Hinge Project Area
Fauna Assessment

Active Malleefowl mound recorded with a motion camera in Hinge project area

Prepared for: Karara Mining Limited
Level 8, 216 St Georges Tce,
Perth, WA 6000

Prepared by: Gillian Basnett and Mike Bamford
M.J. & A.R. Bamford,
BAMFORD CONSULTING ECOLOGISTS.
23 Plover Way
Kingsley, WA, 6026

21th June 2013

EXECUTIVE SUMMARY

Introduction

Karara Mining Limited (KML) is currently undertaking mineral exploration for the Hinge Iron Ore Project, with the intention of developing iron ore deposit, approximately 11 km north of the KMLTerapod deposit, 80 km south-east of Yalgoo and 258 km east of Geraldton.

As part of the environmental impact assessment for the project, Bamford Consulting Ecologists (BCE) was commissioned by KML to undertake a detailed fauna assessment of the Hinge project area. The targeted conservation significant fauna surveys conducted in December 2011 and July and September 2012 will be combined with a Level 1 Survey (as per EPA 2004) for this report.

As only the proposed area for the pit and haul road were known at the time of writing, assessments and recommendations are based on potential impacts from works likely to be carried out with the construction and working of a mine: e.g. waste dumps, roads, topsoil stockpiles, bunds, etc.

The impact assessment process involved the following components:

- The identification of fauna values:
    - Assemblage characteristics: uniqueness, completeness and richness;
    - Recognition of vegetation and soil associations (VSAs) that provide habitat for fauna;
    - Species of conservation significance; and
    - Ecological processes upon which the fauna depend.

- The review of impacting ecological processes such as:
    - Habitat loss leading to population decline;
    - Habitat loss leading to population fragmentation;
    - 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.

Overview of fauna assemblage

The desktop survey identified 245 vertebrate fauna species potentially occurring in the Hinge area. During the surveys in 2011 and 2012, 54 fauna species were recorded, comprising 42 bird, five mammal and seven reptile species. A total of 30 conservation significant vertebrate species and four invertebrate species are considered likely to occur in the Hinge project area. Eight conservation significant vertebrate fauna species were recorded during the field surveys: Western Spiny-tailed Skink, Malleefowl, Major Mitchell's Cockatoo, Redthroat, Western Yellow Robin, Golden Whistler, White-browed Babbler and Crested Bellbird. The conservation significant Shield-backed Trapdoor Spider was also recorded. An additional two conservation significant species were reported in the area by the Badja Station Manager: the Bush Stone-curlew and Kultarr.

Western Spiny-tailed Skink
Fresh scats of the Western Spiny-tailed Skink were found in two different areas in Eucalypt woodland west of the Hinge ridge. Two areas of potential skink habitat (Floristic Community Type 19a) exist in the project area boundary one to the west and one to the east of the main ridge.

Malleefowl
There is extensive suitable habitat for the Malleefowl in the Hinge project area. One active and 24 inactive Malleefowl mounds and two sets of Malleefowl footprints were recorded in the project area. The Active mound was being continually worked between September and November 2012 so it was considered to contain eggs. Active and inactive mounds have been have previously recorded on neighbouring areas, so suitable breeding habitat occurs outside the Hinge project area.

Shield-backed Trapdoor Spider
Extensive suitable habitat exists for the Shield-backed Trapdoor Spider in the Hinge project area. Of 152 quadrats surveyed, 38 quadrats contained spider burrows, with 144 active spider burrows recorded. As with previous studies on the species in the Karara area, the spider was generally recorded from the lower to upper slopes of the Hinge ridge and was virtually absent from the eastern and western plains. Spiders at Hinge were within the lower abundance range to that of other ironstone ridges in the Karara area. Calculated abundance varied within the predicted occupied habitat of the Hinge area. The proposed pit contained 56 burrows per ha, the rest of the Hinge ridge had 132 burrows per ha and the small hill on the eastern edge was well populated with spiders with 414 burrows per ha.

Based on predicted distribution (as bounded by actual occurrence of spiders, suitable vegetation and slope), the spider population size is estimated at 19,541 across the Hinge ridge, and 1,904 within the proposed pit area. As only the proposed pit and about 1000 m of roads are within the predicted distribution and the rest of the Hinge ridge and the hill to the east were to be left undisturbed, the proposed disturbance would only directly impact approximately 15% of the spider population at Hinge based on predicted distribution.

Vegetation and Substrate Associations
Five VSAs were recorded within the Hinge project area. Four of these were considered to be significant for fauna, with impacts of moderate to high significance expected. These VSAs were the banded ironstone ridge, foothills and slopes, drainage lines and Eucalypt woodlands. They were considered important because they are restricted in the local area, declining in the region and support a number of conservation significant species, such as the Malleefowl, Shield-backed Trapdoor Spider and Spiny-tailed Skink, and may support some short-range endemic invertebrates.

Impact Assessment
Impacts upon the fauna assemblage as a whole are expected to be minor as fauna are generally widespread within VSAs that are widespread in the region. Similarly, impacts upon the majority of the conservation significant species are expected to be negligible or minor because their habitat is not restricted or they are not residents in the project area. Conservation significant species of interest are:

- Malleefowl (federally and state listed). One active mound and two sets of footprints recorded. Impact anticipated to be Minor because while the species is known to be sensitive to roadkill, there is extensive suitable habitat on the plains around Hinge away from mining and vehicle acitivty.
- Shield-backed Trapdoor Spider (state listed). Restricted to the slopes of ridges in the region. A population of approximately 19,500 expected within the project area, with an estimate of 10% of predicted distribution likely to be impacted by the proposed pit area. Further development areas for site unknown at time of writing. Impact likely to be moderate but could be reduced to minor if cleared areas kept outside of predicted occupied habitat.
- Spiny-tailed Skink (federally and state listed). Two latrine sites recorded. Impact anticipated to be minor as the Eucalypt Woodland is largely outside the proposed pit area (and assuming any associated infrastrucyre can avoid the Eucalypt Woodland.
- Gilled Slender Blue-tongue (state listed). May possibly occur on Hinge ridge and to be restricted to ridge habitats in the region.
- Western Yellow Robin (locally significant). Recorded on Hinge ridge. Likely to be restricted to dense tall shrublands on slopes of Hinge and other ridges in the region.
- Golden Whistler (locally significant). Recorded on Hinge ridge and likely to be restricted to Hinge and other ridges in the region.
- Woolley's Pseudantechinus (locally significant). Possible resident and likely to be restricted to dense tall shrublands on slopes of Hinge and other ridges in the region.
- SRE invertebrates (locally significant). Likely to be restricted to the ridge within the Hinge project area. Also expected in ridges nearby.

These species are generally susceptible to habitat loss. This is less of a concern for the Malleefowl than the other species because suitable habitat occurs away from the ridge, however the Malleefowl is sensitive to roadkill from increased traffic, and to the effects of feral species.

Most ecological processes are expected to have only minor impacts, the exceptions being increased mortality (such as roadkill), loss of habitat affecting population survival (such as loss restricted VSAs impacting specialist species), and increased feral species (such as foxes, cats and goats), which may experience moderate levels of impacts.

Recommendations to minimise the impacts on the fauna assemblage, VSAs and conservation significant fauna include:

- Minimise roadkill through speed limits and signage;
- Minimise habitat loss and maintain vegetation linkages;
- Minimise disturbance of significant habitats, particularly ironstone ridges, breakaways, rocky rises and drainage lines;

- Avoid disturbance to active or recently active Malleefowl mounds;
- Conduct monitoring programs for the Western Spiny-tailed Skink, Malleefowl and Shield-backed Trapdoor Spider in suitable habitat in surrounding areas;
- Implement feral animal control program, particularly goats;
- Minimise hydrological impacts, including effects on surface runoff;
- Implement a fire management plan based on ecological principles; and
- Rehabilitate disturbed habitat.

Table of Contents

Table of Figures

1 INTRODUCTION

1.1 Introduction

Karara Mining Limted (KML) is currently undertaking mineral exploration for the Karara Iron Ore Project with the intention of developing iron ore deposits at the Hinge deposit, approximately 11 km north of the Terapod deposit 30 km south west of the Golden Grove mine and 80 km south-east of Yalgoo (see Figure 1).

As part of the environmental impact assessment for the project, Bamford Consulting Ecologists (BCE) was commissioned by KML to undertake a fauna assessment of the Hinge project area (Figure 2). The targeted conservation significant fauna surveys conducted in December 2011 and July and September 2012 will be combined with a Level 1 Survey (as per EPA 2004) for this report.

As only the proposed area for the pit and haul roads were known at the time of writing, assessments and recommendations are based on potential impacts from works likely to be carried out with the construction and working of a mine: e.g. waste dumps, roads, topsoil stockpiles, bunds, etc.

1.2 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;
  - Recognition of vegetation and soil associations (VSAs) that provide habitat for fauna;
  - Species of conservation significance; and
  - Ecological processes upon which the fauna depend.
- The review of impacting ecological processes such as:
  - Habitat loss leading to population decline;
  - Habitat loss leading to population fragmentation;
  - 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 development; and provide recommendations to mitigate these impacts. Methods for investigations into the Hinge proposal are outlined in Section 3.

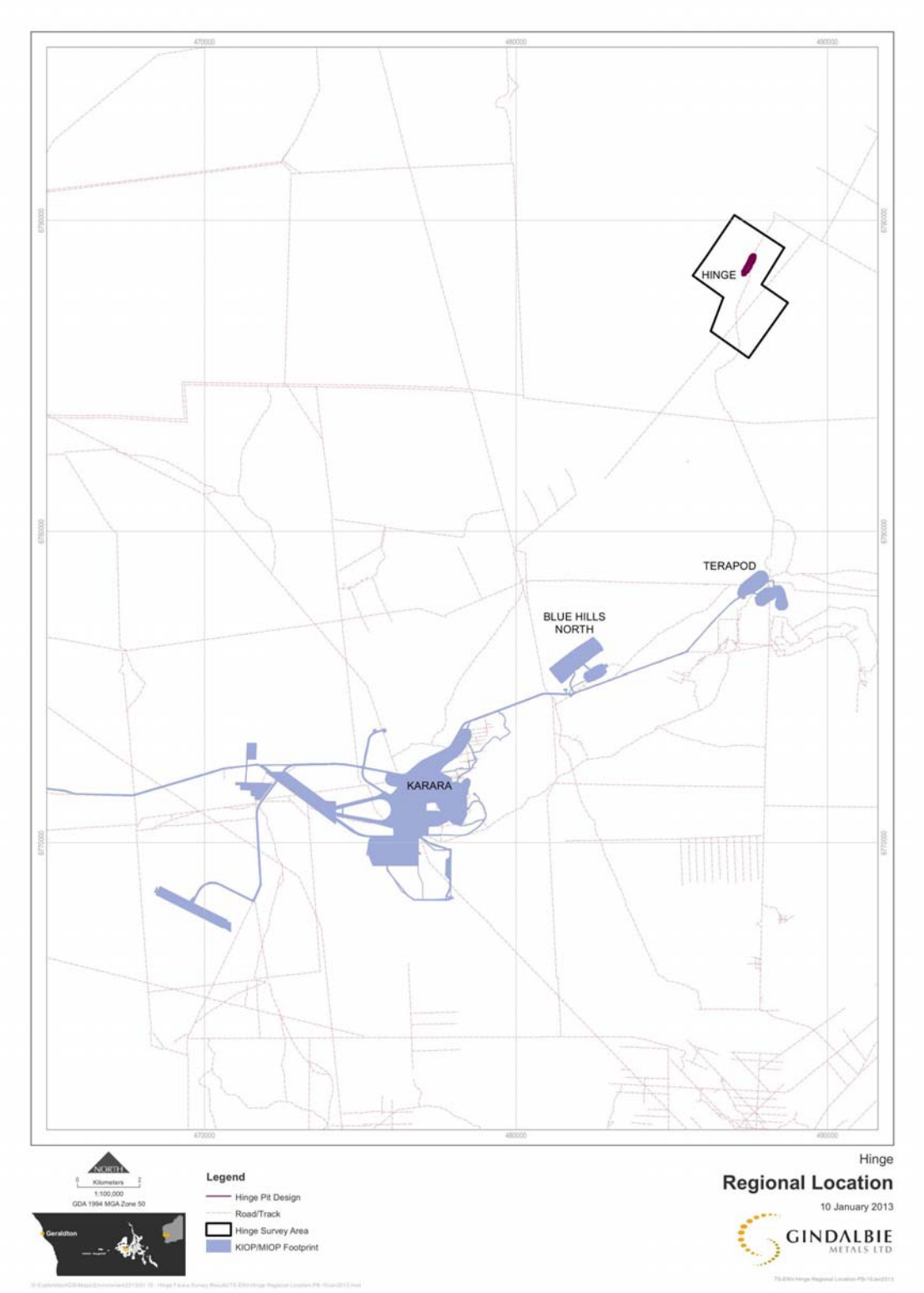

Figure 1: Location of the Hinge project, north of Terapod and south west of the existing Golden Grove mine.

