

Fauna Assessment of the Yeelirrie Fauna Study Area

Impact Assessment Report



Pygopus nigriceps, found in the Yeelirrie fauna study area

Prepared for: URS Australia Pty Ltd,
Level 3, 20 Terrace Rd,
East Perth,
WA, 6004

Prepared by: Mike Bamford, Natalia Huang and Jeff Turpin
M.J. & A.R. Bamford,
CONSULTING ECOLOGISTS.
23 Plover Way,
Kingsley,
WA, 6026



2nd March 2011

ACKNOWLEDGEMENTS

Bamford Consulting Ecologists would like to thank Jessie-Leigh Brown, Geoff Cockerton, Kim Drummond, Jenny Moro and Carolyn Ringrose for reviewing a draft of this report. Rebecca Graham provided vegetation descriptions and Doug Blandford provided comments on soils.

EXECUTIVE SUMMARY

Background

BHP Billiton Yeelirrie Development Company Pty Ltd (BHP Billiton) proposes to develop the Yeelirrie project, located on Yeelirrie Station, near Wiluna, Western Australia. As part of the Environmental Impact Assessment for the project, Bamford Consulting Ecologists (BCE) was commissioned to conduct a Level 2 Fauna Assessment within the Yeelirrie Ministerial Temporary Reserve (TR70/6899), in accordance with Environmental Protection Authority Guidance Statement No. 56 (EPA 2004). The fauna assessment comprised an initial desktop review, site inspection, field surveys and impact assessment. Results of the desktop, site inspection and field surveys are presented in the *Fauna Assessment of the Yeelirrie Project Area: Baseline Report* (BCE 2010). This Impact Assessment Report discusses the potential impacts of the proposed Yeelirrie development upon vertebrate fauna.

Approach to impact assessment

The impact assessment process involves the identification of fauna values of a site, the identification of ecological processes that may impact on these fauna values and how a proposed development might affect those processes. Ecological processes that may be affected then guide management recommendations to minimise impacts of the proposed development on fauna. Fauna values considered are: fauna habitats, fauna assemblage and distribution, and conservation significant fauna. Ecological processes considered with respect to impact assessment are: increased mortality; habitat loss affecting population survival; habitat loss affecting population movement and gene flow; changes to hydroecology; species interactions (feral species, over-abundant native species); changes in fire regime; and dust, noise, light and vibration. Impacts have also been categorised using the criteria presented in Chapter 7 of the Proposed Yeelirrie Development ERMP.

Fauna habitats

Eight broad associations of soils, landform and vegetation, referred to as fauna habitats, were identified. These are: Granite Outcrops and Breakaways, Scattered Shrubs over Spinifex Sandplain, Mulga over Spinifex Sandplain, Acacia Woodland

over Sparse Spinifex, Hardpan Mulga, Calcrete, Calcrete Outwash and Chenopod Shrubland over Sandplain. Areas of these habitats within the Ministerial Temporary Reserve and the main section of the fauna study area (i.e. the approximate 46,500 ha parcel of land that includes the ore body, proposed location of project infrastructure and the buffer area) varied. The area of each of the eight identified fauna habitats proposed to be cleared as a result of the proposed development and the percentage that this loss represents within the fauna study area is:

- Granite Outcrops and Breakaways habitat (areas do not include the Barr Smith Range) - 15 ha to be disturbed out of 1,866 ha (0.8 %) of that available in the fauna study area
- Hardpan Mulga - 835 ha to be disturbed out of 21,230 ha (or 3.9 %) of that available in the fauna study area
- Calcrete - 467 ha to be disturbed out of 2,819 ha (or 16.5 %) of that available in the fauna study area
- Calcrete Outwash - 615 ha to be disturbed out of 3,095 ha (or 19.8 %) of that available in the fauna study area
- Mixed Shrubs over Spinifex Sandplain - 1,431 ha to be disturbed out of 69,839 ha (or 2 %) of that available in the fauna study area. Note: For the purposes of mapping and calculation of fauna habitat areas, fauna habitat categories with Spinifex in common (Scattered Shrubs over Spinifex Sandplain, Mulga over Spinifex Sandplain, Acacia Woodland over Sparse Spinifex) were grouped into one category: Mixed shrubs over Spinifex sandplain.
- Chenopod Shrubland over Sandplain – 0 ha to be disturbed out of 1,215 ha (or 0 %) of that available in the study area.

The fauna assemblage

A vertebrate fauna assemblage of 292 species was identified from the desktop review, and the presence of 160 species was confirmed by BCE surveys. Species identified by the desktop review but not found during BCE surveys are still considered likely to use the fauna study area as the presence and abundance of vertebrate fauna varies seasonally and annually.

The fauna assemblage varied in its distribution across the fauna habitat types. Reptile species richness and abundance were highest on the Scattered Shrubs over Spinifex Sandplain and in part of the Calcrete habitat where *Eucalyptus gypsophila* formed an open woodland. Bird species richness and abundance were highest in this *E. gypsophila* woodland and in the two habitats containing Mulga. Potential impacts on the general vertebrate fauna assemblage are therefore likely to be greater in the *E. gypsophila* woodland subset of the Calcrete habitat, which has a high proportional representation in the fauna study area. As such, this habitat was afforded additional attention in the present impact assessment.

Significant species

The fauna assemblage included 35 species of conservation significance and the presence of 13 of these was confirmed by BCE surveys. Species of most interest to the impact assessment are:

- Malleefowl – present on the basis of a single recently-active mound, but mainly in Acacia shrublands on high ground north and south of the Ministerial Temporary Reserve and fauna study areas; residual impact is categorised as Low
- Slender-billed Thornbill – not recorded by BCE but may be present in subsets of the Chenopod Shrublands over Sandplain, Calcrete and Calcrete Outwash habitats; residual impact is categorised as Moderate
- Black-flanked Rock-Wallaby – present along Granite Outcrops and Breakaways habitat that lie mainly outside the Ministerial Temporary Reserve and fauna study areas; residual impact is categorised as Low
- Brush-tailed Mulgara – present in habitats with spinifex that are most extensive outside the fauna study area; residual impact is categorised as Low
- Bush Stone-curlew – present in dense vegetation along drainage lines within and outside the fauna study area; residual impact is categorised as Low
- Inland Greater Long-eared Bat – present and may rely on tree hollows within the *E. gypsophila* woodland subset of the Calcrete habitat; residual impact is categorised as Low.

Overview of impacts upon vertebrate fauna

The vertebrate fauna assemblage varies between groups and species in its sensitivities to changes in ecological processes. Impacts on ecological processes at the landscape level may be more important than localised impacts. The key ecological processes that may be impacted and are considered particularly important for the fauna assemblage, including conservation significant species, are:

- Increased mortality: Direct impact from mortality during clearing is inevitable but expected to be of low conservation significance. Ongoing mortality from roadkill may be important for Black-flanked Rock-Wallaby, Malleefowl, Australian Bustard and Bush Stone-curlew.
- Habitat loss affecting population survival: Most of the habitats to be affected are well represented, however the greatest proportional loss is of Calcrete Outwash (19.8 % within the fauna study area) and Calcrete (16.6 % within the fauna study area) habitats. *E. gypsophila* woodland subset of Calcrete habitat is important for reptile and bird richness and abundance but mostly common species that are not restricted to this vegetation. The Inland Greater Long-eared Bat may rely on tree hollows in this woodland and so the avoidance or relocation of such hollows would be important to minimise impacts on this species.
- Habitat loss affecting population movement and gene flow: This is an issue for consideration for the Slender-billed Thornbill due to development fragmenting chenopod shrublands on Calcrete Outwash within the fauna study area.
- Changes to hydroecology: i.e. changes to groundwater chemistry and level, changes to surface and sub-surface flow regime. This can affect species reliant on surface water and lead to vegetation changes altering habitat quality. It is of relevance to frogs, seasonal presence of waterbirds and the Bush Stone-curlew.
- Species interactions, specifically changes in feral predators such as cats and foxes: the implementation of the proposed feral management plan and associated control strategies would avoid impacts associated with an increase to feral animals.
- Changes in fire regime. Malleefowl and Brush-tailed Mulgara are sensitive to changes in fire regime.

- Dust, noise, light and vibration. Compromised habitat quality may lead to habitat loss.

