

**Fauna Values of the bauxite-prospective areas
around the Worsley Alumina Refinery
(in WAPL's Collie Sublease)**



Quacking Frog (*Crinia georgiana*). Photo: Wes Bancroft

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EXECUTIVE SUMMARY

Worsley Alumina Pty Ltd (WAPL) currently mines bauxite in the Boddington area and this is transported by conveyor to the company's refinery north-west of Collie. However, there are also bauxite reserves around the refinery, and Bamford Consulting Ecologists was commissioned to undertake an assessment of fauna values in the refinery area, based on a desktop view and intensive field surveys. The aims of fauna assessments such as this include:

- review the list of fauna expected to occur on the site in the light of fauna habitats present, with a focus on investigating the likelihood of significant species being present;
- identify significant or fragile fauna habitats within the study area;
- identify any ecological processes in the study area upon which fauna may depend;
- identify general patterns of biodiversity within or adjacent to the study area, and
- identify potential impacts upon fauna and propose recommendations to minimise impacts.

The desktop review gathered data from a variety of sources, including databases managed by the WA Museum, the WA Department of Environment and Conservation and the federal Department of Environment and Water Resources. In addition, there were personal records from a private property in the west of the project area. The desktop review identified 205 species of vertebrate that may occur in the vicinity of the WAPL Collie sublease: 9 fish, 13 frog, 40 reptile, 108 bird and 35 mammal species (Tables 1 to 5). Of these, 7 frog, 20 reptile, 50 bird and 20 mammal species were recorded during two field surveys that took place in January and May 2007.

There are potentially 28 vertebrate fauna species of conservation significance in the study area. Of these, 11 are of high significance (Conservation Significance Level 1), being listed under legislation, 12 are of moderate conservation significance (Conservation Significance Level 2), being listed as priority species by the Department of Environment and Conservation, and five are of local significance (Conservation Significance Level 3), because they have restricted distributions or occur as isolated populations on the edge of their range. One invertebrate of conservation significance may be present, while collection of millipedes, trapdoor spiders and scorpions found no taxa likely to be short range endemics.

Potential impacts of development of the bauxite resource upon the fauna values of the project area were examined under the following categories:

- Conservation significant fauna. Species of greatest concern are the black-cockatoos (because of loss of nesting trees) and mammals sensitive to roadkill.
- Conservation significant habitats. Impacts may be significant if the habitat is rare, a large proportion of the habitat is affected and/or the habitat supports significant fauna. Watercourses and riparian vegetation are of greatest concern.
- Ecological processes. Ecological processes are complex but in the project area, there are concerns with impacts on both surface and groundwater hydrology, fire, fragmentation of linear habitats (especially watercourses) and artificial lighting. Increased mortality from a number of sources (roadkill, introduced predators) may also be a concern.
- Patterns of biodiversity. Species are not distributed evenly across the landscape or even within one vegetation/landform type. Analysis of trapping and bird census

data found few patterns in biodiversity across the landscape, with a slight trend for Jarrah-Marri forest over a sparse understorey on gravel being slightly richer in birds than other vegetation types. However, other studies have found biodiversity in Jarrah-Marri forest to be highest low in the landscape.

Impacts upon fauna due to development of the bauxite resource are likely to include: some localised loss of habitat, including cockatoo nesting habitat, fragmentation of important habitats (e.g. by roads and access tracks), roadkill, changes in hydrology, changes in the fire regime and changes in the abundance of introduced predators. The significance of these impacts and recommendations for their minimisation are discussed. Key recommendations include taking measures to minimise impacts on black-cockatoo nests and taking measures to minimise roadkill of mammals. Habitat restoration post-mining will also be important for impact minimisation.

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1. INTRODUCTION

1.1 Introduction

Worsley Alumina Pty Ltd (WAPL) is seeking to further its understanding of the significant fauna values in and around the bauxite-prospective areas within its Collie sublease (in the vicinity of WAPL's alumina refinery). WAPL's aim is to include these significant fauna values within a possible future mining proposal for submission to government.

Bamford Consulting Ecologists was commissioned to conduct a literature review, site inspection and field surveys to identify conservation-significant fauna taxa within the survey area (and the habitat required to support these significant fauna taxa), and assess the potential impact of mining-related disturbance within the survey area on these significant fauna and fauna habitat values.

1.2 Study objectives

The objectives of fauna studies in the Environmental Impact Assessment (EIA) process are broadly to determine the fauna values of a site and the likely impacts of a proposed development. This provides government agencies with the information needed to assess the significance of impacts under state and federal legislation. The key objectives of fauna studies are to:

- review the list of fauna expected to occur on the site in the light of fauna habitats present, with a focus on investigating the likelihood of significant species being present;
- identify significant or fragile fauna habitats within the study area;
- identify any ecological processes in the study area upon which fauna may depend, or which may depend on fauna;
- identify general patterns of biodiversity within or adjacent to the study area, and
- identify potential impacts upon fauna and propose recommendations to minimise impacts.

1.3 Project summary

WAPL's bauxite mining activities are currently located south of the town of Boddington (in the eastern jarrah forest) and its refining activities are located near the town of Collie (south-west of the mine). WAPL's Collie sublease surrounds the refinery (see Figure 1) and the company is currently assessing the potential for mining bauxite resource areas within the Collie sublease.

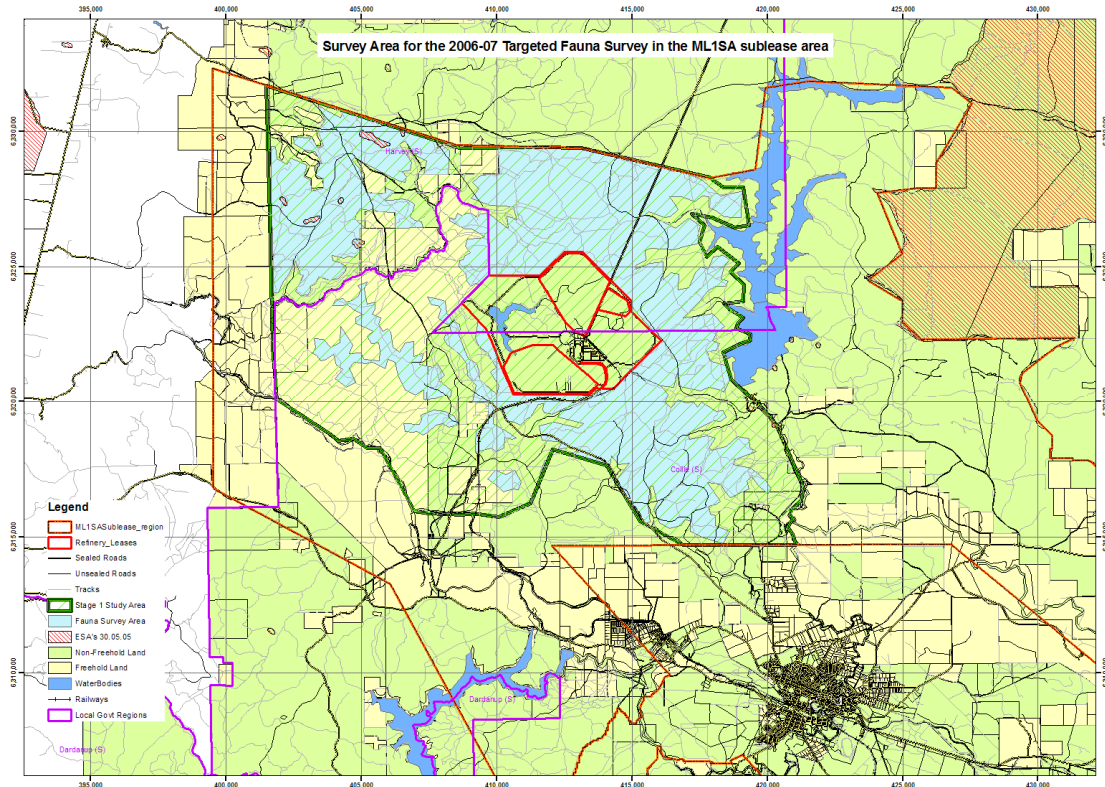


Figure 1. Location of WAPL's Collie sublease, north-west of the town of Collie.

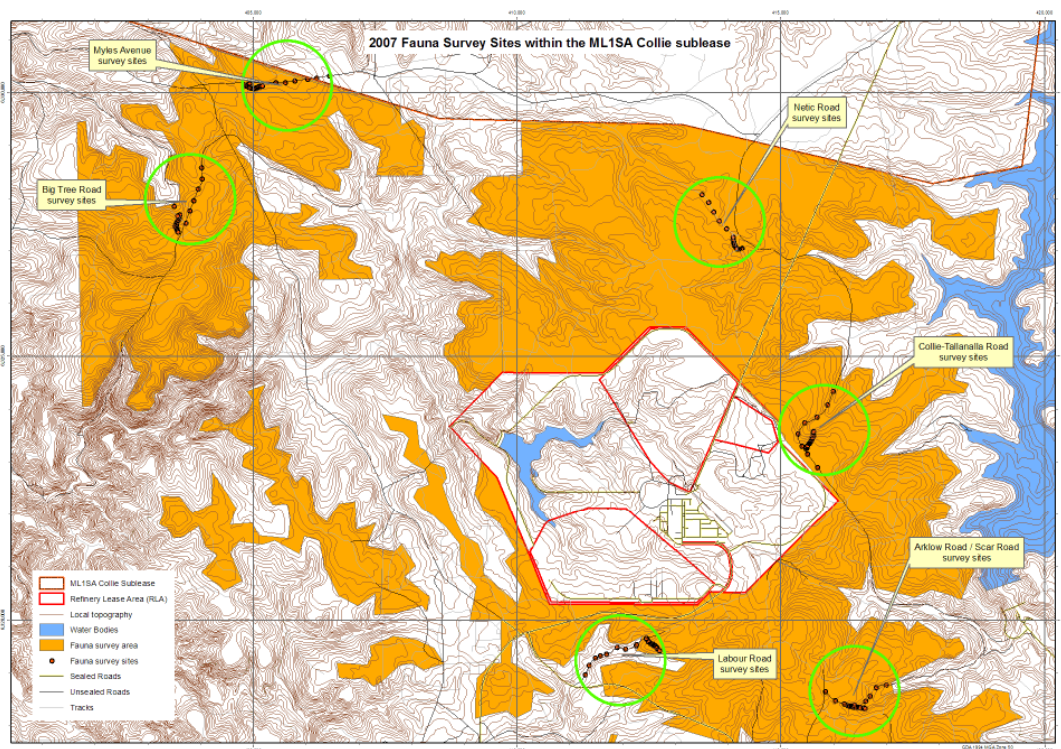


Figure 2. WAPL's Collie sub-lease showing locations of fauna sampling sites.

2 BACKGROUND

2.1 Regional description

The WAPL Collie sublease falls within the Jarrah Forest Bioregion of the Interim Biogeographic Regionalisation for Australia (IBRA) classification system (EA 2000; McKenzie *et al.* 2003). The general features of this region are summarised by McKenzie *et al.* (2003): The region is characterised by “jarrah-marri forest on laterite gravels and, in the eastern part, by marri-wandoo woodlands on clayey soils. There are two subregions within the bioregion – the Northern Jarrah Forest and the Southern Jarrah Forest. The Northern Jarrah Forest overlies Archaean granite and metamorphic rocks capped by an extensive lateritic duricrust that has been dissected by later drainage. It is also interrupted by occasional granite outcrops in the form of isolated hills. Vegetation comprises jarrah-marri forest in the west (with bullich and blackbutt in the valleys), and grades into wandoo woodlands in the east with powderbark on breakaways. There are extensive but localised sand sheets with Banksia low woodlands. Heath is found on granite rocks and as a common understorey of forests and woodlands in the north and east. The lateritic plateau broadens in the Southern Jarrah Forest and slopes gently to the south coast. In the south-east it is almost entirely mantled by sands and is virtually level, which causes poor drainage and numerous wetlands, including Lake Muir. Vegetation comprises jarrah-marri forest in the west grading to marri and wandoo woodlands in the east. Extensive areas of swamp in the south-east are dominated by paperbarks and swamp yate. The forest and woodland understorey reflects the more mesic nature of this area.”

The Jarrah Forest Bioregion falls within the Bioregion Group 2 classification of EPA (2004). This grouping is relevant for environmental impact assessment purposes.

2.2 Description of project area

The project area consists almost entirely of eucalypt (mainly Jarrah and Marri) forest in a region that is transitional between the northern and southern sub-regions described above. The forests occur on lateritic gravels overlain by white sand in some locations, but the sand is not deep enough to support banksia woodlands. The landscape is undulating with loam and clayey soils in valleys supporting Blackbutt, Bullich and *Banksia seminuda*, as well as riparian shrubs such as *Agonis linearifolia*. The region is dissected by few roads and is largely uncleared, although subject to logging. Habitat descriptions are provided in section 4.3.

The survey area is shown in Figure 2 and includes the locations of fauna monitoring sites. Figures 3 and 4 illustrate typical vegetation within the project area.



Figure 3. Upland Jarrah forest on lateritic soil near the Collie-Tallanalla Road site.



Figure 4. Riparian (Bullich over *Agonis linearifolia*) vegetation near the Arklow Road site.

2.3 Assessment of conservation significance

The conservation status of fauna species is assessed under Commonwealth and State Acts such as the *Commonwealth Environment Protection and Biodiversity Conservation Act* (EPBC Act) 1999 and the *Western Australian Wildlife Conservation Act* 1950. The significance levels for fauna used in the EPBC Act are those recommended by the International Union for the Conservation of Nature and Natural Resources (IUCN 2001). The *WA Wildlife Conservation Act* 1950 uses a set of Schedules but also classifies species using some of the IUCN categories. These categories and Schedules are described in Appendix 1.

The EPBC Act also has lists of migratory species that are recognised under international treaties such as the China Australia Migratory Bird Agreement (CAMBA), the Japan Australia Migratory Bird Agreement (JAMBA) and the Bonn Convention (The Convention on the Conservation of Migratory Species of Wild Animals). The list of migratory species under the EPBC Act has been revised to include species only, thus excluding family listings (DEWR, pers. comm.). Those species listed in JAMBA are also protected under Schedule 3 of the *WA Wildlife Conservation Act*. There is a separate list of marine species under the EPBC Act, but this only applies to land and waters under Commonwealth management. Therefore, marine listings are not included in this report.

The Department of the Environment and Water Resources (DEWR, formerly the Department of the Environment and Heritage, Environment Australia) has also supported the publication of reports on the conservation status of most vertebrate fauna species: reptiles (Cogger *et al.* 1993), birds (Garnett and Crowley 2000), monotremes and marsupials (Maxwell *et al.* 1996), rodents (Lee 1995) and bats (Duncan *et al.* 1999). The Threatened Species and Communities Section of DEWR produced a list of Threatened Australian Fauna, although this list is effectively a precursor to the list produced under the EPBC Act. These publications also use the IUCN categories, although those used by Cogger *et al.* (1993) differ in some respects because this report pre-dates categories reviewed by Mace and Stuart (1994) and revisited since by IUCN (2001).

In Western Australia, the Department of Environment and Conservation (DEC) has produced a supplementary list of Priority Fauna, being species that are not considered Threatened under the WA Act but for which the Department feels there is cause for concern. Some Priority species, however, are also assigned to the IUCN Conservation Dependent category. Levels of Priority are described in Appendix 1. Assessments in this report are based on the most recent version of the DEC priority list (January 2007).

Fauna species included under conservation acts and/or agreements are formally recognised as of conservation significance under state or federal legislation. Species listed only as Priority by DEC, or that are included in publications such as Garnett and Crowley (2000) and Cogger *et al.* (1993), but not in State or Commonwealth Acts, are also of recognised conservation significance. In addition, species that are at the limit of their distribution, those that have a very restricted range and those that occur in breeding colonies, such as some waterbirds, can be considered of conservation significance, although this level of significance has no legislative or published recognition and is based on interpretation of distribution information. The WA

Department of Environment (now part of the DEC) used this sort of interpretation to identify significant bird species in the Perth metropolitan area as part of Perth Bushplan (DEP 2000).