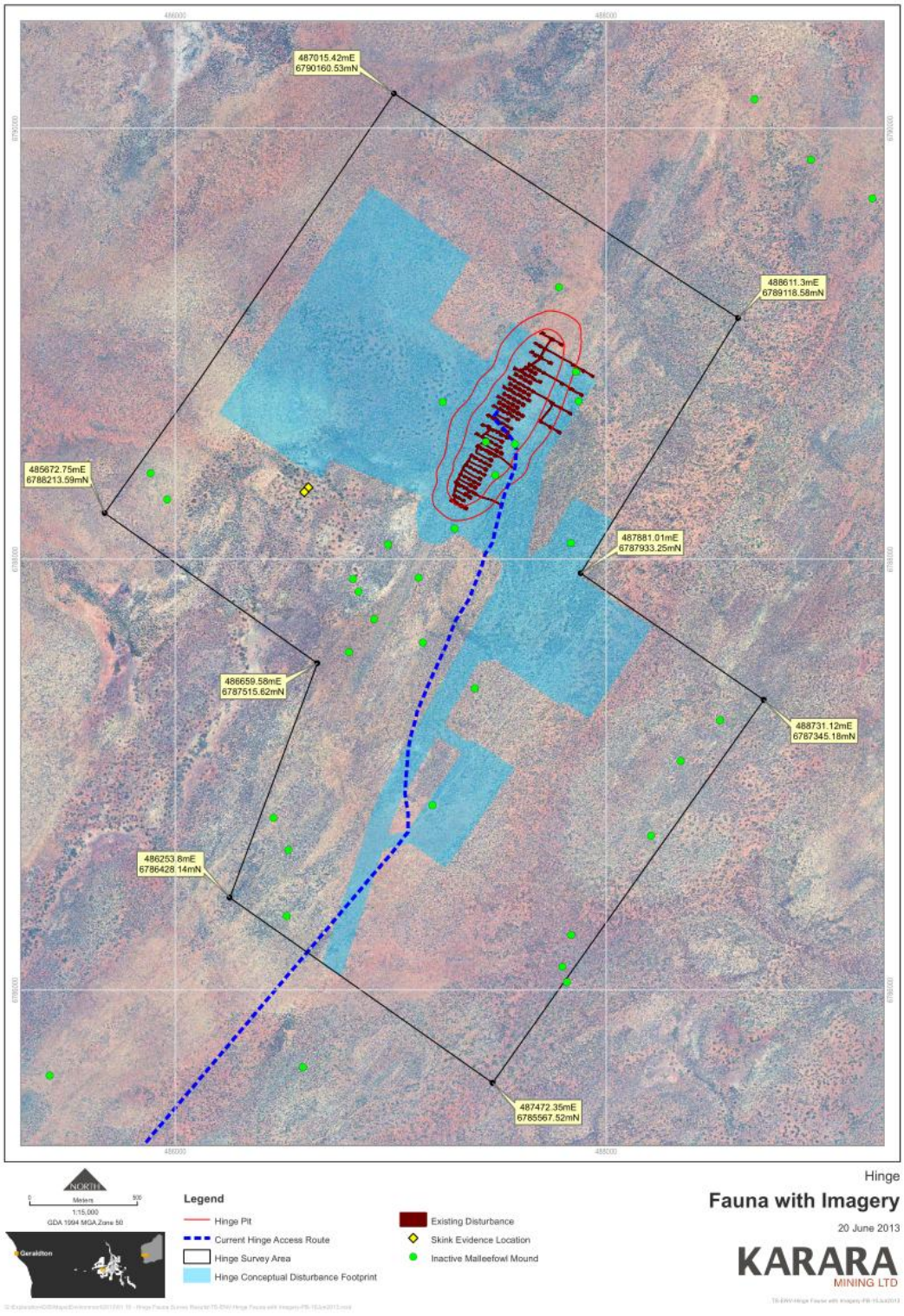

Figure 2: Hinge project area and proposed disturbance area.

Note the black line is the 2012 project area and the red and blue lines, blue shaded area and contours are the proposed disturbance areas.

2 BACKGROUND

2.1 Project Area

The Hinge project area extends northeast to southwest along a banded ironstone ridge for approximately 3.5 km from the proposed Jasper Hills project area (Figure 2). It is 3.5 km by 3 km at its widest points and encompasses approximately 765 ha (Figure 2). Within the project area, the 'disturbance area' is the area that will experience direct disturbance by the proposed mining activities and includes an open pit, waste dump, explosives magazine and access tracks (see Figure 2). The disturbance area is approximately 80 ha in size (Figure 2).

2.2 Regional Description

The project area lies within the Yalgoo Bioregion (YAL, Interim Biogeographical Regionalisation for Australia classification system, EA 2000, McKenzie *et al.* 2003, see Figure 3). Yalgoo Bioregion falls within Bioregion Group 2 classification of EPA (2004). Group 2 comprises "bioregions of Eremaean Botanical Province containing native vegetation that is largely contiguous but used for commercial grazing."

The general features of this region are summarised by McKenzie *et al.* (2003). The region is characterised by low woodlands to open woodlands of *Eucalyptus*, *Acacia* and *Callitris* on red sandy plains. The region is described as:

"*Callitris* - *E. salubris*, mulga and bowgada open woodlands and scrubs on earth to sandy-earth plains in the western Yilgarn Craton and the southern Carnarvon Basin. The latter has a basement of Phanerozoic sediments and is rich in ephemerals. The climate is Mediterranean, semi-arid to arid and warm" (McKenzie *et al.* 2003).

The dominant land use in the region is grazing, with smaller areas of conservation estate, unoccupied Crown land/Crown reserves and mining. Special values of the Bioregion include the Tallering Peak ironstone and jaspilite range (unique landform and vegetation complexes), banded ironstone in the Mt Gibson Ranges (containing a significant number of endangered flora), Warradagga Rock (a granite outcrop with endangered flora and invertebrates in ephemeral ponds) and the Mt Singleton Ranges (where there is a number of endangered flora with some unusual vegetation associations).

Fauna species of conservation significance recorded from the greater region include:

- Western Spiny-tailed Skink (*Egernia stokesii badia*)
- Slender-billed Thornbill (*Acanthiza iredalei iredalei*)
- Carnaby's Black Cockatoo (*Calyptorhynchus latirostris*)
- Peregrine Falcon (*Falco peregrinus*)
- Southwest Carpet Python (*Morelia spilota imbricata*)
- Malleefowl (*Leipoa ocellata*)
- Major Mitchell's Cockatoo (*Cacatua leadbeateri mollis*)
- Shield-backed Trapdoor Spider (*Idiosoma nigrum*)

Figure 3: IBRA Subregions in Western Australia. Note the project lies in the YAL: Yalgoo Bioregion. Red arrow indicates approximate location of Hinge project area.

2.3 Land Types and Land Systems

Payne *et al.* (1998) classified and mapped the land forms of the Yalgoo region including the Hinge area (Figure 4). Land Types are classified according to similarities in landform, soil, vegetation, geology and geomorphology. The Hinge project area contains four major land types as mapped by Payne *et al.* (1998, see Table 1).

Table 1. Major Land Types in the Hinge project area

Land Type	Description
2	Hills with mixed shrublands.
4	Breakaways, stony plains and sandy surfaced plains on granite with mulga shrublands and minor halophytic shrublands.
12	Sandplains with grassy acacia shrublands.
16	Plains with deep sandy soils supporting acacia shrublands and occasionally with wanderrie grasses.

Land Types are further divided into Land Systems based on similarities of vegetation, landform and soil. Land Systems provide an indication of the fauna habitats present at a site. The Land Systems present in the Hinge project area are detailed in Table 2 and shown in Figure 4.

Table 2. Land Systems in the Hinge region

Land System	Landform
Euchre	Low granite breakaways with alluvial plains and sandy tracts.
Joseph	Undulating yellow sandplain.
Tallering	Prominent ridges and hills of banded ironstone, dolerite and sedimentary rocks.
Tealtoo	Level to gently undulating plains with gravely mantles.
Yowie	Loamy plains.

Each Land System is further classified described according to landform, vegetation and soil (see Table 3). The vegetation on the ironstone ridges and hills slopes is predominantly scattered to moderately closed tall shrublands of *Acacia ramulosa* and other mixed acacias. Small areas of breakaway support halophytic shrublands, with plains supporting mostly dense *Acacia* shrublands.

Table 3. Characteristics of Land Systems found in the Hinge area

Land System	Landform	Vegetation
Euchre	Sandplains	Tall Acacia shrublands with a wanderrie grass layer.
	Breakaways	Scattered low shrubland with *Acacia quadrimarginea*, Acacia shrubland, very scattered low shrublands on upper footslopes, with *Ptilotus obovatus* and *Sida calyxhymenia* and *Melaleuca uncinata* tall shrubland near scarp faces.
	Lower Footslopes	Scattered halophytic low shrubland, may be dominated by *Frankenia* spp.
	Stony Plains	Scattered Acacia – Eremophila tall shrublands, chenopod shrublands in saline areas.
	Gritty-surfaced Plains	Scattered *Acacia quadrimarginea* tall shrubland.

Land System	Landform	Vegetation
	Loamy Plains	Scattered moderate to close eucalypt woodland with acacia tall shrubs and *Amphipogon* spp. or *Monachather paradoxa* perennial grasses.
	Alluvial Plains	Scattered moderate to close eucalypt woodland 3 halophytic undershrubs sometimes with *Atriplex* spp. dominant.
	Drainage Lines	Very variable vegetation, some have moderately close *E. loxophleba* woodland with Atriplex undershrubs.
Joseph	Gravelly Sand Sheet	Close mixed shrublands commonly with Acacia, Melaleuca, and Allocasuarina mid and tall shrubs and low heath shrubs or moderately close to close Acacia tall shrublands with an *Amphipogon caricinus* layer.
	Sand Sheet	Close to closed mixed shrublands commonly with Acacia and Melaleuca tall shrubs and low heath shrubs shuch as *Eriostemon* and *Thryptomene* or moderately close to close Acacia tall shrubland.
	Loamy plains	Scattered eucalypt woodland with tall *Acacia ramulosa* and mixed low shrubs or moderately close tall shrublands of *A. ramulosa* shrubland.
	Gritty-surfaced Plains	Scattered Acacia tall shrublands often with *Borya sphaerocephala* in the ground layer and very scattered low myrtaceous shrublands.
Tallering	Ridges and Hills	Scattered to moderately close tall shrublands of *Acacia ramulosa* and other acacias with undershrubs including *Thrytomene* and *Eriostemon* species.
	Hill slopes	Scattered to moderately close tall shrublands of *Acacia ramulosa*. Understorey includes *Eremophila* spp., *Ptilotus obovatus*, *Thrytomene* and *Eriostemon* species.
	Narrow Drainage tracts	Scattered to moderately close tall shrublands of *Acacia ramulosa* with *Eremophila forrestii* and *Ptilotus obovatus* low shrubs.
	Stony plains / gravely plains	Scattered to moderately close tall shrublands of *Acacia ramulosa*. Understorey includes *Eremophila* spp., *Ptilotus obovatus*, *Thrytomene* and *Eriostemon* species.
	Stripped Surfaces (occasional low breakaways)	Very scattered mixed height shrublands with *Acacia ramulosa* and well developed non-halophytic understoreys.
Tealtoo	Stony / Loamy Plains	Moderately close tall acacia shrublands with *Acacia aneura, A ramulosa*, Mallee, *Allocasuarina eriochlamys* and *A. coolgardiensis* with low shrubs.
	Alluvial Plains	Scattered tall Acacia shrublands with Eucalyptus and saltbush.
Yowie	Loamy Plains	Moderately close acacia tall shrublands, dominated by *Acacia ramulosa*, *A. coolgardiensis*, *A. acuminata* subsp. *burkittii* or *A. aneura*, often with emergent *A. aneura* trees or *Callitris glaucophylla* trees, or mallee eucalypts. Occasional *Eucalyptus loxophleba* woodlands with acacia tall shrubs.
	Sandsheet	Moderately close acacia tall shrublands, or acacia shrublands with mallee eucalypts, rarely *Triodia basedowii* hummock grasslands with acacia and eucalypt overstoreys.
	Hardpan Plain	Scattered tall Acacia shrublands.
	Gravelly Plain	Moderately close *A. aneura* or *A. ramulosa* tall shrublands with occasional mallees, and sparse perennial grasses.
	Narrow Drainage Tract	Moderately close to close Acacia tall shrublands with scattered trees and mallees.

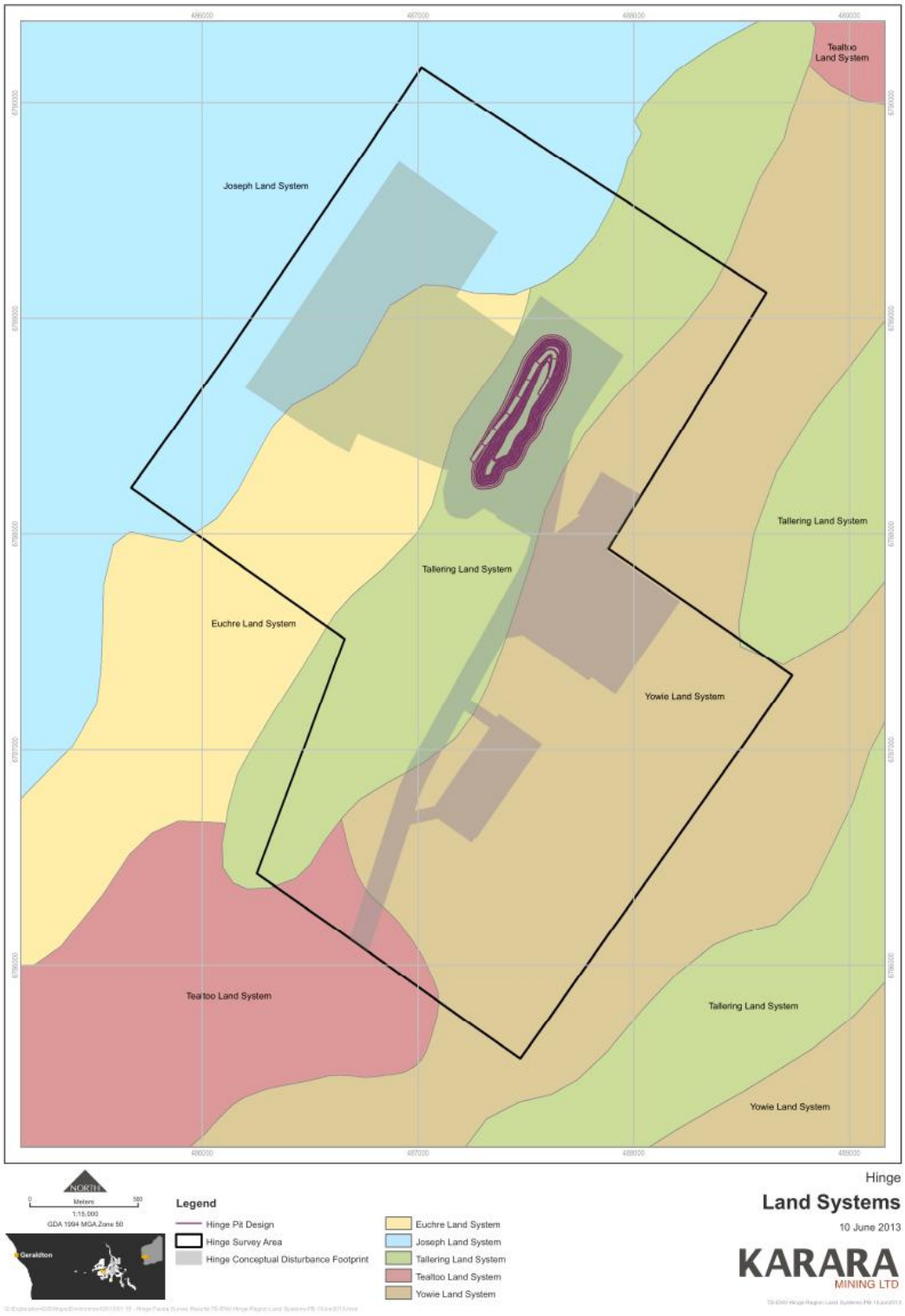

Figure 4: Land Systems of the Hinge project area. The Land Systems comprise Euchre, Joseph, Tallering, Tealtoo and Yowie. The black polygon indicates the approximate location of the Hinge project area.

