Carnarvon Horticulture Expansion
Fauna Assessment

Site 8 within the project area (photo: [redacted])

Prepared for: Strategen
PO Box 243,
Subiaco,WA, 6904

Prepared by: [redacted]
M.J. & A.R. Bamford Consulting Ecologists
23 Plover Way
Kingsley, WA 6026

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Executive Summary

Bamford Consulting Ecologists (BCE) was commissioned by Strategen to conduct a Level 2 fauna assessment (desktop review and single phase fauna survey) for a proposed horticulture expansion for food production along the Gascoyne River in the Carnarvon area. The purpose of this report is to provide information on the fauna values of the survey area, particularly for significant species, an overview of the ecological function of the site within the local and regional context, and to provide discussion on the interaction of the proposal with these fauna values and functions. The fauna investigations were based on a desktop assessment and field surveys undertaken in November 2016. The desktop study identified 233 vertebrate fauna species as potentially occurring in the Carnarvon survey area: 8 frogs, 60 reptiles, 142 birds, and 16 native and 7 introduced mammals. The vertebrate assemblage includes 15 species of conservation significance potentially occurring or known to recorded within the survey area.

Key fauna values are:

Fauna assemblage. Moderately intact (but lacking several mammal species) and moderately rich, and broadly typical of the extensive near-coastal shrublands of the Carnarvon bioregion, and with some fauna species from adjacent bioregions.

Species of conservation significance. Some significant species are likely to occur as residents of the survey area, or at least as regular visitors. Several species have a restricted distribution to within the region, and for several others the survey area represents the northern or southern limit of distribution making their presence in the survey area significant.

Vegetation and Substrate Associations (VSAs). There are five important VSAs identified, all of which are wide spread locally or regionally. Most of the survey area contains open Acacia shrubland plains with varying amounts of sparse eucalyptus woodland and some areas with and patches of Acacia thicket. There are limited creeklines and other low order drainage lines that feed into the Gascoyne River, and some localised low sand dunes that contrast to the extensive surrounding alluvial clay plains, and that support an assemblage of sand-adapted and fossorial reptiles.

Key ecological processes. Local hydrology of the Gascoyne River system, and localised occasional flooding, the fire regime and the presence of feral predators. The Gascoyne River provides dispersal corridors for some fauna, particularly birds.

Potential impacts upon fauna include:

- Habitat loss
- Hydrological change
- Degradation of habitat due to weed invasion.
- Ongoing mortality from operations.
- Species interactions.

Recommendations:

- Minimise alterations of runoff through any retained creeks and drainage lines.
- Avoid changes to drainage that will drain claypan areas adjacent to the proposed activity. This will ensure retention of wader bird habitat (occasional flooded claypans).
- Minimise the disturbance footprint and where possible maintain trees and native shrubs that provide nesting food, shelter and hollows for significant species.
- Clearly delineate areas to be cleared to minimise unnecessary vegetation loss.
- Minimise disturbance to the Gascoyne River and associated minor drainage lines.
- Employ industry standard hygiene to avoid introducing weeds into the project area.
- Consider an education programme to reduce spray drift and dumping on land outside agricultural areas.
- Ensure appropriate waste disposal during construction activities and ongoing to avoid attracting feral species to the area.
- Educate personnel and landholders not to feed (deliberately or inadvertently) feral species.
- Agricultural practices should endeavour to minimise spray drift and light pollution into surrounding native vegetation. During clearing operations, industry standard dust, light and noise suppression should be carried out.

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1 Introduction

Bamford Consulting Ecologists (BCE) was commissioned by Strategen to conduct a Level 2 fauna assessment (desktop review and single phase fauna survey) for a proposed horticulture expansion for food production (the proposal) along the Gascoyne River in the Carnarvon area (the survey area). The purpose of this report is to provide information on the fauna values of the survey area, particularly for significant species, an overview of the ecological function of the site within the local and regional context, and to provide discussion on the interaction of the proposal with these fauna values and functions.

1.1 General Approach to Fauna Impact Assessment

The purpose of impact assessment is to provide government agencies with the information they need 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 Appendices 1 to 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 activity; and provide recommendations to mitigate these impacts.

1.2 Description of Survey Area

The survey area is located approximately 7 kilometres northeast of the township of Carnarvon, and approximately 9 kilometres east of the Indian Ocean on the midwest coast of W.A. (see Figure 1). The survey area is divided into four separate areas: Area B, C, D and E as shown in Figure 1. These four areas are further divided into approximately 19 small and mainly discontinuous portions that comprise the survey area which is located adjacent to existing horticultural land which straddle the north and south sides of the Gascoyne River. It is broadly described as an alluvial plain of loamy clay soils, and with some peripheral patches of areas of ephemeral claypan and occasional low elevation sand dunes. The vegetation is generally typical of the local area and wider bioregion with the exception of the area being in proximity to a major river. The Gascoyne River is the major River system of the region with the river channel (river bed) varying from 300 to 600 metres wide in the vicinity of the project area. The river is mostly dry but will flood during infrequent but heavy rain within its catchment to the east which is an area extending hundreds of kilometres inland to the east over several bioregions.

The survey area is located within the Carnarvon Basin, which extends from Exmouth south to the Murchison River and inland to the Kennedy Range. This area represents a bio-geographic boundary between southwest and arid climatic zones. Patterns of flora and fauna distribution at boundaries such as this can lead to interesting patterns of biodiversity where particular species from adjacent regions or climatic zones can overlap or intersect, and where the range of other south western species can abruptly end.

The vegetation condition is variable across the survey area and ranges from largely intact native vegetation dominated by mixed low open shrublands to highly degraded areas supporting buffel grass and with very sparse remnant low shrubs, trees, and herbaceous species. These degraded areas are presently, or were formerly used for livestock.

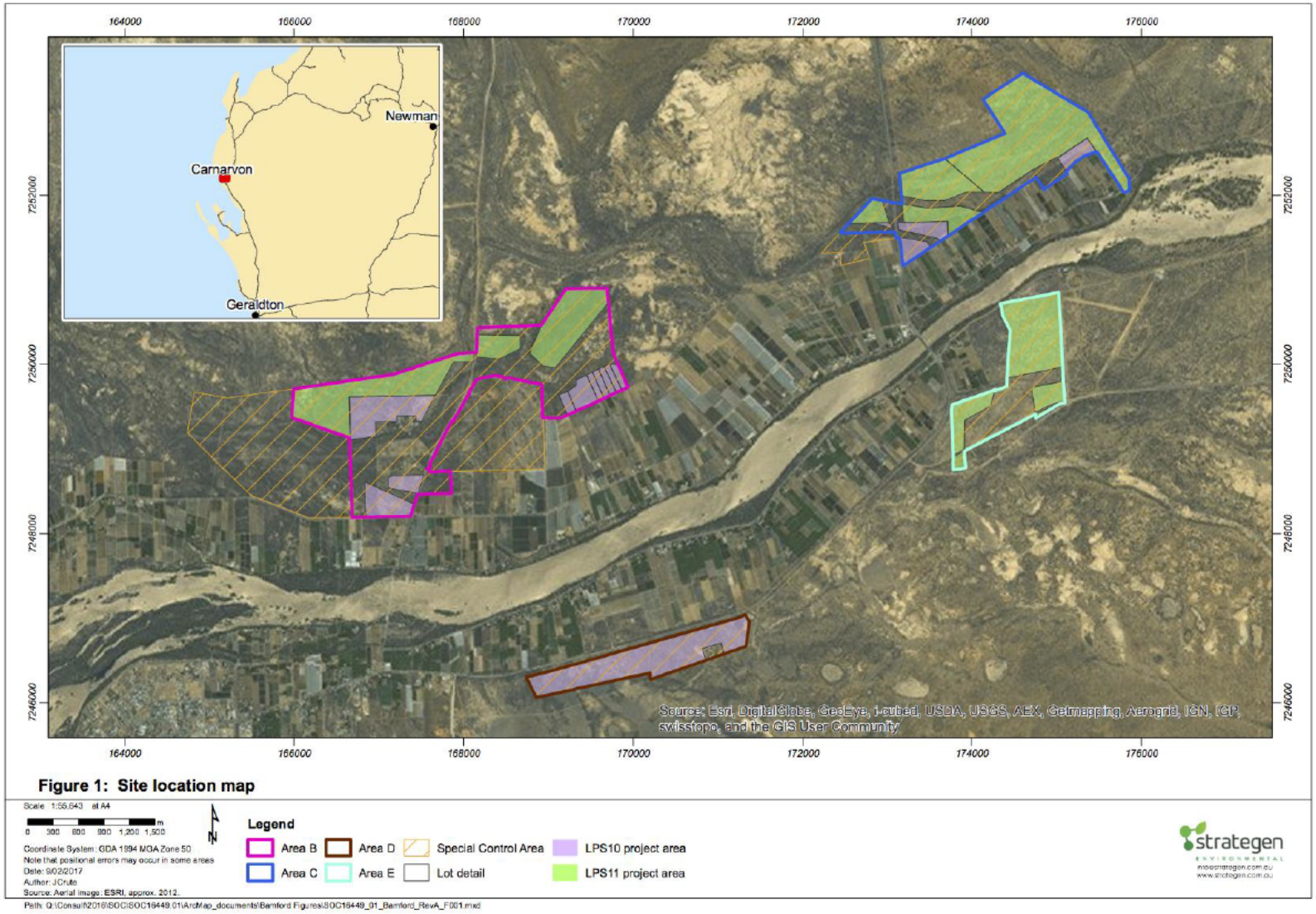


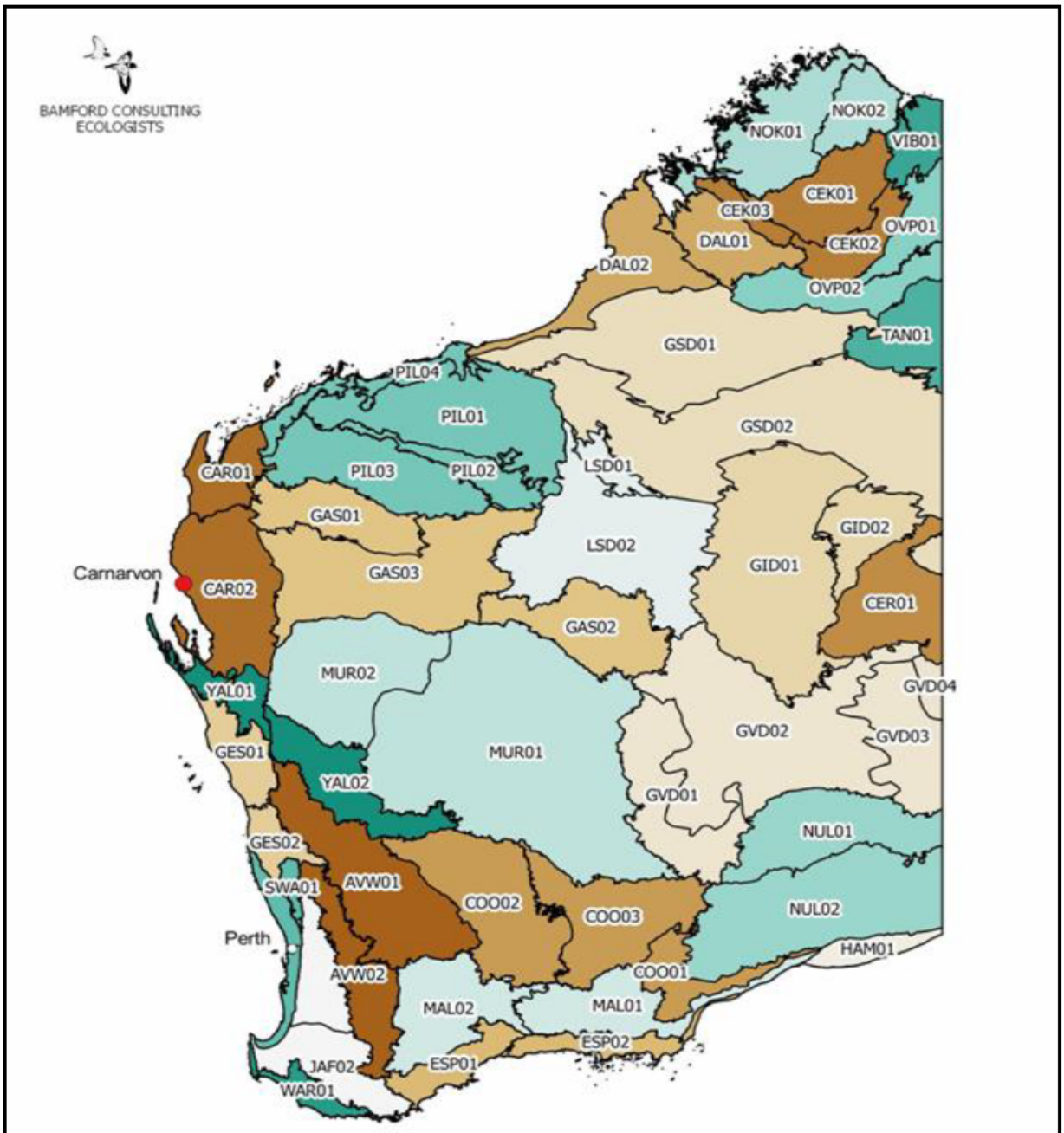
Figure 1. Location of the survey area.

Background

1.3 Regional Description

The Interim Biogeographic Regionalisation of Australia (IBRA) (Environment Australia, 2000) has identified 26 broad bioregions in Western Australia that are further divided into subregions (Figure 2). 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 Wooramel subregion, within the Carnarvon Bioregion (DSEWPaC 2012) as shown in Figure 2.

The Carnarvon bioregion has a low and gently undulating landscape with a mosaic of alluvial plains with chenopods, low shrublands, and with areas of tussock grassland in the north. Major land tenure is pastoral leasehold, with some conservation reserves, such as the Cape Range National Park. The bioregion has a range of industries, including extensive cattle and sheep grazing, salt mining, tourism and fishing. Most of the Carnarvon bioregion has been, and/or is current grazed (Bastin *et al.* 2008).



AVW	Avon Wheatbelt	GAS	Gascoyne	LSD	Little Sandy Desert	SWA	Swan Coastal Plain
CAR	Carnarvon	GES	Geraldton Sandplains	MAL	Mallee	TAN	Tanami
CEK	Central Kimberley	GID	Gibson Desert	MUR	Murchison	VIB	Victoria Bonaparte
CER	Central Ranges	GSD	Great Sandy Desert	NOK	Northern Kimberley	WAR	Warren
COO	Coolgardie	GVD	Great Victoria Desert	NUL	Nullarbor	YAL	Yalgoo
DAL	Dampierland	HAM	Hampton	OVP	Ord Victoria Plain		
ESP	Esperance Plains	JAF	Jarrah Forest	PIL	Pilbara		

Figure 2. IBRA Subregions in Western Australia.

Note that the survey area (indicated by red circle) lies in the CAR02 - Wooramel IBRA subregion.