CONTENTS

1	Introduction.....	8
1.1	Background	8
1.2	Location	8
1.3	The Proposed Yeelirrie Development.....	13
2	Impact Assessment.....	14
2.1	Overview	14
Table 2.1	14
2.2	Fauna Values	15
2.3	Ecological Processes.....	15
2.3.1	Overview.....	15
2.3.2	Increased mortality.....	16
2.3.3	Loss of habitat affecting population survival	16
2.3.4	Loss of habitat affecting population movements and gene flow	17
2.3.5	Species interactions, including predation and competition.....	17
2.3.6	Hydroecology.....	18
2.3.7	Fire	18
2.3.8	Dust, light, noise and vibration.....	18
2.3.9	Bioaccumulation.....	19
2.4	Predicted impact on fauna habitat	19
2.5	Fauna Assemblage and Distribution	24
2.6	Conservation Significant Fauna	25
3	References.....	34
	APPENDICES	37
	Appendix 1. Ecological processes.....	37
	Appendix 2. Categories used in the assessment of conservation status.....	39
	Appendix 3. Summary of potential impacts of the Yeelirrie project to fauna as assessed following the guidance of the EPA's Guidance Statement No. 56.	40

TABLES

Table 2.1. Impact criteria for fauna.....	14
Table 2.2. Residual impacts and significance of fauna habitats.	21
Table 2.3. Residual impacts on species of conservation significance	27

FIGURES

Figure 1. Location map of Yeelirrie	10
Figure 2. Map of Yeelirrie Ministerial Temporary Reserve and the fauna study area.....	12
Figure 3. Fauna habitats within the fauna study area.....	21

Introduction

1.1 Background

BHP Billiton Yeelirrie Development Company Pty Ltd (BHP Billiton) proposes to develop the Yeelirrie ore body (i.e. the proposed Yeelirrie development). As part of the Environmental Review and Management Programme (ERMP) for the proposed development, Bamford Consulting Ecologists (BCE) was engaged to conduct a Level 2 Fauna Assessment of the vertebrate fauna within the Yeelirrie Ministerial Temporary Reserve, in accordance with Environment Protection Authority (EPA, Western Australia) Guidance Statement No. 56 (EPA 2004). A Detailed Level 2 Fauna Assessment involves a comprehensive assessment including a desktop literature study, and multiple field surveys to assess the fauna values in the region. Results of the desktop review, site inspection and field surveys are presented in the *Fauna Assessment of the Yeelirrie Project Area: Baseline Report* (BCE 2010). This report discusses the potential impacts of the proposed Yeelirrie development upon vertebrate fauna and categorises the predicted residual impact as per the criteria provided in Chapter 7 of the ERMP (with the residual impact being that remaining after the successful application of proposed management measures).

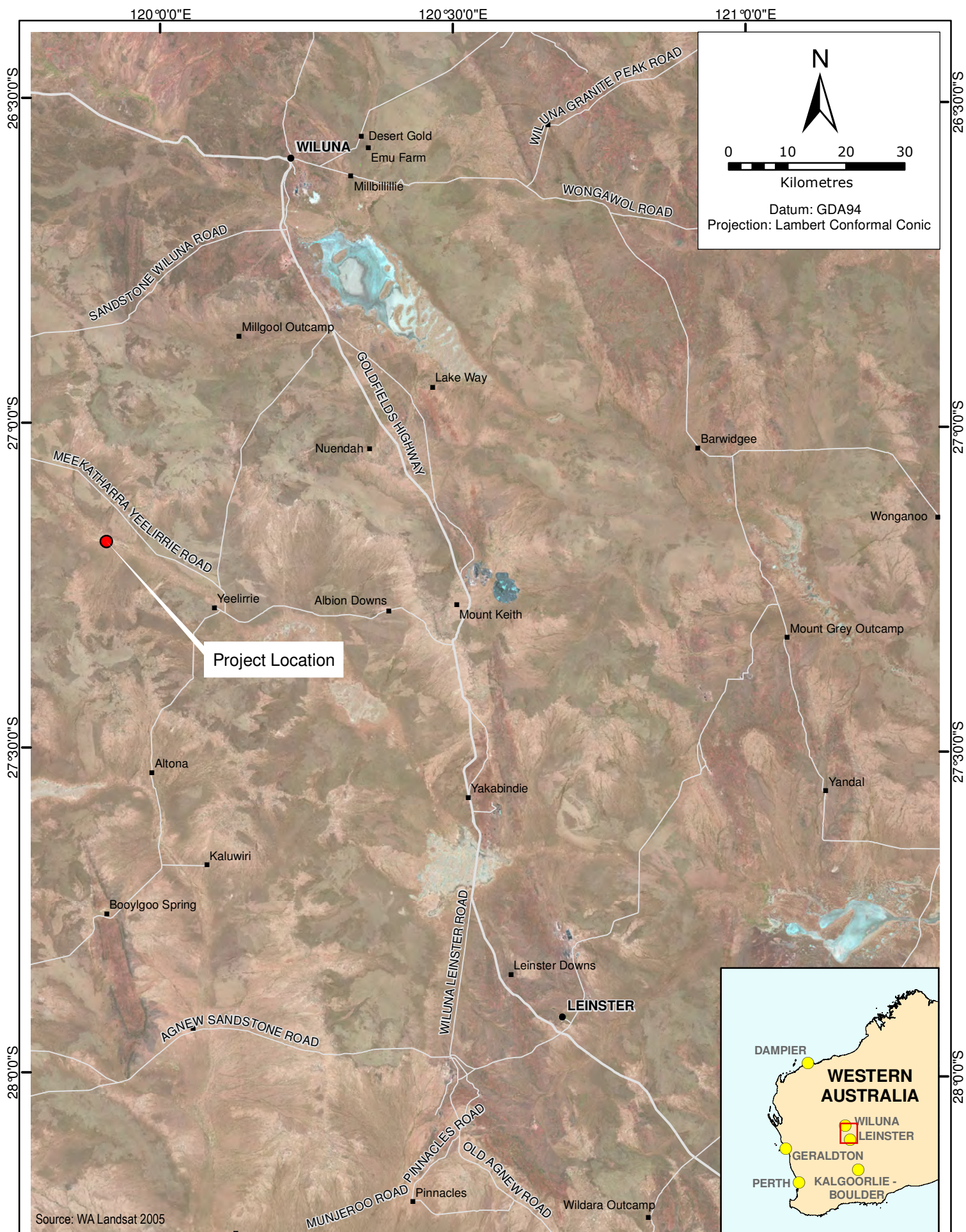
1.2 Location


The fauna study area is located on Yeelirrie Station and forms part of the Shire of Wiluna (Figure 1). The site is located at an elevation of between 480 and 595 m above sea level, and lies approximately 550 km due east of Geraldton, 500 km north of Kalgoorlie, 110 km north-west of Leinster, 80 km south of Wiluna and 60 km west of Mt Keith.

