1	1	1
	Individuals	7	12	4	1	23
Parrots	Species	4	5	2	3	4
	Individuals	753	440	26	125	262
Passerines	Species	10	19	11	11	18
	Individuals	156	125	48	122	497

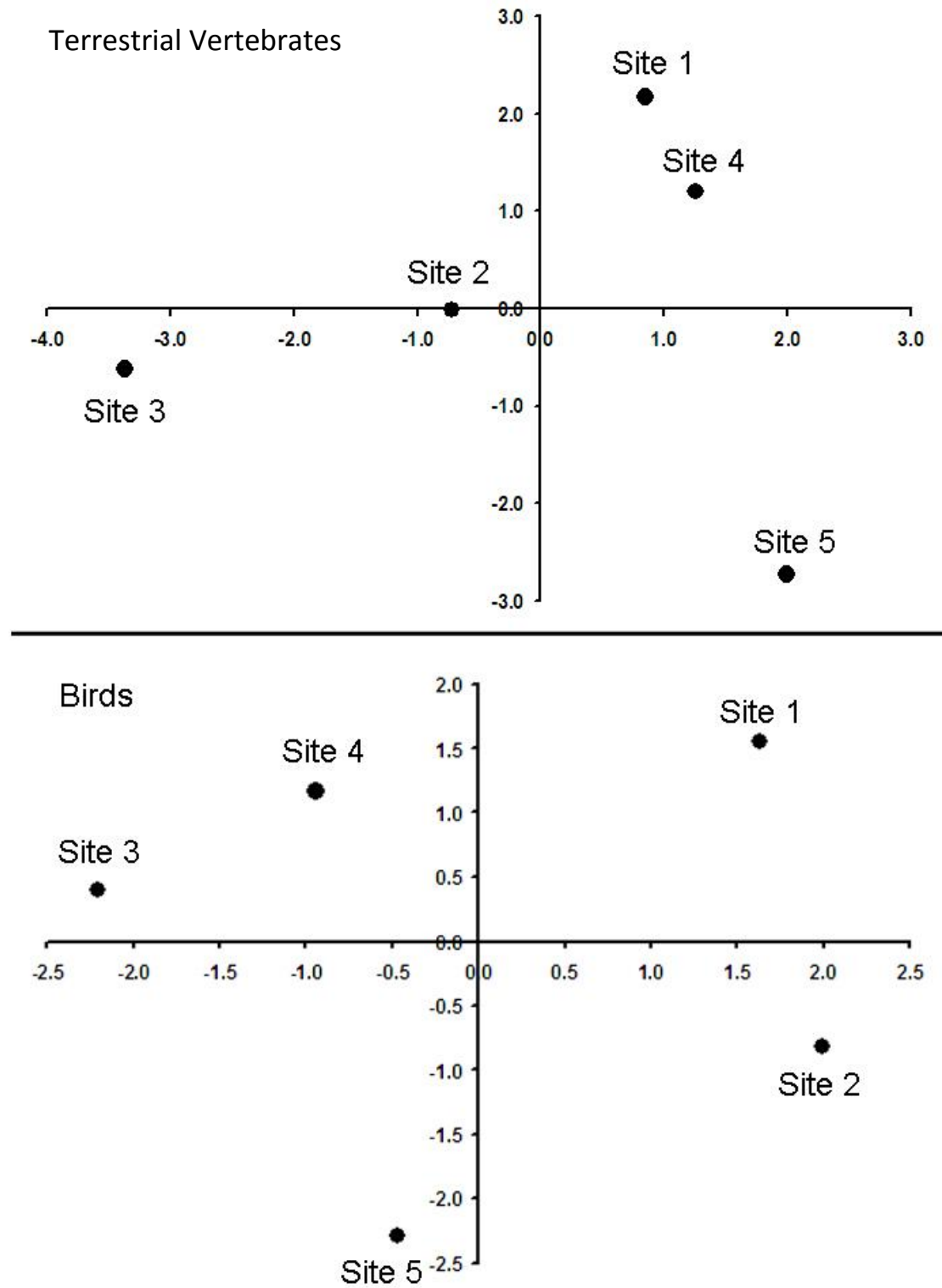


Figure 5. PCA cluster plots of the Nyidinghu survey sites.

3.5 Conservation Significant Species

Of the 28 species of conservation significance expected to occur within the project area (Table 5; also listed in Appendix 4), six species were recorded across the two survey phases:

- CS1 species - Pilbara Olive Python, Fork-tailed Swift, Eastern Great Egret, Peregrine Falcon, Rainbow Bee-eater.
- CS2 species – Australian Bustard.

In addition, inactive mounds of the Western Pebble-mound Mouse were located within the project area.

Conservation significant species can be difficult to detect and may not always be present. Therefore, the predicted status (as defined in Section 2.2.3) of each species of conservation significance that is expected in the project area is presented in Table 11.

Significant species are further discussed below. The potential impacts on significant species are discussed in Section 4 and Table 13.

Conservation Significance Level 1 (CS1) species

Pilbara Olive Python (*Liasis olivaceus barroni*)

This subspecies is restricted to ranges within the Pilbara region and is often recorded near waterholes (Wilson and Swann, 2008). The Pilbara Olive Python has been recorded from the Weeli Wolli Creek area (Naturemap database) and was reported by Marillana Station personnel from sites within the project area. It is therefore expected to be resident along major drainage lines and rocky habitats throughout the project area.

Peregrine Falcon (*Falco peregrinus*)

This species occurs in a variety of habitats, and may breed in the study area, possibly utilising tree hollows in the riverine habitat (ephemeral or permanent) or cliff ledges along gullies and hills (Johnstone and Storr 1998). A pair was recorded over Site 2 (Phase 1) on 8 April 2011. It is expected to be a breeding resident in the project area, with nests either in Riverine trees or nearby cliff-faces. A pair is regularly observed in Mulga woodland on the northern edge of the Fortescue Marshes on Mulga Downs Station (BCE database).

The distribution of the Peregrine Falcon is often tied to the abundance of prey as this species predated heavily on other birds. The Peregrine Falcon lays its eggs in recesses of cliff faces, tree hollows or in large abandoned nests of other birds (Johnstone and Storr 1998). The Peregrine Falcon mates for life with pairs maintaining a home range of about 20 - 30 km² throughout the year. Blakers *et al.* (1984) consider that Australia is one of the strongholds of the species, since it has declined in many other parts of the world.

Night Parrot (*Pezoporus occidentalis*)

This is a poorly-known species with very few recent records. The only recent verified record of this species in the Pilbara was made in 2005 at Minga Well on the northern side of the Fortescue Marsh on Mulga Downs Station (Davis and Metcalf 2008). Little is known of the species' habitat requirements, however many recent records come from spinifex grasslands and chenopod shrublands, although there are also records from Mulga and along rocky breakaways (Higgins 1999). This species is considered a possible resident or regular nomadic visitor within the Fortescue Marsh and its status within the project area is uncertain, but given the nearby recent records it has to be considered at least a possible visitor.

Fork-tailed Swift (*Apus pacificus*)

A small flock (*ca.* 10 birds) of Fork-tailed Swifts was observed over Site 1 (Phase 1) on 8 April 2011. This is a largely aerial species that occurs largely independent of terrestrial habitat types and is likely to be an irregular visitor to the project area.

Rainbow Bee-eater (*Merops ornatus*)

The Rainbow Bee-eater was recorded regularly at Site 2 (Phase 1) in the River Land System, and is expected to be a regular breeding migrant to the project area. It is possibly resident (some northern Australian birds are thought to be non-migratory). Southern Australian populations breed in late September – early October and migrate to northern Australia, Papua New Guinea and eastern Indonesia for the non-breeding season (austral winter; Simpson & Day 2004). It is found in almost any habitat suitable for hawking for insects but is usually restricted to the wetter areas (Johnstone & Storr 1998). Rainbow Bee-eaters breed in a wide variety of sandy habitats across much of the state, from the north Kimberley to the south coast (Johnstone & Storr 1998). Although the Rainbow Bee-eater is listed under the EPBC Act as Migratory, it is a widespread and often opportunistic species.

Migratory waterbirds

Most of the migratory waterbirds listed under the EPBC Act move between northern hemisphere breeding grounds (breeding in the austral winter) and south-east Asia and Australia (in the austral summer). Ten migratory waterbird species have been recorded from the Fortescue Marsh, approximately 25 km north of the project area (see Appendix 4), and one of these (Eastern Great Egret) was recorded during an aerial survey of the Marsh on 17 April 2011 (during the Phase 1 survey). The Eastern Great Egret is not a trans-equatorial migrant, but undertakes long-range movements within Australia and, possibly, to Papua New Guinea and New Zealand.

In years when the marsh contains water, migratory waterbirds are likely to be seasonally present and, in some cases, present in large numbers. Migratory waterbird species are predominantly restricted to wetland environments and are likely to occur only on the marsh and river systems. The Eastern Great Egret will forage along minor watercourses so may regularly visit pools along Weeli Wolli Creek.