2 Methods

2.1 Overview

The methods used for this assessment are based upon the general approach to fauna investigations for impact assessment as outlined in Section 1.1 and with reference to Appendices 1 to 4. Thus, the impact assessment process involves the identification of fauna values, review of impacting processes and preparation of mitigation recommendations.

This approach to fauna impact assessment has been developed with reference to guidelines and recommendations set out by the Western Australian Environmental Protection Authority (EPA) on fauna surveys and environmental protection, and Commonwealth biodiversity legislation (EPA 2002; EPA 2004). The EPA proposes two levels of investigation that differ in the approach to field investigations, Level 1 being a review of data 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 following approach and methods is divided into three groupings that relate to the stages and the objectives of impact assessment:

- Desktop assessment. The purpose of the desktop review is to produce a species list that can be considered to represent the vertebrate fauna assemblage of the project area based on unpublished and published data using a precautionary approach.
- Field investigations. The purpose of the field investigations is to gather information on this assemblage: confirm the presence of as many species as possible (with an emphasis on species of conservation significance), place the list generated by the desktop review into the context of the environment of the project area, collect information on the distribution and abundance of this assemblage, and develop an understanding of the project area's ecological processes that maintain the fauna. Note that field investigations cannot confirm the presence of an entire assemblage, or confirm the absence of a species. This requires far more work than is possible in the EIA process. For example, in an intensive trapping survey, How and Dell (1990) recorded in any one year only about 70% of the vertebrate species found over three years. In a study spanning over two decades, Bamford et al. (2010) has found that the vertebrate assemblage varies over time and space, meaning that even complete sampling at a set of sites only defines the assemblage of those sites at the time of sampling.
- 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 Atlas of Living Australia (ALA), DPaW NatureMap (incorporating the Western Australian Museum's FaunaBase and the DPaW 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) and Anstis (2013);
- Reptiles: Storr *et al.* (1983, 1990, 1999 and 2002) and Wilson and Swan (2013);
- Birds: Blakers *et al.* (1984); Johnstone and Storr (1998, 2004) and Barrett *et al.* (2003); and
- Mammals: Menkhorst & Knight (2004); Churchill (2008); and Van Dyck and Strahan (2008).

Some fauna species likely to occur based on distribution and habitat but not listed in database searches were also considered within the desktop assessment.

Table 1. Sources of information used for the desktop assessment.

Database	Type of records held on database	Area searched
Atlas of Living Australia	Records of biodiversity data from multiple sources across Australia.	Point search: 24.83749°S, 113.0489°E plus 20 km buffer. Searched 21/12/2016
NatureMap (DPaW 2016)	Records in the WAM and DPaW databases. Includes historical data and records on Threatened and Priority species in WA.	Point search: 24.83749°S, 113.0489°E plus 20 km buffer. Searched 21/12/2016
BirdLife Australia Atlas Database (Birdlife Australia 2017)	Records of bird observations in Australia, 1998-2014.	Point search: 24.83749°S, 113.0489°E plus 20 km buffer. Searched 7/1/2017
EPBC Protected Matters (DEE 2017)	Records on matters of national environmental significance protected under the EPBC Act.	Point search: 24.83749°S, 113.0489°E plus 20 km buffer. Searched 6/1/2017

2.2.2 Previous fauna surveys

The desktop assessment included a review of locally relevant ecological studies where available. A flora and fauna study conducted by Burbidge *et al.* (2000) sampled major representative environments throughout the southern Carnarvon basin, defined in the study as the area from Cape Range to the Murchison River and inland to Kennedy Range. The study provides information on

patterns of flora and fauna distribution and biodiversity, and provides a basis for regional conservation planning and monitoring. Vertebrate species recorded during the above mentioned fauna study has been incorporated within the DPaW NatureMap database search and presented in species lists (Appendix 5).

2.2.3 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 Fauna of Western Australia 2016. The authorities used for each vertebrate group were: amphibians (Doughty *et al.* 2016a), reptiles (Doughty et al. 2016b), birds (Johnstone and Darnell 2016), and mammals (Travouillon 2016). In some cases, more widely-recognised names and naming conventions have been followed, particularly for birds where there are national and international naming conventions in place (e.g. the BirdLife Australia working list of names for Australian Birds). 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. For some taxa, recent revision has placed them within new genera, and in these cases, the former Genus is placed in bracket alongside the currently accepted taxonomic grouping.

2.2.4 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 is highly unlikely that these species will be present. Such species can include, for example, seabirds that might occur as extremely rare vagrants at a terrestrial, inland site, but for which the site is of no importance. Species returned from databases but excluded from species lists are presented in Appendices 6 and 7. This includes recently extinct species that may have been locally occurring prior to European colonisation.

Species returned from the databases and not excluded on the basis of ecology or environment are therefore considered potentially present or expected to be present in the survey area at least occasionally, whether or not they were recorded during field surveys, and whether or not the survey area is likely to be important for them. This list of expected species is therefore subject to interpretation by assigning each a predicted status in the survey area.

The status categories used are:

- Resident: species with a population permanently present in the survey area;
- Migrant or regular 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 would have been present but 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.

2.3 Field Survey

2.3.1 Survey overview

The field survey incorporated a range of survey techniques so as to maximise sampling results. The following techniques were used:

The field survey included several components:

- Identification of VSAs;
- Systematic sampling transects;
    - Pit trapping;
    - Funnel trapping;
    - Bird census;
- Motion sensitive cameras
- Nocturnal searching
- Active hand searching
- Opportunistic observations, and
- Opportunistic invertebrate collection.

2.3.2 Dates and Personnel

The survey area was visited on the 7th to 15th November 2016 by the following personnel:

- Dr Mike Bamford (B.Sc. Hons. Ph.D.)
- Mr Andrew Moore (B.App.Sc., M.Sc)
- Mr Peter Smith (As.Dip.Ag)
- Mr Robert Browne-Cooper (B.Sc.)
- Mr Andy McCreery (B.Sc.), and
- Mr Jeff Turpin (B.Sc.)

The field investigations were carried out under Regulation 17 permit No. 01-000118-1.

2.3.3 Vegetation and Substrate Associations

Vegetation and Substrate Associations (VSAs) in the survey area were assessed during the desktop review via aerial images, and as part of the field investigations. Within the survey area, all major VSAs were visited to develop an understanding of major fauna habitat types present and to assess the likelihood of conservation significant species being present in the area.

VSAs found locally but outside the survey area boundary were noted during the field survey to gain an understanding of the extent of VSAs in the local context, and help assess their uniqueness or otherwise and habitat value of the survey area.

2.3.4 Systematic Fauna Sampling

Eight systematic sampling transects were established to sample the fauna assemblage. The sites for transects were chosen across the survey area to sample all major Vegetation/Soil Associations. Each trapping transect consisted of up to 10 locations, spaced approximately 20 metres apart, with a fenced 20 litre pitfall trap at each location. There were three fences extending radially off each pit, approximately 1.2m in length, except for each odd-numbered pit which also had a funnel and a 3 metre fence. All pitfall and funnel traps were operated for five to six consecutive nights. Birds were counted within 25m of the trapping transect (thus a bird census transect of 50m width and approximately 300m long). A separate list of opportunistic bird species was recorded for those heard or observed in the general vicinity but beyond the 25 metre census limits. Details of the eight sampling transects sites are provided in Table 2. The locations of all traps and other fixed point survey methods are presented as Figure 3. Small patches of other VSAs representing relatively minor areas were surveyed opportunistically.

Table 2. Systematic fauna trapping sites.

Site	Trap transect end coordinates		Description	Trap effort
Site 1	Pit 1	49 J 774192 7250939	Along drainage line with small River Gums, open low shrubs and weeds on red loam.	42 pitfall trap nights,
	Pit 7	49 J 774335 7251067		24 funnel trap nights
Site 2	Pit 1	49 J 773425 7250973	Low sandy rise with sparse shrubs over Buffel Grass and weeds.	60 pitfall trap nights,
	Pit 10	49 J 773294 7251027		30 funnel trap nights
Site 3	Pit 1	49 J 776103 7252084	*Acacia tetragonophylla* thicket on clayey-loam.	60 pitfall trap nights,
	Pit 10	49 J 776041 7251945		30 funnel trap nights
Sit 4	Pit 1	49 J 776300 7250943	Mixed thicket with occasional River Gums on clayey loam.	60 pitfall trap nights,
	Pit 10	49 J 776257 7251107		30 funnel trap nights
Site 5	Pit 1	49 J 776654 7247831	*Eucalyptus victrix* open woodland over mixed shrubland including *Scaevola spinescens* on clayey-loam.	60 pitfall trap nights,
	Pit 10	49 J 776837 7247823		30 funnel trap nights
Site 6	Pit 1	49 J 777111 7247984	Mixed dense shrubland dominated by *Scaevola spinescens*, *Acacia tetragonophylla*, and *Acacia victoriae* on clayey loam.	60 pitfall trap nights,
	Pit 10	49 J 776929 7247890		30 funnel trap nights
Site 7	Pit 1	49 J 779747 7253308	Open shrubland of *Acacia victoriae* and chenopods on clayey-loam.	60 pitfall trap nights,
	Pit 10	49 J 779907 7253199		30 funnel trap nights
Site 8	Pit 1	49 J 781595 7253420	Very open River Gum Woodland over medium shurbland of *Acacia tetragonophylla* and *A. victoriae*; many shrubs dead, over grasses and herbs on red loam.	50 pitfall trap nights,
	Pit 10	49 J 781547 7253621		25 funnel trap nights

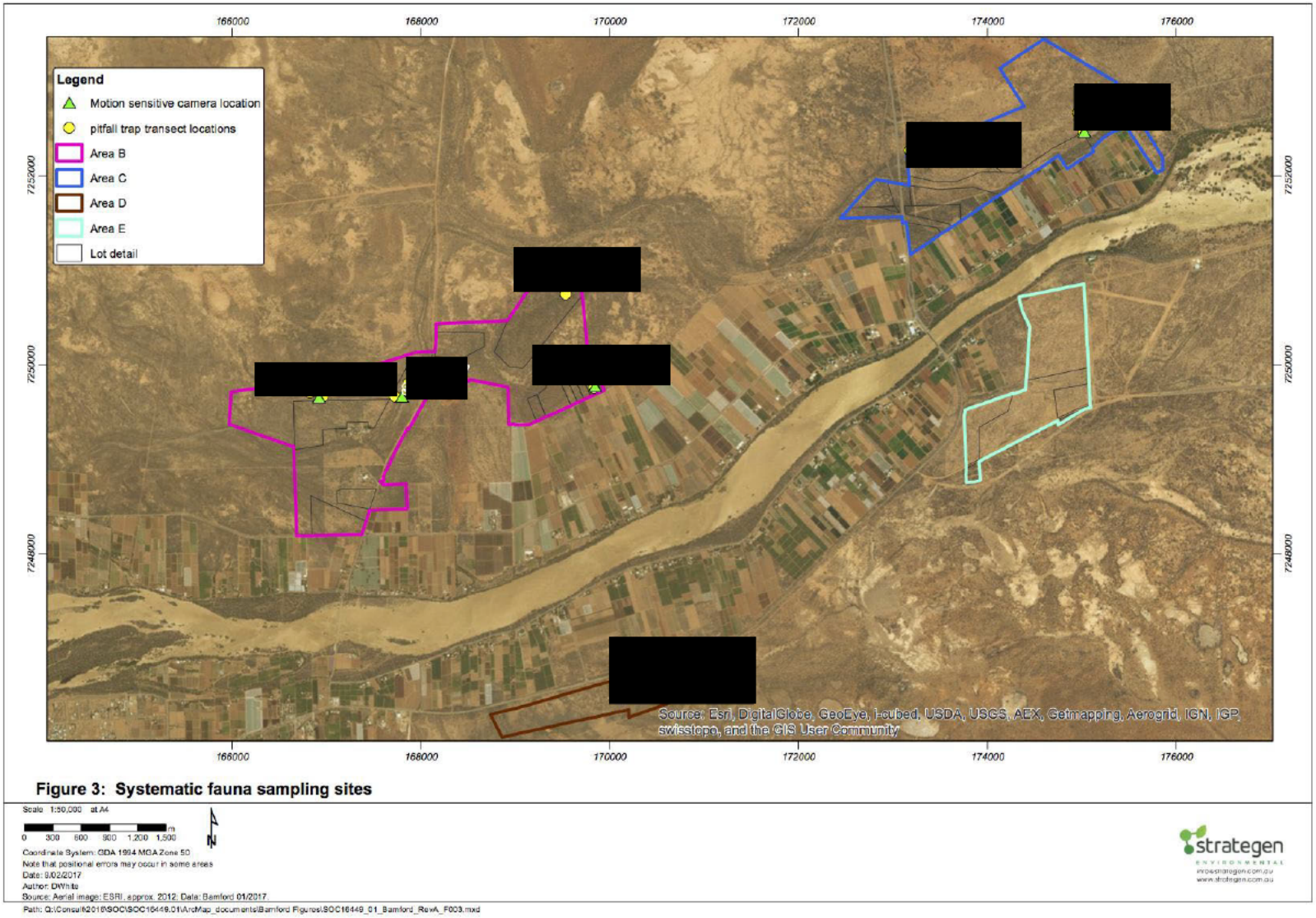


Figure 3. Location of systematic fauna sampling site

2.3.5 Motion sensitive cameras

A motion camera was set close to each of the eight systematic trapping sites (eight cameras in total). These were placed in locations selected to maximise fauna detection such as natural pathways or clearings between native vegetation. A combination of Bushnell® and Reconyx® were used. All cameras were baited with a mixture of rolled oats, peanut butter and sardines contained within PVC bait tubes. Details for camera locations are provided in Table 3 below and in Figure 3. These cameras are useful for recording a range of species, including conservation significant fauna and feral species.

Table 3. Location and details of motion cameras in operation during the fauna assessment.

Location	Camera type	Camera ID	Description	Set	Removed	Easting	Northing
Site 2	Bushnell	BCE21	near pit 3	10/11/16	14/11/16	[redacted]	[redacted]
Site 4	Reconyx	BCE35	near pit 2	10/11/16	14/11/16	[redacted]	[redacted]
Site 5	Reconyx	Buller Nth	near pit 1	10/11/16	14/11/16	[redacted]	[redacted]
Site 7	Reconyx	Buller Sth	near pit 5	10/11/16	15/11/16	[redacted]	[redacted]
site 8	Bushnell	JT1	near pit 1	11/11/16	15/11/16	[redacted]	[redacted]
site 6	Bushnell	JT	near pit 5	11/11/16	14/11/16	[redacted]	[redacted]
site 1	Reconyx	BCE04	near pit 1	10/11/16	14/11/16	[redacted]	[redacted]
site 3	Reconyx	BCE03	near pit 3	10/11/16	14/11/16	[redacted]	[redacted]

2.3.6 Nocturnal searching

Three personnel searched on foot using LED head torches to detect fauna within the survey area targeting nocturnal fauna particularly reptiles. Search areas were chosen having patches of both low shrub vegetation and patches of bare ground where nocturnal reptiles are frequently active and readily detectible. Other areas includes along unsealed tracks and the edges of claypans. Nocturnal searches were undertaken on two nights from 19:30 to 21:00 hours during the field survey.

