Fauna Assessment for Additional Clearing in the Waitsia Project Area

Fenceline through proposed additional clearing area (photo credit: K. Kershaw)

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1 Introduction

Mitsui E&P Australia is developing the Waitsia gas project, east of Dongara, with the project consisting of several wells and interconnecting pipelines. The general project area was assessed for fauna values by Bamford *et al.* (2015), and two further studies were conducted around the Waitsia 03 well site to provide information on value for Carnaby's Black-Cockatoo (Bamford 2016) and to support a Native Vegetation Clearing Permit (NVCP) for an access track and pipeline route to this well (Metcalf and Bamford 2018). Most of these areas lie within agricultural land that has been cleared of native vegetation, but in planning for development of the project, an additional area of native vegetation that intersects with a pipeline route was identified. This area has not been assessed and has not been included in the existing NVCP, and therefore Bamford Consulting Ecologists was commissioned to provide an updated fauna overview for the whole project area, and to discuss the significance for fauna of this additional area of native vegetation.

1.1 Study Objectives

The objectives of the study are to:

1. Conduct a literature review and searches of Commonwealth and State fauna databases;
2. Review the list of fauna expected to occur on the site in the light of fauna habitats present, with a focus on investigating the likelihood of significant species being present e.g. Carnaby's Black-Cockatoo;
3. Identify significant or fragile fauna habitats within the study area;
4. Identify any ecological processes in the study area upon which fauna may depend;
5. Identify general patterns of biodiversity within or adjacent to the study area, and
6. Identify potential impacts upon fauna and propose recommendations to minimise impacts.

Descriptions and background information on these values and processes can be found in Appendices 1 to 4. In particular, Appendix 1 explains and defines the fauna values, including the recognition of three classes of species of conservation significance (CS): those listed under legislation (CS1), those listed as priority by the Department of Biodiversity, Conservation and Attractions (CS2), and those that can be considered of local or other significance, but which have no formal listing (CS3). Appendix 2 describes threatening processes, while Appendix 3 outlines the legal definitions and classes of conservation significance. Appendix 4 presents the threatening processes recognised under legislation. Based on this 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.

1.2 Description of Project Area

The survey area is located east of Dongara and south of The Midlands Highway; approximately 300 kilometres north of Perth (Figure 1). The Waitsia project has a total area of approximately 8400 ha, dominated by cleared agricultural land but with some tracts of native vegetation. There is a spring in the central part of the area (Ejarno Spring) and the Irwin River runs through the north-eastern part of the site.

Within this larger area, the pipeline development is located centrally (see Figure 2). The project's potential area of impact (footprint) is approximately 0.55ha (Figure 3). This impact area lies along a narrow belt of native vegetation that passes through cleared agricultural land just to the north-west of Ejarno Spring. Much of this belt of native vegetation is badly degraded due to grazing by Cattle (Figure 4 and cover photo).

Bamford *et al.* (2015) identified six Vegetation and Substrate Associations across the entire Waitsia project area:

- VSA 1. Agricultural land.
- VSA 2. Kwongan to open banksia woodland on sand.
- VSA 3. Riparian shrub-thicket and woodland on dark peaty-sand (including wetlands such as Ejarno Spring).
- VSA 4. Eucalypt/banksia/acacia low forest on sand.
- VSA 5. York Gum Woodland on red sandy loam.
- VSA 6. Irwin River Red Gum Woodland.

The pipeline project area supports VSA 2 which is patchily distributed in remnant vegetation in the area, but extensive in Yardanogo Nature Reserve to the south. The adjacent area around Ejarno Spring supports VSAs 2, 3 and 4.

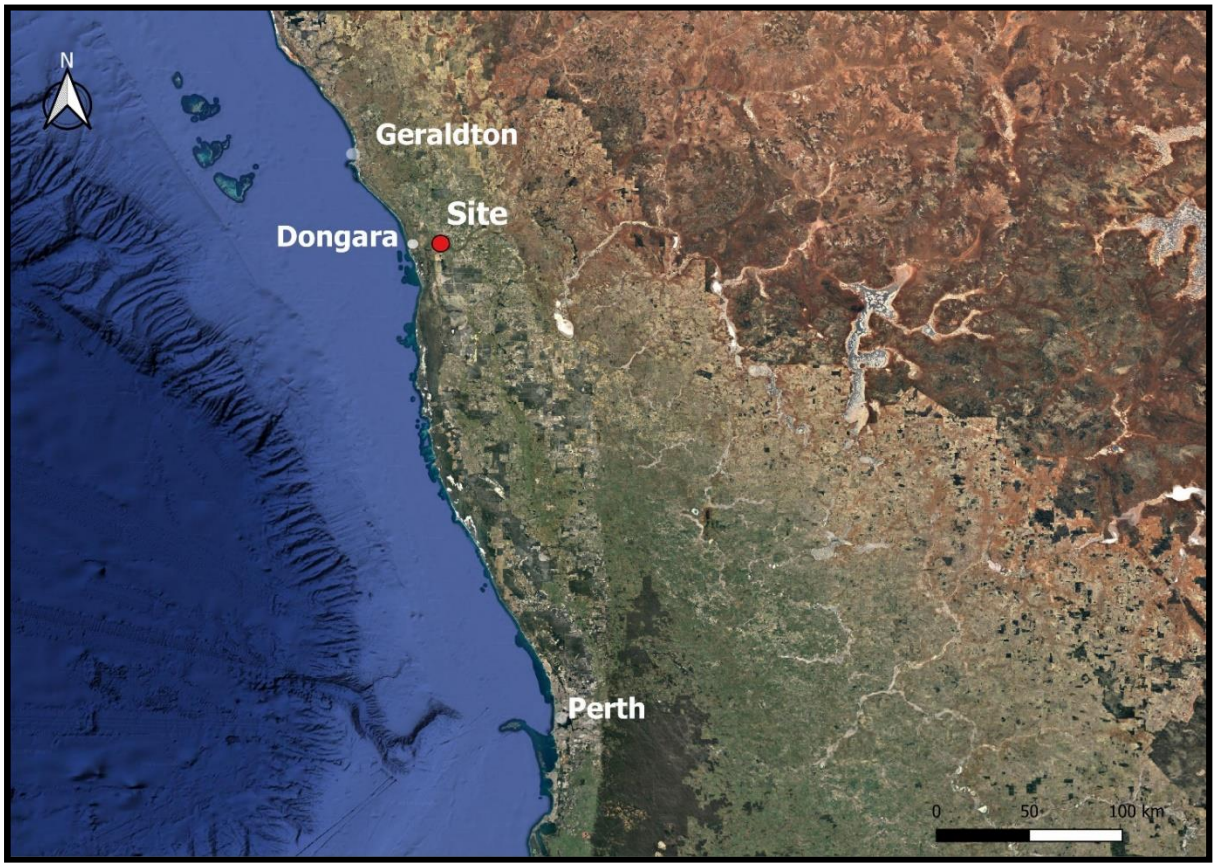


Figure 1. Location of the Waitsia Project Site (red ellipse).