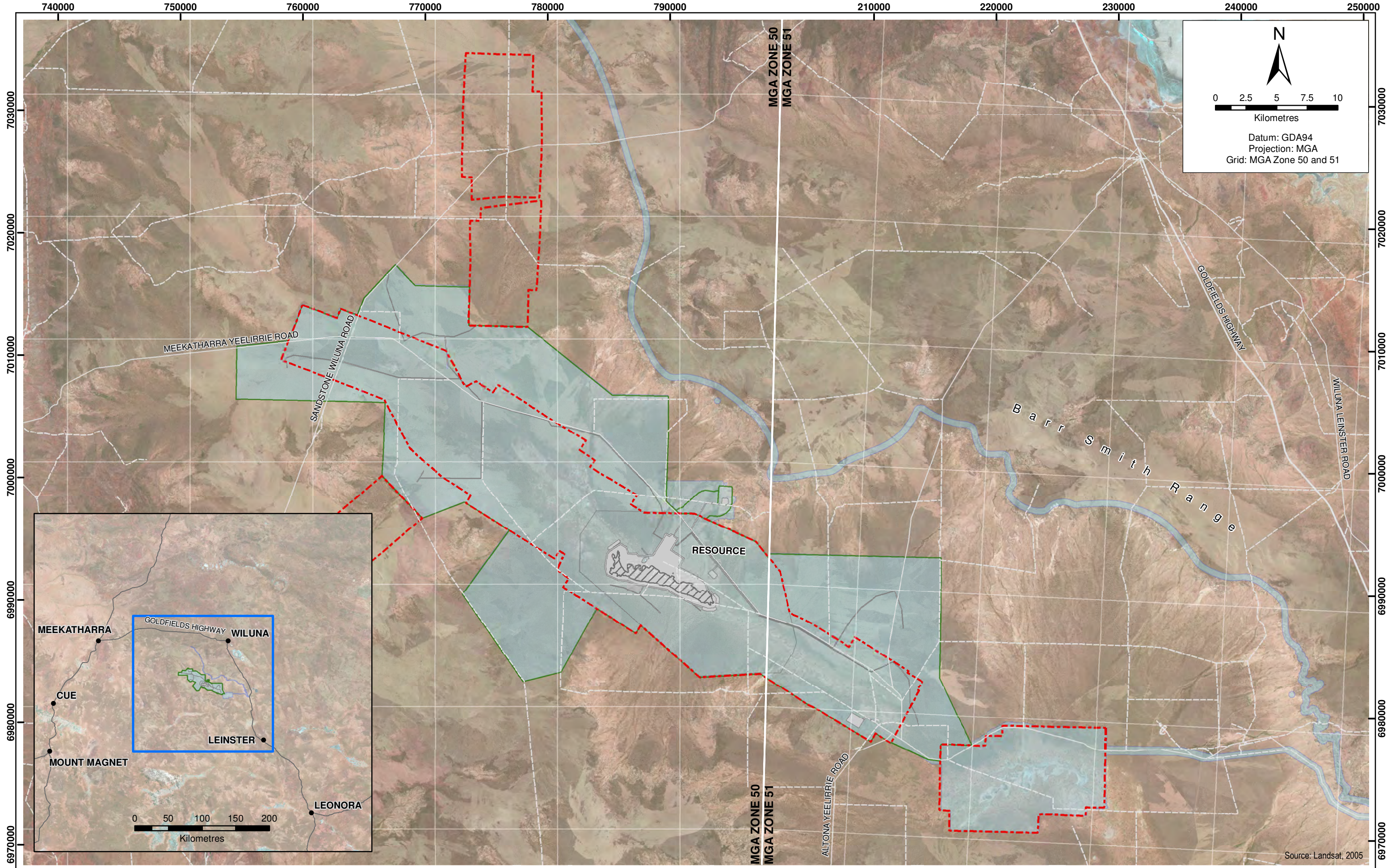
For the purposes of this report, the two main areas relating to the project are: the Ministerial Temporary Reserve and the fauna study area (Figure 2). The Ministerial Temporary Reserve consists of five distinct areas, with the largest of these being the focus of the survey. . The fauna study area has been defined as being the mineral deposit, areas required to support associated infrastructure and a buffer area, and it covers a total of 100,000 ha within the centre of the Ministerial Temporary Reserve.

It is proposed that about 3,500 ha of this study area would be disturbed (the area of disturbance is referred to as the project footprint).

The study area is defined as the areas in which BCE carried out fauna surveys. The desktop review gathered data regionally, including from sites over 50 km from the centre of the Ministerial Temporary Reserve, while field investigations were undertaken across and outside the Ministerial Temporary Reserve. Some field investigations took place outside the Ministerial Temporary Reserve to provide regional context or to target significant species (see Section 2.8). This included parts of the Barr Smith Range (40 km to the north and east of the Ministerial Temporary Reserve) and suitable Mulgara habitat adjacent to the Ministerial Temporary Reserve. These areas were identified on the basis of the desktop review as being of interest for significant species.



<div>BHP Billiton Yeelirrie Development Company Pty Ltd</div>	Project <div>Proposed Yeelirrie Development</div>			Title <div>Regional Location</div>	
<div>BAMFORD CONSULTING ECOLOGISTS</div>	Drawn: RNM/DL	Approved:KD	Date: 06/01/2011	Figure: 1	Rev. C
	Job No.: 42907132	File No.: 42907132-SUS-197_RC.mxd			A4



Legend

- Project Area
- Study Area
- Indicative Project Footprint
- Pit Outline
- Desktop Review Area
- Ministerial Temporary Reserve TR70/6899
- Roads (GA, 2007)
 - Major Road
 - Minor Road
 - Track

BHP Billiton
Yeelirrie Development
Company Pty Ltd



Project Proposed Yeelirrie Development			Title Vertebrate Fauna Study Area	
Drawn: DL/CJT	Approved: KD	Date: 03/02/2011	Figure: 2	Rev. E
Job No.: 42907132	File No.: 42907132-SUS-198_RE.mxd			A3

1.3 The Proposed Yeelirrie Development

For the purpose of the fauna impact assessment, it is beneficial to understand the processes involved in the proposed Yeelirrie development and the location and extent of the proposed habitat loss. To this end, the assumptions used in this impact assessment are based on the project description as provided in Chapter 3, Project Description, of the Yeelirrie ERMP.

2 Impact Assessment

2.1 Overview

The impact assessment process involves the identification of fauna values of a site, the identification of ecological processes that may impact on these fauna values and a discussion of how a proposed development might affect those processes. Ecological processes that may be affected then guide the establishment of, and commitment to, management measures to minimise impacts of the proposed development on fauna.

Once these measures have been identified and committed to, the residual impact of the proposed development may be determined and categorised. For the purpose of the proposed Yeelirrie development, the criteria used to categorise residual impacts is as per that provided in Chapter 7, Impact and Risk Assessment Approach, of the ERMP. A summary of the criteria relevant to fauna is reproduced here as Table 2.1.

Table 2.1 Impact criteria for fauna

Impact Category	Conservation significant¹ fauna and their preferred habitat	Common and otherwise significant² fauna
Negligible	An effect with no detectable impact to a local ³ population or the preferred habitat of a conservation significant species	A short-term ⁴ effect to a local population but no loss of species' viability
Low	A short-term effect to a local population or a credible impact to <30% of a species' preferred habitat	A long-term ⁵ effect to a local population but no loss of species' viability
Moderate	A long-term effect to a local population or a credible impact to >30% and <70% of a species' preferred habitat	The loss of a local population but no loss of species' viability
High	The loss of a local population or a credible impact to >70% of a species' preferred habitat	Irreversible loss of a species' viability

¹ – Conservation significant is a listed species under the EPBC Act; the WA Wildlife Conservation Act or a listed Department of Environment and Conservation Priority species 1 and 2

² – Otherwise significant is a listed Department of Environment and Conservation Priority 3, 4 or 5 species; and species considered to be of local significance to the project area

³ – Local is the proposed Yeelirrie development project area and areas adjacent to transport routes

⁴ – Short-term is <2 years (equating to the proposed development's construction timeframe)

⁵ – Long-term is >2 years

2.2 Fauna Values

For the purposes of the fauna impact assessment, the values have been grouped into:

- Habitat: fauna habitats are described in the *Fauna Assessment of the Yeelirrie Project Area: Baseline Report* (BCE 2010) and are summarised below (Section 3.3). For the purpose of the impact assessment, an understanding of the proposed loss and/or modification to fauna habitat has been treated as a contributing factor to the following two values.
- Fauna assemblage and distribution: this describes the number of species within the fauna study 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 habitats).
- Conservation significant fauna: for the purpose of this impact assessment, conservation significant fauna have been grouped into two categories:
 - **Conservation Significant:** Species listed under State and/or Commonwealth Acts, and Department of Environment and Conservation (DEC) Priority species 1 and 2.
 - **Otherwise Significant:** Species not listed under Acts, DEC Priority species 3, 4 and 5, and those species considered of at least local significance because of their pattern of distribution. This includes isolated populations of widespread species, species at the edge of their range, or species that are sensitive to impacts such as habitat fragmentation.

Details and descriptions of listings under legislation and DEC priority categories are provided in Appendix 3.

2.3 Ecological Processes

2.3.1 Overview

Potential impacts of proposed developments upon fauna values can be related to ecological processes. This is recognised in the literature and under the Environment

Protection and Biodiversity Conservation (EPBC) Act, in which threatening processes are listed (see Appendix 1). Ecological processes that may impact fauna values with respect to mining and uranium mining are discussed below (Sections 2.3.2 to 2.3.9). Ecological processes specific to the proposed Yeelirrie development are discussed in Sections 4 and 5. Rather than being independent of one another, ecological processes are complex and often interrelated. They are the mechanisms by which fauna can be affected by development. Impacts upon ecological processes may be significant if large numbers of species or large proportions of populations are affected.

2.3.2 Increased mortality

Increased mortality can occur during clearing activities with resultant habitat loss, and as a result of a range of other development activities. For example, Dufty (1989) suggested that the greatest cause of adult mortality in populations of Eastern Barred Bandicoots (*Peremeles gunni*) was due to collisions with vehicles. Jones (2000) documented the sudden decline in a population of Eastern Quolls (*Dasyurus viverrinus*) and Tasmanian Devils (*Sarcophilus harrisii*) directly attributed to increased road mortality following the upgrade of a local road. Increased mortality due to roadkill is often much more prevalent in habitats that have been fragmented (Jackson and Griffen 2000, Scheik and Jones 1999, Clevenger and Waltho 2000).