2.3.7 Active hand searching

This method involved turning over ground debris including log, rocks, bark, junk, and raking through leaf-litter and soil to detect fauna. This method specifically targets sheltering reptiles and frogs. Due to the generally warm seasonal temperatures, this activity was limited to the coolest times of the day such early morning and late afternoon where the likelihood of fauna sheltering is highest.

2.3.8 Opportunistic observations

At all times, observations of fauna were noted when they contributed to the accumulation of information on the fauna of the site. These included such casual observations as birds or reptiles seen while walking through the survey area, and observations of local fauna in the Carnarvon area, but outside the survey area.

2.3.9 Opportunistic invertebrate fauna collection

Collecting of invertebrate fauna was limited to only those taxonomic groups that are potential short range endemic (SRE) species such as Isopods, scorpions, pseudoscorpions, mygalomorph spiders, and millipedes. Opportunistic searching for potential SREs included turning over logs and rocks, particularly in moist areas. Potential SRE specimens caught as by-catch in the vertebrate fauna traps were also collected and sent to Phoenix Environmental for identification.

2.4 Survey Limitations

The EPA Guidance Statement 56 (EPA 2004) outlines a number of limitations that may arise during surveying. These survey limitations are discussed in the context of the BCE investigation of the survey area in Table 4. A possible limitation is that aquatic macroinvertebrates could not be sampled from claypans and drainage lines within or adjacent to the project area, but such taxa are likely to be very widespread along the Gascoyne River and its floodplain.

Table 4. Survey limitations as outlined by EPA.

EPA Limitation	BCE Comment
Level of survey.	Level 2 (desktop study and detailed field survey). Survey intensity was deemed adequate due to the level of survey and the amount of database records available in the region.
Competency/experience of the consultant(s) carrying out the survey.	The ecologists have had extensive experience in conducting fauna surveys and have conducted several fauna studies within the Carnarvon Basin. The consultant has extensive experience in the assessment of locally occurring fauna and habitat types.
Scope. (What faunal groups were sampled and were some sampling methods not able to be employed because of constraints?)	The survey focussed on vertebrate fauna, and fauna values for of the significant species potentially occurring, although some potential short-range endemic species were collected when encountered.
Proportion of fauna identified, recorded and/or collected.	Only potential short-range endemic invertebrates were collected. All other specimens (all vertebrate fauna) were identified to species or genus and released at point of capture.
Sources of information e.g. previously available information (whether historic or recent) as distinct from new data.	Sources include previous fauna study in the Carnarvon Basin (Burbidge et.al 2000), and databases (DPaW, EPBC, BCE, ALA, NatureMap, Bird Data database)

EPA Limitation	BCE Comment
The proportion of the task achieved and further work which might be needed.	The survey was completed and the report provides fauna values for the project area. One group of fauna aquatic macro-invertebrates, could not be sampled due to the lack of water in wetlands.
Timing/weather/season/cycle.	Survey was conducted in November 2016. Level 2 fauna surveys are ideally timed for trapping to coincide with spring time. Warm dry weather during the survey was favourable to fauna detection for the majority of target mammal, bird and reptile species
Disturbances (e.g. fire, flood, accidental human intervention etc.) that affected results of survey.	None
Intensity. (In retrospect, was the intensity adequate?)	All major VSAs were visited and significant species habitat and traces were identified. VSAs beyond the survey area limits were also visited to gain local context of the species habitat.
Completeness (e.g. was relevant area fully surveyed).	Site was fully surveyed to the level appropriate for a level 2 assessment and for the proposed impact. Fauna database searches covered a 20 km radius beyond the survey area boundary. Detailed field investigations covered the VSAs present.
Resources (e.g. degree of expertise available in animal identification to taxon level).	Field personnel have extensive experience with fauna and habitat in the region.
Remoteness and/or access problems.	There were no remoteness/access problems encountered.
Availability of contextual (e.g. biogeographic) information on the region.	Regional information was available and was consulted.

2.5 Presentation of results for 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 DSEWPaC (see Appendix 4). 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.
- 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.

The presentation of this assessment follows the general approach to impact assessment as given in Section 1.1, but modified to suit the characteristics of the site. Key components to the general approach to impact assessment are addressed as follows:

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 information from the site inspection;
- Species of conservation significance – based upon desktop assessment and site inspection;
- Recognition of ecotypes or vegetation/substrate associations (VSAs) - based upon desktop assessment and site inspection;
- Patterns of biodiversity across the landscape - based upon desktop assessment and site inspection;
- Ecological processes upon which the fauna depend - based upon desktop assessment and site inspection.

Impact assessment

This section reviews impacting processes (as described in detail in Appendix 2) with respect to the proposed horticulture expansion project and examines the potential effect of these impacts upon biodiversity of the survey area. It thus expands upon Section 1.1 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 that leads 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.

The impact assessment concludes with recommendations based upon predicted impacts and designed to mitigate these.

2.5.1 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 (Appendix 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, but are really only appropriate when considering very large proposed developments. In the case of the current project area of approximately 300ha within a greater landscape, a 15km radius is considered appropriate for context. In the following criteria (Table 5), the significance of impacts is based upon estimated percentage fauna population decline within the immediate area of the surroundings, 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.

The impact assessment concludes with recommendations based upon predicted impacts and designed to mitigate these.

Table 5. 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 the immediate area. No change in viability or conservation status of taxon.
Moderate	Permanent population decline 1-10% within the immediate area. No change in viability or conservation status of taxon.
Major	Permanent population decline >10% within the immediate area. No change in viability or conservation status of taxon.
Critical	Taxon extinction within the immediate area and/or change in viability or conservation status of taxon.

3 Results

3.1 Vegetation and Substrate Associations

Five key Vegetation and Substrate Associations (VSAs) were identified across the survey area and are illustrated in Plates 1 to 5 and mapped (Figure 4). They include:

1. Low sand dune supporting open Acacia. This is comprised of very low open mixed *Acacia* shrubs over annual herbs, and grasses. The substrate is loose pale orange sand formed as low elevation dune ridges. This VSA represents a small proportion of the survey area but the substrate contrasts from other VSAs. This VSA is located in the north-west portion of Area B. Fauna sample site 2 is located within this VSA.

2. Acacia thicket on red clay loam plain. This VSA is dense mixed *Acacia*, often dominated by *Acacia sclerosperma, A. synchronicia* and / or *A. tetragonophylla*, and minor elements such as *Hakea spp*, and occasional emergent *Eucalyptus camaldulensis*. The substrate is red clay loam plain. This VSA is mainly located in the eastern portion of Area B. Fauna sample sites 3 and 4 are located within this VSA.

3. Open Acacia shrubland on red clay loam plain. This VSA is extensive and has similar floristic assemblage to VSA 2 with mixed *Acacia* species being the dominant elements including *Acacia sclerosperma* and / or *A. synchronicia* but in lower density, particularly in the medium to lower vegetation strata. This may be a reflection of the degree of disturbance however the vegetation density will determine the fauna assemblages that it supports due to factors such as food, shelter, ground cover and canopy cover, and therefore the VSA is differentiated primarily in vegetation density. Fauna sample sites 6 and 7 are located within this VSA. The north-western portion of VSA 7 also includes some low open chenopod shrubland of *Maireana polypterygia* and/or and associated with claypan areas subject to occasional brief periods of flooding and represent a small peripheral proportion of the survey area, but are extensive in adjacent northern and southern areas outside the survey area.

4. Open Eucalyptus woodland over open Acacia shrubland plain. This VSA is dominated by mixed open *Acacia sclerosperma, A.tetragonophylla* and *A. victoriae* shrubland with emergent sparse *Eucalyptus camaldulensis* and / or *E. victrix*, with sparse buffel grass and *Rhagodia eremaea* and an Open Tussock grassland of *Cenchrus ciliaris.* The substrate is red clay loam plain. Fauna sample sites 5 and 8 are located within this VSA.

5. Minor creeklines of open River Gum woodland over Acacia shrubland. This VSA is a small proportion of the survey area but is included since creek lines represent a distinct habitat type of interest and relevance surface water flow into the adjacent Gascoyne River. This VSA is characterised by open *E. camaldulensis* and mixed *Acacia* shrubs over buffel grass and annual herbs associated with the minor creeks. The substrate is alluvial sandy loam. This VSA is mainly located within Areas B and C where creek lines can become poorly defined but retain the general vegetation structure. Fauna sample sites 1 is located within this VSA.

In addition to the VSAs within the survey area, other areas of interest such as claypans were noted in areas adjacent to but outside the survey area. These areas were looked at to gain an understanding of

the extent of VSAs on a local scale beyond the survey area boundary and for their potential ecological value for locally occurring conservation significant species.

The distribution of VSAs, based upon interpretation of vegetation mapping, soil characteristics and topography, is presented in Figure 4. Within each VSA there is a range of vegetation condition which varies across the survey area from very good to low condition. Vegetation condition is not mapped although cleared areas are included in figure 4.

Plate 1. VSA 1 - Low sand dune supporting open Acacia. Site 2.

Plate 2. VSA 2 - Acacia thicket on red clay loam plain. Sites 3 and 4.

Plate 3.VSA 3 - Open Acacia shrubland on red clay loam plain. Sites 6 and 7.

Plate 4. VSA 4 - Open Eucalyptus woodland over shrubland plain. Sites 5 and 8.

Plate 5 - VSA 5 – Minor creek with River Gum woodland over mixed shrubland. Site 1.

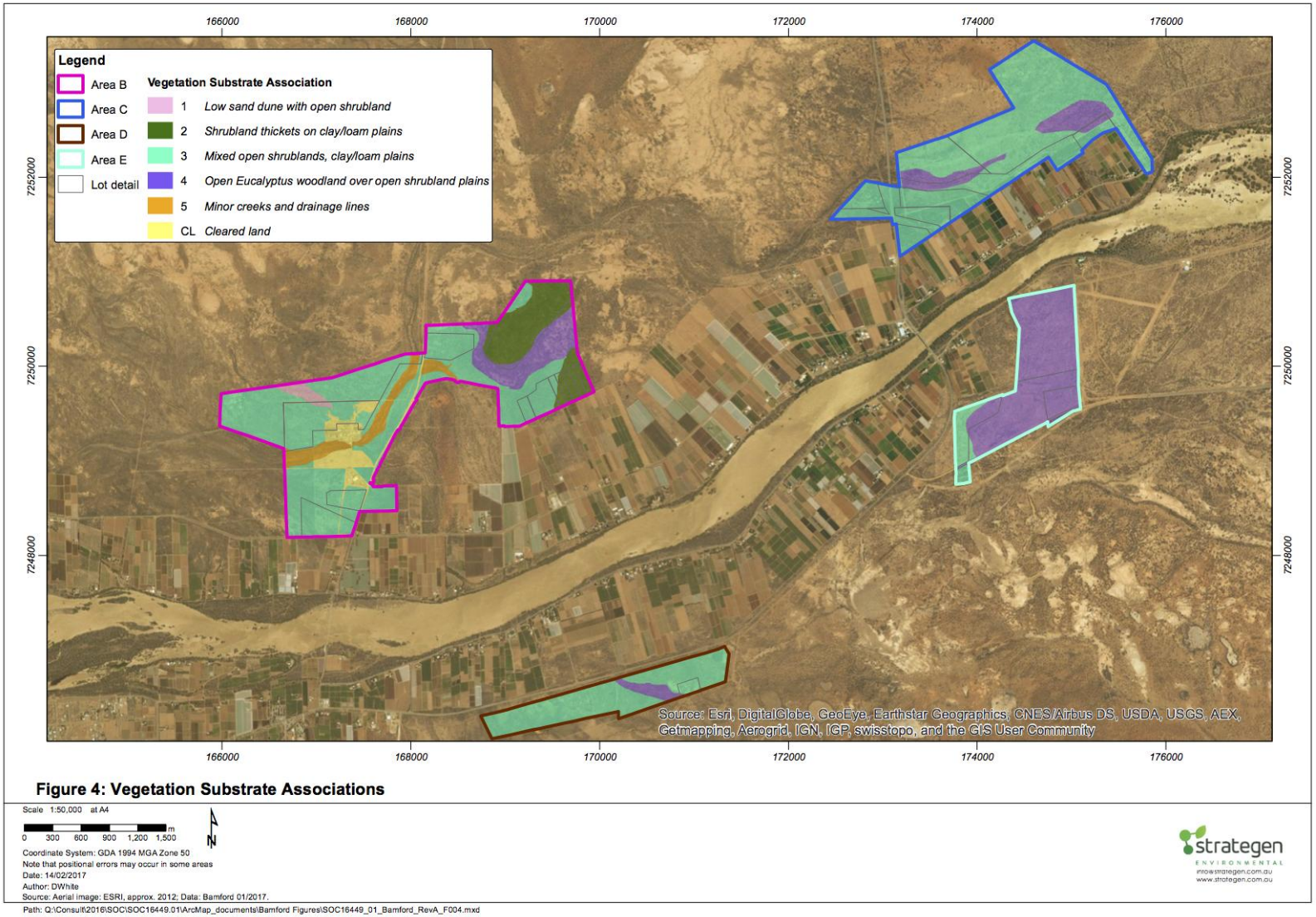


Figure 4. The distribution of VSAs across the project area.

3.2 Fauna

3.2.1 Overview of fauna assemblage

The desktop study identified 233 vertebrate fauna species as potentially occurring in the survey area (see **Table 6** and Appendix 5): 8 frogs, 60 reptiles, 142 birds, and 16 native, and 7 introduced mammals. The presence of 83 (one frog, 24 reptiles, 46 native birds, 2 introduced birds, 4 native mammals and 6 introduced mammals) species were confirmed as present during the field survey of November 2016 as a result of trapping, censusing, cameras and opportunistic observation. A further 32 bird species were recorded opportunistically outside but adjacent to the survey area or within the wider Carnarvon town site.

The eight frog species (1 confirmed present) are all locally common, considered resident and are regionally widespread. With the exception of the Desert Tree Frog (*Litoria rubella*) all others are burrowing species that spend relatively long periods inactive below ground during naturally extended dry periods. These will all breed opportunistically or seasonally within the survey area and adjacent shallow flooded areas depending on substantial rainfall. Irrigation associated with agriculture may extend breeding season or surface activity in localised areas due to surface water availability. Frog breeding events provide an important part of the food web by providing sporadic but abundant food resource for a range of fauna.