Northern Quoll (*Dasyurus hallucatus*)

The status of the Northern Quoll has recently been upgraded to Endangered under the EPBC Act to reflect catastrophic population decline due to poisoning by Cane Toads (*Bufo marinus*). The Northern Quoll is often associated with rocky areas in the Pilbara but also occurs along watercourses. This species formerly occurred across much of northern Australia, from the Pilbara to south-east Queensland, but now only occurs in a number of fragmented populations across its former range (DEWHA, 2010).

The targeted survey (Phase 2) did not detect any evidence of the species within the project area. There are very few confirmed records of the species in the Hamersley Ranges south of the Fortescue Marshes (DEC, 2011), and therefore it may occur only as an occasional visitor in the project area. There was no evidence of resident or substantial populations.

Crest-tailed Mulgara (*Dasyercus cristicauda*)

The Crest-tailed Mulgara prefers mature spinifex grasslands on sandy substrates across the arid zone of Western Australia (Woolley 1995), and could be expected across most of the project area. There is a recent (2011) record from a few kilometres south of Site 3 (BCE database) and the species is expected to be resident in low numbers in the Urandy Land System. There may be a “boom and bust” nature to the lifestyle, with populations contracting to core habitat during difficult times, and expanding rapidly when the conditions improve (Woolley 1995). Further, Woolley (1995) cites examples of local populations disappearing for several years before being repopulated by immigrants in subsequent years.

There has been uncertainty regarding the distribution of the Crest-tailed Mulgara and the similar Brush-tailed Mulgara (*D. blythi*). For most of the last 30 years only the Crest-tailed Mulgara was recognised. More recently, Woolley (2005, 2006) re-assigned the species to the Brush-tailed Mulgara and Crest-tailed Mulgara. The historical taxonomic confusion means that the distribution of the two mulgara species is unclear (Woolley 2005, 2008) and even museum specimens need to be reviewed. However, both species have suffered significant population reduction and fragmentation over the past 80 years (Woolley 2008). The EPBC Act does not recognise the split in this taxon and treats all mulgara as Crest-tailed Mulgara. It is likely, however, that mulgara present in the vicinity of the project area are Brush-tailed Mulgara. The Brush-tailed Mulgara is listed as Priority 4 by the DEC. The approach taken here is that, as a precaution, all mulgara are treated equally (as Crest-tailed Mulgara; Vulnerable) until the EPBC Act is updated.

Bilby (*Macrotis lagotis*)

Once very widespread, the Bilby is now confined to northern and mostly inland locations, particularly sandy deserts where they have an affinity to dunefields (Moseby & O'Donnell 2003) and acacia shrublands associated with paleo-drainage systems (M. Bamford pers. obs.). Johnson (1995) suggested that populations of the species in central Australia are still declining and fragmenting, and (Lavery &

Kirkpatrick (1997) suggest that very small populations may leave traces that incorrectly suggest much larger numbers and healthier populations than is actually the case. There are some historic (early 1980s) records of the Bilby on Marillana Station (N. Dunlop pers. comm.) and it has been recorded on the northern side of the Marshes in the last decade (Bamford 2005). The Bilby is therefore to be a vagrant or occasional visitor in the project area. The Bilby is highly mobile and long-ranging, and may re-establish in areas of suitable habitat at any time.

Pilbara Leaf-nosed Bat (*Rhinonicteris aurantia* Pilbara form)

The Pilbara Leaf-nosed Bat has very specific requirements for roosting caves, which need to provide a stable, hot (28 – 32 °C) and very humid (96 – 100%) environment. Despite no evidence of such caves within the project area, and not being detected in the Anabat surveys, this species is likely to be a foraging visitor to the project area. Transient animals may even roost overnight in crevices and tree hollows.

Conservation Significance Level 2 (CS2) species

Ramphotyphlops ganei (a blind snake)

Only described as a new species in 1998 (Aplin 1998), virtually nothing of the ecology or biology of *R. ganei* is known, although Wilson & Swan (2008) suggested that it may be associated with moist gorges and gullies. The species is known only from a small number of voucher specimens collected from the region (DEC, 2011). This species has also been recorded from ironstone ridge slopes and crests (BCE database). It is considered likely that *R. ganei* is present within the project area but is difficult to detect due to its cryptic nature.

Australian Bustard (*Ardeotis australis*)

Tracks of the Australian Bustard were recorded during both the Phase 1 and Phase 2 surveys, and a road-killed juvenile was found alongside the BHP railway in the Phase 1 survey (April 2011). The species is probably resident in the project area but is likely to vary in abundance seasonally and annually.

Bush Stone-curlew (*Burhinus grallarius*)

In the Pilbara, the Bush Stone-curlew is often associated with woodlands and shrublands along ephemeral or permanent watercourses (M. Bamford pers. obs.). The species is very likely to be resident along Weeli Wolli Creek but is notoriously cryptic when not calling.

Grey Falcon (*Falco hypoleucos*)

The Grey Falcon appears to have a distribution centred around ephemeral or permanent drainage lines and may breed in the lease area, utilising old nests of other species situated in the tallest trees along the river systems (Garnett and Crowley 2000). The Grey Falcon has been recorded in the vicinity of the project area from the

northern side of the Fortescue Marsh (BCE database), and is very likely to be resident along major river systems in the region.

Star Finch (*Neochmia ruficauda subclarescens*)

The western race of the Star Finch is generally found in and around grassland near water (Slater *et al.* 2003; Simpson & Day 2004). It is probably common in the upper reaches of Weeli Wollie Creek south of the project area, but suitable riparian grasslands and rushes are limited in the project area and, therefore, it is expected only as an occasional visitor.

Western Pebble-mound Mouse (*Pseudomys chapmani*)

The Western Pebble-mound Mouse builds characteristic pebble mounds above subterranean burrow systems. It inhabits hummock grassland areas of *Triodia*, *Cassia*, *Acacia* and *Ptilotus* species on skeletal soils containing an abundance of small pebbles (Start & Kitchener 1995). These conditions are most common on spurs and the lower slopes of ridges typical of the Boolgeeda Land System (e.g. Site 3 in the Phase 1 survey) in the study area. A few inactive mounds of the species were recorded in this general location. The mounds did not appear recently active but on this basis it is assumed that the species is present and resident. Active mounds have been found (BCE database 2011) just south of the project area.

Lakeland Downs Mouse (*Leggadina lakedownensis*)

Covacevich (1995) notes that this species is secretive and apparently rare, yet notes that the only two known voucher collections were made at sites where the mice were common enough to be hand-captured. This suggests that the species persists in a “boom-bust” life cycle. Biota (2005) cite a forthcoming publication that states the number of records of the species has increased, and note most of their captures have been made on cracking clays and adjacent habitats in open shrublands and hummock and tussock grasslands. This describes some of the River Land System of Site 2, so the species is expected to be resident (but highly variable in abundance) in this general area.

Long-tailed Dunnart (*Sminthopsis longicaudata*)

Long-tailed Dunnarts occupy scree slopes surrounding rock hills and mesas, but little is known of their biology (Burbidge *et al.* 1995). The species is probably resident in the Boolgeeda Land Systems around Site 3, but may be more common in habitats outside the project area in the Hamersley Ranges. Four specimens from the Pilbara, all from areas in the south of the biogeographical region, have been lodged with the WAM. Current understanding of the breeding biology (Woolley & Valente 1986) suggests that they probably exhibit a “boom-bust” lifestyle.

Ghost Bat (*Macroderma gigas*)

The Ghost Bat formerly occurred over a wide area of central, northern and southern Australia however has declined significantly in the southern parts of its range in the last 200 years (SEWPaC 2010). It now occurs in only a few highly disjunct sites

across northern Australia and in Western Australia is now confined to the Kimberly and Pilbara.

The distribution of Ghost Bats is influenced by the availability of suitable caves and mines for roost sites. The preferred roosting habitats of Ghost Bats in the Pilbara are deep, complex caves beneath bluffs of low rounded hills composed of Marra Mamba geology, Brockman Iron Formations, granite rockpiles and abandoned mines (Armstrong and Anstee, 2000). Churchill (2008) notes that Ghost Bats have a preference for caves with warm and humid microclimates (27°C, 80% humidity).

The Ghost Bat is a carnivorous bat, feeding on large insects, spiders, termites and many types of small vertebrates, including birds, reptiles and other bats (Churchill, 2008). It forages in an area of approximately 60 ha, within a radius of approximately two kilometres from its roost, with up to 20 bats having overlapping ranges (Armstrong and Anstee, 2000). However, Bamford (unpubl data) caught a Ghost Bat (mist-net) flying over the samphire of the Fortescue Marshes probably >5 km from the nearest possible roost.

There is unlikely to be suitable habitat for the species to roost within the project area, but, given the size of its home range, it is likely to be a regular foraging visitor.

Table 11. Status of conservation significant species that are expected to occur in the project area.

Preferred habitat derived from a range of references (Section 2.2.1) and personal experience. See section 2.2.3 for description of expected status categories.