Increased mortality of common species during development is unavoidable but may not be significant for the 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.

2.3.3 Loss of habitat affecting population survival

Excessive loss of habitat can reduce the size of a population to the point where it is unsustainable or more vulnerable to other impacts. The loss of breeding habitat may result in significant population decline in fauna species that congregate in specific habitats or locations to breed. Conservation significant species or species that already occur at low densities may be particularly sensitive to habitat loss affecting population survival.

2.3.4 Loss of habitat affecting population movements and gene flow

Loss of habitat can affect population survival through fragmentation, particularly if the affected habitat is linear and distinctive. This can occur in agricultural landscapes where remnant habitat may be isolated or linear, such as along roads, but also in substantially intact landscapes where there are distinctive habitats along watercourses or associated with geological features. Loss of habitat affects population movements and gene flow by limiting movement of individuals throughout the landscape as a result of fragmentation. For small, terrestrial species, disruptions to population movement and gene flow can also be caused by obstructions associated with the development, such as roads and pipes. Impacts on gene flow can be significant when affecting species already occurring at low densities.

2.3.5 Species interactions, including predation and competition

Changes in species interactions often occur with development. Introduced species, including the feral Cat, Fox and Rabbit may 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 Fox, and to a lesser extent the feral Cat (Burbidge and 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.

While the existing stock watering points would be decommissioned as part of the proposed development, the development would inevitably provide some opportunities for access to fresh water (e.g. from garden reticulation or water from air-conditioners). Changes in the abundance of some native species at the expense of others, due to the provision of fresh watering points, can 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.

2.3.6 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.

Surface and sub-surface water chemistry may be modified by discharge from mines, stockpiled ore and tailings, resulting in a change in pH (Younger *et al.* 2002, Gandy *et al.* 2007, Pereira *et al.* 2009). Accumulation of heavy metals and radionuclides can alter the aquatic environment, affecting the survival of some fauna (Lottermoser and Ashley 2005, Jarvis and Younger 1997, Antunes *et al.* 2007, Pyle *et al.* 2001, Muscatello *et al.* 2008, de Rosemond *et al.* 2005). This is discussed further in Section 2.3.9.

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.

2.3.7 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.

2.3.8 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 and 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.

2.3.9 Bioaccumulation

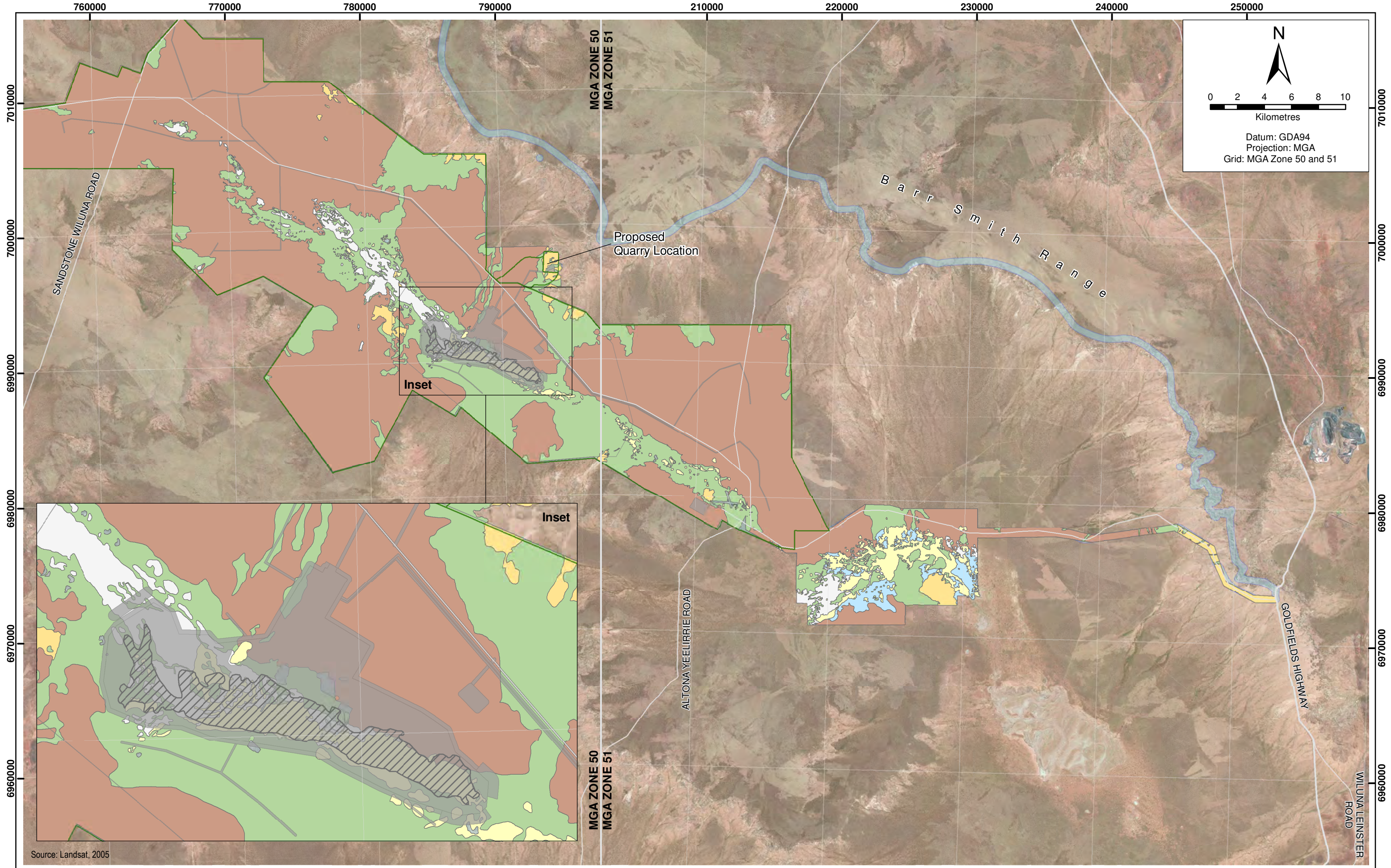
The impact assessment associated with bioaccumulation in fauna is considered in Chapter 10, Radiation, of the Yeelirrie Development ERMP, however for the purposes of completeness a small summary has been provided here. Bioaccumulation of heavy metals and radionuclides within the environment may occur in both the short and long-term. Heavy metals and radionuclides may enter the environment through seepage of contaminants from tailings facilities, dispersal of radioactive dust or long-term dispersal of tailings themselves. An organism may accumulate heavy metals through direct ingestion, inhalation or ingestion of contaminated organisms. While heavy metals occur naturally in the environment, they become a concern for flora and fauna when their environmental concentration increases such that the capacity of a species to regulate the internal concentration of metals is lost.

2.4 Predicted impact on fauna habitat

The significance of impacts upon habitats is related to the fauna they support and the degree of impact from the proposed development. Eight main fauna habitat categories in the fauna study area identified (from an elevation of high to low in the landscape) were:

- Granite Outcrops and Breakaways.
- Scattered Shrubs over Spinifex Sandplain.
- Mulga over Spinifex Sandplain.
- Acacia Woodland over Sparse Spinifex.
- Hardpan Mulga.
- Calcrete (including areas of *Eucalyptus gypsophila* woodland).
- Chenopod Shrubland on Sandplain.
- Calcrete Outwash.

The significance of each habitat for fauna, their representation in the fauna study area, and the area proposed to be impacted are discussed in the *Vertebrate Fauna Baseline Report, Yeelirrie Project* (2011). Figure 3 shows the various habitats and overlays the proposed 3,500 ha area of the disturbance footprint (project footprint).



Source: Landsat, 2005

<div><div></div>Project Area</div> <div><div></div>Study Area</div> <div><div></div>Indicative Project Footprint</div> <div><div></div>Pit Outline</div>	Fauna Habitat derived from Western Botanical (Bamford, 2011) <div><div></div>Calcrete</div> <div><div></div>Calcrete Outwash</div> <div><div></div>Chenopod shrubland over sandplain</div>	<div><div></div>Granite Outcrops and Breakaways</div> <div><div></div>Hardpan Mulga</div> <div><div></div>Mixed Shrubs over Spinifex sandplains</div>	<div><div><div>BHP Billiton</div><div>Yeelirrie Development Company Pty Ltd</div></div><div><div><div></div></div><div>BAMFORD CONSULTING ECOLOGISTS</div></div></div>	<div>Project</div> <div>Proposed Yeelirrie Development</div>	<div>Title</div> <div>Fauna Habitats</div>			
				<div>Drawn: DL</div>	<div>Approved: KD</div>	<div>Date: 24/01/2011</div>	<div>Figure: 3</div>	<div>Rev. A</div>
				<div>Job No.: 42907132</div>	<div>File No.: 42907132-SUS-248.mxd</div>			<div>A3</div>

Table 2.2. Significance and proportional loss of fauna habitats.