The 60 reptile species (24 confirmed present) are mostly considered resident and are regionally widespread in mid-west coastal areas. A number of species are known to be associated with particular VSAs and therefore will have distribution patterns closely aligned with vegetation or soil characteristics. For example, sand dunes with low shrubs (VSA 1) support a number of reptiles adapted to sandy substrates such as fossorial or 'sand swimming' skinks and snakes. Examples include Slender Broad-blazed Slider (*Lerista uniduo*), Blunt-tailed West Coast Slider (*L. praepedita*), and Jan's Banded Snake (*Simoselaps bertholdi*). Whilst VSA 1 is of limited extent within the survey area, similar VSAs of sand dunes supporting shrublands are extensive within the wider region, and known to support a range of common fossorial species.

Some areas within the Wooramel and adjacent bioregions are known to support higher reptile richness than the species assemblages potentially occurring within the survey area. The lack of *Triodia* (hummock grass) sand plains or dunes is a leading factor that accounts for the composition (or lack) of the species as many regionally occurring species are specialised to Triodia dominated VSAs. Therefore whilst many reptiles will occur widely within the bioregion, they are expected to be absent, or at best occur irregularly within the survey area. A number of skinks of the genus *Ctenotus* and dragons of genus *Ctenophorus* are in this category of *Triodia* sandplain specialists.

The extant bird assemblage of 142 species includes 70 classed as residents, of which 39 (56%) were observed during the field survey. Only a small proportion of regular migrants, and visitors were observed, but many are expected only on a sporadic basis following significant rainfall. The bird

assemblage is a biogeographic mixture of south-west species (e.g. Silvereye), Central arid species (e.g. Chiming Wedgebill), Pilbara species (e.g. Blue-winged Kookaburra and White-plumed Honeyeater), and widespread species (e.g. Australian Ringneck and Galah). A locally extinct species, or at best vagrant bird, the Malleefowl is at the historical northern limit of distribution and has suffered from land clearing, changed fire regimes and introduced predators and are further discussed in the section on significant species. A recent record of a mound from Shark Bay (M. Bamford pers.obs) indicates this species may still occur locally on an occasional or vagrant basis.

The extant mammal fauna of 16 native and seven introduced species was documented by 4 native species and six introduced species recorded during the field survey. The extant native mammal fauna is low due to a number of regional and mainland extinctions. It is also noted that about half of the native mammal species in Table 6 are bats.

Table 6. Composition of vertebrate fauna assemblage of the survey area.

Taxon	Number of species	Number of species in each status category				
		Resident	Migrant or regular visitor	Irregular visitor	Vagrant	Locally extinct
Frogs	8 (1)	8 (1)	-	-	-	-
Reptiles	60 (24) (1 introduced)	60 (24)	-	1	-	-
Birds	142 (48) (2 introduced)	70 (36)	44 (9)	24 (1)	4	-
Native Mammals	16 (4)	12 (4)	1	3	-	5-
Introduced Mammals	7 (6)	4 (4)	2 (2)	-	1	-
Total	233 (83)	154 (69)	47 (11)	29 (1)	5 (0)	5 (0)

Values in parenthesis are the number of species confirmed as present within the survey area.

Eight potential Short Range Endemic specimens from candidate species groups were collected as by-catch in fauna traps at sample sites 2 and 3, and include: four scorpions, 1 mygalomorph spider, and three Isopods (Table 7) that were identified by Phoenix Environmental. None of these specimens was identified as a confirmed or listed SRE species. The spider and scorpions were juveniles and not identifiable down to species level. The Isopods were identified as a known but undescribed taxon that has a possibly restricted distribution within the mid-west coastal region.

Table 7. SRE specimens collected during the survey.

Family	Genus and species	Location		Comments and SRE potential
		Lat	Long	
Idiopidae	*Anidiops* sp. Indet.	[redacted]	[redacted]	1 juvenile mygalomorph spider, species identification not possible. Potential SRE. Site 2.
Buthidae	*Lychas* sp. Indet.	[redacted]	[redacted]	1 juvenile scorpion, species identification not possible. Not SRE. Site 3
Buthidae	*Lychas* sp. Indet.	[redacted]	[redacted]	1 juvenile scorpion, species identification not possible. Not SRE. Site 3.
Urodacidae	*Urodacus* sp. Indet.	[redacted]	[redacted]	1 juvenile scorpion, species identification not possible. Potential SRE. Site 3.
Armadillidae	B*uddelundia* '81'	[redacted]	[redacted]	3 female isopods. Only one further record: W.A. Balline ca.28 km S Kalbarri; possibly restricted coastal species. Potential SRE. Site3.
Urodacidae	*Urodacus* sp. Indet.	[redacted]	[redacted]	1 juvenile scorpion, species identification not possible. Potential SRE. Site 3.

3.2.2 Species of conservation significance

The current vertebrate assemblage includes 15 potentially occurring, or confirmed occurring species of conservation significance (Table 8). The overall list of significant species includes 7 CS1, 1 CS2 and 7 CS3 species. Several bird species listed as CS3 in the table were until recently listed as priority fauna (CS2) by DPaW, have been delisted but are acknowledged as CS3 in this report. A further two CS1 and four CS3 species that were recorded in close proximity to the survey area are included in Appendix 6.

Table 8. Composition of conservation significant vertebrate fauna.

Taxon	Conservation Significant fauna		
	CS1	CS2	CS3
Frogs	-	-	-
Reptiles	-	-	3
Birds	7 (1)	1	4 (1)
Native Mammals	-	-	-

Values in parenthesis are the number of conservation significant species recorded within the survey area during the field survey; CS – Conservation Significant).

As outlined in Appendix 3, species classed as CS1 are those listed under WA State and/or Commonwealth legislation, while those classed as CS2 are listed as Priority by the Department of Parks and Wildlife. The CS3 class is more subjective, but includes species that have declined extensively across the mid-west of WA, and some species that occur at the edge of their range in the Carnarvon area, or have limited local range. This makes their presence in the survey area significant as 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).

A list including details of all conservation significant fauna species of the survey area based on the desktop review and their expected status is presented in Table 9 below. Species recorded are indicated in the status column as 'confirmed'.

Table 9. Details on the conservation significant fauna species of the survey area.

Common Name	Latin Name	Conservation Status			Expected status in survey area
Reptiles		SC1	CS2	CS3	
Agamidae					
Collared Dragon	*Ctenophorus clayi*			CS3	Irregular visitor
Gnaraloo Heath Dragon	*Ctenophorus parviceps*			CS3	Irregular visitor
Diplodactylidae					
Exmouth Spiny-tailed Gecko	*Strophurus rankini*			CS3	Irregular visitor
Birds					
MEGAPODIIDAE					
Malleefowl	*Leipoa ocellata*	V S3			Vagrant
APODIDAE					
Fork-tailed Swift	*Apus pacificus*	M S5			Migrant
ACCIPITRIDAE					
White-bellied Sea-Eagle	*Haliaeetus leucogaster*			CS3	Irregular visitor *
Eastern Osprey	*Pandion cristatus*	M S5			Irregular visitor *
FALCONIDAE					
Peregrine Falcon	*Falco peregrinus*	S7			Confirmed. Irregular visitor.
Grey Falcon	*Falco hypoleucos*	V S3			Irregular visitor
OTIDIDAE					
Australian Bustard	*Ardeotis australis*			CS3	Confirmed. Regular visitor
BURHINIDAE					
Bush Stone-curlew	*Burhinus grallarius*			CS3	Regular visitor
MEROPIDAE					

Common Name	Latin Name	Conservation Status			Expected status in survey area
Rainbow Bee-eater	*Merops ornatus*	M S5			Migrant *
MALURIDAE					
Western Grasswren	*Amytornis textilis*		P4		Irregular visitor?
HIRUNDINIDAE					
Barn Swallow	*Hirundo rustica*	M S5			Migrant
ESTRILDIDAE					
Star Finch	*Neochmia ruficauda*			CS3	Regular visitor*
ARMADILLIDAE					
Isopod (slater)	*Buddelundia '81'*			CS3	Resident
Locally extinct species					
Bilby	*Macrotis lagotis*	Ex			Locally extinct
Boodie	*Bettongia lesueur*	Ex			Locally extinct
Shark Bay Mouse	*Pseudomys fieldi*	Ex			Locally extinct
Western Barred Bandicoot	*Perameles bougainville*	Ex			Locally extinct
Chuditch	*Dasyurus geofroii*	Ex			Locally extinct

* Recorded during survey in close proximity to the survey area.

See Appendix 3 for descriptions of conservation significance levels. Species recorded are indicated and the predicted status of each species in the survey area is also given.

EPBC Act listed species: Ex = Extinct, V = Vulnerable, E = Endangered, C = Critically Endangered, M = Migratory.

WC Act listed species: S1 – S7 = Schedule 1 - 7; DEC Priority Species: P1 - P5 = Priority 1 - 5.

3.2.2.1 Species of Conservation Significance level 1

Malleefowl

The Malleefowl is known from mallee eucalypt woodlands, and Dense Acacia shrublands. No mounds were recorded during the field survey. Carnarvon represents the northern limit of this species' distribution. Several historical records around Carnarvon are over 100 years old according to database searches. The closest recent recorded mounds are located approximately 200 km south, from the Shark Bay area (Mike Bamford pers.obs and mapped on the Atlas of Living Australia). Some areas of Acacia thicket (VSA 2) within the survey area represent potentially suitable vegetation, however the low elevation, alluvial topography and fine clay substrate, lacking gravel or pebble, is not considered as a marginal or non-preferred area for nest mounds, and due to the northerly location of the survey area, the Malleefowl is considered to occur rarely as a vagrant.

Rainbow Bee-eater and Fork-tailed Swift

Both these species are of high conservation significance because they are listed as migratory under the EPBC Act and Wildlife Conservation Act, but they are widespread. The Rainbow Bee-eater nests in burrows often in cleared land, or open sandy areas and is potentially a summer breeder within the survey area. VSA 1 is potential nesting habitat for the Rainbow Bee-eater. It was recorded in close

proximity to the survey area and is likely to be a summer breeding migrant resident in the survey area. The Fork-tailed Swift is less predictable but could be a regular, non-breeding summer visitor.

Eastern Osprey

A common and widespread coastal species that also occurs along estuarine and riparian near-coastal areas. It was recorded along the Gascoyne River during the survey and is likely to nest locally in power poles or other tall infrastructure. The survey area lacks suitable open water for hunting and tall nesting structures, but due to local occurrence, the species is considered to be an irregular visitor.

Peregrine Falcon

This species is known to occur over a wide range of environments across Australia. Preferred nesting locations include a range of elevated locations with steep bisected topography such as rocky hills, breakaways, cliffs and high artificial structures. It will also nest in very large, horizontally-aligned tree hollows, and in old Raven nests in tall trees (M. Bamford pers. obs.). The survey area lack elevated landscapes and tall trees, and is marginal nesting habitat at best, but provides habitat for hunting.

Grey Falcon

This species has an extensive but sparse distribution through much or northern Australia. It has been recorded in the wider Carnarvon area including along the Gascoyne River. The Acacia dominated shrublands and woodlands within the project area is potential habitat and proximity to Gascoyne River means that this species potentially visits the site on at least an irregular basis.

Barn Swallow

This species is regular in small numbers as a non-breeding summer migrant across northern Australia, and often occurs in association with man-made structures. It has previously been recorded in the Carnarvon region.

Migratory Waterbirds

This group includes an ibis, two egrets, two terns, and 32 waders (shorebirds) listed as Migratory under federal and/or state legislation and known to occur in the region. A number of species in this group were recorded outside the survey area but within the wider Carnarvon region and are included due to their potential local occurrence in claypan areas located in close proximity to the survey area, particularly near sites 3 and 4. These local claypans are extensive and expected for flood occasionally, providing shallow foraging habitat for a range of wetland species, any of which may occur as vagrants

3.2.2.2 Species of Conservation Significance level 2

Western Grasswren

This species is rare and has a patchy distribution restricted to the Carnarvon Basin area from Shark Bay north to about Exmouth. Whilst not expected to be a resident species of the survey area, it may visit due to local occurrence around Carnarvon and available open Acacia shrub land and grassy habitats (VSA 3 and 4).

3.2.2.3 Species of Conservation Significance level 3

White-bellied Sea-Eagle

This species was recently de-listed as migratory bird (CS1). A common widespread coastal species with similar ecology to the Osprey. Recorded in town site at the Gascoyne River mouth and likely to be an irregular visitor due to proximity of the survey area to the coast and Gascoyne River.

Australian Bustard

This species was recently removed from the DPaW priority fauna list (CS2). While it has declined across the southern half of its range, it remains common and widespread in the north, occurring in a range of open shrubland vegetation types. Recorded during the field survey near the southwest portion of the survey area. It is expected to be a regular visitor in the open shrublands and woodlands, VSAs 3 and 4.

Bush Stone-curlew

This species was recently removed from the DPaW priority fauna list (CS2). While it has declined across the southern half of its range, it remains locally common in the north, and is often associated with vegetation along drainage lines.

Star Finch

This species was recently removed from the DPaW priority fauna list (CS2). A widespread species of northern Australia in riparian areas and swampy margins with rushes or tall lush grasses, and it also forages in nearby grassland and shrubland areas. Recorded during the field survey near the southwest portion of the survey area and is expected to be a regular visitor.

Short Range Endemic (SRE) Invertebrates

The survey area does not generally support the sort of isolated and distinctive landscapes that are conducive to the evolution of SRE invertebrates, but drainage lines in the greater region may have a distinctive riparian invertebrate assemblage. The location of the survey area within the wider Gascoyne drainage system may also be conducive to SRE habitats. Of the eight potential Short Range Endemic specimens, three Isopods collected from pitfall traps at site 3 (VSA 2) were identified as *Buddelundia '81',* a known but undescribed taxon that possibly has a restricted distribution within the mid-west coast region. The only other record of this taxon is from a location just south of Kalbarri.

Aquatic macro-invertebrates can include SRE species and could not be sampled from claypans and/or drainage lines within or close to the project area as these were dry, but such wetlands in the area are well-represented along the Gascoyne River drainage system and floodplain. Therefore, aquatic macro-invertebrates in these wetlands are likely to be widespread at least within the Gascoyne drainage system.

3.2.3 Patterns of biodiversity

Investigating patterns of biodiversity can be complex and are often beyond the scope even of level 2 investigations. However, the presence of a mixture of VSAs is a factor that determines patterns of biodiversity. Within the survey area, the VSAs show varied degrees if vegetation condition. Some portions are mostly intact with minor historical agricultural disturbance, while others are highly degraded with very little vegetation structure or density. Fauna that occur in the open woodlands and shrublands (VSAs 3 and 4) throughout the region are likely to occur in or move through the survey area for foraging, resting, sheltering and nesting, depending on species. Areas that have relatively intact understorey are important for understorey dependent species such as some invertebrates, birds while intact low strata vegetation and associated ground debris are important for a range of invertebrates and small reptiles. Areas of Acacia thickets (VSA 2) are important for species that prefer dense cover such as some birds and mammals. Areas where the vegetation grows on elevated loose sandy substrates (VSA 1) that contrast with low lying alluvial clay support a suite of small vertebrates, particularly reptiles adapted for sandy environments.

