9.3 Terrestrial Fauna

9.3.1 EPA Objective

The EPA's objective for terrestrial fauna is:

- To maintain representation, diversity, viability and ecological function at the species, population and assemblage level.

9.3.2 Relevant Legislation and Policy

This section only addresses State requirements for the protection of fauna. Requirements under the Federal EPBC Act are discussed in Section 10.1.

All native fauna in Western Australia are protected under the *Wildlife Conservation Act 1950* (WC Act). Native fauna species that are rare, threatened with extinction, or have high conservation value are specially protected under the WC Act. The Wildlife Conservation (Specially Protected Fauna) Notice classifies rare and endangered fauna using four conservation schedules:

Schedule 1 – Fauna which are rare or likely to become extinct and are declared to be fauna in need of special protection.

Schedule 2 – Fauna which are presumed to be extinct and are declared to be fauna in need of special protection.

Schedule 3 – Birds which are subject to international agreements and conventions relating to the protection of migratory birds (Section 10.1) and birds in danger of extinction, which are declared to be fauna in need of special protection, and

Schedule 4 – Fauna that are in need of special protection, for reasons other than those reasons mentioned in Schedules 1, 2 or 3.

Threatened Fauna listed under Schedule 1 are classified as follows according to their level of threat using the IUCN Red List criteria:

Critically Endangered (CR): Considered to be facing an extremely high risk of extinction in the wild.

Endangered (EN): Considered to be facing a very high risk of extinction in the wild.

Vulnerable (VU): Considered to be facing a high risk of extinction in the wild.

Extinct (EX): There is no reasonable doubt that the last individual has died.

In addition to Schedules 1-4, DPaW produces a supplementary list of Priority Fauna. Priority Fauna are species that have been identified as requiring further survey and evaluation of their conservation status before deciding whether to list them as Schedule Fauna. Five Priority codes are defined by the DPaW:

Priority One (P1): Poorly-known species (on threatened lands). Species that are known from one or a few locations (generally five or less) which are potentially at risk. All occurrences are either: very small or on lands not managed for conservation, e.g. agricultural or pastoral lands, urban areas, road and rail reserves, gravel reserves and active mineral leases; or otherwise under threat of habitat destruction or degradation. Species may be included if they are comparatively well-known from one or more locations but do not meet adequacy of survey requirements and appear to be under immediate threat from known threatening processes. Such species are in urgent need of further survey.

Priority Two (P2): Poorly-known species (on conservation lands). Species that are known from one or a few locations (generally five or less), some of which are on lands managed primarily for nature conservation, e.g. national parks, conservation parks, nature reserves and other

lands with secure tenure being managed for conservation. Species may be included if they are comparatively well-known from one or more locations but do not meet adequacy of survey requirements and appear to be under threat from known threatening processes. Such species are in urgent need of further survey.

Priority Three (P3): Poorly-known species (some on conservation lands). Species that are known from several locations, and the species does not appear to be under imminent threat, or from few but widespread locations with either large population size or significant remaining areas of apparently suitable habitat, much of it not under imminent threat. Species may be included if they are comparatively well-known from several locations but do not meet adequacy of survey requirements and known threatening processes exist that could affect them. Such species are in need of further survey.

Priority Four (P4): Rare, Near Threatened and other species in need of monitoring.

(a) Rare. Species that are considered to have been adequately surveyed, or for which sufficient knowledge is available, and that are considered not currently threatened or in need of special protection, but could be if present circumstances change. These species are usually represented on conservation lands.

(b) Near Threatened. Species that are considered to have been adequately surveyed and that do not qualify for Conservation Dependent, but that are close to qualifying for Vulnerable.

(c) Species that have been removed from the list of threatened species during the past five years for reasons other than taxonomy.

Priority Five (P5): Conservation Dependent species. Species that are not threatened but are subject to a specific conservation program, the cessation of which would result in the species becoming threatened within five years.

The EPA Position Statement No. 3 outlines the use of terrestrial biological surveys as an element of biodiversity protection in Western Australia (EPA 2002b). Proponents are expected to undertake field surveys that meet the standards, requirements and protocols as determined and published by the EPA. The majority of the studies relied on here were commissioned by the previous owners of the Project, BHP Billiton. Cameco and its consultants have reviewed the fauna surveys undertaken for the Project to confirm the surveys met the requirements for Level 2 biological surveys for assessment of the impacts of the Project.

Further detail on the requirements for fauna surveys is provided in EPA Guidance Statement No. 56 (EPA 2004) and Technical Guide on Terrestrial Vertebrate Fauna Surveys for Environmental Impact Assessment (EPA & DEC 2010).

Guidance Statement No. 20 (EPA 2009) addresses the general standards and risk-based approach for the sampling and assessment of short-range endemic (SRE) invertebrate fauna species in Western Australia. The guidance outlines the EPA's expectations in respect of the quality and quantity of information derived from these surveys, and the consequent analysis, interpretation and reporting.

9.3.2.1 Conservation significance species

Three broad levels of conservation significance can be recognised and are used for the purposes of this assessment:

Conservation Significance (CS) 1: Species listed under the EPBC Act or WC Act;

Conservation Significance (CS) 2: Species listed as Priority by the DPaW but not listed under the EPBC Act or WC Act; and

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.

Conservation significance level 3 (CS3) 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. Short Range Endemic (SRE) invertebrate species (*sensu* Harvey 2002) are also considered to be CS3.

9.3.3 Studies and Investigations

9.3.3.1 General Approach to Fauna Impact Assessment

The purpose of impact assessment is to provide managing agencies with the information they need to decide upon the significance of impacts upon fauna from a proposed development. In this section, the impact assessment process is based on fauna values and impacting processes as summarised below, and the development of proposed action to mitigate impacts:

- Fauna values:
  - assemblage characteristics: uniqueness, completeness and richness;
  - species of conservation significance;
  - recognition of ecotypes or vegetation/substrate associations (VSAs) that provide habitat for fauna, particularly those that are rare, unusual and/or support significant fauna;
  - patterns of biodiversity across the landscape; and
  - ecological processes upon which the fauna depend.
- Impacting processes:
  - habitat loss (leading to population decline and fragmentation);
  - habitat degradation (due to weed invasion);
  - ongoing mortality (leading to population decline);
  - species interactions (feral or overabundant native species);
  - changes in hydroecology;
  - altered fire regimes;
  - disturbance; and
  - bioaccumulation.

In 2015, Cameco commissioned Bamford Consulting Ecologists (BCE) to conduct an update of the impact assessment by reviewing previous reports on the fauna of the area, and revising and updating the species lists presented in earlier reports in terms of taxonomy and changes in conservation legislation. These reports are included in the appendices (BCE 2015a, BCE 2015b; Appendix G1 and G2).

Summary of previous work

A significant level of fauna survey activity has been completed by BHP Billiton and others prior to the acquisition of the Project by Cameco.

The Yeelirrie State Agreement area and surrounds have been extensively surveyed as summarised in Table 9-28 and Table 9-29. Observations on fauna were recorded at Yeelirrie Station during the previous mining trials (anon. 1978), and the Malleefowl Preservation Group (MPG) undertook systematic surveys for Malleefowl at Yeelirrie Station between 2000 and 2006 (Benshemesh *et al.* 2008).

Regional information on fauna was available from Cowan (2001), who reported on vertebrate fauna, and particularly those of conservation significance, in the Murchison subregion. Thompson and Thompson (2006) prepared an inventory of 131 reptile species from a ten year survey covering the area from Wiluna, south to Norseman, west to Merredin, and east to Laverton. Dell *et al.* (1998) summarise the results of surveys of fauna of the Eastern Goldfields undertaken from 1979 to 1981 by the Biological Surveys Committee of Western Australia. In addition to these databases and regional studies, there is information on fauna of Wanjarri Nature Reserve, 50 km east of Yeelirrie (DPaW 2015).

Information from the above sources was supplemented with species expected in the area based on general patterns of distribution. As per the recommendations of EPA (2004), the nomenclature and taxonomic order presented are based on the Western Australian Museum's (WAM) Checklist of the Fauna of Western Australia 2015. The authorities used for each vertebrate group were: amphibians (Doughty and Ellis 2014a), reptiles (Doughty and Ellis 2014b), birds (Johnstone 2013) and mammals (How *et al.* 2013).

Surveys were undertaken by BCE in March 2009, July 2009 and November 2009 (Appendix G3), and included all the major habitats present in the study area (Table 9-29). These surveys involved detailed assessment of 15 sites and were considered equivalent to a Level 2 survey as described in EPA Guidance Statement No. 56 (EPA 2004). In May 2010, BCE conducted targeted and systematic transect searches for conservation significant fauna (e.g. Black-flanked Rock-Wallaby, Mulgara and Malleefowl) (BCE 2011a) (Appendix G3). Other fauna surveys conducted in the region include Rosslyn Hill (70 km north of the study area, (BCE 2014) and near Wiluna (KLA 2012; Outback Ecology 2011). Where relevant, the results of these surveys have been included in the fauna assessment.

Recent work

In 2015, BCE conducted a review of the existing information on the fauna of the Project Area to confirm the extent and validity of the historical work and to revise and update the species lists. The review included a desktop literature review and an extensive site inspection undertaken in March 2015.

The purpose of the field surveys was to supplement existing information compiled from the desktop review, in particular, to determine the fauna assemblages utilising the habitats of the study area and to target species of conservation significance. A summary of the results of these surveys is provided in BCE (2015a) (Appendix G1)

It is important to note that the species lists generated from the desktop review include records drawn from a large region and possibly from environments not represented in the study area. In general, however, species identified by the desktop review process are considered to be potentially present in the study area whether or not they were recorded during field surveys.

Sources of information used for the fauna assessment are listed in Table 9-28. Database searches for State-listed fauna included the WA DPaW Naturemap (incorporating the Western Australian Museum's FaunaBase and the DPaW Threatened and Priority Fauna Database), Birds Australia's Atlas Database and the Atlas of Living Australia Database.

Table 9-28: Sources of information used for the desktop assessment.

Information source	Types of records held on database	Area searched (year)
Database searches		
NatureMap (DPaW 2015)	Records in the WAM and DPaW databases. Includes historical data and records on Threatened and Priority species in WA.	Site plus 40 km buffer (Searched January 2015).
BirdLife Australia Atlas Database (Birdlife Australia 2015)	Records of bird observations in Australia, 1998-2014.	One degree square containing site (Searched January 2015).
Atlas of Living Australia (ALA 2015)	Records held in Australian Museums and government departments.	Yeelirrie study area and surrounds (Searched January 2015).
Malacology and Terrestrial Invertebrate Database (WAM 2009)	Records of the WAM.	Between 26°30' S to 27°30' S, and 119°00' E to 121°00' E. (Searched 2009)
Previous reports		
Vertebrate Fauna Assessment Yeelirrie Project - Baseline Report (BCE 2011a) (Appendix G3)	Detailed Fauna Assessment of the Yeelirrie Study Area, conducted by BCE in 2009 and 2010.	Yeelirrie study area (2009–2010).
Proposed Yeelirrie development Short-range endemic invertebrate baseline Survey (Ecologia 2011a) (Appendix G4)	Detailed Invertebrate Fauna Assessment of the Yeelirrie Project, conducted by Ecologia in 2009 and 2010.	Yeelirrie study area (2009–2010)
Fauna Assessment of the Rosslyn Hill Mine (BCE 2014)	Detailed Fauna Survey conducted by BCE in late 2014.	Rosslyn Hill mining, 70 km north of Yeelirrie study area (2014).
Fauna Assessment at Wiluna West (KLA 2012)	Detailed Fauna Survey conducted by KLA in late 2011.	Wiluna West project, approximately 40 km north of Yeelirrie study area (2011).
Fauna Assessment at Wiluna Uranium Project (Outback Ecology 2011)	Detailed Fauna Survey for Toro Energy Limited Wiluna Uranium Project	Wiluna, approximately 60 km north-west of Yeelirrie study area (2011).
Fauna Assessment of Lorna Glen (DPaW 2015; Cowan 2008)	Species recorded on Lorna Glen station which contains several habitats similar to those found at Yeelirrie (J. Turpin, pers. obs.)	Lorna Glen approximately 180 km north-west of Yeelirrie study area (2008–2014).