Species	Recorded in project area in this survey	Species' habitat	Species' habitat in project area	Expected status in project area
Conservation Significance Level 1				
Pilbara Olive Python <i>Liasis olivaceus barroni</i>	Yes (Reported by Marillana Station personnel)	Generally associated with riverine woodland areas, gorges and large rock holes and swamps.	Limited suitable habitat along major watercourses	Resident
Peregrine Falcon <i>Falco peregrinus</i>	Yes	Habitat generalist favouring areas with cliffs and abandoned nests in tall, wooded forests.	Extensive; potential nesting habitat in trees along Weeli Wolli Creek	Resident
Night Parrot <i>Pezoporus occidentalis</i>	No	Mature spinifex grasslands and chenopod Shrublands, particularly where the two are closely juxtaposed; also potentially a wide range of other environments (Higgins 1999). Fortescue Marsh is a current hotspot for the species.	Uncertain but suitable habitat probably present	Uncertain; may be cryptic resident or irregular visitor
Fork-tailed Swift <i>Apus pacificus</i>	Yes	Nomadic aerial forager following low pressure storm systems, with no reliable reports of them coming to land.	Extensive	Irregular Visitor
Rainbow Bee-eater <i>Merops ornatus</i>	Yes	Any habitat suitable for hawking for insects. Breeds in a wide variety of sandy habitats.	Extensive	Regular Migrant

Species	Recorded in project area in this survey	Species' habitat	Species' habitat in project area	Expected status in project area
Migratory waterbirds 10 species (see Appendix 4)	One species recorded (Eastern Great Egret)	Wetlands; especially with broad shallows.	Mostly confined to Fortescue Marshes but also some suitable along larger watercourses	Regular migrants to irregular visitors
Northern Quoll <i>Dasyurus hallucatus</i>	No	Rocky and broken country in open Eucalypt forest.	Some suitable habitat	Irregular visitor
Crest-tailed Mulgara <i>Dasyercus cristicauda</i>	Known from nearby areas	Mature Spinifex grasslands on sandy substrates.	Extensive	Resident
Bilby <i>Macrotis lagotis</i>	No	Woodlands and grasslands on sandplains and dunefields, often close to drainage systems.	Extensive	Vagrant
Pilbara Leaf-nosed Bat <i>Rhinioncteris aurantia</i>	No	Roosts in warm humid caves, likely to forage throughout project area	No roosting but some foraging habitat	Regular visitor
Conservation Significance Level 2				
blind snake <i>Ramphotyphlops ganei</i>	No	Uncertain; may prefer moist gorges and gullies or grasslands, Shrublands and woodlands.	Uncertain but some suitable habitat probably present	Resident
Australian Bustard <i>Ardeotis australis</i>	Yes	Open or lightly-wooded grasslands and shrublands.	Extensive	Resident
Bush Stone-curlew <i>Burhinus grallarius</i>	No	Grassy woodlands often along watercourses.	Along Weeli Wolli Creek and minor watercourses	Resident
Grey Falcon <i>Falco hypoleucos</i>	No	Habitat generalist including shrubland, grassland and wooded watercourses.	Extensive; potential nesting habitat along Weeli Wolli Creek	Resident

Species	Recorded in project area in this survey	Species' habitat	Species' habitat in project area	Expected status in project area
Star Finch <i>Neochmia ruficauda subclarescens</i>	No	Grasslands near water.	Limited habitat long larger watercourses	Regular visitor
Western Pebble-mound Mouse <i>Pseudomys chapmani</i>	Inactive mounds recorded, active mounds recorded nearby	Hummock grassland on skeletal soils containing an abundance of small pebbles on spurs and the lower slopes of ridges.	Suitable habitat along the lower slopes of hills	Resident
Lakeland Downs Mouse <i>Leggadina lakedownensis</i>	No	Cracking clays and adjacent habitats in open shrublands and hummock and tussock grasslands.	Some possibly suitable habitat.	Resident
Long-tailed Dunnart <i>Sminthopsis longicaudata</i>	No	Scree slopes surrounding rock hills and mesas.	Suitable habitat in the hills.	Likely Resident
Ghost Bat <i>Macroderma gigas</i>	No	Roosts in warm humid caves, likely to forage throughout project area	No roosting but some foraging habitat	Regular visitor

4 Impact Assessment

The impacts of the proposed development are assessed in accordance with Guidance Statement No. 56 (EPA 2004) and with respect to key fauna values (see Section 2.4.1) and impacting processes (see Section 2.4.2). Impacts upon VSAs and significant species are summarised in Tables 12 and 13 respectively, and impacts of the project are summarised in Table 14. Proposed management of impacts is considered in Section 5.

4.1 Loss of Habitat Leading to Population Decline

The proposed Nyidinghu Iron Ore Project lies on land that may be broadly categorised as undeveloped, and has previously been used for rangelands pastoralism. These areas constitute native vegetation that will be affected by the proposed development, and the extent to which these areas will be impacted is uncertain. Since the area is surrounded by similar VSAs and Land Systems that will remain unaffected by this project, the proportional loss of fauna habitats will be low. Some of the VSAs identified, however, such as the red sandplains and dunefields of the Divide Land System and the system along Weeli Wolli Creek, are limited in extent and therefore substantial disturbance could result in population declines. Cumulative impacts also need to be considered. For example, the Boolgeeda Land System is extensively targeted for mining and while generally low in biodiversity, is favoured by the Western Pebble-mound Mouse.

4.2 Loss of Habitat Leading to Population Fragmentation

The majority of the project area lies on contiguous plains and therefore the extent of fragmentation will depend initially upon the amount of vegetation disturbed and the pattern in which this disturbance is undertaken. If small blocks are excised from the surrounding landscape without disruption, then the impact will be low. If the landscape is disturbed in a mosaic pattern then the impact will be high. The effectiveness of rehabilitation may or may not mitigate these impacts. Fauna of linear landscapes, such as Weeli Wolli Creek and the dunefields in the west, are more sensitive to fragmentation than fauna in broadly-distributed landscapes.

4.3 Increased Mortality

Mortality of fauna during clearing and other operations is inevitable, but ongoing mortality may be significant for larger species that may have low population sizes. The major source of ongoing mortality is likely to be roadkill affecting mammals such as kangaroos, Bilby and mulgara, and larger reptiles such as monitor lizards and snakes (potentially including Pilbara Olive Python). The Australian Bustard is also sensitive to roadkill but individuals are highly mobile and therefore localised mortality is unlikely to have a significant impact.

4.4 Hydrological changes

Changes in hydrology within the landscape may result from the project, particularly where drainage lines are affected. The area of greatest concern is the Fortescue Marsh, but the size of the marsh would suggest that the proportional impact of this development will be negligible. Changes to the Weeli Wolli Creek and the surrounding River Land System may have impacts upon many of the fauna in the project area, since this is quite a restricted land system within the project area.

4.5 Species Interactions, including Predation and Competition

The fauna assemblage in the project area and region includes species sensitive to predation by feral species such as Foxes and feral Cats. In addition, feral species such as the Rabbit can affect rehabilitation. Feral species often increase in abundance due to disturbance and human activities, but the project also provides opportunities for the control of feral species (see management below). For example, pastoralism has undoubtedly affected fauna in the region.

4.6 Dust, Noise, Light and Disturbance

Impacts of dust, light, noise and disturbance upon fauna are difficult to predict, but experience from existing mines in the South-West (Worsley and Alcoa operations), and other operations in the Pilbara (BHPBIO Nimingarra, Cattle Gorge, Sunrise Hill) suggests that fauna, including fauna of conservation significance, are very tolerant of these forms of disturbance. Exceptions include species that have very specific refugial habitat requirements, such as the Pilbara Leaf-nosed Bat and the Ghost Bat, but neither of these species is expected to have major roosts within the project area.

4.7 Changes in Fire Regime

The development is likely to increase the potential for bushfire in the region because of ignition sources from machinery and increased numbers of people. Van Vreeswyk *et al.* (2004) suggested that the Divide, Boolgeeda and Urandy Land Systems are naturally subject to fire, and may be at high risk of increased fire events and intensity as a result of the development. Further to impacts of fire, van Vreeswyk *et al.* (2004) noted that all the land systems identified by BCE as VSAs are subject to increased erosion if the vegetation is removed (either directly or by fire). Changing fire regimes have direct (i.e. loss of individuals) and indirect (i.e. population depression) effects on the fauna of the project area, particularly some conservation significant taxa.

4.8 Summary of impacts

The River and Urandy land systems are likely to be the most impacted due to habitat loss, fragmentation and hydrological change (Table 12). Other land systems are well-represented outside the project area, although may still be sensitive to landscape scale impacts such as hydrological change, altered fire regimes and changes in the abundance of feral species. Cumulative impacts with other mining projects in the region may also need to be considered. Both River and Urandy land systems are locally important for biodiversity and for some significant fauna species.

Among fauna species of conservation significance, impacts on most species are expected to be negligible or minor (Table 13). Species where impacts may be of concern are:

- Pilbara Olive Python – species at low population density, restricted in habitat selection and sensitive to roadkill.
- Crest-tailed Mulgara – species present and sensitive to a range of impacting processes such as altered fire regimes, habitat loss and feral predators.
- Bush Stone-curlew – species at low population density and sensitive to roadkill and feral predators.