Waterways can be of significance as they provide a unique environment for aquatic and riparian species such as waterbirds. The minor creeks within the survey area are limited by the sporadic, infrequent and temporary presence of water, but the vegetation along these areas provides some woodland connectivity along the creek system through the landscape to the Gascoyne River and minor creeks, even when dry, retain some relatively moist areas relative to surrounding plain and are refuges for a range of small terrestrial vertebrates in invertebrates. The presence of River Gums containing tree hollows along minor creeks is likely to influence patterns of distribution of fauna that rely on such hollows for shelter and breeding such as micro-bats, some bird and arboreal reptile species. As the landscape of the survey area is largely part of an alluvial plain surrounding the Gascoyne River system, it is subject to occasional flooding such that claypan areas provide brief foraging opportunities for a range of wetland birds. Thee claypans associated with some patches of VSA 3 are extensive outside the survey area.

Some patterns of biodiversity between sample sites and VSAs can be interpreted from capture data for reptile and mammal trapping and bird census from the standardised sampling methods. **Table 10** provides a summary of capture data for each trap transect (fauna sample sites 1-8).

Table 10. Summary of systematic fauna sampling results.

VSA Species	5 Site 1	1 Site 2	2 Site 3	2 Site 4	4 Site 5	3 Site 6	3 Site 7	4 Site 8	Total captures
Strophurus strophurus (gecko)		3		2				1	6
Diplodactylus bilybara (gecko)							1		1
Diplodactylus klugei Gecko)				1	1		3		5
Gehyra variegata (gecko)			1	3	2	8	2	3	19
Heteronotia binoei (gecko)					1			2	3
Lucasium squarrossum (gecko)		1							1
Nephrurus levis (gecko)		3							3
Delma tincta (legless lizard)	1		3			4			8
Lialis burtonis (legless lizard)				1					1
Pygopus nigriceps (legless lizard)			1		1				2
Ctenotus pantherinus (skink)				1			1		2
Lerista macropisthopus (skink)	2		2	6	4	2	2	1	19
Lerista uniduo (skink)		12		1					13
Menetia greyii (skink)	1			3	3	1		1	9
Moloch horridus (dragon)		1		1					2
Pogona minor (dragon)	1		2	1	2	1			7
Demansia calodera (snake)					1				1
Pseudonaja mengdeni (snake)		1							1
Sminthopsis macroura (dasyurid)		2	2			2			6
Mus musculus (rodent)				3		3	1	1	8
Total Species (species richness)	4	7	6	11	8	7	6	6	
Total Captures (fauna abundance)	5	23	11	23	15	21	10	9	117

The table presents a comparative measure of species richness based on the number of species recorded, and fauna abundance based on the total number of animals captured in each of the eight systematic sampling sites. The total number of captures (abundance) of reptiles and mammals combined more or less reflects species richness across the sites. The two most commonly trapped reptiles were the gecko *Gehyra variegata* and skink *Lerista macropisthopis*, with each species accounting for 18 percent of all captures. Both species were also the most widespread, being recorded at more sample sites and across most VSAs than any other species. In contrast, another skink *Lerista uniduo* was abundant only at site 2 (VSA 1), which was the only VSA with loose sandy substrate. This result probably reflects the different substrate preferences of the two *Lerista* skinks: *L. macropisthopis* preferring the hard loamy clay, while *L. uniduo* preferring loose sand of VSA 1. The Knob-tailed Gecko (*Nephrurus levis*), only recorded at VSA 1, also shows preference for loose sandy substrate or the associated higher ground of VSA 1.

Some species that appear to be scarce (low capture number) such as the geckos *Diplodactylus bilybara* and *Lucasium squarrosum* can be abundant, but may be in low numbers due to seasonal influences on activity, and other species may occur naturally low numbers across their range such as the whip snake *Demansia calodera*. All mammal and reptile species recorded are considered common at a regional scale.

The bird census data for each of the eight systematic sample sites is summarised in Table 11 below, showing a total of 618 birds from 19 species recorded. Sites with the highest species count included VSA5 (minor creek) and VSA 2 (shrubland thicket). Species that prefer dense, low vegetation such as Silvereye and Singing Honeyeater were most abundant within this VSA, which also recorded relatively high bird abundance. Site 5 (VSA 4) was noticeably poor in species richness. The most abundant bird across most sites was the Zebra Finch accounting for over half of the birds recorded.

Table 11. Summary of bird census results.

VSA	5	1	2	2	4	3	3	4	Total captures
Species	**Site 1**	**Site 2**	**Site 3**	**Site 4**	**Site 5**	**Site 6**	**Site 7**	**Site 8**	
Australian Bustard		1				1			2
Australian Ringneck	1								1
Black-faced Cuckoo-shrike		4	1						5
Chiming Wedgebill	4		2	4			1		11
Crested Pigeon	5	6				3			14
Grey Shrike-thrush	1								1
Laughing Dove			3	4					7
Little Crow	5	1		21			2	1	30
Nankeen Kestrel		2						1	3
Redthroat			1	3		3	3		10
Rufous Whistler	1			1					2
Rufous Songlark	3	1							4
Silvereye			2	14		2			18
Singing Honeyeater	2		13	10		1	2	1	29
Variegated Fairy-wren			4	4	2	5	2	4	21
White-browed Babbler	1	1		4					6
White-plumed Honeyeater	9	2							11
White-winged Fairy-wren			9	1		4	12	6	32
Zebra Finch	6		20	7	36	294	32	16	411
Total species	11	8	9	11	2	8	7	6	
Total birds	38	18	55	73	38	313	54	29	618

3.2.4 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 4 for descriptions and other ecological processes). These include:

Local hydrology. The entire landscape of the survey area is part of an alluvial floodplain surrounding the Gascoyne River. Temporary wetlands form on claypans very close to the project area and such occasional shallow water-bodies that may be important for mobile wetland fauna. In addition, the Gascoyne River passes close to portions of the survey area, providing some local connectivity for aquatic-associated species. Maintaining local hydrology is considered to be important to fauna in the present project.

Fire. The vegetation of the Carnarvon bioregion is fire-adapted to some degree but the flora and fauna assemblages can be altered by too-frequent fires; and even by fire exclusion. Some species are particularly sensitive to wildfires and altered fire regimes. Fire season may also be important in seed germination. As the site consists of open woodland and shrublands with some areas of shrubland thicket, fire is expected to occur at the site. Fire could further reduce recruitment of the remnant woodland vegetation and hence the biodiversity and resilience of the area in the absence of remedial action.

Feral species and interactions with over-abundant native species. Feral species occur throughout Western Australia, with several feral species being recorded during the field survey. It is expected that the fauna assemblage within the survey areas has been impacted by feral species (particularly foxes and cats), which has resulted in the loss of some mammal and bird species. Rabbits and goats have caused degradation to the native vegetation and, in combination with introduced predators (cats, dogs and foxes), reduces the capacity of the area to support native fauna diversity.

Connectivity and landscape permeability. The survey area is part of a much greater area of native vegetation. The shrublands in the survey area provide connectivity between the native vegetation, particularly to the north and south, with fauna such as birds and mammals likely to move across the landscape. Drainage lines have distinctive vegetation that can be important for connectivity.

3.2.5 Summary of fauna values

The desktop study identified 233 vertebrate fauna species as potentially occurring in the Carnarvon survey area: 8 frogs, 60 reptiles, 142 birds, and 16 native and 7 introduced mammals. The vertebrate assemblage includes 15 species of conservation significance. One possible SRE invertebrate was recorded. A further group of conservation significant species, the migratory shore birds, potentially occur as vagrants on flooded claypan areas located near the northern and southern edges of the survey area. Fauna values within the survey area can be summarised as follows:

Fauna assemblage. Moderately intact (but lacking several mammal species) and moderately rich, and broadly typical of the extensive near-coastal shrublands of the Carnarvon bioregion, and with some fauna species from adjacent bioregions.

Species of conservation significance. Some significant species are likely to occur as residents of the survey area, or at least as regular visitors. Several species have a restricted distribution to within the region, and for several others the survey area represents the northern or southern limit of distribution making their presence in the survey area significant.

The potential occasional occurrence of migratory shorebirds are probably the significant species of greatest note. A number of species in this group were recorded outside the survey area but within the wider Carnarvon area and are included due to their potential local occurrence in claypan areas located in close proximity to the survey area, particularly northern and southern edges. These claypans are extensive beyond the survey area and expected for flood occasionally providing shallow foraging habitat for a range of wetland species, any of which may occur as vagrants for brief periods while surface water is present.

Vegetation and Substrate Associations (VSAs). There are five important VSAs identified. Most of the survey area contains open Acacia shrubland plains with varying amounts of sparse eucalyptus woodland and some areas with chenopods (VSAs 3 and 4), and patches of Acacia thicket. There are limited creeklines and other low order drainage lines (VSA 5) that feed into the Gascoyne River, and some localised low sand dunes (VSA 1) that contrast to the extensive surrounding alluvial clay plains, and that support an assemblage of sand-adapted and fossorial reptiles.

Patterns of biodiversity. Examining patterns of biodiversity in detail is outside the scope of this assessment, but it can be predicted that important features for biodiversity will be: close proximity of the study area to the Gascoyne River, the geographic position and landform characteristics.

Key ecological processes. The main process which may affect the fauna assemblage is likely to be local hydrology of the Gascoyne River system, and localised occasional flooding, the fire regime and the presence of feral predators. The Gascoyne River provides dispersal corridors for some fauna, particularly birds.

4 Impact Assessment

Impacting processes have to be considered in the context of fauna values and the nature of the proposed agricultural expansion, and are examined below. Predicted impacts need to be considered in the light of recommendations made in Section 6.

Habitat loss leading to population decline.

The proposed action would remove native vegetation adjacent to the existing agriculturally developed areas along the Gascoyne River. This does reduce the extent of vegetation and therefore fauna habitats associated with the margins of the floodplain, although such vegetation is widespread along the Gascoyne River. Minor creeks and drainage lines (VSA 5) may be vulnerable to loss as they are limited in extent (see recommendations). Note that some fauna species, such as some birds, may benefit from the food (invertebrates) and water opportunities provided by irrigation and crops. Impacts due to habit loss are expected to be minor.

Habitat loss leading to population fragmentation.

The proposed disturbance footprint is adjacent to existing horticulture areas. For some fauna species, such as small reptiles, this may reduce connectivity between the northern and southern sides of the River by widening the area of agricultural development, although for such species connectivity across the river is probably already limited. The development of a broader section of land especially on the north side of the river may reduce the ability of fauna to move through this landscape.

Degradation of habitat due to weed invasion.

Ground disturbance, irrigation, vehicle movement (tractors and other agricultural equipment) is likely to spread weeds from the existing horticultural areas into the expansion areas, and introduce additional species (see recommendations). During the field investigations, it was noted that vegetation adjacent to existing agricultural areas was already degraded by weed invasion and the dumping of rubbish, some of which clearly came from adjacent farms. These forms of degradation could further widen the area of habitat loss for fauna and in the long-term could be a Moderate impact, although management is possible (see below).

Ongoing mortality from operations.

Some fauna may be at risk from roadkill but this will depend upon levels of vehicle activity. Impact can be assumed to be minor (see recommendations).

Species interactions.

Some of the fauna is sensitive to feral species such as Foxes and Cats. These are present within the survey area and adjacent bushland and agricultural areas. New roads through previously intact native vegetation allow increased access to feral species. Feral species can also be attracted to areas of human activity. Impact can be kept to minor subject to recommendations. The Cane Toad may be

an additional impact if recent modelling of toad spread is accurate, as increased horticulture could aid toad establishment around Carnarvon in the future.

Hydrological change

The minor creek and other drainage lines are likely to be diverted or become part of the expanded irrigation and drainage. Considering that these creeks are dry for the majority of the time, and considering the volumes of water and silt that flow through the Gascoyne River during heavy rain, the hydrological impacts of silt or altered water flow from modifications to natural drainage lines is likely to be negligible. With expanding agriculture, increased sub-surface water abstraction from the Gascoyne River bed may be a risk of impacts on riparian vegetation along the Gascoyne River through reduced water table in the dry season. Impact risk can be reduced to minor subject to recommendations.

Altered fire regimes

The vegetation in general is fire-dependent and many of the fauna species are reliant on particular fire regimes, and therefore sensitive to any alteration to the fire regime. Fire regime and feral species can interact to increase pressure on a species. The proposed activity represents a minor risk of altered fire regimes within the bushland adjacent to the expanded horticulture areas that could affect fauna outside the survey area (see recommendations).

Disturbance (dust, noise, light).

The level of dust, noise and light from the proposed action is uncertain but impacts would be localised and therefore unlikely to be more than minor. See recommendations below.

5 Recommendations

Section 5 (Impact Assessment) identified several potential adverse impacts upon fauna that may occur from the disturbance to the site from the proposed horticulture expansion. Although impacts are mostly expected to be minor or less, any reduction in impacts is desirable, and some assessments of minor or negligible impacts are reliant on recommendations. Management strategies are recommended below to reduce the potential impacts of this development on fauna species.

Hydrological changes

- Minimise alterations of runoff through any retained drainage lines.
- Avoid changes to drainage that will drain claypan areas adjacent to the proposed activity. This will ensure retention of wader bird habitat (occasional flooded claypans).

Loss of habitat

- Minimise the disturbance footprint and where possible maintain trees and native shrubs that provide nesting food, shelter and hollows for significant species.
- Clearly delineate areas to be cleared to minimise unnecessary vegetation loss.

Habitat fragmentation

- Minimise disturbance to the Gascoyne River and associated minor drainage lines.

Weed invasion and habitat degradation

- Employ industry standard hygiene to avoid introducing weeds into the project area.
- Consider an education programme to reduce spray drift and dumping on land outside agricultural areas.

Species interactions

- Ensure appropriate waste disposal during construction activities and ongoing to avoid attracting feral species to the area.
- Educate personnel and landholders not to feed (deliberately or inadvertently) feral species.

Changes in fire regime

- Implement a fire management plan during construction activities to ensure wildfires do not occur as a result of activities and appropriate responses are in place should a wildfire occur.

Dust, noise, light and disturbance

- Agricultural practices should endeavour to minimise spray drift and light pollution into surrounding native vegetation. During clearing operations, industry standard dust, light and noise suppression should be carried out.

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7 Appendices

7.1 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, 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 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 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. 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 DPaW, 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.

7.2 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. 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; 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.

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

IUCN categories (based on review by Mace and Stuart 1994) as used for theEnvironment 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).

7.4 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 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?

7.5 Appendix 5. Vertebrate fauna expected to occur in the survey area.

These lists are derived from the results of database and literature searches and from previous field surveys conducted in the local area. These are:

- ALA = Atlas of Living Australia, searchedSeptember 2016;
- Nat Map = Naturemap Database, searchedSeptember2016;
- Bird Data = Birdlife Australia's Birdata database, searched September 2016;
- RNO = Ravensthorpe Nickel
- BCE 2016= Site inspection September 2016.

