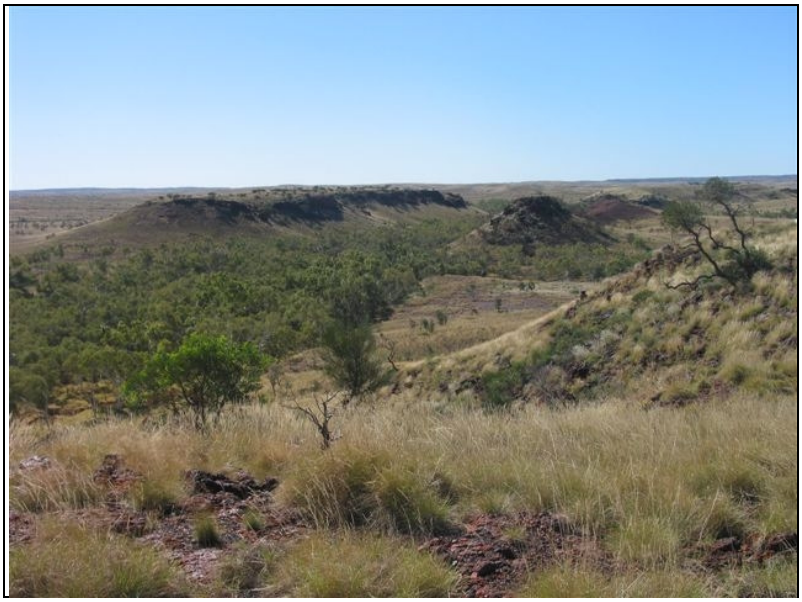
BC Iron Nullagine Project Extension Areas – Bonnie East, Warrigal North and Coongan

Assessment of Fauna Values



Mesas in the Warrigal North Survey Area. (M. Bamford)

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Executive summary

BC Iron is investigating an extension of its Nullagine Iron Ore Project in the eastern Pilbara. This extension involves three prospective areas that lie close to areas investigated for the original Nullagine Iron Ore Project: Bonnie East, Warrigal North and Coongan. Bamford Consulting Ecologists (BCE) was commissioned by BC Iron to conduct an assessment of the fauna values of the Bonnie East, Warrigal North and Coongan survey areas as part of the process for the assessment of environmental impacts of the proposed extension development.

BCE uses an impact assessment process with the following components:

- The identification of fauna values:
    - Assemblage characteristics: uniqueness, completeness and richness;
    - Species of conservation significance;
    - Recognition of vegetation/substrate associations (VSAs) that provide habitat for fauna, particularly those that are rare, unusual and/or support significant fauna;
    - Patterns of biodiversity across the landscape;
    - Ecological processes upon which the fauna depend.
- The review of impacting processes such as:
    - Habitat loss leading to population decline;
    - Habitat loss leading to population fragmentation;
    - Degradation of habitat due to weed invasion leading to population decline;
    - Ongoing mortality from operations;
    - Species interactions including feral and overabundant native species;
    - Hydrological change;
    - Altered fire regimes; and
    - Disturbance (dust, light, noise).
- The recommendation of actions to mitigate impacts.

The fauna investigations were based on a desktop review of data (including those collected in previous comprehensive and ongoing studies for BCI) to produce a list of expected species, and the three extension areas were visited in May 2012. Some further and season-dependent work on bat species was conducted in October 2012 and proposed for May 2013. The aims of the field investigations were to place the results of the desktop review into the perspective of the study area and to familiarise the consultant with the precise locations of the proposed development areas, such as recognising VSAs and collecting some observations on fauna.

The desktop assessment identified 325 vertebrate fauna species as potentially occurring in the three survey areas: 7 fish, 8 frogs, 109 reptiles, 151 birds and 50 mammals. A high proportion of these had been recorded in previous intensive studies carried out by BCE. Key **fauna values** are:

Fauna assemblage – typical of the eastern Pilbara with some species on the eastern edge of their range, and moderately rich despite the local extinction of some mammal species (e.g. 'critical weight range' mammals) as a result of anthropological changes since European settlement of Australia. The variety of vegetation and substrate associations present contributes to species richness. The

assemblage is expected to be the same in each survey area, although there will be differences in the abundance of some species between survey areas.

Significant species – includes five reptile species, at least 23 bird species and 11 mammal species. Many of the significant fauna species are expected only as vagrants or occasional visitors, but at least 10 species are likely to have significant populations in the three survey areas. Of these 10 species, nine are associated with the restricted vegetation and substrate associations of mesas and watercourses in the area. These VSAs are present in all survey areas, but are best represented in the Warrigal North survey area. Several conservation significant species are of particular interest, including: the Northern Quoll (recorded in 2008 within or close to all three areas, not trapped in subsequent surveys but believed to be present in small numbers, and associated with cliff lines and watercourses); Pilbara Olive Python (recorded in the general region and associated with cliff lines and watercourses), Rothschild's Rock-wallaby (recorded close to the Warrigal North survey area and associated with cliff lines), Pilbara Leaf-nosed and Ghost Bats (not recorded but potential habitat may be present in the Warrigal North survey area) and Western Pebble-mound Mouse (recorded on low rocky hills in the general area with active mounds found in Coongan). Note that clifflines and watercourses are potentially suitable for SRE invertebrates, but no species were confirmed. These environments are best developed in the Warrigal North survey area but are linear and extensive beyond the survey areas.

Vegetation and Substrate Associations (VSAs) – five broad VSAs recognised:

- VSA 1. Acacia shrubs over hummock grasslands on stony hills and plains.
- VSA 2. Eucalypt woodland over hummock grasslands on stony hills and plain.
- VSA 3. Bloodwood woodland over hummock grasslands on undulating stony hills.
- VSA 4. Well-developed cliff lines along mesa edges or gorges.
- VSA 5. Riparian zones (including eucalypt riparian woodland and adjacent loam plains supporting shrublands and spinifex).

In a regional context, the most restricted VSAs are the cliff lines (VSA 4) and riparian zones (VSA 5), and these are best developed in the Warrigal North survey area, with the riparian zones including well-developed eucalypt woodland and permanent waterholes. Bloodwood woodland over hummock grasslands on undulating stony hills (VSA 3) was distinctive and restricted to the Bonnie East survey area. The Coongan survey area had the least variety of VSAs and also included some areas badly degraded by livestock.

Patterns of biodiversity – Greatest biodiversity is likely to be present in mesic areas (i.e. VSA 5) and where there is a juxtaposition of several VSAs. The best-developed examples of VSA 5 are in the Warrigal North survey area. Also in the Warrigal North survey area there is a complex of VSAs, with VSA 4 and VSA 5 in close proximity and other VSAs nearby, and a small breeding colony of the Australian Darter and Little Pied Cormorant in trees overhanging Bonnie Pool. The Bonnie East survey area also has a complex of VSAs, including bloodwood woodland (VSA 3), but less well-developed examples of riparian environments. The Coongan survey area is the least rich of the three survey areas in terms of VSAs.

Key ecological processes - Main ecological processes currently affecting the fauna assemblage in the survey areas are landscape permeability (associated with the linear nature of key VSAs), local hydrology (primarily associated with watercourses and the presence of some permanent pools), fire and impacts related to feral predators, livestock and weed invasion. Of these, landscape permeability and local hydrology are especially important in the Warrigal North survey area and sensitive to impacts.

The **impact assessment** found that the main concern was with the potential loss of habitat affecting rare VSAs (cliff lines, VSA 4, and riparian zones, VSA 5) and possible fragmentation of these same VSAs, particularly cliff lines, where they are linear in layout; this is especially the case in Warrigal North. Fragmentation would reduce landscape permeability and may limit the ability of species restricted to cliff lines to move through the area. Hydrological impacts may also be a concern. BC Iron has noted that all practicable efforts will be made to retain landscape connectivity in the post-mining environment and to limit hydrological impacts. It is considered that standard management practices can minimise the effect of other impacting processes.

As part of the impact assessment, a comparison of values and impacts across the three survey areas was made:
Fauna assemblage: similar across the three survey areas.
Species of conservation significance: while all significant species may occur in all survey areas, populations are likely to be greatest in the Warrigal North survey area where cliff lines and/or watercourses are best-developed.
Vegetation and Substrate Associations: the most restricted in area and important for conservation significance species are the cliff lines/rocky margins to mesas and gorges (VSA 4) and the riparian environments (VSA 5). Both these are best represented in the Warrigal North survey area.
Patterns of biodiversity: Concentrations of biodiversity are likely where there are cliff lines and riparian environments, and where these are juxtaposed. This occurs in all survey areas but both VSAs are best represented in the Warrigal North survey area.
Key ecological processes. Ecological processes are the same across the survey areas, but the layout of mesas in the Warrigal North survey area is such that fauna movements may be restricted to linear features.
Impacts. These may be broadly similar across the three survey areas, but the significance of impacts is expected to vary as follows:

- *Bonnie East survey area*. This survey area encompasses a number of tributaries of the Bonnie Creek system, has the best-developed examples of eucalypt and bloodwood woodlands and moderate areas of important VSAs (cliff lines and riparian environments). The layout of these important VSAs along several tributaries means that values are not concentrated in narrow zone as is the case in Warrigal North.
- *Warrigal North survey area*. Impacts expected to be most significant of the three survey areas. Warrigal North includes large areas of important VSAs, they are well-developed examples of these VSAs (e.g. very tall cliff lines, permanent pools along watercourses), and they are strongly linear, making fauna populations particularly vulnerable to fragmentation.

- *Coongan survey area*. Most of the Coongan survey area consists of widespread VSAs and important VSAs are less well-developed, so impacts expected to be less significant than for either the Bonnie East or Warrigal North survey areas.

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1 Introduction

1.1 Background

BC Iron is investigating an extension of its Nullagine Iron Ore Project in the eastern Pilbara. The Nullagine Project Extension involves three tenement areas that lie close to areas investigated for the original Nullagine Iron Ore Project: Bonnie East, Warrigal North and Coongan. Bamford Consulting Ecologists (BCE) was commissioned by BC Iron to conduct an assessment of the fauna values of the Bonnie East, Warrigal North and Coongan areas as part of the process for the assessment of environmental impacts of the proposed extension development.

1.2 General approach to fauna impact assessment

The purpose of impact assessment is to provide stakeholders with the necessary information to decide upon the significance of impacts of a proposed development. BCE uses an impact assessment process with the following components:

- The identification of fauna values:
  - Assemblage characteristics: uniqueness, completeness and richness;
  - Species of conservation significance;
  - Recognition of ecotypes or vegetation/substrate associations (VSAs) that provide habitat for fauna, particularly those that are rare, unusual and/or support significant fauna;
  - Patterns of biodiversity across the landscape;
  - Ecological processes upon which the fauna depend.
- The review of impacting processes such as:
  - Habitat loss leading to population decline;
  - Habitat loss leading to population fragmentation;
  - Degradation of habitat due to weed invasion leading to population decline;
  - Ongoing mortality from operations;
  - Species interactions including feral and overabundant native species;
  - Hydrological change;
  - Altered fire regimes; and
  - Disturbance (dust, light, noise).
- The recommendation of actions to mitigate impacts.

Descriptions and background information on these values and processes can be found in the Appendices (Appendix 1 to Appendix 4). Based on this impact assessment process, the objectives of investigations are to: identify fauna values; review impacting processes with respect to these values and the proposed development; and provide recommendations to mitigate these impacts. Methods for investigation of the Nullagine Project Extension survey areas are outlined in Section 2.

1.3 Description of project

BC Iron proposes to expand the Nullagine Iron Ore Project (the Extension Project) to include new mining areas to the south (Bonnie East, Coongan) and north (Warrigal North) of the current Outcamp mining lease. Mining will be similar to that at Outcamp, targeting mesas and involving the use of surface miners to remove ore without the use of drill and blasting. Waste rock dumps will be located near the respective deposits on raised ground away from drainage lines and areas

potentially subject to flooding. The Channel Iron Deposit (CID) ore will require minimal processing (crushing and screening) before the Direct Shipping Ore (DSO) product is hauled along BC Iron's private haul road to Fortescue Metals Group's (FMG) Christmas Creek rail infrastructure and transported by train to Port Hedland. The Extension Project will utilise existing support infrastructure including the sealed haul road and Christmas Creek railhead, accommodation village and Mine Operations Centre (processing, mine site offices and workshops) established as part of the current BC Iron Nullagine operations. The main new infrastructure required for the Extension Project includes access roads, laydown areas, vehicle maintenance areas and groundwater bores to access water for construction and operational purposes. Subject to regulatory approvals, it is anticipated that construction of the Extension Project will commence in the first quarter of 2014, with operations commencing in the third quarter of 2014.

1.4 Description of project area

The Nullagine Project Extension survey areas are shown in Figure 1. There are three survey areas: the centrally located Bonnie East, Warrigal North in the north, and Coongan in the south. In this report each of these is referred to as a survey area; collectively they are referred to as the survey areas.

1.4.1 Bioregion

The survey areas fall within the Chichester subregion (PIL1) of the Interim Biogeographic Regionalisation for Australia (IBRA) classification system (EA 2000; McKenzie *et al.* 2003). The general features of this subregion are summarised by Mitchell *et al*. (2003): "The region is characterised by undulating Archaean granite, basalt plains and significant areas of basaltic ranges. Plains support a shrub steppe dominated by *Acacia pyrifolia* over *Triodia pungens* hummock grasslands, with *Eucalyptus leucophloia* tree steppes occurring throughout the ranges. North of the Fortescue Valley a shrub steppe of *Acacia inaequilatera* can be found on granite plains with a tree steppe of *Eucalyptus leucophloia* dominating the ranges. The climate is arid (semi-desert) tropical with highly variable rainfall, falling mainly in summer."

The Pilbara is a region of high fauna biodiversity with overlapping biogeographic elements from the Kimberley and South-West, as well as contributions from adjacent desert and Murchison regions, and a high level of endemism. McKenzie *et al*. (2003) provided a detailed description of special values and features of the region with respect to fauna and environments, including significant species and important wetlands. Special fauna values that may be relevant to the survey areas include persisting populations of significant species, species-rich ecosystems associated with watercourses and "species-rich, refugial ecosystems associated with gorges, waterfalls and mountain tops."

1.4.2 Land systems

As part of an inventory survey of the Pilbara (Van Vreeswyk *et al.* 2004), Payne (2004) defined a series of 20 'land types' and, within these, a set of 102 'land systems' to categorise the geology and vegetation associations of the region. Three of Payne's (2004) land systems occur within one or more of the survey areas:

- Robe – present in all three survey areas. Low plateaux, mesas and buttes of limonites supporting soft spinifex (and occasionally hard spinifex) grasslands.
- Rocklea – present in all three survey areas. Basalt hills, plateaux, lower slopes and minor stony plains supporting hard spinifex (and occasionally soft spinifex) grasslands.
- Wona – present only in the Bonnie East survey area. Basalt upland gilgai plains supporting tussock grasslands and minor hard spinifex grasslands.

1.4.3 Vegetation types

Vegetation surveys of the three survey areas yielded the vegetation types listed in Table 1. These are mapped in Figure 2 (Bonnie East survey area), Figure 3 (Warrigal North survey area) and Figure 4 (Coongan survey area).

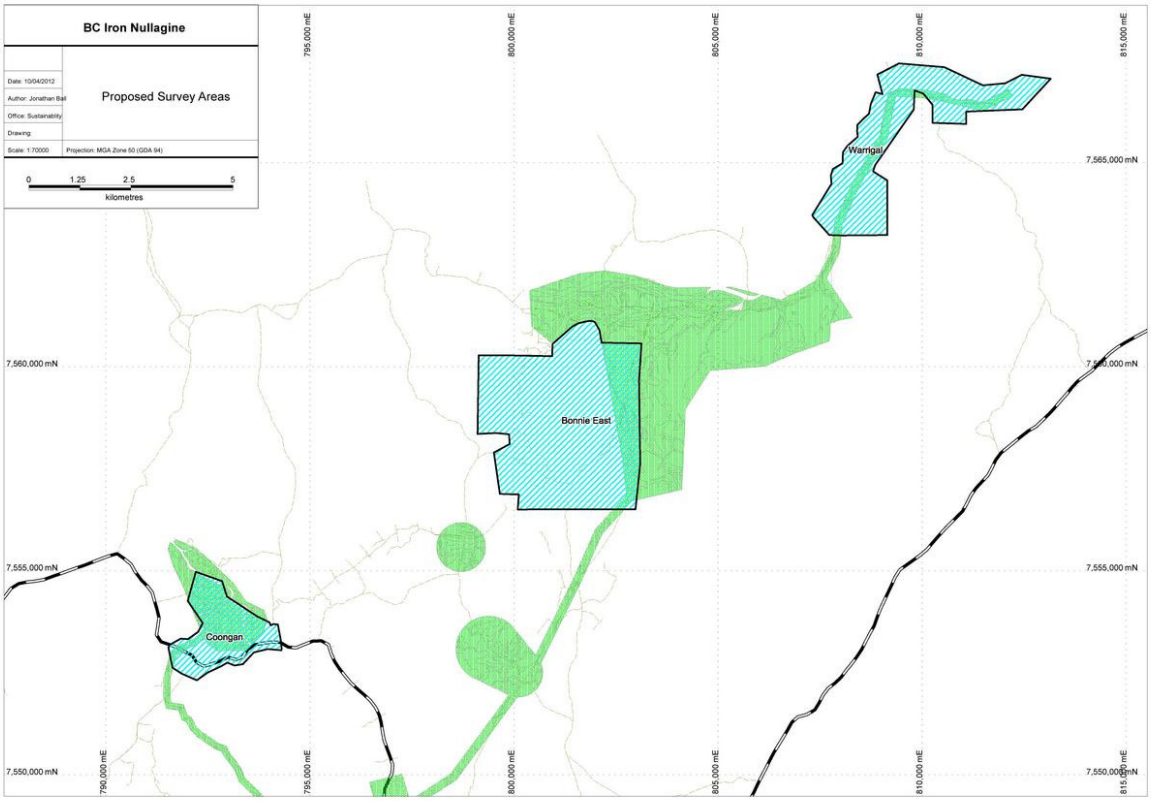

Figure 1. Map of the Nullagine Project Extension survey areas: Bonnie East, Warrigal North and Coongan.