On the basis of the above comments, three levels of conservation significance are recognised in this report:

- *Conservation Significance (CS) 1*: Species listed under State or Commonwealth Acts.
- *Conservation Significance (CS) 2*: Species not listed under State or Commonwealth Acts, but listed in publications on threatened fauna or as Priority species by DEC.
- *Conservation Significance (CS) 3*: Species not listed under Acts or in publications, but considered of at least local significance because of their pattern of distribution. This level may have links to preserving biodiversity at the genetic level (EPA Position Statement No. 3, EPA 2002). For example, 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. Species on the edge of their range, or that are sensitive to impacts such as habitat fragmentation, may also be classed as CS3.

In addition to these statuses, species that have been introduced (INT) are also indicated.

3 METHODS

3.1 Approach and level of assessment

3.1.1 Overview

The fauna assessment and report preparation were carried out with reference to guidance and position statements published by the WA Environmental Protection Authority (EPA) on fauna surveys and environmental protection, and Commonwealth Biodiversity Legislation (e.g. EPA 2002; e.g. EPA 2004). Reference was also made to guidelines for mining proposals published by the Department of Industry and Resources (DoIR 2006). The report synthesises the results of a literature review and two field surveys, and is classified as a Level 2 survey (desktop study, reconnaissance and detailed survey)] according to the EPA Position Statement No. 3 (EPA 2002).

3.1.2 Survey Limitations and Constraints

EPA Guidance Statement 56 outlines a number of limitations that may arise during surveying. The relevance of survey limitations are summarised in Table 3.1.

Table 3.1: Survey Limitations and Constraints

Survey Limitations	Comment
Competency/experience of the consultant/s carrying out the survey;	Field personnel have extensive experience, having completed numerous fauna surveys in the broader south-west region.
Scope (what faunal groups were	All vertebrate fauna groups were surveyed.

sampled and were some sampling methods not able to be employed because of constraints);	Short-range endemic invertebrates were sampled through targeted searching and collection of specimens caught in vertebrate traps. More sampling of SRE invertebrates would have been possible.
Proportion of fauna identified, recorded and/or collected;	Over 50% of the vertebrate assemblage expected to be present was confirmed. Information on SRE invertebrate assemblages is inadequate to calculate proportion sampled.
Sources of information e.g. previously available information (whether historic or recent) as distinct from new data;	There is information from previous fauna and broader biological surveys in the surrounding area e.g. RFA's; and good number of specimens recorded within relevant databases e.g. Birds Australia Atlas II, WA Museum and DEC threatened fauna. Included in the project area is private property where fauna observations have been made by Mike and Mandy Bamford since the mid 1980s.
The proportion of the task achieved and further work which might be needed;	There may be some need for focussed short-range endemic invertebrate surveys.
Timing/weather/season/cycle;	Both surveys followed a year that was considerably drier than average (i.e. 2006). Conditions were cold during the autumn/winter survey.
Disturbances (e.g. fire, flood, accidental human intervention etc.) which affected results of survey;	No disturbances affected survey results.
Intensity (in retrospect, was the intensity adequate);	The survey covered all major habitat types within the study area and utilised a range of trapping techniques.
Completeness (e.g. was relevant area fully surveyed);	Survey complete.
Resources (e.g. degree of expertise available in animal identification to taxon level);	All vertebrate fauna identified to species level, but the identification of SRE invertebrates is incomplete even though specimens were taken to the WA Museum.
Remoteness and/or access problems; and	All areas of the site were accessible.
Availability of contextual (e.g. biogeographic) information on the region.	There is adequate contextual information available for much of the vertebrate species assemblage, but it is lacking in regards to some of the smaller herpetofauna and invertebrate species.

3.2 Personnel

The following personnel were involved in the field surveys:

- Dr Mike Bamford *BSc(Biol.), Hons(Biol.), PhD(Biol.)*
- Dr Wes Bancroft *BSc(Zool./Microbiol.), Hons(Zool.), PhD(Zool.)*
- Mr Brenden Metcalf *BSc(Env. Sci), Hons(Biol.)*
- Mr Ian Harris *BSc(Cons. Biol./Env. Sci.)*

The report was prepared by Wes Bancroft and Mike Bamford.

3.3 Licences and permits

The field survey was conducted under DEC Regulation 17 licence number SF005662.

3.4 Literature search/Sources of information

A list of fauna that would be expected to occur in the vicinity of the WAPL Collie sublease was generated by searching available databases and literature. This was carried out in May 2007. Sources of information included:

- the Western Australian Museum's (WAM) 'Faunabase'.
- Birds Australia's (BA) database for the second Atlas of Australian Birds.
- the Department of Environment and Conservation's (DEC) Threatened and Priority Fauna Database.
- the federal Department of the Environment and Water Resources (DEWR) Environment Protection and Biodiversity Conservation (EPBC) database (EPBC Protected Matters Search Tool).
- the information and species distribution maps provided by Tyler *et al.* (2000), Storr *et al.* (1983; 1990; 1999), Wilson and Swan (2003), Cogger (2000), Johnstone and Storr (1998), Strahan (1995), Menkhorst and Knight (2004) and Churchill (1998).
- the consultants' previous experience of the region's fauna. This is based on surveys carried out in the general area, including observations made on private property on Big Tree Road, north of Mornington Road, in the north-west of the project area. This is a family property and observations on fauna have been maintained since the late 1970s.

The database searches conducted and the areas searched are shown below:

Database	Type of records held in database	Areas searched
Faunabase (WAM)	Records of fauna specimens held in the WA Museum. Includes historical data.	33° 05' to 33° 20' S and 115° 55' to 116° 10' E
Atlas II Database (BA)	Records of bird observations in Australia, 1995-present.	33° 00' to 34° 00' S and 116° 00' to 117° 00' E
Threatened and Priority Fauna Database (DEC)	Information and records on Threatened and Priority fauna species in Western Australia.	33° 05' to 33° 20' S and 115° 55' to 116° 10' E

Environment Protection and Biodiversity Conservation (EPBC) database - EPBC Protected Matters Search Tool (DEWR)	Records on matters protected under the EPBC Act, including threatened species and conservation estate.	33° 05' to 33° 20'S and 115° 55' to 116° 10' E
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Because the proposed project area will not encounter marine systems under Commonwealth control the obligate marine animals were excluded from the results presented here.

3.5 Nomenclature and taxonomy

As per the recommendations of EPA (2004), the nomenclature and taxonomic order presented in this report are based on the Western Australian Museum's *Checklist of the Vertebrates of Western Australia*. The authorities used for each vertebrate group are: amphibians and reptiles (Aplin and Smith 2001), birds (Christidis and Boles 1994; Johnstone 2001), and mammals (How *et al.* 2001).

3.6 Field surveys

3.6.1 Dates of surveys

Two field surveys were conducted: 17th – 24th January and 21st – 27th May 2007. In both surveys work consisted of trapping for frogs, reptiles and mammals, bird surveys, spotlighting, searching for short-range endemic invertebrates, acoustic playback for owls, and harp trapping and acoustic surveys for bats.

Opportunistic observations were made at all times.

3.6.2 Trapping for frogs, reptiles and mammals

Garden *et al.* (2007) endorse a combination of trapping methods for the most successful and cost-efficient detection of reptile and mammal species. Pitfall, funnel, small box (Elliott) and cage traps were used to sample the vertebrate fauna of the WAPL Collie sublease.

Six sites were selected to cover the major habitat types within the survey area and in an attempt to achieve good spatial representation throughout the survey area. These six sites are shown in Figure 2, and were surveyed each day in anti-clockwise order, beginning with the Labour Road site. Locations were (datum WGS84):

- Labour Road: 412463 mE, 6319648 mN to 413695 mE, 6319405 mN.
- Arklow Road/Scar Road: 416258 mE, 6318400 mN to 416586 mE, 6318323 mN.
- Collie-Tallanalla Road: 415456 mE, 6323229 mN to 415620 mE, 6323571 mN.
- Netic Road: 414259 mE, 6327046 mN to 414082 mE, 6327241 mN.
- Myles Avenue: 404833 mE, 6330143 mN to 405174 mE, 6330122 mN.
- Big Tree Road: 403616 mE, 6327682 mN to 403570 mE, 6327357 mN.

At each site 15 pitfall traps were deployed at 25 m intervals along a linear transect. Wherever possible the transects ran from a high to a low point in the local landscape. Pitfall traps were 20L PVC buckets with a flywire-covered drainage hole in the base. A 25 cm high flywire drift-fence extended 2.4 m either side of the pitfall.

In the January survey only, funnel traps were placed on every second pitfall at each transect (including the first and last in the line). Funnel traps catch mainly reptiles

that are inactive in late autumn. Funnel traps were *c.* 15 cm wide and 60 cm long, with a funnel entrance diameter of 5 cm. Funnels were set up at the end of a pitfall drift fence, with the funnel entrance bisected by the fence. Funnel traps were covered with shade cloth or vegetation to provide shelter for captured animals.

A separate cage and Elliott trapping transect was established in the vicinity of each pitfall transect. At each site, a cage and Elliott trap were placed at each of eight locations, at 200 m intervals, along roads or tracks (note that there were only seven trap locations for the Netic Road site). Elliott (*c.* 80 x 100 x 325mm) and cage traps (*c.* 180 x 180 x 600 mm) were placed under vegetation and baited with a mixture of rolled oats, peanut butter and tinned sardines. Cage traps were covered with hessian bags to provide shelter for captured animals.

The locations of the traps are provided in Appendices 2 (pitfalls/funnels) and 3 (cage/Elliott traps).

Each pitfall/funnel transect was operated for a total of five nights (in each survey) and each cage/Elliott transect was operated for a total of four nights (in each survey). Sampling efforts (trapnights) were therefore:

	January	May	Total
Pitfall traps	450	450	900
Funnel traps	450	-	450
Elliott traps	188	188	376
Cage traps	188	188	376

3.6.3 Bird surveys

In conjunction with the checking of traps, systematic bird surveys were undertaken along each of the pitfall trapping transects (a 'transect' count, see Recher 1988), typically between 7am and midday. Birds that were seen or heard within 25 m of the transect (either side, and at the ends) were recorded. Birds seen or heard outside this zone were also noted. For the purposes of Table 10, calculated bird densities are therefore based on an area of approximately 2,1ha around each transect.

3.6.4 Searching for significant species

3.6.4.1 Searching for indirect signs of significant fauna

Species that were identified in the desktop assessment as conservation significant and likely to occur in the WAPL Collie sublease area include several that can be reliably found by searching for evidence of their activities (e.g. tracks, droppings, diggings, feeding signs, burrows, nesting signs). These include: Forest Red-tailed Black-Cockatoo (feeding signs), Carnaby's Cockatoo (feeding signs), Baudin's Cockatoo (feeding signs), Quokka (droppings), Western Ringtail Possum (dreys), Quenda (diggings) and Woylie (diggings). Searching for this sort of evidence was undertaken by walking through habitat considered suitable for these species.

3.6.4.2 Hand searching for significant fauna

Hand searching was carried out in any areas of interest found during the site inspection/field survey. Searching involved raking through leaf-litter, breaking into dead trees, looking under bark, digging up burrows and turning over rocks, logs and dead vegetation. This searching focussed on mesic refugia, particularly in gullies or

watercourses, likely to be important for short-range endemic invertebrates. Reptiles are often also detected by this method.

3.6.5 Nocturnal surveys (spotlighting, owl and bat surveys)

Spotlighting (for nocturnal animals) surveys were undertaken by vehicle on tracks and roads throughout the survey area. These surveys were conducted in the first few hours after dusk.

Spotlighting was conducted on the nights of the 20/01/2007, 22/01/2007 and 25/05/2007.

In conjunction with the spotlighting surveys, owl call playback surveys were conducted. Recordings of owl calls (Boobook Owl, Barking Owl and Masked Owl) were played back, from a stationary point, through a megaphone projection system in approximately one minute loops (per species). Following call playback, spotlighting of the surrounding woodland (on foot) was conducted.

Bats were surveyed by two methods: harp trapping and acoustic surveys. Two harp-traps were erected in the vicinity of the Labour Road site. Traps were located in areas where bats were likely to come close to the ground (e.g. for foraging, drinking) and in areas that were unlikely to have public traffic overnight (to avoid disturbance or tampering with traps). The locations (datum WGS84) of the traps were:

- Harp trap 1: 412266 E, 6319522 N.
- Harp trap 2: 411572 E, 6319316 N.

Traps were operated for four nights each in the January survey. No harp trapping was conducted in the May survey as the likelihood of catching bats in cool weather is very low. Traps were left open overnight and checked the following morning for bats.

Attempts to detect bats were also made by using an ultrasonic detector. This detection was conducted during spotlighting. Echolocation calls were recorded using the Anabat system (Titley Electronics, Ballina, NSW), where calls are recorded through the Anabat II Bat Detector onto a MiniDisc recorder (MZ-R900 Sony). At a later stage the calls were played back through a ZCAIM unit (Titley Electronics, Ballina, NSW) into Anabat software to analyse the call characteristics.

Characteristics used in call analysis included:

- Fmax Maximum call frequency (kHz)
- Fmin Maximum call frequency (kHz)
- Fc Characteristic frequency (kHz)
- Fpeak Frequency with peak number of cycles (kHz)
- DUR Duration of call (ms)

Note that no calls were recorded for bat species that were not also trapped.

4 RESULTS

4.1 Vertebrate fauna

4.1.1 Overview

The literature review identified 205 species of vertebrate that may occur in the vicinity of the survey area. These comprised 9 fish, 13 frog, 40 reptile, 108 bird and 35 mammal species (Tables 1 to 5). These species reflect a 'typical' semi-humid jarrah faunal assemblage (Dell *et al.* 1989; Nichols and Muir 1989; Storr 1991).

Of the total expected vertebrate fauna there are 28 species of conservation significance (11 CS1, 12 CS2 and 5 CS3 species) that may occur in the vicinity of the survey area. These species are indicated in Tables 1 to 5 and are discussed in the following sections of this report. The number of species of conservation significance in each of the vertebrate classes is:

Freshwater fish	1 (1 CS2)
Amphibia (Frogs)	1 (1 CS3)
Reptilia (Reptiles)	4 (1 CS1, 1 CS2, 2 CS3)
Aves (Birds)	10 (6 CS1, 3 CS2, 1 CS3)
Mammalia (Mammals)	12 (4 CS1, 7 CS2, 1 CS3)

Species accounts that provide basic information on the vertebrate species of conservation significance are presented in the sections below for each of the vertebrate classes. These include their conservation status, the reason for their significance, aspects of their ecology and potential threatening processes. Information presented has been collated from a number of references: Storr *et al.* (1983; 1990; 1999; 2002), Marchant and Higgins (1990; 1993), Cogger *et al.* (1993), Lee (1995), Strahan (1995), Higgins and Davies (1996), Maxwell *et al.* (1996), Churchill (1998), Debus (1998), Johnstone and Storr (1998; 2005), Morgan *et al.* (1998), Duncan *et al.* (1999), Higgins (1999), Cogger (2000), DEP (2000), Garnett and Crowley (2000), Allen *et al.* (2003), Burbidge (2004), Menkhorst and Knight (2004) and DEH (2006).

The results of the DEC and EPBC database searches (for species of conservation significance) are presented in Appendices 4 and 5, respectively, but the information provided by these has also been collated in Tables 1 to 5 and the following species accounts.

4.1.2 Freshwater fish

A total of 9 species of freshwater fish may occur in the vicinity of the survey area (Table 1). All but the Mosquitofish and Brown Trout have been recorded in the Earnest River near the Big Tree Road site. Four of these species are introduced into south-western Australia (see Table 1). Of the native species, all but the Pouched Lamprey are endemic to the South-West and this species is of conservation significance (see below).