Status codes:

- CS1, CS2, CS3 = (summary) levels of conservation significance. See Appendix 2 for full explanation.
- EPBC Act listings: E = Endangered, V = Vulnerable, M = Migratory (see Appendix 2).
- Wildlife Conservation Act listings: for all CS1 species S1 to 7 = Schedules 1 to 7 respectively, (see Appendix 2) with rankings shown in square parentheses: [e] = endangered, [v] = vulnerable.
- DEC Priority species: P1 to P5 = Priority 1 to 5 (see Appendix 2).
- LS = considered to be of local significance by Bamford Consulting Ecologists (see Appendix 2).

FROGS

Species		CS	ALA	N.Map	EPBC	BCE 2016	Status
HYLIDAE							
Desert Tree Frog	*Litoria rubella*		X	X			resident
Main's Frog	*Cyclorana maini*		X	X		X	resident
Water Holding Frog	*Cyclorana platycephala*			X			resident
LIMNODYNASTIDAE							
Russell's Toadlet	*Uperoleia russelli*		X	X			resident
Goldfields Bullfrog	*Neobatrachus wilsmorei*		X	X			resident
Tawny Trilling Frog	*Neobatrachus fulvus*			X			resident
Shoemaker Frog	*Neobatrachus sutor*		X	X			resident
MYOBATRACHIDAE							
Spencer's Burrowing Frog	*Platyplectrum spenceri*		X	X			resident
Total number of species	8	0	6	8	0	1	

REPTILES		CS	ALA	N.Map	EPBC	BCE 2016	Status
CHELIDAE							
Flat-shelled Tortoise	*Chelodina steindachneri*		X	X			irregular visitor
AGAMIDAE							
Long-nosed Dragon	*Amphibolurus longirostris*		X	X		X	resident
Collared Dragon	*Ctenophorus clayi*	CS3		X			Irregular visitor
Spotted Military Dragon	*Ctenophorus maculatus*		X	X			resident
Central Netted Dragon	*Ctenophorus nuchalis*		X	X			resident
Gnaraloo Heath Dragon	*Ctenophorus parviceps*	CS3	X				irregular visitor
Western Netted Dragon	*Ctenophorus reticulatus*		X	X			resident
Lozenge-marked Dragon	*Ctenophorus scutulatus*		X	X			resident
Thorny Devil	*Moloch horridus*		X	X		X	resident
Dwarf Bearded Dragon	*Pogona minor*		X	X		X	resident
Mulga Dragon	*Diporiphora amphiboluroides*		X				irregular visitor
DIPLODACTYLIDAE							
Clawless Gecko	*Crenadactylus ocellatus*		X				resident
Western Fat-tailed Gecko	*Diplodactylus bilybara*		X	X		X	resident
Kluge's Gecko	*Diplodactylus klugei*		X			X	resident
Yellow-snouted Ground Gecko	*Lucasium squarrosum*			X		X	resident
Beaked Gecko	*Rhynchoedura ornata*						resident
Exmouth Spiny-tailed Gecko	*Strophurus rankini*	CS3	X	X			Irregular visitor
Western Spiny-tailed Gecko	*Strophurus strophurus*		X	X		X	resident
CARPHODACTYLIDAE							
Smooth Knob-tailed Gecko	*Nephrurus levis*		X	X		X	resident
GEKKONIDAE							
Tree Dtella	*Gehyra variegata*		X	X		X	resident
Bynoe's Gecko	*Heteronotia binoei*		X	X		X	resident
Asian House Gegko	*Hemidactylus frenatus*	int		X		X	resident

REPTILES		CS	ALA	N.Map	EPBC	BCE 2016	Status
PYGOPODIDAE			X				
Excitable Delma	*Delma tincta*		X	X		X	resident
Burton's Snake-lizard	*Lialis burtonis*		X			X	resident
Hooded Scalyfoot	*Pygopus nigreceps*			X		X	resident
SCINCIDAE			X				
Inland Snake-eyed Skink	*Cryptoblepharus australis*		X				resident
Peron's Snake-eyed Skink	*Cryptoblepharus plagiocephalus*		X	X			resident
Helen's Skink	*Ctenotus helenae*		X	X			irregular visitor
Striped Skink	*Ctenotus fallens*			X			resident
Checker-sided Skink	*Ctenotus mimetes*						resident
Leopard Ctenotus	*Ctenotus pantherinus*		X	X		X	resident
Barred Wedge-snouted Skink	*Ctenotus schomburgkii*						resident
Pygmy Spiny-tailed Skink	*Egernia depressa*		X	X			resident
Elegant Slider	*Lerista elegans*						resident
Blinking Broad-blazed Slider	*Lerista connivens*		X	X			resident
Gascoyne Broad-blazed Slider	*Lerista gascoynensis*		X				resident
Unpattened Robust Slider	*Lerista macropisthopus*			X		X	resident
Three-toed Slider	*Lerista micra*		X	X			resident
Keeled Slider	*Lerista planiventralis*		X	X			resident
Blunt-tailed West-coast Slider	*Lerista praepedita*		X	X			resident
Slender Broad-blazed Slider	*Lerista uniduo*		X	X		X	resident
Common Dwarf Skink	*Menetia greyii*		X	X		X	resident
Pale-flecked Snake-eyed Skink	*Morethia lineoocellata*						resident
Western Blue-tongue	*Tiliqua occipitalis*		X	X		X	resident
Bobtail	*Tiliqua rugosa*		X	X		X	resident
VARANIDAE							
Stripe-tailed Monitor	*Varanus caudolineatus*						resident
Pygmy Desert Monitor	*Varanus eremius*			X			resident
Gould's Goanna	*Varanus gouldii*		X	X		X	resident

REPTILES		CS	ALA	N.Map	EPBC	BCE 2016	Status
TYPHLOPIDAE							
Pale-headed Blind Snake	*Anilios hamatus*		X				resident
Beaked Blind Snake	*Anilios grypus*		X				resident
BOIDAE							
Stimson's Python	*Antaresia stimsoni*		X	X			resident
ELAPIDAE			X				
North-western Shovel-nosed Snake	*Brachyurophis approximans*						resident
Black-necked Whipsnake	*Demansia calodera*		X	X		X	resident
Yellow-faced Whip Snake	*Demansia psammophis*		X	X			resident
Moon Snake	*Furina ornata*		X	X			resident
Mulga Snake	*Pseudechis australis*		X	X		X	resident
Gwardar	*Pseudonaja mengdeni*		X	X		X	resident
Ringed Brown Snake	*Pseudonaja modesta*		X	X			resident
Jan's Banded Snake	*Simoselaps bertholdi*		X	X			resident
Rosen's Snake	*Suta fasciata*						resident

BIRDS		CS	ALA	N.Map	EPBC	BA	BCE 2016	Status
CASUARIIDAE								
Emu	*Dromaius novaehollandiae*		X	X		X	X	regular visitor
MEGAPODIIDAE								
Malleefowl	*Leipoa ocellata*	V S3 (CS1)	X		X			vagrant
GURIDAE								
Brolga	*Grus (Mathewsia) rubicunda*		X	X				irregular visitor
PODARGIDAE								
Tawny Frogmouth	*Podargus strigoides*		X	X		X	X	regular visitor
AEGOTHELIDAE								
Australian Owlet Nightjar	*Aegotheles cristatus*		X	X		X		resident
Spotted Nightjar	*Eurostopodus argus*					X		regular visitor
APODIDAE								
Fork-tailed Swift	*Apus pacificus*	M S5 (CS1)	X	X	X	X		migrant
ACCIPITRIDAE								
Whistling Kite	*Haliastur sphenurus*		X	X		X	X	regular visitor
Black-shouldered Kite	*Elanus axillaris*		X	X		X	X	regular visitor
Brahminy kite	*Haliastur indus*		X	X		X	*	irregular visitor
Swamp Harrier	*Circus approximans*		X	X		X		irregular visitor
Wedge-tailed Eagle	*Aquila audax*		X	X		X	X	regular visitor
White-bellied Sea-Eagle	*Haliaeetus leucogaster*	CS3	X	X	X	X	*	irregular visitor
Black Kite	*Milvus migrans*		X	X		X		regular visitor
Little Eagle	*Hieraaetus morphnoides*		X			X		regular visitor
Eastern Osprey	*Pandion cristatus*	M S5 (CS1)	X	X	X	X	*	irregular visitor
Collared Sparrowhawk	*Accipiter cirrocephalus*		X	X		X		regular visitor
Spotted Harrier	*Circus assimilis*		X	X		X		regular visitor

BIRDS		CS	ALA	N.Map	EPBC	BA	BCE 2016	Status
Brown Goshawk	*Accipiter fasciatus*		X	X		X		regular visitor
Black-breasted Buzzard	*Hamirostra melanosternon*		X	X		X		regular visitor
Square-tailed Kite	*Lophoictinia isura*		X	X		X		regular visitor
FALCONIDAE								
Nankeen Kestrel	*Falco cenchroides*		X	X		X	X	resident
Australian Hobby	*Falco longipennis*		X	X		X		regular visitor
Brown Falcon	*Falco berigora*		X	X		X		vagrant
Peregrine Falcon	*Falco peregrinus*	S7 (CS1)	X	X		X	X	irregular visitor
Grey Falcon	*Falco hypoleucos*	V S3 (CS1)	X	X		X		irregular visitor
Black Falcon	*Falco subniger*		X			X		irregular visitor
OTIDIDAE								
Australian Bustard	*Ardeotis australis*	CS3	X	X		X	X	regular visitor
RECURVIROSTRIDAE								
Black-winged Stilt	*Himantopus himantopus*		X	X	X	X	*	irregular visitor
Red-necked Avocet	*Recurvirostra novaehollandiae*		X	X		X		irregular visitor
Banded Stilt	*Cladorhynchus leucocephalus*		X	X		X		irregular visitor
CHARADRIIDAE								
Black-fronted Dotterel	*Elseyornis melanops*		X	X		X		irregular visitor
Red-kneed Dotterel	*Erythrogonys cinctus*		X	X		X		irregular visitor
Inland Dotterel	*Peltohyas australis*					X		irregular visitor
Red-capped Plover	*Charadrius ruficapillus*		X	X	X	X	*	irregular visitor
Banded Lapwing	*Vanellus tricolor*		X	X		X		irregular visitor

BIRDS		CS	ALA	N.Map	EPBC	BA	BCE 2016	Status
PHASIANIDAE								
Stubble Quail	*Coturnix pectoralis*		X	X		X		resident
Brown Quail	*Coturnix ypsilophora*		X	X		X		resident
TURNICIDAE								
Little Button-quail	*Turnix velox*		X	X		X	X	resident
BURHINIDAE								
Bush Stone-curlew	*Burhinus grallarius*	CS3	X					regular visitor
COLUMBIDAE								
Laughing Dove	*Streptopelia senegalensis*	Int	X	X	X	X	X	resident
Spinifex Pigeon	*Geopelia plumifera*					X		regular visitor
Peaceful Dove	*Geopelia striata*		X	X		X	X	resident
Feral Pigeon	*Columba livia*	Int	X	X	X	X	*	resident
Crested Pigeon	*Ocyphaps lophotes*		X	X		X	X	resident
Diamond Dove	*Geopelia cuneata*		X	X		X	X	resident
Common Bronzewing	*Phaps chalcoptera*		X	X		X	X	resident
CACATUIDAE								resident
Galah	*Eolophus roseicapillus*		X	X		X	X	resident
Little Corella	*Cacatua sanguinea*		X	X		X	X	resident
Cockatiel	*Nymphicus hollandicus*		X	X		X		regular visitor
PSITTACIDAE								
Budgerigar	*Melopsittacus undulatus*		X	X		X		regular visitor
Australian Ringneck	*Barnardius zonarius*		X	X		X	X	resident
Elegant Parrot	*Neophema elegans*		X	X		X		regular visitor
Bourke's Parrot	*Neopsephotus bourkii*		X			X		regular visitor
Mulga Parrot	*Psephotus varius*		X	X		X		regular visitor

BIRDS		CS	ALA	N.Map	EPBC	BA	BCE 2016	Status
CUCULIDAE								
Horsfield's Bronze-Cuckoo	*Chrysococcyx basalis*		X			X		regular visitor
Pallid Cuckoo	*Cacomantis pallidus*		X	X		X		regular visitor
Black-eared Cuckoo	*Chrysococcyx osculans*		X			X		regular visitor
Shining Bronze-Cuckoo	*Chrysococcyx lucidus*		X			X		regular visitor
STRIGIDAE								
Southern Boobook	*Ninox novaeseelandiae*		X	X		X		regular visitor
TYTONIDAE								
Barn Owl	*Tyto javanica*		X			X		regular visitor
HALCYONIDAE								
Collared Kingfisher	*Todiramphus chloris*		X	X		X		irregular visitor
Red-backed Kingfisher	*Todiramphus pyrrhopygius*		X	X		X		regular visitor
Sacred Kingfisher	*Todiramphus sanctus*		X	X		X	X	resident
Blue-winged Kookaburra	*Dacelo leachii*		X	X		X	X	resident
MEROPIDAE								
Rainbow Bee-eater	*Merops ornatus*	M S5 (CS1)	X	X	X	X	*	migrant
CORACIIDAE								
Dollarbird	*Eurystomus orientalis*		X	X		X		migrant
CLIMACTERIDAE								
White-browed Treecreeper	*Climacteris affinis*		X					regular visitor
MALURIDAE								
White-winged Fairy-wren	*Malurus leucopterus*		X	X		X	X	resident
Variegated Fairy-wren	*Malurus lamberti*		X	X		X	X	resident
Splendid Fairy-wren	*Malurus splendens*		X	X		X		resident
Western Grasswren	*Amytornis textilis*	CS2	X					regular visitor
Rufous-crowned Emu-wren	*Stipiturus ruficeps*		X					irregular visitor

BIRDS		CS	ALA	N.Map	EPBC	BA	BCE 2016	Status
ACANTHIZIDAE								
Dusky Gerygone	*Gerygone tenebrosa*		X	X		X		irregular visitor
Redthroat	*Pyrrholaemus brunneus*		X	X		X	X	resident
Rufous Fieldwren	*Calamanthus campestris*		X	X		X	X	resident
White-browed Scrubwren	*Sericornis frontalis*		X	X		X		resident
Slender-billed Thornbill	*Acanthiza iredalei*		X	X		X		irregular visitor
Western Gerygone	*Gerygone fusca*		X	X		X		resident
Inland Thornbill	*Acanthiza apicalis*		X					regular visitor
Weebill	*Smicrornis brevirostris*		X	X		X		resident
Chestnut-rumped Thornbill	*Acanthiza uropygialis*		X	X		X		resident
Yellow-rumped Thornbill	*Acanthiza chrysorrhoa*			X		X		irregular visitor
Southern Whiteface	*Aphelocephala leucopsis*			X		X		regular visitor
PARDALOTIDAE								
Red-browed Pardalote	*Pardalotus rubricatus*		X					regular visitor
Striated Pardalote	*Pardalotus striatus*			X		X		resident
MELIPHAGIDAE								
White-plumed Honeyeater	*Ptilotula penicillata*		X	X		X	X	resident
Singing Honeyeater	*Gavicalis virescens*		X	X		X	X	resident
Spiny-cheeked Honeyeater	*Acanthagenys rufogularis*		X	X		X	X	resident
Pied Honeyeater	*Certhionyx variegatus*		X	X		X	X	resident
Crimson Chat	*Epthianura tricolor*		X	X		X		resident
White-fronted Chat	*Epthianura albifrons*		X	X		X		resident
Yellow-throated Miner	*Manorina flavigula*		X	X		X		resident
Brown Honeyeater	*Lichmera indistincta*		X	X		X	X	resident
Orange Chat	*Epthianura aurifrons*		X	X		X		resident