Green shading indicates areas previously surveyed and mapped for vegetation communities.

Table 1. Vegetation types recorded in each of the survey areas (Bonnie East, Warrigal North and Coongan).

'+' indicates vegetation type was recorded within survey area boundary.

Code	Vegetation Type	Warrigal North	Bonnie East	Coongan
D2a	*Corymbia hamersleyana* scattered low trees to low woodland over mixed *Acacia* spp. scattered shrubs to shrubland over mixed *Triodia epactia* hummock / **Cenchrus* spp. tussock grassland	+		+
D2b	*Corymbia hamersleyana* scattered low trees over mixed *Acacia* spp. shrubland over mixed *Triodia epactia* hummock / *Paraneurachne muelleri* tussock grassland	+		
D3a	*Corymbia hamersleyana* scattered trees over scattered mixed shrubs over mixed *Cymbopogon ambiguus* tussock grassland / *Cyperus vaginatus* sedgeland			+
D4a	*Eucalyptus camaldulensis* woodland over mixed shrubland over mixed **Cynodon dactylon* grassland / *Typha domingensis* sedgeland	+		+
D5a	*Eucalyptus leucophloia* scattered trees over mixed *Acacia* spp. shrubland over *Triodia epactia* hummock grassland		+	+
D6a	*Eucalyptus victrix* woodland over *Melaleuca* spp high shrubland over mixed *Triodia epactia* hummock / **Cenchrus* spp. tussock grassland / *Cyperus vaginatus* sedgeland	+	+	+
D8b	Mixed *Acacia* spp. shrubland over *Triodia longiceps* hummock grassland			+
H10a	Mixed *Senna* spp. scattered shrubs over *Triodia epactia* hummock grassland		+	+
H1a	*Corymbia hamersleyana* scattered low trees over mixed *Acacia* spp. scattered shrubs to shrubland over *Triodia epactia* hummock grassland	+	+	
H3a	*Eucalyptus leucophloia* scattered low trees over mixed *Acacia* spp. scattered shrubs to shrubland over *Triodia epactia* hummock grassland		+	+
H3e	*Eucalyptus leucophloia* scattered low trees over mixed *Senna* spp. scattered shrubs over *Triodia brizoides* hummock grassland			+
H9a	Mixed *Acacia* spp. scattered shrubs to shrubland over *Triodia epactia* hummock grassland	+	+	+
H9a4	*Acacia monticola A. ancistrocarpa* and *Grevillea wickhamii* scattered tall shrubs over *Triodia epactia* hummock grassland		+	
H9b	Mixed *Acacia* spp. scattered shrubs to shrubland over *Triodia wiseana* hummock grassland		+	+
Pc1b	Mixed low shrubs over *Ptilotus gomphrenoides* herbland and mixed *Panicum laevinode* open tussock grassland		+	

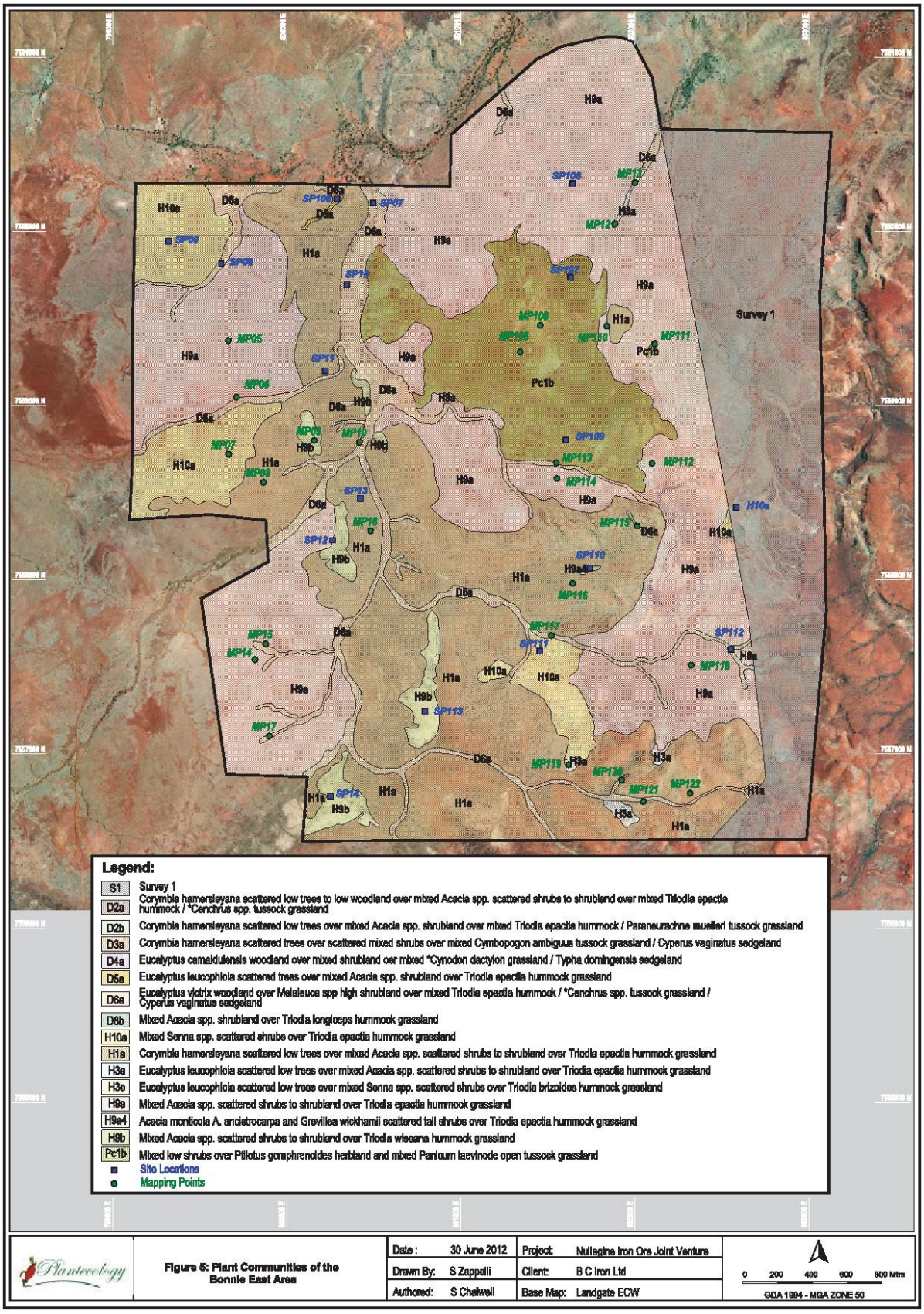

Figure 2. Vegetation mapping of the Bonnie East survey area.

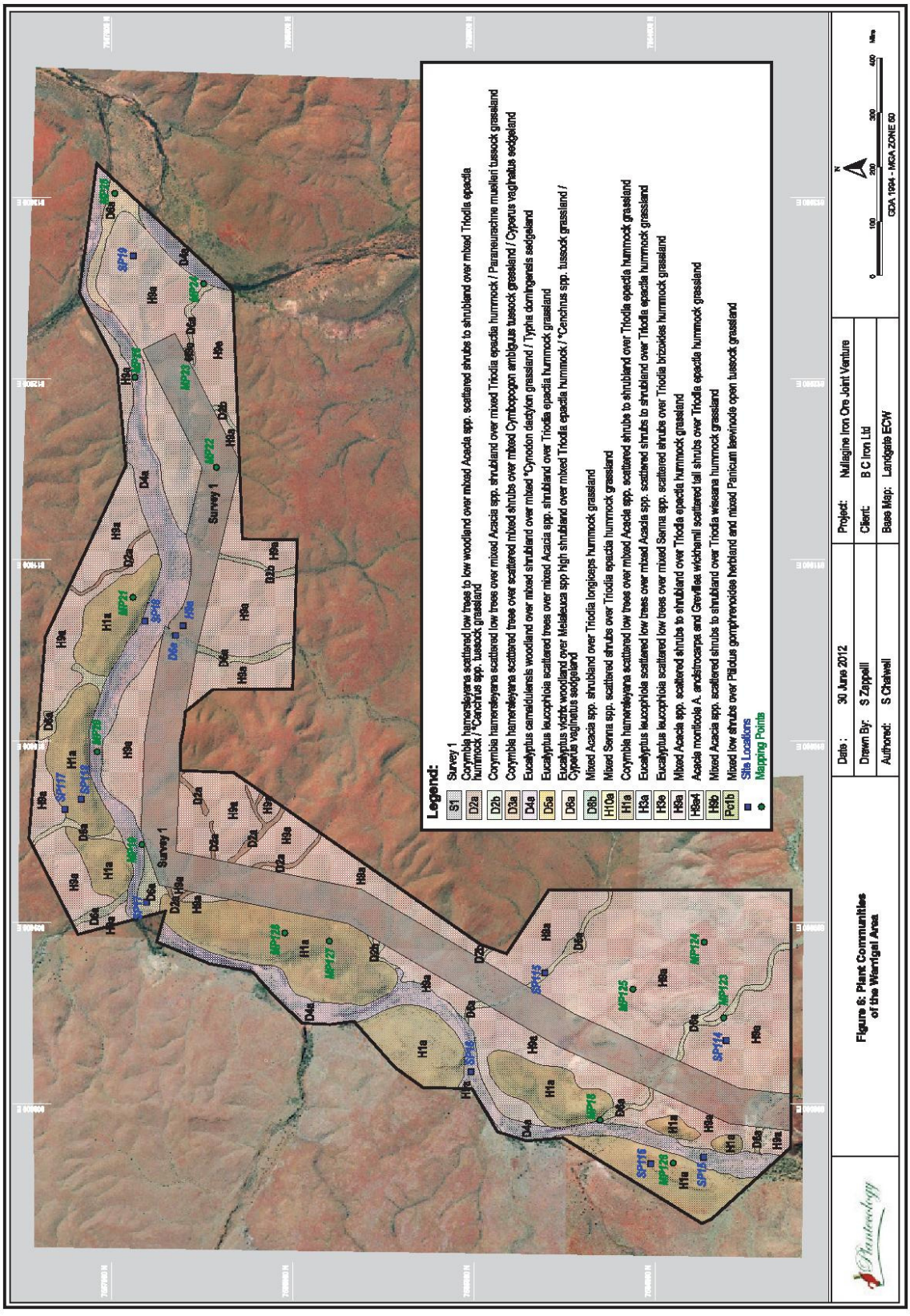

Figure 3. Vegetation mapping of the Warrigal North survey area.

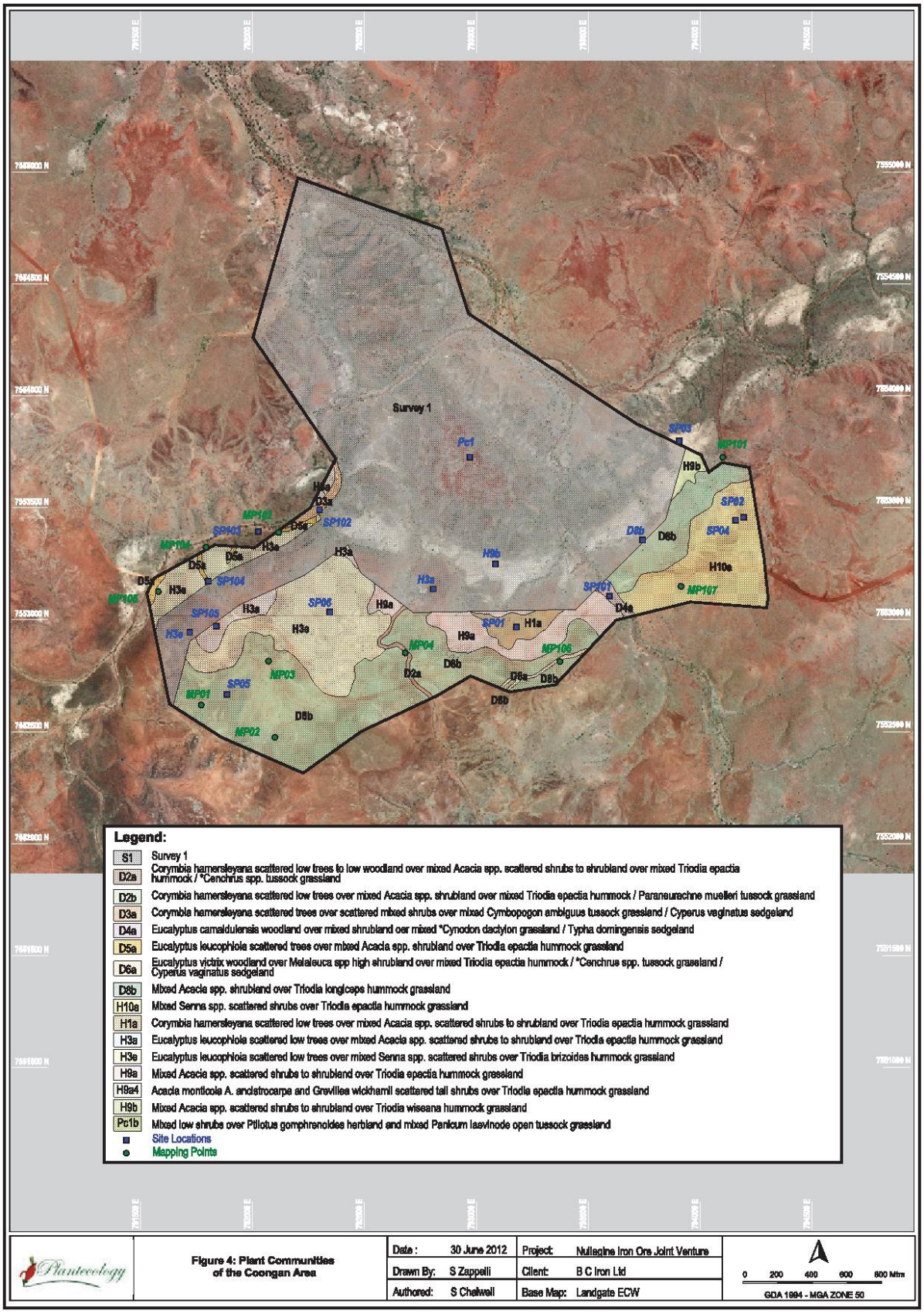

Figure 4. Vegetation mapping of the Coongan survey area.

2 Methods

2.1 Overview

The methods used in these investigations are based upon the general approach to fauna investigations for impact assessment as outlined in Section 1.2 and with reference to Appendices Appendix 1 to Appendix 4. Thus, the impact assessment process involves the identification of fauna values, review of impacting processes and preparation of mitigation recommendations.

In addition, the approach to fauna impact assessment was carried out with reference to guidelines, guidance statements, position statements, bulletins and recommendations set out by the Western Australian Environmental Protection Authority (EPA) on fauna surveys and environmental protection (EPA 2002, 2004), and Commonwealth biodiversity guidance and legislation (DSEWPaC 2010b, a, c, 2011a, b). The EPA proposes two levels of investigation that differ in the approach to field investigations, Level 1 being a review of data/literature and a site reconnaissance to place data into the perspective of the site, and Level 2 being a literature review and intensive field investigations (e.g. trapping and other intensive sampling).

The level of assessment recommended by the EPA is determined by the size and location of the proposed disturbance, the sensitivity of the surrounding environment in which the disturbance is planned, and the availability of pre-existing data. The survey areas lie in a region where repeated level 2 investigations have been undertaken, including for the existing Nullagine Iron Ore Project (see Section 2.2.1,) and, therefore, the present assessment is based largely on a review of existing data, with some targeted field investigations carried out or proposed to investigate groups or species of particular conservation interest.

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

- Desktop assessment. The purpose of the desktop assessment is to produce a species list that can be considered to represent the vertebrate fauna assemblage of the survey areas based on unpublished and published data using a precautionary approach.
- Field investigations. Because of the availability of existing data on the fauna assemblage in the survey areas, field investigations were limited to a site reconnaissance survey (in May 2012), with some additional targeted studies proposed for later in 2012.
- Impact assessment. Determine how the fauna assemblage may be affected by the proposed development based on the interaction of the project with a suite of ecological and threatening processes.

2.2 Desktop Assessment

2.2.1 Sources of information

Information on the fauna assemblage of the survey area was drawn from a wide range of sources. These included state and federal government databases and results of regional studies. Databases accessed were:

- the Department of Environment and Conservation's (DEC) NatureMap Database (incorporating the Western Australian Museum's (WAM) FaunaBase and the DEC Threatened and Priority Fauna Database);
- Atlas of Living Australia (ALA) Database;
- BirdLife Australia's (BA) Atlas Database;
- the EPBC Protected Matters Search Tool (PMST); and
- the BCE database.

Table 2 lists the types of records held in each database, and the limits of the search area for the current report.

Table 2. Fauna databases accessed, including the types of records held and the search areas used for this review.

Database	Type of records held on database	Area searched
NatureMap	Records in the WAM and DEC databases. Includes historical data and records on Threatened and Priority species in WA.	From 21° 30' to 22° 30' S and 119° 00' to 120° 00' E.
ALA	Records from Australia-wide collecting institutions, individual collectors and community groups.	From 21° 30' to 22° 30' S and 119° 00' to 120° 00' E.
BA Atlas	Records of bird observations in Australia, 1998-2012.	From 21° 00' to 23° 00' S and 119° 00' to 120° 00' E.
EPBC PMST	Records on matters of national environmental significance protected under the EPBC Act, including threatened species and conservation estate.	From 21° 30' to 22° 30' S and 119° 00' to 120° 00' E.
BCE	Internal records from a range of other surveys in the region.	General region.

In addition, the following literature was consulted:

- Everard and Bamford (2009): fauna assessment of the entire Nullagine Project area.
- Strategen (2010a, b), Harris *et al*. (2010), and Harris and Bamford (2011): Northern Quoll monitoring and management plans, and monitoring survey results.
- Bamford Consulting Ecologists and Strategen (2011): fauna assessment of the Nullagine Project haul road.