Table 9-29: Vertebrate and invertebrate fauna survey techniques, dates and sampling effort

Survey technique	Total sampling effort	22-30 March 2009	17-22 July 2009	2-11 Nov 2009	6-11 May 2010	13-18 March 2015
Pitfall traps	1,115 trap-nights	X		X		
Elliott traps (including targeted trapping for Mulgara)	835 trap-nights	X		X		
Funnel traps	695 trap-nights	X		X		
Cage traps	100 trap-nights	X				
Bird census	Mornings over ten days at 149 locations with 1,115 census events	X		X		
Harp traps and Anabat echolocation detection	5 nights	X		X		
Motion sensitive cameras	33 nights	X	X	X		
Spotlighting	2 hours/night over 4 nights	X		X		
Targeted searches for Black-flanked Rock-Wallaby	35 hours over 5 days. 2 hours in March 2015	X	X	X	X	X
Targeted searches for Mulgara	80 hours over 9 days. Opportunistic in March 2015	X	X	X	X	X
Targeted searches for Malleefowl	80 hours over 9 days. Opportunistic in March 2015	X	X	X	X	X
Searches for evidence of other conservation significant species	Opportunistically over 19 days in 2009/2010, and over 4 days in 2015.	X	X	X	X	X
Opportunistic observations and searches	During all survey periods	X	X	X	X	X
Targeted searches for the Slender-billed Thornbill and Striated Grasswren	10 hours over 2 days in March 2015. Similar effort in 2009					X
Targeted searches for the Shield-backed Trapdoor Spider and other invertebrates of conservation significance	19 hours over 4 days in March 2015 (BCE). Previous intense surveys by Ecologia in 2009 and 2010 (see 9.3.3.2 below)					X

9.3.3.2 Invertebrate fauna

Invertebrate species considered to be short range endemics (SREs) are of conservation significance, however many have no legislative or published recognition and their significance is based on interpretation of SRE distribution information (Conservation significance Level 3). Harvey (2002) defines invertebrates as SRE species if they have a distribution of <10,000 km^2, and notes that the majority of species that have been classified as SREs have common life history characteristics such as poor powers of dispersal or confinement to discontinuous habitats. Several groups, therefore, have particularly high instances of SRE species: terrestrial Gastropoda (snails and slugs), Oligochaeta (earthworms), Onychophora (velvet worms), Araneae (mygalomorph spiders), Pseudoscorpionida (pseudoscorpions), Schizomida (schizomids), Diplopoda (millipedes), Phreatoicidea (phreatoicidean crustaceans) and Decapoda (freshwater crayfish). The poor understanding of the taxonomy of many of the SRE species hinders their conservation (Harvey 2002).

The species distribution for invertebrates was assessed on a regional basis (Murchison bioregion) since specific knowledge of invertebrate diversity is limited within the Project footprint and surrounding local areas. Therefore, the list of species obtained from database searches represents invertebrate species (targeting SREs) with the potential to be present in the study area. This is particularly important for significant invertebrate species that are often sparse and hard to find. In addition, a search of the Malacology and Terrestrial Invertebrate Database (Western Australian Museum) was conducted for the area (26°30' S to 27°30' S, and 119°00' E to 121°00' E).

Invertebrate fauna sampling

Previous work

During 2009 and 2010, invertebrate fauna assessments were conducted at the Yeelirrie study area (Ecologia 2011a; 2011b) (Appendix G4). The surveys were conducted in accordance with Guidance Statement No. 20: Sampling of Short-range Endemic Invertebrate Fauna for Environmental Impact Assessment in Western Australia (EPA 2009). Invertebrate survey methodology and effort is provided in Ecologia (2011a; 2011b) (Appendix G4). Other surveys conducted in the region include at Rosslyn Hill (70 km north of the study area, BCE 2014) and near Wiluna (KLA 2012; Outback Ecology 2011). Where relevant, the results of these surveys were drawn upon to develop this fauna assessment.

Recent work

In 2015, Cameco commissioned BCE to carry out a review of the existing information on the invertebrate fauna of the area and to revise and update the species lists presented in the earlier reports in terms of taxonomy and changes in conservation legislation. An extensive site inspection (four days) was undertaken in March 2015 with particular emphasis on searching for signs of conservation significant invertebrate species within the study area (BCE 2015b; Appendix G2).

During this site inspection, locations where *Idiosoma* sp. had been found by Ecologia were targeted in order to characterise the environment with which this species is associated, and to collect specimens to confirm the identification and determine the relationship of the species to the Shield-backed Trapdoor Spider *Idiosoma nigrum*. The Shield-backed Trapdoor Spider is listed under both State and Federal legislation, but Ecologia concluded the taxon they found at Yeelirrie was a related, undescribed but therefore unlisted species, although likely to be an SRE.

9.3.4 Existing Environment

Regional Context

The area of the proposed Yeelirrie development lies within the Eastern Murchison subregion of the Murchison Bioregion. The Murchison Bioregion falls within the Bioregion Group 2 classification, which is described as areas of 'native vegetation that are largely contiguous but are used for commercial grazing' (EPA 2004).

The key features of the region with relevance to terrestrial fauna are as follows:

- A north-west to south-east palaeo-valley with granite breakaways and a valley floor characterised by outcropping calcrete rises and a series of flats and clay flats. The margins of the calcrete system are surrounded by numerous irregular small to large playas that run approximately parallel to the calcrete expression.
- The vegetation of the region reflects its semi-arid climate, including Spinifex grasslands, Acacia and Mulga woodlands and some areas of the calcrete rises supporting open eucalypt woodland.
- There is widespread evidence of habitat modification and fragmentation through livestock grazing, introduced animal and plant species and altered fire regimes.
- Only 1.4% of the subregion is vested within conservation reserves (Cowan 2001). These are the Lake Mason and Kaluwirri Pastoral Leases, which lie approximately 30 km west of the Yeelirrie study area, and the Wanjarri Nature Reserve located 50 km east of the Yeelirrie study area.

9.3.4.1 Fauna habitats

BCE (2011a) describes eight major Vegetation and Substrate Associations (VSAs) (distinct environments that provide habitat for fauna) occurring across the Study Area (Figure 9-18):

- Granite Outcrops and Breakaways. Supporting mixed shrubland on gravelly/sand. Some areas of chenopod shrubland on heavier soil also present;
- Hardpan Mulga. Mulga woodland with poorly-developed understorey on hard loam soils;
- Calcrete. Low calcrete rises with Eucalypt open woodland (variable) over a sparse shrubland;
- Calcrete Outwash. Clayey-loam and clay flats, subject to occasional inundation with some open claypans. Vegetation includes Acacia open shrubland, sometimes with thickets of *Melaleuca xerophila*, and chenopod shrub-heaths;
- Chenopod Shrubland over Sandplain. These shrublands occur in sandy soils on the margins of playas in the southeast of the study area;
- Spinifex Sandplain. Sandplains dominated by Triodia hummock grasslands and scattered shrubs with areas of open Acacia/Eucalypt woodland;
- Mulga over Spinifex Sandplain. Mulga woodland over Spinifex on sandy-loam soils; and
- Acacia woodland over sparse Spinifex. Areas of dense Acacia woodland with or without a Spinifex understorey of variable density.

Further information on the flora and vegetation within the Study Area is provided in Section 9.1.

9.3.4.2 The Vertebrate Fauna Assemblage

The fauna assemblage of the Yeelirrie study area was generated and updated using previous reports in the area (BCE 2011a; 2014), relevant fauna databases, current literature and a site inspection in March 2015. The vertebrate fauna assemblage is expected to be composed of 294 species, including: 11 frog, 88 reptile, 156 bird, 30 native mammal and nine introduced mammal species (Appendix G1). Thirty-five of the species expected to occur in the region are of conservation significance. Field investigations have confirmed the presence of 173 fauna species, comprising of four frog, 49 reptile, 94 bird, 21 native mammal and five introduced species (BCE 2015a).

Overall, the assemblage of vertebrate fauna expected to occur reflects the transition zone from the Murchison to the arid interior. This assemblage contains both species typical of the Murchison area (e.g. Woolley's Pseudantechinus, Stripe-tailed Monitor) and species typical of the central deserts (e.g. Striated Grasswren), and some more typical of the south-west (such as the Grey Currawong, Regent Parrot and Malleefowl). As a result, a diverse fauna assemblage is expected to occur within the study area where ranges of species with predominantly southern, eastern or northern distributions overlap. Consequently, some fauna species expected in the region occur near the extreme edge of their range.

9.3.4.3 Vertebrate Fauna of Conservation Significance

Of the 35 conservation significant species which could potentially occur within the Yeelirrie study area, (Table 9-30), twenty-two species are of high significance (Conservation Significance [CS] Level 1), being listed under legislation; five are of moderate conservation significance (CS2), being listed as priority species by DPaW; and eight species of local significance (CS3), because they have restricted distribution or are listed as declining in the region. The list includes two reptile species, 27 bird species and six mammal species. Ten of the 35 species were confirmed by BCE as being present in the region during the surveys conducted in 2011 and 2015.

The categories used for the expected status of fauna in the study area include:

- **Resident**: species with a population permanently present in the survey area;
- **Regular migrant or visitor**: species that occur within the survey area regularly in at least moderate numbers, such as part of annual cycle;
- **Irregular visitor**: species that occur within the survey 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 survey area in at least moderate numbers and for some time;
- **Vagrant**: species that occur within the survey area unpredictably, in small numbers and/or for very brief periods. Therefore, the survey area is unlikely to be of importance 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 survey area.

The Northern Marsupial Mole (*Notoryctes caurinus*) is listed under Schedule 1 of the WC Act and as Endangered under the EPBC Act, but no suitable habitat for this species (i.e., sand dunes) is present in the study area or close to the study area. Searches of other databases found the species more than 400 km away (DPaW 2015). Therefore, this species has been omitted as potentially being present in the Project Area. The Oriental Plover (*Charadrius veredus*) listed under Schedule 3 of the WC Act is a migratory wetland species but is unlikely to occur in the study area, except possibly as a vagrant.

The suite of significant species includes many that are expected to occur only as vagrants or irregular visitors, and thus for which the site is of low importance, except where it may have value for connectivity. Some species, such as the Night Parrot, are unlikely to be extant in the Project Area but have been included in species lists based on previous records, distribution and suitable habitat. Conservation significant fauna species listed under State legislation are discussed in detail below. Further discussion of species listed under the EPBC Act is provided in Section 10.1.3. Locations of records of conservation significant fauna are provided in Figure 9-18. Potential impacts on fauna and proposed management actions are discussed in Section 9.3.5.

Table 9-30: Conservation status of significant vertebrate fauna species expected to occur in the Study Area (based on desktop reviews and surveys) and their expected status.

(Species recorded by BCE at Yeelirrie are indicated with 'X')

Common Name	Latin Name	Conservation Status (refer to Section 9.3.2)			Expected status in study area	Local records	BCE (2011a)	BCE (2015a)
		WC Act	P	CS3				
Conservation Significance 1 (CS1 – State listing only)								
*Malleefowl	*Leipoa ocellata*	S1			Resident	Yeelirrie	X	
*Black-flanked Rock-Wallaby	*Petrogale lateralis*	S1			Resident	Albion Downs	X	X
*Rainbow Bee-eater	*Merops ornatus*	S3			Regular migrant	Yeelirrie	X	X
*Fork-tailed Swift	*Apus pacificus*	S3			Irregular visitor	Yeelirrie		X
Peregrine Falcon	*Falco peregrinus*	S4			Resident	Yeelirrie	X	
Major Mitchell's Cockatoo	*Cacatua leadbeateri*	S4			Irregular visitor	Yeelirrie		
Grey Falcon	*Falco hypoleucos*	S1			Irregular visitor	Wanjarri		
*Princess Parrot	*Polytelis alexandrae*		P4		Irregular visitor	Wanjarri		
*Night Parrot	*Pezoporus occidentalis*	S1			Vagrant	None recent		
*Great Desert Skink	*Liopholis kintorei*	S1			Unknown	Wanjarri		
*Greater Bilby	*Macrotis lagotis*	S1			Vagrant	Wiluna		
*Eastern Great Egret	*Ardea modesta*	S3			Irregular visitor	Yeelirrie		
*Common Sandpiper	*Acitis hypoleucos*	S3			Irregular visitor	Meekatharra		
*Common Greenshank	*Tringa nebularia*	S3			Irregular visitor	Cue		
*Marsh Sandpiper	*Tringa stagnatalis*	S3			Irregular visitor	Cue		
*Wood Sandpiper	*Tringa glareola*	S3			Irregular visitor	Cue		
*Red-necked Stint	*Calidris ruficollis*	S3			Irregular visitor	Cue		
*Sharp-tailed Sandpiper	*Calidris acuminata*	S3			Irregular visitor	Yeelirrie		
*Curlew Sandpiper	*Calidris ferruginea*	S3			Irregular visitor	Lake Austin		

Common Name	Latin Name	Conservation Status (refer to Section 9.3.2)			Expected status in study area	Local records	BCE (2011a)	BCE (2015a)
		WC Act	P	CS3				
*Black-tailed Godwit	*Limosa limosa*	S3			Irregular visitor	Yeelirrie		
*Oriental Plover	*Charadrius veredus*	S3			Vagrant	None but returned from EPBC search		
Conservation Significance 2 (CS2)								
Australian Bustard	*Ardeotis australis*		P4		Resident	Yeelirrie	X	X
Striated Grasswren	*Amytornis s. striatus*		P4		Resident	Yeelirrie		
Brush-tailed Mulgara	*Dasycercus blythi*		P4		Resident	Yeelirrie	X	X
Long-tailed Dunnart	*Sminthopsis longicaudata*		P4		Resident	Rosslyn Hill		
Inland Long-eared Bat	*Nyctophilus major tor*		P4		Resident	Yeelirrie	X	
Conservation Significance 3 (CS3)								
Bush Stone-curlew	*Burhinus grallarius*			X	Resident	Yeelirrie	X	X
Square-tailed Kite	*Lophoictinia isura*			X	Resident	Yeelirrie	X	
Scarlet-chested Parrot	*Neophema splendida*			X	Irregular Visitor	Wanjarri		
Regent Parrot	*Polytelis anthopeplus*			X	Vagrant	Wanjarri		
Grey Honeyeater	*Conopohila whitei*			X	Resident	Wanjarri		
Rufous-crowned Emu-wren	*Stipiturus ruficeps*			X	Resident	Wanjarri		
Kultarr	*Antechinomys laniger*			X	Resident	Mount Keith		
Legless-lizard	*Aprasia picturata*			X	Resident	Wiluna		

* Also listed under the EPBC Act (Section 10.1.3)

WC Act listed species: S1 - S4 = Schedule 1 - 4,

DPaW Priority Species: P1 - P5 = Priority 1 - 5.