Conservation Significance Level 2 (C23)*Geotria australis*

Pouched Lamprey

Listed as Priority 1 by DEC, the ammocoete larvae of this species are abundant in the Earnest River (M. Bamford pers. obs) and the species probably occurs in all seasonal and permanent watercourses in the region. The adults of this species migrate to the ocean but return to freshwater streams to breed.

Native freshwater fish of the South-West generally favour streams that are cool, heavily shaded by overhanging vegetation and have low turbidity (Morgan *et al.* 1998). A number of species, including the Pouched Lamprey, also migrate up and down stream for breeding. Therefore, water quality, fringing vegetation and barriers to movement are important for them. Impacts of introduced species are poorly documented, but the species of most concern, the Mosquitofish, does very poorly in cool forest streams, being favoured in such environments when clearing and damming create open, sunlit and warm bodies of water.

4.1.3 Amphibians (Amphibia)

A total of 13 species of frog may occur in the vicinity of the survey area (Table 2). One of the frog species that may be present is considered to be of conservation significance. This is outlined below:

Conservation Significance Level 3 (CS3)*Heleioporus barycragus*

Hooting Frog

Although not listed as a threatened or priority species, the distribution of *H. barycragus* is not well understood. If present in the survey area, this species would be at the extreme south of its known range.

The field surveys recorded seven species of frog, none of which is of conservation significance (see Table 2). Frogs are sensitive to water quality and the majority of species in the area, especially in the genera *Heleioporus*, *Limnodynastes* and *Pseudophryne*, are terrestrial as adults, moving kilometres into forest outside the winter/spring breeding season.

4.1.4 Reptiles (Reptilia)

A total of 40 species of reptile may occur in the vicinity of the survey area (Table 3). Four of the reptile species that may be present are considered to be of conservation significance. These are outlined below:

Conservation Significance Level 1 (CS1)*Morelia spilota imbricata*

Carpet Python (south-western population)

Listed as Specially Protected (Schedule 4) under the WA Wildlife Conservation Act and also as Priority 4 by DEC and is of concern because this subspecies has declined dramatically in the face of urban development and land clearing. *M. s. imbricata* occurs in the south-western of WA, south of a line that runs from approximately Geraldton in the north-west to Eyre in the south-east. It prefers undisturbed bushland and rocky outcrops and is often arboreal. It preys on birds, other reptiles and small to medium size mammals. At least six other subspecies of *M. spilota* are recognised

around Australia. The Carpet Python is known from private property along Big Tree Road (M. Bamford pers. obs).

Conservation Significance Level 2 (CS2)

Ctenotus delli

Darling Range Heath Ctenotus

Listed as Priority 4 by DEC and is of concern because this species is restricted to the Darling Range between Mundaring and Collie. *C. delli* prefers lateritic and clay substrates in Jarrah/Marri woodlands.

Conservation Significance Level 3 (CS3)

Egernia pulchra pulchra

South-western Spectacled Rock Egernia

Although not listed as a threatened or priority species, *E. pulchra* occurs in three discrete populations. *E. p. longicauda* is restricted to the Jurien islands. *E. p. pulchra* occurs in two disjunct areas: in the hills between Julimar (near Muchea) and Collie, and from Cape Naturaliste to the Stirling Range and Cheyne Beach. Animals recorded from the survey area form part of the restricted Julimar to Collie population.

Lerista microtis microtis

a skink

Although not listed as a threatened or priority species, this species has three disjunct populations in Western Australia: from Dwellingup to Collie (*L. m. microtis*), from Margaret River to Bremer Bay (*L. m. microtis*) and from East Mount Barren to Israelite Bay (*L. m. intermedia*). Animals recorded from the survey area form part of the restricted Dwellingup to Collie population.

The field surveys recorded 20 species of reptile, of which two were of conservation significance: *E. p. pulchra* and *L. m. microtis* (see Table 3). These species are discussed further in 'Impact Assessment: Conservation significant fauna' (page 23).

4.1.5 Birds (Aves)

A total of 180 species of bird may occur in the vicinity of the survey area (Table 4). This includes three species that have been introduced into south-western Australia (see Table 4). Ten of the bird species that may be present are considered to be of conservation significance. These are outlined below:

Conservation Significance Level 1 (CS1)

Falco peregrinus

Peregrine Falcon

Listed as Specially Protected (Schedule 4) under the WA Wildlife Conservation Act. *F. peregrinus* is cosmopolitan but uncommon throughout Australia and prefers sites with tall perches (such as gorges, trees or power poles).

Calyptorhynchus banksii naso

Forest Red-tailed Black-Cockatoo

Listed as Vulnerable (Schedule 1) under the WA Wildlife Conservation Act and is of concern because clearing has greatly reduced the available breeding and feeding habitat. Feral bees and Galahs also compete with *C. b. naso* for nesting hollows. Climate change may explain the westward contraction of this subspecies into areas with higher rainfall. *C. b. naso* occurs in the south-west of Western Australia, approximately south-west of a line between Gingin and the Green Range (near

Wellstead, east of Albany). This range of this subspecies is closely tied to the distribution of Marri (*Corymbia calophylla*); the favoured nesting and food tree of *C. b. naso*. At least four other subspecies of *C. banksii* have been recognised (*C. b. banksii*, *C. b. graptogyne*, *C. b. samueli* and *C. b. macrorhynchus*). *C. b. samueli* and *C. b. macrorhynchus* occur in the Wheatbelt/southern Murchison and Kimberley region of Western Australia, respectively.

Calyptorhynchus latirostris

Carnaby's Cockatoo

Listed as Endangered under the EPBC Act and Endangered (Schedule 1) under the WA Wildlife Conservation Act. *C. latirostris* occurs in the south-west of Western Australia, approximately south-west of a line between the Murchison River (near Kalbarri) and Cape Arid National Park (east of Esperance). This species generally breeds in inland areas, moving to cooler, coastal areas for the non-breeding period (late spring to mid-winter). It has recently begun breeding on coastal areas due to loss of inland breeding habitat. Land clearing and degradation has reduced available breeding sites (tree hollows) and fragmented breeding and feeding sites. Feral bees, galahs and corellas out-compete *C. latirostris* for nesting hollows. Illegal trapping and smuggling also threaten this species.

Calyptorhynchus baudinii

Baudin's Cockatoo

Listed as Vulnerable under the EPBC Act and as Endangered (Schedule 1) under the WA Wildlife Conservation Act. *C. baudinii* occurs in the deep south-west of Western Australia, approximately south-west of a line between Morangup (near Bullsbrook, north of Perth) and Waychinicup National Park (east of Albany). Birds generally breed in the Karri, Marri and Wandoo forests in the southern parts of the species' range and move north to the Darling Range and Swan Coastal Plain during autumn and winter (non-breeding period). Clearing for agriculture and logging has removed nesting and feeding trees for this species.

Apus pacificus

Fork-tailed Swift

Merops ornatus

Rainbow Bee-eater

Both these species are listed as Migratory under the EPBC Act. *A. pacificus* breeds in Siberia and the Himalayas and migrates to arrive in Australia in October, returning to the breeding grounds by May or June. Movements within Australia are in response to weather patterns, with this species often following thunderstorms. It is a highly aerial species that rarely comes to ground. *M. ornatus* occurs year-around in the tropics, with a southward migration, to both south-eastern and south-western Australia, in early spring. Southern birds return north in autumn. When present, *M. ornatus* is common and prominent in natural and altered environments.

Conservation Significance Level 2 (CS2)*Ninox connivens connivens*

Barking Owl (southern population)

Listed as Priority 2 by DEC and of concern because the population of this subspecies has declined dramatically as a result of habitat clearing and logging. *N. c. connivens* occurs in the south-west of Western Australia, approximately south-west of a line between the Greenough River (south of Geraldton) and Esperance. The northern subspecies, *N. c. peninsularis*, occurs in the Pilbara and Northern Territory and is not currently listed as a threatened or priority species.

Tyto novaehollandiae novaehollandiae Masked Owl (southern population)

Listed as Priority 3 by DEC and is of concern because the population and range of this subspecies has declined dramatically as a result of habitat clearing. *T. n.*

novaehollandiae occurs in the deeper south-west of Western Australia, with recent surveys (see Garnett and Crowley 2000) recording birds only from the area between Margaret River and Manjimup. The former range of *T. n. novaehollandiae* extended from Carnarvon to the Nullarbor. Three other subspecies are recognised within Australia, with only *T. n. kimberli* (listed as Vulnerable under the EPBC Act and as Priority 1 by DEC) occurring elsewhere in Western Australia (Kimberley region).

Falcunculus frontatus leucogaster Crested Shrike-tit (south-west population)

Listed as Priority 4 by DEC and is of concern because land clearing has substantially reduced the area of suitable habitat for this species, and the population size has been considerably reduced. *F. f. leucogaster* occurs in the south-west of Western Australia, south of a line between Geraldton and Point Culver (east of Israelite Bay). *F. f. leucogaster* favours smooth-barked eucalypts (Karri, Wandoo, Flooded Gum, Salmon Gum) and Jam over rough-barked species (Jarrah).

Conservation Significance Level 3 (CS3)*Polytelis anthopeplus anthopeplus* Regent Parrot (western population)

Assessed as 'Lower Risk (Least Concern)' by Garnett and Crowley (2000) because a decline in population density has been observed in at least half the range of this subspecies, but density has also increased in other parts of the range. Clearing for agriculture and the death of suitable nest trees (particularly *Eucalyptus salmonophloia*) due to salinity may be responsible for the decline in the WA wheatbelt. *P. a. anthopeplus* occurs in the south-west of Western Australia. An eastern states' subspecies, *P. a. monarchoides*, is also recognised.

The field surveys recorded 50 species of bird, of which two were of conservation significance: Forest Red-tailed Black-Cockatoo and Baudin's Cockatoo (see Table 4). In addition, the Barking Owl has been observed on private property on Big Tree Road (M. Bamford pers. obs). These species are discussed further in 'Impact Assessment: Conservation significant fauna' (page 23).

4.1.6 Mammals (Mammalia)

A total of 35 species of mammal may occur in the vicinity of the survey area (Table 5). This includes eight species that have been introduced into south-western Australia. Twelve of the mammal species that may be present are considered to be of conservation significance. These are outlined below:

Conservation Significance Level 1 (CS1)*Dasyurus geoffroii* Chuditch

Listed as Vulnerable under the EPBC Act and Vulnerable (Schedule 1) under the WA Wildlife Conservation Act. A ten year recovery plan was published in 1991 and has since been successfully implemented. Habitat alteration through clearing, grazing and changed fire regimes, competition with foxes and cats for food, predation by foxes,

hunting, and poisoning all threaten *D. geoffroii*. This species occupies large home ranges, is highly mobile and appears able to utilise bush remnants and corridors.

Phascogale tapoatafa

Brush-tailed Phascogale

Listed as Vulnerable under the WA Wildlife Conservation Act and is of concern because it is threatened by habitat clearing and alteration, a reduction in hollow-bearing trees (particularly as a result of clearing and logging), and predation by cats and foxes. *P. t. tapoatafa* is sparsely distributed in the south-west of Western Australia.

Myrmecobius fasciatus

Numbat

Listed as Vulnerable under the EPBC Act and Vulnerable (Schedule 1) under the WA Wildlife Conservation Act and is of concern because of population decline associated with increased predation. Introduced cats and foxes are mostly responsible, but there has also been an increase in the number of natural predators (particularly birds of prey) as a result of habitat clearing. *M. fasciatus* has been reintroduced into predominantly fox-baited habitat at Dryandra State Forest (near Narrogin); Perup (east of Manjimup), Boyagin (north-east of Wandering), Karroun Hill (south of Paynes Find) and Dragon Rocks (between Hyden and Newdegate) nature reserves; Stirling Range National Park; and the Jarrah forest at Batalling (between Collie and Darkan) and Dale (west of Beverley).

Setonix brachyurus

Quokka

Listed as Vulnerable under the EPBC Act and Vulnerable (Schedule 1) under the WA Wildlife Conservation Acts and is of concern because of fox predation and habitat degradation (through increased fire frequency). Secure populations occur on Rottnest and Bald Islands. Mainland populations are sparse and severely fragmented, and occur between Dwellingup and the Green Range (east of Albany) where they prefer very dense, wet vegetation in forests or adjacent to swamps. Northern Jarrah forest populations continue to decline.

Pseudocheirus occidentalis

Western Ringtail Possum

Listed as Vulnerable under the EPBC Act and Vulnerable (Schedule 1) under the WA Wildlife Conservation Act and is of concern because fox and cat predation has greatly reduced the range and abundance of this species, and has fragmented remaining populations. Habitat clearing for housing between Busselton and Augusta continues to be a major threatening process. *P. occidentalis* is most abundant in Peppermint forests and occurs only in localised, disjunct populations in the Jarrah forest. *P. occidentalis* is endemic to the south-west of Western Australia, between Busselton and Albany.

Conservation Significance Level 2 (CS2)*Isoodon obesulus fusciventer*

Southern Brown Bandicoot, Quenda

Listed as Priority 5 by DEC and is of concern because habitat clearing and fragmentation, fire, and predation by foxes, cats and domestic dogs threaten this species. *I. o. fusciventer* occurs in the south-west of Western Australia. Two other subspecies are recognised, neither of which occurs in Western Australia.

Bettongia penicillata

Woylie, Brush-tailed Bettong

Listed as Priority 5 by DEC and is of concern because habitat clearing and fragmentation, fire, predation by foxes and cats, and competition with introduced herbivores (e.g. rabbits, stock) threaten this species. The only natural populations of this species occur in the south-west of Western Australia, at Dryandra State Forest (near Narrogin) and the areas surrounding Perup (east of Manjimup) and Tutanning (north-east of Narrogin) nature reserves. *B. penicillata* has been reintroduced into predominantly fox-baited habitat at Batalling (between Collie and Darkan) state forest, Boyagin (north-east of Wandering) and Nambung (near Cervantes) nature reserves, Julimar (near Bindoon) conservation park and small numbers have been introduced into the northern Jarrah forest. Fox baiting has successfully increased the existing populations of this species.

Macropus eugenii derbianus

Tammar Wallaby

Listed as Priority 5 by DEC and is of concern because of fox predation and the loss of suitable thickets due to habitat clearing. Remnant populations exist at sites in the wheatbelt that have been subject to fox control. These include: Dryandra State Forest (near Narrogin); Perup (east of Manjimup), Boyagin (north-east of Wandering), Tutanning (north-east of Narrogin) and Nambung (near Cervantes) nature reserves; Batalling (between Collie and Darkan) state forest, Fitzgerald River (east of Bremer Bay) National Park and areas near Pingelly and Hopetoun.

Macropus irma

Brush Wallaby

Listed as Priority 4 by DEC and is of concern because it is threatened by habitat clearing and fragmentation, predation by foxes and illegal hunting. *M. irma* occurs in the south-west of Western Australia, from approximately Geraldton to Esperance.

Falsistrellus mackenziei

Western False Pipistrelle

Listed as Priority 4 by DEC. *F. mackenziei* occurs in the wet sclerophyll and higher rainfall areas of dry sclerophyll forest in the south-west of Western Australia.

Hydromys chrysogaster

Water Rat, Rakali

Listed as Priority 4 by DEC and is of concern because the species' population is in decline, particularly along rivers affected by salinity or degradation. In Western Australia *H. chrysogaster* occurs in the south-west, along parts of the Pilbara coast (including some islands) and in the Kimberley. It also occurs throughout northern and eastern Australia. The distribution of this species is very patchy within this range.