Information from the above sources was supplemented with species expected in the area based on general patterns of distribution. Sources of information used for these general patterns were:

- Frogs: Tyler & Doughty (Tyler and Doughty 2009);
- Reptiles: Storr *et al*. (1983, 1990, 1999, 2002), and Wilson and Swan (2011);
- Birds: Johnstone and Storr (1998, 2005) and Barrett *et al*. (2003); and
- Mammals: Van Dyck and Strahan (2008); Churchill (2009) and Menkhorst and Knight (2011).

2.2.2 Nomenclature and taxonomy

As per the recommendations of EPA (2004), the nomenclature and taxonomic order presented in this report are based on the Western Australian Museum's (WAM) Checklist of the Vertebrates of Western Australia 2008. The authorities used for each vertebrate group were: amphibians (Doughty and Maryan 2011a), reptiles (Doughty and Maryan 2011b), birds (Christidis and Boles 2008; Gill and Donsker 2012), and mammals (How *et al.* 2009). English names of species, where available, are used throughout the text; Latin species names are presented with corresponding English names in tables in the appendices.

2.3 Field investigations

2.3.1 Overview of field investigations

There are two components to the Level 1 (*sensu* EPA 2004) field investigations for the Nullagine Project Extension:

(i) a site reconnaissance of the Nullagine Project Extension survey areas conducted in May 2012 (that formed the basis for the assessment in this report); and

(ii) targeted studies of conservation significant species, including Pilbara Leaf-nosed Bat and Ghost Bat conducted in October 2012 (Metcalf and Bamford 2013). This survey involved the use of ultra-sonic recording equipment and searching of caves. Results are summarised in this report; but for further details of methodology and findings please refer to Metcalf and Bamford (2013).

2.3.2 Site reconnaissance

The site reconnaissance surveys were undertaken on the 22nd and 23rd of May 2012. During this period, the proposed extension survey areas (Bonnie East, Warrigal North and Coongan) were inspected, with detailed on-foot inspections used to:

- Record vegetation and substrate types;
- Make opportunistic observations on fauna (particularly birds); and
- Search for evidence of conservation significant fauna (see below).

2.3.3 Searching for evidence of significant species

The presence of a number of species of conservation significance can be detected through searching for evidence such as scats (e.g. Northern Quoll, Australian Bustard), tracks (e.g. Bilby, Australian Bustard), nests/burrows/dwellings (e.g. mounds of Western Pebble-mound Mouse; burrows of Bilby, mulgara and Rainbow Bee-eater; caves for Pilbara Leaf-nosed Bat and Ghost Bat) and feeding signs. Thus, at all times when in appropriate habitat, personnel kept watch for these signs.

Short Range Endemic (SRE) invertebrates had previously been sampled to only a limited extent (Everard and Bamford 2009), and since those investigations the EPA has produced a guidance statement to provide advice on appropriate levels of sampling for a project (Environmental Protection Authority 2009). This advice involves an initial risk assessment based upon the nature of the landscape and therefore the likelihood of the presence of SRE species, and the potential threat from the proposed development upon any SRE fauna that may be present.

The extension project areas lie in a landscape of low rocky hills, mesas and undulating plains, dissected by seasonal watercourses including Bonney Creek, which has some permanent pools. Both the rocky hills and the plains are very extensive in the region, while the watercourses are part of a broad drainage system that extends well outside the project areas, and most other environments are also regionally extensive. Such broadly represented environments across the landscape are not conducive to the evolution of SRE invertebrates, which are generally favoured by the presence of fragmented, isolated and often mesic refugia (Harvey 2002). The largest of the mesas, such as those in Warrigal North, have the greatest potential for SRE invertebrates, but are part of a linear system (ie they are not isolated). These mesas do have caves and steep, south-facing (therefore cool) slopes, which can provide the right sort of environment for SRE invertebrates, but the systems are not isolated. Caves that were visited (also to check for bat roosts) were dry rather than moist, and the geology of the hill is such that there was moisture and water only in the streambed; there were no moist seepages on the slopes. Because of the lack of isolation and the lack of mesic refugia, the likelihood of SRE invertebrates would appear to be low. This is not to say, however, that there are not invertebrates of taxonomic interest in mesa caves and along watercourses throughout the region. In addition, stygofauna may be present but are addressed separately.

The areas of proposed impact are high in the landscape, with the ore bodies consisting of the upper levels of the mesas. Therefore there would be some loss of dry caves and upper mesas. There is intended to be no impact on watercourses. Therefore, the project is likely to affect some caves but not to affect watercourses.

Despite the conclusion that the likelihood of the presence of and impact on SRE invertebrates was low, some searching for and collection of invertebrates was carried out. This focussed on taxa that are known to include SRE species where environments are conducive to their evolution, such as scorpions, land snails, psuedoscorpions, millipedes and slaters (Harvey 2002). The approach used was:

- General hand-searching by raking through litter and looking under logs, rocks and bark as recommended by the EPA (2009).
- Land snails were searched for in rocky environments (including caves) and along the watercourses as in parts of the Pilbara there is a high richness of SRE snail species. However, the project areas are on the edge of the known range of this group (Solem 1997). Other invertebrate taxa potentially of interest were included in this searching.
- Large invertebrates were checked in pitfalls set for vertebrates.

2.3.4 Licences and personnel

The site inspection carried out in May 2012 reconnaissance and hollow-bearing tree surveys were conducted under Department of Environment and Conservation (DEC) Regulation 17 licence number SF008265 held in the name of Dr Mike Bamford. Field personnel were:

- Dr Mike Bamford *BSc(Biol.), Hons(Biol.), PhD(Biol.*)
- Dr Wes Bancroft *BSc(Zool./Microbiol.), Hons(Zool.), PhD(Zool.)*
- Mr Peter Smith *DipAg*
- Mrs Sarah Smith *BSc(Biol.)*

The report was prepared by Wes Bancroft and Mike Bamford.

2.4 Analysis and interpretation of data

2.4.1 Interpretation of species lists

Species lists generated from the review of sources of information are generous as they include records drawn from a large region and possibly from environments not represented in the survey areas. Therefore, some species that were returned by one or more of the data searches have been excluded because their ecology, or the environment within the survey areas, meant that it was highly unlikely that these species would be present. In general, however, species returned by the desktop review process are considered to be potentially present in the survey areas whether or not they were recorded during field investigations. This is because fauna are highly mobile, often seasonal and frequently cryptic. This is particularly important for significant species that are often rare and hard to find.

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

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

2.5 Survey limitations

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

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

EPA Limitation	BCE Comment
Level of survey.	Intermediate between Levels 1 and 2, with extensive existing information but detailed reconnaissance and some targeted work on significant species.
Competency/experience of the consultant(s) carrying out the survey.	The authors have had extensive experience in conducting fauna assessments in the region; 30 years in the case of the supervising scientist (Dr Mike Bamford).
Scope. (What faunal groups were sampled and were some sampling methods not able to be employed because of constraints?)	Scope of field investigations was to assess habitat and to target signs of conservation significant species/groups.
Proportion of fauna identified, recorded and/or collected.	All vertebrate fauna observed were identified.
Sources of information e.g. previously available information (whether historic or recent) as distinct from new data.	Detailed sources of existing data from previous studies (see Section 2.2.1).
The proportion of the task achieved and further work which might be needed.	Site inspection completed. Proposed targeted surveys for bats to be undertaken later in 2012.
Timing/weather/season/cycle.	Field investigations carried out at an appropriate time of the year.
Disturbances (e.g. fire, flood, accidental human intervention etc.), which affected results of survey.	No disturbances affected the survey.
Intensity. (In retrospect, was the intensity adequate?)	Survey intensity adequate to record VSAs/important habitat features and likelihood of conservation significant fauna presence.
Completeness (e.g. was relevant area fully surveyed).	Entirety of the survey areas was visited.
Resources (e.g. degree of expertise available in animal identification to taxon level).	All vertebrate species identified to species (sometimes sub-species) level.
Remoteness and/or access problems.	No difficulties with access were encountered.
Availability of contextual (e.g. biogeographic) information on the region.	Detailed local and regional information was available and consulted.

2.6 Impact assessment

While some impacts are unavoidable during project development, of concern are long-term, deleterious impacts upon biodiversity. This is reflected in documents such as the Significant Impact

Guidelines provided by the federal Department of Sustainability, Environment, Water, Population and communities (DSEWPaC see Appendix 4). Significant impacts may occur if:

- There is direct impact upon a Vegetation/Substrate Association (VSA) and the VSA is rare, a large proportion of the VSA is affected and/or the VSA supports significant fauna;
- There is direct impact upon conservation significant fauna; or
- Ecological processes are altered and this affects large numbers of species or large proportions of populations, including significant species.

The impact assessment process therefore involves reviewing the fauna values identified through the desktop assessment and field investigations with respect to the project and impacting processes. The severity of impacts on the fauna assemblage and conservation significant fauna can then be quantified on the basis of predicted population change (as outlined in Table 4).

The presentation of this assessment follows the general approach to impact assessment as given in Section 1.2, but modified to suit the characteristics of the site and the field investigations for the Nullagine Project Extension proposal. Key components to the general approach to impact assessment are addressed in Sections 2.6.1 and 2.6.2.

Table 4. Assessment criteria of impacts upon fauna.

Impact Category	Observed Impact
Negligible	Effectively no population decline; at most few individuals impacted and any decline in population size within the normal range of annual variability.
Minor	Short-term population decline (recovery after end of project) within project area, no change in viability of conservation status of population. Where environment permanently altered, no change in viability or conservation status of population
Moderate	Permanent population decline, change in viability or conservation status of population considered unlikely
Major	Permanent population decline resulting in change in viability or conservation status of population
Critical	Taxon extinction (i.e. extinction of species, sub-species or of a recognisably discrete genetic population).

2.6.1 Fauna values

This section presents the results of the desktop and field investigations in terms of key fauna values (described in detail in Appendix 1):

- Assemblage characteristics (uniqueness, completeness and richness) - based upon desktop assessment, and some information from the reconnaissance survey;
- Species of conservation significance – based upon desktop assessment and reconnaissance;
- Recognition of ecotypes or vegetation/substrate associations (VSAs) - based upon desktop assessment and reconnaissance;
- Patterns of biodiversity across the landscape - based upon desktop assessment and reconnaissance for general patterns; and

- Ecological processes upon which the fauna depend - based upon desktop assessment and reconnaissance.

2.6.2 Impact assessment

This section reviews impacting processes (as described in detail in Appendix 2) with respect to the proposal and examines the potential effect of these impacts upon biodiversity of the alignment. It thus expands upon the Project Description (Section 1.3) and discusses the contribution of the project to impacting processes, and the consequences of this with respect to biodiversity. A major component of impact assessment is consideration of threats to species of conservation significance as these are a major and sensitive element of biodiversity. Therefore, the impact assessment includes the following:

- Review of impacting processes; will the proposal result in:
  - Habitat loss leading to population decline, especially for significant species;
  - Habitat loss leading to population fragmentation, especially for significant species;
  - Weed invasion occur and lead to habitat degradation;
  - Ongoing mortality;
  - Species interactions that adversely affect native fauna, particularly significant species;
  - Hydrological change;
  - Altered fire regimes; and
  - Disturbance (dust, light, noise)?
- Summary of impacts upon significant species, and other fauna values.

3 Results

It is expected that the fauna composition of the three extension survey areas within the Nullagine Project Extension area (i.e. Bonnie East, Warrigal North and Coongan) will be similar, although with some differences in importance related to each survey area's particular characteristics. Therefore, discussions of the fauna assemblage, conservation significant species, vegetation and substrate associations, patterns of biodiversity, and key ecological processes are applicable to all survey areas, unless explicitly stated otherwise. The impact assessment section (Section 4) discusses the significance for fauna of each survey area.

3.1 Fauna assemblage

The desktop study identified 325 vertebrate fauna species as potentially occurring in the survey areas (see Table 5 and Appendix 5). As noted above (Section 2.4.1), this list almost certainly includes species that do not occur in the area, but they have been included to avoid overlooking species that may be of importance. The presence of some of the expected species was confirmed during field investigations (indicated in Appendix 5). The assemblage includes at least 41 species of conservation significance, which are discussed further in Section 3.2.

Key features of the assemblage are:

- Uniqueness: The assemblage is broadly typical of much of the Pilbara. Much of the assemblage consists of species associated with drainage lines, pools and rocky environments, but it includes a suite of species associated with sandy soils that may or may not be present; sandy soils are limited in the survey areas, but there are sandy loams associated with some of the drainage systems. Because the area is in the Eastern Pilbara, there are probably some species that are close to the limit of their range. For example the Bonney Downs area seems to be about the eastern limit of both the Northern Quoll and the Pilbara Olive Python.
- Regional representation: The assemblage is widely-represented on a regional basis.
- Completeness: The assemblage lacks a number of medium sized ("critical weight range") mammals (e.g. Pig-footed Bandicoot, *Chaeropus ecaudatus*; Golden Bandicoot, *Isoodon obesulus auratus*; Western Barred Bandicoot, *Perameles bougainville*; Burrowing Bettong, *Bettongia lesueur*; Rufous Hare-Wallaby, *Lagorchestes hirsutus*; Lesser Stick-nest Rat, *Leporillus apicalis*; and Greater Stick-nest Rat, *Leporillus conditor*; Burbidge and McKenzie 1989) but is substantially complete. Some critical weight range mammals have declined across much of Australia due to factors such as predation by feral species (particularly the Red Fox) and altered fire regimes as a result of anthropological changes since European settlement of Australia (Burbidge and McKenzie 1989). The assemblage may also lack other species due to localised degradation due to weed invasion and livestock grazing, or there may be species that occur at unusually low densities due to this degradation.
- Richness: The assemblage appears rich because the survey areas provide a very wide range of environments, from permanent water and riverine woodland to a range of vegetation types on substrates such as rocky hills, rocky plains and sandy-loam soils.

As a fauna value, the most important features of the assemblage are that it is a moderately rich assemblage that combines species associated with a range of different environments, and includes

species close to the eastern edge of their range in the Pilbara. As noted above, the assemblage is expected to be the same in each survey area, although there will be differences in the abundance of some species between survey areas; the importance of such differences are considered below.

Table 5. Composition of vertebrate fauna assemblage expected to occur in the vicinity of the survey areas, and those recorded during previous field investigations.

Taxon	Number of species expected	Number recorded	Significant fauna expected		
			CS1	CS2	CS3
Freshwater Fish	7	4	-	-	-
Frogs	8	4	-	-	1
Reptiles	109 (1*)	39	1	4	1
Birds	151	96	11	5	7
Mammals	50 (9*)	25	4	6	1
Total	325	168	16	15	10

* Number of introduced species included in the total

3.2 Species of conservation significance

Details on species of conservation significance are presented in Table 6. Some of these species are considered unlikely to be present or to occur only as vagrants, but some are expected to be resident or regularly present, with some recorded during field investigations. Further information on these is presented below.

3.2.1 Conservation significance level 1

- Pilbara Olive Python. Recorded previously from the local area and is usually associated with rocky hills and watercourses. However, it ranges widely from such locations with animals apparently moving several hundred metres between watercourses and waterholes (I. Harris pers. comm.). Likely to be resident in the survey areas.
- Fork-tailed Swift. A highly aerial species that is mostly independent of terrestrial ecosystems and is likely to pass over the survey areas as a vagrant. It is unlikely to suffer significant impacts from mining activities.
- Cattle Egret, White-bellied Sea-Eagle, Australian Painted Snipe, Oriental Plover, Red-necked Stint, White-winged Black Tern. All expected to be vagrants to water bodies within the survey areas. The tern has been recorded on one occasion previously and a single Australian Painted Snipe was observed near Bonnie Pool in October 2012.
- Eastern Great Egret. Likely to be an irregular visitor to water bodies, especially after significant rainfall that may attract greater numbers of this species to the region.
- Peregrine Falcon, Rainbow Bee-eater. Both likely to be residents or regular visitors to the survey areas. The bee-eater is a widespread species that has been recorded regularly in the region and may construct nesting burrows in areas of sand (e.g. riparian areas) but is unlikely to be significantly impacted by mining activities. Although not recorded by BCE, there is

potential for the falcon to nest along cliffs or in tall trees along creeklines within the survey areas.

- Night Parrot. One of Australia's rarest and least-known birds and, therefore, difficult to assess. A sighting of this species was made near the northern edge of the Fortescue Marshes in April 2005 (approximately 50 km to the south-west of the survey areas). Habitat preferences of the Night Parrot are poorly understood with some evidence to suggest it occurs in regions of spinifex and chenopod shrublands (such as around the Fortescue Marshes), but there are historic records from spinifex and breakaway country (Higgins 1989). Given its rarity and the absence of chenopod shrublands in the survey areas, it is considered to be potentially a vagrant.
- Crest-tailed Mulgara, Bilby. The survey areas generally lacks the softer substrates (e.g. sands, loams) preferred by these mammals, although there are some possibly suitable soils along larger watercourses, notably in the south of the Warrigal North survey area. Nevertheless, both species are known from the greater region and may pass through the survey areas as vagrants. See notes on mulgara taxonomy and distribution, below.
- Northern Quoll. Recorded in the survey areas in initial fauna surveys in 2008 and has been the subject of targeted monitoring since then. Despite extensive survey effort, no quolls have been recorded since the 2008 survey, although small numbers of scats have been found suggesting that the species is still present but is virtually undetectable. Scat records include at a location in the Coongan survey area (at 792680 mE, 7553985 mN), where the species was trapped in 2008 and two scats were found in December 2011, but no scats were found in June 2011 or May 2012. It is likely that the region currently represents marginal habitat for this species and that it is colonised on an episodic basis as populations expand during periods (years or decades) of favourable conditions (e.g. consistent rainfall, minimal burning). All three survey areas have some suitable habitat for this species, but particularly the Warrigal North survey area.
- Pilbara Leaf-nosed Bat. This bat requires very specific roosting conditions in caves and/or mines: hot (28–32°C) and humid (96–100%). The mesas in and near the Warrigal North survey area may contain suitable roost sites for this species. While it is unlikely that this species roosts in the Bonnie East or Coongan survey areas, if it is present in the region it may forage throughout all survey areas. The closest known roost (in the available literature) is Copper Hills mine[1], c. 40 km north of the Warrigal North survey area, where an estimated 10-20 individuals roost. This species was the subject of targeted surveys in October 2012 (Metcalf and Bamford 2013). Its presence was confirmed in the Warrigal North survey area with several records of individuals foraging along watercourses. However, no roost sites in caves were found despite extensive searching, and the general impression was that caves in the area are too shallow to provide the specific roosting conditions required by the species.