In addition, the Slender billed Thornbill (*Acanthiza iredalei*) which is not listed under the WC Act, but is listed as Vulnerable under the EPBC Act, has been recorded as an irregular visitor near Lake Way (Section 10.1).

State Listed Conservation Significant Species (CS 1)

Malleefowl (Schedule 1)

One Malleefowl mound was recorded within the study area by BCE during the field surveys (BCE 2011a). A recently used mound (based on the presence of eggshell fragments) was recorded amongst closed Acacia shrubland on the northern sandplain, approximately 2 km north of the resource area.

Additionally, the Malleefowl Preservation Group has conducted regular (annual) monitoring of Malleefowl mounds at Yeelirrie since 2000, with recent surveys conducted in 2013 and 2014 (Benshemesh *et al*. 2008; MPG 2014). Two active mounds from 40 known monitored mounds were recorded in 2013 and none in 2014, (Figure 9-18) indicating an extant population persists in the area.

Most known Malleefowl mounds are situated away from the orebody, within stands of dense Mulga woodland. A cluster of monitored mounds is located close to the study area, including approximately 10 km north of the orebody and 20 km south of the orebody but these are currently inactive (Figure 9-18).

Suitable habitat for this species does occur within the study area and development envelope, and a resident population is clearly present in the study area, with birds likely to at least move through the development envelope. Large areas of suitable habitat for this species occur outside the Project footprint.

At the periphery of a species' range, environmental conditions are typically stressful and populations are comparatively small and isolated (Scoble 2011). Yeelirrie lies near the northern limit of the Malleefowl's range (although a small population is known to the north at Lorna Glen, J. Turpin, *pers. obs.*). As such, the population at Yeelirrie is likely to be somewhat isolated and vulnerable to environmental change (BCE 2015a). The Yeelirrie population is likely to be small and therefore sensitive to the loss of a few individuals.

Black-flanked Rock-Wallaby (Schedule 1)

The Black-flanked Rock-Wallaby was known to occur in the region with several anecdotal reports of the species along the Barr Smith Range, and rock-wallaby scats were recorded from a cave within the Barr Smith Range, approximately 40 km east of the study area (BCE 2011a) (Figure 9-18). Several scats were collected during the 2015 assessment and forwarded to Australian Wildlife Forensic Services. Genetic analysis (White 2015) confirmed the species identification as the Black-flanked Rock-Wallaby (*Petrogale lateralis*), and most likely the sub-species *P. l. lateralis*.

The Black-flanked Rock-Wallaby relies on behavioural (occupying caves and exhibiting nocturnal foraging activity) rather than physiological responses for survival during adverse conditions (Bradshaw *et al*. 2001; King and Bradshaw 2008). As a result, sites containing permanent water (such as along the Barr Smith Range) are important for the species in the arid zone, allowing animals to occupy sub-optimal habitat with inferior thermal refuge (Pearson 2012). While much of the rocky habitat along the Barr Smith Range appears marginal, the presence of scattered waterholes in association with caves and rock crevices may allow the species to persist. While not expected to occur within habitats associated with the orebody, the species may persist in the extensive rocky habitats to the north and south (BCE 2015a). The assumed status of Black-flanked Rock-Wallaby remains "resident", although all scats located in 2015 were old and an extant population has not been located. There will be some disturbance to rocky habitats associated with the Barr Smith Range (e.g. quarry for access roads).

Night Parrot (Schedule 1)

The Night Parrot is included as potentially occurring due to the presence of suitable habitat and historical records. However an extant population is unlikely.

Great Desert Skink (Schedule 1)

The status of the Great Desert Skink is listed as Unknown. While no evidence of the species was recorded by BCE (2011a; 2015a), there is potential for the species to occur at Yeelirrie, due to the extensive availability of suitable habitat (spinifex sandplains) and records nearby (at Wanjarri Nature Reserve, DPaW 2015). The species has a clumped distribution which is influenced by fire regimes (McAlpin 1997).

Greater Bilby (Schedule 1)

There are anecdotal records of the Greater Bilby further north (e.g. Rosslyn Hill near Wiluna, BCE 2014), and the species is thriving at the DPaW managed Lorna Glen (J. Turpin, *pers. obs.*), approximately 180 km north-west of the study area. The Greater Bilby has a large home range and individuals can disperse widely (Southgate *et al.* 2007). As such, while no signs of Bilbies were recorded by BCE during field surveys, suitable habitat (spinifex sandplains) is extensive at Yeelirrie and it is feasible that individuals may move through the area currently, or in the near future.

Grey Falcon (Schedule 1)

The Grey Falcon is infrequently recorded over much of arid and semi-arid Australia and occurs at low densities (BirdLife International 2015). Regional records come from Wanjarri and Lorna Glen (DPaW 2015). The distribution of the Grey Falcon is centred on inland drainage systems and nests are usually in the tallest trees along watercourses. At Yeelirrie it is likely to occur as an occasional visitor only, as the site lacks the sort of tree-lined watercourses favoured by the species.

Peregrine Falcon (Schedule 4)

The Peregrine Falcon was recorded along a cliff ledge in the Barr Smith Range in 2009 (BCE 2011a) (Figure 9-18). The study area is likely to lie within the foraging territory of a pair, and these birds may nest on a cliff edge in the Barr Smith Range.

Major Mitchell's Cockatoo (Schedule 4)

The Major Mitchell's Cockatoo was formerly more widespread and is patchily distributed across its range (BirdLife Australia 2015). It has been formerly recorded at Yeelirrie, however BCE found no evidence of its occurrence and as such it is likely to be an irregular visitor.

Princess Parrot (Priority 4 – DPaW)

The Princess Parrot is considered a CS1 species due to its listing as Vulnerable under the EPBC Act (Section 10.1). At the State level it is listed as Priority 4 by DPaW. The Princess Parrot is an irregular visitor to the Yeelirrie area (sometimes at intervals of more than 20 years) and to most sites in its range (Garnett and Crowley 2000), and movements are largely unknown (Higgins 1999). The species has been recorded at Wanjarri Nature Reserve (DPaW 2015), however few other records exist for the region.

State Listed Migratory species (CS1)

Twelve migratory bird species (including two landbirds and ten waterbirds) listed under Schedule 3 of the WC Act, were identified as potentially occurring in the study area. These species are also listed as Migratory under the EPBC Act (Section 10.1).

Migratory landbirds

The Rainbow Bee-eater was recorded throughout the study area in 2009, 2010 and 2015 (BCE 2011a; 2015a). While of high conservation significance because of its listing as a migratory species under Schedule 3 of the WC Act and the EPBC Act, it is widespread across Australia and frequently uses disturbed environments.

The Fork-tailed Swift is likely to be an irregular visitor to the study area and was recorded at Yeelirrie during the 2015 survey, with two sightings of several (and possibly the same) birds (BCE 2015a). It is a highly aerial species and largely independent of terrestrial environments.

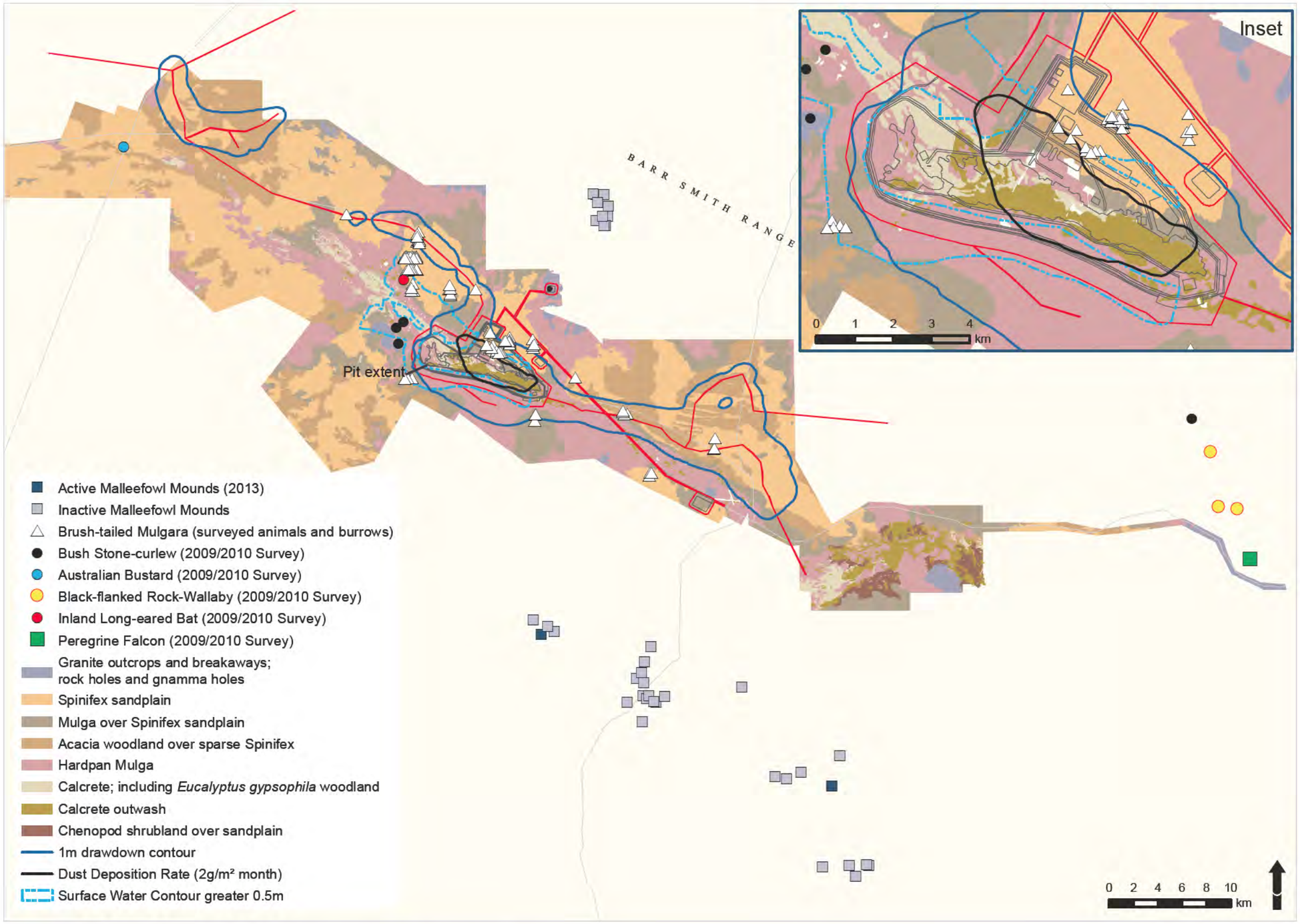

Figure 9-18: Locations of conservation significant fauna records across the Yeelirrie project