Conservation Significance Level 3 (CS3)

Mormopterus sp. (*M. planiceps*: long penis form, part). Regarded as 'Species 4, population O' by Adams *et al.* (1988). Western Freetail-bat

Although not listed as a threatened or priority species, there is currently a major revision of many *Mormopterus* species and subspecies throughout Australia. This species, the 'Western Freetail-bat', occurs in south western Western Australia, from approximately Lancelin to Kalgoorlie to Eyre (including the wheatbelt), and

represents the south-western population of the species formerly recognised as *M. planiceps*. Six other taxa are currently recognised from the original *M. planiceps* complex, with two of these also occurring in WA i.e. the Inland Freetail bat (species 3) and the Little Western Freetail Bat (species 5, populations U and V).

The field surveys recorded 20 species of mammal, of which four were of conservation significance: Quokka, Tammar, Woylie, Brush Wallaby and Western False Pipistrelle (see Table 5). In addition, the Rakali or Water-Rat has been recorded on private property on Big Tree Road and the Chuditch has been seen along Mornington road west of Big Tree Road (M. Bamford pers. obs.). These species are discussed further in 'Impact Assessment: Conservation significant fauna' (page 23).

4.2 Invertebrate fauna

One invertebrate species of conservation significance was returned by the DEC database search (Appendix 4):

Conservation Significance Level 2 (CS2)

Pachysaga munggai a cricket

Listed as Priority 3 by DEC. The type locality of this species is near Jarrahdale (1 km south on the Vasse Highway).

The potential also exists for other short-range endemics to occur in the vicinity of the survey area. Harvey (2002) notes that the majority of species that have been classified as short-range endemics have common life history characteristics such as poor powers of dispersal or confinement to discontinuous habitats. Several groups, therefore, have particularly high instances of short-range endemic species: Gastropoda (snails and slugs), Oligochaeta (earthworms), Onychophora (velvet worms), Araneae (mygalomorph spiders), Pseudoscorpionida (pseudoscorpions), Schizomida (schizomids), Diplopoda (millipedes), Phreatoicida (phreatoicidan crustaceans), and Decapoda (freshwater crayfish). The poor understanding of the taxonomy of many of the short-range endemic species hinders their conservation (Harvey 2002).

4.3 Fauna habitats

The major fauna habitats within the survey area include:

- Jarrah/Marri forest on lateritic soils (Figure 3).
- Jarrah/Marri forest on sandy soils.
- She-oak woodland.
- Permanently inundated wetlands and drainage lines (lakes and rivers, see Semeniuk and Semeniuk 1996). See also Figure 4.
- Seasonally inundated or waterlogged wetlands and drainage lines (sumplands, creeks, floodplains, damplands, troughs and palusplains, see Semeniuk and Semeniuk 1996).

The survey area lacks some distinctive and rare habitats associated with granite outcrops, as occur further north.

4.4 Field survey results

4.4.1 Trapping for frogs, reptiles and mammals

A total of 97 species were recorded in one or more of the two field surveys. These comprised 7 frogs, 20 reptiles, 50 birds and 20 mammals (see Tables 2 to 5). The January survey recorded 84 species (1 frog, 20 reptiles, 48 birds and 15 mammals) and the May survey recorded 61 species (7 frogs, 3 reptiles, 38 birds and 13 mammals; see Tables 2 to 5).

4.4.1.1 Fauna captured

A total of 29 species were captured by pitfall, funnel, cage or Elliott trapping during the field surveys (23 species in the January survey and 11 in the May survey, see Tables 6 and 7). Twenty-three species were captured by pitfall or funnel trapping (Table 6) and nine species were captured by cage or Elliott trapping (Table 7). A total of 276 captures were made (by any trap method across both surveys, see Tables 6, 7 and 8). The most commonly encountered species were *Crinia georgiana* (32% of captures), *Antechinus flavipes* (13%), *Morethia obscura* (10%), *Lerista distinguenda* (9%) and *Lerista microtis* (9%; see Table 8).

Five species of bats were captured by harp trapping during the January survey (no harp trapping was conducted in May). A summary of the species captured is shown in Table 9.

4.4.1.2 Patterns of biodiversity

Captures were relatively evenly spread across all sites sampled (Table 8). The species richness of each site was also relatively even, with 10 or 11 species recorded at most sites (15 species were recorded at the Arklow/Scar Road site; Table 8).

For each pitfall/funnel location, the basic vegetation, soil and topography were scored. The categories of these are presented in Appendix 6, along with the number of nights of trapping conducted in each category. For each category (of vegetation, soil and topography) the number of pitfall and funnel captures (all species and surveys pooled) was standardised for the number of trap nights within that category. Analysis of variance of these data indicated that there was no significant influence of any vegetation, soil or topographic type on the distribution of fauna. The recorded distribution of fauna was not significantly different from what would be expected if all captures were distributed at random: vegetation ($\chi^2 = 10.7$, d.f. = 11, $P = 0.472$), soil ($\chi^2 = 7.8$, d.f. = 6, $P = 0.254$) and topography ($\chi^2 = 6.2$, d.f. = 8, $P = 0.624$).

4.4.2 Bird surveys

4.4.2.1 Birds recorded

A total of 28 species of bird were recorded during the bird surveys (Table 10). The most commonly encountered bird species were Inland Thornbill, Baudin's Cockatoo and Forest Red-tailed Black-Cockatoo. Overall bird density was 4.21 birds ha⁻¹ day⁻¹.

4.4.2.2 Patterns of biodiversity

Species richness of the six sites ranged from 8 to 17 species, with the most species recorded at the Labour Road site and least at Netic Road (Table 10). Bird density ranged from 2.35 to 5.76 birds ha⁻¹ day⁻¹ (Table 10). The highest density was recorded at Labour Road and the least at Arklow Road/Scar Road (Table 10).

As for the pitfall/funnel trapping results, the number of birds recorded (all species and surveys pooled) was standardised for the number of survey days within each category of vegetation, soil and topographic type. Analyses of variance of these data indicate that vegetation ($\chi^2 = 63.8$, d.f. = 11, $P < 0.001$), soil ($\chi^2 = 18.3$, d.f. = 6, $P = 0.005$) and topography ($\chi^2 = 31.6$, d.f. = 8, $P < 0.001$) all influence the distribution of birds. These data should, however, be interpreted with caution due to the low sample sizes. Cautiously, it appears that more birds were recorded in Marri and Jarrah over open understorey and in areas with a gravel substrate. Fewer than expected birds were recorded in the riparian zones sampled. This, however, may be due to poor visibility in the dense vegetation of riparian zones.

4.4.3 Searching for, and opportunistic sightings of, significant species

Searching for signs of significant vertebrate species found evidence of several species:

Red-tailed Black-Cockatoo (CS1). Feeding signs (Jarrah nuts) were observed throughout the survey area in both surveys, and the species was seen regularly. Woylie (CS2). Some potential Woylie diggings were observed around the Big Tree Road site in both surveys. Some 'chew' marks on fungi were also observed in this area in the May survey. A young female was caught in January at the Big Tree Road site.

Quokka (CS1). Droppings that were likely to be from Quokka were observed along the drainage line leading up to the Labour Road site in both surveys. At least one Quokka was seen at the Labour Road site, in dense riparian vegetation.

Tammar (CS2). One roadkilled specimen on the refinery entrance road in January.

Quenda (CS2). Despite searching, no Quenda diggings were located. This species has not been observed on private property along Big Tree Road, where observations have been maintained since the late 1970s. This suggests that the species is very scarce in the area.

Hand searching during the field survey located several invertebrate species.

Specimens were returned to the WAM for identification. None of the species was considered to be a short-range endemic. The species were:

- *Atelomastix nigrescens* (Lulomorphidae). A millipede. Found throughout the survey area (i.e. all sampling sites) under leaf litter and in pitfall traps. Particularly abundant in the May survey. This species is known to be widespread in the jarrah forest.
- *Antichiropus variabilis*. A millipede. Widespread in the Jarrah forest.
- *Cercophonius sulcatus* (Bothriuridae). A scorpion. Found near the Arklow/Scar Road site in the January survey. All members of this genus known in WA are widespread.
- *Archisometrus* sp. (Buthidae). A scorpion. From the Labour Road and Big Tree Road sites.
- *Aname* sp. (Nemesiidae). A trapdoor spider. Captured in pitfall traps at the Netic Road site in the January survey. Not identified to species but believed to be widespread.
- *Chenistonia tepperi* ? (Nemesiidae). One of the trapdoor spiders, although this species lives in a burrow without a trapdoor. *C. tepperi* is widespread in southern WA. ()

- *Aganippe rhapsiduca* (Idiopidae). A trapdoor spider. Found throughout the survey area and widespread in southern WA, although the currently recognised species probably contains several distinct taxa. In the Jarrah forest the species commonly occurs in loam soils alongside watercourses (B. Main pers. comm.).

A number of opportunistic recordings of significant fauna were made. These are presented in Table 11.

4.4.4 Nocturnal surveys (spotlighting, owl and bat surveys)

The spotlighting surveys recorded several species: *Litoria adelaidensis*, *L. moorei*, *Parasuta nigriceps*, *Trichosurus vulpecula* and *Macropus irma*. No owls were detected by the call playback surveys. No additional bat species to those captured were detected by acoustic recording and analysis.

5 IMPACT ASSESSMENT

5.1 Impacting processes

There are several processes that may adversely affect fauna in the mining of the survey area. These include:

- Death/injury of fauna during clearing, grading and impacts with vehicles/machinery;
- Loss of habitat (clearing);
- Fragmentation of habitat;
- Degradation of habitat as a result of the spread of the Dieback fungus (*Phytophthora cinnamomi*);
- Obstructions (e.g. pipes on ground, roads) to the movements of terrestrial fauna;
- Impacts to surface and groundwater flows (through vegetation clearing, interception of the ground water table and dewatering);
- Changes in the abundance of feral species;
- Direct and indirect impacts of dust;
- Disturbance of fauna in nearby areas from artificial light, noise and even personnel feeding selected species.

Some impacts upon fauna are unavoidable during a resource development project. Of concern are long-term, deleterious impacts upon biodiversity. These are discussed below under the following categories:

- Conservation significant fauna. Impacts may be significant if species of conservation importance are affected.
- Conservation significant habitats. Impacts may be significant if the habitat is rare, a large proportion of the habitat is affected and/or the habitat supports significant fauna.
- Ecological processes. Ecological processes are complex and can include hydrology, fire, predator/prey relationships and spatial distribution of a population (see discussion below). Impacts upon ecological processes may be significant if large numbers of species or large proportions of populations are affected.
- Patterns of biodiversity. Species are not distributed evenly across the landscape or even within one vegetation/landform type. There may be zones of high biodiversity such as particular habitats or ecotones (transitions between habitats).

The potential impacts to fauna of the proposal as assessed following the guidance of the EPA's Guidance Statement No. 56. Table 13 summarises the level of impact associated with the proposed disturbance.

5.2 Conservation significant fauna

A relative risk assessment for the species of conservation significance is presented in Table 12. This is a subjective assessment based on:

- The level of conservation significance of each species (i.e. CS1, CS2 or CS3; see Background);
- The inferred status of the species within the survey area (based on observations made during the field surveys, published information about the range and preferred habitats of each species, and the consultants' experience with these species);
- The type and magnitude of the potential impacts relevant to each species, and the likelihood of these impacts actually occurring.

The relative risk assessment of the conservation significant species highlights several species that are of greatest concern. Effectively, these are species that are most likely to occur in the survey area and/or are most likely to be significantly impacted by the proposed operations. The species are:

- *Calyptorhynchus banksii naso* (Forest Red-tailed Black-Cockatoo) - CS1
- *Calyptorhynchus baudinii* (Baudin's Cockatoo) - CS1
-
- *Setonix brachyurus* (Quokka) - CS1
- *Isoodon obesulus fusciventer* (Quenda) - CS2
- *Bettongia penicillata olgiby* (Woylie) - CS2
- *Macropus irma* (Brush Wallaby) - CS2
- *Macropus eugenii* (Tamar Wallaby) – CS2

For the two black-cockatoo species, the major concern is the loss of nesting trees. Note that Carnaby's Cockatoo, while it may visit the area occasionally, is likely to be present in only small numbers and is unlikely to breed in the area, although it does breed just east of Collie (M. Bamford, pers. obs.). For the remaining species, all mammals, major concerns are with roadkill, particularly if roads are placed close to water courses, and impacts of introduced predators. Fire may also be a concern. Management recommendations for these species are considered in section 6. Migratory bird species listed for the survey area are uncommon in forest habitat.

The relative risk of impact to all other species of conservation significance is considered to be negligible, low or low-moderate (see Table 12) because there is either a low likelihood of the species being present within the survey area or there is a low likelihood of these species being strongly affected by operations. Although some of these remaining conservation significant species are susceptible to the likely impacts of the proposed operations, it is considered unlikely that this will have a sustained, significant impact on these species. Despite this, some of the management recommendations (section 6) are intended to minimise impacts on these and other species.

5.3 Conservation significant habitats

Habitats of conservation significance tend to be those that are both rare across the landscape and that are important for significant species and/or for biodiversity. In the project area, watercourses and associated riparian vegetation are small in extent and are important for a number of significant species, particularly mammals such as the Quokka, Tammar and Rakali. On a different scale, individual old trees with large hollows are important for nesting, particularly by black-cockatoos. Jarrah-Marri forest, while important for many species, is widespread.

Although the Western Ringtail Possum was listed in the results of the search of the EPBC Threatened Species database, the preferred habitat of this species (WA Peppermint *Agonis flexuosa*) was not observed during the surveys. A small population of this species is known from suitable habitat near Stirling Dam, east of Harvey.

5.4 Ecological processes

Chapin *et al.* (2002) defined an ecosystem (ecological) process as the transfer of matter or energy between components (either biotic or abiotic) of an ecosystem. These include processes such as inter- or intra-specific interactions (e.g. predation, competition) and physical or biophysical interactions (e.g. photosynthesis, hydrological fluxes, erosion). Amundson and Jenny (1997) suggest that ecosystem processes (and, hence, ecosystem 'function') are driven or influenced by at least five main factors: climate, parent material, topography, biota and time. Human activity may directly or indirectly affect these factors and may, therefore, also impact upon ecosystem processes and ecosystems.

5.4.1 EPBC key threatening processes

Under the EPBC Act (1999), a key threatening process is an ecological interaction that threatens or may threaten the survival, abundance or evolutionary development of a threatened species or ecological community (DEWR 2007a). There are currently 17 key threatening processes listed by the federal Department of the Environment and Water Resources (DEWR 2007b). Several of these processes are applicable to the survey area:

- Competition and land degradation by feral rabbits;
- Dieback caused by the root-rot fungus (*Phytophthora cinnamomi*);
- Infection of amphibians with chytrid fungus resulting in chytridiomycosis;
- Land clearance;
- Loss of climatic habitat caused by anthropogenic emissions of greenhouse gases;
- Predation by feral cats;
- Predation by the European Red Fox (*Vulpes vulpes*);
- Predation, habitat degradation, competition and disease transmission by feral pigs;

5.4.2 Ecological processes relating to connectivity

Soule *et al.* (2004) reviewed the role of landscape connectivity in conservation and identified seven ecological processes that are most relevant to the conservation of biodiversity in Australia.

- Critical species interactions (highly interactive species)
- Long distance biological movement
- Disturbance at local and regional scales

- Global climate change
- Hydroecology
- Coastal zone fluxes
- Spatially-dependent evolutionary processes (range expansion and gene flow)

5.4.3 Project-specific ecological processes

There are common themes through the ecological processes outlined by Soule *et al.* (2004), the key threatening processes listed by (DEWR 2007b) and some of the impacts discussed with respect to threatened species (see Vertebrate fauna and Invertebrate fauna in the Results). The simplified categories of ecological processes relevant to the environmental management of the survey area are discussed below.