Of the impacting processes, concerns can be summarised as follows:

- Loss of habitat leading to population decline – possibly some concern in the River and Urandy land systems. Cumulative impacts with other mining in the region need to be considered.
- Loss of habitat leading to population fragmentation – may be a concern along River and Divide land systems as these are linear and development may lead to fragmentation and disrupt fauna movement.
- Increased mortality – of concern for some fauna species, especially Pilbara Olive Python and Bush Stone-curlew.
- Hydrological changes – may be effects along the River land system but potentially on other systems where groundwater may be affected.
- Species Interactions – such interactions are already occurring. There is potential for both negative and positive impacts from the proposed development upon feral species.
- Dust, noise, light and disturbance – impacts uncertain but some precautions are advised.
- Changes in fire regime – a major ecological factor in the region's fauna with potential for both negative and positive impacts from the proposed development.

Table 12. Potential impacts and significance of VSAs.

VSA	Representation	Conservation Significance	Possible Impacts	Significance of Impact
Shrubs and spinifex on red longitudinal sand-dunes Divide Land System	Moderately widespread in region, and the majority in good condition. Within the project area mostly confined to the extreme west	Supports a rich fauna and provides potential core habitat for several conservation significant fauna, particularly Bilby.	Some loss and fragmentation of this VSA.	Minor. VSA is largely outside impact areas. Fragmentation will need management.
Open woodland of eucalypts over Buffel Grass on brown rocky loam River Land System	Restricted in region along watercourses, and the majority is degraded. Within the project area, it is restricted to the Weeli Wolli creekline.	Supports a rich fauna and may provide nesting habitat for several conservation significant birds.	Some loss and fragmentation of this VSA. Possible hydrological disruption.	Moderate. Loss of large trees is to be avoided. Fragmentation and hydrology may require management
Open low shrubland of mixed acacia over Spinifex on rocky/gravelly lower slopes of hills Boolgeeda Land System	Widespread in region (particularly the Hamersley Range), and the majority in good condition. Mostly confined to the southwest of the project area, and extending into the ridges of the Hamersley Ranges outside the project area	Has the most depauperate fauna association within the project area, but with some habitat specialist conservation significant fauna.	Most or all of this VSA is outside impact areas.	Minor as little direct impact.

VSA	Representation	Conservation Significance	Possible Impacts	Significance of Impact
<p>Open low shrubland of mixed acacia over spinifex on red sandy loam plain.</p> <p>Urandy Land System</p>	<p>Patchily distributed regionally, although the majority is in good condition. Covers the majority of the southern end of the project area.</p>	<p>Has a diverse vertebrate fauna and is likely to provide core habitat to several conservation significant fauna, including Mulgara, Lakeland Downs Mouse, Australian Bustard and possibly Bilby</p>	<p>Some loss and fragmentation of this VSA.</p>	<p>Moderate. VSA is restricted and patchy outside impact areas, and represents a large component of the proposed development footprint. Fragmentation will need management to restrict impacts on all conservation significant fauna.</p>
<p>Mulga over Buffel Grass on red clayey-loam.</p> <p>Fan Land System</p>	<p>Regionally restricted to a small area north of Newman, and heavily degraded. Occurs in part of the project area but a large section lies outside to the north-east.</p>	<p>Has a diverse vertebrate fauna and is likely to provide core habitat to several conservation significant fauna, including Mulgara, , Lakeland Downs Mouse, Australian Bustard and possibly Bilby</p>	<p>Some loss and fragmentation of this VSA.</p>	<p>Minor. VSA is well-represented outside project area. Fragmentation will need management to restrict impacts on conservation significant fauna.</p>

Table 13. Potential impacts on species of conservation significance expected to occur in the project area. Details on the status and habitat of each species in the project area are given in Table 10.

Potential impacts include threatening processes as listed in Section 2.4.2. Impact assessment criteria as defined in Table 2.

Species		Potential impacts	Impact Assessment
Conservation Significance level 1			
Pilbara Olive Python	<i>Liasis olivaceus barroni</i>	Some loss and fragmentation of habitat. Potential roadkill.	Minor (to moderate?). Most suitable habitat is outside project area.
Peregrine Falcon	<i>Falco peregrinus</i>	Low possibility of loss of a nest site.	Negligible
Night Parrot	<i>Pezoporus occidentalis</i>	Possibly some loss of habitat	Minor Status of species in project area is not known, but it is present in the region and there are some records of it making use of habitat types represented in the project area.
Fork-tailed Swift	<i>Apus pacificus</i>	None as mainly aerial species.	Negligible
Rainbow Bee-eater	<i>Merops ornatus</i>	Some localised loss of breeding habitat.	Minor. Species very widespread.
Migratory waterbirds	10 species (see Appendix 4)	Low possibility of hydrological change affecting the Fortescue Marsh.	Minor. Marsh is so extensive that hydrological effects along Weeli Wolli creek unlikely to have an impact on the larger system.
Northern Quoll	<i>Dasyurus hallucatus</i>	Low possibility of some loss of habitat.	Minor. Core habitat is outside the project area and population in region not confirmed.

Species	Potential impacts	Impact Assessment
Crest-tailed Mulgara <i>Dasyercus cristicauda</i>	Likely to suffer impacts of habitat loss and fragmentation, degradation as a result of fire, increased mortality and feral predation.	Moderate. Species has strong affinities to habitats within the project area (e.g. Urandy Land System), and is susceptible to several impacts. A small population (assumed to be this species under current taxonomy) has been confirmed nearby.
Bilby <i>Macrotis lagotis</i>	Impact unlikely as species probably vagrant in project area. If present, could lose some habitat and be affected by roadkill, altered fire regimes and changes in abundance of feral species.	Minor. Species probably vagrant. Fire management and feral control as part of general environmental stewardship could actually benefit species.
Pilbara Leaf-nosed Bat <i>Rhinonictoris aurantia</i>	Some loss of foraging habitat. No roosting habitat recorded or expected in project area.	Minor. Core roosting habitat is outside the project area.
Conservation Significance level 2		
blind snake <i>Ramphotyphlops ganeii</i>	Some loss and fragmentation of habitat.	Minor but status of species in area uncertain.
Australian Bustard <i>Ardeotis australis</i>	Some loss of habitat and possibility of increased mortality on roadsides.	Minor. Species is widespread and versatile in natural and altered habitats.
Bush Stone-curlew <i>Burhinus grallarius</i>	Some loss of breeding habitat and possibility of increased mortality on roadsides. Could also be affected by increased abundance of feral species.	Moderate. Species is widespread but generally in low numbers, so loss of few individuals could be significant.
Grey Falcon <i>Falco hypoleucos</i>	Low possibility of loss of nesting site.	Negligible.
Star Finch <i>Neochmia ruficauda subclarescens</i>	Some loss of habitat.	Minor. Species is widespread and suitable habitat in project area is limited.

Species		Potential impacts	Impact Assessment
Western Pebble-mound Mouse	<i>Pseudomys chapmani</i>	Some loss of habitat.	Minor to moderate. Most habitat is outside the project area but project may contribute to cumulative habitat loss for this species.
Lakeland Downs Mouse	<i>Leggadina lakedownensis</i>	Habitat loss and fragmentation.	Minor to moderate. Species may be associated with VSAs along Weeli Wolli Creek where loss and fragmentation is possible.
Long-tailed Dunnart	<i>Sminthopsis longicaudata</i>	Low possibility of some loss of habitat.	Minor. Core habitat is outside the project area.
Ghost Bat	<i>Macroderma gigas</i>	Some loss of foraging habitat. No roosting habitat expected in project area.	Minor. Core habitat is outside the project area.

Table 14. Summary of potential impacts of the Nyidinghu Iron Ore Proposal on fauna as assessed following the guidance of the EPA's Guidance Statement No. 56.

Factor	Scale and Nature of Impact (EPA No. 56)	Explanation
Degree of habitat degradation or clearing within the local area or region	Moderate	Some of the VSAs proposed for disturbance are regionally restricted and provide potential core habitat for conservation significant fauna.
Size/scale of proposal/impact	Low	Project is comparatively small.
Rarity of vegetation and landforms	Moderate	The project proposes to disturb the Urandy and Fan Land Systems, which are regionally restricted.
Refugia	Low	Typical refugial habitat (e.g. breakaways and the Fortescue Marsh) is mostly outside project area, but some of the habitats within the project area, such as large trees, may provide important refugia for species.
Fauna protected under international agreements or treaties, Specially Protected or Priority Fauna	Moderate	Project has the potential to adversely affect a few significant species such as the Crest-tailed Mulgara, and possibly also Pilbara Olive Python, Bush Stone-curlew and Bilby.
Size of remnant and condition/intactness of habitat and faunal assemblage	Low	Remnants are mostly large and contiguous within and outside the project area. Fragmentation may have ongoing impacts.
Ecological linkage	Moderate	Many of the conservation significant fauna within the habitats are particularly susceptible to fragmentation impacts.
Heterogeneity or complexity of the habitat and faunal assemblage	Moderate	Within the region, the project area supports a wide range of VSAs, from rocky hills high in the landscape to watercourses and wetlands.