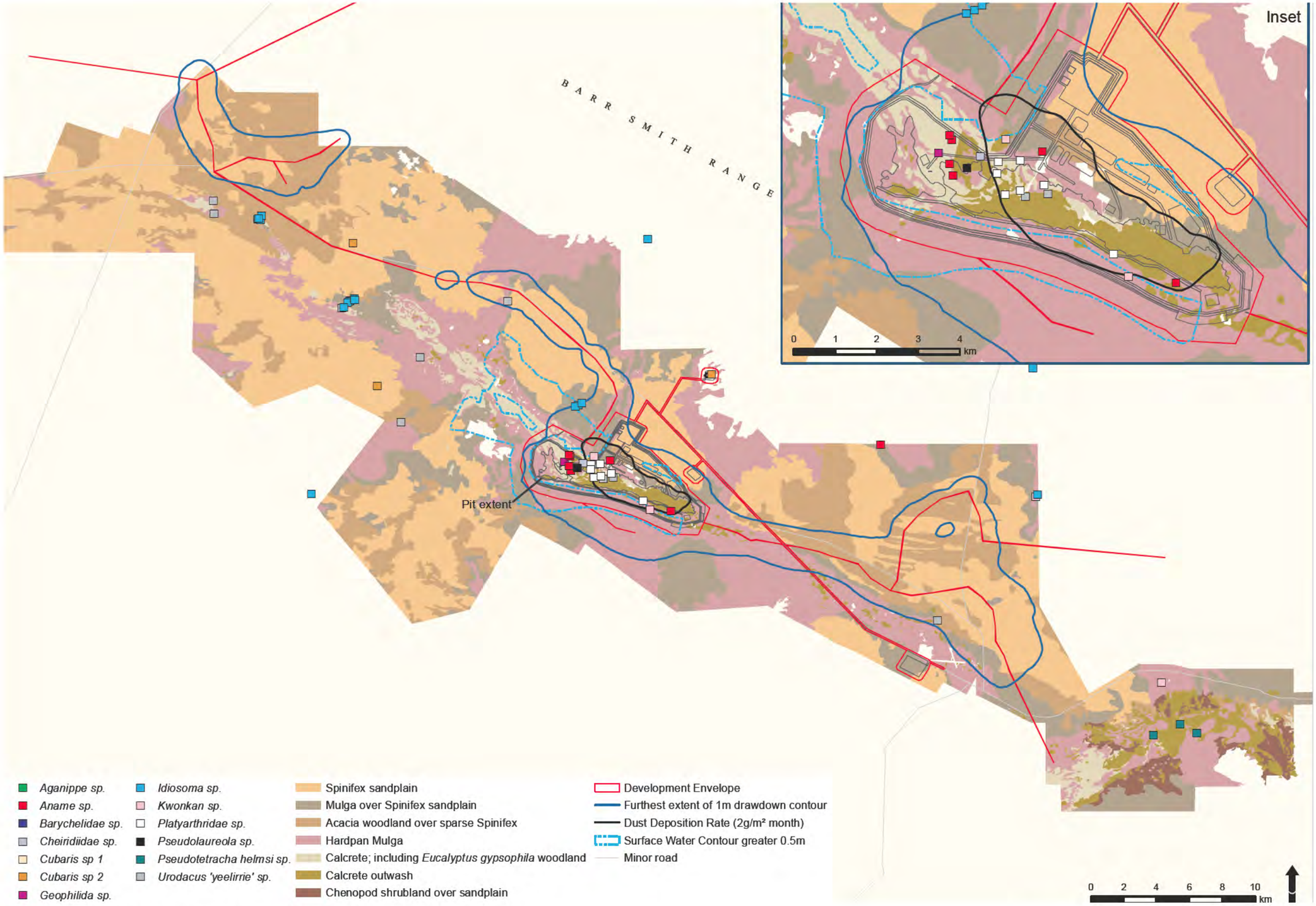

Figure 9-19: Short range endemic invertebrate fauna observations

Migratory waterbirds

Waterbirds listed as Migratory under Schedule 3 of the WC Act and under the EPBC Act, that may periodically utilise the study area during migration include the Eastern Great Egret, Oriental Plover, Common Sandpiper, Common Greenshank, Marsh Sandpiper, Wood Sandpiper, Red-necked Stint, Sharp-tailed Sandpiper, Curlew Sandpiper and Black-tailed Godwit. Of these, the Eastern Great Egret, Sharp-tailed Sandpiper and Black-tailed Godwit have been recorded in the area, although the godwit should be considered a rare vagrant as it is primarily a marine coastal species. The other species may utilise seasonal wetlands in the region irregularly; several seasonal wetlands were identified during a site inspection in March 2015 but no migratory waterbird species were observed (BCE 2015a).

All these migratory waterbirds (and other waterbird species expected to be present at least occasionally) may utilise seasonal or artificial waterbodies associated with the Project (e.g. the evaporation pond). The potential interaction of migratory waterbirds listed under the EPBC Act and the proposed Project is discussed in Section 10.1.4.

Species listed as Priority by the DPaW but not listed under legislation (CS2).

Australian Bustard (Priority 4)

The Australian Bustard was recorded throughout the Yeelirrie study area, particularly associated with spinifex sandplain. It was seen in 2009, 2010 and 2015 (BCE 2011a; BCE 2015a). It is a widespread species across much of the northern half of Australia.

Striated Grasswren (Priority 4)

While not recorded during the BCE surveys, there are three records of this species at Yeelirrie, including at a location approximately 5 km south of the orebody (BirdLife Australia 2015). This location was visited in March 2015 and while the environment appeared suitable, no birds were observed (BCE 2015a). This species has a highly patchy and fragmented distribution due to a reliance on mature spinifex grassland (Garnett *et al.* 2011) and can be difficult to detect. Given the Birdlife Australia record and the apparent suitability of the vegetation, it is likely to occur on the spinifex sandplains adjacent to the orebody.

Brush-tailed Mulgara (Priority 4)

The Brush-tailed Mulgara was recorded extensively across the Yeelirrie study area (BCE 2011a; 2015a) (Figure 9-18). It was most abundant within sandplain sites dominated by spinifex (and was absent from calcrete habitats). A total of 154 burrow systems was recorded in 842 ha of search area, equating to 0.18 burrows/ha; 86 burrows were active (0.1 burrows/ha, BCE 2011a). Suitable habitat for the Brush-tailed Mulgara comprises approximately 69.9 % (69,840 ha) of the study Area (BCE 2011a) and there are expected to be in excess of 6900 active burrow systems within this area (using the burrow densities observed at Yeelirrie). Brush-tailed Mulgara are generally considered to be solitary, with males and females found in the same burrow only during the mating season (van Dyck and Strahan 2008). Therefore, the study area may support several thousand Brush-tailed Mulgara.

Long-tailed Dunnart (Priority 4)

The Long-tailed Dunnart favours rocky habitats and is likely to occur within the breakaway systems to the north and south of the Yeelirrie orebody area. It was recorded on hills near Wiluna in November 2014 (BCE 2014).

Inland Long-eared Bat (Priority 4)

This species was recorded by BCE during the previous field surveys (BCE 2011a) and may rely on tree hollows within the *E. gypsophila* woodland subset of the Calcrete VSA.

Species not listed under legislation or in publications, but considered of at least local significance because of their pattern of distribution (CS3).

Eight species are considered to be of local conservation significance (CS3) due to restricted ranges,

- *Aprasia picturata* considered uncommon in the region;
- Square-tailed Kite, Kultarr, Grey Honeyeater*, Rufous-crowned Emu-wren*, Scarlet-chested Parrot*, which have been recorded near the limit of their range;
- Regent Parrot*; and
- Bush stone-curlew.

(*Recorded at the Wanjarri Nature Reserve, DPaW 2015).

The status of the Bush Stone-curlew was delisted in December 2014 from Priority 4 (DPaW) to unlisted, but is still considered locally significant as the species has suffered significant declines and is sparsely distributed in southern WA. The Bush Stone-curlew was recorded at several sites at Yeelirrie (BCE 2011a) and occurs both within habitats associated with the orebody and along drainage systems near rocky habitats associated with the Barr Smith Range. The species is moderately widespread and suitable habitat is extensive outside the study area.

9.3.4.4 Conservation significant invertebrate species

Ecologia (2011a, 2011b) conducted detailed invertebrate fauna assessments of the Yeelirrie study area during 2009/2010 and collected 42 species. Invertebrate surveys conducted by Ecologia (2011a) were reviewed by BCE in March 2015 (BCE 2015b; Appendix G2). Updated database searches and further field investigations identified 18 conservation significant invertebrates in the Yeelirrie study area (Table 9-31). This includes one species listed as Vulnerable under the EPBC and WC Acts, three confirmed SRE taxa and 13 species with the potential to be SRE taxa (based on the current but limited knowledge). Database searches revealed the possibility of at least one further listed species to occur, *Kwonkan moriartii* (Priority 4, DPaW), although three *Kwonkan* species were collected by Ecologia (2011a) and none was identified as *K. moriartii*. This suggests that *K. moriartii* may not be present and therefore it is not included in Table 9-31. Locations of conservation significant invertebrate species are provided in Figure 9-19).

Shield-backed Trapdoor Spider (Schedule 1)

The Shield-backed Trapdoor Spider (*Idiosoma nigrum*) was recorded from 17 locations at Yeelirrie by BCE (2015b) (Figure 9-19). This was the *Idiosoma* sp. recorded by Ecologia (2011a), but specimens collected in March 2015 were identified as the listed Shield-backed Trapdoor Spider by Phoenix Environmental (2015).

This species appears to occur in low densities but is widespread across the Yeelirrie lease, favouring Acacia shrublands with a sandy substrate to depth of at least 30 cm, and lacking the clay layer or hardpan that is common across much of the area. It appears to be absent from the grey loamy-clay soils around some calcrete areas and in the main development footprint. Spiders also appear absent from shallow, rocky soils of the Barr-Smith Range. The nearest other known records of the species come from Weld Range (approximately 200 km to the west), where it is restricted to the slopes of ironstone ridges (BCE 2015b).

The Shield-backed Trapdoor Spider occurs at Yeelirrie in apparently much lower densities than those observed elsewhere. The species has been recorded in densities of 50 - 400 spiders per hectare in suitable habitat on banded ironstone ridges of the Midwest (BCE 2011c). However, at Yeelirrie densities appear to be much lower, with typically only one or two spiders recorded across a number of hectares. At Yeelirrie, the spider does not appear to form matriarchal clusters, which is perhaps an artefact of low recruitment rates (BCE 2015b).

Table 9-31: Conservation status of significant invertebrate species recorded in the region. Records within and outside the disturbance footprint are noted. (based on Ecologia 2011a; BCE 2015b)

Taxa	Species Name	Conservation Status	Disturbance Footprint Collection		Vegetation and Substrate Association type					
			In	Out	HM	C	CO	SS	PB	PY
Mygalomorph	Shield-backed Trapdoor Spider **Idiosoma nigrum*	CS1 Schedule 1	Yes	Yes				X		
Isopod	Platyarthridae/ Bathytropidae	Confirmed SRE	Yes	No	X	X	X			
Isopod	*Pseudolaureola* sp.	Confirmed SRE	Yes	No			X			
Carabidae	Tiger beetle *Pseudotetracha helmsi*	Confirmed SRE	No	Yes						X
Mygalomorph	*Aganippe* sp.	Potential SRE	No	Yes	X					
Mygalomorph	*Aname* 'MYG170'	Potential SRE	Yes	No	X	X	X			
Mygalomorph	*Aname* 'MYG212'	Potential SRE	Yes	Yes			X	X		
Mygalomorph	Barychelidae	Potential SRE	Yes	No			X			
Mygalomorph	*Kwonkan* 'MYG171'	Potential SRE	Yes	No	X					
Mygalomorph	*Kwonkan* 'MYG172'	Potential SRE	Yes	No		X			X	
Mygalomorph	*Kwonkan* 'MYG210'	Potential SRE	No	Yes	X					
Mygalomorph	*Kwonkan* 'MYG211'	Potential SRE	No	Yes	X					
Scorpion	*Urodacus* 'yeelirrie'	Potential SRE	Yes	Yes	X	X	X			
Pseudoscorpion	Cheiridiidae	Potential SRE	Yes	No			X			
Isopod	*Cubaris* sp. 1	Potential SRE	Yes	No		X				
Isopod	*Cubaris* sp. 2	Potential SRE	Yes	Yes	X		X			
Centipede	*Geophilida*	Potential SRE	Yes	No	X					

* Also listed under the EPBC Act.

Vegetation and Substrate Associations (VSA) types = HM (Hardpan Mulga), C (Calcrete), CO (Calcrete Outwash), SS (Spinifex Sandplain), PB (Play B), PY (Playa Yeelirrie). VSA types are described in Section 9.3.4.2.