3 METHODS

3.1 Overview

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

In addition, the approach to fauna impact assessment was carried out with reference to guidelines 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 data 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.

Due to the size and location of the proposed project, KML requested a Level 1 Fauna Survey with some additional targeted sampling where particular fauna values were present. A Level 1 Fauna Survey consists of a desktop assessment and basic ground-truthing through a reconnaissance survey.

BCE has undertaken a number of Level 1 Fauna Assessments in the region such as Shine in 2008, Karara and Mungada in 2006. Species data has therefore been aquired from these and other targed surveys, updated using a database search. To collect further information on conservation significant fauna in the area, BCE conducted additional targeted surveys in December 2011 and July and September 2012.

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 surveys. The purpose of a field survey is to verify the accuracy of the desktop study; to further delineate and characterise the fauna and faunal assemblages present in the target area; and to identify potential impacts.
- Impact assessment. The impact assessment determines how the fauna assemblage may be affected by the proposed development based on the interaction of the project with a suite of ecological processes.

3.2 Desktop Assessment

3.2.1 Sources of information

Information for this fauna assessment was drawn primarily from the DEC's NatureMap (2012), the Birds Australia Atlas Database, DEC Threatened Fauna Database and *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) Protected Matters Search Tool. All databases were interrogated in October 2012 (see Table 4). This information was supplemented with species expected in the area based on general patterns of distribution. Sources of information used for these general patterns were: frogs (Tyler *et al.* 2000), reptiles (Storr *et al.* 1983, 1990, 1999 and 2002, Cogger 2000, Wilson and Swan 2010), birds (Blakers *et al.* 1984, Johnstone and Storr 1998, Johnstone and Storr 2004, Simpon and Day 1999), and mammals (Churchill 1998, Strahan 1995, Menkhorst and Knight 2004). Results of the desktop assessment provided guidance as to the methodology employed during the reconnaissance surveys.

BCE has conducted a number of fauna surveys in the Karara area to the north and south of Hinge (approximately 15 km north and 30 km south). Surveys have been undertaken across several areas including Karara ridge, Blue Hills ridge, Terapod, Mungada ridge, Spyder, Hinge and Jasper ridge (e.g. Bamford and Wilcox 2004, Bamford 2006, Bamford and Metcalf 2008, Huang and Bamford 2011, Turpin *et al.* 2012). Records from all previous surveys conducted by BCE in the Karara area were consulted as part of the desktop assessment.

Table 4: Database searches for desktop assessment

Title	Comments	Area searched / Date
NatureMap	Records of specimens held in the WA Museum. DEC records, information and records on Threatened and Priority species in Western Australia. Includes historical data.	29° 2'4"S, 116°52'4"E, plus 40km buffer - October 2012.
Birds Australia Atlas Database	Records of bird observations in Australia, 1998-2011.	Species list for the 1 degree grid cell containing 116.867878°, -29.034664°- October 2012.
EPBC Protected Matters Search Tool	Records on matters protected under the EPBC Act, including threatened species and conservation estate.	29° 2'4"S, 116°52'4"E, plus 10km buffer - January 2012.

3.2.2 Nomenclature and taxonomy

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

3.2.3 Definition of conservtion significance

Three levels of conservation significance are recognised in this report and are described in detail in Appendix 1. In summary, the levels are:

- Conservation Significance level 1 (CS1). Species listed under legislation such as the *WA Wildlife Conservation Act* and/or the *Environment Protection and Biodiversity Conservation Act.* These acts include species listed under international treaties.
- Conservation Significance level 2 (CS2). Species listed as priorty by the DEC but not listed under legislation.
- Conservation Significance level 3 (CS3). Species with no formal listing but considered of significance because they have a restricted distribution, occur as an iolated population or occur on the edge of their range.

3.2.4 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 project 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 project area, meant that it was highly unlikely that these species would be present. In general, however, species returned by the desktop review process are considered to be potentially present in the project area whether or not they were recorded during field surveys. This is because fauna are highly mobile, often seasonal and frequently cryptic. This is particularly important for significant species that are often rare and hard to find.

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

- Resident: species with a population permanently present in the project area;
- Regular migrant or visitor: species that occur within the project area regularly in at least moderate numbers, such as part of annual cycle;
- Irregular Visitor: species that occur within the project 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 project area in at least moderate numbers and for some time;
- Vagrant: species that occur within the project area unpredictably, in small numbers and/or for very brief periods. Therefore, the project area is unlikely to be important for the species; and
- Locally extinct: species that has not been recently recorded in the local area and therefore is almost certainly no longer present in the project area.

3.3 Field Survey

3.3.1 Overview

The field surveys were undertaken to record the fauna values of the site. This included:

a. habitat assessment involving identification of significant VSAs including those suitable to support species of conservation significance;
b. targeted searching for conservation significant fauna, including Malleefowl, Shield-backed Trapdoor Spider and the Western Spiny-tailed Skink;
c. opportunistic fauna observations.

3.3.2 Dates and personnel

The three field surveys conducted in the Hinge Project Area took place from December 16th to 20th 2011, 19th – 25th July 2012 and September 27th to October 3rd 2012. Personnel involved were:

- Mike Bamford (B.Sc. Hons. Ph.D). (December, July and October)
- Robert Browne-Cooper (B.Sc.). (December)
- Gillian Basnett (B.Sc. M.Sc. M.Sc Reseach). (December and July)
- Tim Gamblin (B.Sc.). (December)
- Natalia Huang (B.Sc. Hons.). (December)
- Wes Bancroft (B.Sc. (Zool./Microbiol.) Hons, PhD). (July)
- Cameron Everard (B. Sc. Env. Sci.). (July)
- Jeff Turpin (B.Sc.). (October)
- Sarah Smith (B.Sc.). (October)
- Peter Smith (Dip. Ag.). (October)
- Katherine Chuk (BSc. Hons.). (October)

Field work was carried out from under Department of Environment and Conservation (DEC) Regulation 17 Licences SF008162 and SF008813.

This fauna assessment document was prepared by Ms Gillian Basnett and Dr Mike Bamford.

3.3.3 Vegetation and substrate associations

Vegetation and Substrate Associations (VSAs) throughout the project area were assessed during the desktop review and as part of the field investigations in 2011 and 2012. Within the Hinge project area each major VSA was 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.

3.3.4 Targeted surveys for conservation significant species

Significant species recorded during the desktop assessment include several that can be found by searching for evidence of their activities (e.g. scats, tracks, diggings, burrows). These included the Malleefowl (which create distinctive mounds and have distinctive tracks), Western Spiny-tailed Skink (communal scat latrines) and the Shield-backed Trapdoor Spider (which builds a distinctive burrow containing a trap door and a twig-lining radiating from the burrow entrance). Searching for evidence of significant fauna was therefore undertaken by searching habitat considered suitable for such species and recording opportunistic sightings.

A review of methodology conducted in each of the 2011 and 2012 surveys is presented in the following pages.

December 2011 Survey

The December 2011 field survey was focused on presence/absence and abundance of the conservation significant Shield-backed Trapdoor Spiders, detailed results are outlined in Bamford and Bancroft 2011. Two survey approaches were used: a quadrat-based transect survey and the createrion of monitoring plots of Matriachal Clusters. The quadrat based survey focused on proposed drill pads and involved traversing eight transects of varying length over the Hinge ridge to search for evidence of spider burrows in 10 m by 10 m areas set up every 50 metres (Figure 5 and Table 5). This search technique is consistent with previous spider surveys conducted in the Karara area to the south. All spider quadrat searches for all three surveys were sufficiently thorough to be confident that if no spiders were found in the quadrat, then it is likely none were present. Information recorded for each burrow included approximate lumen diameter (and therefore age class) and status of the burrow (active/inactive). Two to three personnel walked each transect, a total of 62 quadrats were surveyed. Four matriarchal clusters were set up during this survey.

Table 5: Details of transects surveyed in December 2011.

Transect	Easting	Northing	Habitats
1 (start)	487675	6789002	Upper slope mixed Acacia myrtaceous shrubland on gravely loam.
1 (end)	487936	6788851	
2 (start)	487537	6788997	Mid slope mixed Acacia shrubland some areas open tall shrubland on gravely loam.
2 (end)	487927	6788746	
3 (start)	487471.7	6788905.3	Acacia myrtaceous shrubland with occasional York Gum on gravely loam.
3 (end)	487878.2	6788650.6	
4 (start)	487503	6788754	Tall Acacia shrubland over sparse understorey on rocky clay loam with some outcropping.
4 (end)	487782	6788590	
5 (start)	487454	6788668	Tall Acacia shrubland on rocky gravely loam with some outcopping.
5 (end)	487561	6788606	
6 (start)	487404	6788582	Mixed open Acacia myrtaceous shrubland on rocky clay loam.
6 (end)	487511	6788519	
7 (start)	487350	6788439	Mixed open Acacia myrtaceous shrubland on gravely clay loam.
7 (end)	487436	6788391	
8 (start)	487325	6788396	Mixed Acacia Melalecua shrubland on cobble clay loam.
8 (end)	487410	6788348	

July 2012 Survey

The July 2012 field surveys consisted targeted searches for the Western Spiny-tailed Skink, Malleefowl and the Shield-backed Trapdoor Spider evidence and habitat in the site Hinge A (Table 6 and Figure 5). The survey included two transects running the length of the site (approximately 550 metres each) walked by 4 personnel spaced 40 metres apart, which covered the whole Hinge A site.

Table 6. Coordinates for the corners of Hinge A survey area inspected in July 2012.

Hinge A	North West Courner	North East Courner	South West Courner	South East Courner
Easting	487189	487453	486933	487195
Northing	6789213	6789074	6788725	6788586

Western Spiny-tailed Skink

Any York Gum woodland considered suitable habitat in Hinge A was identified and large eucalpyts and logs were searched for evidence (scats) of the Western Spiny-tailed Skink.

Malleefowl

Any Malleefowl mounds or tracks identified were described and locations recorded. A 300 metre section on the Western boundary of Hinge A was more intensively survyed for mounds with personnel 10 metres apart as large numbers of Malleefowl footprints were identified in the area.

Shield-backed Trapdoor Spider

Along each 550 metre transect, 10 x 10 m quadrats were set up every 100 to 200 metres in suitable habitat and intensively searched for spider burrows for a minimum of 10 minutes by four personnel. Details of any Shield-backed Trapdoor Spider burrows identified were recorded. Six quadrats were surveyed (Table 7).

Table 7: Locations of Shield-Backed Trapdoor Spider quadrats surveyed in July 2012 within the Hinge A project area.

Quadrat	Easting	Northing
Hinge A Spider Quadrat 1	487377.2	6788928
Hinge A Spider Quadrat 2	487331.7	6788865
Hinge A Spider Quadrat 3	487239.9	6788660
Hinge A Spider Quadrat 4	487211.8	6788569
Hinge A Spider Quadrat 5	487107.8	6788822
Hinge A Spider Quadrat 6	487175.2	6789026

September/October 2012

Due to an expansion to the boundaries of the project area and KML plans to progress mining in the area, further surveys were required on conservation significant species in the areas now already covered in December 2011 and July 2012.

Western Spiny-tailed Skinks

Seven transects 100 metres wide (Figure 5 and Table 8) were searched by five people at 20 spacings for Mallefowl mounds and Western Spiny-tailed Skinks, with quadrtas searched for Shield-backed Trapdoor Spiders spaced regularly along these transects.

Table 8. Start, Centre and End points of the seven transects surveyed for Malleefowls, Spiders and Skinks in September/October 2012.

Transect	Easting	Northing
T1 East end	487494	6785602
T1 Centre	486662	6786233
T1West End	486296	6786528
T2 East end	487794	6786007
T2 Centre	486984	6786588
T2 West End	486483	6786989
T3 East End	488005	6786314
T3 Centre	487070	6787090
T3 West End	486640	6787365
T4 East End	488278	6786762
T4 Centre	487217	6787521
T4 West end	485855	6788337
T5 East End	488625	6787190
T5 Centre	487420	6787972
T5 West End	486006	6788695
T6 East End	488009	6788150
T6 Centre	487551	6788370
T6 West End	486232	6789022
T7 East End	488250	6788525
T7 Centre	487785	6788942
T7West End	486526	6789436

Malleefowl

Methodology for Malleefowl surveys used was consistent with that conducted by BCE in previous surveys of the Karara and Shine area and recommended by the Malleefowl Preservation Group. Personnel were spaced 20m apart and walked slowly up a transect searching for Malleefowl mounds. Information collected on each mound included height, width, crater depth (if present), activity, building materials, vegetation, landscape placement and GPS coordinates (see Appendix 6).