5.4.3.1 Increased mortality

Vehicle movement and operation may result in the death or injury of fauna as a result of collisions. Direct mortality of common species during clearing is unavoidable but can be minimised (see section 6 – Management and Monitoring Recommendations). Direct mortality of rare species, and ongoing mortality such as due to roadkill, may have a significant impact (Taylor and Goldingay 2004). Fragmentation of habitat can severely affect wildlife and lead to mortality through collision with vehicles (Scheick and Jones 1999; Cleverger and Waltho 2000; Jackson and Griffin 2000). Dufty (1989) suggested that the greatest cause of adult mortality in populations of Eastern Barred Bandicoots (*Perameles gunni*) was due to collisions with vehicles. Jones (2000) documented the sudden decline in a population of Eastern Quolls (*Dasyurus viverrinus*) and Tasmanian Devils (*Sarcophilus harrisii*) directly attributed to increased road mortality following the upgrade of a local road. Direct and ongoing mortality (in particular from road collisions) may be a concern for the viability of species that occur at low population densities in the survey area. Species such as the Carpet Python and Chuditch may be attracted to roads (for foraging or basking) and species such as the Quenda, Woylie, Brush Wallaby, Tammar and Quokka are susceptible to road kill as they transit across roads (as observed during these surveys; see Table 11). These species will be particularly vulnerable to vehicle collision at dusk and throughout the night.

5.4.3.2 Loss of habitat affecting population survival

Some loss of habitat is inevitable but can be minimised through controls during clearing. Clearing of habitat may result in loss of refugia for fauna. The impact of land clearing on fauna will be roughly proportional to the amount of habitat cleared (although some habitats may be more significant than others). Of greatest concern is the loss of rare habitat that supports significant species within the survey area, especially drainage lines and wetlands. Loss of habitat can reduce population size and that, for some species, may be critical. Rehabilitation may also be possible.

5.4.3.3 Loss of habitat affecting population movements and gene flow

Large-scale movements may be essential for the survival of many species of vertebrates and invertebrate fauna. 'Landscape permeability' (the movement of biota through the landscape, Soule *et al.* 2004) should be preserved to allow passage of these species. Similarly, range expansion and gene flow are very important for the preservation of biodiversity and habitat connectivity is required to allow these processes to occur.

Areas of greatest concern within the survey area are those with linear morphology (e.g. watercourses) that may be disrupted by development. Roads may also present a barrier for the movement of small species. Fragmentation of important habitat by roads and access tracks (e.g. the separation of uncommon habitat units from one another) may be of concern for some species (e.g. Quokka).

5.4.3.4 *Species interactions, including predators and other feral species*

Some species within ecosystems have disproportionately high levels of interactions with other species (Soule *et al.* 2004). This is usually through the construction of structures (e.g. burrows) or through interactions such as predation, pollination and competition. Introduced predators, including the feral cat and fox, may have adverse impacts upon native species. In particular, several mammal species expected in the area are sensitive to predation by foxes. Foxes (and feral cats) can increase in abundance around minesites due to the inadvertent increase in food supply from scraps, increases in the abundance of rodents, or the deliberate feeding by personnel. Feral pigs impact on native ecosystems through predation, destruction of habitat, competition and disease transmission (DEH 2005). Pigs are known from the survey area and may place additional pressure on uncommon species or ecosystems if these are already isolated (e.g. through habitat fragmentation) by the proposed project.

5.4.3.5 *Hydroecology*

Interruptions of hydroecological processes (e.g. through the removal or modification of vegetation, mining, dewatering, diversion of natural drainage) can have massive effects because they underpin primary production in ecosystems and there are specific, generally rare habitats that are hydrology-dependent. Roads may also alter both surface and sub-surface hydrology. Fauna that are dependent on wetlands or mesic environments (such as frogs and some short range endemic invertebrates) may be impacted by hydroecological change. Barriers to movement of aquatic fauna can adversely affect native fish while clearing and damming along watercourses can favour introduced fish species over native species.

5.4.3.6 *Climate change*

As a result of human induced climate change, the climatic 'envelope' (the climatic zone within which a species exists, Soule *et al.* 2004) of many species will physically shift or even cease to exist. Some species may not be able to keep pace with the geographical movement (or disappearance) of their climatic envelope. Conversely, climate change may exacerbate the spread of other species in areas where current competitors or disease cannot follow. The predicted effects of climate change should be considered in the long-term management of fauna within the survey area.

5.4.3.7 *Fire*

Fire is a natural feature of the environment in the survey area, but frequent, extensive fires may adversely impact some fauna, particularly mammals. As an example, the conservation significant Quokka requires a mosaic of recently burnt and long-unburnt refugia (Hayward *et al.* 2007). The potential for accidental fire will increase with development. There may be some potential to use roads and infrastructure as fire-breaks to deliberately create a mosaic of fire ages, while protecting long-unburnt habitats that may be important for fauna.

5.4.3.8 *Artificial light and noise*

Impacts of artificial light and noise upon fauna are difficult to predict. As such, it is best to take a precautionary approach. The death of very large numbers of insects has been reported around some remote minesites and attracts other fauna (including introduced predators), as well as presumably reducing the populations of insects in surrounding habitats.

6 MANAGEMENT AND MONITORING RECOMMENDATIONS

Recommendations to minimise potential impacts to fauna within the survey area are discussed below.

Recommendation 1:

Limit loss of habitat by restricting the number of roads constructed and keeping the area of infrastructure to a minimum. Also, prevent degradation of vegetation surrounding study areas by increasing the awareness of personnel and restricting access to areas of significant vegetation.

Reason:

Retain as much habitat as possible, in the best condition possible. This will help retain the fauna values already present at the site and facilitate rehabilitation.

Recommendation 2:

Minimise night driving.

Reason:

Many animals will use roads as a basking (e.g. reptiles), roosting (e.g. birds) or foraging (e.g. reptiles, birds, mammals) at night, particularly in the summer months. Minimising the amount of vehicle traffic at night will reduce the mortality of fauna on roads. Several of the conservation significant mammals in the area are susceptible to road collisions.

Recommendation 3:

Infrastructure and roads should be located in order to minimise fragmentation of important habitats.

Reason:

The mortality of fauna on roads is likely to be high. Positioning infrastructure and roads to avoid fragmenting important or biodiverse habitats (e.g. drainage lines) will likely reduce the passage of fauna across roads and, hence, reduce mortality. Roads that run parallel and close to drainage lines may result in high rates of roadkill of significant mammals.

Recommendation 4:

Limiting speed limits (e.g. 50kph day-time, 40kph night-time) should be considered in areas of high wildlife activity, such as close to watercourse crossings.

Reason:

This will reduce the mortality of fauna due to collisions, which is particularly relevant to some threatened mammal species. It will also reduce dust emissions over road-side vegetation, which leads to vegetation loss and a reduction in habitat values.

Recommendation 5:

Roadkilled fauna should be reported to site environmental personnel. Any fauna suspected of being of conservation significance should be reported to the relevant conservation authority (e.g. Quokka, Woylie, Tammar Wallaby).

Reason:

This will allow monitoring of the ongoing impacts of the mine and increase the knowledge of the fauna in the area.

Recommendation 6:

Where roads, mining or other infrastructure cross linear habitats, consideration should be given to facilitating movement of fauna so that the infrastructure does not form a barrier.

Reason:

Fragmentation of fauna populations can affect their survival. Installation of underpasses may reduce the chance of mortality.

Recommendation 7:

Continue to research the breeding activity of Black-Cockatoos within the lease area.

Reason:

The Black-Cockatoos were highlighted as species of high risk of impact. Understanding if and, if so, where, these birds nest within the survey area will be of high importance to mitigating impacts on these species. This may require the identification of nest trees so that these can be avoided where possible. Installation of nest boxes to mitigate the loss of nest trees may be an option.

Recommendation 8:

Manage the spread of Dieback (*Phytophthora cinnamomi*).

Reason:

P. cinnamomi has the potential to greatly reduce the quality of vegetation and, hence, the quality of habitat for fauna.

Recommendation 9:

Feral fauna, particularly cats, foxes and pigs, should not be encouraged. Feral animal control strategies should be implemented where necessary.

Reason:

Cats and foxes are often attracted to mine infrastructure and are significant predators of native wildlife, particularly mammals and possibly the Carpet Python. Pigs may significantly damage habitats.

Recommendation 10:

To adopt the precautionary principle, lighting should be directed away from natural habitats so that light-spill is minimised.

Reason:

Minimise death of insects attracted to lights and possible impacts on other fauna.

Recommendation 11:

Environmental education and training of staff should be conducted.

Reason:

All employees have the potential to assist fauna conservation within the mining lease. Appropriate education should be offered to assist staff and contractors in identifying significant fauna (and the reasons for their significance), to understand how they can aid their conservation and to improve the overall understanding of fauna conservation.

Recommendation 12:

Consider providing signage to indicate important fauna or habitats, while ensuring this does not encourage illegal trapping or other deleterious activities.

Reason:

To clearly identify important fauna or habitats and to assist in the education of staff and contractors in conserving fauna.

Recommendation 13:

A fire prevention and control strategy should be implemented to prevent extensive fires burning across the site. The creation of a mosaic of fire ages is desirable.

Reason:

Extensive fires can negatively impact fauna, but a mosaic of fire ages across the landscape favours species diversity.

Recommendation 14:

Ensure hydrological impacts either from groundwater use or interference with drainage lines are minimised. Groundwater levels and seasonal surface water flow should be monitored. Any changes attributable to mine activities should be corrected so as to minimise disturbance to fauna or their habitats.

Reason:

Habitats along drainage lines are locally significant for fauna and changes in hydrology may impact on the riparian habitats and the fauna that utilise them. Changes in groundwater levels may affect any groundwater dependent ecosystems, which may consequently impact on fauna utilising such areas.

Recommendation 15:

After mining, appropriate revegetation of all disturbed areas (mining areas, unnecessary roads, areas of infrastructure) should be carried out, using locally collected seed.

Reason:

Insofar as possible, return disturbed areas into habitat that can support a faunal assemblage similar to those that occurred there before the disturbance.

The above recommendations should be considered for incorporation into management and monitoring programs, from the planning and construction phases, through to the operational and closure phases.

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8 TABLES

Table 1. Fish that may occur in the vicinity of the survey area. Status is assigned as described in section 2 (Background). ‘+’ indicates a species was recorded directly.

Species		Status	Jan	May
GEOTRIIDAE (Pouched lampreys)				
<i>Geotria australis</i>	Pouched Lamprey	CS2		
PLOTOSIDAE (Eel-tailed catfishes)				
<i>Tandanus bostocki</i>	Freshwater Cobbler			
GALAXIIDAE (Jollytails or native minnows)				
<i>Galaxias occidentalis</i>	Western Minnow			
PERCICHTHYIDAE (Australian freshwater basses and cods)				
<i>Bostockia porosa</i>	Nightfish			
NANNOPERCIDAE (Pygmy-perches)				
<i>Edelia vittata</i>	Western Pygmy-perch			
SALMONIDAE (Trout and salmon)				
<i>Oncorhynchus mykiss</i>	Rainbow Trout	INT		
<i>Salmo trutta</i>	Brown Trout	INT		
POECILIIDAE (Live-bearers)				
<i>Gambusia holbrooki</i>	Mosquitofish	INT		
PERCIDAE (Perches)				
<i>Perca fluviatilis</i>	Redfin Perch	INT		

Table 2. Amphibians that may occur in the vicinity of the survey area. Status is assigned as described in section 2 (Background). ‘+’ indicates a species was recorded directly.

Species		Status	Jan	May
HYLIDAE (Tree frogs)				
<i>Litoria adelaidensis</i>	Slender Tree Frog			+
<i>Litoria moorei</i>	Motorbike Frog			+
MYOBATRACHIDAE (Ground frogs)				
<i>Heleioporus barycragus</i>	Hooting Frog	CS3		
<i>Heleioporus eyrei</i>	Moaning Frog			
<i>Heleioporus inornatus</i>	Whooping Frog			+
<i>Heleioporus psammophilus</i>	Sand Frog			
<i>Limnodynastes dorsalis</i>	Banjo Frog, Pobblebonk			+
<i>Neobatrachus pelobatoides</i>	Humming Frog			
<i>Crinia georgiana</i>	Quacking Frog		+	+
<i>Crinia glauerti</i>	Glauert's Froglet			
<i>Crinia pseudinsignifera</i>	Bleating Froglet			+
<i>Geocrinia leai</i>	Lea's Frog			+
<i>Pseudophryne guentheri</i>	Günther's Toadlet			

Table 3. Reptiles that may occur in the vicinity of the survey area. Status is assigned as described in section 2 (Background). '+' indicates a species was recorded directly.

Species		Status	Jan	May
CHELUIDAE (Side-necked freshwater turtles)				
<i>Chelodina oblonga</i>	Long-necked Tortoise			
AGAMIDAE (Dragons)				
<i>Pogona minor</i>	Western Bearded Dragon			
GEKKONIDAE (Geckos)				
<i>Diplodactylus polyophthalmus</i>	Speckled Stone Gecko		+	
<i>Underwoodisaurus milii</i>	Barking Gecko			
<i>Christinus marmoratus</i>	Marbled Gecko		+	+
PYGOPODIDAE (Legless lizards)				
<i>Aprasia pulchella</i>	Granite Worm-lizard		+	
<i>Aprasia repens</i>	Sand-plain Worm-lizard			
<i>Lialis burtonis</i>	Burton's Legless Lizard			
SCINCIDAE (Skinks)				
<i>Acriscosincus trilineatum</i>	Cool Skink		+	
<i>Cryptoblepharus plagiocephalus</i>	Fence Skink		+	
<i>Ctenotus catenifer</i>				
<i>Ctenotus delli</i>	Dell's Skink	CS2		
<i>Ctenotus impar</i>	South-western Odd-striped Ctenotus			
<i>Ctenotus labillardieri</i>	Red-legged Ctenotus		+	
<i>Egernia kingii</i>	King's Skink		+	
<i>Egernia luctuosa</i>	Western Glossy Swamp Egernia			
<i>Egernia napoleonis</i>	Salmon-bellied Skink		+	
<i>Egernia pulchra</i>	Spectacled Rock Egernia	CS3	+	
<i>Glaphyromorphus gracilipes</i>				
<i>Hemiergis initialis</i>	Five-toed Earless Skink			
<i>Hemiergis peronii</i>			+	+
<i>Lerista distinguenda</i>	South-western Four-toed Lerista		+	
<i>Lerista microtis microtis</i>		CS3	+	+
<i>Menetia greyii</i>	Common Dwarf Skink			
<i>Morethia obscura</i>	Dusky Morethia		+	
<i>Morethia lineocellata</i>	Western Pale-flecked Morethia		+	
<i>Tiliqua rugosa</i>	Bobtail		+	
VARANIDAE (Monitors and goannas)				
<i>Varanus gouldii</i>	Sand Goanna		+	
<i>Varanus rosenbergi</i>	Heath Monitor		+	
TYPHLOPIDAE (Blind snakes)				
<i>Ramphotyphlops australis</i>	Southern Blind Snake		+	
<i>Ramphotyphlops pinguis</i>	Fat Blind Snake			
BOIDAE (Pythons)				
<i>Morelia spilota imbricata</i>	Carpet Python	CS1		

Table 3 (cont.)

Species	Status	Jan	May
ELAPIDAE (Venomous land snakes)			
<i>Echiopsis curta</i>	Bardick		
<i>Elapognathus coronatus</i>	Crowned Snake		
<i>Neelaps bimaculatus</i>	Black-naped Snake		
<i>Notechis scutatus</i>	Tiger Snake		
<i>Parasuta gouldii</i>	Gould's Snake		
<i>Parasuta nigriceps</i>	Black-backed Snake	+	
<i>Pseudonaja affinis</i>	Dugite	+	
<i>Simoselaps bertholdi</i>	Jan's Banded Snake		

Table 4. Birds that may occur in the vicinity of the survey area. Status is assigned as described in section 2 (Background). Species marked with a superscript ‘w’ are generally dependent on wetlands, species marked with a superscript ‘a’ are highly aerial species. ‘+’ indicates a species was recorded directly, ‘F’ indicates a species was recorded by foraging signs.