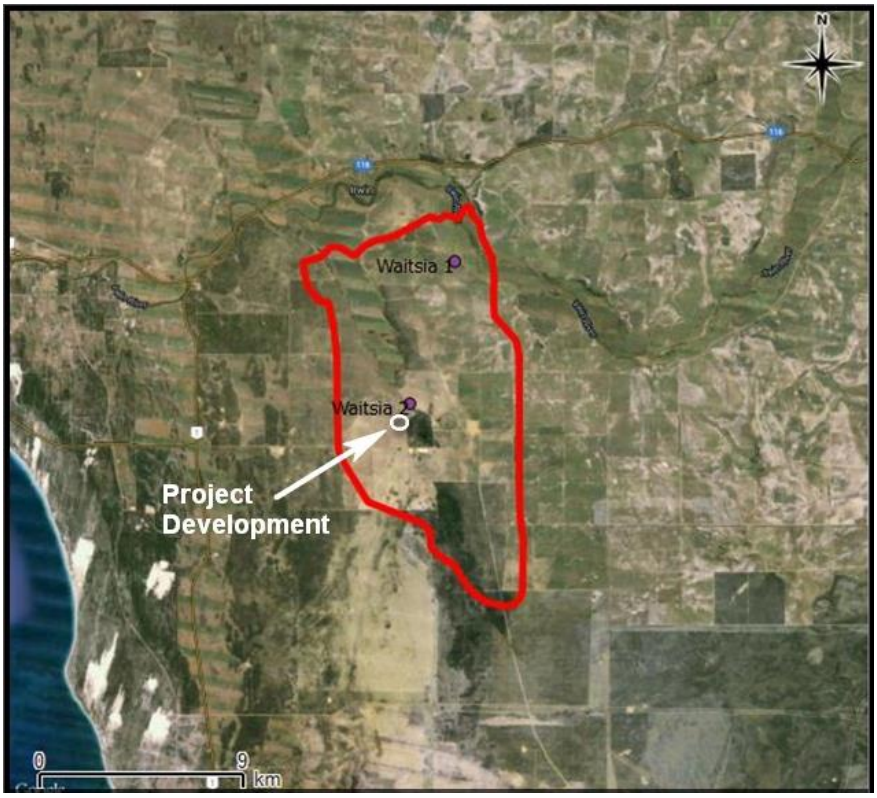


Figure 2. Location of Waitsia Wells project area (red border) in 2015 and proposed pipeline clearing area (white arrow; white ellipse).

Figure 3. Location of vegetation impact area in the project site south-west of Waitsia-02. Ejano Spring lies just to the south-east.

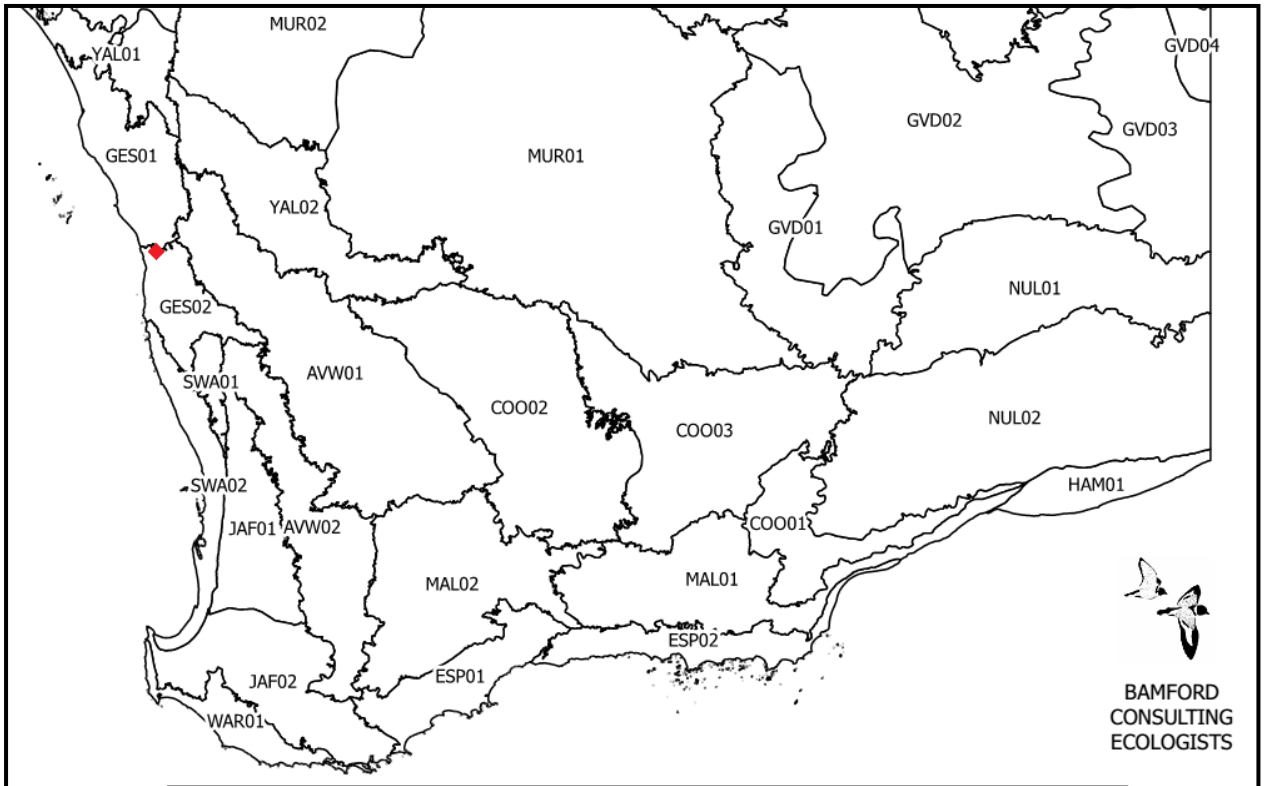
Figure 4. Vegetation at approximate location of pipeline. It is VSA 2, Kwongan to open banksia woodland on sand, but with severe degradation from grazing by cattle.

2 Background

2.1 Regional Description

The Interim Biogeographic Regionalisation of Australia (IBRA) (Environment Australia, 2000) has identified 26 bioregions in Western Australia (Figure 5). Bioregions are classified on the basis of climate, geology, landforms, vegetation and fauna (Thackway and Cresswell, 1995). IBRA Bioregions are affected by a range of different threatening processes and have varying levels of sensitivity to impact (EPA, 2004).

The survey area lies in the Geraldton Sandplains Bioregion, on the border between the Geraldton Hills (GES01) and the Lesueur Sandplain (GES02) subregions (DSEWPaC 2012c). This is a region extensively cleared for agriculture; as a result of the level of clearing, remnant native vegetation is generally considered to be of interest to conservation agencies. The native vegetation consists largely of Kwongan: species-rich proteaceous heath.



AVW	Avon Wheatbelt	HAM	Hampton	SWA	Swan Coastal Plain
COO	Coolgardie	JAF	Jarrah Forest	WAR	Warren
ESP	Esperance Plains	MAL	Mallee	YAL	Yalgoo
GES	Geraldton Sandplains	MUR	Murchison		
GVD	Great Victoria Desert	NUL	Nullarbor		

Figure 5. IBRA Subregions in Western Australia.

Note the survey area lies between the GES01 and GES02 IBRA subregions.

3 Methods

3.1 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 DBCA Naturemap (incorporating the Western Australian Museum's FaunaBase and the DBCA Threatened and Priority Fauna Database), BirdLife Australia's Atlas Database (BA), the EPBC Protected Matters Search Tool and the BCE database (Table 1). 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 *et al.* (2000);
- Reptiles: Storr *et al.* (1983); Storr *et al*. (1990); Storr *et al*. (1999); Storr *et al.* (2002) and Wilson & Swan (2008);
- Birds: Blakers *et al*. (1984); Johnstone and Storr (1998, 2004) and Barrett et al. (2003); and
- Mammals: Menkhorst & Knight (2001); Strahan (2004); Churchill (2008); and Van Dyck and Strahan (2008).

Table 1. Sources of information used for the desktop assessment

Database	Type of records held on database	Area searched
NatureMap (DBCA 2019)	Records in the WAM and DBCA databases. Includes historical data and records on Threatened and Priority species in WA.	29°18'15"S, 115° 5'40"E – plus 20 km buffer.
BirdLife Australia Atlas Database	Records of bird observations in Australia, 1998-2015.	Species list for search polygon of 20km buffer from: 29°18'15"S, 115° 5'40"E
EPBC Protected Matters	Records on matters of national environmental significance protected under the EPBC Act.	29°18'15"S, 115° 5'40"E – plus 10 km buffer

3.2 Previous Fauna Surveys

A number of fauna studies have previously been conducted in the region, providing familiarity with the project area and unpublished fauna data from BCE records. These studies include:

- A Level 2 fauna survey conducted by BCE in the Mt Adams Road area on behalf of Tronox (Metcalf and Bamford 2008). This study area is just south of the Waitsia Wells project area, and work carried out included searching for significant species, spotlighting, trapping, bat surveys and bird surveys.
- More recent work carried out in the Tronox study area that targeted the Western Ground Parrot (Bamford 2012).
- A Level 1 fauna assessment of the Waitsia Wells study area (Bamford *et al.* 2015), part of the broader area within which the Waitsia 03 project is located.
- An assessment of the Waitsia 03 project area and its significance for Black Cockatoo spp. (Bamford 2016). This included a detailed site inspection of the Waitsia 03 site, quantification of banksia density and flowering, and a comparison of the extent of similar vegetation across Yardanogo Nature Reserve.
- In conjunction with a site visit conducted by Dr Mike Bamford (13th Nov 2017), these previous studies were used to identify the fauna values of the Waitsia 03 project area with regard to clearing principles detailed in schedule 5 (WA) Environmental Protection Act 1986 (Metcalf and Bamford 2018). This included assessing large trees their potential as nesting habitat for black-cockatoos.
- Several projects just west of the Brand Highway (Ventnor Resources; Norwest Energy) and further south for Iluka (Eneabba).