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6 Appendices

Appendix 1. Assessment of Conservation Status. Assessment of Conservation Status.

Categories used in the assessment of conservation status

IUCN categories (based on review by Mace and Stuart 1994) as used for the *Environment Protection and Biodiversity Conservation Act 1999* and the *Western Australian Wildlife Conservation Act 1950*.

Extinct	Taxa not definitely located in the wild during the past 50 years.
Extinct in the Wild	Taxa known to survive only in captivity.
Critically Endangered	Taxa facing an extremely high risk of extinction in the wild in the immediate future.
Endangered	Taxa facing a very high risk of extinction in the wild in the near future.
Vulnerable	Taxa facing a high risk of extinction in the wild in the medium-term future.
Near Threatened	Taxa that risk becoming Vulnerable in the wild.
Conservation Dependent	Taxa whose survival depends upon ongoing conservation measures. Without these measures, a conservation dependent taxon would be classed as Vulnerable or more severely threatened.
Data Deficient (Insufficiently Known)	Taxa suspected of being Rare, Vulnerable or Endangered, but whose true status cannot be determined without more information.
Least Concern.	Taxa that are not Threatened.

Schedules used in the WA Wildlife Conservation Act

Schedule 1	Rare and Likely to become Extinct.
Schedule 2	Extinct.
Schedule 3	Migratory species listed under international treaties.
Schedule 4	Other Specially Protected Fauna

WA Department of Environment and Conservation Priority species (species not listed under the Conservation Act, but for which there is some concern).

Priority 1	Taxa with few, poorly known populations on threatened lands.
Priority 2	Taxa with few, poorly known populations on conservation lands; or taxa with several, poorly known populations not on conservation lands.
Priority 3	Taxa with several, poorly known populations, some on conservation lands.
Priority 4.	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.
Priority 5	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 (IUCN Conservation Dependent).

Appendix 2. Ecological processes.

Ecological processes are processes that maintain ecosystems and biodiversity. They are important for the assessment of impacts of development proposals, because ecological processes make ecosystems sensitive to change. The issue of ecological processes, impacts and conservation of biodiversity has an extensive literature. Following are examples of the sorts of ecological processes that need to be considered.

Ecological processes relevant to the conservation of biodiversity in Australia (Soule *et al.* 2004):

- Critical species interactions (highly interactive species);
- Long distance biological movement;
- Disturbance at local and regional scales;
- Global climate change;
- Hydroecology;
- Coastal zone fluxes;
- Spatially-dependent evolutionary processes (range expansion and gene flow); and
- Geographic and temporal variation of plant productivity across Australia.

Threatening processes (EPBC Act)

Under the EPBC Act (1999), a key threatening process is an ecological interaction that threatens or may threaten the survival, abundance or evolutionary development of a threatened species or ecological community. There are currently 17 key threatening processes listed by the federal Department of the Environment, Water, Heritage and the Arts).

- Competition and land degradation by feral/unmanaged Goats (*Capra hircus*);
- Competition and land degradation by feral Rabbits (*Oryctolagus cuniculus*);
- Dieback caused by the root-rot fungus (*Phytophthora cinnamomi*);
- Incidental catch (bycatch) of Sea Turtles during coastal otter-trawling operations within Australian waters north of 28 degrees South;
- Incidental catch (or bycatch) of seabirds during oceanic longline fishing operations;
- Infection of amphibians with chytrid fungus resulting in chytridiomycosis;
- Injury and fatality to vertebrate marine life caused by ingestion of, or entanglement in, harmful marine debris;
- Land clearance;

- Loss of biodiversity and ecosystem integrity following invasion by the Yellow Crazy Ant (*Anoplolepis gracilipes*) on Christmas Island, Indian Ocean;
- Loss of climatic habitat caused by anthropogenic emissions of greenhouse gases;
- Predation by exotic rats on Australian offshore islands of less than 1000 km² (100,000 ha);
- Predation by feral Cats (*Felis catus*);
- Predation by the European Red Fox (*Vulpes vulpes*);
- Predation, Habitat Degradation, Competition and Disease Transmission by Feral Pigs (*Sus scrofa*);
- Psittacine Circoviral (beak and feather) Disease affecting endangered psittacine species;
- The biological effects, including lethal toxic ingestion, caused by Cane Toads (*Bufo marinus*); and
- The reduction in the biodiversity of Australian native fauna and flora due to the red imported fire ant, *Solenopsis invicta*.

General processes that threaten biodiversity across Australia (The National Land and Water Resources Audit):

- Vegetation clearing;
- Increasing fragmentation, loss of remnants and lack of recruitment;
- Firewood collection;
- Grazing pressure;
- Feral animals;
- Exotic weeds;
- Changed fire regimes;
- Pathogens;
- Changed hydrology—dryland salinity and salt water intrusion;
- Changed hydrology—other such as altered flow regimes affecting riparian vegetation; and
- Pollution.

Appendix 3. GPS coordinates of fauna survey techniques.**Sampling locations (pitfall traps and birds) in the Phase 1 survey (April 2011).**

Land System	Easting	Northing	Land System	Easting	Northing
Site 1			Site 2		
Divide	725865	7506188	River	740599	7487359
Divide	725880	7506204	River	740562	7487320
Divide	725908	7506241	River	740532	7487309
Divide	725940	7506274	River	740494	7487289
Divide	725964	7506302	River	740452	7487248
Divide	725990	7506337	River	740404	7487212
Divide	726022	7506344	River	740353	7487184
Divide	726013	7506371	River	740312	7487158
Divide	726030	7506393	River	740288	7487132
Divide	726058	7506412	River	740238	7487035
Divide	725978	7506439	River	740129	7487043
Divide	725961	7506418	River	740151	7487090
Divide	725942	7506392	River	740267	7487226
Divide	725930	7506375	River	740324	7487245
Divide	725921	7506353	River	740360	7487245
Divide	725922	7506331	River	740419	7487273
Divide	725914	7506316	River	740479	7487314
Divide	725907	7506302	River	740507	7487350
Divide	725892	7506301	River	740534	7487376
Divide	725886	7506284	River	740576	7487395
Site 3			Site 4		
Boolgeeda	737974	7486308	Urandy	743547	7494662
Boolgeeda	738018	7486315	Urandy	743521	7494627
Boolgeeda	738052	7486329	Urandy	743489	7494591
Boolgeeda	738094	7486336	Urandy	743458	7494558
Boolgeeda	738136	7486341	Urandy	743429	7494515

Land System	Easting	Northing
Boolgeeda	738176	7486356
Boolgeeda	738212	7486361
Boolgeeda	738272	7486363
Boolgeeda	738320	7486374
Boolgeeda	738358	7486376
Boolgeeda	737985	7486230
Boolgeeda	738026	7486242
Boolgeeda	738068	7486238
Boolgeeda	738116	7486248
Boolgeeda	738183	7486265
Boolgeeda	738235	7486272
Boolgeeda	738297	7486291
Boolgeeda	738336	7486297
Boolgeeda	738387	7486304
Boolgeeda	738427	7486303
Site 5		
Fan	738946	7496514
Fan	738933	7496488
Fan	738920	7496463
Fan	738913	7496426
Fan	738900	7496389
Fan	738882	7496340
Fan	738859	7496305
Fan	738833	7496265
Fan	738822	7496239
Fan	738798	7496192

Land System	Easting	Northing
Urandy	743405	7494484
Urandy	743379	7494446
Urandy	743356	7494412
Urandy	743337	7494369
Urandy	743314	7494329
Urandy	743502	7494681
Urandy	743486	7494634
Urandy	743457	7494634
Urandy	743427	7494614
Urandy	743391	7494590
Urandy	743351	7494563
Urandy	743313	7494518
Urandy	743249	7494481
Urandy	743217	7494443
Urandy	743196	7494406
Site 5		
Fan	738582	7496327
Fan	738632	7496349
Fan	738674	7496383
Fan	738707	7496400
Fan	738734	7496420
Fan	738776	7496443
Fan	738818	7496469
Fan	738842	7496485
Fan	738873	7496510
Fan	738911	7496541

Appendix 4. Species expected to occur (and those recorded) within the Marillana Nyidinghu Iron Ore project area.

Expected species are based on reviews of the NatureMap (DEC), Birds Australia (B.A.), the EPBC Protected Matters Search Tool (EPBC) databases, the Bamford Consulting Ecologists (BCE) database, and of the broader literature (Lit). Species recorded in the current surveys are indicated under “This survey”. Levels of conservation significance are listed under Status.