Isopod. Platyarthridae/Bathytropidae

Sixteen specimens of an undescribed slater genus and species from either the family Platyarthridae or Bathytropidae were collected from within the Project footprint, and were found within the Calcrete, Calcrete Outwash and Hardpan Mulga habitats (Ecologia 2011a). These families are poorly known in Australia and Western Australia with only one described species from each (Ecologia 2011a). The undescribed genus from Yeelirrie is considered to be an ancient Gondwanan group, and all of the previous examples of this morphology have been considered a SRE. Likewise, this species is considered to be a SRE (Ecologia 2011a) (Figure 9-19).

Isopod. Pseudolaureola sp

The Isopod *Pseudolaureola* sp. was collected from Calcrete Outwash (within the proposed mine footprint) and is thought be an undescribed species. The genus is considered a relictual taxon of the Gondwanan rainforest and all known species in the genus are SREs, therefore it is highly likely that this species is also a SRE (Ecologia 2011a).

Tiger beetle - *Pseudotetracha helmsi*

The tiger beetle *Pseudotetracha helmsi* was collected at three sites from the Yeelirrie Playa (Figure 9-19). Tiger beetles are predatory and some are known to have restricted distributions around ephemeral salt lakes (Ecologia 2011a). This species was previously known only from a few salt lakes located in the Murchison Bioregion and is considered a SRE. A tiger beetle collected by BCE at Sir Samuel salt lake in March 2015 was *Megacephala* sp. and is not considered an SRE (Phoenix Environmental 2015).

Other potential SRE invertebrates

A further 13 invertebrate species have the potential to be SREs (Table 9-31). However, due to the limited survey work in the region and therefore limited information on distribution, habitat and taxonomy, this cannot be confirmed; their possible SRE status may simply be an artefact of the lack of regional collection. The 13 species nominated as potentially SREs were classified based on their biology or taxonomy (Ecologia 2011a). Some appeared to be habitat-limited, while several specimens collected by Ecologia could not be identified to species level due to the poor taxonomic knowledge of such groups, but are considered potential SREs because of biology or knowledge of closely related species (i.e. closely related species have restricted distributions). Additionally, some undescribed species were collected from the Yeelirrie area (e.g. the spider *Aname*, the scorpion *Urodacus* 'Yeelirrie', the pseudoscorpion (Family Cheiridiidae) and two species of isopod *Cubaris*), and as such their distribution and SRE status are unknown.

9.3.4.5 Patterns of Biodiversity

The fauna assemblage varied in its distribution across the VSA types. Reptile species richness and abundance were highest on spinifex sandplain and in part of the calcrete VSA where *Eucalyptus gypsophila* formed an open woodland. Bird species richness and abundance were highest in this *E. gypsophila* woodland and in the two VSAs containing Mulga. With the exception of the *E. gypsophila* woodland subset of the Calcrete VSA, most of these VSAs are extensive outside the fauna study area. The rocky breakaways and outcrops away from the orebody support restricted species (such as the Black-flanked Rock-Wallaby, Long-tailed Dunnart, Woolley's Pseudantechinus) and the seasonal wetlands (playas) are likely to support irregular visits of migratory waterbirds.

A habitat analysis by Ecologia (2011a) showed no statistically significant difference between SRE species diversity and habitat type inside and outside the Project footprint. SRE species distribution depends on micro habitats ('island' habitats) rather than broadscale habitat types. Furthermore, all of the habitat types extend beyond the proposed Project Development Envelope indicating a potential for all species to be found outside the Project.

9.3.4.6 Key Ecological Processes

One of the dominant ecological processes currently affecting the fauna assemblage in the study area is hydrology, with other processes including fire, feral species and interactions with native species, habitat degradation due to weed invasion and connectivity. Long-unburnt habitats are important for some species, including the Malleefowl, Striated Grasswren and Shield-backed Trapdoor Spider.

9.3.4.7 Introduced Fauna

The desktop study identified nine introduced fauna species as potentially occurring in the Yeelirrie study area. Six species were recorded during the field surveys (BCE 2011a; 2015a). The European red fox is considered absent by the caretakers at Yeelirrie and appears to be very uncommon. Wild dogs/dingoes appear to be common and those seen have been of a consistent appearance, suggesting the level of interbreeding between domestic dogs and dingoes is low. The feral cat and rabbit were confirmed as resident and the camel and cattle confirmed as irregular visitors. The house mouse, donkey, horse and goat are expected to be resident, although goat numbers can be strongly suppressed by dingoes.

Predation by feral species is a major factor in the decline of Australian mammals (Burbidge and McKenzie 1989). Introduced herbivores can significantly alter the vegetation composition and thus fire regimes, in turn affecting native fauna that rely on these habitats. Dingoes can suppress the numbers of foxes, goats and feral cats, but the dingo is also an efficient predator.

9.3.5 Potential Impacts and Management

The impact assessment process is described in detail in BCE (2011a). While some impacts are unavoidable during a development, of concern are long term, deleterious impacts upon biodiversity and reflected in documents such as the Significant Impact Guidelines (DoE, 2013). Significant impacts may occur if:

- there is direct impact upon a VSA and the VSA is rare, a large proportion of the VSA is affected and/or the VSA supports significant fauna;
- there is direct impact upon conservation significant fauna; and
- ecological processes are altered and this affects large numbers of species or large proportions of populations, including significant species.

The impact assessment process therefore involves reviewing the fauna values identified through the desktop assessment and field investigations with respect to the Project and impacting processes. The severity of impacts on the fauna assemblage and conservation significant fauna can then be quantified on the basis of predicted population change.

9.3.5.1 Impacts to VSAs

Eight major VSAs were identified across the Yeelirrie Study Area and surrounding landscape (Figure 9-18 and Figure 9-19). Hardpan Mulga, Spinifex Sandplain, Calcrete Outwash, Mulga over Spinifex Sandplain and Calcrete dominate most of the disturbance footprint with much smaller areas of rocky breakaway also included. The uranium orebody is situated within the calcrete habitats, which are regionally uncommon although not restricted to the study area. Potential impacts on the general vertebrate fauna assemblage are likely to be greater in the *E. gypsophila* woodland subset of the Calcrete habitat, which has a high proportional representation in the study area. Other VSAs in the study area, such as the mulga and spinifex sandplains are widespread.

Areas of each VSA within the study area are given in Table 9-32 (BCE 2011a). The original disturbance footprint proposed by BHP Billiton, which correlates to Cameco's development envelope (Figure 6-2), was centred on the calcrete and calcrete outwash VSAs and extended on the adjacent sandplain and hardpan mulga. Minor areas of granite outcrop / breakaway are proposed for disturbance (17 ha), and the sandplains supporting chenopod shrubland (in the south-east) occurred outside the proposed disturbance. Proposed disturbance to the VSAs within the study area are outlined below (Table 9-32).

Cameco has looked at the potential maximum worst-case impacts on VSAs as a result of clearing, dust deposition, groundwater drawdown and inundation as a result of altered surface drainage patterns. Table 9-32, Figure 9-18 and 9-19 present the potential indirect impacts of the Project. Table 9-30 quantifies the potential worst case impact on habitat when considering groundwater drawdown (>1 m drawdown), dust deposition (>2 g/m^2/month) and surface water impacts (>0.5 m flooding during a 1:1000 year ARI).

Table 9-32: Areas of VSAs within the Study Area and disturbance footprint

			Direct Impacts (ha)	Additional area potentially affected by indirect impacts (ha)			
VSA Type	Study Area (ha)	Inside Development Envelope (ha)	To be cleared	Dust Deposition (>2 g/m²/month)	Groundwater drawdown (>1 m drawdown)	Surface Water (>0.5 m flooding after 1:1000 year ARI)	Worst Case percentage impacted (%)
Granite Outcrops and Breakaways	1,866	53.2	17 (0.9%)	0	0	135.3	8.2
Spinifex Sandplain	38473	910.7	612 (1.6%)	0	NA	527.2	3.0
Hardpan Mulga	21,230	1798.6	738 (3.5%)	0	NA	985.5	8.1
Calcrete	2,819	540.6	216 (7.7%)	0	13.0	329.5	19.9
Calcrete Outwash	3,095	685.7	548 (17.7%)	0	149.8	42.5	23.9
Chenopod Shrubland over Sandplain	1,215	0	0 (0%)	0	0	0	0
Acacia Woodland over Sparse Spinifex	17178	130.6	64 (0.4%)	0	4910	0.1	29.0
Mulga over Spinifex Sandplain	14186	659.7	145 (1.0%)	19.5	NA	906.8	7.6

The following should be noted when considering the worst case scenario on habitat:

- highly unlikely to occur;
- indirect impacts to habitat do not necessarily correlate to fauna impacts;
- dust impacts outside the Development Envelope are negligible;
- impacts of groundwater drawdown will not affect all species within the habitat; and
- impacts to habitat as a result of a 1:1000 year ARI event are likely to be temporary.

The likelihood of indirect impacts affecting conservation significant species is discussed further below.

9.3.5.2 Impacting processes

The following sections examine possible impacts upon fauna values based upon the impacting or threatening processes outlined in Bamford (2015a).

The key threatening processes are:

- habitat loss (leading to population decline and fragmentation);
- habitat degradation (due to weed invasion);
- mortality (leading to population decline);
- species interactions (feral or overabundant native species);
- hydroecology (including introduction of project-related water sources);

- altered fire regimes;
- disturbance; and
- bioaccumulation.

Loss of habitat leading to population decline

Some loss of habitat is inevitable but can be minimised through controls during clearing. Rehabilitation of disturbed areas may also be implemented as soon as possible after clearing. The small area of impact in relation to the surrounding landscape means that loss of VSAs is unlikely to have long term adverse impacts upon vertebrate fauna populations in the region. The *E. gypsophila* woodland subset of the Calcrete VSA 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 VSAs but the consequence of Project development may be a localised decline in population size of otherwise common species. Some SRE invertebrate species appear to have a high reliance on the Calcrete VSA with a resultant impact classed as Moderate (Table 9-34).

Loss of habitat leading to population fragmentation

Some landscape features within the development envelope may have a connectivity function for fauna, aiding them to move through the landscape. Therefore, impacts upon these features could disrupt this movement, facilitating population fragmentation. For example, the remaining patches of *E. gypsophila* woodland would be fragmented and this may affect the ability of some fauna species to move across the landscape. Such connectivity can be important for vertebrate fauna in which population size is low and thus population isolation can increase the risk of local extinction, but fragmentation is not considered a risk to vertebrate species in the area. The Slender-billed Thornbill is reliant on chenopod shrublands, but has not been recorded at Yeelirrie.

Degradation of habitat due to weed invasion

Weed invasion of the development envelope is currently minimal.

Ongoing mortality

Increased mortality is inevitable during clearing and from ongoing activities, such as roadkill due to animals being struck by vehicles, or birds striking infrastructure entrapment of fauna in open excavations and fauna attracted into production areas (e.g. in search of food, such as dead insects underneath lights, or water). In general, areas to be cleared are small within the context of the regional landscape so mortality during clearing is likely to represent only small proportions of regional populations. For common species, levels of mortality are unlikely to be significant in a conservation sense, but there are welfare issues. However, the viability of species that occur at low population densities in areas adjacent to the development envelope may be compromised by ongoing mortality. For example, a population of Malleefowl is present in the development envelope, while Black-flanked Rock-Wallabies may also persist. In populations that could be as low as 10 or 20 animals, roadkill is a concern and even the loss of one or two individuals can be significant.

Species interactions

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). Interactions between dingoes and foxes mean that fox numbers can increase if dingo numbers decline. 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.

Existing stock watering points have been decommissioned as part of the station's environmental management, however 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, could occur due to the provision of fresh watering points. Harrington (2002) found the presence of artificial fresh water points in the semi-arid mallee rangelands influences 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.

The dingo was recorded along the Barr Smith Range. Dingoes contribute to ecosystem stability by suppressing introduced predators (feral cat and fox) and herbivores (rabbit and feral goat, Dickman *et al*., 2009). This species may be playing an important role in the survival of the Black-flanked Rock-Wallaby along the Barr Smith Range and any management of feral species may need to consider this role.

Hydroecology

Impacts to fauna species may occur if interruptions to hydroecological processes affect VSAs. The two Mulga VSAs (Hardpan Mulga and Mulga over spinifex on sandy loam) are likely to be reliant on surface and sub-surface flows that may be altered by clearing, earthworks and drainage management. Several vegetation types within the Study Area (e.g. *E. gypsophila* woodland on the Calcrete VSA) are expected to be reliant on groundwater (Section 9.1.4) and may be affected by groundwater drawdown as a result of pit dewatering and operation of the water supply wellfield.