Shield-backed Trapdoor Spider

Five people surveyed each Shield-backed Trapdoor Spider quadrat (10m by 10m) (Figure 6 Table 9) for 10 minutes at 200m intervals (closer in good habitat) along the 7 transects with a few extra quadrats searched in the proposed pit area on the ridge.

Based on the locations of spider burrow records from all three surveys, it was possible to estimate the extent of predicted occupied habitat by the spider on the Hinge ridge and calculate the approximate abundance of burrows per ha of suitable habitat. This made it possible to provide an estimated population size of the Shield-backed Trapdoor Spider on the Hinge ridge. Predicted occupied habitat was calculated as the area that enclosed quadrats with spider burrows as well as contained suitable vegetation and contours. Similar calculations have recently been conducted for tenements in the Karara area, including Shine (Huang and Bamford 2011). The present study provides more detailed information to provide a more accurate account of the distribution and abundance of spiders at Hinge.

Table 9. Shield-backed Trapdoor Spider quadrats surveyed in September / October 2012.

Quadrat	Easting	Northing	Vegetation
1A	486762.25	6786189.41	Acacia tall, open shrubland on loam with some gravel
1B	486835.85	6786103.63	Acacia open shrubland on loam
1C	486926.16	6786047.78	Acacia open shrubland on loam
1D	487078.26	6785921.54	Acacia tall, open shrubland on loam
1E	487277.19	6785789.14	Acacia tall, open shrubland on loam with some gravel
1F	487391.9	6785671.83	Eucalypt and melaleuca open woodland over acacia tall shrubland on gravelly sandy-loam
1G	487492.34	6785601.58	Eucalypt and sand pine open woodland over acacia tall shrubland on sandy-loam
1H	486606.63	6786319.08	Eucalypt low woodland over low shrubland on gravelly loam
1I	486533.02	6786408.51	Mixed shrubland on gravelly loam
1J	486439.99	6786464.02	Tall acacia shrubland, gravelly loam
1K	486366.31	6786529.3	Mixed tall shrubland on gravelly loam
2A	487793.39	6786005.75	Eucalypt low , open woodland over acaica tall open shrubland on gravelly-loam
2B	487688.57	6786163.52	Eucalypt open woodland over acaia tall, closed shrubland on gravelly-sandy-loam
2C	487516.41	6786299.38	Scattered sand pines over acacia tall, open shrubland on sandy loam
2D	487382.4	6786430.53	Acacia open shrubland on loam
2E	487172.2	6786535.77	Eucalypt open woodland over acacia tall, open shrubland on loam
2F	487003.68	6786619.23	Acacia low shrubland on gravelly-loam
2G	486484.15	6786990.89	Acacia tall shrubland on gravelly loam
2H	486562.99	6786926.72	Acacia tall shrubland, cobbles, gravel and loam, some lichen
2I	486622.56	6786847.58	Acacia tall shrubland, cobbles, gravel and loam, some lichen
2J	486722.31	6786803.71	Eucalypt and acacia tall shrubland, few cobbles, gravelly loam, no lichen
2K	486795.41	6786725.13	Acacia and melaleuca shrubland on gravelly loam
2L	486916.72	6786635.41	Acacia low shrubland on gravelly-loam
3A	487053.26	6787118.4	Mixed tall shrubland on rocks cobble gravel loam and lichen

3B	486970.92	6787179.58	Mixed tall shrubland on gravelly loam
3C	486897.14	6787244.2	Closed shrubland with cobbels gravel and loam
3D	486796.03	6787289.84	Low shrubland on gravelly loam
3E	486695.38	6787361.52	Acacia shrubland on slightly gravelly loam
3F	487141.9	6787077.18	Acacia shrubland on rock gravel loam, lichen present
3G	487220.54	6787012.56	Acacia shrubland on gravelly loam
3H	487297.53	6786939.97	Acacia tall open shrubland rocky gravelly loam, lichen
3I	487398.87	6786863.63	Acacia low shrubland on gravelly-loam
3J	487543.21	6786719.32	Eucalypt open woodland over acacia tall, open shrubland on loam
3K	487697.36	6786591.74	Acacia closed shrubland on loam
3L	487862.01	6786472.61	Acacia closed shrubland on loam
3M	488031.54	6786373.65	Acacia closed shrubland on loam
4A	486926.66	6787746.67	Acacia open shrubland on gravelly loam
4B	487015.32	6787694.7	Mixed shrubland on cobbles gravelly loam
4C	487156.19	6787617.64	Acacia tall closed shrubland on gravelly loam
4D	488278	6786763	Acacia shrubland, few emergent Eucalypts, gravelly loam
4E	488207	6786836	Acacia shrubland with rocks, cobbles, loam and lichen
4F	488127	6786885	Acacia shrubland rocks cobbles loam and lichen
4G	487261.33	6787537.1	Acacia closed shrubland on gravelly loam
4H	487340.56	6787473.26	Eucalyptus open woodland over mixed shrubland on gravelly loam
4I	487485.01	6787331.27	Acacia tall open shrubland slightly gravelly loam
4J	487646.56	6787212.34	Eucalypt and acacia open woodland over acacia low shrubland on loam
4K	487826.96	6787120.58	Eucalypt, sand pine and acacia tall shrubland on loam
4L	488000.86	6787011.41	Acacia shrubland on gravelly loam
4M	488077.45	6786947.01	Acacia open shrubland on cobbles, gravel loam and lichen
4N	486310.13	6788165.75	Acacia open shrubland on rocks cobbles gravel and loam
4O	486495.71	6788091.96	Acacia tall open shrubland on rock cobbles gravel and loam
4P	486687.12	6788018.17	Acacia tall shrubland on loam
4Q	486836.25	6787875.53	Acacia tall shrubland on gravel loam some cobbles and lichen
5A	488623.09	6787192.63	Acacia tall open shrubland on gravelly loam with lichen
5B	488553.41	6787267.68	Acacia tall shrubland on gravelly loam
5C	488461.63	6787333.95	Acacia tall shrubland on gravelly loam with lichen
5D	488386.3	6787403.68	Eucalypt woodland over acacia tall shrubland on gravelly loam
5E	488193.74	6787476.71	Eucalypt and sand pine open woodland over acacia open tall shrubland on sandy-loam
5F	488044.35	6787608.4	Eucalypt and sand pine open woodland over acacia open tall shrubland on sandy-loam
5G	487871.9	6787715.58	Acacia tall shrubland on gravelly loam
5H	487695.37	6787813.22	Acacia tall shrubland on gravelly loam
5I	487512.15	6787890.36	Acacia tall shrubland on gravelly loam
5J	487385.81	6787934.09	Acacia tall open shrubland on cobbles, gravel and loam with some lichen
5K	487298.12	6787995.93	Acacia and melaleuca tall shrubland on cobbles, gravel, loam
5L	487203.74	6788023.74	Acacia tall shrubland on cobbles, gravel, loam and lichen

5M	487113.05	6788061.65	Mixed shrubland with rocks cobble gravel loam lichen
5N	487027.79	6788118.83	Acacia closed tall shrubland with rocks cobbles gravel loam and lichen
5O	486928.05	6788149.96	Acacia shrubland with rocks, cobbles, loam and lichen
5P	486849.49	6788220.67	Scattered eucalypts over acacia open shrubland on cobbles gravel and loam
5Q	486646.92	6788253.56	Eucalypt open woodland over acacia open shrubland on cobbles and loam
5R	486462.79	6788341.98	Eucalypt very open woodland over open mixed shrubland on cobbles gravel and loam
6A	487964	6788175	Scattered eucalypts over acacia tall closed shrubland on loam
6B	487795	6788278	Acacia tall closed shrubland on gravelly loam
6C	487620	6788379	Eucalypt and acacia tall shrubland on gravelly loam
6D	487507	6788377	Eucalypt and acacia tall shrubland on loam
6E	487413	6788423	Acacia shrubland on cobbles gravel and loam with lichen
6F	487326	6788450	Acacia shrubland on cobbles gravel and loam with lichen
6G	487229	6788494	Acacia shrubland on cobbles gravel and loam with little lichen
6H	487140	6788540	Acacia shrubland on cobbles gravel and loam with little lichen
6I	486973	6788646	Acacia shrubland on gravelly loam
6J	486790	6788725	Eucalypt and sand pine open woodland on sandy loam
7A	487961.42	6788791.83	Acacia tall shrubland on gravel loam with some lichen
7B	488095	6788688	Acacia tall shrubland on gravelly loam
7C	488202	6788567	Scattered eucalypts over acacia tall open shrubland on gravelly loam
Opportunistic 1	487597	6788528	
Opportunistic 2	487029.83	6787170.45	

3.3.5 Opportunistic observations

At all times during the 2011 and 2012 surveys, opportunistic 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 travelling through the site.

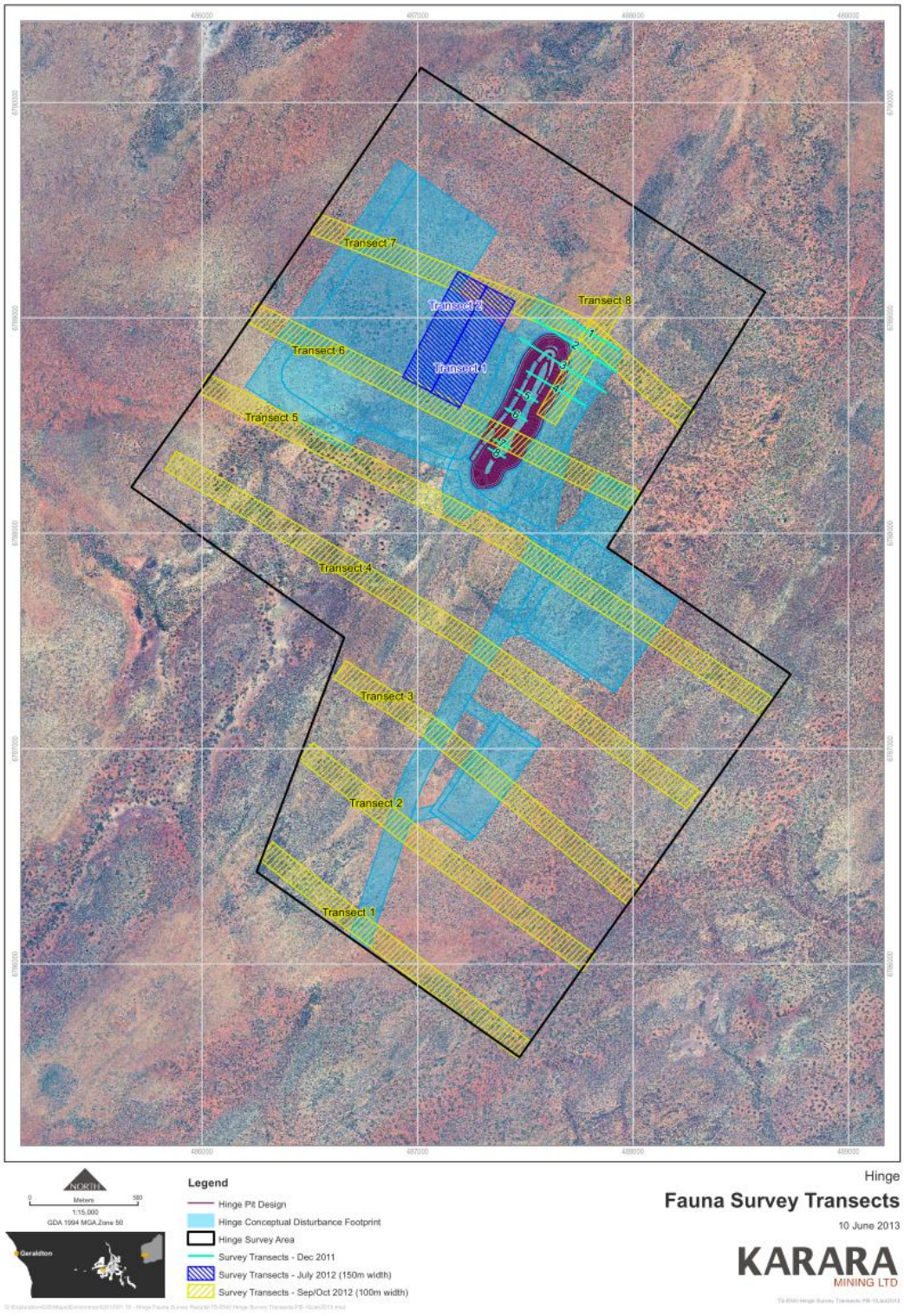

Figure 5: Fauna surveys conducted in 2011 and 2012 at Hinge.

Note: The December 2011 survey transects (light blue) focused on Shield-backed Trapdoor Spiders in proposed drill pads. The July 2012 survey area (shaded blue) and the September/October 2012 survey transects (shaded yellow) focused on Malleefowls, Western Spiny-tailed Skinks and Shield-backed Trapdoor Spiders. Refer to text for details on survey methodology along each transect.