Mulgara taxonomy and distribution

Two species of 'mulgara' have been recognised by Woolley (2005): the Brush-tailed Mulgara (*Dasycercus blythi*) and the Crest-tailed Mulgara (*D. cristicauda*). Both species have a wide and overlapping distribution in arid Australia. These two species can be sympatric in places, but probably utilise different parts of the environment on a local scale when they are recorded in the same area. Pavey *et al*. (2011) found that *D. blythi* occurred on sandplains and gibber plains, with *D. cristicauda* occurring on sand ridges with spinifex (*Triodia* spp.). Because the recognition of two mulgara species has been

[1] 21 37.696°S, 119 59.391°E

so recent, the identity of museum specimens must be re-checked before the true range limits of both can be determined (Woolley 2005, 2008). Western Australian mulgara records and specimens in from prior to 2005 are mostly listed as *D. cristicauda*, but many may be *D. blythi*. At present, it appears that both species occur in the Pilbara.

3.2.2 Conservation significance level 2

- *Ctenotus nigrilineatus*, *Ctenotus uber johnstonei*, *Lerista macropisthopus remota*, *Ramphotyphlops ganei*. All are DEC priority listed reptiles that may occur (in suitable habitat) in the vicinity of the survey areas. None has been recorded by BCE in field investigations to date.
- Grey Falcon. Recorded in wooded creek line near the present camp, this species is likely to be a resident or regular foraging visitor to the survey areas. It may nest in tall trees along creeklines in all three survey areas.
- Australian Bustard. This species is probably present regularly in small numbers in grasslands around the survey areas. It is a widespread and wide-moving that is unlikely to be significantly impacted by mining activities.
- Bush Stone-curlew, Star Finch. Both have been recorded associated with drainage systems in the region. It is likely that they are resident in the broader region (and may use suitable habitat within the survey areas). The Star Finch was present in the Warrigal North survey area in 2008 and this is probably the only one of the three survey areas with suitable habitat for the species, although it is likely to disperse through the other areas.
- Princess Parrot. May occur unpredictably, as a vagrant, if seasonal conditions in the arid zone are suitable.
- Brush-tailed Mulgara. Generally prefers softer substrates (e.g. sands, loams) that are not widely available in the survey areas but are present along the margins of watercourses. See notes on mulgara taxonomy and distribution in Section 3.2.1.
- Long-tailed Dunnart, Short-tailed Mouse. Priority listed species that occur in the broader region but have not been recorded by BCE in the vicinity of the survey areas. The dunnart appears to be a specialist of rocky habitats. Short-tailed Mouse populations appear to fluctuate dramatically, probably in response to environmental conditions and food availability. The Pilbara population, which may represent a distinct taxon (Van Dyck and Strahan 2008), has a preference for sandy and cracking clay/gilgai soils (B. Metcalf pers. obs.). Habitat along some watercourses may be suitable and there is an area of loam plain in the south of the Bonnie East survey area that may be suitable.
- Spectacled Hare-wallaby. In Western Australia this species is now restricted to a few small isolated patches in the Pilbara and Kimberley. There may be some suitable habitat (typically long-unburnt Spinifex) in valleys within the survey areas, but it is not considered likely to be present.
- Ghost Bat. The mesas within and near the Warrigal North survey area may contain suitable roost sites (caves) for this species. While it is unlikely that this species roosts in the Bonnie East or Coongan survey areas, if it is present in the region it may forage throughout all three survey areas. Along with the Pilbara Leaf-nosed Bat, this species was subject to a targeted survey in October 2012; no records of the species were made. While it seems unlikely that there are any roosts, even in the Warrigal North survey area, the species should still be considered an occasional visitor.

- Western Pebble-mound Mouse. This species generally occurs on the lower slopes of rocky hills where it uses small stones to build its distinctive mounds. Numerous mounds attributable to this species have been found previously in the local area (Everard and Bamford 2009); it was common in upland areas and slopes with gravelly soils and spinifex. The availability of suitable substrate within the three survey areas was much more restricted than the broader area (survey area substrates lacked the smaller gravels required by this species), although a large, active mound was found in the Coongan survey area at 793309 mE, 7553019 mN and a group of four mounds was found on a low stony hill just south of the Bonnie East survey area (798835 mE, 7556127 mN).

3.2.3 Conservation significance level 3

- Glandular Toadlet. Has a restricted distribution within the northern Pilbara and is probably associated with rocky areas near water. Thus likely to be present in all three survey areas.
- Pilbara Monitor. This is considered to be locally important because it is a Pilbara endemic, is restricted to rocky environments and is being considered to taxonomic revision, with a northern Pilbara and a southern Pilbara species (B. Maryan pers. comm.). One was observed in the Warrigal North survey areas in June 2012, and the species is probably confined to the best developed rocky areas in the landscape.
- Pheasant Coucal, Black-tailed Treecreeper, Southern Whiteface, Western Quail-thrush. Considered locally important species because the survey areas are at the edge of their range. None of these species has been recorded during field investigations, and given they are generally conspicuous; it is likely they are not present (except possibly as vagrants).
- Rufous-crowned Emu-wren, Striated Grasswren, Grey Honeyeater. Considered locally important species because they are uncommon and patchily distributed. The Striated Grasswren was recorded in long-unburnt spinifex in the Coongan survey area in 2008.
- Rothschild's Rock-Wallaby. This species is not of recognised conservation significance but it is infrequently encountered and endemic to the Pilbara. It was recorded in the Warrigal North survey area in 2008 and in 2012 by Metcalf and Bamford (2013), and the Warrigal North survey area provides suitable habitat, but most rocky areas elsewhere within the survey areas (i.e. Bonnie East and Coongan survey areas) do not provide sufficient complex habitat.
- SRE invertebrates. No species confirmed, with one undescribed scorpion (*Lychas 'pilbara'*) collected in 2008 from shrubland on stony soil is known from other locations across the Pilbara. Slaters (*Buddelina* sp.) were also collected in 2008 but this genus is widespread in the Pilbara. A terrestrial snail was collected in a gorge at Coongan in December 2012 and was identified as *Succinea* sp.. This is considered to be widespread taxon and therefore not an SRE (Whisson 2013). As noted in Section 2.3.3, watercourses and mesas in the region may provide the sorts of environmental conditions that can support the evolution of SRE invertebrate species, but the connectivity along watercourses in particular means that such species are likely to have a long but narrow distribution that extends well outside impact areas.

3.2.4 Summary of species of conservation significance

Significant species expected to occur within or in the vicinity of the survey areas include a number of particular interest that are either confirmed to be present or may be present and are of high conservation significance, and are also associated with the sorts of environments likely to be impacted in the survey areas. These are:

- Pilbara Olive Python (rocky slopes, often near pools)
- Pilbara Monitor (steep rocky slopes and hills)
- Grey Falcon (eucalypts along watercourses)
- Bush Stone-curlew (minor watercourses)
- Star Finch (rushes and other riparian vegetation around pools)
- Northern Quoll (steep rocky slopes and hills)
- Pilbara Leaf-nosed Bat (deep caves for roosting)
- Ghost Bat (deep caves for roosting)
- Western Pebble-mound Mouse (lower slopes of hills)
- Rothschild's Rock-Wallaby (steep rocky slopes and hills).

This suite of conservation significant species of particular interest may occur in all survey areas, but the importance of each area differs because of the specific requirements of each species (as indicated above). The Warrigal North survey area provides (or may provide) important habitat for all the above species. In contrast, the Bonnie East and Coongan survey areas may provide important habitat only for the Pilbara Olive Python, Grey Falcon, Bush Stone-curlew and Western Pebble-mound Mouse. The habitat associations of these species are further discussed in section 3.4 and Table 7.

Table 6. Conservation status of significant fauna species expected to occur in the vicinity of the survey areas (based on desktop review and field investigations).

See Appendix 1 for descriptions of conservation significance levels. In addition:

- EPBC Act listings: E = Endangered, V = Vulnerable, M = Migratory (see Appendix 3).
- Wildlife Conservation Act listings: S1 = Schedule 1, S3 = Schedule 3, S4 =Schedule 4 (see Appendix 3) with rankings shown in square parentheses: [c] = critically endangered, [e] = endangered, [v] = vulnerable.
- DEC Priority species: P1 to P5 = Priority 1 to 5 (see Appendix 3).
- LS = considered to be of local significance by Bamford Consulting Ecologists, TU = taxonomic uncertainty (see Appendix 1).

Species that have been recorded in the area are indicated by '+' and the predicted status of each species in the survey areas is also given (as per Section 2.4.1).

Species		CS1		CS2	CS3	Recorded	Predicted Status
		EPBC Act	WC Act				
FROGS							
Uperoleia glandulosa	Glandular Toadlet				LS	+	Resident.
REPTILES							
Ctenotus nigrilineatus				P1			Resident (if present).
Ctenotus uber johnstonei				P1			Resident (if present).
Lerista macropisthopus remota				P2			Resident (if present).
Varanus pilbarensis	Pilbara Rock Monitor				LS		Resident (if present).
Ramphotyphlops ganei				P1			Resident (if present).
Liasis olivaceus barroni	Pilbara Olive Python	V	S1[v]			+	Resident.
BIRDS							
Apus pacificus	Fork-tailed Swift	M	S3				Vagrant.
Ardea modesta	Eastern Great Egret	M	S3				Irregular visitor.
Ardea ibis	Cattle Egret	M	S3				Vagrant.
Haliaeetus leucogaster	White-bellied Sea-Eagle	M	S3				Vagrant.
Falco hypoleucos	Grey Falcon			P4		+	Resident or regular visitor.
Falco peregrinus	Peregrine Falcon		S4				Resident or regular visitor.

Species		CS1		CS2	CS3	Recorded	Predicted Status
		EPBC Act	WC Act				
Ardeotis australis	Australian Bustard			P4		+	Resident or regular visitor.
Burhinus grallarius	Bush Stone-curlew			P4		+	Resident or regular visitor.
Charadrius veredus	Oriental Plover	M	S3				Vagrant.
Rostratula australis	Australian Painted Snipe	V	S1(v)			+	Vagrant
Calidris ruficollis	Red-necked Stint	M	S3				Vagrant.
Chlidonias leucopterus	White-winged Black Tern	M	S3			+	Vagrant.
Polytelis alexandrae	Princess Parrot			P4			Vagrant.
Pezoporus occidentalis	Night Parrot	E, M	S1[c]				Vagrant.
Centropus phasianinus	Pheasant Coucal				LS		Vagrant.
Merops ornatus	Rainbow Bee-eater	M	S3			+	Resident or regular visitor.
Climacteris melanura	Black-tailed Treecreeper				LS		Resident (if present).
Stipiturus ruficeps	Rufous-crowned Emu-wren				LS		Resident (if present).
Amytornis striatus	Striated Grasswren				LS	+	Resident.
Aphelocephala leucopsis	Southern Whiteface				LS		Resident (if present).
Conopophila whitei	Grey Honeyeater				LS		Irregular visitor.
Cinclosoma marginatum †	Western Quail-thrush				LS		Vagrant.
Neochmia ruficauda subclarescens	Star Finch			P4		+	Resident.
MAMMALS							
Dasycercus blythi	Brush-tailed Mulgara			P4			Vagrant.
Dasycercus cristicauda	Crest-tailed Mulgara	V	S1[v]				Vagrant.
Dasyurus hallucatus	Northern Quoll	E	S1[e]			+	Resident or irregular visitor.
Sminthopsis longicaudata	Long-tailed Dunnart			P4			Vagrant.
Macrotis lagotis	Bilby	V	S1[v]				Vagrant.
Lagorchestes conspicillatus leichardti	Spectacled Hare-Wallaby			P3			Vagrant.
Petrogale rothschildi	Rothschild's Rock-Wallaby				LS		Resident.

Species		CS1		CS2	CS3	Recorded	Predicted Status
		EPBC Act	WC Act				
Macroderma gigas	Ghost Bat			P4			Uncertain, but probably at least an irregular visitor. Possibility of roost sites to be investigated.
Rhinonicteris aurantia (Pilbara form)	Pilbara Leaf-nosed Bat	V	S1[v]				Present and probably a regular foraging visitor. Unlikely to be roosting in survey areas.
Leggadina lakedownensis	Short-tailed Mouse			P4			Vagrant.
Pseudomys chapmani	Western Pebble-mound Mouse			P4		+	Resident.

† Formerly the Western Australian population (subspecies) of the Chestnut-breasted Quail-thrush (*Cinclosoma castaneothorax*), this taxon is now recognised as a full species (Toon *et al.* 2010; Gill and Donsker 2013).

3.3 Vegetation and substrate associations (VSAs)

The survey areas lie in the Chichester subregion, span three land systems and support 15 vegetation types (see Section 1.4). Each survey area is described below (based on the site inspection in May 2012 and previous experience in the region).

Bonnie East survey area: consists of two weathered mesas with the ephemeral Bonnie Creek traversing the western side of southern mesa then passing between the two mesas before continuing northwards along the eastern side of the northern mesa. North and west of Bonnie East consists of a high, undulating landscape; south and east of Bonnie East resembles a low plain. The undulating landscape contains areas of Bloodwood Woodland and some mallee over spinifex on calcareous soil. The substrate surface reflects a mixture of small rocks but generally not the sort of fine rocky surface used by the Western Pebble-mound Mouse. Bonnie Creek is lined with river gums and its tributaries with mixed acacia and bloodwood.

Warrigal North survey area: represents a complex assemblage of very large mesas adjacent to Bonnie Creek, with some areas of spinifex–clad undulating rocky hills close-by. Mesas are well-developed with prominent cliffs (especially east of Bonnie Pool). Bonnie Creek has well-developed eucalypt woodland and acacia thickets as well as several long, semi-permanent and permanent pools. Loam soils supporting spinifex and shrublands occur adjacent to watercourses in some areas. The tops of the mesas support spinifex with scattered shrubs and an open woodland of small eucalypts on a rocky/boulder substrate.

Coongan survey area: mostly consists of undulating rocky hills clad in spinifex with scattered shrubs and the occasional eucalypt. A gorge system with well-developed rocky cliff lines and lots of small caves occurs mainly within the existing (approved) Nullagine Project Area. There is a watercourse lined with eucalypt woodland and acacia shrubland near Coongan Mill (793440 mE, 7553200 mN).

On the basis of these descriptions and familiarity with the general region, the following VSAs are recognised:

VSA 1. Acacia shrubs over hummock grasslands on stony hills and plains (photos 1, 2, 3 and 4). Mixed *Acacia* shrub species over hummocking grasses such as *Triodia epactia* on stony soils, with some gravel and loam. Extensive and well-represented in the region, including across parts of all three survey areas.

- *Conservation significance*: Low but can support the Western Pebble-mound Mouse where the stony hills are well-developed.

VSA 2. Eucalypt woodland over hummock grasslands on stony hills and plain (photo 5). Eucalyptus trees (e.g. *E. leucophloia*) trees over hummocking grasses such as *Triodia epactia* on stony soils. Moderately extensive and well-represented in the region; often well-developed on mesa-tops such as in the Warrigal North survey area.

- *Conservation significance*: Low.

VSA 3. Bloodwood woodland over hummock grasslands on undulating stony hills (photo 6). *Corymbia hamersleyana* trees over hummocking grasses such as *Triodia epactia.* Some calcareous stony soils. These woodlands appear to have limited representation within the broader region but are extensive in the Bonnie East survey area.

- *Conservation significance*: Low to moderate. This VSA may be of higher value seasonally, when bloodwoods are in flower; providing foraging resource for honeyeaters, as well as invertebrates and associated predators (e.g. insectivorous birds and bats).

VSA 4. Well-developed cliff lines along mesa edges or gorges (photo 7 and, 8). Variable vegetation (although usually shrubs, hummock grasses and occasional eucalypts) on very steep, rocky slopes. May have considerable bare areas of large exposed rocks, rock piles or scree slopes. Caves and crags are present to varying degrees. Linear and narrow in the context of the broader landscape. Although widespread regionally, this VSA comprises a very small proportion of the total landscape. It is extensive in the Warrigal North survey area with small areas in Coongan and Bonnie East survey areas.

- *Conservation significance*: High. This VSA provides the potential for significant refugia for some fauna, in the form of caves or interstitial spaces between rocks. These areas are preferred by some conservation significant species such as Northern Quoll, Rothschild's Rock-wallaby, Pilbara Monitor, Pilbara Leaf-nosed Bat and Ghost Bat. The presence of roosting caves used by the two bat species would be extremely significant. In the Warrigal North survey area in particular, this VSA is linear and this may allow for movement of dependent fauna through the landscape.

VSA 5. Riparian zones (photos 9, 10, 11 and 12). Ephemeral drainage lines and permanent pools, and surrounding vegetation (often dominated by large eucalypts that form a riparian woodland). Substrate variable, including sands, loams, gravel, cobbles and exposed rock; the loam soils extend away from watercourses in some broad valleys. Shrub and tree density considerably greater than non-riparian VSAs. Linear and narrow in the context of the broader landscape. Although well represented, regionally, this VSA comprises a relatively small proportion of the overall landscape.

- *Conservation significance*: Very high. In arid landscapes drainage systems are vital as a source of free-water for fauna; thus they attract fauna from surrounding areas (on a daily, seasonal or even permanent basis). They provide characteristic and regionally limited refugia (e.g. moist or humid areas) for fauna (especially some short-range endemic invertebrates). Water-dependent species such as fish, some frogs and waterbirds are dependent on these systems for persistence in the region. They also regularly act as a conduit along which fauna may pass through the landscape. Facilitation of landscape permeability (to fauna) is a vital ecosystem function of this VSA. Consequently, riparian areas typically have a high to very high (relative) abundance and richness of fauna species. A number of the significant species are dependent upon riparian zones. The loam-dominated substrate in this VSA is locally uncommon and may support a range of burrowing fauna (e.g. burrowing frogs, semi-fossorial reptiles, burrowing mammals potentially including Mulgara) not regularly encountered in other, rock-dominated VSAs.