Common Name	Species	Conservation Status	B.A.	DEC	EPBC	BCE	Lit	This survey
Freshwater fish								
Pilbara Eel-tailed Catfish	<i>Tandanus hrytlii</i>						x	x
Western Rainbowfish	<i>Melanotaenia australis</i>						x	x
Spangled Grunter	<i>Leiopotherapon unicolor</i>					x	x	
Frogs								
HYLIDAE								
Main's Frog	<i>Cyclorana maini</i>			x		x		x
Waterholding Frog	<i>Cyclorana platycephala</i>					x	x	
Desert Tree Frog	<i>Litoria rubella</i>			x		x		x
MYBATRACHIDAE								
Douglas' Toadlet	<i>Pseudophryne douglasi</i>			x				
Russell's Toadlet	<i>Uperoleia russelli</i>			x				
Birds								
CASUARIIDAE								
Emu	<i>Dromaius novaehollandiae</i>		x	x		x		x
PHASIANIDAE								
Stubble Quail	<i>Coturnix pectoralis</i>					x	x	
Brown Quail	<i>Coturnix ypsilophora</i>					x	x	
ANATIDAE								
Plumed Whistling-Duck	<i>Dendrocygna eytoni</i>		x			x		
Black Swan	<i>Cygnus atratus</i>					x		x
Australian Shelduck	<i>Tadorna tadornoides</i>		x					x
Australian Wood Duck	<i>Chenonetta jubata</i>		x	x×				
Grey Teal	<i>Anas gracilis</i>		x			x		x
Pacific Black Duck	<i>Anas superciliosa</i>		x			x		

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Common Name	Species	Conservation Status	B.A.	DEC	EPBC	BCE	Lit	This survey
Hardhead	<i>Aythya australis</i>		x					
PODICIPEDIDAE								
Australasian Grebe	<i>Tachybaptus novaehollandiae</i>		x	x			x	
Hoary-headed Grebe	<i>Poliiocephalus poliocephalus</i>						x	
COLUMBIDAE								
Common Bronzewing	<i>Phaps chalcoptera</i>		x	x		x		
Crested Pigeon	<i>Ocyphaps lophotes</i>		x	x		x		x
Spinifex Pigeon	<i>Geophaps plumifera</i>		x			x		x
Diamond Dove	<i>Geopelia cuneata</i>		x	x		x		x
Peaceful Dove	<i>Geopelia striata</i>		x	x		x		
PODARGIDAE								
Tawny Frogmouth	<i>Podargus strigoides</i>		x					
EUROSTOPODIDAE								
Spotted Nightjar	<i>Eurostopodus argus</i>		x			x		x
AEGOTHELIDAE								
Australian Owlet-nightjar	<i>Aegotheles cristatus</i>		x					x
APODIDAE								
Fork-tailed Swift	<i>Apus pacificus</i>	CS1			x		x	x
ANHINIGIDAE								
Australasian Darter	<i>Anhinga novaehollandiae</i>		x	x				
PHALACROCORCIDAE								
Little Pied Cormorant	<i>Microcarbo melanoleucos</i>		x			x		
Little Black Cormorant	<i>Phalacrocorax sulcirostris</i>		x			x		
PELECANIDAE								
Australian Pelican	<i>Pelecanus conspicillatus</i>						x	x
CICONIIDAE								
Black-necked Stork	<i>Ephippiorhynchus asiaticus</i>		x					
ARDEIDAE								
White-necked Heron	<i>Ardea pacifica</i>		x	x		x	x	
Eastern Great Egret	<i>Ardea modesta</i>	CS1	x			x	x	x
Cattle Egret	<i>Ardea ibis</i>	CS1			x			

Common Name	Species	Conservation Status	B.A.	DEC	EPBC	BCE	Lit	This survey
White-faced Heron	<i>Egretta novaehollandiae</i>		x			x		x
Little Egret	<i>Egretta garzetta</i>		x					
Nankeen Night-Heron	<i>Nycticorax caledonicus</i>					x	x	
THRESKIORNITHIDAE								
Straw-necked Ibis	<i>Threskiornis spinicollis</i>		x	x		x		x
Royal Spoonbill	<i>Platalea regia</i>		x					
Yellow-billed Spoonbill	<i>Platalea flavipes</i>		x			x		
ACCIPITRIDAE								
Eastern Osprey	<i>Pandion cristatus</i>	CS1						
Black-shouldered Kite	<i>Elanus axillaris</i>						x	
Square-tailed Kite	<i>Lophoictinia isura</i>		x			x		
Black-breasted Buzzard	<i>Hamirostra melanosternon</i>						x	x
White-bellied Sea-Eagle	<i>Haliaeetus leucogaster</i>	CS1				x		
Whistling Kite	<i>Haliastur sphenurus</i>		x	x		x		x
Black Kite	<i>Milvus migrans</i>		x	x				x
Brown Goshawk	<i>Accipiter fasciatus</i>		x	x		x		x
Collared Sparrowhawk	<i>Accipiter cirrocephalus</i>		x			x	x	x
Spotted Harrier	<i>Circus assimilis</i>		x	x		x		x
Wedge-tailed Eagle	<i>Aquila audax</i>		x	x		x		x
Little Eagle	<i>Hieraaetus morphnoides</i>		x	x		x		
FALCONIDAE								
Nankeen Kestrel	<i>Falco cenchroides</i>		x	x		x		x
Brown Falcon	<i>Falco berigora</i>		x	x		x		x
Australian Hobby	<i>Falco longipennis</i>		x	x		x		x
Grey Falcon	<i>Falco hypoleucos</i>					x	x	
Peregrine Falcon	<i>Falco peregrinus</i>	CS1	x			x	x	x
RALLIDAE								
Buff-banded Rail	<i>Gallirallus philippensis</i>		x					
Spotless Crake	<i>Porzana tabuensis</i>					x	x	
OTIDIDAE								
Australian Bustard	<i>Ardeotis australis</i>	CS2	x	x		x	x	x

Common Name	Species	Conservation Status	B.A.	DEC	EPBC	BCE	Lit	This survey
BURHINIDAE								
Bush Stone-curlew	<i>Burhinus grallarius</i>	CS2				X	X	
RECURVIROSTRIDAE								
Black-winged Stilt	<i>Himantopus himantopus</i>			X		X		X
Red-necked Avocet	<i>Recurvirostra novaehollandiae</i>					X		X
CHARADRIDAE								
Red-capped Plover	<i>Charadrius ruficapillus</i>					X	X	
Oriental Plover	<i>Charadrius veredus</i>	CS1					XX	
Black-fronted Dotterel	<i>Elseyaornis melanops</i>		X	X		X		X
Red-kneed Dotterel	<i>Erythrogonys cinctus</i>			X		X		
SCOLOPACIDAE								
Common Sandpiper	<i>Actitis hypoleucos</i>	CS1					X	
Common Greenshank	<i>Tringa nebularia</i>	CS1					X	
Marsh Sandpiper	<i>Tringa stagnatilis</i>	CS1				X	X	
Red-necked Stint	<i>Calidris ruficollis</i>	CS1				X	X	
TURNICIDAE								
Little Button-quail	<i>Turnix velox</i>		X	X		X		X
GLAREOLIDAE								
Oriental Pratincole	<i>Glareola maldivarum</i>	CS1				X	X	
Australian Pratincole	<i>Stiltia isabella</i>					X	X	
LARIDAE								
Gull-billed Tern	<i>Gelochelidon nilotica</i>					X	X	X
Whiskered Tern	<i>Chlidonia hybrida</i>					X		X
CACTUIDAE								
Galah	<i>Eolophus roseicapillus</i>		X	X		X		X
Little Corella	<i>Cacatua sanguinea</i>		X	X		X		X
Cockatiel	<i>Nymphicus hollandicus</i>		X	X		X		X
PSITTACIDAE								
Australian Ringneck	<i>Barnardius zonarius</i>		X	X		X		X
Mulga Parrot	<i>Psephotus varius</i>						X	
Budgerigar	<i>Melopsittacus undulatus</i>		X	X		X		X

Common Name	Species	Conservation Status	B.A.	DEC	EPBC	BCE	Lit	This survey
Bourke's Parrot	<i>Neopsephotus bourkii</i>					X	X	
Elegant Parrot	<i>Neophema elegans</i>					X	X	
Night Parrot	<i>Pezoporus occidentalis</i>	CS1			X	X	X	
CUCULIDAE								
Horsfield's Bronze-Cuckoo	<i>Chalcites basalis</i>		X	X		X		X
Black-eared Cuckoo	<i>Chrysococcyx osculans</i>			X		X		
Pallid Cuckoo	<i>Cacomantis pallidus</i>		X	X		X		X
STRIGIDAE								
Barking Owl	<i>Ninox connivens</i>					X	X	
Southern Boobook	<i>Ninox novaeseelandiae</i>		X	X		X		X
TYTONIDAE								
Eastern Barn Owl	<i>Tyto javanica</i>		X					X
HALCYONIDAE								
Blue-winged Kookaburra	<i>Dacelo leachii</i>		X	X		X		
Red-backed Kingfisher	<i>Todiramphus pyrrhopygia</i>		X	X		X		X
Sacred Kingfisher	<i>Todiramphus sanctus</i>		X	X		X		
MEROPIIDAE								
Rainbow Bee-eater	<i>Merops ornatus</i>	CS1	X	X	X	X	XX	X
CLIMACTERIDAE								
Black-tailed Treecreeper	<i>Climacteris melanura</i>						X	
PTILONORHYNCHIDAE								
Western Bowerbird	<i>Ptilonorhynchus guttatus</i>		X	X				X
MALURIDAE								
Splendid Fairy-wren	<i>Malurus splendens</i>					X	X	
White-winged Fairy-wren	<i>Malurus leucopterus</i>		X	X		X		X
Variegated Fairy-wren	<i>Malurus lamberti</i>		X	X		X		X
Rufous-crowned Emu-wren	<i>Stipiturus ruficeps</i>					X	X	
Striated Grasswren	<i>Amytornis striatus</i>		X	X				
ACANTHIZIDAE								
Redthroat	<i>Pyrrholaemus brunneus</i>		X					
Weebill	<i>Smicromis brevirostris</i>		X			X		X