BIRDS		CS	ALA	N.Map	EPBC	BA	BCE 2016	Status
White-fronted Honeyeater	*Purnella albifrons*		X	X		X		resident
Black Honeyeater	*Sugomel niger*		X	X		X		resident
Grey-headed Honeyeater	*Ptilotula keartlandi*		X			X		resident
POMATOSTOMIDAE								
White-browed Babbler	*Pomatostomus superciliosus*		X	X		X	X	resident
Grey-crowned Babbler	*Pomatostomus temporalis*		X	X		X		resident
PSOPHODIDAE								
Chiming Wedgebill	*Psophodes occidentalis*		X	X		X	X	resident
Chestnut-breasted Quail-thrush	*Cinclosoma (castaneothorax*		X					irregular visitor
CAMPEPHAGIDAE								
Black-faced Cuckoo-shrike	*Coracina novaehollandiae*		X	X		X	X	resident
White-winged Triller	*Lalage sueurii*		X	X		X	X	resident
PACHYCEPHALIDAE								
Grey Shrike-thrush	*Colluricincla harmonica*		X	X		X	X	resident
White-breasted Whistler	*Pachycephala lanioides*		X	X		X		regular visitor
Rufous Whistler	*Pachycephala rufiventris*		X	X		X	X	resident
Mangrove Golden Whistler	*Pachycephala melanura*		X					vagrant
OREOICIDAE								
Crested Bellbird	*Oreoica gutturalis*		X	X		X	X	resident
ARTAMIDAE								
Pied Butcherbird	*Cracticus nigrogularis*		X	X		X	X	resident
White-breasted Woodswallow	*Artamus leucorynchus*		X	X		X	*	regular visitor
Black-faced Woodswallow	*Artamus cinereus*		X	X		X		resident

BIRDS		CS	ALA	N.Map	EPBC	BA	BCE 2016	Status
Australian Magpie	*Cracticus tibicen*		X	X		X		resident
Masked Woodswallow	*Artamus (Campbellornis) personatus*		X	X		X		resident
Grey Butcherbird	*Cracticus torquatus*		X	X		X		resident
Little Woodswallow	*Artamus (Angroyan) minor*		X					regular visitor
RHIPIDURIDAE								
Willie Wagtail	*Rhipidura (Sauloprocta) leucophrys*		X	X		X		resident
Mangrove Grey Fantail	*Rhipidura phasiana*		X	X		X		vagrant
Grey Fantail	*Rhipidura albiscapa*		X	X		X		resident
CORVIDAE								
Little Crow	*Corvus bennetti*		X	X		X	X	resident
Torresian Crow	*Corvus orru*		X	X		X		resident
Australian Raven	*Corvus coronoides*		X	X		X		resident
MONARCHIDAE								
Magpie-lark	*Grallina cyanoleuca*		X	X		X	X	resident
PETROICIDAE								
Red-capped Robin	*Petroica goodenovii*		X	X		X		resident
Hooded Robin	*Melanodryas cucullata*		X			X		resident
LOCUSTELLIDAE								
Brown Songlark	*Cincloramphus cruralis*		X	X		X	X	resident
Rufous Songlark	*Cincloramphus (Maclennania) mathewsi*		X	X		X	X	resident
Little Grassbird	*Megalurus gramineus*		X	X		X		regular visitor
Spinifexbird	*Eremiornis carteri*		X					irregular visitor

BIRDS		CS	ALA	N.Map	EPBC	BA	BCE 2016	Status
HIRUNDINIDAE								
Tree Martin	*Petrochelidon nigricans*		X			X	*	resident
Welcome Swallow	*Hirundo neoxena*		X	X		X	*	resident
White-backed Swallow	*Cheramoeca leucosterna*		X	X		X	X	resident
Fairy Martin	*Petrochelidon ariel*		X			X		regular visitor
Barn Swallow	*Hirundo rustica*	M S5 (CS1)	X	X	X	X		migrant
NECTARINIIDAE								
Mistletoebird	*Dicaeum hirundinaceum*		X	X		X	X	resident
ESTRILDIDAE								
Zebra Finch	*Taeniopygia guttata*		X	X		X	X	resident
Star Finch	*Neochmia ruficauda*	CS3	X	X		X	*	regular visitor
Painted Finch	*Emblema pictum*		X					irregular visitor
ALAUDIDAE								
Horsfield's Bushlark	*Mirafra javanica*		X	X		X		regular visitor
MOTACILLIDAE								
Australasian Pipit	*Anthus novaeseelandiae*		X	X		X	X	resident
TIMALIIDAE								
Silvereye	*Zosterops lateralis*		X	X		X	X	resident
Yellow White-eye	*Zosterops luteus*		X	X		X		regular visitor
Total Number of Species Expected:	142	14	136	116	10	129	56	

MAMMALS		SC	ALA	N.Map	EPBC	BCE 2016	Status
TACHYGLOSSIDAE							
Echidna	*Tachyglossus aculeatus*					X	Resident
DASYURIDAE							
Stripe-faced Dunnart	*Sminthopsis macroura*		X	X		X	Resident
MACROPODIDAE							
Red Kangaroo	*Macropus rufus*		X	X		X	Regular visitor
MOLOSSIDAE							
White-striped Freetail-bat	*Austronomus australis*		X	X			Regular visitor
Northern Freetail-bat	*Chaerephon jobensis*			X			Regular visitor
VESPERTILIONIDAE							
Lesser Long-eared Bat	*Nyctophilus geoffroyi*			X			Regular visitor
Little Broad-nosed Bat	*Scotorepens greyii*			X			Regular visitor
PTEROPODIDAE			X				
Black Flying-fox	*Pteropus alecto*			X			Vagrant
MURIDAE							
Spinifex Hopping-mouse	*Notomys alexis*		X	X		X	Resident
INTRODUCED MAMMALS							
Dog/Dingo	*Canis lupus*	Int.				X	Regular visitor
Goat	*Capra hircus*	Int.			X	X	Regular visitor
Cat	*Felis catus*	Int.			X	X	Resident
House Mouse	*Mus musculus*	Int.				X	Resident
Rabbit	*Oryctolagus cuniculus*	Int.			X	X	Resident
Sheep	*Ovis aries*	Int.	X	X			Vagrant
Red Fox	*Vulpes vulpes*	Int.			X	X	Resident
Total Number of Species Expected:	**16**	**7**	**6**	**9**	**4**	**10**	

7.6 Appendix 6. Wetland Birds potentially occurring as vagrants of flooded claypans in close proximity to survey area.

WETLAND BIRDS		CS	ALA	N.Map	EPBC	BA	BCE 2016	Status
ANATIDAE								
Pacific Black Duck	*Anas superciliosa*		X			X	*	vagrant
Grey Teal	*Anas gracilis*		X	X			*	vagrant
Black Swan	*Cygnus atratus*		X	X		X		vagrant
Hardhead	*Aythya australis*		X	X		X	*	vagrant
Pink-eared Duck	*Malacorhynchus membranaceus*		X	X		X		vagrant
Australian Wood Duck	*Chenonetta jubata*		X	X		X		vagrant
Plumed Whistling-Duck	*Dendrocygna (Leptotarsis) eytoni*		X	X		X	*	vagrant
Australian Shelduck	*Tadorna (Casarca) tadornoides*		X	X		X	*	vagrant
Musk Duck	*Biziura lobata*		X	X		X		vagrant
Australasian Shoveler	*Anas rhynchotis*		X	X		X		vagrant
Wandering Whistling-Duck	*Dendrocygna arcuata*		X	X		X		vagrant
Chestnut Teal	*Anas castanea*		X	X		X		vagrant
Freckled Duck	*Stictonetta naevosa*	CS3	X	X		X		vagrant
Eurasian Wigeon	*Mareca penelope*	Int				X		vagrant
PODICIPEDIDAE								
Australasian Grebe	*Tachybaptus novaehollandiae*		X	X		X		vagrant
Hoary-headed Grebe	*Poliocephalus poliocephalus*		X	X		X		vagrant
Great Crested Grebe	*Podiceps cristatus*		X	X		X		vagrant
ANHINGIDAE								
Australasian Darter	*Anhinga novaehollandiae*		X	X		X	*	vagrant
PHALACROCORACIDAE								
Little Black Cormorant	*Phalacrocorax sulcirostris*		X	X		X	*	vagrant

WETLAND BIRDS		CS	ALA	N.Map	EPBC	BA	BCE 2016	Status
Little Pied Cormorant	*Microcarbo melanoleucos*		X	X		X		vagrant
Pied Cormorant	*Phalacrocorax varius*		X	X		X	*	vagrant
Great Cormorant	*Phalacrocorax carbo*		X	X		X		vagrant
PELICANIDAE								
Australian pelican	*Pelecanus conspicillatus*		X	X		X	*	vagrant
ARDEIDAE								
Eastern Great Egret	*Ardea modesta*	M S5 (CS1)	X	X	X	X	*	vagrant
White-faced Heron	*Egretta novaehollandiae*		X	X		X	*	vagrant
Little Egret	*Egretta garzetta*		X	X		X	*	vagrant
White-necked Heron	*Ardea (Ardea) pacifica*		X	X		X		vagrant
Cattle Egret	*Ardea ibis*	M S5 (CS1)	X	X	X	X		vagrant
Eastern Reef Egret	*Egretta sacra*		X			X		vagrant
Nankeen Night-Heron	*Nycticorax caledonicus*		X	X		X		vagrant
Intermediate Egret	*Ardea intermedia*		X	X		X		vagrant
Striated Heron	*Butorides striatus*		X	X		X		vagrant
THRESKIORNITHIDAE								
Sacred Ibis	*Threskiornis molucca*		X	X		X	*	vagrant
Straw-necked Ibis	*Threskiornis spinicollis*		X	X		X	*	vagrant
Yellow-billed Spoonbill	*Platalea flavipes*		X	X		X		vagrant
Glossy Ibis	*Plegadis falcinellus*	M S5 (CS1)	X	X		X		vagrant
Royal Spoonbill	*Platalea regia*		X	X		X		vagrant
RALLIDAE								
Eurasian Coot	*Fulica atra*		X	X		X	*	vagrant
Black-tailed Native-hen	*Tribonyx ventralis*		X	X		X		vagrant
Australian Spotted Crake	*Porzana fluminea*		X	X		X		vagrant

WETLAND BIRDS		CS	ALA	N.Map	EPBC	BA	BCE 2016	Status
Spotless Crake	*Porzana tabuensis*		X	X		X		vagrant
Buff-banded Rail	*Gallirallus philippensis*		X	X		X		vagrant
Dusky Moorhen	*Gallirallus tenebrosa*					X		vagrant
Baillon's Crake	*Porzana pusilla*		X	X		X		vagrant
Purple Swamphen	*Porphyrio porphyrio*		X	X		X		vagrant
ROSTRATULIDAE								
Australian Painted Snipe	*Rostratula australis*	E S2 (CS1)	X	X		X		vagrant
SCOLOPACIDAE								
Common Sandpiper	*Tringa hypoleucos*	V S3 (CS1)	X	X	X	X	*	vagrant
Common Greenshank	*Tringa nebularia*	M S5 (CS1)	X	X	X	X		vagrant
Common Redshnk	*Tringa totanus*	M S5 (CS1)		X		X		vagrant
Wood Sandpiper	*Tringa glareola*	M S5 (CS1)	X	X	X	X		vagrant
Grey-tailed Tattler	*Tringa brevipes*	M S5 (CS1)	X		X	X		vagrant
Red-necked Stint	*Calidris ruficollis*	M S5 (CS1)	X	X	X	X		vagrant
Bar-tailed Godwit	*Limosa lapponica*	V S3 (CS1)	X	X	X	X	*	vagrant
Sharp-tailed Sandpiper	*Calidris acuminata*	M S5 (CS1)	X	X		X		vagrant
Curlew Sandpiper	*Calidris ferruginea*	V S3 (CS1)	X	X	X	X		vagrant
Whimbrel	*Numenius phaeopus*	M S5 (CS1)	X	X	X	X		vagrant
Eastern Curlew	*Numenius madagascariensis*	V S3 (CS1)	X	X	X	X		vagrant
Sanderling	*Calidris alba*	M S5 (CS1)	X	X	X	X		vagrant
Long-toed Stint	*Calidris subminuta*	M S5 (CS1)	X	X		X		vagrant

WETLAND BIRDS		CS	ALA	N.Map	EPBC	BA	BCE 2016	Status
Ruddy Turnstone	*Arenaria interpres*	M S5 (CS1)	X	X	X	X		vagrant
Marsh Sandpiper	*Tringa stagnatilis*	M S5 (CS1)	X			X		vagrant
Broad-billed Sandpiper	*Limicola falcinellus*	M S5 (CS1)		X		X		vagrant
Terek Sandpiper	*Tringa cinereus*	M S5 (CS1)	X		X	X		vagrant
Little Curlew	*Numenius minutus*	M S5 (CS1)	X	X		X		vagrant
Great Knot	*Calidris tenuirostris*	V S3 (CS1)	X	X	X	X	*	vagrant
Red Knot	*Calidris canutus*	M S5 (CS1)	X	X	X	X		vagrant
Black-tailed Godwit	*Limosa limosa*	M S5 (CS1)	X		X	X		vagrant
Ruff	*Philomachus pugnax*	M S5 (CS1)	X	X		X		vagrant
Pectoral Sandpiper	*Calidris melanotos*	M S5 (CS1)	X	X		X		vagrant
Asian Dowitcher	*Limnodromus semipalmatus*	M S5 (CS1)	X	X		X		vagrant
GLAREOLIDAE								
Oriental Pratincole	*Glareola maldivarum*	M S5 (CS1)	X	X		X		vagrant
Australian Pratincole	*Stiltia isabella*		X	X		X		vagrant
HAEMATOPODIDAE								
Pied Oystercatcher	*Haematopus longirostris*		X	X		X	*	vagrant
Sooty Oystercatcher	*Haematopus fuliginosus*		X	X		X		vagrant
CHARADRIIDAE								vagrant
Greater Sand Plover	*Charadrius (Charadrius) leschenaultii*	V S3 (CS1)	X	X	X	X		vagrant
Grey Plover	*Pluvialis squatarola*	M S5 (CS1)	X	X	X	X	*	vagrant
Pacific Golden Plover	*Pluvialis fulva*	M S5 (CS1)	X	X		X		vagrant
Lesser Sand Plover	*Charadrius mongolus*	V S3 (CS1)	X	X		X	*	vagrant
Little Ringed Plover	*Charadrius dubius*	M S5 (CS1)	X	X		X		vagrant