An assessment of the potential impacts from the 50 ha evaporation pond on migratory waterbird species was conducted by BCE (2015a). The development of the evaporation pond would establish a new and large artificial water body in an arid area and may attract numbers of waterbirds.

The evaporation pond will be approximately 1,000 m by 500 m and up to 5 m deep. The pond will be constructed from local earth and rock material with steep slopes and will be fenced.

Predicted mineral concentrations within the evaporation pond are expected to change over the life of the mine. Initially, the pH is predicted to be 10.64 (alkaline) with discharge of up to 42,632 t/ hr (at 1.07 t/m^3), with a salinity similar to seawater (31.05 g/L). Salinity is likely to increase to approximately ten times that of seawater over the life of the mine.

The evaporation pond has some potential to attract wildlife. Migratory waterbirds, including sandpipers, often live in environments where the only available drinking water is seawater but will drink water of lower salinity if available. If salinity stratification occurs, the surface layer of water may be palatable to some wildlife and the possibility exists of a lens of low salinity water forming at the surface following heavy rain, or from the accumulation of low salinity groundwater. However, these effects are likely to be offset by mixing following rain, and by evapo-concentration at other times. If exceptional rainfall did create a layer of near-fresh water, this would occur at a time when numerous other and more attractive/accessible sources of fresh water would be available in the region, including the numerous claypans within the study area. In comparison to natural water bodies, evaporation ponds are expected to be characterised by steep banks, which lack shallow sandy shores, riparian vegetation (habitat) and shade, and therefore less attractive to fauna.

In the modelling of the water quality, it was assumed that water will come to the evaporation pond after a settling period in the tailings storage facility of and will contain dissolved constituents only. The model considers the changing salinity and metals concentrations as additional tailings liquor and water from other sources is added.

The total dissolved solids (TDS) of the tailings slurry was predicted to be 106 g/L (URS, 2015). A number of scenarios of cycling evaporation and filling of the pond were modelled with similar results in that they both reach 200 g/L after just over one year. The uranium concentrations also show similar results between the two scenarios. The model predicts that uranium reaches 130 mg/L approximately. For both scenarios the model predicts the precipitation of several carbonates, including magnesium carbonate ($MgCO_3$), dolomite ($(CaMg))CO_3)_2$) and strontianite ($SrCO_3$).

- Frequent cycling of an evaporation cell between its operating volume (90% maximum volume) and its minimum transfer volume (80% maximum volume) resulted in a TDS of 200 g/L in approximately 1 year;
- The model shows that three solid phases dominate the precipitated solids, dolomite ($CaMg(CO_3)_2$), magnesite ($MgCO_3$), and strontianite ($SrCO_3$). The precipitation of the solids does not seem to significantly affect the pH of the water in the evaporation cell;
- The pH of the evaporation cell was maintained at about 9.5 with total evaporation of 10% and 34%. Even when 80% of the cell was evaporated, the pH and chemistry did not change significantly;
- Higher volume evaporation and transfers did not change the time it took to reach a TDS of 200 g/L;
- Uranium steadily increases in concentration through the life of the cell reaching about 130 mg/L at 200 g/L salinity;
- The high concentration of carbonates keeps uranium in solution by forming stable uranyl carbonates; and
- There is evidence to suggest that radium-226 significantly adsorbs to oxidized forms of iron and will remain bound to solids in the TSF.

Based on the modelling, uranium concentrations in the evaporation pond water is expected to increase to aroun 130 mg/L which is approximately double the Uranium No Observable Impact Level (NOAEL) benchmark of 68.8.mg/L for drinking water for birds, although how concentration change over time will need to be monitored. However, give the salinity levels of the pond water, it is unlikely that birds would consume the pond water. Note that the presence of a water body in an arid landscape will attract passing waterbirds at least occasionally, even if the water is completely unpalatable. A consequence of this could be occasional and largely unavoidable bird deaths, as some such passing waterbirds are likely to be weak and would be unlikely to survive under normal circumstances. In the Australian arid zone, dead waterbirds are quite commonly encountered beside roadside puddles and even on dry lake beds (M. Bamford *pers. obs*.).

Several deterrents will be used to discourage waterbirds from the evaporation pond and will be outlined in a Fauna Management Plan to be developed for the Project. Bird deterrents are used at the Olympic Dam mine site, South Australia, where acidic liquid is stored. A rotating beacon with an intermittent beam directed at a shallow angle across the water surface (in combination with gas guns) effectively discouraged most waterbirds (Read 1999).

Further mitigation measures include:

- conducting an ecological risk assessment of the evaporation ponds;
- implementing a water quality monitoring program and adapting fauna management strategies (e.g. bird deterrents) based on the outcomes of the program;
- monitoring bird visitation of the evaporation ponds and reporting fauna deaths; and
- fencing off the evaporation ponds from terrestrial mammals to minimise exposure during the initial period when the salinity of the water is close to sea levels.

If mitigation measures are successfully implemented, impacts on migratory water birds are expected to be minor.

Potential loss of habitat due to impacts on phreatophytic vegetation

As detailed in Table 9-12 (see Section 9.1), there is approximately 7,134.2 ha of phreatophytic vegetation associations within the Local Study Area. Of this potentially 1,388.4 ha will be impacted, experiencing a drawdown >1 m, through dewatering and water supply activities. Potential impacts to fauna as a result of this impact include:

- Malleefowl are associated with both Acacia shrubland and Mulga woodland, which are potentially phreatophytic. Areas of suitable habitat for this species occur within the local study area but are extensive outside the area of predicted drawdown and also outside the Local Study Area. The species appears to favour the dense shrublands on the rocky plateaus away from the predicted area of impact.
- Spinifex hummock grassland supports Mulgara and some conservation significant birds, such as the Striated Grasswren, but these particular vegetation species are unlikely to be groundwater dependent. Large areas of suitable habitat for this species occur outside the predicted area of impact.
- Some other habitats identified as groundwater dependent have the potential to support significant bird species, none of which have currently been recorded from the Local Study Area and so are thought to only rarely visit the area. For example *Eucalyptus gypsophila* woodland has the potential to support Major Mitchell's Cockatoo and Princess Parrot but populations do not currently reside at Yeelirrie.
- Conservation significant invertebrate species associated with phreatophytic vegetation associations are the Shield-backed Trapdoor Spider (Acacia shrublands) and Isopod. Platyarthridae/Bathytropidae (Hardpan Mulga). The Shield-backed Trapdoor Spider was recorded across a number of habitat types but appears to favour Acacia shrublands on the sandplain and Hardpan Mulga habitats which are extensive outside the predicted area of impact. Impacts to the Isopod. Platyarthridae/Bathytropidae (Hardpan Mulga) is unknown but Hardpan Mulga is also extensive outside the predicted area of impact.

In addition to groundwater drawdown impacts there may be impacts on fauna as a result of groundwater re-injection. However, the extent of this impact will be restricted to the final mine footprint.

As a result of this assessment the impact to fauna habitat from the impact to groundwater dependent ecosystems is likely to be low to negligible.

Altered fire regimes

While the biota of the region is probably adapted to a particular fire regime, it is likely this regime has been altered since European settlement. Utilising a mosaic burning regime is likely to benefit both native flora and fauna, and aid in the control of unplanned wildfires. Mulga in particular is sensitive to fire, while biodiversity in spinifex grasslands can be altered by changes in the fire regime. Mining activities can lead to a change in the fire regime if not appropriately managed.

Disturbance

Impacts of dust, light, disturbance and noise upon fauna are considered likely. This may impact fauna if there is an increase in artificial lighting in the development envelope. For example, mortality of insects was noted around existing operations due to insects being attracted to lights; the consequence of such mortality is not understood but on a precautionary basis should be minimised.

Bioaccumulation

Bioaccumulation of heavy metals and radionuclides within the environment can occur in both the short and long term. Heavy metals and radionuclides may enter the environment through

seepage of contaminants from evaporation ponds or dispersal of mineralised dust. 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 fauna when their environmental concentration increases to the extent that the capacity of a species to regulate the internal concentration of metals is lost.

An assessment of the potential radiation impacts on terrestrial fauna and any other non-human biota was conducted using the ERICA tool.

9.3.5.3 Impacts on Conservation Significant Fauna

Impacts upon conservation significant vertebrate species are summarised in Table 9-33 and are mostly considered to be Negligible to Minor. Impacts to conservation significant invertebrate species are summarised in Table 9-34 and are predicted to be Minor to Moderate.

The higher risk to some significant invertebrates is due to their reliance on the Calcrete VSA which has the highest proportional impact of VSAs (Table 9-32). The generally low levels of impact are due to the site's location within a largely intact landscape; a landscape expected to contain large areas of the same VSAs as those present within the development envelope. With appropriate management, the combination of the above factors is likely to result in only localised reductions in the population size of common and some significant species, roughly proportional to the percentage of habitat impact. This is greatest for invertebrates that may be reliant upon calcrete areas that are well-represented within the disturbance footprint. Despite this, even these VSAs are represented outside the disturbance footprint and no regional loss of species or fauna assemblage viability is expected. Habitat degradation as a result of altered hydrology, fire, predation from feral fauna and birds visiting hazardous evaporation ponds may be of some concern. Potential impacts to key fauna values are summarised in Table 9-35.

Table 9-33: Impacts on conservation significant vertebrate species

(Status in area refers to the predicted status of the species and includes reference to records from recent surveys)

Species (Conservation Status)	Status in area	Habitat	Potential impact and management
Conservation Significance 1 (CS1) Threatened Species			
Leipoa ocellata Malleefowl Vul (EPBC) S1 (WCA)	Resident/ Recorded	Dense Acacia shrublands	**Minor.** Local population probably small and therefore sensitive to the loss of a few individuals, but the population is outside the Development Envelope. Potential impacts include roadkill, loss of habitat, increase in feral predators and a change in fire regime. Mitigation measures include management of fire and feral animals, restrictions on speed for project-related vehicles. Large areas of suitable habitat for this species occur outside the Project footprint.
Petrogale lateralis Black-flanked Rock-Wallaby Vul (EPBC) S1 (WCA)	Resident/ Old records (BCE 2011a; 2015a)	Rocky outcrops with caves and rock piles associated with the Barr Smith Range.	**Minor.** Increase in feral predators could impact on what is an isolated and relict population if it exists in the region. There is some risk of increased roadkill due to increased traffic on the Yeelirrie–Meekatharra Road. Mitigation measures include management of fire and feral animals, restrictions on speed for project-related vehicles.

Species (Conservation Status)	Status in area	Habitat	Potential impact and management
Polytelis alexandrae Princess Parrot Vul (EPBC) P4 (DPaW)	Irregular visitor/ Not recorded.	*E. gypsophila* woodland	**Negligible.** Only an irregular visitor to the study area. Recorded at Wanjarri Nature Reserve (DPaW 2015). Potential impacts include loss of habitat, removal of hollow- bearing trees, changes in fire regime, dust, light, noise and vibration. Management measures as above for the Malleefowl.
Acanthiza iredalei Slender-billed Thornbill Vul (EPBC)	Irregular visitor/ Not recorded.	Chenopod shrubland.	**Negligible.** Resident population unlikely and vegetation marginal for species, but could occur occasionally as a result of individuals dispersing from nearby. Management measures as above for Malleefowl and Princess Parrot. Preferred habitat for this species occurs on the Yeelirrie Pastoral Lease outside the development envelope.
Pezoporus occidentalis Night Parrot Cri End (EPBC) S1 (WCA)	Vagrant/ Not recorded.	Triodia grassland and sandplain	**Negligible.** Some loss of habitat and possibility of increased mortality on roadsides. An extant population is unlikely to exist in the region. The species may be nomadic, but may potentially occur due to the presence of suitable habitat and historical records.
Liopolis kintorei Great Desert Skink Vul (EPBC) S1 (WCA)	Unknown/ Not recorded.	Spinifex sandplains	**Negligible.** Not known from the study area and presence seems unlikely. Recorded at Wanjarri Nature Reserve (DPaW 2015a). If present, potential impacts include increased mortality, loss of habitat, increase in feral predators, changes in fire regime. Management measures include management plans for fire and feral animals (including stray stock), and restrictions on speed for project-related vehicles.
Macrotis lagotis Greater Bilby Vul (EPBC) S1 (WCA)	Vagrant/ Not recorded.	Spinifex sand plains.	**Minor.** Extensive habitat available in the study area and thus feasible for individuals to move through the area currently or in the future. Potential impacts if species present would include increased mortality, loss of habitat, increase in feral predation and changes in fire regime. Management measures include management plans for fire and feral animals (including stray stock) and restrictions on speed for project-related vehicles.
Falco hypoleucos Grey Falcon S1 (WCA)	Irregular visitor/ Not recorded.	Acacia shrublands and tree-lined watercourses.	**Negligible.** Only an irregular visitor to the study area. Recorded at Wanjarri Nature Reserve (DPaW 2015). Potential impacts include loss of habitat, changes in fire regime, dust, light, noise and vibration. Management measures as above for Malleefowl and Princess Parrot. Maintain breeding sites if found.