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Common Name	Species	Conservation Status	B.A.	DEC	EPBC	BCE	Lit	This survey
Western Gerygone	<i>Gerygone fusca</i>		X	X		X		X
Slaty-backed Thornbill	<i>Acanthiza robustirostris</i>					X	X	
Yellow-rumped Thornbill	<i>Acanthiza chrysorrhoa</i>					X	X	
Chestnut-rumped Thornbill	<i>Acanthiza uropygialis</i>		X	X		X		X
Inland Thornbill	<i>Acanthiza apicalis</i>		X			X		
PARDALOTIDAE								
Red-browed Pardalote	<i>Pardalotus rubricatus</i>		X	X		X		X
Striated Pardalote	<i>Pardalotus striatus</i>		X	X		X		
MELIPHAGIDAE								
Pied Honeyeater	<i>Certhionyx variegatus</i>						X	
Singing Honeyeater	<i>Lichenostomus virescens</i>		X	X		X		X
Grey-headed Honeyeater	<i>Lichenostomus keartlandi</i>		X			X		X
White-plumed Honeyeater	<i>Lichenostomus penicillatus</i>		X	X		X		X
White-fronted Honeyeater	<i>Purnella albifrons</i>						X	
Yellow-throated Miner	<i>Manorina flavigula</i>		X	X		X		X
Spiny-cheeked Honeyeater	<i>Acanthagenys rufogularis</i>		X	X		X		X
Grey Honeyeater	<i>Conopophila whitei</i>					X	X	
Crimson Chat	<i>Epthianura tricolor</i>		X	X		X		X
Orange Chat	<i>Epthianura aurifrons</i>					X	X	
Black Honeyeater	<i>Sugomel niger</i>			X				X
Brown Honeyeater	<i>Lichmera indistincta</i>		X	X		X		X
Black-chinned Honeyeater	<i>Melithreptus gularis</i>						X	
POMATOSTOMIDAE								
Grey-crowned Babbler	<i>Pomatostomus temporalis</i>		X	X		X		X
White-browed Babbler	<i>Pomatostomus superciliosus</i>		X					
PSOPHODIDAE								
Chestnut-breasted Quail-thrush	<i>Cinclosoma castaneothorax</i>						X	
Chiming Wedgebill	<i>Psophodes occidentalis</i>		X	X				
NEOSITTIDAE								
Varied Sittella	<i>Daphoenositta chrysoptera</i>					X	X	
CAMPEPHAGIDAE								
Ground Cuckoo-shrike	<i>Coracina maxima</i>					X	X	

Common Name	Species	Conservation Status	B.A.	DEC	EPBC	BCE	Lit	This survey
Black-faced Cuckoo-shrike	<i>Coracina novaehollandiae</i>		X			X		X
White-winged Triller	<i>Lalage sueurii</i>		X	X		X		X
PACHYCEPHALIDAE								
Rufous Whistler	<i>Pachycephala rufiventris</i>		X	X		X		X
Grey Shrike-thrush	<i>Colluricincla harmonica</i>		X	X		X		X
Crested Bellbird	<i>Oreoica gutturalis</i>		X	X		X		X
ARTAMIDAE								
Masked Woodswallow	<i>Artamus personatus</i>		X	X		X		X
White-browed Woodswallow	<i>Artamus superciliosus</i>					X		
Black-faced Woodswallow	<i>Artamus cinereus</i>		X	X		X		X
Little Woodswallow	<i>Artamus minor</i>		X	X		X		
Grey Butcherbird	<i>Cracticus torquatus</i>		X	X		X		X
Pied Butcherbird	<i>Cracticus nigrogularis</i>		X	X		X		X
Australian Magpie	<i>Cracticus tibicen</i>		X	X		X		X
RHIPIDURIDAE								
Grey Fantail	<i>Rhipidura albiscapa</i>					X	X	
Willie Wagtail	<i>Rhipidura leucophrys</i>		X	X		X		X
CORVIDAE								
Little Crow	<i>Corvus bennetti</i>		X	X				X
Torresian Crow	<i>Corvus orru</i>		X	X		X		X
MONARCHIDAE								
Magpie-lark	<i>Grallina cyanoleuca</i>		X	X		X		X
PETROICIDAE								
Red-capped Robin	<i>Petroica goodenovii</i>		X	X		X		X
Hooded Robin	<i>Melanodryas cucullata</i>		X	X		X		X
ALAUDIDAE								
Horsfield's Bushlark	<i>Miraфра javanica</i>		X	X		X		X
ACROCEPHLIDAE								
Australian Reed-Warbler	<i>Acrocephalus australis</i>		X					
MEGALURIDAE								
Rufous Songlark	<i>Cincloramphus mathewsi</i>		X	X		X		
Brown Songlark	<i>Cincloramphus cruralis</i>		X	X		X		

Common Name	Species	Conservation Status	B.A.	DEC	EPBC	BCE	Lit	This survey
Spinifexbird	<i>Eremiornis carteri</i>							X
HIRUNDINIDAE								
White-backed Swallow	<i>Cheramoeca leucosterna</i>						X	
Welcome Swallow	<i>Hirundo neoxena</i>		X			X		
Fairy Martin	<i>Petrochelidon ariel</i>		X					X
Tree Martin	<i>Petrochelidon nigricans</i>		X	X				X
NECTARINIIDAE								
Mistletoebird	<i>Dicaeum hirundinaceum</i>		X			X		X
ESTRILDIDAE								
Zebra Finch	<i>Taeniopygia guttata</i>		X	X		X		X
Star Finch	<i>Neochmia ruficauda subclarescens</i>					X	X	
Painted Finch	<i>Emblema pictum</i>		X	X		X		X
MOTCILLIDAE								
Australasian Pipit	<i>Anthus novaeseelandiae</i>		X	X		X		X
Reptiles								
CHELUIDAE								
Flat-shelled Tortoise	<i>Chelodina steindachneri</i>			X		X		
CARPHODACTYLIDAE								
	<i>Nephrurus wheeleri</i>			X		X		
DIPLODACTYLIDAE								
Clawless Gecko	<i>Crenadactylus ocellatus</i>			X				
Fat-tailed Gecko	<i>Diplodactylus conspicillatus</i>			X		X		X
	<i>Diplodactylus pulcher</i>			X				
	<i>Diplodactylus savagei</i>			X				
	<i>Lucasium stenodactylum</i>			X		X		X
	<i>Lucasium wombeyi</i>			X				X
Marbled Velvet Gecko	<i>Oedura marmorata</i>			X				
Beaked Gecko	<i>Rhynchoedura ornata</i>			X		X		X
	<i>Strophurus elderi</i>			X				X
	<i>Strophurus jeanae</i>			X				X
	<i>Strophurus wellingtonae</i>			X				X

Common Name	Species	Conservation Status	B.A.	DEC	EPBC	BCE	Lit	This survey
GEKKONIDAE								
	<i>Gehyra pilbara</i>			X				
	<i>Gehyra punctata</i>			X				
	<i>Gehyra purpurascens</i>			X				X
	<i>Gehyra variegata</i>			X		X		X
Bynoe's Gecko	<i>Heteronotia binoei</i>			X		X		X
Desert Cave Gecko	<i>Heteronotia spelea</i>			X		X		
PYGOPODIDAE								
	<i>Delma butleri</i>			X				
	<i>Delma elegans</i>			X				
	<i>Delma haroldi</i>			X				X
	<i>Delma nasuta</i>			X				
	<i>Delma pax</i>			X				X
	<i>Delma tincta</i>			X				
	<i>Lialis burtonis</i>			X		X		X
	<i>Pygopus nigriceps</i>			X				X
SCINCIDAE								
	<i>Carlia munda</i>			X		X		X
	<i>Carlia triacantha</i>			X				
	<i>Cryptoblepharus buchananii</i>			X		X		
	<i>Cryptoblepharus ustulatus</i>			X				
	<i>Ctenotus ariadnae</i>							X
	<i>Ctenotus duricola</i>			X				X
	<i>Ctenotus grandis</i>							X
	<i>Ctenotus hanloni</i>			X				X
	<i>Ctenotus helenae</i>			X				
	<i>Ctenotus leonhardii</i>			X				X
Leopard Ctenotus	<i>Ctenotus pantherinus</i>			X		X		X
	<i>Ctenotus piankai</i>			X				
	<i>Ctenotus rubicundus</i>			X		X		
	<i>Ctenotus rutilans</i>			X				X
Rock Ctenotus	<i>Ctenotus saxatilis</i>			X		X		X