WETLAND BIRDS		CS	ALA	N.Map	EPBC	BA	BCE 2016	Status
Oriental Plover	*Charadrius veredus*	M S5 (CS1)			X	X		vagrant
Masked Lapwing	*Vanellus miles*					X		vagrant
LARIDAE								
Silver Gull	*Chroicocephalus novaehollandiae*		X	X		X	*	vagrant
Franklin's Gull	*Leucophaeus pipixcan*					X		vagrant
Whiskered Tern	*Chlidonias hybrida*		X			X		vagrant
Caspian tern	*Hydroprogne caspia*		X	X		X	*	vagrant
Gull-billed tern	*Gelochelidon nilotica*		X	X		X	*	vagrant
Crested tern	*Thalasseus bergii*		X	X		X		vagrant
Pacific Gull	*Larus pacificus*		X	X		X		vagrant
Kelp Gull	*Larus dominicanus*					X		vagrant
Fairy Tern	*Sternula nereis*		X			X		vagrant
White-winged Black Tern	*Chlidonias leucopterus*		X			X		vagrant
Lesser crested tern	*Thalasseus bengalensis*		X	X		X		vagrant
Common Tern	*Sterna hirundo*	M S5 (CS1)	X	X		X		vagrant
Little tern	*Sternula albifrons*		X	X		X		vagrant
Sooty tern	*Onychoprion fuscata*		X					vagrant
Roseate Tern	*Sterna dougallii*	M S5 (CS1)	X	X		X		vagrant
Common Noddy	*Anous stolidus*				X			vagrant
ACROCEPHALIDAE								
Australian Reed Warbler	*Acrocephalus australis*		X	X		X		vagrant
Total Number of Species Expected:	99	39	90	81	21	96	24	

7.7 Appendix 7. Vertebrate species returned in database searches but unlikely to occur in Carnarvon survey area.

Database searches often return found nearby but that are unlikely to be present in the survey area due to lack of suitable habitat (e.g. aquatic species) or ecological barriers preventing them from reaching the area (e.g. island species). There are also some collection location errors, out-of-date Latin names, zoo specimens and subtleties of distribution that are not recognised in databases. The species listed below are considered highly unlikely to be found in the survey area (although some species could occur as very rare vagrants).

Common name	Scientific name
REPTILES	
Shaded-litter Rainbow-skink	*Carlia munda*
Green Turtle	*Chelonia mydas*
Loggerhead Turtle	*Caretta caretta*
Leatherback Turtle	*Dermochelys coriacea*
Flathback Turtle	*Natator depressus*
Elegant Seasnake	*Hydrophis elegans*
North-western Mangrove Seasnake	*Ephalophis greyi*
Olive-headed Seasnake	*Hydrophis major*
BIRDS	
Grey Wagtail	*Motacilla cinerea*
Night Parrot	*Pezoporus occidentalis*
Shy Albatross	*Thalassarche cauta*
White-capped Albatross	*Thalassarche cauta subsp.steadi*
Campbell Albatross	*Thalassarche impavida*
Black-browed Albatross	*Thalassarche melanophris*
Common Noddy	*Anous stolidus*
Southern Giant-Petrel	*Macronectes giganteus*
Wedge-tailed Shearwater	*Ardenna pacifica*
Fleshy-footed Shearwater	*Puffin carneipes*
Wilson's storm-petrel	*Oceanites oceanicus*
Lesser Frigatebird	*Fregata ariel*
Australasian gannet	*Morus serrator*
Brown Skua	*Stercorarius antarcticus*
MAMMALS	
Bernier Is. Banded Hare-wallaby	*Lagostrophus fasciatus subsp. fasciatus*
Humpback Whale	*Megaptera novaeangliae*
Dugong	*Dugong dugon*
Bryde's Whale	*Balaenoptera edeni*
Pygmy Sperm Whale	*Kogia breviceps*
Indo-Pacific Bottlenose Dolphin	*Tursiops aduncus*

7.8 Appendix 8. Annotated list of species recorded during the fauna survey.

List includes observation of fauna within the survey area from around Carnarvon town.

No.	Species and observational notes
Frog	
1	*Cyclorana maini.* One in aestivation cocoon at depth of about 12cm under bush in clayey-loam soil at site 4.
Reptiles	
2	*Diplodactylus bilybara* (formerly *D. conspicillatus*). One found while installing traps at site 6. Head-torched near site 3. Caught at site 7.
3	*Diplodactylus klugei* (split off *D.pulcher*) One caught at site 7, and head-torched near site 3.
4	*Gehyra variegata*. Caught at sites 3 and 4, and head-torched near site 3.
5	*Hemidactylus frenatus.* On buildings in town.
6	*Heteronotia binoei*. Caught at most sites, 6 under junk/sheet iron near site 2 on 11/11. And head-torched near site 3.
7	*Lucasium squarrosum*. Caught at site 2.
8	*Nephrurus levis*. Several caught at site 2.
9	*Strophorus strophurus*. Several caught at most sites, one under dead bush near site 2, and head-torched near site 3.
10	*Delma tincta*. Trapped at most sites. Slough under sheet iron at site 6.
11	*Lialis burtonis*. One caught at site 4.
12	*Pygopus nigriceps*. Caught at sites 3 and 5.
13	*Amphibolurus longirostris*. One observed active below River Gums on Gascoyne Rv
14	*Moloch horridus*. Caught at sites 2 and 4.
15	*Pogona minor*. One caught at site 4 and 5.
16	*Ctenotus pantherinus*. Caught at sites 4 and 7. Under debris at site 6.
17	*Lerista uniduo.* Several caught at site 2.
18	*Lerista macropisthopus*. Caught at most sites.
19	*Menetia greyii*. Trapped at sites 5 and 8. Observed active in leaf litter near site 8.
20	*Tiliqua rugosa.* One on motion camera at sites 1 and 4, another caught by a Whistling Kite.
21	*Tiliqua occipitalis*. One observed southwest of Site 8 in Area C.
22	*Varanus gouldii*. One on motion camera at site 2 pit 3.
23	*Demansia calodera*. One caught at site 5.
24	*Pseudechis australis*. Remains of an immature Mulga Snake under sheet iron near site 2. Slough of large adult found near site 8. A roadkill near Gascoyne Rv.
25	*Pseudonaja mengdeni.* One caught at site 2. Old slough under sheet iron near site 2.

No.	Species and observational notes
Birds	
26	Emu. Two near site 1 (8/11).
27	Australian Shelduck. Carnarvon WWPT (15/11).
28	Pacific Black Duck. Carnarvon WWPT (15/11).
29	Grey Teal. Carnarvon WWPT (15/11).
30	Hardhead. Carnarvon WWPT (15/11).
31	Plumed Whistling-Duck. Carnarvon WWPT (15/11).
32	Eurasian Coot. Carnarvon WWPT (15/11).
33	Black-winged Stilt. Carnarvon WWPT (15/11).
34	Common Sandpiper. Carnarvon WWPT (15/11).
35	Pied Oystercatcher. South Carnarvon Inlet mudflats (16/11).
36	Pied Cormorant. South Carnarvon Inlet mudflats (16/11).
37	Bar-tailed Godwit. South Carnarvon Inlet mudflats (16/11).
38	Red-capped Plover. South Carnarvon Inlet mudflats (16/11).
39	Great Knot. South Carnarvon Inlet mudflats (16/11).
40	Great Egret. South Carnarvon Inlet mudflats (16/11).
41	Caspian Tern. South Carnarvon Inlet mudflats (16/11).
42	Lesser Sand Plover. South Carnarvon Inlet mudflats (16/11).
43	Grey Plover. South Carnarvon Inlet mudflats (16/11).
44	Australasian Darter. South Carnarvon Inlet mudflats (16/11).
45	Gull-billed Tern. Carnarvon WWPT (15/11). South Carnarvon Inlet mudflats (16/11).
46	Sacred Ibis. One perched on post in horticultural area (7/11) and single birds occasionally in town. Group of about 5 near water tank (10/11).
47	Straw-necked Ibis. One in town (10/11).
48	White-faced Heron. One over horticultural areas (9/11), two near site 4 (10/11), one near site 2.
49	Laughing Dove. Two seen at site 3 (8/11) and small numbers in town.
50	Crested Pigeon. Small groups throughout.
51	Diamond Dove. One seen in degraded, open area near site 1. Two seen about 5 km north of site on Hwy.
52	Peaceful Dove. Several calling at site 8. Also off-site in riparian habitat south of Gascoyne Rv mouth.
53	Common Bronzewing. Off-site in riparian habitat south of Gascoyne Rv mouth.
54	Australian Bustard. Three over horticultural areas near sites 5 and 6 (9/11).

No.	Species and observational notes
55	Wedge-tailed Eagle. Adult on nest in river gum just north of site 3.
56	Brahminy Kite. Pair over fascine frequently.
57	Whistling Kite. Several flying over horticultural areas regularly.
58	Nankeen Kestrel. Several seen around horticultural areas and elsewhere. At least one active nest near site 1. A fledgling in hollow calling near site 8, parent seen nearby.
59	Black-shouldered Kite. Pair over horticultural areas regularly, and one at site 1 along creek (11/11).
60	Australian Ringneck. Two in town (8/11) and two over agricultural areas (10/11).
61	Little Corella. Flocks over horticultural areas.
62	Galah. Few around open flats, and in town.
63	Silver Gull. Small numbers throughout town.
64	Caspian Tern. Occasional birds over the fascine.
65	Common Sandpiper. One on rocks of fascine opposite accommodation.
66	White-winged Fairy-wren. Parties in low shrubland throughout.
67	Variegated Fairy-wren. Party in site 3 and two coloured males in site 4 amongst several groups.
68	Redthroat. Calling at most sites.
69	Spiny-cheeked Honeyeater. One at site 8 (10/11).
70	White-plumed Honeyeater. In town and along rivers with River Gums. Adult feeding fledgling at site 1.
71	Singing Honeyeater. Occasionally throughout.
72	Pied Honeyeater. Off-site in riparian habitat south of Gascoyne Rv mouth.
73	Brown Honeyeater. Off-site in riparian habitat south of Gascoyne Rv mouth.
74	Chiming Wedgebill. Calling at several sites.
75	Crested Bellbird. Immature seen and adult heard just off Barrawarra Road near Site 3.
76	White-browed Babbler. Party at site 4, and site 1.
77	Rufous Whistler. One calling in Site 4 (9/11) and occasionally elsewhere.
78	Grey Shrike-thrush. One calling from dense vegetation at site 1 (7/11) and site 4 (8/11) and site 8 (10/11).
79	Black-faced Cuckoo-shrike. Few present throughout.
80	White-winged Triller. Female seen near site 2, and a male at 3.
81	Zebra Finch. Small groups throughout. Occasional flocks up to 50 birds.
82	Star Finch. Off-site in riparian habitat south of Gascoyne Rv mouth.
83	Mistletoebird. Heard near site 8.
84	Magpie-lark. Few around horticultural areas.

No.	Species and observational notes
85	Pied Butcherbird. Few around including with dependent young.
86	Little Crow. Present throughout, with groups of up to 40 around horticultural areas.
87	White-breasted Woodswallow. In Carnarvon townsite 16/11/
88	Welcome Swallow. Abundant in town.
89	Tree Martin. Few over site 8 (10/11). And several over the fascine.
90	Rufous Songlark. One calling at site 1 (7/11).
91	Brown Songlark. One seen near Ste 1 (11/11).
92	Silvereye. Small groups in acacia thickets.
93	White-backed Swallow. One near Bibbawarra Rd over orchard just nth Gascoyne Rv. Another in town site.
94	Peregrine Falcon. One mobbing a Nankeen Kestrel just southwest of site 2 on 11/11.
95	Rainbow Bee-eater. Two observed, flying and landing in agricultural area just south of Gascoyne Rv at Rotary Park on 11/11. Also off-site in riparian habitat sth of Gascoyne Rv.
96	Sacred Kingfisher. One n agricultural area just south of Gascoyne Rv at Rotary Park on 11/11.
97	Blue-winged Kookaburra. One near Gascoyne Rv south of Site 2 on 11/11.
98	Little Black Cormorant. One in canal at accommodation on 11/11.
99	Australian Pipit. North of site 1 near cattle yard on 12/11.
100	Osprey. In Gascoyne river bed on 12/11.
101	White-bellied Sea Eagle. Off-site in riparian habitat south of Gascoyne Rv mouth.
102	Straw-necked Ibis. On lawn near canal near accommodation 0n 13/11.
103	Rufous Fieldwren. Two seen close to site 6 on 13/11.
104	Feral Pigeon. Several seen in town and on orchards.
105	Tawny Frogmouth. Active at night on North River Rd 13/11.
106	Little Button Quail. One found at night near site 3.
107	Australian Pelican. One over town on 14/11.
108	Little Egret. Four seen over fascine on 15/11 early a.m.
	Mammals
109	Spinifex Hopping Mouse. Recorded on motion camera at site 2.
110	White-faced Dunnart. Caught at most sites. A juvenile and lactating female recorded.
111	Red Kangaroo. Recorded on motion camera, site 1. Scats and tracks in many areas.
112	Goat. Scats and skeletal remains noted. Small group at site 8.
113	Dog/Dingo. Scats noted in several areas.

No.	Species and observational notes
114	European Mouse. Caught at four sites.
115	Rabbit. Scats noted in many areas.
116	Fox. Recorded on motion camera, sites 5 and 7. Foot prints, scats and skeletal remains noted within survey area.
117	Cat. Recorded on motion camera, site 3. Foot prints noted within survey area.

7.9 Appendix 9. Motion Camera Results.

Camera	BCE 21	BCE 3	BCE 4	Bl/Nth	Bl/Sth	JT 1	BCE 35	JT 2
Site	2	3	1	5	7	?	4	?
Species								
Crested Pigeon	(3)1*							
Desert Hopping-mouse	-25							
Gould's Goanna	-12							
Laughing Dove		(3) 1*			(3) 1*			
Felis catus (Cat)		(1) 1*						
Red Kangaroo			(126) 2*					
Bobtail			(42)4*				(45) 1*	
Fox				(20)2*	(129)4*			
Mus							(15) 1*	
Total images	150	87	4017	55	1182	no data	4165	no data

Number in brackets is how many images

Number before * is how many events

7.10 Appendix 10. Site fauna photos.

Diamond Dive	Eastern Osprey
	
Zebra Finch	Black-faced Cuckoo-Shrike
	
Kluge's Gecko	Hooded Scalyfoot
	
Thorny Devil	Broad Striped Slider