3.3 Nomenclature and taxonomy

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

3.3.1 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 area. Therefore, some species that were returned by one or more of the data searches have been excluded because their ecology, or the environment within the survey area, meant that it was highly unlikely that these species would be present. Some are also known to be regionally extinct. In general, however, species returned by the desktop review process are considered to be potentially present in the survey area whether or not they were recorded during field surveys, and whether or not the survey area is likely to be important for them. 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. Species returned from databases but excluded from species lists are presented in Appendix 7.

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

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

These status categories make it possible to distinguish between vagrant species, which may be recorded at any time but for which the site is not important in a conservation sense, and species which use the site in other ways but for which the site is important at least occasionally. This is particularly useful for birds that may naturally be migratory or nomadic, and for some mammals that can also be mobile or irruptive, and further recognises that even the most detailed field survey can fail to record species which will be present at times, or may have been previously confirmed as present. The status categories are assigned conservatively. For example, a lizard known from the general area is assumed to be a resident unless there is very good evidence that the site will not support it, and even then it may be classed as a vagrant rather than assumed to be absent if the site might support dispersing individuals. Locally extinct species are placed in a separate table to avoid confusion.

3.4 Impact Assessment

While some impacts are unavoidable during a development, of concern are long-term, deleterious impacts upon biodiversity. This is reflected in documents such as the Significant Impact Guidelines provided by DotE (see Appendix 5). Significant impacts may occur if:

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

The impact assessment process therefore involves reviewing the fauna values identified through the desktop assessment and regional 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.

With such a small impact area (the pipeline project area where it crosses a belt of native vegetation), it is important to note that impacts are considered beyond the actual limit of the impact footprint.

3.4.1 Criteria for impact assessment

Impact assessment criteria are based on the severity of impacts on the fauna assemblage and conservation significant fauna, and were quantified on the basis of predicted population change (Table 2). Population change can be the result of direct habitat loss and/or impacts upon ecological processes.

The significance of population change is contextual. The EPA (2004) suggests that the availability of fauna habitats within a radius of 15km can be used as a basis to predict low, moderate or high impacts. In this case, a high impact is where the impacted environment and its component fauna is rare (<5% of the landscape within a 15km radius or within the Bioregion), whereas a low impact is where the environment is widespread (10% of the local landscape). Under the Ramsar Convention, a wetland that regularly supports 1% of a population of a waterbird species is considered to be significant. These provide some guidance for impact assessment criteria. In the following criteria (Table 2), the significance of impacts is based upon percentage population decline within a 15 km radius (effectively local impact) and upon the effect of the decline upon the conservation status of a recognised taxon (recognisably discrete genetic population, sub-species or species). Note that percentage declines can usually only be estimated on the basis of distribution of a species derived from the extent of available habitat.

Table 2. 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	Population decline temporary (recovery after end of project such as through rehabilitation) or permanent, but <1% within 15 km radius of centrepoint of impact area (or within

	bioregion if this is smaller). No change in viability or conservation status of taxon.
Moderate	Permanent population decline 1-10% within 15 km radius. No change in viability or conservation status of taxon.
Major	Permanent population decline >10% to 50% within 15 km radius. No change in viability or conservation status of taxon
Critical	Taxon decline >50% to extinction within 15 km and/or change in viability or conservation status of taxon.

4 Results

4.1 Vertebrate Fauna

4.1.1 Overview of fauna assemblage

Previous studies and this desktop review have identified 246 vertebrate fauna species as potentially occurring in the overall Waitsia area (see Appendix 6): two fish, 10 frogs, 40 reptiles, 167 birds, 16 native and 11 introduced mammals. This assemblage incudes 28 vertebrates and two invertebrates of conservation significant invertebrate fauna (Table 3); these are discussed in Section 4.1.2. As noted in Section 3.1.4, this assemblage comes from databases and includes species that may occur occasionally in the region, but for which it is not important (such as birds that rarely fly overhead). It is also based upon a search area of some 20km radius that encompasses the overall Waitsia project area, whereas the project area for the current assessment is just where the pipeline route crosses an area of native vegetation, with a total impact footprint of 0.55ha. The fauna assemblage in this small area thus may be a subset of the overall Waitsia project area, but the total assemblage is considered here as some impacts may be 'off-site'. For example, there are freshwater fish in Ejano spring that would not be impacted by clearing for the pipeline, but could be affected by altered hydrology, hydrocarbon spills and other associated impacts of the project.

The two fish are both known from the Irwin River in the north of the overall Waitsia project area, but the introduced Green Swordtail was also observed in Ejano Spring (Bamford *et al*. 2015). There appeared to be no native fish in the spring.

The ten frog species are all likely to be residents in the overall Waitsia project area, and can be expected to be at least regular visitors to the pipeline area because Ejano Spring, where many of them are likely to breed, is so close by. The Turtle Frog is entirely terrestrial and may be resident in the pipeline area despite the degraded condition of the vegetation. All the frog species are at least moderately widespread in the South-West.

The assemblage of 40 reptile species is broadly typical of the region and includes some elements more typical of slightly further inland, and a suite of species associated with the northern coastal sandplains. All are potential residents in the overall Waitsia project area and could occur in the native vegetation around Ejano Spring. Because of the small area and degraded nature of the pipeline project area, not all species would be present but detailed sampling would be required to confirm presence or absence. Some of the reptile species are of conservation significance and are discussed below (Section 4.1.2).

The bird assemblage of 167 species is very rich as it comes from a large area that provides a wide range of habitats; for example, it includes waterbirds that may visit Ejano Spring, flooded paddocks and roadside ditches. Many fewer species would routinely utilise the pipeline project area; on the November 2017 site visit to Waitsia 3, just 14 bird species were seen over several hours and across a much larger area (Metcalf and Bamford 2018). Such a small number of species may similarly use the pipeline project area, but impacts need to be considered over a wider area, such as in and around Ejano spring. Some of the bird species are of conservation significance and are discussed below (Section 4.1.2). Only one mammal species of conservation significance is expected still to occur in the overall Waitsia project area.

The key features of the fauna assemblage expected in the overall Waitsia project area are:

- Uniqueness: The assemblage is not particularly unique as similar assemblages and environments occur in greater region of the northern coastal plain (Geraldton Sandplains bio-region), but Ejano Spring is likely to attract waterbirds (in small numbers) that are not usually seen in this region.
- Completeness: The assemblage is incomplete due to the historical loss of native vegetation when it was converted to farmland and the consequent loss of habitats. The introduction of feral predators has also contributed to species loss. Loss of mammal species is notable. Many of the birds may also have declined but still occur in larger areas of native vegetation or as irregular visitors.
- Richness: The assemblage appears rich because of the inclusion of many species, such as waterbirds, that may be only occasional visitors. The Geraldton Sandplains bio-region is recognised as being biodiverse.

The assemblage is incomplete due to habitat loss, being within and surrounded by open farmland, and impacts of feral species. Much of the predicted assemblage is associated with small native vegetation patches. The assemblage is typical of that occurring in fragmented rural landscapes on the northern coastal plain. It is not practical to determine a fauna assemblage for the small pipeline project area, but the bulk of the assemblage of the greater area could be expected at least occasionally and, as noted above, in terms of impact assessment onsite and offsite impacts need to be considered. The juxtaposition of the pipeline project area and the surrounds of Ejano spring is significant in this respect.