A map of the VSAs is provided in Figure 5.

Photo 1. VSA 1: Acacia shrubs over hummock grasslands on stony hills and plain in the north of the Warrigal North survey area, with cliffs along mesas (VSA 4) and riparian woodland along Bonnie Creek (VSA 5) in the background.

Photo 2. VSA 1: Acacia shrubs over hummock grasslands on stony hills and plain in the north of the Warrigal North survey area.

Photo 3. VSA 1: Acacia shrubs over hummock grasslands on stony hills and plain in the Bonnie East survey area.

Photo 4. VSA 1: Acacia shrubs over hummock grasslands on stony hills and plain in the Coongan survey area. The vegetation in this area is degraded along Hillside Road.

Photo 5. VSA 2: Eucalypt woodland over hummock grasslands on stony hills and plains in Bonnie East survey area. This VSA also well-represented on mesa tops in Warrigal North survey area.

Photo 6. VSA 3: Bloodwood woodland over hummock grasslands on undulating stony hills in Bonnie East survey area.

Photo 7. VSA 4: cliff line along mesa edge, overlooking riparian woodland along Bonnie Creek (VSA 5) in Warrigal North survey area.

Photo 8. Massive mesa with tall cliffs (VSA 4) in the east of the Warrigal North survey area.

Photo 9. VSA 5: open woodland of river gums along a drainage line in the Bonnie East survey area.

Photo 10. View from mesa top in the Warrigal North survey area, showing riparian woodland along Bonnie Creek (VSA 5) along the base of mesa (VSA 4).

Photo 11. Riparian woodland (VSA 5) with VSA 1 on stony hills in the background; Coongan survey area.

Photo 12. VSA 5. Shrubland and spinifex on loam substrates adjacent to a drainage line in the south of the Warrigal North survey area.

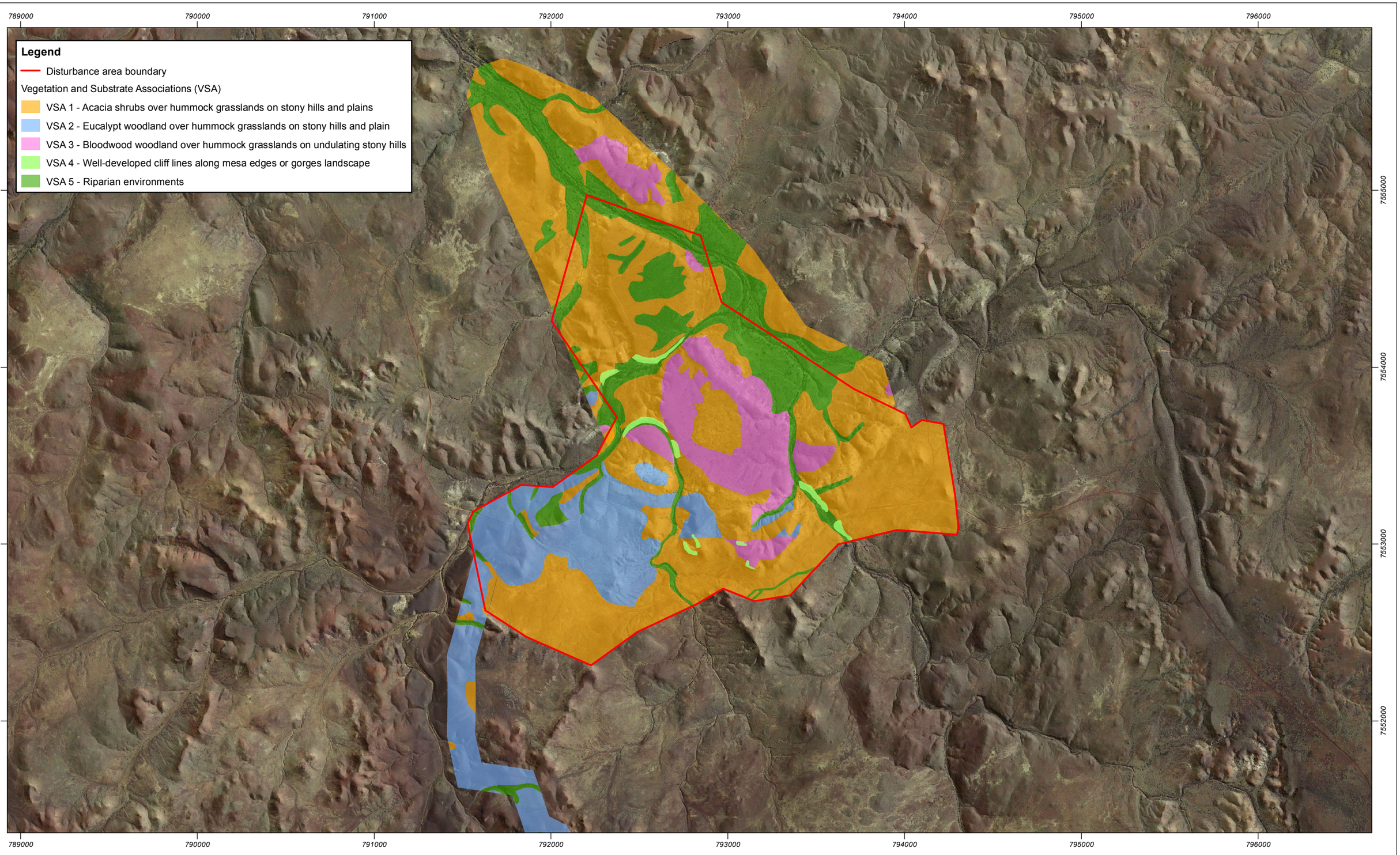

Figure 5 Map of the vegetation and substrate associations (VSAs) within the Coongan survey area

Scale 1:20,000 at A3

0 150 300 450 600 750 Meters

N

Coordinate System: MGA50
Note that positional errors may occur in some areas
Date: 7/03/2013
Author: JCrute
Source: Client 2011-2012.

Path: Q:\GIS\Consult\2012\BCI\BCI12047\Projects\Fauna_Level1_report\BCI12047_01_Fauna_Level1report_F005_A3.mxd

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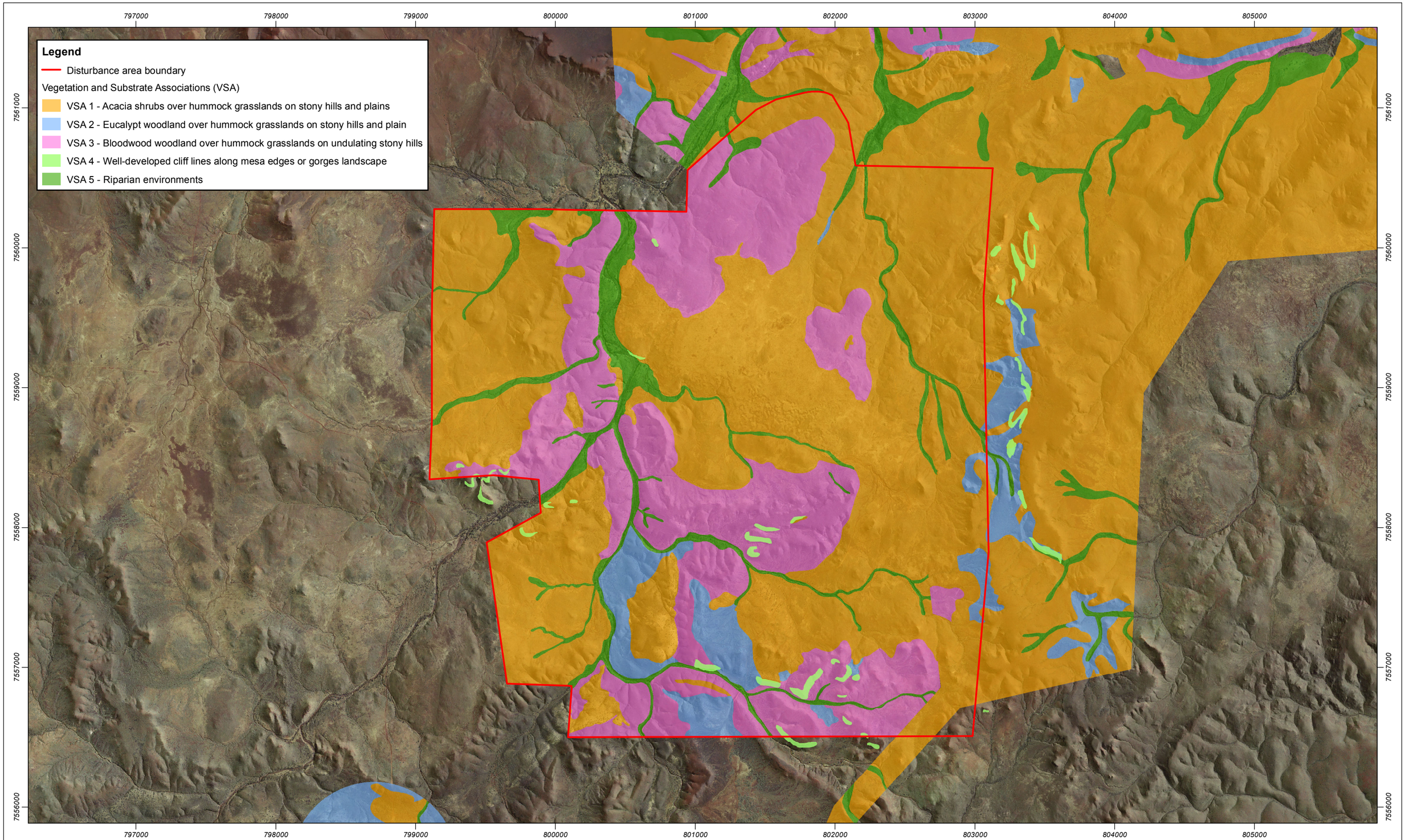

Figure 6 Map of the vegetation and substrate associations (VSAs) within the Bonnie East survey area

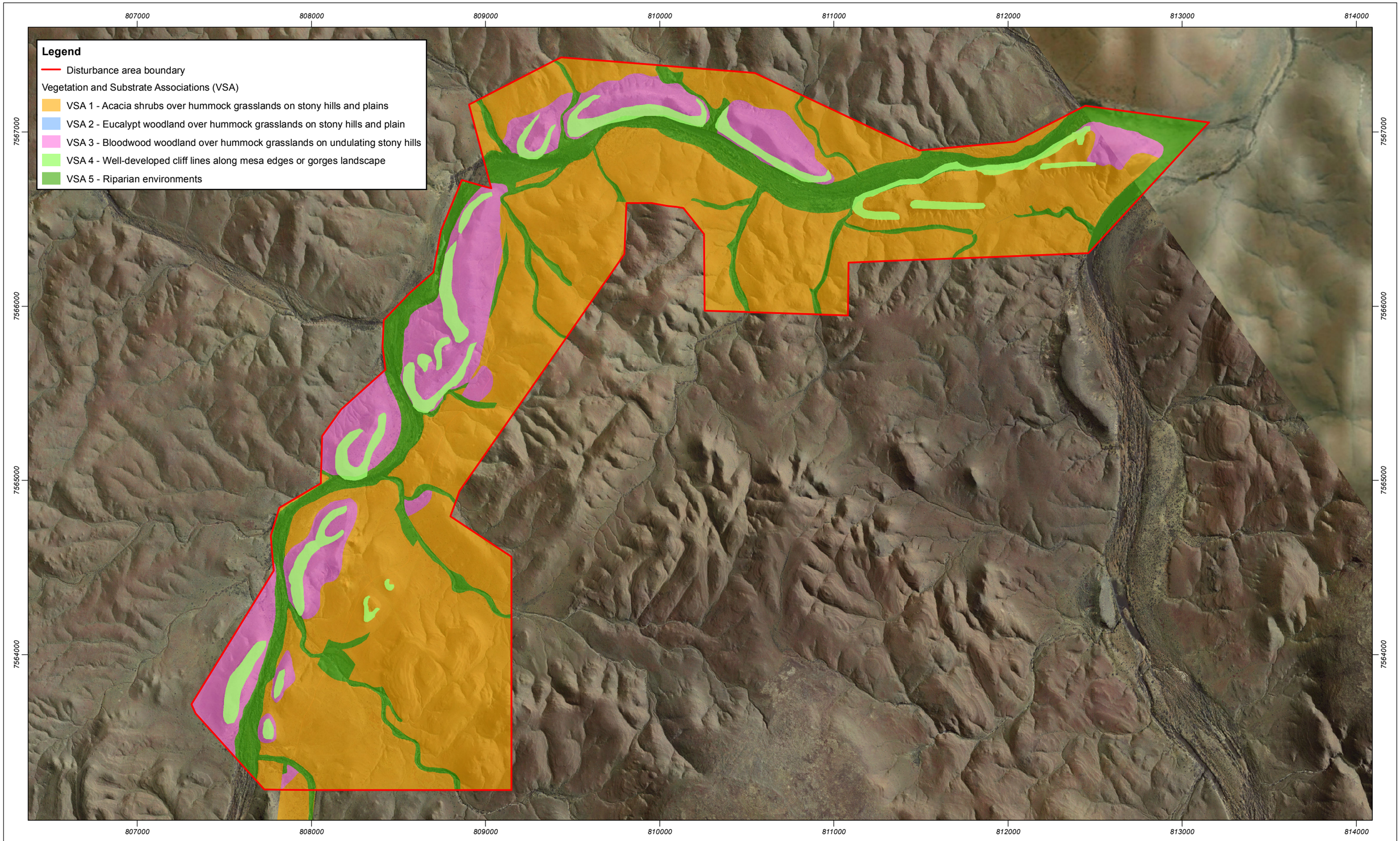

Figure 7 Map of the vegetation and substrate associations (VSAs) within the Warrigal survey area

Scale 1:20,000 at A3

0 150 300 450 600 750 Meters

N

Coordinate System: MGA50
Note that positional errors may occur in some areas
Date: 7/03/2013
Author: JCrute
Source: Client 2011-2012.

Path: Q:\GIS\Consult\2012\BCI\BCI12047\Projects\Fauna_Level1_report\BCI12047_01_Fauna_Level1report_F007_A3.mxd

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3.3.1 Summary of vegetation and substrate associations

The conservation importance of VSAs is a function of their usage by significant species, biodiversity and their regional representation. The riparian zones (VSA 5) and cliff lines (VSA 4) are important because they are limited in distribution, support significant fauna and provide connectivity through the landscape. These two VSAs are often associated and are particularly well-developed in the Warrigal North survey area. The bloodwood woodland on stony hills (VSA 3) is next in importance, primarily because of its contribution to biodiversity. This VSA is extensive in the Bonnie East survey area. The remaining two VSAs (acacia shrubland over spinifex on stony hills, VSA 1, and eucalypt woodland on stony hills, VSA 2) are widespread within and outside the survey areas and not of high importance for fauna.

3.4 Patterns of biodiversity and other field observations

Some important patterns of biodiversity are described above (Sections 3.2 and 3.3) and can be summarised as follows:

- Significant species. As noted in Section 3.2, the Warrigal North survey area provides (or may provide) important habitat for all the species of conservation significance above species, whereas the Bonnie East and Coongan survey areas may provide important habitat only for some of these species. The preferred habitats (VSAs) of the conservation significant species listed in section 0 are presented in Table 7.
- Concentrations of biodiversity. Greatest biodiversity is likely to be present in mesic areas (ie. VSA 5) and where there is a juxtaposition of several VSAs. The best-developed examples of VSA 5 are in the Warrigal North survey area. Also in the Warrigal North survey area there is a complex of VSAs, with VSA 4 and VSA 5 in close proximity (e.g. see Photos 7, 8, 10 and cover photo), and other VSAs nearby. The Bonnie East survey area also has a complex of VSAs, including bloodwood woodland (VSA 3), but less well-developed examples of riparian environments (VSA 5). Coongan is the least rich of the three survey areas in terms of VSAs, and has also suffered some degradation along Hillside Road and around Coongan Bore.

Sampling carried out in 2008 (Everard and Bamford 2009) included some sites very close to the three extension survey areas, but the main value of this sampling lies with the confirmation of the presence of a number of species (see Appendix 5). Field investigations in 2012 confirmed the presence of a number of species, but all were expected and most had been previously recorded. Of note, however, was a small breeding colony of the Australian Darter and Little Pied Cormorant in trees overhanging Bonnie Pool (Warrigal North survey area).

Table 7. The vegetation and substrate associations (VSAs) likely to be used by the main species of conservation significance expected to occur within the survey areas.

See section 3.2 for more detail on species of conservation significance.
See section 3.3 for more detail on VSAs.

	VSA 1. Acacia shrubs over hummock grasslands on stony hills and plains.	**VSA 2.** Eucalypt woodland over hummock grasslands on stony hills and plain.	**VSA 3.** Bloodwood woodland over hummock grasslands on undulating stony hills.	**VSA 4.** Well-developed cliff lines along mesa edges or gorges landscape.	**VSA 5.** Riparian environments
Pilbara Olive Python				X	X
Pilbara Monitor				X	
Grey Falcon					X
Bush Stone-curlew					X
Star Finch					X
Northern Quoll				X	X
Pilbara Leaf-nosed Bat				X	X
Ghost Bat				X	X
Western Pebble-mound Mouse	X	X	X		
Rothschild's Rock-Wallaby				X	

3.5 Key ecological processes in the survey areas

The nature of the landscape and the fauna assemblage indicate some of the ecological processes that may be important in maintaining the fauna of the Nullagine Project Extension survey areas. These include:

3.5.1 Landscape permeability

Linear landforms such as drainage lines and associated vegetation (i.e. the riparian VSA), and chains of mesas (in part, the cliff line VSA) are likely to play an important role in the passage of fauna through the landscape. These linear features are geologically very distinct and also reasonably limited in their representation in the broader region. As a result, they are a conspicuous feature in a landscape dominated by more widely represented and less geologically distinct VSAs (such as those comprising hummock grasslands on gently undulating stony hills and plains). It is highly likely that fauna also recognise this distinction and are attracted to the linear features; Bennett (2003) noted that fauna often use drainage lines as 'highways' through the landscape. It should be noted that not all fauna will pass through the landscape in this way.