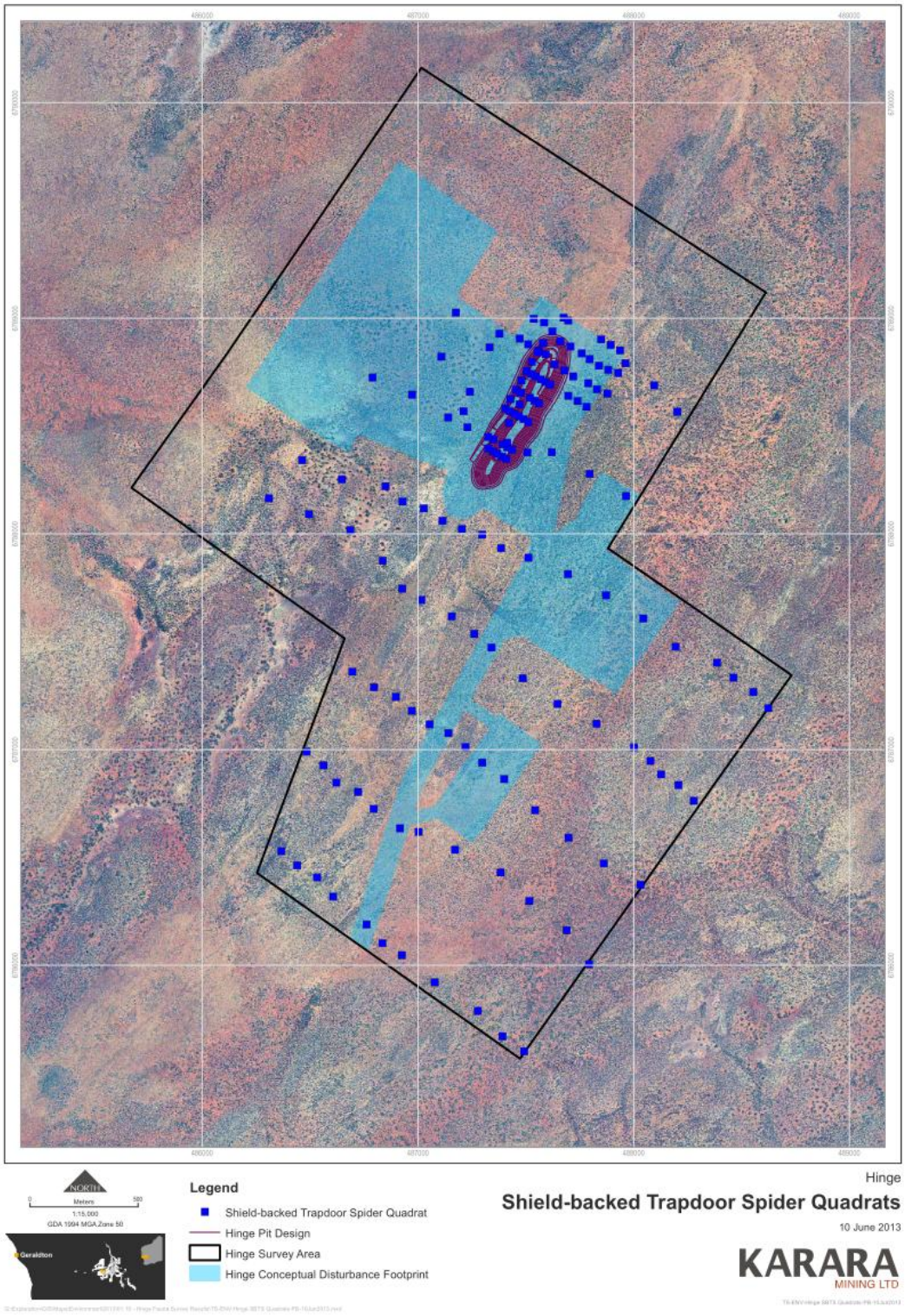

Figure 6. Spider Quadrats for all three surveys in 2011 and 2012.

3.4 Limitations

The EPA (2004 - Guidance for the assessment of environmental factors: Terrestrial fauna surveys for environmental impact assessment in Western Australia) outlines a number of limitations that may arise during surveying. These survey limitations are addressed in Table 10.

Table 10: Survey limitations as per EPA Guidance Statement 56 (EPA 2004)

Limitation	Comment
Level of survey.	Level 1 and targeted survey (desktop study and three field surveys). Survey intensity was deemed adequate to identify significant fauna and habitats occurring in the area.
Competency/experience of the consultant(s) carrying out the survey.	The field ecologists (authors) have had extensive experience in conducting desktop reviews and site inspections. BCE has had extensive experience conducting surveys in the region, including the Karara Iron Ore Project area and Shine Iron Ore Project area, 40 km to the south and 20 km to the north of the Hinge Iron Ore Project area respectively.
Scope. (What faunal groups were sampled and were some sampling methods not able to be employed because of constraints?)	Targeted searching for Malleefowl, Shield-backed Trapdoor Spider and the Western Spiny-tailed Skink was conducted across the project area.
Proportion of fauna identified, recorded and/or collected.	No specimens collected, all fauna observed identified.
Sources of information e.g. previously available information (whether historic or recent) as distinct from new data.	Sources include previous reports on the fauna of the survey area (BCE reports); databases (BA, DEC, WAM, EPBC)
The proportion of the task achieved and further work which might be needed.	Field surveys completed.
Timing/weather/season/cycle.	Level 1 survey conducted October 2012, targeted field surveys conducted December 2011 and July and September/October 2012.
Disturbances (e.g. fire, flood, accidental human intervention etc.) which affected results of survey.	No disturbances affected the survey.
Intensity. (In retrospect, was the intensity adequate?)	Survey intensity was moderate (desktop study and three field surveys), and supported by previous intensive studies in nearby and similar habitats.
Completeness (e.g. was relevant area fully surveyed).	Desktop study covered project area and adjacent habitats. Field surveys covered all areas of proposed disturbance and adjacent habitats.
Resources (e.g. degree of expertise available in animal identification to taxon level).	All species identified to species (sometimes sub-species) level.
Remoteness and/or access problems.	No access problems.
Availability of contextual (e.g. biogeographic) information on the region.	Extensive regional (e.g. BCE database) information was available and was consulted.

3.5 Impact Assessment

3.5.1 Fauna values and ecological processes

As outlined in Section 1.2, the impact assessment process involves identifying fauna values and reviewing impacting ecological processes. Fauna values include fauna assemblage and distribution, VSAs, and conservation significant fauna (see Appendix 1). Ecological processes that may impact upon these fauna values are discussed in Appendix 2, with processes specific to this project examined in Section 5.4. While some impacts are unavoidable during a development, of concern are long-term, deleterious impacts upon biodiversity. These are discussed under the following categories:

- VSAs. Impacts may be significant if the VSA is rare, a large proportion of the VSA is affected and/or the VSA supports significant fauna.
- Conservation significant fauna. Impacts may be significant if species of conservation importance are affected.
- Processes. Ecological processes are complex and can include hydrology, fire, predator/prey relationships and spatial distribution of a population (see discussion below). Impacts upon ecological processes may be significant if large numbers of species or large proportions of populations are affected.

The mining footprint outlined in Figure 2 was used to determine impact assessment was based on the disturbance likely to occur with the introduction of a new mine on Hinge. Some recommendations will suggest where development will cause least damage to conservation significant fauna.

3.5.2 Criteria for impact assessment

Impact assessment criteria are based on the severity of impacts on the fauna assemblage and conservation significant fauna, and were quantified on the basis of predicted population change (Table 11). Population change can be the result of direct habitat loss and/or impacts upon ecological processes.

Table 11: Criteria for impact assessment

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

4 RESULTS

4.1 Vegetation and Substrate Associations

Five major vegetation and substrate associations were found within the vicinity of the project area and are described below.

1. **Banded Ironstone Ridges** (Plates 1)**.** This is a low ridge and is the Hinge deposit. It supports mixed shrubland and low woodland of mostly *Acacia*, growing in generally shallow rocky-loam soils. This is part of the Tallering Land System (Section 2.3).

Plate 1. Example of Banded Ironstone Ridge

2. **Foothills and slopes** (Plates 2 and 3)**.** This flanks the Hinge ridge. It supports a combination of low to tall shrubland of mostly open acacia (dominated by *Acacia ramulosa*) and melaleuca on gravelly-loam soils. This is part of the Tallering Land System (Section 2.3).

Plate 2. Foothills and slopes at Hinge

Plate3. Foothills and slopes at Hinge

3. **Adjacent Plains** (Plate 4)**.** Plains of red loam soils, supporting mixed Acacia species at variable densities occur adjacent to the Hinge Ridge. *Callitris* is present in some areas of sandy-loam soils. Emergent eucalypts are a significant component of this landform, and generally occur close to the foothills and in low-lying areas where water may concentrate. These are part of the Euchre, Joseph, Tealtoo or Yowie Land Systems (Section 2.3).

Plate 4. Adjacent plains at Hinge

4. **Minor Drainage Line**. Numerous minor and incised drainage tracts traverse the project area. These areas generally support very dense Acacia shrubland. This is part of the Euchre, Tallering or Yowie Land System (Section 2.3).

(No photograph available)

5. **Eucalypt woodland (Plates 5 and 6).** Some areas of eucalypt woodland occur in the project area. The woodland contains a number of large hollow-bearing trees and logs and fallen timber at ground level. This is part of the Euchre, Joseph and Tealtoo Land System (Section 2.3).

Plate 5. Eucalypt woodland at Hinge

Plate 6. Eucalypt woodland at Hinge

4.2 Vertebrate Fauna

4.2.1 Overview of fauna assemblage

The desktop survey identified 245 fauna species potentially occurring in the Hinge area (Appendix 5; summarised in Table 12). During the surveys in 2011 and 2012, 54 fauna species were recorded, comprising 42 bird, five mammal and seven reptile species.

A total of 30 conservation significant vertebrate species and four invertebrate species are considered likely to occur in the Hinge project area. Eight conservation significant fauna species were recorded during the field surveys (see Table 12). An additional two conservation significant species were reported in the area by the Badja Station Manager: the Bush Stone-curlew and Kultarr.

Contributing factors to faunal richness of the Hinge area are the biogeographic location of the area, with faunal elements from the Southwest, Murchison and arid zone effectively overlapping, and habitat diversity, linked to the presence of the ironstone ridges. The assemblage is generally complete apart from the lack of some mammals, as is typical of inland Australia. The assemblage is unique on the ironstone ridges and slopes but generally widespread across the plains. This vertebrate assemblage is typical of the southern Murchison with a strong representation of generally widespread arid zone species, but also species more typical of the Wheatbelt. Some of the southern species that have been recorded, such as the Golden Whistler, are probably present in vegetation that depends upon the micro-climate created by the ironstone hills. There are also species recorded or expected that are likely to be dependent upon the rocky habitat. These include a few species, such as Woolley's Pseudantechinus, that range well into the Pilbara and are at the southern extent of their range in the Karara area, just to the south of Hinge.

Locations of significant species recorded during the survey are provided in Appendix 6. Details of each conservation significant species expected to occur in the project area are provided in Table 12. Conservation significant fauna species occurring or likely to occur in the project area are discussed in the following sections; discussions on the results of the targeted Western Spiny-tailed Skink, Malleefowl and Shield-backed Trapdoor Spider surveys are presented in Section 4.4.

Table 12: Composition of vertebrate fauna expected to occur and recorded (in parenthesis) in the Hinge project area

Taxon	Number species expected	Total species recorded	Significant fauna expected (recorded) in project area			
			CS1	CS2	CS3	INT
Frogs	8	0	-	-	-	-
Reptiles	65	7	3 (1)	-	2	-
Birds	140	42	6 (2)	7 (2)	9 (3)	1
Native Mammals	27	2	-	-	3	
Introduced Mammals	5	3	-	-	-	5 (3)
Total	**246**	**54**	**9 (3)**	**7 (2)**	**14 (3)**	**6 (3)**

Table 13: Details of conservation significant species expected to occur in the Hinge project area

Conservation status as per Appendix 1 and 4, status in project area as per Section 3.2.3.
"BIF" indicates species dependant on Banded Ironstone Formation ridges; "LC" indicates species listed as threatened (least concern) by Garnett *et al.* (2010); "DW" indicates declining woodland species; "RL" indicates species at limit of their range.

CONSERVATION SIGNIFICANT FAUNA		Conservation Status				Records		Habitat		Expected status in Project Area
COMMON NAME	SPECIES NAME	EPBC	WA Act	DEC	Local	Project Area	Local Area	Type	Presence In Project Area	
Reptiles										
Western Spiny-tailed Skink	*Egernia stokesii badia*	END	End			**Recorded**	Karara, south of Hinge	Eucalypt woodlands (eg. York Gum)	Yes	Resident
Gilled Slender Blue-tongue	*Cyclodomorphus branchialis*		S1				Karara , Mungada	Acacia shrublands, BIF ridges	Yes	Resident
Southwest Carpet Python	*Morelia spilota imbricata*		S4				Koolanooka Range, Yalgoo	Rocky ridges, outcrops	Yes	Potential Resident
Reticulated Velvet Gecko	*Oedura reticulata*				CS3		Karara	Eucalypt woodland	Yes	Potential Resident
Mulga Dragon	*Caimanops amphiboluroides*				CS3		Mungada Ridge	Acacia Woodlands (Mulga)	Yes	Resident
Birds										
Malleefowl	*Leipoa ocellata*	VUL, MIG	S1			**Recorded**	Karara	Acacia shrublands, no recent records	Yes	Resident
Slender-billed Thornbill	*Acanthiza iredalei*	VUL					Mt Magnet	Samphire, Chenopods	No	Vagrant
Peregrine Falcon	*Falco peregrinus*		S4		BIF		Mungada	Rocky ridges, major drainage lines	Yes	Regular Visitor
Major Mitchell's Cockatoo	*Lophochroa leadbeateri*		S4			**Recorded**	Karara	Major drainage line, woodland	Yes	Resident / Visitor
Rainbow Bee-eater	*Merops ornatus*	MIG	S3				Karara	Watercourses, woodland	Yes	Regular Visitor
Fork-tailed Swift	*Apus pacificus*	MIG	S3				Morawa	Aerial	Yes	Irregular Visitor
Crested Bellbird (southern)	*Oreoica gutturalis gutturalis*			P4		**Recorded**	Karara	Mallee, Heath, Woodland	Yes	Resident
White-browed Babbler (southern)	*Pomatostomus superciliosus ashbyi*			P4		**Recorded**	Karara	Eucalypt woodland, Acacia Shrubland	Yes	Resident