4.1.2 Species of conservation significance

Details on species of conservation significance returned from the database and expected (including those recorded) to occur in the overall Waitsia project area (even as vagrants) are presented in

Table 3. This list includes two invertebrate, one amphibian, six reptile, 20 bird and one mammal species. These species are discussed below with emphasis on their likely status in the pipeline project area.

Species of Conservation Significance Level 1.

Malleefowl

This species is known from the region, but may be locally extinct in the overall Waitsia project area and is unlikely to occur in the pipeline area, except perhaps for the occasional vagrant bird. It has not been confirmed in studies conducted in the Waitsia area or nearby by BCE.

Carnaby's Black-Cockatoo

Carnaby's Black-Cockatoo is present in the greater Waitsia project area, with a roosting site identified just north-east of Waitsia 3, and reports that breeding occurs along the Irwin River (Bamford *et al.* 2015). Foraging habitat was also assessed around Waitsia 3 (Bamford 2016). The pipeline project area does contain a very small amount of foraging habitat (<1ha), although this is in poor condition due to Cattle grazing. No nest trees are located in this area.

Western Ground Parrot

Although probably locally extinct, the status of this species is becoming critical, with the known population on the south coast ca. 100 birds, and an unconfirmed population on the northern sandplains. Previous aural surveys in the area (Metcalf and Bamford 2008, Bamford 2012) as well as aural surveys in the current field survey have failed to locate this species.

Fork-tailed Swift

The Fork-tailed Swift is largely aerial but may over-fly the survey area occasionally.

Peregrine Falcon

This species is found in a variety of habitats, including rocky ledges, cliffs, watercourses, open woodland and acacia shrublands. The distribution of the Peregrine Falcon is often tied to the abundance of prey as this species predates heavily on other birds. The Peregrine Falcon lays its eggs in recesses of cliff faces, tree hollows or in large abandoned nests of other birds (Birds Australia, 2008). The Peregrine Falcon mates for life with pairs maintaining a home range of about 20 -30 km square throughout the year. Blakers *et al.* (1984) consider that Australia is one of the strongholds of the species, since it has declined in many other parts of the world. This species could forage over the pipeline project area but this area does not provide suitable nesting habitat.

Conservation Significant Waterbirds

A variety of conservation significant waterbirds, mostly listed as Migratory, may occur occasionally in the overall Waitsia project area, particularly in the vicinities of Ejarno Spring and the Irwin River, and also when paddocks flood. The pipeline project area does not provide habitat but is close to Ejarno Spring.

Species of Conservation Significance Level 2.

Woma

The south-west population of the Woma is classified as Priority 1 by the DBCA, but Cogger *et al*. (1993) classified it as Endangered, whilst Maryan (2005) suggests it may be critically endangered given the rarity of recent sightings. Possible threats to the species may include increased predation of young individuals by introduced predators (e.g. feral Cats and Foxes) and a loss of habitat (Maryan, 2005). Habitats within the project area are suitable and the few recent records of this species in the South-West have been nearby (Watheroo and Badgingarra), but the species could be locally extinct.

Black-striped Snake

The Black-striped Snake is restricted to the west coast region from Cataby south to Mandurah, with an apparently isolated population recorded near Dongara (Bush *et al.* 2007, Metcalf & Bamford 2008). It is likely to occur in sandy soils throughout the overall Waitsia project area, and could be present in the pipeline area.

Brush Wallaby

The Brush Wallaby occurs in south-western Australia, from Kalbarri to Cape Arid, but has suffered a large range reduction and fragmentation of populations due to clearing for agriculture and predation by introduced predators (DPaW, 2012a). It has been recorded in the general region (Metcalf and Bamford 2008) and individuals may occasionally utilise the belt of native vegetation through which the pipeline passes.

Species of Conservation Significance Level 3.

Although not listed as threatened or priority, these species are considered to be of local conservation significance. The Slender Tree-Frog and Tiger Snake are at the northern edge of their ranges and the White-spotted Ground Gecko and White-breasted Robin have restricted distributions. The Australian Bustard, Southern Scrub-robin, Rufous Fieldwren and Crested Bellbird have all declined severely due to clearing across the Wheatbelt, while the Carpet Python has also declined due to a combination of habitat loss and predation by feral predators (Bush *et al.* 2007). None of these species is very likely to occur regularly in the pipeline project area, but they occur in the overall Waitsia area and individuals may occasionally be present.

Conservation significant invertebrates

The Shield-backed Trapdoor Spider *Idiosoma nigrum* was returned from databases, and while this is listed as of high conservation significance, a recent review by Rix *et al.* (2018) indicates that the *Idiosoma* species in the southern Geraldton Sandplain region is likely to be *I. kwongan*, or possibly *I. araneceum*. Neither is considered of conservation significance.

The millipede *Antichiropus* Eneabba 1 is a short range endemic which is found in Eneabba but has also been recorded at Mt Adams, where it is associated with Acacia thickets close to wetlands (Metcalf & Bamford 2008). It could therefore occur in damp soils around Ejarno spring.

Table 3. Conservation status and of significant fauna species expected to occur in the region (based on desktop review) and the likelihood of their presence in the overall Waitsia project area, bold indicates species recorded in field surveys in the overall Waitsia project area.

CS Species		Status	CS Level	Expected presence Waitsia
INVERTEBRATES				
Shield-back Trapdoor Spider	*Idiosoma ?nigrum*	V S1	CS1	Uncertain taxonomy
millipede	*Antichiropus* Eneabba 1		CS3	Resident
AMPHIBIANS				
Slender Tree Frog	*Litoria adelaidensis*		CS3	**Resident**
REPTILES				
White-spotted Ground Gecko	*Diplodactylus alboguttatus*		CS3	Resident
Woma	*Aspidites ramsayi*	P1	CS2	Resident/ locally extinct?
Carpet Python	*Morelia spilota imbricata*		CS3	Resident
Tiger Snake	*Notechis scutatus*		CS3	**Resident**
Black-striped Snake	*Neelaps calonotos*	P3	CS2	Resident
BIRDS				
Malleefowl	*Leipoa ocellata*	V S1	CS1	Vagrant
Fork-tailed Swift	*Apus pacificus*	M S3	CS1	Irregular visitor
Eastern Great Egret	*Ardea modesta*	M S3	CS1	**Regular visitor**
Cattle Egret	*Ardea ibis*	M S3	CS1	Vagrant
White-bellied Sea-Eagle	*Haliaeetus leucogaster*	M S3	CS1	Vagrant
Peregrine Falcon	*Falco peregrinus*	S4	CS1	Irregular visitor
Australian Bustard	*Ardeotis australis*		CS3	Regular visitor
Common Sandpiper	*Actitis hypoleucos*	M S3	CS1	Irregular visitor
Curlew Sandpiper	*Calidris ferruginea*	Cr, M S1 S3	CS1	Irregular visitor
Red-necked Stint	*Calidris ruficollis*	M S3	CS1	Irregular visitor
Common Greenshank	*Tringa nebularia*	M S3	CS1	Irregular visitor
Western Corella	*Cacatua pastinator*		CS3	Irregular visitor
Carnaby's Black-Cockatoo	*Calyptorhynchus latirostris*	E S1	CS1	**Regular migrant**
Western Ground Parrot	*Pezoporus flaviventris*	Cr S1	CS1	Resident/locally extinct?
Rufous Fieldwren	*Calamanthus campestris*		CS3	**Resident**
Shy Heathwren	*Calamanthus cautus*		CS3	Resident
Crested Bellbird	*Oreoica gutturalis*		CS3	Resident
Southern Scrub-robin	*Drymodes brunneopygia*		CS3	**Resident**
White-breasted Robin	*Eopsaltria georgiana*		CS3	**Resident**
MAMMALS				
Brush Wallaby	*Notamacropus irma*	P4	CS2	Resident
Total Number of Species:	**30**			**Recorded: 7**

See Appendix 4 for descriptions of conservation significance levels. The predicted status of each species in the survey area is given. EPBC Act listed species: V = Vulnerable, E = Endangered, Cr = Critically Endangered, M = Migratory. Biodiversity Conservation Act listed species: S1 - S4 = Schedule 1 - 4, DEC Priority Species: P1 - P5 = Priority 1 - 5.