Fauna Habitat	Representation	Conservation Significance	Significance, proportional loss of fauna habitats and proposed management
Granite Outcrops and Breakaways; rock holes and gnamma holes (Granite System)	Barr Smith Range to the north, extensive in south, regionally small in extent. Rock holes and gnamma holes restricted in region. Area set aside for the quarry impinges upon Barr Smith Range but actual quarry footprint and associated infrastructure do not affect this habitat.	Rock and gnamma holes are significant water sources for many local species. Habitat supports some species of high conservation significance, notably Black-flanked Rock-Wallaby.	0.8 % of this habitat within the fauna study area is within project footprint.
Hardpan Mulga	Moderately extensive within the Ministerial Temporary Reserve and 21,230 ha within the fauna study area. Regionally very extensive.	High species richness and abundance of birds.	3.9 % of this habitat within the fauna study area is within the project footprint. Habitat likely to be sensitive to changes in hydrology De-stocking of the Yeelirrie Pastoral Lease and preserving 2760 ha of this habitat for conservation outside of the mine lease and on the Yeelirrie Station is proposed.
Calcrete; including <i>Eucalyptus gypsophila</i> woodland	Restricted in extent to the margins of claypan areas and has poor regional representation. The calcrete soils have formed high in an ancient drainage system and apparently similar landscapes lower in the drainage system have higher salt loads. 2,035 ha within the Ministerial Temporary Reserve and 2,819 ha in fauna study area.	The largest trees in the immediate area occur in this habitat and thus may be of local importance for birds and other species reliant on large trees for foraging and nesting. A rich and abundant reptile and bird fauna in the <i>E. gypsophila</i> woodland. This woodland may provide an unusual concentration of rare resources for fauna, such as tree hollows and dense leaf-litter. Bush Stone-curlew recorded and Inland Greater Long-eared Bat may roost in the tree hollows. Some parts of this habitat may support the conservation significant Slender-billed Thornbill.	16.5 % of this habitat within the fauna study area is within the project footprint. De-stocking of the Yeelirrie Pastoral Lease and preserving 1366 ha of this habitat for conservation outside of the mine lease and on the Yeelirrie Station is proposed. Hollows within branches of <i>E. gypsophila</i> tree to be cleared would be removed and re-affixed to nearby trees that would be retained.
Calcrete Outwash	Restricted in extent within the fauna study area to small areas close to the ore body. Similar areas within the region appear to be more saline. 921 ha within Ministerial Temporary Reserve and 3,095 ha in fauna study area.	Calcrete Outwash includes chenopod shrublands that may support the conservation significant Slender-billed Thornbill and might be important for population movements of this species. Waterbird usage likely to occur infrequently but will include significant species, although probably in small numbers.	19.8 % of this habitat within the fauna study area is within the project footprint. De-stocking of the Yeelirrie Pastoral Lease and preserving 730 ha of this habitat for conservation outside of the mine lease and on the Yeelirrie Station is proposed.

Fauna Habitat	Representation	Conservation Significance	Significance, proportional loss of fauna habitats and proposed management
		Some parts of this habitat may support the conservation significant Slender-billed Thornbill.	
Chenopod Shrubland over Sandplains; in the playa system	1,215 ha in fauna study area.	Some parts of this habitat may support the conservation significant Slender-billed Thornbill.	No impact anticipated
Mixed Shrubs over Spinifex Sandplain*	Very extensive within and outside the Ministerial Temporary Reserve.	Spinifex on sandplain has a generally high species richness and abundance for reptiles. High population density of the Brush-tailed Mulgara and may support some species of conservation significance such as Great Desert Skink, Striated Grasswren, Rufous-crowned Emu-wren and Desert Mouse.	Less than 2 % of this habitat within fauna study area is within the project footprint. De-stocking of the Yeelirrie Pastoral Lease and preserving 75,108 ha of this habitat for conservation outside of the mine lease and on the Yeelirrie Station is proposed.
Mulga over Spinifex Sandplain*	Extensive within the Ministerial Temporary Reserve and fauna study area. Regionally very extensive.	High species richness and abundance of birds. Also supports low population density of the Brush-tailed Mulgara.	Less than 2 % of this habitat within fauna study area is within the project footprint. De-stocking of the Yeelirrie Pastoral Lease and preserving 75,108 ha of this habitat for conservation outside of the mine lease and on the Yeelirrie Station is proposed.
Acacia Woodland over Sparse Spinifex*	Moderately extensive within the Ministerial Temporary Reserve and fauna study area. Regionally very extensive.	Generally low species richness and abundance. The single Malleefowl mound found within the fauna study area was in this habitat but it was inactive and there were no signs of recent visitation by the species. Malleefowl more common in acacia shrublands high in the landscape and outside the Ministerial Temporary Reserve.	Less than 2 % of this habitat within fauna study area is within the project footprint. Habitat likely to be sensitive to changes in hydrology and often occurs along old drainage lines. De-stocking of the Yeelirrie Pastoral Lease and preserving 75,108 ha of this habitat for conservation outside of the mine lease and on the Yeelirrie Station is proposed.

* For the purposes of calculating fauna habitat areas, habitat categories with Spinifex in common (Scattered Shrubs over Spinifex Sandplain, Mulga over Spinifex Sandplain, Acacia Woodland over Sparse Spinifex) were grouped into one category: Mixed shrubs over Spinifex sandplain, of which 69,839 ha are present in the fauna study area. Two percent of this habitat within fauna study area is within the project footprint.

2.5 Fauna Assemblage and Distribution

The *Fauna Assessment of the Yeelirrie Project Area: Baseline Report* (BCE 2011) found that the general fauna assemblage was typical of the Murchison region, with a mixture of desert, south-west and Murchison elements, and that there were some distinct patterns of distribution across the landscapes of the Ministerial Temporary Reserve. These are important for assessing the significance of impacts. Important patterns of distribution are:

- High reptile species richness and abundance in Scattered shrubs over Spinifex sandplain habitat;
- High bird species richness and abundance in Mulga habitats; and
- High bird and reptile species richness and abundance in *E. gypsophila* woodland subset of the Calcrete habitat.

With the exception of the *E. gypsophila* woodland subset of the Calcrete habitat, most of these habitats are extensive outside the fauna study area. However, a number of effects upon areas of high biodiversity need to be considered with respect to some ecological processes (as outlined in Section 2.3). For example:

Increased mortality – some increase in mortality is inevitable with development close to areas of high biodiversity. This could come from roadkill, birds striking infrastructure and fauna attracted into production areas in search of food, such as death of insects underneath lights.

Habitat loss affecting population survival - the *E. gypsophila* woodland subset of the Calcrete habitat would be impacted and is an area of high species richness and abundance, but the vertebrate assemblage does not appear unique or to contain species not found elsewhere in the area. For example, much of the species richness and abundance is due to species attracted by the concentration of Eucalypt canopy, leaf-litter and possibly tree-hollows. These features are found in other habitats but the consequence may be a localised decline in population size of otherwise common species.

Habitat loss affecting population movement and gene flow – With the exception of the Slender-billed Thornbill, there do not appear to be vertebrate species confined to the Calcrete and Calcrete Outwash habitats that might have their populations fragmented by the proposed development, but the mine and associated infrastructure would reduce the capacity of even moderately mobile fauna to move along the paleodrainage system. For example, remaining patches of *E. gypsophila* woodland would be fragmented and this may affect the ability of some fauna species to move across the landscape. The distribution of habitat that *may* be suitable for the Slender-billed Thornbill is a subset of Calcrete, Calcrete Outwash and Chenopod Shublands over Sandplains habitat.

Changes to hydroecology – the two Mulga habitats are likely to be reliant on surface and sub-surface flows that may be altered by clearing, earthworks and drainage management. The *E. gypsophila* woodland is also potentially reliant on groundwater. As a result, habitat degradation may occur beyond the clearing footprint.