CONSERVATION SIGNIFICANT FAUNA		Conservation Status				Records		Habitat		Expected status in Project Area
COMMON NAME	**SPECIES NAME**	**EPBC**	**WA Act**	**DEC**	**Local**	**Project Area**	**Local Area**	**Type**	**Presence In Project Area**	
Rufous Fieldwren (western wheatbelt)	*Calamanthus campestris montanellus*			P4			Mongers Lake	Low, sparse heath, saltmarsh or samphire	No	Vagrant
Australian Bustard	*Ardeotis australis*			P4			Mongers Lake	Plains	Yes	Irregular visitor
Bush Stone-curlew	*Burhinus grallarius*			P4		**Recorded ***	Badja, Mulloo Hill	Mulga shrublands	Yes	Resident
Grey Falcon	*Falco hypoleucos*			P4			None	Drainage lines, plains	Yes	Vagrant
Square-tailed Kite	*Lophoictinia isura*				LC		Mungada	Eucalypt woodland	Yes	Regular Visitor
Regent Parrot	*Polytelis anthopeplus anthopeplus*				LC		Karara	Eucalypt woodland	Yes	Regular Visitor
Scarlet-chested Parrot	*Neophema splendida*				LC		None	Eucalypt woodland, Mallee	Yes	Vagrant
Redthroat	*Sericornis brunneus*				LC	**Recorded**	Karara	Acacia Shrublands	Yes	Resident
Southern Scrub-robin	*Drymodes brunneopygi*						Mongers Lake	Mallee, vegetation	Yes	Irregular visitor
Western Yellow Robin	*Eopsaltria griseogularis rosinae*				LC	**Recorded**	Karara	Dense vegetation on ironstone slopes	Yes	Resident
Rufous Tree-creeper	*Climacteris rufa*				RL		Karara	Eucalypt woodland	Yes	Irregular visitor
Golden Whistler	*Pachycephala pectoralis*				RL	**Recorded**	Karara	Forest, Eucalypt woodland	Yes	Resident
Gilbert's Whistler	*Pachycephala gilberti*				DW		Mungada	Woodland, Thicket	Yes	Resident
Grey Honeyeater	*Conopophila whitei*				RL		Mongers Lake	Mulga Shrublands	Yes	Irregular visitor
MAMMALS										
Woolley's Pseudantechinus	*Pseudantechinus woolleyae*				CS3		Karara	Rocky Ridges, BIF	Yes	Resident
Kultarr	*Antechinomys laniger*				CS3	**Recorded ***	Badja	Acacia Mallee shrubland	Yes	Resident
Common Brushtail Possum	*Trichosurus vulpecula vulpecula*				CS3		Lochada	Eucalypt Forest, Woodland	Yes	Irregular visitor

CONSERVATION SIGNIFICANT FAUNA		Conservation Status				Records		Habitat		Expected status in Project Area
COMMON NAME	**SPECIES NAME**	**EPBC**	**WA Act**	**DEC**	**Local**	**Project Area**	**Local Area**	**Type**	**Presence In Project Area**	
Invertebrates										
Shield-backed Trapdoor Spider	*Idiosoma nigrum*		S1			**Recorded**	Karara	Ironstone ridges, slopes	Yes	Resident
Millipede	*Antichiropus sp. nov. 'PM1'*				SRE		Karara	Temporary wetlands	No	Resident
Millipede	*Antichiropus sp. nov. 'Karara'*				SRE		Karara	Ironstone Ridges	Yes	Resident
Scorpion	*Urodacus 'Mt Gairdner'*				SRE		Karara	Ironstone Ridges	Yes	Resident

* Recorded by Badja Station Manager Mr Roger Pitman.

4.2.2 Amphibians

Eight frog species are expected to occur in the vicinity of the Hinge project area (see Appendix 5). No conservation significant species are expected. All species are water-holding or burrowing and arid zone species, and most have broad distributions across the Murchison and Goldfields. The only species with a restricted distribution is *Neobatrachus centralis,* which in Western Australia is currently believed to occur only in the Mt Magnet area, although it occurs elsewhere in Australia (Tyler *et al.* 2000). However, this species is very difficult to distinguish from *Neobatrachus sutor* and *Neobatrachus kunupalari,* and may be more widespread in Western Australia than is currently believed to be the case.

The amphibians of the area do not require permanent pools of standing water. These species are adapted to survive long periods of little to no rainfall and will emerge after sufficient rainfall to breed in temporary pools of freshwater. An expected total of eight species is somewhat elevated in the region because the ironstone hills create runoff that forms the temporary pools suitable for breeding. Runoff from the hills is therefore a critical environmental feature for the amphibian fauna of the area.

4.2.3 Reptiles

A total of 65 species of reptile may occur in the vicinity of Hinge project area, with seven species recorded during the surveys (Appendix 5). Five reptile species of conservation significance are expected to be present. This includes three species of high conservation significance (CS1): the Western Spiny-tailed Skink, the Southwest Carpet Python and the Gilled Slender Blue-tongue. A further two species of local significance (CS3) are also expected. Conservation significant reptiles are described below and summarised in Table 12. Evidence of the Western Spiny-tailed Skink was found in the Hinge project area in 2012; its presence in the project area is discussed in Section 4.4.1.

Conservation Significance Level 1 (CS1)

Southwest Carpet Python ***Morelia spilota imbricata*** **(Sch4)**

This species is listed as Schedule 4 (Specially Protected) under the WA *Western Australian Wildlife Conservation Act 1950* (Wildlife Conservation Act) and also as Priority 4 by DEC, and is of concern because this subspecies has declined dramatically in the face of urban development and land clearing. The Southwest Carpet Python occurs in south west Western Australia, north to Geraldton (Moresby Range) and Yalgoo, east to Pinjin, Kalgoorlie and the Fraser Range (WAM 2008). It prefers undisturbed bushland and rocky outcrops and is often arboreal. It preys on birds, other reptiles and small to medium sized mammals and requires large areas of bushland to survive. The Southwest Carpet Python is a slow-moving species and is susceptible to vehicle strikes (roadkill) and predation by Dogs, Cats and Foxes. The Western Australian Museum lists Yalgoo as the north-easterly limit of this species distribution (DEC 2012). The Carpet Python has been recorded from the region at the Koolanooka Range (I. Harris, pers. comm.), however has not been recorded in the Karara area by BCE. The Hinge project area may be just outside the range of the species, but it may also be present.

Western Spiny-tailed Skink ***Egernia stokesii badia*** **(EPBC Endangered)**

The Western Spiny-tailed Skink is listed as Endangered under the EPBC Act and under Schedule 1 of the Wildlife Conservation Act (see Plate 10). This species occurs in the Murchison region and in the Wheatbelt, from Mullewa south to Kellerberrin. In the Wheatbelt this species has been recorded from eucalypt woodlands, including from the Morawa area. How *et al.* (2003) located several populations of the Western Spiny-tailed Skink in the Karara region, from Buntine Nature Reserve, Perenjori town, Bowgada Nature Reserve north-east of Morawa and south of Rothsay. Harris and Bamford (2008) have recorded it in York Gum woodland throughout the Karara/Mungada area. It occurs in eucalypt woodland with "considerable numbers of large fallen logs over 25 cm in diameter" (How *et al.* 2003), with recent studies on behalf of Gindalbie (Harris and Bamford 2008) suggesting that it also relies on intact understorey vegetation around the logs where it shelters.

The Western Spiny-tailed Skink lives in small groups and each group has a single characteristic faecal pile ('latrine') that is usually located outside occupied logs (How *et al.* 2003). The presence of these faecal piles has been previously used to survey for this species in the Mid-West and Murchison regions (How *et al.* 2003). BCE recorded the species in eucalypt woodland within the Hinge project area (see Section 4.4.1).

Plate 10: Western Spiny-tailed Skink. Latrine sites of this species were recorded from the Hinge project area in September/October 2012.

Gilled Slender Blue-tongue ***Cyclodomorphus branchialis*****(Sch 1)**

The Gilled Slender Blue-tongue is listed under Schedule 1 of the Wildlife Conservation Act. It has a restricted distribution, confined to the Midwest coast from the Murchison River to the Irwin River and inland to Mt Magnet (Bush *et al.* 2007). This species is only known from a few locations, recorded from loamy soils in wattle woodlands and rocky areas (Bush *et al*. 2007).

The Gilled Slender Blue-tongue has been recorded by BCE on the Karara ridge (August 2006) and the Mungada ridge to the south of the Hinge project area. Other records (two further specimens, M. Bamford unpub. data) are all from rocky habitat, suggesting that the species may be restricted to such environments. Wilson and Swan

(2003), however, suggest that it occurs on heavy red soils. The Gilled Slender Blue-tongue has a restricted distribution, which may be disjunct due to the pattern of habitat availability. This species has been recorded from a banded ironstone ridge crest, a habitat found in the project area. As such, this species is likely to occur on the Hinge ridge.

Conservation Significance Level 3 (CS3)

Reticulated Velvet Gecko ***Oedura reticulata***

Mulga Dragon ***Caimanops amphiboluroides***

Both the Reticulated Velvet Gecko and the Mulga Dragon have been recorded by BCE in the Karara area and occur there near the extreme limit of their known ranges.

The Reticulated Velvet Gecko was recorded in eucalypt woodland just east of the Skyhook iron ore deposit (southern end of Mungada ridge). The Reticulated Velvet Gecko is widespread in suitable habitat (woodland of smooth-barked eucalypts) of the Wheatbelt and Goldfields, but is at the northern edge of its range in the Hinge region.

The Mulga Dragon is usually recorded in acacia woodland of the plains. Although with a distribution across much of the Murchison, this species is infrequently encountered during surveys. The Mulga Dragon occurs in the Shine region just to the north of Hinge and so may occur in the project area at the southern edge of its range.

4.2.4 Birds

Appendix 5 lists 140 bird species considered likely to occur in the general region. A total of 90 bird species has been recorded in the Karara/Mungada/Shine/Hinge region, with 42 of these in the Hinge project area.

The bird assemblage displays similar biogeographic patterns to that of the reptiles, with assemblage composition determined by geography and habitat availability. As with the reptiles, the richness of the bird assemblage is strongly influenced by the habitat diversity of the site. A prominent component of the bird assemblage is the species that occur in the thickets and dense shrublands (e.g. fairy-wrens, Redthroat, and Golden Whistler) that are associated with run-off sites and lower slopes around the ironstone hills. There are also many bird species that are irruptive (opportunistic breeders) and the presence and abundance of species such as the Budgerigar and Zebra Finch is largely independent of the local environment. Note: waterbirds have not been included in the bird assemblage as suitable habitat is not present in the project area.

A total of 22 conservation significant bird species may occur in the Hinge area. These are described below, with summary information in Table 12. Seven conservation significant bird species were recorded from the project area during the three surveys. An additional five conservation significance species were recorded south of Hinge in the Karara area. The Badja Station Manager also reported the Bush Stone-curlew as being present around the Badja Homestead (R. Pitman, pers. comm.). The Malleefowl was recorded at Hinge (mounds and individual); Section 4.4.2 presents the results of the targeted Malleefowl surveys.

Conservation Significance Level 1 (CS1)

Malleefowl ***Leipoa ocellata*** **(EPBC Vulnerable)**

The Malleefowl is listed as Vulnerable under the EPBC and Wildlife Conservation Acts. In Western Australia, Malleefowl occur mainly in scrubs and thickets of Mallee (*Eucalyptus* spp.), Boree (*Melaleuca lanceolata*) and Bowgada (*Acacia linophylla*), and also other dense litter-forming shrublands including Mulga (*Acacia aneura*) Shrublands (Johnstone and Storr 2004). Around Karara and Mungada, the species is closely associated with the slopes of hills as the heavy soils of the surrounding plains appear unsuitable for mound construction (Bamford 2008). The species' distribution was once larger and less fragmented, but the widespread clearing of suitable habitat, coupled with the degradation of habitat by fire and livestock, and fox predation, have reduced Malleefowl numbers considerably.

The Malleefowl previously inhabited a large part of arid inland Western Australia however has undergone a dramatic range reduction in the region. Malleefowl are known to occur in the Karara area and may be still declining due to predation pressure and habitat degradation by fire.

The Malleefowl was recorded within the Hinge project area; results of the Malleefowl surveys conducted at Hinge are discussed in Section 4.4.2 below.

Slender-billed Thornbill ***Acanthiza iredalei iredalei*** **(EPBC Vulnerable)**

The Slender-billed Thornbill is listed as Vulnerable under the EPBC Act. The Slender-billed Thornbill occurs in shrubland, typically in areas of saltmarsh dominated by samphire, bluebush (*Maireana*) or saltbush (*Atriplex*) around salt lakes or low heath on sandplain (Pavey 2006). The species occurs in a number of disjunct populations in Western Australia, from Shark Bay to the Nullarbor (Johnstone and Storr 2004). The Western Slender-billed Thornbill is considered uncommon, rare (and in some areas locally extinct) in inland Western Australia. The species is declining in much of its range owing to the degradation of chenopod vegetation by livestock and rabbits (Johnstone and Storr 2004). In the Northern Territory, the western subspecies of the Slender-billed Thornbill is classified as Regionally Extinct (Pavey 2006). The Slender-billed thornbill is unlikely to be present within the project area due to a lack of suitable habitat.

Peregrine Falcon ***Falco peregrinus*** **(Sch 4)**

The Peregrine Falcon is classified as "Specially Protected Fauna" under Schedule 4 of the Wildlife Conservation Act. This species is found in a variety of habitats, including rocky ledges, cliffs, watercourses, open woodland and acacia shrublands. The distribution of the Peregrine Falcon is often tied to the abundance of prey as this species predates heavily on other birds. The Peregrine Falcon lays its eggs in recesses of cliff faces, tree hollows or in large abandoned nests of other birds (Birds Australia 2008). Blakers *et al.* (1984) consider that Australia is one of the strongholds of the species, since it has declined in many other parts of the world.

A breeding pair of Peregrine Falcons has been recorded by BCE in the Karara area, on the eastern edge of the Mungada ridge, an area with steep slopes and lots of exposed rock. The nest site looked to be well-used, so possibly the pair forages mostly to the east of Mungada ridge. Territory size varies greatly in the Peregrine Falcon, but in a semi-arid environment pairs may forage over several hundred square kilometres (Marchant and Higgins 1993). The Hinge area is likely to form a component of a Peregrine Falcon's foraging range, however breeding habitat at Hinge (large, steep cliff faces) is lacking.