4.2 Patterns of biodiversity

Investigating patterns of biodiversity can be complex and also more relevant to impact assessment when addressing projects of at least moderate size, rather than the very small area involved with this pipeline project. However, some observations of value can be made. The impact area for the pipeline is VSA 2, which ordinarily would be rich in fauna species, but in this case it is highly degraded and is therefore likely to have abnormally low biodiversity. The adjacent area around and including Ejarno Spring is, by contrast, likely to be very rich in biodiversity and this juxtaposition is important when considering impacts.

4.3 Ecological processes

The nature of the landscape and the fauna assemblage indicate some of the ecological processes that may be important for ecosystem function (see Appendix 5 for descriptions and other ecological processes). These are the processes that sustain and influence the fauna assemblage. These include:

Local hydrology. The greater Waitsia study area has one major drainage line (Irwin River), one spring (Ejarno) and several seasonal wetlands in the south that are probably linked to Ejarno spring. The seasonal wetlands and Ejarno Spring in particular are likely to be sensitive to changes in groundwater levels. The pipeline project area is close to Ejarno Spring.

Fire. Banksia woodlands of the Geraldton Sandplains are fire-adapted but the flora and fauna assemblages can be altered by too-frequent fires, too hot fires and even by fire exclusion. Fire season may also be important. The assemblage in the pipeline project area and adjacent native vegetation has almost certainly been altered by changes in the fire regime, although it is difficult to determine recent fire history where there have been grazing impacts.

Feral species and interactions with over-abundant native species. The fauna assemblage of the survey areas has already been impacted by feral species (loss of a major component of the mammal fauna), and feral herbivores are leading to degradation of native vegetation. Signs of Fox, Pig, Rabbit and Cat were found in the general survey area in previous site visits.

Connectivity and landscape permeability. The overall Waitsia project area encompasses an agricultural landscape and a large reserve (Yardanogo Nature Reserve) in the south. In extensively cleared areas, connectivity is an important factor influencing the persistence of fauna, and the specific pipeline project area passes through a narrow belt of native vegetation that currently functions to provide such connectivity, although the severe degradation almost certainly compromises that function.

4.4 Summary of Fauna Values

Previous studies and this desktop review have identified 246 vertebrate fauna species as potentially occurring in the overall Waitsia area, 10 frogs, 40 reptiles, 167 birds, 16 native and 11 introduced mammals. Only a proportion of this assemblage would regularly use the pipeline project area because of the area's small size and poor condition, but the entire assemblage needs to be considered because of the nature of impacts that can include off-site effects.

Fauna values within the study area can be summarised as follows:

Fauna assemblage. Rich in the Geraldton Sandplain Bioregion but locally depauperate in the overall Waitsia Project area except in the extensive Yardanogo Nature Reserve in the south. The pipeline project area is likely to have a very poor fauna assemblage due to degradation, but a wide range of species may use the small site intermittently. Being adjacent to bushland around Ejarno Spring means the pipeline project area may support more fauna species, at least occasionally, than would be the case if it were an isolated patch of degraded vegetation.

Species of conservation significance. A large number of significant species may be present in the region, but many of these are migratory waterbirds that would only occasionally use wetlands in the general area in small numbers. Most other significant species would probably be restricted to larger areas of native vegetation, but this could include the bushland around Ejarno Spring, adjacent to the pipeline project area, although unlikely in the project area itself.

Vegetation and Substrate Associations (VSAs). The pipeline project area supports a very degraded example of VSA 2, which is regionally widespread. The adjacent area including and around Ejarno Spring contains several other distinctive and restricted VSAs, notably the spring itself. VSAs 2 can be of value for Carnaby's Black-Cockatoo but the pipeline project area is very small.

Patterns of biodiversity. Detailed patterns of biodiversity could not be examined, but it can be predicted that biodiversity will be low in the degraded vegetation of the pipeline project area.

Key ecological processes. Main processes currently affecting the fauna assemblage in the survey area include local hydrology, fire, feral species and connectivity. Connectivity is important across much of the overall Waitsia project area because of the extent of clearing for agriculture, with narrow belts of native vegetation facilitating fauna movements across the landscape. Species loss in remnant areas of native vegetation would probably be greater if not for such connectivity. The pipeline project area intersects one such corridor of native vegetation which, despite being degraded by grazing, will still serve to provide some landscape connectivity. This may be important for supporting fauna in the Ejarno Spring area.

Based on the small size and disturbed nature of the vegetation, a field survey for fauna prior to pipeline construction is not recommended. Mitigation of impact on potential fauna species should be carried out as detailed in Section 5.

5 Potential impact of the Pipeline on Fauna

Mitsui E&P is investigating the Waitsia project area east of Dongara, Western Australia, and specifically needs to seek a NVCP for a section of pipeline that passes through a narrow belt of native vegetation not included in previous assessments. The following sections examine possible impacts upon fauna values described in Section 4 with reference specifically to the pipeline project area. Impacts are summarised in Tables 4 and 5, and recommendations relating to impacts are discussed below. Impacting or threatening processes are outlined in Appendix 3.

Impacts of greatest concern relate to loss of connectivity and possibly also hydroecology. Habitat degradation is already a major concern at the pipeline site. Recommendations for impact mitigation include:

- Habitat loss leading to population decline. Minimise footprint. Rehabilitate where possible.
- Population fragmentation. Minimise footprint. Ensure pipeline does not form a barrier to fauna movement (presumably the pipeline will either be raised or buried).
- Fauna mortality. If a trench is constructed, it may need to be checked for trapped fauna.
- Ecohydrology. Develop an understanding of the surface and sub-surface drainage and possible effects of drilling activities upon groundwater in order to identify the potential for hydrological changes that could potentially impact fauna habitats.
- Feral species. Ensure that these are not encouraged during construction such as by managing wastes and educating personnel not to provide food (either deliberately or inadvertently) for feral fauna.
- Fire. Implement fire prevention plans such as standard hot work procedures, and ensure that risk to bushland around Ejarno spring is minimised. This may be through induction of personnel.
- Disturbance. Ejarno spring is an important natural area close to the pipeline project and may need to be protected. This could include simply ensuring that lighting is not directed towards the spring area, and educating personnel not to disturb the area.

Table 4. Summary of potential impacts upon fauna values related to the pipeline project.

Impacting process	Impact
Habitat loss leading to population decline	**Negligible.** Only localised and very small area of habitat loss. Some potential for fauna mortality during construction (see recommendations below).
Population fragmentation and disruption of movement and gene flow due to habitat fragmentation	**Moderate.** The pipeline project area provides connectivity for the Ejano Spring bushland area which may be important for fauna populations in that area. Its function for connectivity is already compromised by degradation due to grazing. The risk of impact from the pipeline will need to be managed (see recommendations below).
Increased mortality leading to population decline; e.g. due to ongoing roadkill	**Negligible.** Once construction is complete, there is no reason to expect an increase in ongoing mortality assuming there is little change in vehicle movements through the area. The completed pipeline should pose no ongoing risk to fauna as long as it does not create a barrier to movement of terrestrial fauna (see recommendations below).
Habitat degradation due to weed invasion	**Minor.** The areas to be cleared already have a high level of weed invasion and are badly degraded by grazing. It is not known if there is potential for a reduction in degradation due to grazing as part of the project.
Hydroecology	**Minor**. The pipeline project area does pass close to Ejano Spring but it is assumed that ground disturbance will only affect the surface soil and thus will not affect hydrological systems in the area. This does need to be verified. Potential for hydrocarbon spill may need to be considered, particularly during construction.
Species interactions due to feral or over-abundant native species	**Negligible.** Three may be a slight increase in activity of feral fauna during disturbance associated with construction, but the area is already highly disturbed with feral species present.
Altered fire regimes	**Minor.** There will be an increase in fire risk during construction but this can almost certainly be managed through standard procedures such as hot work permits.
Effects of disturbance, dust and light	**Negligible.** There will be some temporary disturbance during construction but the site is already exposed. Effects of disturbance upon the nearby Ejarno Spring area may need to be considered and are discussed below under recommendations.