Species interactions – feral predators may be attracted to areas of disturbance and thus predation pressure could increase. However, most of the species that contribute to high biodiversity in these areas are small and not known to be particularly sensitive to predation by species such as the Fox and feral Cat. In contrast, some of the biodiversity is related to the abundance of small birds such as fairy-wrens, which are likely to decline if aggressive, native bird species increase due to the provision of artificial water sources.

Residual impact

With appropriate management, the combination of the above factors is likely to result in a localised, long-term reduction in population size of a range of common species, but no loss of species or fauna assemblage viability. As such, the residual impact is categorised as low.

2.6 Conservation Significant Fauna

The key ecological processes that may be impacted and are considered particularly important for conservation significant species are equivalent to that for the general fauna assemblage. Potential impacts from the proposed Yeelirrie development on

conservation significant species that are likely to occur in the fauna study area are discussed in Table 2.3. This table also categorises the residual impact on each species as per the criteria defined in Section 2.1 (as per Chapter 7 of the ERMP).

Table 2.3. Residual impacts on species of conservation significance

Species	Species significance (EPBC / DEC Pr. 1,2,3,4 or 5 / SRE)	Status in area	Presence and description of preferred habitat	Potential impact and management	Residual impact ¹
CONSERVATION SIGNIFICANT					
<i>Leipoa ocellata</i> Malleefowl	Vulnerable (EPBC) Schedule 1 (WA Act)	Resident	Some may occur throughout habitats in the Ministerial Temporary Reserve and project areas, but the population appears to be concentrated in acacia shrublands on high ground to the north and south	Local population probably small and therefore sensitive to loss of a few individuals, but population mainly outside fauna study area. Potential impacts include roadkill, loss of habitat, increase in feral predators, change in fire regime. Management measures include management plans for fire and feral animals, restrictions on speed for project-related vehicles, de-stocking of the Yeelirrie Pastoral Lease and 34,400 ha of preferred habitat on Yeelirrie Station has been proposed for conservation management.	Low
<i>Polytelis alexandrae</i> Princess Parrot	Vulnerable (EPBC) Pr. 4 (DEC)	Irregular Visitor	Some; <i>E. gypsophila</i> woodland patches	Negligible impact as only an irregular visitor to fauna study area. Potential impacts include loss of habitat, removal of hollow-bearing trees, changes in fire regime, dust, light, noise and vibration.	Negligible
<i>Lophocroa leadbeateri</i> Major Mitchell's Cockatoo	Schedule 4 (DEC)	Irregular Visitor	Some; <i>E. gypsophila</i> woodland patches	Negligible impact as only an irregular visitor to fauna study area. Potential impacts include loss of habitat, removal of hollow-bearing trees, changes in fire regime, dust, light, noise and vibration.	Negligible
<i>Merops ornatus</i> Rainbow Bee-eater	Migratory (EPBC)	Regular Visitor	Extensive; all habitats with breeding in sandy and sandy-loam soils	Species is widespread and versatile in natural and altered habitats. Potential impacts include increased mortality, loss of habitat.	Negligible
<i>Apus pacificus</i> Fork-tailed Swift	Migratory (EPBC)	Irregular Visitor	Not applicable; aerial species	None as mainly aerial species.	Negligible
<i>Falco peregrinus</i> Peregrine Falcon	Schedule 4 (WA Act)	Resident	Minimal; potential breeding sites along Barr Smith Range and in <i>E. gypsophila</i> woodland	Probably a resident but impact may be limited to displacement of a breeding pair. Potential impacts include loss of habitat, disturbance of nesting sites.	Negligible

Species	Species significance (EPBC / DEC Pr. 1,2,3,4 or 5 / SRE)	Status in area	Presence and description of preferred habitat	Potential impact and management	Residual impact ¹
<i>Limosa limosa</i> Black-tailed Godwit	Migratory (EPBC)	Vagrant	Negligible; seasonal waterbodies in some areas.	Negligible impact as only a vagrant. Potential impacts include loss of habitat, changes to hydroecology, introduction of hazardous and non-hazardous waterbodies.	Negligible
<i>Tringa nebularia</i> Common Greenshank	Migratory (EPBC)	Irregular Visitor	Negligible; seasonal waterbodies in some areas.	Negligible impact as only an irregular visitor. Potential impacts include loss of habitat, changes to hydroecology, introduction of hazardous and non-hazardous waterbodies.	Negligible
<i>Tringa stagnatalis</i> Marsh Sandpiper	Migratory (EPBC)	Irregular Visitor	Negligible; seasonal waterbodies in some areas.	Negligible impact as only an irregular visitor. Potential impacts include loss of habitat, changes to hydroecology, introduction of hazardous and non-hazardous waterbodies.	Negligible
<i>Tringa hypoleucos</i> Common Sandpiper	Migratory (EPBC)	Irregular Visitor	Negligible; seasonal waterbodies in some areas.	Negligible impact as only an irregular visitor. Potential impacts include loss of habitat, changes to hydroecology, introduction of hazardous and non-hazardous waterbodies.	Negligible
<i>Tringa glareola</i> Wood Sandpiper	Migratory (EPBC)	Irregular Visitor	Negligible; seasonal waterbodies in some areas.	Negligible impact as only an irregular visitor. Potential impacts include loss of habitat, changes to hydroecology, introduction of hazardous and non-hazardous waterbodies.	Negligible
<i>Calidris ruficollis</i> Red-necked Stint	Migratory (EPBC)	Irregular Visitor	Negligible; seasonal waterbodies in some areas.	Negligible impact as only an irregular visitor. Potential impacts include loss of habitat, changes to hydroecology, introduction of hazardous and non-hazardous waterbodies.	Negligible
<i>Calidris acuminata</i> Sharp-tailed Sandpiper	Migratory (EPBC)	Irregular Visitor	Negligible; seasonal waterbodies in some areas.	Negligible impact as only an irregular visitor. Potential impacts include loss of habitat, changes to hydroecology, introduction of hazardous and non-hazardous waterbodies.	Negligible

Species	Species significance (EPBC / DEC Pr. 1,2,3,4 or 5 / SRE)	Status in area	Presence and description of preferred habitat	Potential impact and management	Residual impact ¹
<i>Calidris ferruginea</i> Curlew Sandpiper	Migratory (EPBC)	Irregular Visitor	Negligible; seasonal waterbodies in some areas.	Negligible impact as only an irregular visitor. Potential impacts include loss of habitat, changes to hydroecology, introduction of hazardous and non-hazardous waterbodies.	Negligible
<i>Ardea modesta</i> Eastern Great Egret	Migratory (EPBC)	Irregular Visitor	Negligible; seasonal waterbodies in some areas.	Negligible impact as only an irregular visitor. Potential impacts include loss of habitat, changes to hydroecology, introduction of hazardous and non-hazardous waterbodies.	Negligible
<i>Acanthiza iredalei</i> Slender-billed Thornbill	Vulnerable (EPBC)	Irregular Visitor	Some; small areas of chenopod shrublands (a sub set of Calcrete and Calcrete outwash and Chenopod Shrublands over Sandplain habitats) in Ministerial Temporary Reserve	Potential reduction and even loss of local populations if species occurs within fauna study area as a result of habitat loss, changes to hydroecology, introduction of hazardous and non-hazardous waterbodies, and disturbance from dust, light, noise and vibration. Approximately 294 ha of preferred habitat is likely to be disturbed due to the Yeelirrie development, and approximately 470 ha of preferred habitat on Yeelirrie Station has been proposed for conservation management.	Moderate
<i>Petrogale lateralis</i> Black-flanked Rock-Wallaby	Schedule 1 (WA Act)	Resident	Negligible; rocky outcrops with caves and rock piles associated with the Barr Smith Range. May forage and move into Ministerial Temporary Reserve and fauna study areas during dispersal.	Increase in feral predators could impact on what is an isolated and relictual population, however the successful implementation of the proposed feral animal management plan would negate this project impact. A small population may also be particularly vulnerable to roadkill as the Yeelirrie access road is situated alongside suitable habitat and as such restrictions on speed for project-related vehicles would be imposed. The proposed quarry impacts approximately 15 ha of preferred habitat. A further 227 ha of preferred habitat on Yeelirrie Station has been proposed for conservation management.	Low