Species		Status	Jan	May
CASUARIIDAE (Cassowaries and emus)				
<i>Dromaius novaehollandiae</i>	Emu		+	+
PHASIANIDAE (Pheasants and allies)				
<i>Coturnix ypsilophora</i>	Brown Quail			
ANATIDAE (Ducks and allies)				
<i>Tadorna tadornoides</i>	Australian Shelduck ^w			
<i>Chenonetta jubata</i>	Australian Wood Duck ^w			
<i>Anas superciliosa</i>	Pacific Black Duck ^w			
<i>Anas gracilis</i>	Grey Teal ^w			
ARDEIDAE (Hérons, bitterns and egrets)				
<i>Egretta novaehollandiae</i>	White-faced Heron ^w			
<i>Ardea pacifica</i>	White-necked Heron ^w			
ACCIPITRIDAE (Osprey, hawks and eagles)				
<i>Elanus axillaris</i>	Black-shouldered Kite		+	
<i>Lophoictinia isura</i>	Square-tailed Kite			
<i>Haliastur sphenurus</i>	Whistling Kite			
<i>Circus approximans</i>	Swamp Harrier ^w			
<i>Accipiter fasciatus</i>	Brown Goshawk		+	
<i>Accipiter cirrhocephalus</i>	Collared Sparrowhawk			
<i>Aquila audax</i>	Wedge-tailed Eagle		+	
<i>Hieraaetus morphnoides</i>	Little Eagle			
FALCONIDAE (Falcons)				
<i>Falco berigora</i>	Brown Falcon			
<i>Falco longipennis</i>	Australian Hobby			
<i>Falco peregrinus</i>	Peregrine Falcon	CS1		
<i>Falco cenchroides</i>	Nankeen Kestrel			
RALLIDAE (Rails, gallinules and coots)				
<i>Porphyrio porphyrio</i>	Purple Swamphen ^w			
TURNICIDAE (Button-quails)				
<i>Turnix varia</i>	Painted Button-quail		+	F
CHARADRIIDAE (Lapwings, plovers and dotterels)				
<i>Elsayornis melanops</i>	Black-fronted Dotterel ^w			
<i>Vanellus tricolor</i>	Banded Lapwing			
COLUMBIDAE (Pigeons and doves)				
<i>Columba livia</i>	Feral Pigeon (Rock Dove)	INT		
<i>Streptopelia senegalensis</i>	Laughing Turtle-Dove	INT		
<i>Phaps chalcoptera</i>	Common Bronzewing		+	+
<i>Phaps elegans</i>	Brush Bronzewing			
<i>Ocyphaps lophotes</i>	Crested Pigeon			

Table 4 (cont.)

Species		Status	Jan	May
CACATUIDAE (Cockatoos)				
<i>Calyptorhynchus banksii</i>	Red-tailed Black-Cockatoo	CS1	+	+
<i>Calyptorhynchus latirostris</i>	Carnaby's Cockatoo	CS1		
<i>Calyptorhynchus baudinii</i>	Baudin's Cockatoo	CS1	+	+
<i>Cacatua roseicapilla</i>	Galah			
PSITTACIDAE (Parrots)				
<i>Glossopsitta porphyrocephala</i>	Purple-crowned Lorikeet			+
<i>Polytelis anthopeplus</i>	Regent Parrot	CS3		
<i>Platycercus icterotis</i>	Western Rosella		+	+
<i>Barnardius zonarius</i>	Australian Ringneck		+	+
<i>Purpureicephalus spurius</i>	Red-capped Parrot		+	+
<i>Neophema elegans</i>	Elegant Parrot			
CUCULIDAE (Old world cuckoos)				
<i>Cuculus pallidus</i>	Pallid Cuckoo			
<i>Cacomantis flabelliformis</i>	Fan-tailed Cuckoo			
<i>Chrysococcyx basalis</i>	Horsfield's Bronze-Cuckoo			
<i>Chrysococcyx lucidus</i>	Shining Bronze-Cuckoo			
STRIGIDAE (Hawk owls)				
<i>Ninox connivens connivens</i>	Barking Owl (southern)	CS2		
<i>Ninox novaeseelandiae</i>	Southern Boobook			
TYTONIDAE (Barn owls)				
<i>Tyto novaehollandiae novaehollandiae</i>	Masked Owl	CS2		
<i>Tyto alba</i>	Barn Owl			
PODARGIDAE (Australian frogmouths)				
<i>Podargus strigoides</i>	Tawny Frogmouth			
AEGOTHELIDAE (Owlet-nightjars)				
<i>Aegotheles cristatus</i>	Australian Owlet-nightjar		+	
APODIDAE (Swifts)				
<i>Apus pacificus</i>	Fork-tailed Swift ^a	CS1		
HALCYONIDAE (Kingfishers)				
<i>Dacelo novaeguineae</i>	Laughing Kookaburra	INT	+	+
<i>Todiramphus sanctus</i>	Sacred Kingfisher			
CLIMACTERIDAE (Trecreepers)				
<i>Climacteris rufa</i>	Rufous Trecreeper		+	+
MEROPIDAE (Bee-eaters)				
<i>Merops ornatus</i>	Rainbow Bee-eater	CS1		
MALURIDAE (Fairy-wrens, emu-wrens and grasswrens)				
<i>Malurus splendens</i>	Splendid Fairy-wren		+	+
<i>Malurus elegans</i>	Red-winged Fairy-wren		+	
<i>Stipiturus malachurus</i>	Southern Emu-wren			

Table 4 (cont.)

Species	Status	Jan	May
PARDALOTIDAE (Pardalotes, bristlebirds, scrubwrens, thornbills and allies)			
<i>Pardalotus punctatus</i>	Spotted Pardalote	+	+
<i>Pardalotus striatus</i>	Striated Pardalote	+	+
<i>Sericornis frontalis</i>	White-browed Scrubwren	+	+
<i>Smicrornis brevirostris</i>	Weebill	+	
<i>Gerygone fusca</i>	Western Gerygone	+	+
<i>Acanthiza apicalis</i>	Inland Thornbill	+	+
<i>Acanthiza inornata</i>	Western Thornbill	+	+
<i>Acanthiza chrysorrhoa</i>	Yellow-rumped Thornbill		+
MELIPHAGIDAE (Honeyeaters)			
<i>Anthochaera carunculata</i>	Red Wattlebird	+	+
<i>Anthochaera lunulata</i>	Western Wattlebird	+	
<i>Lichenostomus virescens</i>	Singing Honeyeater		
<i>Melithreptus brevirostris</i>	Brown-headed Honeyeater		
<i>Melithreptus lunatus</i>	White-naped Honeyeater	+	+
<i>Lichmera indistincta</i>	Brown Honeyeater	+	+
<i>Phylidonyris novaehollandiae</i>	New Holland Honeyeater	+	+
<i>Phylidonyris nigra</i>	White-cheeked Honeyeater	+	
<i>Phylidonyris melanops</i>	Tawny-crowned Honeyeater		
<i>Acanthorhynchus superciliosus</i>	Western Spinebill	+	+
<i>Epthianura albifrons</i>	White-fronted Chat		
PETROICIDAE (Robins)			
<i>Microeca fascinans</i>	Jacky Winter		
<i>Petroica multicolor</i>	Scarlet Robin	+	+
<i>Melanodryas cucullata</i>	Hooded Robin		
<i>Eopsaltria griseogularis</i>	Western Yellow Robin	+	+
<i>Eopsaltria georgiana</i>	White-breasted Robin	+	+
NEOSITTIDAE (Sittellas)			
<i>Daphoenositta chrysoptera</i>	Varied Sittella	+	+
PACHYCEPHALIDAE (Whistlers, shrike-thrushes and allies)			
<i>Falcunculus frontatus</i>	Crested Shrike-tit	CS2	
<i>Pachycephala pectoralis</i>	Golden Whistler	+	+
<i>Pachycephala rufiventris</i>	Rufous Whistler		
<i>Colluricincla harmonica</i>	Grey Shrike-thrush	+	+
DICRURIDAE (Monarchs, fantails and drongos)			
<i>Myiagra inquieta</i>	Restless Flycatcher		
<i>Grallina cyanoleuca</i>	Magpie-lark	+	+
<i>Rhipidura fuliginosa</i>	Grey Fantail	+	+
<i>Rhipidura leucophrys</i>	Willie Wagtail	+	+
CAMPEPHAGIDAE (Cuckoo-shrikes and trillers)			
<i>Coracina novaehollandiae</i>	Black-faced Cuckoo-shrike	+	+
<i>Lalage sueurii</i>	White-winged Triller		

Table 4 (cont.)

Species	Status	Jan	May
ARTAMIDAE (Woodswallows, butcherbirds and currawongs)			
<i>Artamus cinereus</i>	Black-faced Woodswallow		
<i>Artamus cyanopterus</i>	Dusky Woodswallow	+	
<i>Cracticus torquatus</i>	Grey Butcherbird	+	
<i>Gymnorhina tibicen</i>	Australian Magpie	+	+
<i>Strepera versicolor</i>	Grey Currawong	+	+
CORVIDAE (Crows and allies)			
<i>Corvus coronoides</i>	Australian Raven	+	+
MOTACILIDAE (Old world wagtails and pipits)			
<i>Anthus novaeseelandiae</i>	Richard's Pipit		
PASSERIDAE (Sparrows, weaverbirds, waxbills and allies)			
<i>Stagonopleura oculata</i>	Red-eared Firetail	+	
DICAEIDAE (Flowerpeckers)			
<i>Dicaeum hirundinaceum</i>	Mistletoebird		
HIRUNDINIDAE (Swallows and martins)			
<i>Hirundo neoxena</i>	Welcome Swallow		
<i>Hirundo nigricans</i>	Tree Martin	+	
SYLVIIDAE (Old world warblers)			
<i>Acrocephalus stentoreus</i>	Clamorous Reed-Warbler		
<i>Megalurus gramineus</i>	Little Grassbird		
<i>Cincloramphus mathewsi</i>	Rufous Songlark		
<i>Cincloramphus cruralis</i>	Brown Songlark		
ZOSTEROPIDAE (White-eyes)			
<i>Zosterops lateralis</i>	Silvereye	+	+

Table 5. Mammals that may occur in the vicinity of the survey area. Status is assigned as described in section 2 (Background). ‘+’ indicates a species was recorded directly, ‘D’ indicates a species was recorded by droppings, ‘T’ indicates a species was recorded by tracks.

Species		Status	Jan	May
TACHYGLOSSIDAE (Echidnas)				
<i>Tachyglossus aculeatus</i>	Echidna		D	D
DASYURIDAE (Dasyurids)				
<i>Antechinus flavipes</i>	Yellow-footed Antechinus, Mardo		+	+
<i>Dasyurus geoffroi</i>	Chuditch	CS1		
<i>Phascogale t. tapoatafa</i>	Brush-tailed Phascogale	CS1		
<i>Sminthopsis gilberti</i>	Gilbert's Dunnart		+	+
MYRMECOBIIDAE (Numbat)				
<i>Myrmecobius fasciatus</i>	Numbat	CS1		
PEREMELIDAE (Bandicoots)				
<i>Isoodon obesulus</i>	Southern Brown Bandicoot, Quenda	CS2		
POTOROIDAE (Potoroos and bettongs)				
<i>Bettongia penicillata</i>	Woylie, Brush-tailed Bettong	CS2	+	
MACROPODIDAE (Kangaroos, wallabies and tree kangaroos)				
<i>Macropus eugenii</i>	Tammar Wallaby	CS2	+	
<i>Macropus fuliginosus</i>	Western Grey Kangaroo		+	+
<i>Macropus irma</i>	Brush Wallaby	CS2	+	+
<i>Setonix brachyurus</i>	Quokka	CS1	+	+
PHALANGERIDAE (Brushtail possums)				
<i>Trichosurus vulpecula</i>	Brushtail Possum		+	
PSEUDOCHEIRIDAE (Ringtail possums)				
<i>Pseudocheirus occidentalis</i>	Western Ringtail Possum	CS1		
BURRAMYIDAE (pygmy possums)				
<i>Cercartetus concinnus</i>	Western Pygmy Possum			+
TARSIPEDIDAE (honey possums)				
<i>Tarsipes rostratus</i>	Honey Possum			
VESPERTILIONIDAE (Vespertilionid bats)				
<i>Chalinolobus gouldii</i>	Gould's Wattled Bat			
<i>Chalinolobus morio</i>	Chocolate Wattled Bat		+	
<i>Falsistrellus mackenziei</i>	Western False Pipistrelle	CS2	+	
<i>Nyctophilus geoffroyi</i>	Lesser Long-eared Bat		+	
<i>Nyctophilus gouldi</i>	Gould's Long-eared Bat		+	
<i>Nyctophilus timoriensis</i>	Greater Long-eared Bat			
<i>Vespadelus regulus</i>	Southern Forest Bat		+	
MOLOSSIDAE (Freetail bats)				
<i>Mormopterus</i> sp. (<i>M. planiceps</i> , long penis form). Listed as ‘Species 4, population O’ by Adams <i>et al.</i> (1988).		CS3		
<i>Tadarida australis</i>	White-striped Freetail Bat			+

Table 5 (cont.)

Species		Status	Jan	May
MURIDAE (Rats and mice)				
<i>Hydromys chrysogaster</i>	Water Rat, Rakali	CS2		
<i>Mus musculus</i>	House Mouse	INT		+
<i>Rattus fuscipes</i>	Moodit, Bush Rat			
<i>Rattus rattus</i>	Black Rat	INT		
<i>Rattus norvegicus</i>	Brown Rat	INT		+
LEPORIDAE (Rabbits and hares)				
<i>Oryctolagus cuniculus</i>	Rabbit	INT	D	D
CANIDAE (Dogs and foxes)				
<i>Canis lupus</i>	Dog	INT		
<i>Vulpes vulpes</i>	Red Fox	INT		T
FELIDAE (Cats)				
<i>Felis catus</i>	Cat	INT		
SUIDAE (Pigs)				
<i>Sus scrofa</i>	Pig	INT	T	T

Table 6. The total numbers of each species captured by pitfall and funnel trapping in the January and May surveys. The number of funnel captures only is shown in parentheses. Note that there was no funnel trapping conducted in the May survey. Species are presented in taxonomic order. See Tables 2 to 5 for common names.

Species	January	May	TOTAL
AMPHIBIANS			
<i>Heleioporus inornatus</i>		15	15
<i>Limnodynastes dorsalis</i>		1	1
<i>Crinia georgiana</i>	1	87	88
<i>Crinia pseudinsignifera</i>		2	2
REPTILES			
<i>Diplodactylus polyopthalmus</i>	2 (1)		2 (1)
<i>Christinus marmoratus</i>	2 (1)	1	3 (1)
<i>Aprasia pulchella</i>	2		2
<i>Acritoscincus trilineatum</i>	5 (3)		5 (3)
<i>Cryptoblepharus plagiocephalus</i>	1		1
<i>Ctenotus labillardieri</i>	6 (4)		6 (4)
<i>Egernia napoleonis</i>	10 (5)		10 (5)
<i>Egernia pulchra</i>	1 (1)		1 (1)
<i>Hemiergus peroni</i>	2 (2)	1	3 (2)
<i>Lerista distinguenda</i>	24 (1)		24 (1)
<i>Lerista microtis</i>	25 (6)		25 (6)
<i>Morethia lineocellata</i>	1		1
<i>Morethia obscura</i>	28 (15)		28 (15)
<i>Ramphotyphlops australis</i>	1		1
<i>Pseudonaja affinis</i>	1 (1)		1 (1)
MAMMALS			
<i>Antechinus flavipes</i>	7 (1)	3	10 (1)
<i>Sminthopsis gilberti</i>	2	5	7
<i>Cercatetus concinnus</i>		1	1
<i>Mus musculus</i>		1	1
TOTAL	121 (41)	117	238 (41)

Table 7. The total numbers of each species captured by Elliott and cage trapping in the January and May surveys. The number of cage captures is shown in parentheses. Species are presented in taxonomic order. See Tables 2 to 5 for common names.