Table 5. Summary of potential impacts upon key fauna values, including conservation significant species that are expected to occur in the survey area.

Fauna Value	Nature and Significance of Impact		Action required
	Potential Impacts	Significance	
Fauna assemblage	Reduction in area of vegetation may result in reduced population sizes and reduced connectivity.	Negligible	Minimise footprint. Rehabilitation.
VSAs	Small losses of degraded habitat.	Negligible	Minimise footprint. Rehabilitation.
Significant fauna	Small losses of degraded habitat, but in close proximity to intact habitat of significant species.	Minor	Minimise footprint; ensure Ejarno Springs area is not affected.
Ecological processes	Some possible impacts on connectivity fire regimes, hydrology and feral predators in adjacent bushland and connectivity	Moderate	Management to prevent off-site impacts. Maintain or enhance connectivity.

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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 to 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, relict 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 Biodiversity, Conservation and Attractions (DBCA) 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 2.

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. Populations on the edge of a species' range are often less abundant and more vulnerable to local extinction than populations at the centre of the range (Curnutt *et al*. 1996), and thus such populations can be considered significant. In addition, species that are sensitive to impacts such as habitat fragmentation may be classed as CS3, as may colonies of waterbirds. The Western Australian Department of Environmental Protection, now DPaW, used this sort of interpretation to identify significant bird species in the Perth metropolitan area as part of the Perth Bushplan (Dell and Banyard 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 (e.g. Gleeson and Gleeson 2012) and under the EPBC Act, in which threatening processes are listed. 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 (Gleeson and Gleeson 2012, Soule *et al.* 2004). 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) and Read *et al.* (2015) 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; Bamford and Roberts 2003). 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). 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. 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. 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 (Ex)	Taxa known to survive only in captivity.
Critically Endangered (CR)	Taxa facing an extremely high risk of extinction in the wild in the immediate future.
Endangered (E)	Taxa facing a very high risk of extinction in the wild in the near future.
Vulnerable (V)	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 (S1)	Critically Endangered fauna.
Schedule 2 (S2)	Endangered fauna
Schedule 3 (S3)	Vulnerable Migratory species listed under international treaties.
Schedule 4 (S4)	Presumed extinct fauna
Schedule 5 (S5)	Migratory birds under international agreement
Schedule 6 (S6)	Conservation dependant fauna
Schedule 7 (S7)	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 (P1)	Taxa with few, poorly known populations on threatened lands.
Priority 2 (P2)	Taxa with few, poorly known populations on conservation lands; or taxa with several, poorly known populations not on conservation lands.
Priority 3 (P3)	Taxa with several, poorly known populations, some on conservation lands.
Priority 4. (P4)	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 (P5)	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 20 key threatening processes listed by the federal Department of the Environment (DotE 2014b):

- Competition and land degradation by rabbits.
- Competition and land degradation by unmanaged goats.
- Dieback caused by the root-rot fungus (Phytophthora cinnamomi).
- Incidental catch (bycatch) of Sea Turtle 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.
- Novel biota and their impact on biodiversity.
- Predation by European red fox.
- Predation by exotic rats on Australian offshore islands of less than 1000 km^2 (100,000 ha).
- Predation by feral cats.

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

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 (2011) 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 interfere with the recovery of the species?

Appendix 5. Fauna expected to occur in the overall Waitsia project area.

Frog species.

FROGS		**CS**	**N**	**EPBC**	**BCE**	**Waitsia**
HYLIDAE						
Slender Tree Frog	*Litoria adelaidensis*	CS3	X			X
Motorbike Frog	*Litoria moorei*		X			X
MYOBATRACHIDAE						
Bleating Froglet	*Crinia pseudinsignifera*		X			X
Western Spotted Frog	*Heleioporus albopunctatus*		X			
Moaning Frog	*Heleioporus eyrei*		X		X	X
Sand Frog	*Heleioporus psammophilus*		X			
Pobblebonk Frog	*Limnodynastes dorsalis*				X	X
Turtle Frog	*Myobatrachus gouldii*				X	
Humming Frog	*Neobatrachus pelobatoides*		X		X	
Crawling Toadlet	*Pseudophryne guentheri*		X		X	
Number of Species:	**10**	**0**	**8**	**0**	**5**	**5**

Reptile species.

REPTILES		CS	N	EPBC	BCE	Waitsia
CHELUIDAE						
Steindachner's Tortoise	*Chelodina steindachneri*		X			
AGAMIDAE						
Western Heath Dragon	*Ctenophorus adelaidensis*		X		X	
Spotted Military Dragon	*Ctenophorus maculatus*		X		X	
Central Netted Dragon	*Ctenophorus nuchalis*		X			
Lozenge-marked Dragon	*Ctenophorus scutulatus*		X			
Thorny Devil	*Moloch horridus*				X	
Dwarf Bearded Dragon	*Pogona minor*		X		X	
DIPLODACTYLIDAE						
White-spotted Ground Gecko	*Diplodactylus alboguttatus*	CS3			X	
Western Stone Gecko	*Diplodactylus granariensis*				X	
	Lucasium maini		X			
	Strophurus spinigerus		X		X	
GEKKONIDAE						
	Gehyra variegata		X		X	
PYGOPODIDAE						
Javelin Legless Lizard	*Alcys concinna*					
Sand-plain Worm-lizard	*Aparasia repens*					
Fraser's Legless Lizard	*Delma fraseri*		X		X	X
	Delma greyii				X	
	Lialis burtonis		X		X	X
Keeled Legless Lizard	*Pletholax gracilis*		X			
Common Scaly Foot	*Pygopus lepidopodus*		X		X	
SCINCIDAE						
Fence Skink	*Cryptoblepharus buchani*				X	X
	Ctenotus fallens				X	
	Ctenotus impar				X	
	Ctenotus pantherinus				X	
Western Slender Blue-tongue	*Cyclodomorphus celatus*				X	
	Lerista christinae				X	
	Lerista elegans		X		X	X
	Lerista kingi		X			
	Lerista lineopunctulata		X			
	Lerista planiventralis		X			
	Lerista praepedita		X		X	

REPTILES		CS	N	EPBC	BCE	Waitsia
	Menetia greyii		X		X	X
Western Bluetongue	*Tiliqua occipitalis*		X			
Bobtail	*Tiliqua rugosa*		X		X	X
VARANIDAE						
Bungarra or Sand Monitor	*Varanus gouldii*		X		X	
Black-headed Monitor	*Varanus tristis*					
PYTHONIDAE						
Woma, Ramsay`s Python	*Aspidites ramsayi*	S4 P1				
Carpet Python	*Morelia spilota imbricata*	CS3	X			
ELAPIDAE						
Shovel-nosed Snake	*Brachyurophis semifasciata*					
Yellow-faced Whipsnake	*Demansia psammophis*		X			X
Bardick	*Echiopsis curta*		X			
Black-striped Snake	*Neelaps calonotos*	P3	X		X	
Tiger Snake	*Notechis scutatus*	CS3				X
Gould's Snake	*Parasuta gouldii*		X		X	
Mulga Snake	*Pseudechis australis*		X		X	
Western Brown Snake	*Pseudonaja mengdeni*		X		X	
Jan's Banded Snake	*Simoselaps bertholdi*		X		X	
Total Number of Species Expected:	**40**	**4**	**30**	**1**	**28**	**8**

Bird species.