Species (Conservation Status)	Status in area	Habitat	Potential impact and management
Falco peregrinus Peregrine Falcon S4 (WCA)	Irregular visitor/ Not recorded. Resident/ Recorded (BCE 2011a)	Cliffs and *E. gypsophila* woodland.	**Negligible.** Probably a resident but impact may be limited to the potential displacement of a breeding pair. Potential impacts include loss of habitat, disturbance of nesting sites. Maintain breeding sites if found.
Lophocroa leadbeateri Major Mitchell's Cockatoo S4 (WCA)	Irregular visitor/ Not recorded.	*E. gypsophila* woodland.	**Negligible.** Only an irregular visitor to the study area. Potential impacts include loss of habitat, removal of hollow- bearing trees, changes in fire regime, dust, light, noise and vibration. Management measures as above for Malleefowl and Princess Parrot. Maintain breeding sites if found.
Conservation Significance 1 (CS1) Migratory Species			
Merops ornatus Rainbow Bee-eater Mig (EPBC) S3 (WCA)	Regular migrant/ Recorded (BCE 2011a; 2015a)	Sandy- loam soils.	**Negligible.** Species is widespread and versatile in natural and altered habitats. Potential impacts include increased mortality and loss of habitat. Mitigation measures include management plans for fire and feral animals and protecting nest sites during earthworks and road maintenance.
Apus pacificus Fork-tailed Swift Mig (EPBC)S3 (WCA)	Irregular visitor/ Recorded (BCE 2015a)	Not applicable: aerial species	**Negligible.** Highly aerial species and largely independent of terrestrial environments, so no impacts expected.
Migratory waterbirds (see Table 9-30)	Vagrants to irregular visitors, usually in very small numbers	Seasonal waterbodies	**Minor**. Only present infrequently and usually in small numbers. Potential impacts include loss of habitat, changes to hydroecology, introduction of hazardous and non-hazardous water bodies. Management measures include decommissioning of existing stock watering points and management of evaporation ponds.
Conservation Significance 2 (CS2)			
Ardeotis australis Australian Bustard P4 (DPaW)	Resident/ Recorded (BCE 2011a; 2015a).	Spinifex sand plains.	**Negligible.** Species is widespread. Potential impacts include increased mortality, loss of habitat, increase in feral predators, change in fire regime, dust, light, noise and vibration. Mitigation measures include implementation of management plans for fire and feral animals (including stray stock), and restrictions on speed for project-related vehicles.

Species (Conservation Status)	Status in area	Habitat	Potential impact and management
Amytornis striatus Striated Grasswren P4 (DPaW)	Resident/ Not recorded.	Spinifex sandplains with an overstorey of shrubs, usually mallee eucalypts.	**Minor.** Probably present in the area. Recorded at Wanjarri Nature Reserve (DPaW 2015) and in Birdlife records for Yeelirrie. Potential impacts include loss of habitat, increase in feral predators, change in fire regime, dust, light, noise and vibration. Mitigation measures include implementation of management plans for fire and feral animals (including stray stock), and restrictions on speed for project-related vehicles.
Dasycercus blythi Brush-tailed Mulgara P4 (DPaW)	Resident/ Recorded (BCE, 2011a; 2015a)	Spinifex sand plains, mulga shrubland and open woodland.	**Minor.** Some populations are present in the study area, but extensive suitable habitat occurs outside the study area. Potential impacts include increased mortality, loss of habitat, increase in feral predators, change in fire regime, dust, light, noise and vibration. Mitigation measures include management plans for fire and feral animals (including stray stock).
Sminthopsis longicaudata Long-tailed Dunnart P4 (DPaW)	Resident/ Not recorded.	Rocky ridges, stony slopes with Spinifex.	**Minor.** Key habitat outside impact areas. Recorded 70 km north of study area (BCE 2014). Potential impacts include loss of habitat, increase in feral predators and change in fire regime. Management measures include management plans for fire and feral animals.
Nyctophilus major Inland Long-eared Bat P4 (DPaW)	Resident/ Recorded (BCE, 2011a)	Spinifex sand plains. May roost in tree hollows in *E. gypsophila* woodland.	**Minor.** Species is widespread but important regional roosting habitat may be in the *E. gypsophila* woodland. Potential impacts include loss of habitat, change in fire regime, dust, light, noise and vibration. Management measures include implementation of a management plan for fire, use of directional lighting and the avoidance of hollow-bearing E. *gypsophila* wherever practicable and where not practicable, the collection and re-affixing of suitable hollows to trees that would be retained.
Conservation Significance 3 (CS3)			
Burhinus grallarius Bush Stone-curlew	Resident/ Recorded (BCE 2011a; 2015a)	*E. gypsophila* woodland, dense Acacia shrublands, gnamma holes and Casuarina woodland.	**Minor.** Species is widespread and suitable habitat is extensive outside the study area, but population is small and uses habitat in the 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. Mitigation measures include implementation of management plans for fire and feral animals (including stray stock).

Species (Conservation Status)	Status in area	Habitat	Potential impact and management
Lophoictinia isura Square-tailed Kite	Resident/ Recorded (BCE 2011a)	*E. gypsophila* woodland and Mulga shrubland.	**Negligible.** Potential impact includes loss of habitat. Mitigation measures include implementation of management plans for fire, and clearing controls.
Neophema splendida Scarlet-chested Parrot	Irregular visitor/ Not recorded.	*E. gypsophila* woodland and Mulga shrubland.	**Minor.** Recorded at Wanjarri Nature Reserve (DPaW 2015). Negligible impact as only an irregular visitor to the fauna study area. Potential impacts include loss of habitat, loss of breeding habitat (Eucalypt tree hollows), changes in hydroecology, fire regime, dust, light, noise and vibration. Mitigation measures include implementation of management plans for fire and clearing controls. Where not practicable, the collection and re-affixing of suitable hollows to trees that would be retained.
Polytelis anthopeplus Regent Parrot	Vagrant/ Not recorded.	Woodland.	**Negligible.** Recorded at Wanjarri Nature Reserve (DPaW 2015). Potential impact includes loss of habitat. Management measures include management plan for fire.
Conopophila whitei Grey Honeyeater	Resident/ Not recorded.	Mulga shrubland.	**Negligible.** Recorded at Wanjarri Nature Reserve (DPaW 2015). Potential impacts include change in fire regime, dust, light, noise and vibration. Management measures include implementation of a management plan for fire.
Stipiturus ruficeps Rufous-crowned Emu-wren	Resident/ Not recorded.	Spinifex sandplains.	**Minor.** Probably not present in area but suitable habitat present. Recorded at Wanjarri Nature Reserve (DPaW, 2015). Changed fire regimes could lead to local extinction however the successful implementation of the fire management plan would minimise this loss. Potential impacts include loss of habitat, change in fire regime, dust, light, noise and vibration. Management measures include implementation of management plans for fire and dust.
Antichinomys laniger Kultarr	Resident/ Not recorded.	Open plains.	**Negligible.** Species is widespread and suitable habitat is largely outside the fauna study area. Recorded at Mount Keith. Potential impacts include increased mortality, loss of habitat, increase in feral predators, change in fire regime, dust, light, noise and vibration. Mitigation measures include management plans for fire and feral animals (including stray stock).

Species (Conservation Status)	Status in area	Habitat	Potential impact and management
Aprasia picturata Legless lizard	Unknown/ Not recorded.	Rocky ridges.	**Negligible.** Habitat outside the Project Area. Recorded at Wiluna. Management measures include implementation of a management plan for fire.

Table 9-34: Impacts on conservation significant invertebrate species

Species (Conservation Status)	Collected outside disturbance footprint?	Habitat	Potential impact and management
Mygalomorph Shield-backed Trapdoor Spider *Idiosoma nigrum* (Vul - EPBC; S1 - WCA)	Yes	Sandplain	**Minor.** Potential impacts to this species relate to dust generation from nearby activities as suitable habitat is outside direct impact areas. Minimise indirect impacts, such as dust suppression along roads through implementation of a dust management plan.
Isopod Platyarthridae/ Bathytropidae (Confirmed SRE)	No but habitat present outside footprint	Calcrete, Outwash, Hardpan Mulga.	**Moderate**. Potential impacts include loss of habitat, changes to hydro-ecology and dust generation. Mitigation measures include suppression of dust, surface water management and clearing controls.
Isopod *Pseudolaureola* sp. (Confirmed SRE)	No but habitat present outside footprint	Calcrete, Outwash	**Moderate.** Potential impacts include loss of habitat, changes to hydro-ecology and dust generation. Mitigation measures include suppression of dust, surface water management and clearing controls.
Carabidae Tiger Beetle *Pseudotetracha helmsi* (Confirmed SRE)	Yes	Playa	**Negligible.** Potential impacts include loss of habitat, dust generation and changes to surface water. Restrict vehicle traffic at the Yeelirrie Playa to a minimum and keep to existing tracks. Manage dust, surface water, and implement clearing controls.
Mygalomorph *Aganippe* sp. (Confirmed SRE)	Yes	Hardpan Mulga	**Negligible.** Potential impacts to this species relate to dust generation from nearby activities. Mitigation measures include suppression of dust and surface water management.
Mygalomorph Aname 'MYG170' (Potential SRE)	No but habitat present outside footprint	Calcrete, Hardpan Mulga	**Minor.** Potential impacts include loss of habitat and changes in hydroecology and dust. Mitigation measures include suppression of dust, surface water management and clearing controls.

Species (Conservation Status)	Collected outside disturbance footprint?	Habitat	Potential impact and management
Mygalomorph Aname 'MYG212' (Potential SRE)	Yes	Calcrete Outwash, Sandplain	**Moderate.** Potential impacts include loss of habitat and dust generation. Mitigation measures include suppression of dust, surface water management and clearing controls.
Mygalomorph Barychelidae (Potential SRE)	No but habitat present outside footprint	Calcrete Outwash	**Moderate.** (Insufficient data). Potential impacts include loss of habitat and dust generation. Mitigation measures include suppression of dust, surface water management and clearing controls.
Pseudoscorpion Cheridiidae (Potential SRE)	No but habitat present outside footprint	Calcrete Outwash	**Moderate.** (Insufficient data). Potential impacts include loss of habitat and dust generation. Mitigation measures include suppression of dust, surface water management and clearing controls.
Isopod *Cubaris* sp. 1 (Potential SRE)	No but habitat present outside footprint	Calcrete	**Minor.** (Insufficient data). Potential impacts include loss of habitat and dust generation. Mitigation measures include suppression of dust, surface water management and clearing controls.
Isopod *Cubaris* sp. 2 (Potential SRE)	Yes	Hardpan Mulga, Sandplain	**Negligible.** Potential impacts to this species relate to dust generation from nearby activities. Mitigation measures include suppression of dust, surface water management and clearing controls.
Centipede Chilopod Geophilida (Potential SRE)	No but habitat present outside footprint	Hardpan Mulga	**Minor.** (Insufficient data). Potential impacts include loss of habitat, changes to hydro-ecology and dust generation. Mitigation measures include suppression of dust, surface water management and clearing controls.
Mygalomorph *Kwonkan* 'MYG171' (Potential SRE)	No but habitat present outside footprint	Hardpan Mulga	**Minor**. (Insufficient data). Potential impacts include loss of habitat, changes to hydro-ecology and dust generation. Mitigation measures include suppression of dust, surface water management and clearing controls.

Species (Conservation Status)	Collected outside disturbance footprint?	Habitat	Potential impact and management
Mygalomorph *Kwonkan* 'MYG172' (Potential SRE)	No but habitat present outside footprint	Calcrete	**Minor.** (Insufficient data). Potential impacts include loss of habitat and changes to hydro-ecology. Mitigation measures include suppression of dust, surface water management and clearing controls.
Mygalomorph *Kwonkan* 'MYG210' (Potential SRE)	Yes	Hardpan Mulga	**Negligible.** Potential impacts to this species relate to dust generation from nearby activities. Mitigation measures include suppression of dust, surface water management and clearing controls.
Mygalomorph *Kwonkan* 'MYG211' (Potential SRE)	Yes	Hardpan Mulga	**Negligible.** Potential impacts to this species relate to dust generation from nearby activities. Mitigation measures include suppression of dust, surface water management and clearing controls.
Scorpion *Urodacus* 'yeelirrie' (Potential SRE)	Yes	Hardpan Mulga	Potential impacts include loss of habitat and dust generation. Mitigation measures include suppression of dust, surface water management and clearing controls.