Species	January	May	TOTAL
REPTILES			
<i>Egernia kingii</i>	1		1
<i>Egernia napoleonis</i>	1		1
<i>Tiliqua rugosa</i>	1 (1)		1 (1)
<i>Varanus rosenbergi</i>	1		1
MAMMALS			
<i>Antechinus flavipes</i>	3	24	27
<i>Bettongia penicillata</i>	1 (1)		1 (1)
<i>Trichosurus vulpecula</i>	1 (1)		1 (1)
<i>Mus musculus</i>		4	4
<i>Rattus norvegicus</i>		1 (1)	1 (1)
TOTAL	9 (3)	29 (1)	38 (4)

Table 8. The total numbers of each species captured by any form of trapping at each site (both surveys pooled). Data exclude harp trapping for bats. Species are presented in taxonomic order. See Tables 2 to 5 for common names.

Species	Arklow Road/Scar Road	Big Tree Road	Collie-Tallanalla Road	Labour Road	Myles Road	Netic Road	TOTAL
AMPHIBIANS							
<i>Heleioporus inornatus</i>	2				1	12	15
<i>Limnodynastes dorsalis</i>						1	1
<i>Crinia georgiana</i>	12	8	13	17	15	23	88
<i>Crinia pseudinsignifera</i>			2				2
REPTILES							
<i>Diplodactylus polyopthalmus</i>		1		1			2
<i>Christinus marmoratus</i>	1				2		3
<i>Aprasia pulchella</i>	1		1				2
<i>Acritoscincus trilineatum</i>	1	1		2		1	5
<i>Cryptoblepharus plagiocephalus</i>			1				1
<i>Ctenotus labillardieri</i>	2			2	1	1	6
<i>Egernia kingii</i>				1			1
<i>Egernia napoleonis</i>	2	1		5		3	11
<i>Egernia pulchra</i>		1					1
<i>Hemiernia peroni</i>	3						3
<i>Lerista distinguenda</i>	3	8	3	2	5	3	24
<i>Lerista microtis</i>	6		1	13	2	3	25
<i>Morethia lineocellata</i>					1		1
<i>Morethia obscura</i>	5	9	2	3	1	8	28
<i>Tiliqua rugosa</i>				1			1
<i>Varanus rosenbergi</i>	1						1
<i>Ramphotyphlops australis</i>			1				1
<i>Pseudonaja affinis</i>					1		1
MAMMALS							
<i>Antechinus flavipes</i>	7	14	5	5		6	37
<i>Sminthopsis gilberti</i>	2		5				7
<i>Bettongia penicillata</i>		1					1
<i>Trichosurus vulpecula</i>		1					1
<i>Cercatetus concinnus</i>			1				1
<i>Mus musculus</i>		1			2	2	5
<i>Rattus norvegicus</i>	1						1
TOTAL	49	46	35	52	31	63	276
Species Richness	15	11	11	11	10	11	29

Table 9. Bats captured by harp trapping during the January survey. Species are presented in taxonomic order. See Table 5 for common names.

Species	19/01/2007	20/01/2007	21/01/2007	22/01/2007	23/01/2007	TOTAL
<i>Chalinolobus morio</i>	1		23	1	3	28
<i>Falsistrellus mackenziei</i>				1		1
<i>Nyctophilus geoffroyi</i>		1	2	1		4
<i>Nyctophilus gouldi</i>			3	7	4	14
<i>Vespadelus regulus</i>	1	1	2	2	1	7
TOTAL	2	2	30	12	8	54

Table 10. The mean density (birds ha⁻¹ day⁻¹)# of each bird species recorded along each pitfall transect (all surveys pooled). The number of surveys (out of 10) in which a bird species was recorded is shown in parentheses, followed by the range of abundances recorded along the entire transect (i.e. not a density measure). Species presented in taxonomic order. See Table 4 for scientific names.

Species	Arklow Road/Scar Road	Big Tree Road	Collie-Tallanalla Road	Labour Road	Myles Road	Netic Road
Forest Red-tailed Black-Cockatoo	0.53 (2, 1 - 4)	0.74 (2, 3 - 4)		0.85 (3, 1 - 5)		
Baudin's Cockatoo			0.32 (1, 3)	0.32 (1, 3)	0.42 (2, 2)	1.06 (1, 10)
Australian Ringneck	0.1 (1, 1)			0.1 (1, 1)		
Red-capped Parrot	0.42 (2, 2)	0.1 (1, 1)		0.21 (2, 1)		0.32 (2, 1 - 2)
Rainbow Bee-eater					0.21 (1, 2)	
Splendid Fairy-wren					0.53 (2, 2 - 3)	0.32 (1, 3)
Red-winged Fairy-wren			0.53 (2, 2 - 3)	0.21 (1, 2)		
Spotted Pardalote	0.1 (1, 1)	0.1 (1, 1)	0.32 (3, 1)	0.21 (2, 1)	0.1 (1, 1)	
Striated Pardalote		0.1 (1, 1)	0.21 (1, 2)	0.42 (2, 2)		0.21 (1, 2)
White-browed Scrubwren		0.1 (1, 1)			0.21 (2, 1)	
Western Gerygone		0.21 (2, 1)	0.21 (2, 1)	0.32 (3, 1)		
Inland Thornbill	0.21 (1, 2)	0.42 (3, 1 - 2)	1.49 (9, 1 - 2)	0.96 (4, 1 - 3)	2.77 (10, 1 - 5)	0.64 (3, 1 - 3)
Western Thornbill		0.21 (1, 2)		0.1 (1, 1)		0.42 (2, 1 - 3)
White-naped Honeyeater		0.1 (1, 1)	0.21 (2, 1)	0.42 (4, 1)	0.1 (1, 1)	
Brown Honeyeater		0.21 (1, 2)		0.1 (1, 1)	0.1 (1, 1)	
New Holland Honeyeater					0.1 (1, 1)	
White-cheeked Honeyeater				0.32 (1, 3)		
Western Spinebill				0.1 (1, 1)		
Scarlet Robin					0.21 (2, 1)	0.21 (1, 2)
Western Yellow Robin		0.21 (2, 1)				
White-breasted Robin	0.1 (1, 1)		0.1 (1, 1)		0.1 (1, 1)	

Table 10 (cont.)

Species	Arklow Road/Scar Road	Big Tree Road	Collie-Tallanalla Road	Labour Road	Myles Road	Netic Road
Varied Sitella	0.42 (1, 4)	0.64 (1, 6)				
Golden Whistler		0.21 (2, 1)	0.21 (2, 1)	0.21 (2, 1)		
Grey Shrike-thrush			0.1 (1, 1)		0.1 (1, 1)	
Grey Fantail	0.1 (1, 1)	0.42 (4, 1)	0.1 (1, 1)	0.32 (3, 1)	0.1 (1, 1)	0.21 (2, 1)
Australian Magpie		0.21 (1, 2)				
Australian Raven		0.1 (1, 1)				
Silvereye	0.32 (2, 1 - 2)		0.21 (1, 2)	0.53 (3, 1 - 3)	0.42 (2, 2)	
Mean total density (all birds/ha)	2.35	4.16	4.05	5.76	5.55	3.41
Species Richness	9	16	12	17	14	8

birds ha⁻¹ day⁻¹ calculated based on 2.1ha/transect (see section 3.6.3), and the duration of sampling each transect (each transect once per day).

Table 11. Opportunistic records of significant vertebrate fauna within the survey area. See Tables 4 and 5 for scientific names. Datum: WGS84.

Date	Number Seen	Easting	Northing	Notes
Forest Red-tailed Black-Cockatoo (CS1)				
20/01/2007	4-6	403605	6327782	Near Big Tree Road site.
22/01/2007	3	417423	6320282	
22/05/2007	12	415590	6318004	Feeding on Jarrah.
22/05/2007	4	416160	6318417	
Baudin's Cockatoo (CS1)				
21/01/2007	3	415837	6318638	Feeding on <i>Banksia grandis</i> .
21/01/2007	2	415392	6323291	Flying over.
22/01/2007	3	411572	6319316	Calling in drainage line.
23/01/2007	5	411068	6318758	Calling around dusk.
Brush Wallaby (CS2)				
22/01/2007	1	417423	6320282	Road kill on Collie-Tallanalla Road.
24/01/2007	1	407413	6330284	Road kill on Myles Road.
Quokka (CS1)				
22/01/2007	1	412053	6319438	Seen crossing road.
24/01/2007	1	416684	6321261	Road kill on Collie-Tallanalla Road.

Table 12. Relative risk assessment of conservation significant species that are likely to occur in the vicinity of the survey area.

	Status on Site	Greatest Potential Impact(s)	Relative Overall Risk of Impact
Conservation Significance Level 1 Species			
<i>Morelia spilota imbricata</i>	Not recorded during field surveys but likely to be present (suitable habitat occurs within site and recorded on private property on Big Tree Road).	Habitat loss and road mortality.	Low to Moderate.
<i>Falco peregrinus</i>	Not recorded during field surveys but possibly present (suitable habitat occurs within site).	Susceptibility to disturbance.	Low.
<i>Calyptrorhynchus banksii naso</i>	Present.	Loss or disruption of nesting and foraging sites.	High.
<i>Calyptrorhynchus latirostris</i>	Not recorded during field surveys but possibly present at some times of the year (suitable habitat occurs within site).	Loss or disruption of nesting and foraging sites.	Low.
<i>Calyptrorhynchus baudinii</i>	Present.	Loss or disruption of nesting and foraging sites.	High.
<i>Apus pacificus</i>	Not recorded during field surveys but may be a vagrant over site.	Negligible.	Negligible.
<i>Merops ornatus</i>	Not recorded during field surveys but likely to be present during summer (suitable habitat occurs within site and recorded, including breeding on private property on Big Tree Road).	Disruption of nesting sites.	Low.
<i>Dasyurus geoffroii</i>	Not recorded during field surveys but highly likely to be present (suitable habitat occurs within site and seen on Mornington Road west of Big Tree Road (September 2006, M. Bamford pers. obs.)).	Habitat loss and road mortality.	Low.
<i>Phascogale tapoatafa</i>	Not recorded during field surveys but likely to be present (suitable habitat occurs within site).	Habitat loss, population fragmentation and clearing mortality.	Low to Moderate.
<i>Myrmecobius fasciatus</i>	Not recorded during field surveys and unlikely to be present (locally extinct).	Habitat loss, disturbance and road mortality.	Negligible.
<i>Setonix brachyurus</i>	Present.	Habitat loss, population fragmentation and road mortality.	High.
<i>Pseudocheirus occidentalis</i>	Not recorded during field surveys but possibly present (some possibly suitable habitat occurs within site).	Habitat loss.	Low.

Table 12 (cont.)

	Status on Site	Greatest Potential Impact(s)	Relative Overall Risk of Impact
Conservation Significance Level 2 Species			
<i>Pachysaga munggai</i> (a cricket)	Not recorded – may be present.	Habitat loss	Low.
<i>Ctenotus delli</i>	Not recorded during field surveys but possibly present (some possibly suitable habitat occurs within site).	Habitat loss, population fragmentation and clearing mortality.	Low.
<i>Ninox connivens connivens</i>	Not recorded during field surveys but likely to be present (suitable habitat occurs within site and recorded on private property on Big Tree Road).	Susceptibility to disturbance.	Low.
<i>Tyto novaehollandiae novaehollandiae</i>	Not recorded during field surveys and unlikely to be present (site is outside species' current known range).	Susceptibility to disturbance.	Negligible.
<i>Falcunculus frontatus</i>	Not recorded during field surveys but likely to be present in low densities (suitable habitat occurs within site).	Habitat loss and disturbance.	Low.
<i>Isoodon obesulus fusciventer</i>	Not recorded during field surveys but highly likely to be present (suitable habitat occurs within site).	Habitat loss and road mortality.	Moderate.
<i>Bettongia penicillata olgiby</i>	Present (in low numbers).	Habitat loss and road mortality.	Moderate to High.
<i>Macropus eugenii derbianus</i>	Present.	Road mortality.	Low.
<i>Macropus irma</i>	Present.	Road mortality.	High.
<i>Falsistrellus mackenziei</i>	Present.	Loss of roosting sites and susceptibility to disturbance.	Low.
<i>Hydromys chrysogaster</i>	Not recorded during field surveys but likely to be present (suitable habitat occurs within site and recorded on private property on Big Tree Road).	Habitat loss and disturbance.	Low.

Table 12 (cont.)

	Status on Site	Greatest Potential Impact(s)	Relative Overall Risk of Impact
Conservation Significance Level 3 Species			
<i>Heleioporus barycragus</i>	Not recorded during field surveys but possibly present (suitable habitat occurs within site but site is at southern limit of the species' range).	Loss or disruption of breeding sites.	Low.
<i>Egernia pulchra</i>	Present.	Habitat loss, population fragmentation and clearing mortality.	Low.
<i>Lerista microtis</i>	Present.	Habitat loss, population fragmentation and clearing mortality.	Low.
<i>Polytelis anthopeplus anthopeplus</i>	Not recorded during field surveys and unlikely to be present (due to lack of suitable habitat).	Negligible.	Negligible.
<i>Mormopterus</i> sp. (Species 4, population O)	Not recorded during field surveys but likely to be present (suitable habitat occurs within site).	Susceptibility to disturbance.	Low.

Table 13. The potential impacts to fauna of the proposal as assessed following the guidance of the EPA's Guidance Statement No. 56. (Terrestrial fauna surveys for environmental impact assessment in Western Australia, EPA 2004)

Factor	Impact and explanation
Degree of habitat degradation or clearing within the local area or region.	Low to moderate (although large tracts of adjacent land is forested, such areas are affected by logging, fire management and feral species. As such, these areas may not support the same fauna assemblages present within the study area).
Size/scale of proposal/impact.	High (>50 ha - Bioregion Group 2)
Rarity of vegetation and landforms.	Low (impacted vegetation and landforms are extensive in sub-region)
Significant Habitats	High (dense riparian vegetation is a significant habitat known to support significant fauna populations e.g. Quokka).
Refugia.	The potential impact is high (dense riparian vegetation within the study area is known to support Quokka; there may also be short-range endemic invertebrates in the area).
Fauna protected under international agreements or treaties, Specially Protected or Priority Fauna.	High (a number of CS1 and CS2 fauna species are known to occur in the area and there is potential for some of these to be impacted by any development).
Size of remnant and condition/intactness of habitat and faunal assemblage.	Moderate to high (the project area supports good quality habitat that is well represented outside the study area. The fauna assemblage is remarkably intact).
Ecological linkage.	Low to moderate (the vegetation does provide linkages within a partially cleared and partially reforested landscape. Reforested areas may act as corridors for movement for some groups within the species assemblage. Clearing of linear habitats e.g. riparian habitats, within the area may disrupt the movement of some species).
Heterogeneity or complexity of the habitat and faunal assemblage.	High to moderate (project area has high habitat heterogeneity).

9 APPENDICES

Appendix 1. Categories used in the assessment of conservation status.

IUCN categories (based on review by Mace and Stuart 1994) as used for the Environmental Protection and Biodiversity Conservation (EPBC) Act and the WA Wildlife Conservation Act.

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

Schedules used in the WA Wildlife Conservation Act.

Schedule 1. Rare and likely to become Extinct.
Schedule 2. Extinct.
Schedule 3. Migratory species listed under international treaties.
Schedule 4. Other specially protected fauna.