BIRDS		CS	N	EPBC	BA	BCE	Waitsia
CASUARIIDAE							
Emu	*Dromaius novaehollandiae*		X		X	X	X
MEGAPODIIDAE							
Malleefowl	*Leipoa ocellata*	V S1		X	X		
PHASIANIDAE							
Stubble Quail	*Coturnix pectoralis*		X		X		X
ANATIDAE							
Chestnut Teal	*Anas castanea*				X		
Grey Teal	*Anas gracilis*		X		X		
Mallard	*Anas platyrhynchos*	Int.	X	X			
Australasian Shoveler	*Anas rhynchotis*		X		X		
Pacific Black Duck	*Anas superciliosa*		X		X		X
Hardhead	*Aythya australis*		X		X		
Australian Wood Duck	*Chenonetta jubata*		X		X		
Black Swan	*Cygnus atratus*		X		X		X
Pink-eared Duck	*Malacorhynchus membranaceus*		X		X		
Australian Shelduck	*Tadorna tadornoides*		X		X		
PODICIPEDIDAE							
Great Crested Grebe	*Podiceps cristatus*				X		
Hoary-headed Grebe	*Poliocephalus poliocephalus*		X		X		
Australasian Grebe	*Tachybaptus novaehollandiae*		X		X		
COLUMBIDAE							
Rock Dove	*Columba livia*	Int.	X	X	X		
Diamond Dove	*Geopelia cuneata*		X		X		
Crested Pigeon	*Ocyphaps lophotes*		X		X	X	X
Common Bronzewing	*Phaps chalcoptera*		X		X	X	X
Brush Bronzewing	*Phaps elegans*		X		X	X	X
Laughing Dove	*Streptopelia senegalensis*	Int.	X	X	X	X	
PODARGIDAE							
Tawny Frogmouth	*Podargus strigoides*				X	X	
CAPRIMULGIDAE							
Spotted Nightjar	*Eurostopodus argus*					X	
AEGOTHELIDAE							
Australian Owlet-nightjar	*Aegotheles cristatus*				X		
APODIDAE							
Fork-tailed Swift	*Apus pacificus*	M S3		X	X		
ANHINGIDAE							
Australasian Darter	*Anhinga novaehollandiae*		X		X		

BIRDS		CS	N	EPBC	BA	BCE	Waitsia
PHALACROCORACIDAE							
Little Pied Cormorant	*Microcarbo melanoleucos*				X		X
Great Cormorant	*Phalacrocorax carbo*		X		X		
Little Black Cormorant	*Phalacrocorax sulcirostris*		X		X		
Pied Cormorant	*Phalacrocorax varius*		X		X		
PELECANIDAE							
Australian Pelican	*Pelecanus conspicillatus*		X		X		
ARDEIDAE							
Eastern Great Egret	*Ardea modesta (alba)*	M S3	X	X	X		X
Cattle Egret	*Ardea ibis*	M S3	X	X			
White-necked Heron	*Ardea pacifica*		X		X		
White-faced Heron	*Egretta novaehollandiae*		X		X		X
Nankeen Night-Heron	*Nycticorax caledonicus*				X		
PLATALEIDAE							
Yellow-billed Spoonbill	*Platalea flavipes*		X		X		
Australian White Ibis	*Threskiornis molucca*				X		X
Straw-necked Ibis	*Threskiornis spinicollis*		X		X		X
ACCIPITRIDAE							
Collared Sparrowhawk	*Accipiter cirrocephalus*				X	X	
Brown Goshawk	*Accipiter fasciatus*		X		X	X	
Wedge-tailed Eagle	*Aquila audax*		X		X	X	X
Swamp Harrier	*Circus approximans*				X		
Spotted Harrier	*Circus assimilis*				X		
Black-shouldered Kite	*Elanus axillaris*		X		X		
White-bellied Sea-Eagle	*Haliaeetus leucogaster*	M S3	X	X	X		
Whistling Kite	*Haliastur sphenurus*		X		X	X	
Little Eagle	*Hieraaetus morphnoides*		X		X	X	
Square-tailed Kite	*Lophoictinia isura*					X	
Black Kite	*Milvus migrans*		X				
FALCONIDAE							
Brown Falcon	*Falco berigora*		X		X	X	
Nankeen Kestrel	*Falco cenchroides*		X		X	X	X
Australian Hobby	*Falco longipennis*		X		X	X	X
Peregrine Falcon	*Falco peregrinus*	S4	X		X		
RALLIDAE							
Eurasian Coot	*Fulica atra*		X		X		
Buff-banded Rail	*Gallirallus philippensis*		X				X?
Purple Swamphen	*Porphyrio porphyrio*						X
Australian Spotted	*Porzana fluminea*		X				

BIRDS		CS	N	EPBC	BA	BCE	Waitsia
Crake							
Black-tailed Native-hen	*Tribonyx ventralis*		X		X		
OTIDIDAE							
Australian Bustard	*Ardeotis australis*	P4	X		X		
RECURVIROSTRIDAE							
Black-winged Stilt	*Himantopus himantopus*		X		X		
Red-necked Avocet	*Recurvirostra novaehollandiae*		X				
CHARADRIIDAE							
Inland Dotterel	*Charadrius australis*				X		
Red-capped Plover	*Charadrius ruficapillus*		X		X		
Black-fronted Dotterel	*Elseyornis melanops*		X *		X		
Red-kneed Dotterel	*Erythrogonys cinctus*		X		X		
Banded Lapwing	*Vanellus tricolor*		X		X	X	
SCOLOPACIDAE							
Common Sandpiper	*Actitis hypoleucos*	M S3		X	X		
Ruddy Turnstone	*Arenaria interpres*	IA	X*				
Sharp-tailed Sandpiper	*Calidris acuminata*	IA	X	X			
Curlew Sandpiper	*Calidris ferruginea*	M S1 S3		X	X		
Red-necked Stint	*Calidris ruficollis*	M S3	X		X		
Common Greenshank	*Tringa nebularia*	M S3	X				
Marsh Sandpiper	*Tringa stagnatilis*	IA	X				
TURNICIDAE							
Painted Button-quail	*Turnix varia*						
Little Button-quail	*Turnix velox*				X		
CACATUIDAE							
Western Corella	*Cacatua pastinator*	CS3	X		X	X	
Little Corella	*Cacatua sanguinea*		X		X		
Red-tailed Black-Cockatoo	*Calyptorhynchus banksii*		X		X		*
Carnaby's Black-Cockatoo	*Calyptorhynchus latirostris*	E S1	X	X	X	X	X
Galah	*Eolophus roseicapillus*				X	X	X
Major Mitchell's Cockatoo	*Lophochroa leadbeateri*				X		
Cockatiel	*Nymphicus hollandicus*				X		
PSITTACIDAE							
Australian Ringneck	*Barnardius zonarius*		X		X	X	X
Budgerigar	*Melopsittacus undulatus*		X		X		

BIRDS		CS	N	EPBC	BA	BCE	Waitsia
Elegant Parrot	*Neophema elegans*				X	X	*
Scarlet-chested Parrot	*Neophema splendida*					X	
Western Ground Parrot	*Pezoporus flaviventris*	Cr S1					
Regent Parrot	*Polytelis anthopeplus*		X		X		
Mulga Parrot	*Psephotus varius*				X		
CUCULIDAE							
Fan-tailed Cuckoo	*Cacomantis flabelliformis*		X		X		X
Pallid Cuckoo	*Cacomantis pallidus*		X		X		
Horsfield's Bronze-Cuckoo	*Chalcites basalis*				X	X	
Shining Bronze-Cuckoo	*Chalcites lucidus*		X		X		
Black-eared Cuckoo	*Chalcites osculans*			X	X		
STRIGIDAE							
Southern Boobook	*Ninox novaeseelandiae*		X		X		
TYTONIDAE							
Barn Owl	*Tyto alba*				X		
HALCYONIDAE							
Laughing Kookaburra	*Dacelo novaeguineae*	Int.	X		X		
Red-backed Kingfisher	*Todiramphus pyrrhopygius*				X		
Sacred Kingfisher	*Todiramphus sanctus*		X		X		
MEROPIDAE							
Rainbow Bee-eater	*Merops ornatus*		X	X	X	X	
MALURIDAE							
Variegated Fairy-wren	*Malurus lamberti*		X		X	X	X
White-winged Fairy-wren	*Malurus leucopterus*		X		X	X	X
Blue-breasted Fairy-wren	*Malurus pulcherrimus*		X		X		
Splendid Fairy-wren	*Malurus splendens*		X		X	X	X
Southern Emu-wren	*Stipiturus malachurus*				X		
ACANTHIZIDAE							
Inland Thornbill	*Acanthiza apicalis*		X		X	X	
Yellow-rumped Thornbill	*Acanthiza chrysorrhoa*		X		X		X
Chestnut-rumped Thornbill	*Acanthiza uropygialis*		X		X		
Rufous Fieldwren	*Calamanthus campestris montanellus*		X		X	X	X
Shy Heathwren	*Calamanthus cautus*				X		
Western Gerygone	*Gerygone fusca*		X		X	X	X
Redthroat	*Pyrrholaemus brunneus*				X		
White-browed Scrubwren	*Sericornis frontalis*		X		X	X	X