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Common Name	Species	Conservation Status	B.A.	DEC	EPBC	BCE	Lit	This survey
	<i>Ctenotus schomburgkii</i>			X				
	<i>Ctenotus serventyi</i>			X				
	<i>Ctenotus uber</i>			X				
Slender Blue-tongue	<i>Cyclodomorphus melanops</i>			X		X		X
Pygmy Spiny-tailed Skink	<i>Egernia depressa</i>			X				
	<i>Egernia formosa</i>			X				
Pilbara Skink	<i>Egernia pilbarensis</i>			X				
Narrow-banded Sand Swimmer	<i>Eremiascincus fasciolatus</i>			X				
Broad-banded Sand Swimmer	<i>Eremiascincus richardsonii</i>			X				X
	<i>Lerista amicornum</i>			X				X
	<i>Lerista bipes</i>			X				X
	<i>Lerista labialis</i>			X				X
	<i>Lerista jacksoni</i>					X		X
	<i>Lerista muelleri</i>			X				X
	<i>Lerista neander</i>			X				
	<i>Lerista timida</i>							X
	<i>Lerista zietzi</i>			X				
	<i>Menetia greyii</i>			X		X		X
	<i>Menetia surda</i>			X				
	<i>Morethia ruficauda</i>			X		X		
	<i>Notoscincus ornatus</i>			X				
	<i>Proablepharus reginae</i>			X				
Central Blue-tongue	<i>Tiliqua multifasciata</i>			X		X		
AGAMIDAE								
	<i>Amphibolurus longirostris</i>			X		X		X
	<i>Caimanops amphiboluroides</i>			X				
	<i>Ctenophorus caudicinctus</i>			X		X		X
	<i>Ctenophorus isolepis</i>			X				X
	<i>Ctenophorus nuchalis</i>			X		X		X
	<i>Ctenophorus reticulatus</i>			X		X		
	<i>Diporiphora valens</i>			X				
	<i>Pogona minor</i>			X		X		X

Common Name	Species	Conservation Status	B.A.	DEC	EPBC	BCE	Lit	This survey
	<i>Tympanocryptis cephalus</i>			X				
VARANIDAE								
Spiny-tailed Monitor	<i>Varanus acanthurus</i>			X		X		X
Short-tailed Pygmy Monitor	<i>Varanus brevicauda</i>			X		X		
Pilbara Mulga Monitor	<i>Varanus bushi</i>			X		X		
	<i>Varanus caudolineatus</i>			X				
Pygmy Desert Monitor	<i>Varanus eremius</i>			X				X
Perentie	<i>Varanus giganteus</i>			X				
Bungarra or Sand Monitor	<i>Varanus gouldii</i>			X				X
Yellow-spotted Monitor	<i>Varanus panoptes</i>			X		X		X
Pilbara Rock Monitor	<i>Varanus pilbarensis</i>			X				X
Racehorse Monitor	<i>Varanus tristis tristis</i>			X		X		X
TYPHLOPIDAE								
	<i>Ramphotyphlops ammodytes</i>			X		X		
	<i>Ramphotyphlops ganei</i>	CS2		X			X	
	<i>Ramphotyphlops grypus</i>			X		X		
	<i>Ramphotyphlops hamatus</i>			X				
	<i>Ramphotyphlops waitii</i>			X				
BOIDAE								
Pygmy Python	<i>Antaresia perthensis</i>			X		X		X
Stimson's Python	<i>Antaresia stimsoni</i>			X		X		X
Black-headed Python	<i>Aspidites melanocephalus</i>			X		X		X
Pilbara Olive Python	<i>Liasis olivaceus barroni</i>	CS1		X	X		X	X
ELAPIDAE								
Pilbara Death Adder	<i>Acanthophis wellsi</i>			X		X		
NW Shovel-nosed Snake	<i>Brachyuropis approximans</i>			X				X
Yellow-faced Whipsnake	<i>Demansia psammophis</i>			X		X		X
Rufous Whipsnake	<i>Demansia rufescens</i>			X				
Moon Snake	<i>Furina ornata</i>			X				
Monk Snake	<i>Parasuta monachus</i>			X				X
Mulga Snake	<i>Pseudechis australis</i>			X		X		X
Ringed Brown Snake	<i>Pseudonaja modesta</i>			X				

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Common Name	Species	Conservation Status	B.A.	DEC	EPBC	BCE	Lit	This survey
Western Brown Snake	<i>Pseudonaja mengdeni</i>			x				x
Rosen's Snake	<i>Suta fasciata</i>			x				
Spotted Snake	<i>Suta punctata</i>							
Mammals								
TACHYGLOSSIDAE								
Echidna	<i>Tachyglossus aculeatus</i>					x	x	
DASUYRIDAE								
Mulgara	<i>Dasyercus cristicauda</i>	CS1					x	
Kaluta	<i>Dasykaluta rosamondae</i>			x		x		x
Northern Quoll	<i>Dasyurus hallucatus</i>	CS1			x		x	
Pilbara Ningau	<i>Ningau timealeyi</i>			x		x		x
Undescribed Pilbara planigale	<i>Planigale sp. 1</i>					x	x	
Undescribed Pilbara planigale	<i>Planigale sp. 2</i>					x		
Rory's Pseudantechinus	<i>Pseudantechinus roryi</i>						x	
Woolley's Pseudantechinus	<i>Pseudantechinus woolleyae</i>						x	x
Stripe-faced Dunnart	<i>Sminthopsis macroura</i>					x	x	
Hairy-footed Dunnart	<i>Sminthopsis hirtipes</i>						x	x
Long-tailed Dunnart	<i>Sminthopsis longicaudata</i>	CS2					x	
THYLACOMYIDAE								
Bilby	<i>Macrotis lagotis</i>	CS1			x		x	
MACROPODIDAE								
Euro	<i>Macropus robustus</i>			x		x		x
Red Kangaroo	<i>Macropus rufus</i>			x		x		x
Rothschild's Rock-wallaby	<i>Petrogale rothschildi</i>						x	
Spectacled Hare-Wallaby	<i>Lagorchestes conspicillatus</i>	CS2					x	
MEGADERMATIDAE								
Ghost Bat	<i>Macroderma gigas</i>	CS2		x		x	x	
HIPPOSIDERIDAE								
Pilbara Leaf-nosed Bat	<i>Rhinonictoris aurantia</i>	CS1		x	x		x	
EMBALLONURIDAE								
	<i>Taphozous georgianus</i>			x		x		x
	<i>Taphozous hilli</i>						x	

Common Name	Species	Conservation Status	B.A.	DEC	EPBC	BCE	Lit	This survey
Yellow-bellied Sheathtail Bat	<i>Saccolaimus flaviventris</i>			X			X	X
MOLOSSIDAE								
White-striped Mastiff Bat	<i>Tadarida australis</i>			X		X	X	
	<i>Chaerephon jobensis</i>			X		X		X
Beccari's Freetail-bat	<i>Mormopterus beccarii</i>						X	
VESPERTILLIONDAE								
	<i>Nyctophilus geoffroyi</i>			X		X		X
Northwestern Long-eared Bat	<i>Nyctophilus bifax daedalus</i>						X	
	<i>Chalinolobus gouldii</i>			X		X		X
Chocolate Wattled Bat	<i>Chalinolobus morio</i>						X	
	<i>Scotorepens greyii</i>			X		X		X
	<i>Vespadelus finlaysoni</i>			X		X		X
MURIDAE								
Lakeland Downs Mouse	<i>Leggadina lakedownensis</i>	CS2					X	
House Mouse	<i>Mus musculus</i>	INT		X		X		
Spinifex Hopping Mouse	<i>Notomys alexis</i>			X				
Western Pebble-mound Mouse	<i>Pseudomys chapmani</i>	CS2		X		X	X	X
Desert Mouse	<i>Pseudomys desertor</i>			X		X	X	X
Sandy Inland Mouse	<i>Pseudomys hermannsburgensis</i>			X		X		X
Rock Rat	<i>Zyzomys argurus</i>			X		X		X
LEPORIDAE								
Rabbit	<i>Oryctolagus cuniculus</i>	INT			X	X		
CANIDAE								
Dingo	<i>Canis lupus dingo</i>	INT				X	X	X
Fox	<i>Vulpes vulpes</i>	INT			X	X		
FELIDAE								
Cat	<i>Felis catus</i>	INT			X	X		X
EQUIDAE								
Horse	<i>Equus caballus</i>	INT				X	X	
Donkey	<i>Equus asinus</i>					X		

Common Name	Species	Conservation Status	B.A.	DEC	EPBC	BCE	Lit	This survey
CAMELIDAE								
Dromedary Camel	<i>Camelus dromedarius</i>	INT				x	x	
BOVIDAE								
European Cattle	<i>Bos taurus</i>	INT				x	x	x

Appendix 5. Species returned from databases that are unlikely to occur within the project area, or that may occur as very infrequent vagrants.

Common Name	Species Name	Conservation Code	B.A.	DEC	EPBC	Lit	Reason
Mammals							
Wongai Ningau	<i>Ningau ridei</i>			x			Outside distribution
Birds							
Flock Bronzewing	<i>Phaps histrionica</i>	Priority 4				x	locally extinct
Masked Owl	<i>Tyto novaehollandiae</i>					x	outside distribution