Species	Species significance (EPBC / DEC Pr. 1,2,3,4 or 5 / SRE)	Status in area	Presence and description of preferred habitat	Potential impact and management	Residual impact ¹
<i>Dasyercus cristicauda</i> Crest-tailed Mulgara	Vulnerable (EPBC) Schedule 1 (WA Act)	Unlikely to be present	Unknown due to recent taxonomic revision. Probably sand dunes and grasslands near salt lakes.	If the species is present, it may occur in shrublands within or close to the Ministerial Temporary Reserve. Potential impacts include increased mortality, loss of habitat, increase in feral predators, change in fire regime, dust, light, noise and vibration. Potential management measures are considered the same as the Brush-tailed Mulgara.	Low
<i>Macrotis lagotis</i> Greater Bilby	Vulnerable (EPBC) Schedule 1 (WA Act)	Locally Extinct	Extensive; Spinifex Sandplains adjacent to ore deposit.	Some habitat is within Ministerial Temporary Reserve although local population is probably extinct already. Potential impacts if species present would include increased mortality, loss of habitat, increase in feral predators, change in fire regime, dust, light, noise and vibration.	Negligible
<i>Liopolis kintorei</i> Great Desert Skink	Vulnerable (EPBC) Schedule 1 (WA Act)	Unknown	Minimal; species prefers sandy soils whereas even sandplains in Ministerial Temporary Reserve are a sandy-loam.	Not known from Ministerial Temporary Reserve but some potential for the species to be present regionally. Potential impacts include increased mortality, loss of habitat, increase in feral predators, changes in fire regime	Negligible
OTHERWISE SIGNIFICANT					
<i>Dasyercus blythi</i> Brush-tailed Mulgara	Pr 4 (DEC)	Resident	Extensive; Spinifex sandplains adjacent to ore deposit, areas of Mulga shrubland and open woodland to the south of ore deposit.	Some populations are present in fauna study area (1283 ha), but extensive suitable habitat occurs outside the Ministerial Temporary Reserve on Yeelirrie Station. Potential; impacts include increased mortality, loss of habitat, increase in feral predators, change in fire regime, dust, light, noise and vibration. Approximately 75,108 ha of preferred habitat on Yeelirrie Station has been proposed for conservation management.	Low

Species	Species significance (EPBC / DEC Pr. 1,2,3,4 or 5 / SRE)	Status in area	Presence and description of preferred habitat	Potential impact and management	Residual impact ¹
<i>Burhinus grallarius</i> Bush Stone-curlew	Pr 4 (DEC)	Resident	Extensive; <i>E. gypsophila</i> woodland, dense Acacia shrublands, gnamma holes and Casuarina woodland.	Species is widespread and suitable habitat is extensive outside fauna study area, but population is small and uses habitat within fauna study area. Potential impacts include increased mortality, loss of habitat, increase in feral predators, changes in hydroecology, change in fire regime, dust, light, noise and vibration.	Low
<i>Ardeotis australis</i> Australian Bustard	Pr 4 (DEC)	Resident	Some; sandplains adjacent to ore deposit.	Species is widespread. Potential impacts include increased mortality, loss of habitat, increase in feral predators, change in fire regime, dust, light, noise and vibration.	Negligible
<i>Falco hypoleucos</i> Grey Falcon	Pr 4 (DEC)	Irregular Visitor	Some; dense Acacia shrublands within Ministerial Temporary Reserve.	Impact unlikely; rare visitor across several habitats. Potential impacts include loss of habitat, disturbance of nesting sites, change in fire regime.	Negligible
<i>Amytornis striatus</i> Striated Grasswren	Pr 4 (DEC)	Resident	Some	Probably not present in area. Changed fire regimes could lead to local extinction however the successful implementation of the fire management plan would negate this loss. Potential impacts include loss of habitat, increase in feral predators, change in fire regime, dust, light, noise and vibration.	Negligible
<i>Nyctophilus major tor</i> Inland Greater Long-eared Bat	Pr 4 (DEC)	Resident	Probably extensive; Spinifex sandplains adjacent to ore deposit, open woodlands. May roost in tree hollows in <i>E. gypsophila</i> woodland.	Species is widespread but important regional roosting habitat may be in the <i>E. gypsophila</i> woodland. Management measures include the avoidance of hollow-bearing <i>E. gypsophila</i> wherever practicable and where not practicable, the collection and re-affixing of suitable hollows to trees that would be retained. Potential impacts include loss of habitat, change in fire regime, dust, light, noise and vibration. Approximately 27,364 ha of preferred habitat on Yeelirrie Station has been proposed for conservation management.	Low

Species	Species significance (EPBC / DEC Pr. 1,2,3,4 or 5 / SRE)	Status in area	Presence and description of preferred habitat	Potential impact and management	Residual impact ¹
<i>Sminthopsis longicaudata</i> Long-tailed Dunnart	Pr 3 (DEC)	Resident	Negligible; rocky ridges and stony slopes with Spinifex associated with the Barr Smith Range. May forage and move into Ministerial Temporary Reserve during dispersal.	Key habitat outside impact areas. Potential impacts include loss of habitat, increase in feral predators, and changes to the fire regime.	Negligible
<i>Aprasia picturata</i>	Locally significant	Unknown	Negligible; rocky areas associated with the Barr Smith Range.	Habitat outside Ministerial Temporary Reserve. Potential impacts include loss of habitat	Negligible
<i>Lophoictinia isura</i> Square-tailed Kite	Locally significant	Regular Visitor	Some; <i>E. gypsophila</i> woodland patches within the Ministerial Temporary Reserve, extensive areas of Mulga shrubland.	Potential impact includes loss of habitat.	Negligible
<i>Polytelis anthopeplus</i> Regent Parrot	Locally significant	Vagrant	Some, but usage probably infrequent.	Potential impact includes loss of habitat.	Negligible
<i>Neophema splendida</i> Scarlet-chested Parrot	Locally significant	Irregular Visitor	Some; <i>E. gypsophila</i> woodland patches and extensive areas of Mulga shrubland within the Ministerial Temporary Reserve. Potential breeding in <i>Es gypsophila</i> woodland	Negligible impact as only an irregular visitor to fauna study area. Potential impacts include loss of habitat, loss of breeding habitat (Eucalypt tree hollows), changes in hydroecology, change in fire regime, dust, light, noise and vibration.	Negligible
<i>Stipiturus ruficeps</i> Rufous-crowned Emu-wren	Locally significant	Resident	Extensive; Spinifex sandplains adjacent to ore deposit.	Probably not present in area, changed fire regimes could lead to local extinction however the successful implementation of the fire management plan would negate this loss. Potential impacts include loss of habitat, change in fire regime, dust, light, noise and vibration.	Negligible
<i>Conopophila whitei</i> Grey Honeyeater	Locally significant	Resident	Extensive; areas of Mulga shrubland within the Ministerial Temporary Reserve.	Most habitat is outside areas proposed areas of disturbance. Potential impacts include loss of habitat, change in fire regime, dust, light, noise and vibration.	Negligible

Species	Species significance (EPBC / DEC Pr. 1,2,3,4 or 5 / SRE)	Status in area	Presence and description of preferred habitat	Potential impact and management	Residual impact ¹
<i>Antichinomys laniger</i> Kultarr	Locally significant	Resident	Minimal; stony plains occurs mostly outside the fauna study area near granite breakaways, but some close to quarry site.	Species is widespread and suitable habitat is largely outside the fauna study area. Potential impacts include increased mortality, loss of habitat, increase in feral predators, change in fire regime, dust, light, noise and vibration.	Negligible
<i>Pseudomys desertor</i> Desert Mouse	Locally significant	Resident	Extensive; Spinifex Sandplains adjacent to ore deposit, small areas of chenopod shrublands in Ministerial Temporary Reserve.	Species is widespread and suitable habitat is mostly outside proposed areas of disturbance. Potential impacts include increased mortality, loss of habitat, increase in feral predators, change in fire regime, dust, light, noise and vibration.	Negligible

¹ – for the purpose of assessing impacts on conservation significant fauna, the relevant impact criteria as per Table 5.1 has been used for those species deemed to be conservation significant or otherwise significant.