In addition, the linear landforms also happen to provide highly desirable resources (for fauna) not observed elsewhere within the survey areas: ephemeral and permanent water sources, caves and deep rock crevices/spaces.

The combination of linkage and important resources may make these areas particularly important for the distribution of irruptive species, for example Northern Quoll. In times of regional population increase, the riparian and cliff VSAs may enable migration from core refugia and passage to new areas. Interrupting the ecological linkage provided by the linear landforms may thus compromise the movement of some species through the broader landscape.

The Warrigal North survey area is dominated by linear features (Bonnie Creek and associated VSA 5) and the line of mesas that run roughly alongside the creek. Bonny East and Coongan survey areas also have these features, but they are less well-developed but also more dispersed. For example, in the Bonnie East survey area the watercourses are complex and many-branched, rather than consisting of a single major watercourse with few tributaries as through the Warrigal North survey area.

3.5.2 Local hydrology

Seasonal watercourses are present in all three survey areas, but only the Warrigal North area has permanent pools. In the southern portion of Warrigal North and towards the south-east of Bonnie East, there are plains of loam soils where drainage may occur as surface flows as well as in defined watercourses. Such areas of surface flow can be of interest with respect to impacts.

3.5.3 Fire

Fire is recognised as a factor in the dynamics of fauna populations in Western Australia; it is also one of the factors that has contributed to the decline and local extinction of some mammal and bird species (Burbidge and McKenzie 1998). Some of the conservation significant species expected in the

vicinity of the survey areas show a preference for burnt or recently burnt areas (e.g. Bilby) while others have a strong preference for long-unburnt sites (e.g. Spectacled Hare-Wallaby, Rufous-crowned Emu-wren, Striated Grasswren). In terms of conservation management, it is not fire *per se* but the fire regime that is important, with evidence that infrequent, extensive and intense fires adversely affect biodiversity, whereas frequent fires that cover small areas and are variable in both season and intensity can enhance biodiversity. A fine-scale mosaic of burnt and unburnt sites appears to be beneficial to fauna.

There was evidence of fire affecting native vegetation in the region at the time of the survey; an area north of the Coongan survey area had been burnt recently. This fire appeared to have created a desirable mosaic of burnt and unburnt patches. In addition, a much larger fire had burnt through much of the local area at some point after the 2008 field investigations (Everard and Bamford 2009), with an apparent decline in overall biodiversity immediately subsequent. It was suggested that this fire contributed to the local decline of the Northern Quoll (Harris and Bamford 2011).

3.5.4 Fauna interactions and weeds

Introduced fauna species are present in the area, including the Feral Cat and Red Fox, and these have almost certainly contributed to the decline and local extinction of some mammal species in particular. In addition, however, Bonney Downs is a working cattle station and, therefore, livestock are present, and these affect vegetation through grazing and trampling. Impacts appear to be greatest along watercourses. Impacts of weeds are also greatest along watercourses, where the introduced Buffel Grass is well-established and appears to have replaced many native grasses in some areas.

3.6 Summary of fauna values

Fauna values in the three survey areas are summarised below. The Warrigal North survey area stands out as being rich in fauna, important for significant species, having the best representation of important VSAs and being important with respect to some ecological processes.

3.6.1 Fauna assemblage

The fauna assemblage is broadly typical of the eastern Pilbara, moderately rich, combines species associated with a range of different environments and includes species close to the eastern edge of their range in the Pilbara. The assemblage is expected to be the same in each survey area, although there will be differences in the abundance of some species, which may be important for those of conservation significance.

3.6.2 Species of conservation significance

The survey areas may support up to 41 species of conservation significance, and 10 of these are considered of particular interest because they are present (or strongly suspected of being present) and the survey areas are likely to be important for them. With one exception, the Western Pebble-mound Mouse that occurs on rocky lower slopes, these 10 significant species are associated with rocky slopes (VSA 4) and/or environments associated with watercourses (VSA 5). While these VSAs are present in all three survey areas, they are best-developed in the Warrigal North survey area.

3.6.3 Vegetation and substrate associations

Five VSAs are recognised (see Figure 5):

- VSA 1. Acacia shrubs over hummock grasslands on stony hills and plains.
- VSA 2. Eucalypt woodland over hummock grasslands on stony hills and plain.
- VSA 3. Bloodwood woodland over hummock grasslands on undulating stony hills.
- VSA 4. Well-developed cliff lines along mesa edges or gorges landscape.
- VSA 5. Riparian environments.

The most restricted VSAs, and also those most important for significant fauna and general fauna biodiversity, are the cliff lines/rocky margins to mesas and gorges (VSA 4) and the riparian environments (VSA 5). Both these are best represented in the Warrigal North survey area. These are also the most limited VSAs in area. The bloodwood woodland (VSA 3) is also at least locally restricted and best-represented in the Bonnie East survey area.

3.6.4 Patterns of biodiversity

Key patterns of biodiversity are that both significant species and general biodiversity are concentrated in mesic areas (VSA 5), rocky areas (VSA 4) and where these two VSAs are juxtaposed. As a result, the Warrigal North survey area is of particular significance with respect to patterns of biodiversity. The Bloodwood woodland (VSA 3) is also of interest as it may be seasonally important for nectarivorous birds; it is best represented in the Bonnie East survey area.

3.6.5 Key ecological processes

Main ecological processes currently affecting the fauna assemblage in the survey areas are landscape permeability (associated with the linear nature of key VSAs), local hydrology (primarily associated with watercourses and the presence of some permanent pools), fire and impacts related to feral predators, livestock and weed invasion.

3.6.6 Comparison of fauna values across the three survey areas

Fauna assemblage: similar across the three survey areas.
Species of conservation significance: most are associated with cliff lines and/or watercourses that are best developed in the Warrigal North survey area. Thus, while all significant species may occur in all survey areas, populations are likely to be greatest in the Warrigal North survey area.
Vegetation and Substrate Associations: the most restricted in area and important for conservation significance species are the cliff lines/rocky margins to mesas and gorges (VSA 4) and the riparian environments (VSA 5). Both these are best represented in the Warrigal North survey area.
Patterns of biodiversity: Concentrations of biodiversity are likely where there are cliff lines and riparian environments, and where these are juxtaposed. This occurs in all survey areas but both VSAs are best represented in the Warrigal North survey area.
Key ecological processes. Ecological processes are the same across the survey areas, but the layout of mesas in the Warrigal North survey area is such that fauna movements may be restricted to linear features.

4 Impact assessment

Many of the potential impacts of the proposed Nullagine Project Extension have already been imposed, and are being managed, as a result of existing mining operations. The extension may, in some instances, increase some of these impacts but in many cases there is likely to be no appreciable net change in risk. The following impact assessment reflects this potential for cumulative impacts and also assumes reasonable mitigation measures (such as dust suppression, speed limits, appropriate land rehabilitation, monitoring of the water table) are taking place as standard. It is also imperative to note that the impact assessment presented here focuses on the potential change in impacts as a result of the proposed extension, relative to the existing status quo, and not the overall impact of all mining activity in the region.

Impacting processes are discussed below and summarised in Table 8. Reference should be made to the broad principles outlined for each of the following categories in Appendix 2, and the assessment criteria for impacts to fauna listed in Table 4.

4.1 Loss of habitat leading to population decline

Some loss of habitat is inevitable but can be minimised through controls during land clearing and land restoration initiatives Of greatest concern is the loss of VSAs that have limited representation in the region and that support significant species, or a disproportionately high faunal diversity (e.g. riparian zones and associated environments (VSA 5) and cliff lines (VSA 4). Loss of habitat will lead to at least local declines in the populations of these species. As there are other areas of similar VSAs in the region (outside of the survey areas) that are not targeted for mining, regional populations of these species should persist, but will be reduced in size.

The proposed extension will result in the additional loss of some locally important habitat and this is likely to represent a Minor or Moderate impact to fauna. Habitat loss in the Warrigal North survey area is likely to be of greatest concern as this area supports the best-developed examples of rocky cliff lines (VSA 4) and includes areas targeted for mining.

4.2 Loss of habitat leading to population fragmentation

With respect to fragmentation of habitat, the areas of greatest concern are potentially important linear landscape features (e.g. cliff lines, riparian areas). These VSAs are likely to support greater fauna diversity, may potentially support more conservation significant species and almost certainly act as a major conduit for the movement of fauna through the region. Fragmentation of these features may result in medium- to long-term impacts to landscape permeability for some species. Mining necessarily targets mesas and, particularly in the Warrigal North survey area, these are linear in formation. However, since mining activities will be limited to the extent of economically available ore, it is anticipated that functional rocky cliff lines will remain post-mining. This has been demonstrated at Outcamp 1, where mining has been completed and the rocky mesa edge has been substantially retained. It is assumed that the adjacent riparian VSA will be largely unaffected by mining.

Fragmentation of important habitat by roads and access tracks (e.g. the separation of mesa or gully systems from one another or the fragmentation of one mesa or gully system) may be of concern for some species. For example, roads and pipelines may also present a barrier for the movement of small species.

The result of fragmentation will greatly depend on the geographic extent to which it occurs, the degree of rehabilitation/mitigation and the time which these processes take, but it is likely to represent a Moderate impact to fauna and to be of most concern in the Warrigal North survey area.

4.3 Degradation of habitat due to weed invasion

Weed invasion of habitat within and around the survey areas was considerable as a result of cattle grazing. Buffel Grass (*Cenchrus ciliaris*) was extensive in riparian zones. Given adequate hygiene practices, it is unlikely that clearing of vegetation and the increase in traffic will introduce weed species that are not already at the site. There is some minor increased risk of weed invasion (into non-infested areas) due to increased traffic volumes, but if habitat disturbance is restricted to mining pods then weed invasion into non-mined habitats is likely to be negligible.

The extent of this impact depends largely upon management but is mostly likely to be Negligible or Minor if management is adequate.

4.4 Ongoing mortality

Direct mortality of common species during clearing is unavoidable but can be minimised with good practice and procedures. Direct mortality of rare species, and ongoing mortality due to roadkill may have a significant impact. If roads are upgraded or added as part of the extension, and with a consequent increase in vehicular traffic, there will be an increased risk of roadkill of conservation significant species that are susceptible to road mortality; particularly the Pilbara Olive Python. Direct and ongoing mortality (in particular from road collisions) may be a concern for the viability of species, such as the python, that occur at low population densities in the area.

Ongoing mortality due to road kill will be very site specific and is most likely to occur where roads pass between mesas or cross watercourses. Such situations are likely to arise in all three survey areas. If managed well, the risk of increased mortality will occur only for the life of the mine, so can be considered temporary and therefore only a Minor impact.

4.5 Species interactions

Introduced species, including the feral Cat, Red Fox, House Mouse and domestic Cattle, may have adverse impacts upon native species through predation, competition or habitat degradation. Feral predators can increase in abundance around minesites in remote areas due either to the inadvertent increase in food supply from scraps and increases in the abundance of rodents, or the deliberate feeding by personnel. This can be controlled, to some extent, by good management. Given existing operations and activity in the region (e.g. the Materials Operations Centre and accommodation camp), the proposed extension is unlikely to appreciably change the abundance of feral fauna.

While it was evident that many native birds of prey are attracted to existing mine operations (to hunt or scavenge for displaced fauna), it is unlikely that there will be an overabundance of native species as a result of the development of the extension areas.

Therefore, it is considered that the impact to fauna due to changes in feral or overabundant native species will be Negligible.

4.6 Hydrological change

The Warrigal North and Bonnie East survey areas encompass watercourses that are part of the Bonnie Creek system, and the Coongan survey area has drainage lines that feed into the Coongan River. These are highly significant for fauna but direct impacts from mining should be limited as ore bodies are located high in the landscape. There is likely to be a limited increase in groundwater use which would be of greater concern due to the sensitivity especially of permanent water bodies in the Warrigal North survey area. Impacts could occur from road construction/placement, diversions of flow and turbid runoff, but it should be possible to manage these effects. Sheet flow may be a factor in some parts of the Warrigal North and Bonnie East survey areas, but these are outside mining areas; however road design in these areas will need to accommodate existing flow patterns. Across all three survey areas, hydrological impacts are anticipated to be Minor with appropriate design, although water levels in permanent pools in the Warrigal North survey area may need to be monitored.

4.7 Altered fire regimes

Fire is a natural feature of the environment in the survey areas, but frequent, extensive fires may adversely impact some fauna, particularly mammals. Given the existing operations and associated management procedures, there should be little risk of a change in the fire regime (or risk of fire) as a result of the proposed extension.

Impacts of altered fire regimes are therefore anticipated to be Negligible.

4.8 Disturbance

There is likely to be some additional localised disturbance during the development and operation of the extension areas. Impacts of light and noise upon fauna are difficult to predict. As such, it is best to take a precautionary approach. Given the environment, dust may be of concern; flora surrounding mining developments and infrastructure (especially roads) in the arid zone can be coated with dust and this may adversely affect their survival. Impacts may flow-on to associated fauna, but this is also poorly understood and difficult to predict. Dust, noise and lighting management procedures are currently in place for the existing Nullagine Iron Ore Project and haul roads are sealed with bitumen to help further reduce dust emissions.

Disturbance from people may be an issue around permanent pools in the Warrigal North survey area where there is a small breeding colony of the Australian Darter and Little Pied Cormorant. Such colonies can be sensitive to disturbance and permanent water bodies in general provide a drought refuge for waterbirds.

The additional impacts of disturbance in the proposed extension areas are likely to have a Negligible or Minor effect on fauna. Disturbance near permanent water in the Warrigal North survey area may adversely affect fauna but will be temporary.

4.9 Summary of impacts

Most impacting processes are expected to have only negligible or minor impacts, although in some cases this assumes management will take place (Table 8). The impact of fragmentation/loss of landscape permeability is anticipated to be Moderate because the linear riparian and cliff line VSAs may be disconnected, with this being a particular concern in the Warrigal North survey area. Note that the loss of habitat leading to population fragmentation assumes that this ecological function will be greatly reduced following the commencement of mining, due to the targeting of mesas and associated cliff lines. However, targeted mining is expected to leave functional cliff lines in place post-mining; mining at Outcamp 1 has demonstrated that cliff-lines along the edge of mesas will be retained to a large degree.

With respect to fauna values, a number have impacts of concern (Table 9). These relate almost entirely to the disruption of the cliff line and riparian VSAs due to the loss of habitat or impacts to movement of species restricted or largely restricted to these VSAs (e.g. Northern Quoll, Pilbara Leaf-nosed Bat, Ghost Bat, Pilbara Olive Python, fish, some frogs and waterbirds). The greatest concern is in the Warrigal North survey area.

Across the three survey areas impacts are broadly similar; thus all proposed developments will results in some habitat loss and fragmentation, for example, and potentially could result in hydrological change if watercourses are altered. However, the significance of impacts is expected to vary as follows:

Bonnie East survey area: impacts are expected to be more significant here than for the Coongan survey area, being a large survey area with a complex pattern of VSAs, including moderate areas of important VSAs (cliff lines and riparian environments) and the best developed examples of eucalypt and bloodwood woodlands. The Bonnie East survey area encompasses a number of tributaries of the Bonnie Creek drainage system with the advantage that VSA values are not concentrated in narrow zones as is the case in the Warrigal North survey area.

Warrigal North survey area: impacts here are expected to be the most significant of the three survey areas. The Warrigal North survey area includes large areas of important VSAs, they are well-developed examples of these VSAs (e.g. very tall cliff lines, permanent/semi-permanent pools along watercourses) and they are strongly linear, making fauna populations particularly vulnerable to fragmentation.

Coongan survey area. Impacts expected to be less significant than for either the Bonnie East or Warrigal North survey areas, as this is a smaller area with only small areas of important VSAs. Most of the Coongan survey area consists of widespread VSAs. It is also located in the upper reaches of the catchment where watercourses are minor.

Table 8. Summary assessment of impacting processes and the possible effects of the proposed development upon fauna values.

Impacting process	Impact
Habitat loss leading to population decline.	**Minor or Moderate**. Local loss of restricted VSAs (e.g. riparian zones, cliff lines) can be expected to lead to localised population declines, but there are nearby areas of similar VSAs.
Population fragmentation and disruption of movement and gene flow due to habitat fragmentation.	**Moderate.** Some fragmentation of potentially important linear landscape features (e.g. cliff lines, riparian areas) may occur, and this may result in medium- to long-term impacts to landscape permeability for some species. However, targeted mining of the mesas should result in the retention of mesa cliff-lines so as to minimise this form of disturbance.
Habitat degradation due to weed invasion.	**Negligible**. Some minor increased risk of weed invasion due to increased traffic volumes, but if habitat disturbance is restricted to mining pods then weed invasion into non-mined habitats likely to be negligible. Cattle are a vector for weed transmission and already have access throughout the survey areas.
Increased mortality leading to population decline (e.g. due to ongoing roadkill).	**Minor**. If roads are upgraded or added, and with a consequent increase in vehicular traffic, there will be an increased risk of roadkill of significant species that occur in very low numbers in the area (and are more susceptible to road mortality), particularly Pilbara Olive Python.
Species interactions due to feral or over-abundant native species.	**Negligible**. Given existing operations and activity in the region, the proposed extension is unlikely to appreciably change the abundance of feral fauna.
Hydrological change.	**Minor**. Mining activities are unlikely to directly affect either watercourses or areas of sheet flow, but management and design will be required such as ensuring that roads do not impede water movement.
Changes in fire regime.	**Negligible**. Given the existing operations and associated management procedures, there should be little risk of a change in the fire regime (or risk of fire) as a result of the proposed extension.
Effects of disturbance, dust and light.	**Negligible or Minor**. Some disturbance may result from the effects of dust, light and vibration, but are mostly unknown. Disturbance of waterbirds at waterholes may need to be managed.