Major Mitchell's Cockatoo ***Cacatua leadbeateri*** **(Sch 4)**

Major Mitchell's Cockatoo is listed under Schedule 4 (Other Specially Protected Fauna) of the Wildlife Conservation Act. This species is sporadically distributed through arid and semi-arid Australia and may occur in woodland, sparsely timbered grasslands and shrublands and rocky outcrops (DEC Threatened and Priority Fauna Database 2008). This species was recorded on numerous occasions in the eucalypt woodland in the Karara area south of Hinge. Major Mitchell's Cockatoo was recorded in the south west of the Hinge project area. Birds will almost certainly visit the project area to forage.

Fork-tailed Swift ***Apus pacificus*** **(EPBC Migratory)**

The Fork-tailed Swift is listed as Migratory under the EPBC Act and under Schedule 3 of the Wildlife Conservation Act. The Fork-tailed Swift is an aerial species largely independent of terrestrial habitats. It has been recorded from the region, including from Morawa (Birds Australia 2008).

Rainbow Bee-eater ***Merops ornatus*** **(EPBC Migratory)**

The Rainbow Bee-eater is listed as Migratory under the EPBC Act and under Schedule 3 of the Wildlife Conservation Act. This species inhabits open woodland, open forest, grasslands and arid woodlands especially along watercourses.

The Rainbow Bee-eater occurs year-round in the tropics of northern Australia, with a southward migration, to both south-eastern and southwestern Australia, in early spring. Southern birds return north in autumn (Johnstone and Storr 1998). It occurs in the better watered parts of Western Australia, between the Kimberley and southwest, preferring lightly wooded, preferably sandy country near water (Johnstone and Storr 1998). It nests in burrows dug usually at a slight angle in flat ground, gently elevated slopes, sandy banks (such as creek banks), grasslands and often at the margins of roads or tracks. The Rainbow Bee-eater has a very widespread distribution over Australia, wintering in northern Australia and Indonesia, and migrating south during September and October (Johnstone & Storr 1998).

Although a species of high conservation significance, it is abundant and versatile in its selection of nest sites. This species is common, widespread and often breeds in disturbed areas such as ridges along roadside. The Rainbow Bee-eater has been recorded in the Karara area and is likely to occur in the Hinge project area.

Conservation Significance Level 2 (CS2)

Crested Bellbird (southern) ***Oreoica gutturalis gutturalis*** **(DEC Priority 4)**
The southern sub-species of the Crested Bellbird is listed as Priority 4 by DEC. This sedentary and solitary species inhabits the drier mallee woodlands and heaths of the southern parts of Western Australia (DEC 2008). The Crested Bellbird (southern) has declined in abundance as a result of habitat loss (land clearance) and is particularly sensitive to habitat fragmentation. The southern race of the Crested Bellbird occurs from near Geraldton on the west coast, through the wheatbelt to the southern coast of Western Australia, east of Esperance. The northern race (which is not considered significant) occurs from the Murchison and across much of WA except the Kimberley; both races occur in eastern Australia.

The Crested Bellbird was recorded from the Hinge project area, from eucalypt woodland and Acacia shrubland. The birds present in the project area may not strictly be the Wheatbelt race but are likely to be transitional with the non-significant northern race. The Crested Bellbird is locally widespread in the Karara area (BCE records).

Western Wheatbelt White-browed Babbler ***Pomatostomus superciliosus ashbyi*** **(DEC Priority 4)**
The DEC lists this sub-species as Priority 4. The Western Wheatbelt White-browed Babbler occurs in eucalypt forests and woodlands in the southwest of Western Australia. Clearing for agriculture has removed most of the White-browed Babbler's habitat in the wheatbelt of Western Australia (Saunders and Ingram 1995).

The White-browed Babbler was recorded within the Hinge project area, in dense Acacia shrubland. The White-browed Babbler occurs in the southwest of Western Australia, south of a line between approximately Jurien Bay and Hopetoun. The White-browed Babblers present in the project area may therefore not strictly be the Wheatbelt race but is likely to be transitional with the non-significant northern race, *P. s. superciliosus*.

Rufous Fieldwren (western wheatbelt) ***Calamanthus campestris montanellus*** **(DEC Priority 4)**
The Western Wheatbelt sub-species of Rufous Fieldwren is listed as Priority 4 by DEC. This species lives in low, sparse heath, saltmarsh or samphire, with or without emergent trees (DEC 2008). The decline of the Rufous Fieldwren has been attributed to habitat loss (agricultural clearing has removed large tracts of suitable habitat). Habitat degradation by stock and weeds continues to threaten this species. The Rufous Fieldwren persists in continuous habitat that surrounds the Wheatbelt.

The Rufous Fieldwren was not recorded within the Hinge project area. Neither has it been recorded by BCE in the Karara area. This species has been recorded in the region from Mongers Lake but is unlikely to occur in the Hinge area due to the lack of suitable habitat.

Australian Bustard ***Ardeotis australis*** **(DEC Priority 4)**
The Australian Bustard is listed as Priority 4 by DEC. The Australian Bustard is a large, ground-dwelling bird occurring in open or lightly wooded grasslands, chenopod

flats and plains (Johnstone and Storr 1998). It is nomadic and may range over very large areas, largely dependent on rainfall and food availability. Habitat degradation by sheep and rabbits, predation by foxes and cats and illegal shooting have caused a decline in the Bustard's numbers and range in the last century (Frith 1976). This species is known from the region, with records from Perenjori and Mongers Lake (DEC 2008).

This species may occur periodically in the Hinge area in open woodland and open shrublands, but is not dependent on habitats occurring within the disturbance footprint.

Bush Stone-curlew ***Burhinus grallarius*** **(DEC Priority 4)**

The ground-dwelling Bush Stone-curlew is listed as Priority 4 by the DEC. The Bush Stone-curlew inhabits lightly timbered open woodlands (DEC 2008) and dense Acacia shrublands (J. Turpin, pers. obs.). This species has suffered significant declines and is sparsely distributed in the southern parts of Western Australia (Birds Australia 2008).

The Bush Stone-curlew has been recorded from Badja homestead and also near Yalgoo (from Mulloo Hill, 70km north of Hinge, Birds Australia 2008). The Bush Stone-curlew is known to occur from dense Acacia shrublands on Banded Ironstone ridges (such as at Weld Range, J Turpin, pers. obs.). Due to these records, the Bush Stone-curlew is considered likely to be present at least as a visitor to the Hinge project area, including the impact area.

Grey Falcon ***Falco hypoleucos*** **(DEC Priority 4)**

The Grey Falcon is classified as Priority 4 by the DEC and Vulnerable by Garnett *et al.* (2010). The Grey Falcon is nomadic, inhabiting lightly timbered riverine plains. It appears to have a distribution centred around ephemeral or permanent drainage lines, utilising old nests of other species situated in the tallest trees along the river systems (Garnett *et al.* 2010). This species has been recorded in the Geraldton area (Birds Australia 2008). The Grey Falcon is unlikely to be present in the Hinge project area due to lack of suitable habitat, although may pass through or over the area (foraging) as a vagrant.

Conservation Significance Level 3 (CS3)

Square-tailed Kite ***Lophoictinia isura*** **[Threatened (least concern)]**

The Square-tailed Kite is listed as threatened (Least Concern) under the Action Plan for Australian Birds (Garnett and Crowley 2000). The Square-tailed Kite is sparsely distributed over much of the Australian mainland, with a few scattered records from the Karara region (Birds Australia 2008). The Square-tailed Kite is a specialised predator of the canopy, foraging primarily over forest, woodland, mallee and heath (Garnett and Crowley 2000). This species was recorded during a BCE survey in November 2008, south of Hinge, foraging over eucalypt woodland south of the Mungada ridge. This species is likely to occur in the Hinge area as an occasional visitor.

Regent Parrot ***Polytelis anthopeplus anthopeplus*** **[Lower Risk (least concern)]**

The western sub-species of the Regent Parrot is assessed as 'Endangered (Least Concern)' by Garnett *et al.* (2010) because a decline in population density has been observed in at least half the range of this subspecies. Clearing for agriculture and the decline of suitable nest trees (particularly *Eucalyptus salmonophloia*) due to salinity may be responsible for the decline in the WA wheatbelt. An eastern states subspecies, *P. a. monarchoides*, is also recognised.

The Regent Parrot was recorded south of Hinge in the Karara area, from eucalypt woodland and from Acacia shrubland. The species is considered likely to occur within the Hinge disturbance footprint.

Scarlet-chested Parrot ***Neophema splendida*** **[Threatened (least concern)]**

The Scarlet-chested Parrot has declined over much of its range and is listed as threatened under the Action Plan for Australian Birds (Garnett and Crowley 2000). This species formerly occurred across the Murchison and into the southwest of Western Australia, however has declined in the Goldfields and has not been recorded regularly near the West Australian coast since 1854 (Garnett and Crowley 2000). Most recent records for the Scarlet-chested Parrot come from arid inland Australia including the Great Victoria Desert. This species may be locally extinct in the Murchison and is likely to occur in the Hinge area only as a very rare vagrant.

Redthroat ***Sericornis brunneus*** **[Lower Risk (least concern)]**

The Redthroat is assessed as 'Lower Risk (Least Concern)' by Garnett and Crowley (2000) because habitat clearing and overgrazing have decreased the range and abundance of this species. The Redthroat, however, remains widespread in parts of its range. In Western Australia this species favours inland regions, from the mid-west Gascoyne/Pilbara coast to the South Australian and Northern Territory borders. The Redthroat was recorded throughout the Hinge project area in dense Acacia shrubland.

Western Yellow Robin ***Eopsaltria griseogularis rosinae*** **[Lower Risk (least concern)]**

The Wheatbelt population of Western Yellow Robin is assessed as 'Lower Risk (Least Concern)' by Garnett and Crowley (2000) because much of this subspecies' habitat has been cleared for agriculture and the subspecies continues to disappear from remnants. The Western Yellow Robin occurs in the wheatbelt within the 200 – 500 mm rainfall zone (in an approximate strip between Shark Bay and the Nullarbor). Western Yellow Robin intergrades with *E. g. griseogularis* (conservation significant on the Swan Coastal Plain) in the higher rainfall areas of the southwest. The Western Yellow Robin occurs in eucalypt woodland, mallee and Acacia shrubland.

This species was recorded by BCE in the Karara area, in low numbers, and was seemingly dependent on thicker vegetation in gullies and creeklines. All records were in such vegetation along the western side of Mungada ridge. The Western Yellow Robin is widespread from the southern Murchison to the Goldfields and parts of the lower Southwest but has disappeared from much of the Wheatbelt.

The Western Yellow Robin was recorded in the Hinge project area and is likely to occur within the dense vegetation.

Southern Scrub-robin ***Drymodes brunneopygi*** **[Lower Risk (least concern)]**

The Southern Scrub-robin is assessed as 'Lower Risk (Least Concern)' by Garnett and Crowley (2000) because of this species' tendency to disappear from fragmented vegetation blocks. This species occurs in Mallee, dry scrub, heaths, lignum on claypans and coastal tea-tree thickets.

The Southern Scrub-robin has been recorded from the region, from near Mongers Lake and near Perenjori (Birds Australia 2008). This species may occur within dense vegetation in the Hinge area but has not been found around Karara.

Rufous Tree-creeper ***Climacteris rufa (*****Range Limit)**

The Rufous Tree-creeper occurs in the Karara area at the northern extreme of its range. This species occurs in eucalypt woodlands where it nests in tree-hollows. The Rufous Tree-creeper was recorded on a number of occasions in the Karara area, south of the Hinge project area and may therefore occur in the eucalypt woodlands areas of the impact area.

Golden Whistler ***Pachycephala pectoralis*** **(Range Limit)**

The Golden Whistler is a widespread species but occurs in the Karara area at the northern limit of its range. This species inhabits forests and some woodlands in southern Australia (Birds Australia 2008). The Golden Whistler was recorded in dense, tall acacia thickets in various locations in the Hinge project area.

Previous BCE records suggest this species is confined to thick shrubland of the lower slopes of the hills. The Golden Whistler occurs in the Hinge disturbance footprint, and with a restricted distribution, is likely to be impacted by habitat disturbance.

Gilbert's Whistler ***Pachycephala gilberti (*****Declining Woodland Species)**

The Gilbert's Whistler is recognized as declining by Saunders and Ingram (1995). This species occurs in thickets within woodlands of inland southern Australia. The Gilbert's Whistler has a very patchy distribution across the southern Murchison, Goldfields and parts of the Wheatbelt. In the project area, it may occur in any dense thickets along the lower slopes of the ironstone ridges, and has been previously recorded on the western side of Mungada ridge.

Grey Honeyeater ***Conopophila whitei (*****Range Limit)**

The Grey Honeyeater is an uncommon species and if present in the Hinge area would be at the extreme of its range. The Grey Honeyeater may occur within the Mulga shrublands of the project area, but probably only as an occasional visitor.

4.2.5 Mammals

A total of 27 species of native mammal may occur in the vicinity of the Hinge project area (Appendix 5). Five species (two native and three introduced) were recorded throughout the surveys. These comprised the Echidna, Euro, Fox, Rabbit and Goat.

The mammal assemblage expected in the Hinge area is reduced because of a high rate of local extinction; there are expected to be 27 native mammal species extant in the area but 22 locally extinct mammals (Appendix 5). This high rate of extinction among mammals is typical of mainland Australia and has been associated with a wide range of factors, including changes in fire regimes, introduced predators and competition with introduced herbivores (including livestock) (Burbidge and MacKenzie 1989). The extinct Lesser Stick-nest Rat (*Leporillus apicalis*) and Boodie or Burrowing Bettong (*Bettongia lesueur*) formerly occurred in the region and remnants of their shelters (nests and burrow systems) were recorded at Shine to the north of the Hinge project area in 2010 and 2011.