3 References

- Anon. (1978). Unpubl. Species list for Yeelirrie Project area from 1978 ERMP.
- Antunes, S.C., de Figueiredo, D.R., Marques, S.M., Castro, B.B., Pereira, R. and Goncalves, F. (2007). Evaluation of water column and sediment toxicity from an abandoned uranium mine using a battery of bioassays. *Science of the Total Environment* 374: 252-259.
- Benshemesh, J. (1990). Management of Malleefowl with regard to fire. In J. C. Noble, P. J. Joss and G. K. Jones (Eds) *The Mallee Lands, a Conservation Perspective*. Pp. 206-211. CSIRO, Melbourne.
- Benshemesh, J. (1992). The conservation ecology of Malleefowl, with particular regard to fire. Ph.D. Thesis. Monash University, Clayton.
- Benshemesh, J. (2000). National Recovery Plan for Malleefowl. Department of Environment and Heritage:
- Benshemesh, J., S. Dennings, C. Danzi, and A. Sanders. (2008). Malleefowl searches at Yeelirrie station in arid Western Australia: a valuable collaboration between industry and volunteers. In: Davies S.J.J.F. (ed) *Katanning National Malleefowl Forum 2007*. School of Environmental Biology Bulletin No.28, Curtin University of Technology, Perth WA
- Bamford Consulting Ecologists, BCE (Mike Bamford, Jeff Turpin and Natalia Huang) (2010). Fauna assessment of the Yeelirrie project area: impact assessment report. Report to URS Environmental, Western Australia.
- Burbidge, A.A. & McKenzie, N.L. 1989, 'Patterns in the modern decline of Western Australia's vertebrate fauna: causes & conservation implications.' , *Biological Conservation*, vol. 50, pp. 143-98.
- Clevenger, A. P. and Waltho, N. (2000). Factors Influencing the Effectiveness of Wildlife Underpasses in Banff National Park, Alberta, Canada. *Conservation Biology* 14: 1-11.
- deRosemond, S.C., Liber, K. and Rosaasen, A. (2005). Relationship between embryo selenium concentration and early life stage development in white sucker

- (*Catostomus commersoni*) from a northern Canadian lake. *Bulletin of Environmental Contamination and Toxicology* 74: 1134-1142.
- Dufty, A.C. (1989). Some Population characteristics of *Perameles gunnii* in Victoria. *Wildlife Research*: 18 (3) 355 – 365
- Environmental Protection Authority. (2004). Guidance for the assessment of environmental factors: Terrestrial fauna surveys for environmental impact assessment in Western Australia. No. 56. Environmental Protection Authority, Perth, Western Australia.
- Fox, B.J. (1982). Fire and mammalian secondary succession in an Australian coastal heath. *Ecology* 63: 1332-1341.
- Gandy, C.J., Smith, J.W.N. and Jarvis, A.P. (2007). Attenuation of mining-derived pollutants in the hyporheic zone: A review. *Science of the Total Environment* 373: 435-446.
- Gill, A.M., Groves, R.H. and Noble, I.R. (1981). *Fire and the Australian Biota*. Australian Academy of Science, Canberra.
- Harrington, R. (2002). The effects of artificial watering points on the distribution and abundance of avifauna in an arid and semi-arid mallee environment. PhD thesis, Department of Zoology, The University of Melbourne.
- Jackson, S. D. and Griffin, C. R. (2000). A Strategy for Mitigating Highway Impacts on Wildlife. Pp. 143 – 159, In Messmer, T. A and B. West, (eds) *Wildlife and Highways: Seeking Solutions to an Ecological and Socio – economic Dilemma*. The Wildlife Society.
- Jarvis, A.P. and Younger, P.L. (1997). Dominating chemical factors in mine water induced impoverishment of the invertebrate fauna of two streams in the Durham coalfield, UK. *Chemical Ecology* 13: 249-270.
- Jones, M.E. (2000). Road upgrade, road mortality and remedial measures: impacts on a population of eastern quolls and Tasmanian devils. *Wildlife Research* 27: 289 – 296.
- Kofoed, P. (1998). A wizard with wavelengths. *ECOS magazine* 96. CSIRO.

- Letnic, M., Dickman, C.R., Tischler, M.K., Tamayo, B. and Beh, C.L. (2004). The responses of small mammals and lizards to post-fire succession and rainfall in arid Australia. *Journal of arid environments* 59 (1): 85-114.
- Lottermoser, B.G. and Ashley, P.M. (2005). Tailings dam seepages at the rehabilitated Mary Kathleen uranium mine, Australia. *Journal of Geochemical Exploration* 85: 119-137.
- Muscatello, J.R., Belknap, A.M. and Janz, D.M. (2008). Accumulation of selenium in aquatic systems downstream of a uranium mining operation in northern Saskatchewan, Canada. *Environmental Pollution* 156: 387-393.
- National Parks and Wildlife Service (2002). Warrumbungle Brush-tailed Rock-wallaby Endangered. Population Recovery Plan. NSW National Parks and Wildlife Service, Hurstville, NSW.
- Pereira, R., Marques, C.R., Silva Ferreira, M.J., Neves, M.F.J.V., Caetano, A.L., Antunes, S.C., Mendo, S and Goncalves, F. (2009). Phytotoxicity and genotoxicity of soils from an abandoned uranium mine area. *Applied Soil Ecology* 42: 209-220.
- Pyle, G.G., Swanson, S.M. and Lehmkuhl, D.M. (2001). Toxicity of uranium mine-receiving waters to caged fathead minnows, *Pimephales promelas*. *Ecotoxicological Environment and Safety* 48: 202-214.
- Rich, C. and Longcore, T. (2006). *Ecological Consequences of Artificial Night Lighting*. Island Press.
- Soule, M. E., Mackey, B. G., Recher, H. F., Williams, J. E., Woinarski, J. C. Z., Driscoll, D., Dennison, W. C. and Jones, M. E. (2004). The role of connectivity in Australian conservation. *Pacific Conservation Biology* 10: 266-279.
- Western Botanical (2010 *in prep*). Flora and Vegetation Baseline Report for the BHP Billiton Yeelirrie Project.
- Younger, P.L., Banwart, S.A. and Hedin, R.S. (2002). Mine water: hydrology, pollution, remediation. Kluwer Academic Publishers, London.

APPENDICES

Appendix 1. 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.

(Taken from http://www.wilderness.org.au/articles/wc_science, viewed 30 December 2008)

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*);
 - The reduction in the biodiversity of Australian native fauna and flora due to the red imported fire ant, *Solenopsis invicta*.
- (taken from <http://www.environment.gov.au/cgi-bin/sprat/public/publicgetkeythreats.pl> viewed on 30 December 2008)

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.

(taken from Cork S, Sattler P and Alexandra J (2006), 'Biodiversity' theme commentary prepared for the 2006 Australian State of the Environment Committee, Department of the Environment and Heritage, Canberra, <http://www.deh.gov.au/soe/2006/commentaries/biodiversity/index.html>; viewed on 30 December 2008).

Appendix 2. Categories used in the assessment of conservation status

Categories used for the Environmental Protection and Biodiversity Conservation (EPBC) Act	
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 Conservation and Land Management Priority Species	
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 3. Summary of potential impacts of the Yeelirrie project to 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	Low	Fauna study area largely undisturbed with low grazing pressure in recent years, so project will introduce disturbance into an area where there is little current disturbance.
Size/scale of proposal/impact	High	While the project is small in comparison with typical mining developments, with about 3,500 ha of vegetation proposed to be impacted within a fauna study area of 46,500 ha, a project area of 88,000 ha and a Ministerial Temporary Reserve of >100,000 ha; the proposed clearing is above the EPA No. 56 stated thresholds of >10ha, >50ha and >75ha and therefore triggers 'high'
Rarity of vegetation and landforms	Low to Moderate	Vegetation and landform directly impacted by project as a measure of fauna habitat vary between 0.8 % and 19.8 % of the habitat within the fauna study area.
Significant habitats	Low	There are no important feeding or breeding areas or habitats for species protected under international agreements or treaties (e.g. RAMSAR wetlands, migrating birds), Specially Protected and/or Priority Fauna. See below for refugial habitats.
Refugia	Low to Moderate	Typical refugial habitat (e.g. breakaways) is mostly outside fauna study area, but some of the habitats with the fauna study area, such as the <i>E. gypsophila</i> woodland, provides a high concentration of some environmental features such as eucalypt canopy and tree hollows (16.5% of this habitat within the fauna study area would be impacted).
Fauna protected under international agreements or treaties, Specially Protected or	Low to Moderate	Small numbers of such species and mostly outside fauna study area or only occurring as vagrants.

Priority Fauna		
Other significant fauna or fauna assemblages	Low	The impacted areas do not support fauna or fauna assemblages that have particular significance for ecological reasons and/or large populations/ seasonal concentrations of particular species.
Size of remnant and condition/intactness of habitat and faunal assemblage	Moderate	Habitats largely intact, but fauna assemblage has lost some species.
Ecological linkage	Moderate	Fauna study area may facilitate/restrict movement along old drainage line.
Heterogeneity or complexity of the habitat and faunal assemblage	Moderate	The area has a similar range of habitats and faunal assemblages relative to the characteristics at the local and regional scale.