Table 9. Summary of possible impacts upon key fauna values.

Fauna Value	Impacts from proposal	Significance of impacts
Fauna assemblage	Loss of habitat (cliff line VSA; VSA 4); this VSA is locally important for biodiversity.	**Minor**. Fauna assemblage is well-represented regionally
VSAs	Mining is targeting mesas and, as a result, is likely to impact on portions of the cliff line VSA (VSA 4). There is also potential for impacts to the riparian VSA (VSA 5). Both these VSAs are restricted in area; other VSAs are widespread.	**Moderate**. High proportional (but localised) alteration/loss of the cliff-line VSA (VSA 4) of greatest concern. This VSA is of high value to fauna and is also important for landscape permeability (see below).
Pilbara Olive Python, Grey Falcon, Bush Stone-curlew, Star Finch	Species dependent upon riparian VSA (VSA 5) which may be impacted.	**Minor**. Impacts should be manageable.
Northern Quoll, Rothschild's Rock-wallaby, Pilbara Monitor	Species dependent upon cliff line VSA (VSA 4) which will be impacted.	**Moderate**. High proportional (but localized) alteration/loss of the cliff line VSA (VSA 4) may impact on local populations of these species.
Cave-roosting conservation significant bats (Pilbara Leaf-nosed Bat, Ghost Bat)	Presence of roosting caves and, especially, maternity roosts considered to be unlikely based on targeted searching carried out in October 2012, but at least the Pilbara Leaf-nosed Bat is present regularly.	**Minor**. Pilbara Leaf-nosed Bat is present regularly (at least in the Warrigal North survey area) but low likelihood of a significant roost (e.g. maternity roost). Species may suffer loss of some foraging habitat.
Western Pebble-mound Mouse	Some loss of habitat on lower slopes of hills	**Minor**. While some loss of habitat will occur, much of the species' habitat is outside potential impact areas, and habitat is extensive in the immediate region

Fauna Value	Impacts from proposal	Significance of impacts
Landscape permeability	Some fragmentation of potentially important linear landscape features (e.g. cliff line and possibly riparian VSAs) may occur, and this may result in medium- to long-term impacts to landscape permeability for some species.	**Moderate**. Movement of fauna, including significant species, may be restricted where mining targets linear landscape features such as the mesas in the Warrigal North survey areas. However, the post-mining mesa profile is likely to retain features similar to the current environment; continuing to provide a linear access corridor for local species. Potential mine areas in the Bonnie East and Coongan survey areas are not as linear as in the Warrigal North survey area.
Other ecological processes (e.g. fire regimes, feral fauna, hydrology)	Interaction of the project with other ecological processes are expected to be slight, with the possible exception of hydrology.	**Negligible or Minor.** Management and monitoring required in some cases, most notably with hydrology and permanent pools in the Warrigal North survey area

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6 Appendices

Appendix 1. Explanation of fauna values.

Fauna values are the features of a site and its fauna that contribute to biodiversity, and it is these values that are potentially at threat from a development proposal. Fauna values can be examined under the five headings outlined below. It must be stressed that these values are interdependent and should not be considered equal, but contribute to an understanding of the biodiversity of a site. Understanding fauna values provides opportunities to predict and therefore mitigate impacts.

Assemblage characteristics

Uniqueness. This refers to the combination of species present at a site. For example, a site may support an unusual assemblage that has elements from adjacent biogeographic zones, it may have species present or absent that might be otherwise expected, or it may have an assemblage that is typical of a very large region. For the purposes of impact assessment, an unusual assemblage has greater value for biodiversity than a typical assemblage.

Completeness. An assemblage may be complete (i.e. has all the species that would have been present at the time of European settlement), or it may have lost species due to a variety of factors. Note that a complete assemblage, such as on an island, may have fewer species than an incomplete assemblage (such as in a species-rich but degraded site on the mainland).

Richness. This is a measure of the number of species at a site. At a simple level, a species rich site is more valuable than a species poor site, but value is also determined, for example, by the sorts of species present.

Vegetation/substrate associations (VSAs)

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

Because VSAs provide the habitat for fauna, they are important in determining assemblage characteristics. For the purposes of impact assessment, VSAs can also provide a surrogate for detailed information on the fauna assemblage. For example, rare, relictual or restricted VSAs should automatically be considered a significant fauna value. Impacts may be significant if the VSA is rare, a large proportion of the VSA is affected and/or the VSA supports significant fauna. The disturbance of even small amounts of habitat in a localised area can have significant impacts to fauna if rare or unusual habitats are disturbed.

Patterns of biodiversity across the landscape

This fauna value relates to how the assemblage is organised across the landscape. Generally, the fauna assemblage is not distributed evenly across the landscape or even within one VSA. There may be zones of high biodiversity such as particular environments or ecotones (transitions between VSAs). There may also be zones of low biodiversity. Impacts may be significant if a wide range of species is affected even if most of those species are not significant per se.

Species of conservation significance

Species of conservation significance are of special importance in impact assessment. The conservation status of fauna species in Australia is assessed under Commonwealth and State Acts such as the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) and the Western Australian *Wildlife Conservation Act 1950* (Wildlife Conservation Act). In addition, the Western Australian Department of Environment and Conservation (DEC) recognises priority levels, while local populations of some species may be significant even if the species as a whole has no formal recognition. Therefore, three broad levels of conservation significance can be recognised and are used for the purposes of this report, and are outlined below. A full description of the conservation significance categories, schedules and priority levels mentioned below is provided in Appendix 3.

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

Species listed under the EPBC Act are assigned to categories recommended by the International Union for the Conservation of Nature and Natural Resources (IUCN) and reviewed by Mace and Stuart (1994), or are listed as migratory. Migratory species are recognised under international treaties such as the China Australia Migratory Bird Agreement (CAMBA), the Japan Australia Migratory Bird Agreement (JAMBA), the Republic of South Korea Australia Migratory Bird Agreement (ROKAMBA), and/or the Convention on the Conservation of Migratory Species of Wild Animals (CMS; also referred to as the Bonn Convention). The Wildlife Conservation Act uses a series of Schedules to classify status, but also recognizes the IUCN categories and ranks species within the Schedules using the categories of Mace and Stuart (1994).

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

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

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

This level of significance has no legislative or published recognition and is based on interpretation of distribution information, but is used here as it may have links to preserving biodiversity at the genetic level (EPA 2002). If a population is isolated but a subset of a widespread (common) species, then it may not be recognised as threatened, but may have unique genetic characteristics. Conservation significance is applied to allow for the preservation of genetic richness at a population

level, and not just at a species level. Species on the edge of their range, or that are sensitive to impacts such as habitat fragmentation, may also be classed as CS3, as may colonies of waterbirds. The Western Australian Department of Environmental Protection, now DEC, used this sort of interpretation to identify significant bird species in the Perth metropolitan area as part of the Perth Bushplan (DEP 2000).

Invertebrate species considered to be short range endemics (SREs) also fall within the CS3 category, as they have no legislative or published recognition and their significance is based on interpretation of distribution information. 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), Phreatoicidea (phreatoicidean crustaceans), and Decapoda (freshwater crayfish). The poor understanding of the taxonomy of many of the short-range endemic species hinders their conservation (Harvey 2002).

Introduced species

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

Ecological processes upon which the fauna depend

These are the processes that affect and maintain fauna populations in an area and as such are very complex; for example, populations are maintained through the dynamic of mortality, survival and recruitment being more or less in balance, and these are affected by a myriad of factors. The dynamics of fauna populations in a project may be affected by processes such as fire regime, landscape patterns (such as fragmentation and/or linkage), the presence of feral species and hydrology. Impacts may be significant if processes are altered such that fauna populations are adversely affected, resulting in declines and even localised loss of species. Threatening processes as outlined below are effectively the ecological processes that can be altered to result in impacts upon fauna.

Appendix 2. Explanation of threatening processes.

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

Loss of habitat affecting population survival

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

Loss of habitat leading to population fragmentation

Loss of habitat can affect population movements by limiting movement of individuals throughout the landscape as a result of fragmentation. Obstructions associated with the development, such as roads, pipes and drainage channels, may also affect movement of small, terrestrial species. Fragmented populations may not be sustainable and may be sensitive to effects such as reduced gene flow.

Degradation of habitat due to weed invasion leading to population decline

Weed invasion can occur as a result of development and if this alters habitat quality, can lead to effects similar to habitat loss.

Increased mortality

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

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

Species interactions, including predation and competition

Changes in species interactions often occur with development. Introduced species, including the feral Cat, Red Fox and Rabbit may have adverse impacts upon native species and development can alter their abundance. In particular, some mammal species are very sensitive to introduced predators and the decline of many mammals in Australia has been linked to predation by the Red Fox, and to a lesser extent the feral Cat (Burbidge and McKenzie 1989). Introduced grazing species,

such as the Rabbit, Goat, Camel and domestic livestock, can also degrade habitats and deplete vegetation that may be a food source for other species.

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

Hydroecology

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

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

Fire

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

Dust, light, noise and vibration

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

The death of very large numbers of insects has been observed around some remote mine sites and attracts other fauna, notably native and introduced predators (M.Bamford pers. obs). The abundance of some insects can decline due to mortality around lights, although this has previously been recorded in fragmented landscapes where populations are already under stress (Rich and Longcore 2006). Artificial night lighting may also lead to disorientation of migratory birds. Aquatic habitats and open habitats such as grasslands and dunes may be vulnerable to light spill.

Appendix 3. Categories used in the assessment of conservation status.

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

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

Schedules used in the WA *Wildlife Conservation Act 1950*

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 *Wildlife Conservation Act 1950*, 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 4. Ecological and threatening processes identified under legislation and in the literature.

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

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

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

Threatening processes (EPBC Act)

Under the EPBC Act, a key threatening process is an ecological interaction that threatens or may threaten the survival, abundance or evolutionary development of a threatened species or ecological community. There are currently 19 key threatening processes listed by the federal Department of Sustainability, Environment, Water, Population and Communities (DSEWPaC):

- Competition and land degradation by feral/unmanaged Goats (*Capra hircus*);
- Competition and land degradation by feral Rabbits (*Oryctolagus cuniculus*);
- Dieback caused by the root-rot fungus (*Phytophthora cinnamomi*);
- Incidental catch (bycatch) of Sea Turtles during coastal otter-trawling operations within Australian waters north of 28 degrees South;
- Incidental catch (or bycatch) of seabirds during oceanic longline fishing operations;
- Infection of amphibians with chytrid fungus resulting in chytridiomycosis;
- Injury and fatality to vertebrate marine life caused by ingestion of, or entanglement in, harmful marine debris;
- Invasion of northern Australia by Gamba Grass and other introduced grasses;
- Land clearance;
- Loss and degradation of native plant and animal habitat by invasion of escaped garden plants, including aquatic plants;
- Loss of biodiversity and ecosystem integrity following invasion by the Yellow Crazy Ant (*Anoplolepis gracilipes*) on Christmas Island, Indian Ocean;
- Loss of climatic habitat caused by anthropogenic emissions of greenhouse gases;
- Predation by exotic rats on Australian offshore islands of less than 1000 km2 (100 000 ha);
- Predation by feral Cats (*Felis catus*);
- Predation by the European Red Fox (*Vulpes vulpes*);

- Predation, Habitat Degradation, Competition and Disease Transmission by Feral Pigs (*Sus scrofa*);
- Psittacine Circoviral (beak and feather) Disease affecting endangered psittacine species;
- The biological effects, including lethal toxic ingestion, caused by Cane Toads (*Bufo marinus*); and
- The reduction in the biodiversity of Australian native fauna and flora due to the imported Red Fire Ant, *Solenopsis invicta*.

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

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

In addition to the above processes, DSEWPaC has produced Significant Impact Guidelines that provide criteria for the assessment of the significance of impacts. These criteria provide a framework for the assessment of significant impacts. The criteria are listed below.

- Will the proposed action lead to a long-term decrease in the size of a population?
- Will the proposed action reduce the area of occupancy of the species?
- Will the proposed action fragment an existing population?
- Will the proposed action adversely affect habitat critical to the survival of a species?
- Will the proposed action disrupt the breeding cycle of a population?
- Will the proposed action modify, destroy, remove, isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline?
- Will the proposed action result in introducing invasive species that are harmful to a critically endangered or endangered species becoming established in the endangered or critically endangered species' habitat?
- Will the proposed action introduce disease that may cause the species to decline?
- Will the proposed action will interfere with the recovery of the species?

Appendix 5. Species expected in the vicinity of the survey areas, and those recorded during previous field investigations.

Species marked with a superscript 'w' are generally dependent on wetlands, species marked with a superscript 'a' are highly aerial species.

Status codes:

- CS1, CS2, CS3 = (summary) levels of conservation significance. See Appendix 1 for full explanation.
- EPBC Act listings: E = Endangered, V = Vulnerable, M = Migratory (see Appendix 3).
- Wildlife Conservation Act listings: S1 = Schedule 1, S3 = Schedule 3, S4 =Schedule 4 (see Appendix 3) with rankings shown in square parentheses: [c] = critically endangered, [e] = endangered, [v] = vulnerable.
- DEC Priority species: P1 to P5 = Priority 1 to 5 (see Appendix 3).
- LS = considered to be of local significance by Bamford Consulting Ecologists, TU = taxonomic uncertainty (see Appendix 1).
- Int = introduced species.

See Section 2.2.1 for sources of information (for the generation of expected species lists).

Species recorded by Everard and Bamford (2009), Harris *et al*. (2010), Harris and Bamford (2011), and/or in subsequent field investigations (e.g. the 2012 Northern Quoll monitoring, the field reconnaissance survey for the extension areas) are indicated by '+'.

Species		Status	Recorded
Clupeidae (Herrings)			
Nematalosa erebi	Bony Bream [w]		+
Plotosidae (Eel-tailed catfish)			
Neosilurus hyrtlii	Hyrtl's Tandan [w]		
Atherinidae (Hardyheads)			
Craterocephalus cuneiceps	Murchison River Hardyhead [w]		
Melanotaeniidae (Rainbowfish)			
Melanotaenia australis	Western Rainbowfish [w]		+
Terapontidae (Grunters)			
Amniataba percoides	Barred Grunter [w]		
Leiopotherapon unicolor	Spangled Perch [w]		+
Mugilidae (mullets)			
Mugil cephalus	Sea Mullet		+
Hylidae (Tree frogs)			
Cyclorana maini	Main's Frog		+
Cyclorana platycephala	Water-holding Frog		
Litoria rubella	Desert Tree Frog [w]		+
Limnodynastidae (Burrowing frogs)			
Neobatrachus aquilonius	Northern Burrowing Frog		+
Notaden nichollsi	Desert Spadefoot		
Myobatrachidae (Ground frogs)			
Pseudophryne douglasi	Douglas' Toadlet		
Uperoleia glandulosa	Glandular Toadlet	CS3 (LS)	+
Uperoleia russelli	Russell's Toadlet		

Species		Status	Recorded
Cheluidae (Side-necked turtles)			
Chelodina steindachneri	Steindachner's Turtle [w]		+
Agamidae (Dragons)			
Amphibolurus gilberti	Gilbert's Dragon		
Amphibolurus longirostris	Long-nosed Dragon		+
Ctenophorus caudicinctus	Ring-tailed Dragon		+
Ctenophorus isolepis	Central Military Dragon		
Ctenophorus nuchalis	Central Netted Dragon		
Ctenophorus reticulatus	Western Netted Dragon		+
Diporiphora winneckei	Canegrass Dragon, Blue-lined Dragon		
Pogona minor	Western Bearded Dragon		+
Tympanocryptis cephalus	Pebble Dragon		
Diplodactylidae (Diplodactylid geckoes)			
Crenadactylus ocellatus	Clawless Gecko		
Diplodactylus conspicillatus	Fat-tailed Gecko		
Diplodactylus pulcher			
Diplodactylus savagei	Tree Dtella		+
Lucasium stenodactylum	Sand-plain Gecko		+
Lucasium wombeyi			+
Oedura marmorata	Marbled Velvet Gecko		
Rhynchoedura ornata	Beaked Gecko		
Strophurus elderi	Jewelled Gecko		+
Strophurus jeanae			
Strophurus strophurus	Western Spiny-tailed Gecko		
Strophurus wellingtonae			+
Carphodactylidae (Carphodactylid geckoes)			
Nephrurus laevissimus	Pale Knob-tailed Gecko		
Nephrurus wheeleri	Banded Knob-tailed Gecko		
Gekkonidae (Gekkonid geckoes)			
Gehyra pilbara	Pilbara Dtella		+
Gehyra punctata	Spotted Dtella		
Gehyra variegata	Variegated Dtella		+
Hemidactylus frenatus	Asian House Gecko	Int	
Heteronotia binoei	Bynoe's Gecko		+
Heteronotia spelea	Desert Cave Gecko		
Pygopodidae (Legless lizards)			
Delma borea			
Delma butleri			+
Delma elegans			
Delma haroldi			

Species		Status	Recorded
Delma nasuta			+
Delma pax			+
Delma tincta			
Lialis burtonis	Burton's Legless Lizard		+
Pygopus nigriceps	Western Hooded Scaly-foot		
Scincidae (Skinks)			
Carlia munda			+
Carlia triacantha			
Cryptoblepharus buchananii	Buchanan's Snake-eyed Skink		
Cryptoblepharus plagiocephalus	Fence Skink		
Cryptoblepharus ustulatus			
Ctenotus ariadnae			
Ctenotus duricola			
Ctenotus grandis			
Ctenotus hanloni			
Ctenotus helenae			
Ctenotus leonhardii			
Ctenotus nigrilineatus		CS2 (P1)	
Ctenotus pantherinus	Leopard Ctenotus		+
Ctenotus piankai			+
Ctenotus rubicundus			
Ctenotus rufescens			
Ctenotus saxatilis	Rock Ctenotus		+
Ctenotus schomburgkii			
Ctenotus serventyi			
Ctenotus uber johnstonei		CS2 (P1)	
Cyclodomorphus melanops			+
Egernia depressa	Pygmy Spiny-tailed Skink		
Egernia formosa			
Egernia pilbarensis			
Eremiascincus fasciolatus	Narrow-banded Sand-swimmer		
Eremiascincus richardsonii	Broad-banded Sand-swimmer		+
Lerista amicorum			
Lerista bipes			
Lerista macropisthopus remota		CS2 (P2)	
Lerista muelleri			+
Lerista rhodonoides			
Menetia greyii	Common Dwarf Skink		
Menetia surda			
Morethia ruficauda			+