Table 9-35: Summary of potential impacts on key fauna values and proposed actions

Fauna Value	Nature and Significance of Impact		Proposed Actions
	Potential Impacts	Significance	
Fauna assemblage	Increased mortality, loss of habitat and species interactions.	Minor as impacts very localised in a regional context	Minimise impact footprint, rehabilitate where possible, manage ongoing mortality, monitor / manage impacts from evaporation ponds. Minimise hydrological impacts to maintain fauna assemblage.
VSAs	Loss of habitat, altered hydroecology, habitat degradation through weed invasion or altered fire regimes.	Minor as these are widespread in the region except Calcrete VSA	Minimise footprint especially in Calcrete VSA, monitor vegetation condition and minimise hydrological impacts to maintain phreatophytic VSAs.

Fauna Value	Nature and Significance of Impact		Proposed Actions
	Potential Impacts	Significance	
Significant fauna	Ongoing mortality, loss of habitat and species interactions. Changes to fire regimes and hydrological flows. Disturbance from dust, noise and light spill. Fauna consuming water from evaporation ponds.	**Vertebrate Fauna** Minor as impacts are localised but consideration needed for Malleefowl and Black-flanked Rock-Wallaby. **Invertebrate Fauna** Minor to Moderate as impacts are localised but consideration needed for *Idiosoma nigrum*, Pseudolaureola, Platyarthridae/ Bathytropidae and Cheiridiidae.	Minimise footprint, retain / manage areas of importance for conservation. Monitor important populations of conservation significant fauna. Retain tree hollows for birds. Manage feral species as required. Monitor / manage impacts from evaporation ponds and dust. Minimise hydrological impacts to maintain phreatophytic VSAs.
Patterns of biodiversity	**Vertebrate Fauna** The most significant VSAs in terms of biodiversity are watercourses and areas of spinifex on sandy-loam soil, and these are largely outside areas of direct impact. The most-impacted VSA is low in biodiversity within the context of the region, although rocky hills and watercourses within the VSA may be of interest for some taxa. **Invertebrate Fauna** The most significant VSAs are the calcrete habitats. Some SRE species were only recorded in such habitats but these also occur away from the mine footprint.	Minor as impacts very localised	Minimise footprint where possible. Monitor / manage impacts from evaporation ponds. Minimise hydrological impacts to maintain phreatophytic VSAs
Ecological processes	Potential impacts on hydrology. Some possible impacts on fire regimes and feral predators.	Minor but changes to hydrology could be a concern.	Management to prevent any impacts to local hydrology. Manage fire and feral species where necessary.

9.3.5.4 Assessment of Impacts from Dust and Radiological Effects to Fauna

This section discusses the potential dust and radiological effects of the operation on fauna. The assessment considers the primary pathway for impacts outside the operation, which is the release of airborne dusts and their deposition in the environment. The operation is designed to prevent release of water off site therefore this pathway is not considered here.

The deposition of operation originated dust results in the deposition of radionuclides onto soils and the subsequent incorporation into the soils. The assessment utilises the ERICA software tool

and the change in soil radionuclide concentrations to make a qualitative assessment of potential risk to a set of standard fauna species. The ERICA assessment was conducted for the full set of reference animals. In addition, an assessment was conducted for kangaroos which utilised the recently published concentrations ratios in APRANSA 2014. To take account of the difference in physical dimensions of the kangaroo (compared to the reference animals), Cameco has utilised the functionality within the ERICA software to create a kangaroo model (based on an ellipsoid). Note that ARPANSA 2014 does not provide concentration ratio values for thorium for kangaroos, therefore the default ERICA value for large mammals is used in the assessment.

Dust

Air quality modelling has been conducted for the Project and is discussed in detail in Section 9.8.

To assess the impact of dust emissions on fauna and habitat, the emissions of total suspended particulates (TSP) resulting from the operation of the Project (predicted operationally contributed annual average ground-level concentration of TSP) were considered.

There are currently no known measurements of TSP in the region. The standard conversion ratios detailed in the United States Environmental Protection Agencies (US EPA's) Compilation of Air Pollution Emission Factors Volume 1 (AP-42) and in the NPI Handbooks, have found that PM10 is usually 50% of the TSP concentration. In accordance with standard industry practice, this ratio has been employed for this assessment.

The New South Wales Environmental Protection Authority (NSW EPA) has set dust deposition impact assessment criterion to prevent impacts to residential amenity. The impact assessment criterion is expressed as an incremental increase in dust deposition levels over background due to the operation of a facility of 2.0 g/m²/month (DEC, 2006). Due to the absence of dust deposition monitoring data in the vicinity of the proposed Yeelirrie Uranium Project, the impact assessment criterion specified by the NSW EPA has been used in this assessment.

Modelling predicts that the operation contribution of the Project to is less than 1g/m^2/month (see Table 9-68). At this level, it is unlikely that dust deposition from the Project will impact fauna and habitat.

Radiation

The ERICA Tool

The ERICA assessment tool was developed under the European Commission to provide a method of assessing the impact of radiological contaminants on the natural environment. The ERICA tool and assessment process which is conducted in three "tiers" is discussed in Section 9.1.5.

The ERICA tool presents the results as the dose rates to the organisms, and also in terms of the "Risk Quotient" (i.e. the ratio of the dose rate to the screening rate).

Soil Radionuclide Concentrations

Soil radionuclide concentrations are discussed in Section 9.1.5. As noted, the modelled change in soil radionuclide concentrations at the project boundary is 45Bq/kg for each radionuclide in the uranium decay series and after 15 years of deposition.

Concentration Ratios

For animals, the concentration ratios represent the ratio of organism whole body radionuclide activity concentration in fresh weight, compared to the activity concentration of that radionuclide in the media (soil or water) where the organism lives. For a terrestrial assessment this is the Becquerels per kilogram (Bq/kg) whole organism (fresh weight) per Bq/kg soil (dry weight).

Cameco has analysed kangaroo and soil data collected by BHP Billiton at Yeelirrie to develop local concentration ratios (see Technical Appendix J1). A summary of the values, together with recently published Australian concentrations ratios (ARPANSA 2014) and the ERICA default concentration ratios (for large mammals) can be seen in Table 9-36.

Table 9-36: Comparison of whole organism concentration ratios

Sample Type	Concentration Ratio (Bq/kg [fresh weight] per Bq/kg [soil])		
	U238	Ra226	Pb210
Uranium	0.005	0.005	0.007
Thorium	0.000	0.0086	-
Radium	0.044	0.062	0.041
Lead	0.037	0.016	0.020
Polonium	0.089	0.031	0.55

ERICA Kangaroo

The ERICA software provides the opportunity to expand the assessment beyond the reference animals and plants when necessary. The recent ARPANSA 2014 publication provides concentrations ratios for kangaroos and, as noted, the assessment has been conducted using this recent data. As the kangaroo is dimensionally different from the ERICA default large mammal, an ellipsoid for an additional ERICA reference species was developed. The species was termed "Kangaroo" and was given the following attributes; mass 50kg, height 1.5m, width 0.75m, depth 0.75m.

Table 9-37: Tier 2 ERICA assessment

Organism	CR Origin	Risk Quotient (expected value)	Risk Quotient (conservative value)
	Default	0.04	0.11
Organism	CR Origin	Risk Quotient	0.10
(expected value)	Risk Quotient	0.04	0.12
(conservative value)	Default	0.03	0.08
Arthropod - Detritivore	Default	0.04	0.11
Flying insect	Default	0.03	0.10
Mollusc - Gastropod	Default	0.04	0.12
Bird	Default	0.03	0.08
Amphibian	Default	0.05	0.14
Reptile	Default	0.05	0.15
Kangaroo (Cameco generated ellipsoid)	ARPANSA 2014	0.10	0.31
Mammal (large)	Default	0.04	0.13
Mammal (small burrowing)	Default	0.04	0.13

A Tier 2 ERICA assessment was conducted using a soil radionuclide concentration of 45 Bq/kg (each uranium series radionuclide) and using a combination of default concentration ratios and derived ratios for different organisms and the resulting risk quotients shown in Table 9-37.

Note that the ERICA assessment was conservatively conducted using the ARPANSA 2014 concentration ratios for kangaroos and the ERICA default figure for thorium.

No species exceeded the screening level of 10µGy/h.

The Risk Quotient is the ratio of the derived dose rate to the screening level. When the risk quotient is less than 1, no additional assessment is required.

Impact from Radon and Radon Decay Products

An impact assessment on fauna from radon and its decay products was conducted using the tool of Vives i Batlle et al. (2008;2012). The default values were used and the input radon concentration was 10Bq/m^3, based on the modelled average annual radon concentration at the project boundary.

The output of the calculator indicated that none of the 70 species assessed would be exposed to more that 10uGy/hr under the default conditions, with the highest being less than 1uGy/h. Further assessment was therefore not deemed to be necessary.

In summary, the risk to fauna from operation originated dust and radionuclides is very low.

9.3.5.5 Summary of Management Measures

Cameco will develop a Fauna Management Plan to minimise, manage and monitor potential impacts from the Project on native fauna. Management measures are likely to include the following:

General - Avoid and Minimise

- Cameco will minimise ground disturbance and clearing activities in accordance with a Flora and Vegetation Management Plan to be developed for the Project. The ground disturbance protocol will ensure that areas to be cleared are first inspected by qualified environmental personnel to determine if there are any significant habitats or signs of significant fauna activity.
- If populations of significant species are identified within Project boundary (e.g. lay down areas or storage areas), alternative areas must be considered and evaluated where practicable.
- If populations of significant species are identified within Project boundary and disturbance to those areas cannot be avoided, a specialist zoologist will be consulted prior to ground disturbance.
- A site vegetation clearing permit will be completed and authorised by site environmental personnel prior to ground disturbance.
- There will be no unauthorised driving off tracks, night driving will be limited and vehicle speeds will be restricted around the Project and sensitive habitats. Dust suppression along access roads will be managed under site management procedures.
- Waste disposal areas around the site will be maintained to a high standard. Inert and putrescible waste will be disposed of to an authorised landfill on site which will be fenced to prevent access by native and introduced fauna. The presence of introduced fauna species and pests will be monitored and appropriate control measures implemented if necessary.
- The evaporation pond will be inspected daily for fauna and bird access. Should fauna visitations to the facilities be considered significant, measures will be taken to deter fauna.
- Changes to surface water flow regimes will be managed in accordance with a Surface Water Management Plan to be developed for the Project.
- Cameco is committed to the removal of stock and decommissioning of existing stock watering points (in consultation with relevant stakeaholders) across the entire Yeelirrie Station, which will reduce trampling, weed infestations and competition from abundant native and introduced species. Cameco will develop a whole of Pastoral Lease management plan to ensure that areas of high conservation value are managed accordingly.
- Feral fauna management measures will also be implemented which take into consideration the role of dingoes in suppressing foxes.

- A fire management plan will be developed and implemented for the Project, with hot work permits required prior to commencing any activity that may create an ignition source. Fire extinguishers will be available in all hot work areas and personnel will be trained in their use. Cameco will have an emergency response plan for the Project, which will include response to bushfires, and a plan for controlled burning around the Project Area.
- Hydrocarbons and chemicals will be transported, stored and used in accordance with Australian standards and guidelines. Spill kits will be made available on site and hydrocarbon and chemical spills will be immediately cleaned up and the incident reported.

General - Rehabilitate

- Disturbed areas that are no longer required will be progressively rehabilitated over the life of the mine in accordance with the Mine Closure and Rehabilitation Plan.
- The pit will be progressively backfilled and rehabilitated from year 11.

Conservation Significant Species - Avoid and Minimise

- Training on the identification and reporting of conservation-significant fauna species will be included in the Cameco site induction.
- The ground disturbance guideline will ensure that areas to be cleared are first inspected by qualified environmental personnel to determine if there are any significant habitats or signs of significant fauna activity. Training on vegetation clearing procedures will be included in an environmental induction.
- Work with DPaW and local indigenous groups to assist in the implementation of a landscape scale fire management program.
- Cameco will work with DPaW and local indigenous groups to assist in the implementation of a landscape scale fire management program to manage habitat for conservation of significant species.

9.3.6 Outcomes

Taking into account the project design and proposed management measures to be implemented, Cameco believes that the Proposal will meet the EPA's objective of maintaining the representation, diversity, viability and ecological function at the species, population and assemblage level.

9.3.7 Commitments

Cameco commits to:

- Develop and implement a Fauna Management Plan.