BIRDS		CS	N	EPBC	BA	BCE	Waitsia
Weebill	*Smicrornis brevirostris*		X		X	X	X
PARDALOTIDAE							
Spotted Pardalote	*Pardalotus punctatus*				X	X	
Striated Pardalote	*Pardalotus striatus*		X		X	X	X
MELIPHAGIDAE							
Spiny-cheeked Honeyeater	*Acanthagenys rufogularis*		X		X	X	X
Western Spinebill	*Acanthorhynchus superciliosus*				X		
Red Wattlebird	*Anthochaera carunculata*		X		X	X	X
Western Wattlebird	*Anthochaera lunulata*				X	X	
Black Honeyeater	*Certhionyx niger*						
Pied Honeyeater	*Certhionyx variegatus*				X		
White-fronted Chat	*Epthianura albifrons*		X		X	X	
Crimson Chat	*Epthianura tricolor*		X		X	X	
Tawny-crowned Honeyeater	*Glyciphila melanops*		X		X	X	X
White-plumed Honeyeater	*Lichenostomus penicillatus*				X		
Singing Honeyeater	*Lichenostomus virescens*		X		X	X	X
Brown Honeyeater	*Lichmera indistincta*		X		X	X	X
Yellow-throated Miner	*Manorina flavigula*		X		X	X	X
Brown-headed Honeyeater	*Melithreptus brevirostris*				X		
White-cheeked Honeyeater	*Phylidonyris niger*		X		X	X	X
New Holland Honeyeater	*Phylidonyris novaehollandiae*				X		
White-fronted Honeyeater	*Purnella albifrons*				X		
POMATOSTOMIDAE							
White-browed Babbler	*Pomatostomus superciliosus*				X		
CINCLOSOMATIDAE							
Chiming Wedgebill	*Psophodes occidentalis*				X		
CAMPEPHAGIDAE							
Black-faced Cuckoo-shrike	*Coracina novaehollandiae*		X		X	X	
White-winged Triller	*Lalage sueurii*		X		X	X	
PACHYCEPHALIDAE							
Grey Shrike-thrush	*Colluricincla harmonica*		X		X	X	X
Crested Bellbird	*Oreoica gutturalis*	P4	X		X	X	
Western Whistler	*Pachycephala occidentalis*		X		X	X	X
Rufous Whistler	*Pachycephala rufiventris*		X		X	X	X
ARTAMIDAE							
Black-faced	*Artamus cinereus*		X		X	X	

BIRDS		CS	N	EPBC	BA	BCE	Waitsia
Woodswallow							
Dusky Woodswallow	*Artamus cyanopterus*				X		
Masked Woodswallow	*Artamus personatus*				X		
Pied Butcherbird	*Cracticus nigrogularis*		X		X	X	X
Australian Magpie	*Cracticus tibicen*		X		X		X
Grey Butcherbird	*Cracticus torquatus*		X		X		X
Grey Currawong	*Strepera versicolor*		X		X	X	
RHIPIDURIDAE							
Grey Fantail	*Rhipidura albiscapa*				X	X	X
Willie Wagtail	*Rhipidura leucophrys*		X		X	X	X
CORVIDAE							
Little Crow	*Corvus bennetti*				X	X	
Australian Raven	*Corvus coronoides*		X		X	X	X
Torresian Crow	*Corvus orru*				X		
MONARCHIDAE							
Magpie-lark	*Grallina cyanoleuca*		X		X	X	X
PETROICIDAE							
Southern Scrub-robin	*Drymodes brunneopygia*	CS3			X		X
White-breasted Robin	*Eopsaltria georgiana*	CS3	X		X	X	X
Western Yellow Robin	*Eopsaltria griseogularis*				X		
Hooded Robin	*Melanodryas cucullata*				X		
Jacky Winter	*Microeca fascinans*				X		
Red-capped Robin	*Petroica goodenovii*		X		X	X	X
SYLVIIDAE							
Australian Reed-Warbler	*Acrocephalus australis*		X		X		
Little Grassbird	*Megalurus gramineus*		X				
ALAUDIDAE							
Brown Songlark	*Cincloramphus cruralis*		X		X	X	X
Rufous Songlark	*Cincloramphus mathewsi*		X		X	X	
ZOSTEROPIDAE							
Silvereye	*Zosterops lateralis*		X		X	X	X
HIRUNDINIDAE							
White-backed Swallow	*Cheramoeca leucosterna*		X		X	X	
Welcome Swallow	*Hirundo neoxena*		X		X	X	X
Fairy Martin	*Petrochelidon ariel*		X		X		
Tree Martin	*Petrochelidon nigricans*		X		X	X	X
DICAEIDAE							
Mistletoebird	*Dicaeum hirundinaceum*		X		X	X	X
ESTRILDIDAE							
Zebra Finch	*Taeniopygia guttata*		X		X	X	

BIRDS		CS	N	EPBC	BA	BCE	Waitsia
MOTACILLIDAE							
Australasian Pipit	*Anthus novaeseelandiae*				X	X	X
Total Number of Species Expected:	**167**	**CS: 21 Int: 4**	**122**	**14**	**160**	**70**	**58**

Mammal species.

MAMMALS		CS	N	EPBC	BCE	Waitsia
TACHYGLOSSIDAE						
Echidna	*Tachyglossus aculeatus*				X	X
DASYURIDAE						
Fat-tailed Dunnart	*Sminthopsis crassicaudata*		X			
Little Long-tailed Dunnart	*Sminthopsis dolichura*				X	
White-tailed Dunnart	*Sminthopsis granulipes*				X	
Grey-bellied Dunnart	*Sminthopsis fuliginosa*					
PHALANGERIDAE						
Brushtail Possum	*Trichosurus vulpecula*					X
TARSIPEDIDAE						
Honey Possum, Noolbenger	*Tarsipes rostratus*		X		X	
MACROPODIDAE						
Western Grey Kangaroo	*Macropus fuliginosus*				X	X
Brush Wallaby	*notamacropus irma*	P4	X		X	
PTEROPODIDAE						
Little Red Flying Fox	*Pteropus scapulatus*		X*			
VESPERTILIONIDAE						
Chocolate Wattled Bat	*Chalinolobus morio*				X	
Lesser Long-eared Bat	*Nyctophilus geoffroyi*				X	
Southern Forest Bat	*Vespadelus regulus*				X	
MOLOSSIDAE						
White-striped Freetail Bat	*Austronomus australis*				X	
MURIDAE						
Ashy-grey Mouse/Noodji	*Pseudomys albocinereus*				X	

MAMMALS		**CS**	**N**	**EPBC**	**BCE**	**Waitsia**
Bush Rat	*Rattus fuscipes*					
INTRODUCED MAMMALS						
European Cattle	*Bos taurus*			X		
Dog, Dingo	*Canis lupus*			X		
Goat	*Capra hircus*			X		
Horse	*Equus caballus*		X			
Cat	*Felis catus*		X	X	X	X
House Mouse	*Mus musculus*		X	X		
Rabbit	*Oryctolagus cuniculus*			X	X	
Sheep	*Ovis aries*		X			
Black Rat	*Rattus rattus*			X		
Pig	*Sus scrofa*			X		X
Red Fox	*Vulpes vulpes*			X	X	X
Number of Native Species:	**16**	**1**	**7**	**9**	**14**	**5**