Species		Status	Recorded
Notoscincus ornatus			
Proablepharus reginae			
Tiliqua multifasciata	Centralian Blue-tongue		+
Varanidae (Monitors and goannas)			
Varanus acanthurus	Spiny-tailed Monitor		+
Varanus brevicauda	Short-tailed Pygmy Monitor		
Varanus caudolineatus	Stripe-tailed Monitor		
Varanus eremius	Pygmy Desert Monitor		
Varanus giganteus	Perentie		+
Varanus gilleni	Pygmy Mulga Monitor		
Varanus gouldii	Sand Goanna		
Varanus panoptes	Yellow-spotted Monitor		+
Varanus pilbarensis	Pilbara Rock Monitor	CS3 (LS)	+
Varanus tristis	Black-headed Monitor		+
Typhlopidae (Blind snakes)			
Ramphotyphlops ammodytes			
Ramphotyphlops ganei		CS2 (P1)	
Ramphotyphlops grypus	Beaked Blind Snake		+
Ramphotyphlops pilbarensis	Pilbara Blind Snake		
Boidae (Pythons)			
Antaresia perthensis	Pygmy Python		
Antaresia stimsoni	Stimson's Python		
Aspidites melanocephalus	Black-headed Python		+
Aspidites ramsayi	Woma		
Liasis olivaceus barroni	Pilbara Olive Python	CS1 (V, S1[v])	+
Elapidae (Venomous land snakes)			
Acanthophis pyrrhus	Desert Death Adder		
Acanthophis wellsi	Pilbara Death Adder		+
Brachyurophis approximans	Northwestern Shovel-nosed Snake		
Demansia psammophis	Yellow-faced Whipsnake		+
Demansia rufescens	Rufous Whipsnake		
Furina ornata	Moon Snake		+
Parasuta monachus	Monk Snake		
Pseudechis australis	Mulga Snake		
Pseudonaja modesta	Ringed Brown Snake		
Pseudonaja mengdeni	Gwardar		+
Simoselaps anomalus	Desert Banded Snake		
Suta fasciata	Rosen's Snake		+
Suta punctata	Spotted Snake		
Vermicella snelli			

Species		Status	Recorded
Casuariidae (Cassowaries and emus)			
Dromaius novaehollandiae	Emu		+
Phasianidae (Pheasants and allies)			
Coturnix pectoralis	Stubble Quail		
Coturnix ypsilophora	Brown Quail		+
Anatidae (Ducks and allies)			
Dendrocygna eytoni	Plumed Whistling-Duck [w]		+
Cygnus atratus	Black Swan [w]		+
Tadorna tadornoides	Australian Shelduck [w]		
Malacorhynchus membranaceus	Pink-eared Duck [w]		
Podicipedidae (grebes)			
Tachybaptus novaehollandiae	Australasian Grebe		+
Anas gracilis	Grey Teal [w]		
Anas superciliosa	Pacific Black Duck [w]		+
Columbidae (Pigeons and doves)			
Phaps chalcoptera	Common Bronzewing		+
Ocyphaps lophotes	Crested Pigeon		+
Geophaps plumifera	Spinifex Pigeon		+
Geopelia cuneata	Diamond Dove		+
Geopelia striata	Peaceful Dove		+
Podargidae (Australian frogmouths)			
Podargus strigoides	Tawny Frogmouth		+
Eurostopodidae (Eared-nightjars)			
Eurostopodus argus	Spotted Nightjar		+
Aegothelidae (Owlet-nightjars)			
Aegotheles cristatus	Australian Owlet-nightjar		+
Apodidae (Typical swifts)			
Apus pacificus	Fork-tailed Swift [a]	CS1 (M, S3)	
Anhingidae (Darters)			
Anhinga novaehollandiae	Australasian Darter [w]		+
Phalacrocoracidae (Cormorants)			
Microcarbo melanoleucos	Little Pied Cormorant [w]		+
Phalacrocorax sulcirostris	Little Black Cormorant [w]		+
Pelicanidae (Pelican)			
Pelecanus conspicillatus	Australian Pelican [w]		+
Ardeidae (Herons, bitterns and egrets)			
Ardea pacifica	White-necked Heron [w]		+
Ardea modesta	Eastern Great Egret [w]	CS1 (M, S3)	+
Ardea ibis	Cattle Egret	CS1 (M, S3)	
Egretta novaehollandiae	White-faced Heron [w]		+

Species		Status	Recorded
Nycticorax caledonicus	Nankeen Night Heron [w]		+
Threskiornithidae (Ibises and spoonbills)			
Threskiornis spinicollis	Straw-necked Ibis		+
Platalea flavipes	Yellow-billed Spoonbill [w]		
Accipitridae (Osprey, hawks and eagles)			
Elanus axillaris	Black-shouldered Kite		+
Lophoictinia isura	Square-tailed Kite		
Hamirostra melanosternon	Black-breasted Buzzard		
Haliaeetus leucogaster	White-bellied Sea-Eagle [w]	CS1 (M, S3)	
Haliastur sphenurus	Whistling Kite		+
Milvus migrans	Black Kite		+
Accipiter fasciatus	Brown Goshawk		+
Accipiter cirrocephalus	Collared Sparrowhawk		
Circus assimilis	Spotted Harrier		+
Circus approximans	Swamp Harrier [w]		
Aquila audax	Wedge-tailed Eagle		+
Hieraaetus morphnoides	Little Eagle		+
Falconidae (Falcons)			
Falco cenchroides	Nankeen Kestrel		+
Falco berigora	Brown Falcon		+
Falco longipennis	Australian Hobby		+
Falco hypoleucos	Grey Falcon	CS2 (P4)	+
Falco subniger	Black Falcon		
Falco peregrinus	Peregrine Falcon	CS1 (S4)	
Rallidae (Rails, gallinules and coots)			
Tribonyx ventralis	Black-tailed Native-hen [w]		
Otididae (Bustards)			
Ardeotis australis	Australian Bustard	CS2 (P4)	+
Burhinidae (Stone-curlews)			
Burhinus grallarius	Bush Stone-curlew	CS2 (P4)	+
Recurvirostridae (Stilts and avocets)			
Himantopus himantopus	Black-winged Stilt [w]		
Recurvirostra novaehollandiae	Red-necked Avocet [w]		
Cladorhynchus leucocephalus	Banded Stilt [w]		
Charadriidae (Lapwings, plovers and dotterels)			
Charadrius ruficapillus	Red-capped Plover [w]		
Charadrius veredus	Oriental Plover [w]	CS1 (M, S3)	
Elseyornis melanops	Black-fronted Dotterel [w]		+
Erythrogonys cinctus	Red-kneed Dotterel [w]		

Species		Status	Recorded
Rostratulidae (Painted-snipe)			
Rostratula australis	Australian Painted Snipe [w]	CS1 (V, M, S3)	+
Scolopacidae (Curlews, godwits, snipe, sandpipers and allies)			
Calidris ruficollis	Red-necked Stint [w]	CS1 (M, S3)	
Turnicidae (Button-quails)			
Turnix velox	Little Button-quail		+
Glareolidae (Pratincoles)			
Stiltia isabella	Australian Pratincole		
Laridae (Gulls, terns and allies)			
Chlidonias leucopterus	White-winged Black Tern [w]	CS1 (M, S3)	+
Cacatuidae (Cockatoos)			
Eolophus roseicapillus	Galah		+
Cacatua sanguinea	Little Corella		+
Nymphicus hollandicus	Cockatiel		+
Psittacidae (Parrots)			
Polytelis alexandrae	Princess Parrot	CS2 (P4)	
Barnardius zonarius	Australian Ringneck		+
Melopsittacus undulatus	Budgerigar		+
Neopsephotus bourkii	Bourke's Parrot		
Neophema elegans	Elegant Parrot		
Pezoporus occidentalis	Night Parrot	CS1 (E, M, S1[c])	
Cuculidae (Old world cuckoos)			
Centropus phasianinus	Pheasant Coucal	CS3 (LS)	
Chalcites basalis	Horsfield's Bronze-Cuckoo		+
Chalcites osculans	Black-eared Cuckoo		+
Cacomantis pallidus	Pallid Cuckoo		+
Strigidae (Hawk owls)			
Ninox connivens	Barking Owl		
Ninox novaeseelandiae	Southern Boobook		+
Tytonidae (Barn owls)			
Tyto javanica	Eastern Barn Owl		
Halcyonidae (Tree kingfishers)			
Dacelo leachii	Blue-winged Kookaburra		+
Todiramphus pyrrhopygius	Red-backed Kingfisher		+
Todiramphus sanctus	Sacred Kingfisher		+
Meropidae (Bee-eaters)			
Merops ornatus	Rainbow Bee-eater	CS1 (M, S3)	+
Climacteridae (Australo-Papuan treecreepers)			
Climacteris melanura	Black-tailed Treecreeper	CS3 (LS)	

Species		Status	Recorded
Ptilonorhychidae (Bowerbirds)			
Ptilonorhynchus guttatus	Western Bowerbird		+
Maluridae (Fairy-wrens, emu-wrens and grasswrens)			
Malurus leucopterus	White-winged Fairy-wren		+
Malurus lamberti	Variegated Fairy-wren		+
Stipiturus ruficeps	Rufous-crowned Emu-wren	CS3 (LS)	
Amytornis striatus	Striated Grasswren	CS3 (LS)	+
Acanthizidae (Australasian warblers)			
Calamanthus campestris	Rufous Fieldwren		+
Pyrrholaemus brunneus	Redthroat		
Smicrornis brevirostris	Weebill		+
Gerygone fusca	Western Gerygone		
Acanthiza robustirostris	Slaty-backed Thornbill		
Acanthiza chrysorrhoa	Yellow-rumped Thornbill		+
Acanthiza uropygialis	Chestnut-rumped Thornbill		
Aphelocephala leucopsis	Southern Whiteface	CS3 (LS)	
Pardalotidae (Pardalotes)			
Pardalotus rubricatus	Red-browed Pardalote		+
Pardalotus striatus	Striated Pardalote		
Meliphagidae (Honeyeaters)			
Certhionyx variegatus	Pied Honeyeater		
Lichenostomus virescens	Singing Honeyeater		+
Lichenostomus keartlandi	Grey-headed Honeyeater		+
Lichenostomus plumulus	Grey-fronted Honeyeater		
Lichenostomus penicillatus	White-plumed Honeyeater		+
Manorina flavigula	Yellow-throated Miner		+
Acanthagenys rufogularis	Spiny-cheeked Honeyeater		+
Conopophila whitei	Grey Honeyeater	CS3 (LS)	
Epthianura tricolor	Crimson Chat		+
Epthianura aurifrons	Orange Chat		
Sugomel niger	Black Honeyeater		+
Lichmera indistincta	Brown Honeyeater		+
Melithreptus gularis	Black-chinned Honeyeater		+
Pomatostomidae (Babblers)			
Pomatostomus temporalis	Grey-crowned Babbler		+
Pomatostomus superciliosus	White-browed Babbler		
Eupetidae (Quail-thrush and allies)			
Cinclosoma marginatum	Western Quail-thrush	CS3 (LS)	
Psophodes occidentalis	Chiming Wedgebill		

Species		Status	Recorded
Neosittidae (Sitellas)			
Daphoenositta chrysoptera	Varied Sittella		
Campephagidae (Cuckoo-shrikes and trillers)			
Coracina maxima	Ground Cuckoo-shrike		
Coracina novaehollandiae	Black-faced Cuckoo-shrike		+
Lalage sueurii	White-winged Triller		+
Pachycephalidae (Whistlers, shrike-thrushes and allies)			
Pachycephala rufiventris	Rufous Whistler		+
Colluricincla harmonica	Grey Shrike-thrush		+
Oreoica gutturalis	Crested Bellbird		+
Artamidae (Woodswallows, butcherbirds and currawongs)			
Artamus personatus	Masked Woodswallow		+
Artamus cinereus	Black-faced Woodswallow		+
Artamus minor	Little Woodswallow		+
Cracticus torquatus	Grey Butcherbird		
Cracticus nigrogularis	Pied Butcherbird		+
Cracticus tibicen	Australian Magpie		+
Rhipiduridae (Fantails)			
Rhipidura albiscapa	Grey Fantail		
Rhipidura leucophrys	Willie Wagtail		+
Corvidae (Crows and allies)			
Corvus bennetti	Little Crow		
Corvus orru	Torresian Crow		+
Monarchidae (Flycatchers, monarchs and magpie-lark)			
Grallina cyanoleuca	Magpie-lark		+
Petroicidae (Robins)			
Petroica goodenovii	Red-capped Robin		
Melanodryas cucullata	Hooded Robin		
Alaudidae (Old world larks)			
Mirafra javanica	Horsfield's Bushlark		+
Acrocephalidae (Reed-warblers)			
Acrocephalus australis	Australian Reed-Warbler [w]		+
Megaluridae (Grassbirds)			
Megalurus gramineus	Little Grassbird [w]		
Cincloramphus mathewsi	Rufous Songlark		+
Cincloramphus cruralis	Brown Songlark		+
Eremiornis carteri	Spinifexbird		+
Hirundinidae (Swallows and martins)			
Cheramoeca leucosterna	White-backed Swallow		
Hirundo neoxena	Welcome Swallow		

Species		Status	Recorded
Petrochelidon nigricans	Tree Martin		+
Petrochelidon ariel	Fairy Martin		+
Nectariniidae (Sunbirds and allies)			
Dicaeum hirundinaceum	Mistletoebird		+
Estrildidae (Finches)			
Taeniopygia guttata	Zebra Finch		+
Neochmia ruficauda subclarescens	Star Finch	CS2 (P4)	+
Emblema pictum	Painted Finch		+
Motacillidae (Old world wagtails and pipits)			
Anthus novaeseelandiae	Australasian Pipit		+
Tachyglossidae (Echidnas)			
Tachyglossus aculeatus	Echidna		+
Dasyuridae (Dasyurids)			
Dasycercus blythi	Brush-tailed Mulgara	CS2 (P4)	
Dasycercus cristicauda	Crest-tailed Mulgara	CS1 (V, S1[v])	
Dasykaluta rosamondae	Little Red Kaluta		+
Dasyurus hallucatus	Northern Quoll	CS1 (E, S1[E])	+
Ningaui timealeyi	Pilbara Ningaui		
Planigale sp. (aff *maculata*)	Planigale		+
Pseudantechinus roryi	Rory's Pseudantechinus		+
Pseudantechinus woolleyae	Woolley's Pseudantechinus		
Sminthopsis longicaudata	Long-tailed Dunnart	CS2 (P4)	
Sminthopsis macroura	Stripe-faced Dunnart		+
Sminthopsis youngsoni	Lesser Hairy-footed Dunnart		
Thylacomyidae (Bilbies)			
Macrotis lagotis	Bilby, Dalgyte	CS1 (V, S1[v])	
Macropodidae (Kangaroos, wallabies and tree kangaroos)			
Lagorchestes conspicillatus leichardti	Spectacled Hare-Wallaby	CS2 (P3)	
Macropus robustus	Euro		+
Macropus rufus	Red Kangaroo		+
Petrogale rothschildi	Rothschild's Rock-Wallaby	CS3 (LS)	+
Pteropodidae (Fruit bats)			
Pteropus alecto	Black Flying-fox		
Pteropus scapulatus	Little Red Flying-fox		
Emballonuridae (Sheathtail bats)			
Saccolaimus flaviventris	Yellow-bellied Sheathtail-bat		+
Taphozous georgianus	Common Sheathtail-bat		+
Taphozous hilli	Hill's Sheathtail-bat		
Megadermatidae (Ghost Bat)			
Macroderma gigas	Ghost Bat	CS2 (P4)	

Species		Status	Recorded
Hipposideridae (Leaf-nosed bats)			
Rhinonicteris aurantia (Pilbara form)	Pilbara Leaf-nosed Bat	CS1 (V, S1[v])	+
Vespertilionidae (Vespertillionid bats)			
Chalinolobus gouldii	Gould's Wattled Bat		+
Chalinolobus morio	Chocolate Wattled Bat		
Nyctophilus bifax	Northwestern Long-eared Bat		
Nyctophilus geoffroyi	Lesser Long-eared Bat		
Scotorepens greyii	Inland Broad-nosed Bat		+
Vespadelus finlaysoni	Finlayson's Cave Bat		+
Molossidae (Freetail bats)			
Chaerephon jobensis	Northern Freetail-bat		+
Mormopterus beccarii	Beccari's Freetail-bat		+
Tadarida australis	White-striped Freetail-bat		+
Muridae (Rats and mice)			
Leggadina lakedownensis	Short-tailed Mouse	CS2 (P4)	
Mus musculus	House Mouse	Int	+
Notomys alexis	Spinifex Hopping-mouse		
Pseudomys chapmani	Western Pebble-mound Mouse	CS2 (P4)	+
Pseudomys delicatulus	Delicate Mouse		
Pseudomys desertor	Desert Mouse		+
Pseudomys hermannsburgensis	Sandy Inland Mouse		
Zyzomys argurus	Common Rock-rat		+
Leporidae (Rabbits and hares)			
Oryctolagus cuniculus	Rabbit	Int	
Canidae (Dogs and foxes)			
Canis lupus	Dog/Dingo	(Int)	+
Vulpes vulpes	Red Fox	Int	
Felidae (Cats)			
Felis catus	Cat	Int	+
Equidae (Horses)			
Equus asinus	Donkey	Int	
Equus caballus	Horse	Int	
Camelidae (Camels)			
Camelus dromedarius	Dromedary Camel	Int	
Bovidae (Horned ruminants)			
Bos taurus	European Cattle	Int	+
Capra hircus	Goat	Int	