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

Priority 1. Taxa with few, poorly known populations on threatened lands.
Priority 2. Taxa with few, poorly known populations on conservation lands; or taxa with several, poorly known populations not on conservation lands.
Priority 3. Taxa with several, poorly known populations, some on conservation lands.
Priority 4. Taxa in need of monitoring. Taxa which are considered to have been adequately surveyed, or for which sufficient knowledge is available, and which are considered not currently threatened or in need of special protection, but could be if present circumstances change.
Priority 5. Taxa in need of monitoring. Taxa which are not considered threatened but are subject to a specific conservation program, the cessation of which would result in the species becoming threatened within five years (IUCN Conservation Dependent).

Appendix 2. Location and vegetation, soil and topography of the pitfall traps at the Labour Road (L), Arklow Road/Scar Road (A), Collietallanalla Road (C), Netic Road (N), Myles Road (M) and Big Tree Road (B) sites. Datum: WGS84.

Trap	Easting	Northing	Vegetation	Soil	Topography
L-1	412454	6319640	Marri, Jarrah and Bullich over <i>Gastrolobium</i> understorey	Gravel	Lower slope
L-2	412464	6319624	Marri and Jarrah over <i>Gastrolobium</i> understorey	Gravel	Mid slope
L-3	412481	6319592	Marri and Jarrah over open understorey	Gravel	Mid slope
L-4	412484	6319581	Marri and Jarrah over open understorey	Gravel	Hill top
L-5	412498	6319579	Marri and Jarrah over open understorey	Gravel	Hill top
L-6	412530	6319553	Marri and Jarrah over open understorey	Gravel	Hill top
L-7	412550	6319540	Marri and Jarrah over open understorey	Gravel	Hill top
L-8	412565	6319535	Marri, Jarrah and <i>Banksia grandis</i> over closed understorey	Gravel	Hill top
L-9	412591	6319515	Marri, Jarrah and <i>Banksia grandis</i> over open understorey	Gravel	Hill top
L-10	412612	6319501	Marri, Jarrah and <i>Banksia grandis</i> over open understorey	Gravel	Hill top
L-11	412622	6319496	Marri, Jarrah and <i>Banksia grandis</i> over open understorey	Gravel	Hill top
L-12	412639	6319474	Marri, Jarrah and <i>Banksia grandis</i> over open understorey	Gravel	Hill top
L-13	412645	6319465	Marri, Jarrah and <i>Banksia grandis</i> over open understorey	Gravel	Upper slope
L-14	412671	6319433	Marri, Jarrah and <i>Banksia grandis</i> over open understorey	Gravel	Mid slope
L-15	412695	6319405	Marri, Jarrah and <i>Banksia grandis</i> over open understorey	Gravel	Mid slope
A-16	416265	6318375	Marri and Jarrah over open understorey	Sand	Gentle slope
A-17	416286	6318373	Marri and Jarrah over open understorey	Sand	Gentle slope
A-18	416307	6318359	Marri and Jarrah over open understorey	Sand	Gentle slope
A-19	416334	6318359	Marri and Jarrah over open understorey	Sand	Gentle slope
A-20	416357	6318355	Marri and Jarrah over open understorey	Sand	Gentle slope
A-21	416377	6318338	Marri and Jarrah over open understorey	Sand	Gentle slope
A-22	416407	6318346	Marri and Jarrah over open understorey	Sand	Gentle slope
A-23	416427	6318346	Marri and Jarrah over open understorey	Sand	Gentle slope
A-24	416422	6318344	Marri and Jarrah over open understorey	Sand	Riparian edge
A-25	416474	6318342	Marri and Jarrah over open understorey	Sand	Riparian edge
A-26	416491	6318341	Marri, Jarrah, Bullich and <i>Banksia seminuda</i> over swamp thicket	Sand and clay	Riparian zone
A-27	416504	6318330	Marri, Jarrah, Bullich and <i>Banksia seminuda</i> over swamp thicket	Sand and clay	Riparian zone

A-28	416557	6318325	Marri, Jarrah, Bullich and Banksia seminuda over swamp thicket	Sand and clay	Riparian zone
A-29	416568	6318326	Marri, Jarrah, Bullich and Banksia seminuda over swamp thicket	Sand and clay	Riparian zone
A-30	416586	6318323	Marri, Jarrah, Bullich and Banksia seminuda over swamp thicket	Sand and clay	Riparian zone
C-31	415468	6323247	Marri and Jarrah over Gastrolobium and Bracken understorey	Gravel	Hill top
C-32	415488	6323261	Marri, Jarrah and She-oak over Gastrolobium and Bracken understorey	Gravel	Hill top
C-33	415484	6323279	Marri, Jarrah and She-oak over Gastrolobium and Bracken understorey	Gravel	Hill top
C-34	415506	6323306	Marri, Jarrah and She-oak over Gastrolobium and Bracken understorey	Gravel	Hill top
C-35	415538	6323345	Marri, Jarrah, She-oak and Banksia grandis over Gastrolobium and Bracken understorey	Gravel and exposed rock	Upper slope
C-36	415540	6323358	Marri, Jarrah, She-oak and Banksia grandis over Gastrolobium and Bracken understorey	Gravel and exposed rock	Upper slope
C-37	415558	6323377	Marri, Jarrah, She-oak and Banksia grandis over Gastrolobium and Bracken understorey	Gravel and exposed rock	Upper slope
C-38	415561	6323389	Marri, Jarrah, She-oak and Banksia grandis over Gastrolobium and Bracken understorey	Gravel and exposed rock	Upper slope
C-39	415573	6323406	Marri, Jarrah, She-oak and Banksia grandis over Gastrolobium and Bracken understorey	Gravel and exposed rock	Upper slope
C-40	415589	6323447	Marri, Jarrah, She-oak and Banksia grandis over Gastrolobium and Bracken understorey	Gravel and exposed rock	Upper slope
C-41	415599	6323456	Marri, Jarrah, She-oak and Banksia grandis over Gastrolobium and Bracken understorey	Gravel and exposed rock	Mid slope
C-42	415615	6323497	Marri, Jarrah, She-oak and Banksia grandis over Gastrolobium and Bracken understorey	Gravel and exposed rock	Mid slope
C-43	415611	6323522	Marri, Jarrah and Bullich over Gastrolobium and Bracken understorey	Gravel	Lower slope
C-44	415610	6323556	Marri, Jarrah and Bullich over Gastrolobium and Bracken understorey	Gravel	Lower slope
C-45	415620	6323571	Marri, Jarrah and Bullich over Gastrolobium and Bracken understorey	Gravel	Lower slope
N-46	414259	6327046	Marri, Jarrah and Bullich over Gastrolobium understorey	Sand and clay	Flats
N-47	414248	6327037	Marri and Jarrah over open understorey	Sand and clay	Flats
N-48	414215	6327028	Marri and Jarrah over open understorey	Sand and clay	Flats
N-49	414195	6327022	Marri and Jarrah over Gastrolobium understorey	Gravel	Flats
N-50	414169	6327022	Marri and Jarrah over Gastrolobium understorey	Gravel	Flats
N-51	414152	6327048	Marri and Jarrah over Gastrolobium understorey	Gravel	Flats
N-52	414143	6327063	Marri and Jarrah over Gastrolobium understorey	Sand and clay	Flats
N-53	414135	6327085	Marri and Jarrah over Gastrolobium understorey	Sand and clay	Flats
N-54	414119	6327106	Marri and Jarrah over Gastrolobium understorey	Sand and clay	Flats
N-55	414113	6327128	Marri and Jarrah over Gastrolobium understorey	Gravel and sand	Gentle slope
N-56	414107	6327153	Marri and Jarrah over Gastrolobium understorey	Gravel and sand	Gentle slope
N-57	414105	6327169	Marri and Jarrah over Gastrolobium understorey	Gravel and sand	Gentle slope
N-58	414097	6327200	Marri and Jarrah over Gastrolobium understorey	Sand	Gentle slope
N-59	414089	6327220	Marri and Jarrah over Gastrolobium understorey	Gravel and sand	Gentle slope
N-60	414082	6327241	Marri and Jarrah over Gastrolobium understorey	Gravel and sand	Gentle slope

M-61	404839	6330143	Marri and Jarrah over open understorey	Gravel and exposed rock	Gentle slope
M-62	404863	6330119	Marri and Jarrah over open understorey	Gravel and exposed rock	Gentle slope
M-63	404889	6330115	Marri and Jarrah over open understorey	Gravel and exposed rock	Gentle slope
M-64	404912	6330103	Marri and Jarrah over open understorey	Gravel and exposed rock	Gentle slope
M-65	404933	6330092	Marri and Jarrah over open understorey	Gravel, loam and clay	Flats
M-66	404964	6330082	Marri and Jarrah over open understorey	Gravel, loam and clay	Flats
M-67	404988	6330075	Marri and Jarrah over dense Leptospermum swamp thicket	Sand and clay	Flats
M-68	405018	6330067	Marri and Jarrah over dense Leptospermum swamp thicket	Sand and clay	Flats
M-69	405034	6330078	Marri and Jarrah over dense Leptospermum swamp thicket	Sand and clay	Flats
M-70	405067	6330085	Marri and Jarrah over dense Leptospermum swamp thicket	Sand and clay	Flats
M-71	405085	6330096	Marri and Jarrah over dense Leptospermum swamp thicket	Sand and clay	Flats
M-72	405101	6330106	Marri and Jarrah over dense Leptospermum swamp thicket	Sand and clay	Flats
M-73	405127	6330113	Marri and Jarrah over open understorey	Sand	Flats
M-74	405146	6330118	Marri and Jarrah over open understorey	Gravel	Gentle slope
M-75	405174	6330122	Marri and Jarrah over open understorey	Gravel	Gentle slope
B-76	403605	6327682	Marri and Jarrah over swampy thicket	Loam	Valley floor
B-77	403591	6327622	Marri and Jarrah over open understorey	Loam	Valley floor
B-78	403593	6327616	Marri and Jarrah over open understorey	Gravel	Lower slope
B-79	403586	6327604	Marri and Jarrah over open understorey	Gravel	Lower slope
B-80	403576	6327579	Marri and Jarrah over open understorey	Gravel	Mid slope
B-81	403564	6327566	Marri and Jarrah over Gastrolobium understorey	Gravel and exposed rock	Mid slope
B-82	403552	6327549	Marri and Jarrah over Gastrolobium understorey	Gravel and exposed rock	Mid slope
B-83	403542	6327520	Marri and Jarrah over Gastrolobium understorey	Gravel and exposed rock	Mid slope
B-84	403538	6327500	Marri and Jarrah over Gastrolobium understorey	Gravel and exposed rock	Upper slope
B-85	403526	6327472	Marri and Jarrah over Gastrolobium understorey	Gravel and exposed rock	Upper slope
B-86	403534	6327441	Marri and Jarrah over Gastrolobium understorey	Gravel and exposed rock	Upper slope
B-87	403551	6327419	Marri and Jarrah over Gastrolobium understorey	Gravel and exposed rock	Hill top
B-88	403557	6327395	Marri and Jarrah over Gastrolobium understorey	Gravel and exposed rock	Hill top
B-89	403567	6327380	Marri and Jarrah over Gastrolobium understorey	Gravel and exposed rock	Hill top
B-90	403570	6327357	Marri and Jarrah over Gastrolobium understorey	Gravel and exposed rock	Hill top

Appendix 3. Location of the cage/Elliott traps at the Labour Road (L), Arklow Road/Scar Road (A), Collie-Tallanalla Road (C), Netic Road (N), Myles Road (M) and Big Tree Road (B) sites. Datum: WGS84.

Trap	Easting	Northing	Trap	Easting	Northing
L-1	412440	6319647	N-25	414158	6327039
L-2	412253	6319503	N-26	414096	6327260
L-3	412053	6319438	N-27	413967	6327426
L-4	411896	6319473	N-28	413826	6327564
L-5	411696	6319343	N-29	413726	6327742
L-6	411481	6319271	N-30	413627	6327921
L-7	411361	6319132	N-31	413499	6328068
L-8	411291	6318956	B-32	403498	6327843
A-9	415837	6318638	B-33	403568	6327667
A-10	416026	6318466	B-34	403718	6327527
A-11	416198	6318408	B-35	403796	6327757
A-12	416395	6318385	B-36	403872	6327954
A-13	416600	6318454	B-37	403961	6328169
A-14	416686	6318556	B-38	404030	6328360
A-15	416804	6318711	B-39	404024	6328574
A-16	416990	6318766	M-40	406446	6330307
C-17	415689	6322895	M-41	406200	6330272
C-18	415500	6323145	M-42	406026	6330248
C-19	415392	6323291	M-43	405785	6330210
C-20	415320	6323525	M-44	405607	6330187
C-21	415445	6323735	M-45	405422	6330181
C-22	415685	6323847	M-46	405204	6330188
C-23	415884	6324073	M-47	404925	6330177
C-24	415983	6324330			

Appendix 4. Results of the DEC Threatened Species Database search. The DEC categories are explained in Appendix 1.

Schedule 1	
<i>Calyptorhynchus banksii</i>	Red-tailed Black-Cockatoo
<i>Calyptorhynchus latirostris</i>	Carnaby`s Cockatoo
<i>Calyptorhynchus baudinii</i>	Baudin`s Cockatoo
<i>Dasyurus geoffroii</i>	Chuditch
<i>Setonix brachyurus</i>	Quokka
Priority 3	
<i>Pachysaga munggai</i>	a cricket
Priority 4	
<i>Ctenotus delli</i>	Dell`s Skink
<i>Macropus irma</i>	Brush Wallaby
Priority 5	
<i>Isoodon obesulus</i>	Quenda
<i>Bettongia penicillata</i>	Woylie
<i>Macropus eugenii</i>	Tammar

Appendix 5. Results of the EPBC Threatened Species Database search. EPBC categories are explained in Appendix 1.

Endangered	
<i>Calyptorhynchus latirostris</i>	Carnaby`s Cockatoo
Vulnerable	
<i>Calyptorhynchus baudinii</i>	Baudin`s Cockatoo
<i>Dasyurus geoffroii</i>	Chuditch
<i>Pseudocheirus occidentalis</i>	Western Ringtail Possum
<i>Setonix brachyurus</i>	Quokka
Migratory	
<i>Ardea alba</i>	Great Egret
<i>Ardea ibis</i>	Cattle Egret
<i>Haliaeetus leucogaster</i>	White-bellied Sea-Eagle
<i>Apus pacificus</i>	Fork-tailed Swift
<i>Merops ornatus</i>	Rainbow Bee-eater

Appendix 6. The number of trap nights for each category of vegetation, soil and topography scored for each pitfall/funnel trap location.

Vegetation categories	Trap nights
Marri and Jarrah over dense Leptospermum swamp thicket	75
Marri and Jarrah over Gastrolobium and Bracken understorey	15
Marri and Jarrah over Gastrolobium understorey	285
Marri and Jarrah over open understorey	380
Marri and Jarrah over swampy thicket	15
Marri, Jarrah and Banksia grandis over closed understorey	10
Marri, Jarrah and Banksia grandis over open understorey	90
Marri, Jarrah and Bullich over Gastrolobium and Bracken understorey	40
Marri, Jarrah and Bullich over Gastrolobium understorey	30
Marri, Jarrah and She-oak over Gastrolobium and Bracken understorey	35
Marri, Jarrah, Bullich and Banksia seminuda over swamp thicket	65
Marri, Jarrah, She-oak and Banksia grandis over Gastrolobium and Bracken understorey	100
Total:	1140

Soil categories	Trap nights
Gravel	380
Gravel and exposed rock	275
Gravel and sand	60
Gravel, loam and clay	25
Loam	25
Sand	155
Sand and clay	220
Total:	1140

Topographic categories	Trap nights
Flats	230
Gentle slope	250
Hill top	210
Lower slope	80
Mid slope	125
Riparian edge	25
Riparian zone	65
Upper slope	130
Valley floor	25
Total:	1140