The extant mammal assemblage consists largely of widespread, arid zone species. The influence of biogeography on the richness of the mammal assemblage is less than seen with birds and reptiles, although Woolley's Pseudantechinus is found largely to the north and is at the extreme south of its range in the southern Murchison.

Habitat diversity is also not as strong an influence upon mammal species richness as seen with birds and reptiles. Eleven of the 27 native species are bats and these may roost in caves and crevices in the ridges as well as in tree hollows in eucalypts, while Woolley's Pseudantechinus may be confined to the ironstone ridges, as it is largely restricted to rocky environments elsewhere in its range. Mitchell's Hopping-Mouse, if present, will occur in areas of sandy-loam soils.

Three of the mammal species that may be present are considered to be of conservation significance. These are outlined below, with a summary of conservation status and impacts in Table 12.

Conservation Significance Level 3 (CS3)

Woolley's Pseudantechinus ***Pseudantechinus woolleyae***

Woolley's Pseudantechinus occurs in arid Western Australia from the Pilbara south to the Goldfields. This species favours rocky, rugged stony habitats and has been recorded through the Murchison. Although not listed as a threatened or priority species, Woolley's Pseudantechinus is sparsely distributed between the Pilbara and Murchison regions of Western Australia and occurs in the Karara area in the extreme southwest of its range. The species' strong habitat preference for rocky hills means that populations may be fragmented, particularly in southern areas where such habitat is isolated by expansive plains.

Kultarr ***Antechinomys laniger***

The Kultarr is widespread across arid Australia but is uncommon over much of its range. It favours habitat that is open, arid and treeless with sparse grasses and small shrubs. Although not listed as threatened or a Priority species by DEC, its sparse

distribution, seasonal fluctuations in population and its decline and local extinctions in NSW, Queensland, Northern Territory and South Australia make it vulnerable to habitat loss and predation.

The Kultarr has been reported on Badja Station by the Badja Station Manager (R. Pitman, pers. comm.).

Common Brushtail Possum ***Trichosurus vulpecula vulpecula***

The Common Brushtail Possum has undergone a significant reduction in distribution in Western Australia, and the Midwest in particular (How and Hilcox 2000). In Western Australia, it is now generally confined to the temperate southwest, Kimberley and Pilbara coast. This species inhabits a range of habitats including forests and woodlands containing large hollow bearing trees and ground refuges (such as hollow logs, DEC 2008). Its status in the project area is uncertain but the species was observed 50km to the southwest of Karara in April 2006 (G. Woodman, pers. comm.). The Brush-tailed Possum is common in parts of the Southwest and elsewhere in Australia, but inland populations from the Murchison and Goldfields are virtually extinct, so a record near the project area is regionally significant.

4.3 Short-range Endemic and other significant Invertebrates

Invertebrates in general are beyond the scope of evaluation for environmental impact assessment because there are so many species and their taxonomy is so poorly understood, but it is possible to focus on a small number of taxa that are short-range endemics (SRE), while some species are listed under legislation. Harvey (2002) notes that the majority of invertebrate 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), Schizomida (schizomids; spider-like arachnids), Diplopoda (millipedes), Phreatoicidea (phreatoicidean crustaceans), and Decapoda (freshwater crayfish).

Detection resources, personnel skilled in identification and a regional-scale understanding of taxa distributions are very limited for many of these groups. There are, therefore, only a few groups of SRE invertebrates for which sufficient expertise and data exist to make positive identifications, place findings in a regional context and to make confident conclusions of a taxon's status within a project area. In addition, some of these taxa are absent from the semi-arid landscape of the project area. In the case of the Hinge project the groups likely to be present and for which sufficient expertise is available are:

- Snails,
- Trapdoor (mygalomorph) spiders,
- Pseudoscorpions,
- Scorpions,
- Millipedes, and
- Slaters

There are four conservation significant invertebrate species expected to occur in the Hinge project area. The Shield-backed Trapdoor Spider *Idiosoma nigrum* is of conservation status CS1; it is listed under Schedule 1 (Endangered) of the *Wildlife Conservation Act* and has been recorded at Hinge. It is found from the western Wheatbelt in the vicinity of Toodyay, Northam and Beverley to north of Kalbarri, with most records from the Wheatbelt but some from the adjacent Murchison (Burbidge 2004, B. Main pers. comm.). Shield-backed Trapdoor Spiders have been found throughout ironstone ridges in the Karara area, in gravelly-loam soils on the mid to upper slopes of the Mungada, Karara, Blue Hills, Spyder, Hinge and Terapod ridges (Huang and Bamford 2011). Results of the targeted surveys for the Shield-backed Trapdoor Spider at Hinge are discussed in Section 4.4.3 below.

The potential exists for SRE species to occur in the vicinity of the Hinge project because the landscape with ironstone ridges surrounded by broad plains is ideal for the persistence of relictual populations and the evolution of SRE species. Three SRE species have been previously recorded in the Karara area by BCE (identifications by Harvey 2006). These include:

- *Antichiropus* sp. nov. 'PM1' (short range endemic);
- *Antichiropus* sp. nov. 'Karara' (short range endemic); and
- *Urodacus* Mt Gairdner (short range endemic).

Slaters of at least one species have also been collected at Karara and near Minjar, but cannot at present be identified.

While these species were recorded in the Karara area, surveys for SRE species have not been conducted in the Hinge project area and it is unknown if these species are present, although the similarity of the environment makes this likely.

Antichiropus sp. nov. 'PM1' has previously been collected from Karara but is currently undescribed. The specimens collected came from the margin of a temporary wetland alongside the proposed Karara haul road and were not associated with any ironstone ridges. It is considered to be an SRE species but occurs across the northern Wheatbelt and southern Murchison from East Yuna Nature Reserve to Lake Ninnan Shire Reserve, a linear distance of some 310 km. Therefore, although it is an SRE species, if it does occur at Hinge, it is not likely to be confined to the project area.

Antichiropus sp. nov. 'Karara' was only collected in July 2008 (M. Bamford pers. comm.) and appears to be confined to the ridges of Mungada, Karara and Blue Hills. Surveys for the millipede have not been conducted in the Hinge project area. The millipede genus *Antichiropus* is very species-rich and if it is present in the project area, it may be represented by yet another species. Whichever species this is, it is also likely to occur on surrounding hills in the Hinge area, outside of the impact zone.

Two specimens of *Urodacus* Mt Gairdner were collected on the Karara ridge and on the Mungada ridge. *Urodacus* Mt Gairdner is considered to be an SRE species with the only other known specimen from Mt Gairdner, some 200 km to the southeast. Therefore, if the species does occur at Hinge, it is not confined to the project area.

Other invertebrate species recorded by BCE in the Karara area are widespread and not considered to be short-range endemics or otherwise significant. These include:

- *Gaius villosus* (mygalomorph spider) widespread across inland southern WA and in the Karara area was recorded from loam and clayey-loam soils of the plain, often in thickets of *Acacia* aff. *coolgardiensis*;
- an undescribed species of *Aname* (Nemesiidae, Mygalomorph);
- *Aganippe rhaphiduca* (mygalomorph spider); widespread across inland southern WA and with a burrow similar to that of the Shield-backed Tapdoor Spider, but occurs in sandy loam to loam soils;
- scorpion *Archisometrus* sp. (Buthidae); and
- scorpion *Isometroides* sp. (Buthidae).

4.4 Targeted Surveys

4.4.1 Western Spiny-tailed Skink

Western Spiny-tailed Skinks are mostly found in York Gum (*Eucalyptus loxophleba)* woodlands but can also be found in Gimlet (*E. salubris)* or Samon Gum (*E. salmonophlois)* woodland. Populations have been found in patches as small as 1 ha but the highest numbers are usually found where there are fallen logs and low intensity grazing (How *et al.* 2003; Cogger 2000). The species has been recorded throughout eucalypt woodland in the Karara area to the south of Hinge.

There were two areas mapped as containing *E. loxophleba* woodland (19a) suitable for the Western Spiny-tailed Skink habitat in the Hinge project area (see Figure 7 and 8). During the September/October 2012 survey it was determined that of these two areas, the north western strip was better suited for skinks as it contained larger trees with more hollow logs. Two Western Spiny-tailed Skink scat deposits were recorded in this area in 2012 (at 486617.6E, 6788332N and 486599.1E, 6788311N, Figure 8). The scats were not very fresh so it is not certain if any animals were resident, but these records indicate that the species likely to be present in suitable habitat within the broader Hinge area.

4.4.2 Malleefowl

Within the Hinge project area, one active and 24 inactive Malleefowl mounds have been recorded throughout the surveys (Figure 10). The active mound was recorded in September/October 2012 and is located within the project area at 487796E, 6786108N (Figure 10). Two adult Malleefowl were recorded working the mound between October and November 2012 (Figure 11). The presence of eggshell on the mound indicates it was used the previous year. In November 2012 it was considered likely to still contain eggs.

Two sets of Malleefowl footprints were identified in July 2012 on the western boundary of the project area (487075E, 6789029N, Figure 10 and Figure 12).

Details of Malleefowl mounds recorded during the 2011 and 2012 surveys are provided in Appendix 6. In 2011 no active mounds were identified. In July 2012 one

inactive mound was identified and September/October 2012 1 active and 23 inactive mounds were recorded (Figure 10). The active mound was located in the southeastern courner of the site 487796E, 6786108N (Figure 10). A motion camera was installed on the mound that showed it being worked by two adult birds between October and November 2012 when it was collected (Figure 11, see Figures 13 and 14 for photographs of inactive mounds). Mounds are not concentrated along ridges, as is the case around Karara and Mungada, probably because more of the soils on the plains surrounding Hinge are a sandy loam, whereas the soils of the plains around Karara and Mungada are heavy loams and clays not generally suitable for mound construction.

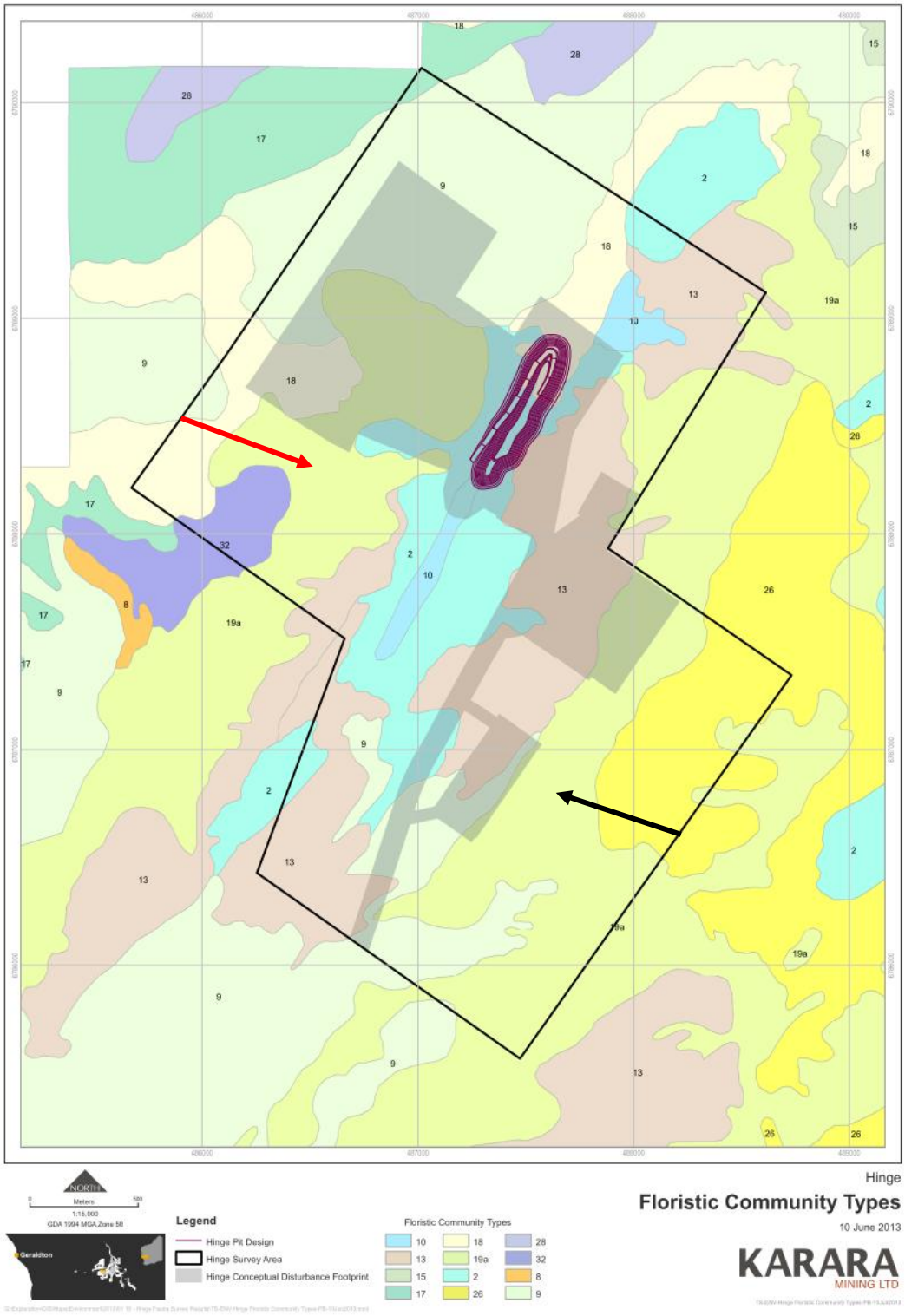

Figure 7. Vegetation map of Hinge project area; potentially suitable habitat for the Western Spiny-tailed Skink is vegetation type 19a (York Gum *Eucalyptus loxophleba* Woodland, red and black arrows). Black outline is the project area, and the red arrow indicates where Western Spiny-tailed Sinks were recorded.

Figure 8. Example of Western Spiny-tailed Skink Habitat found on Hinge.

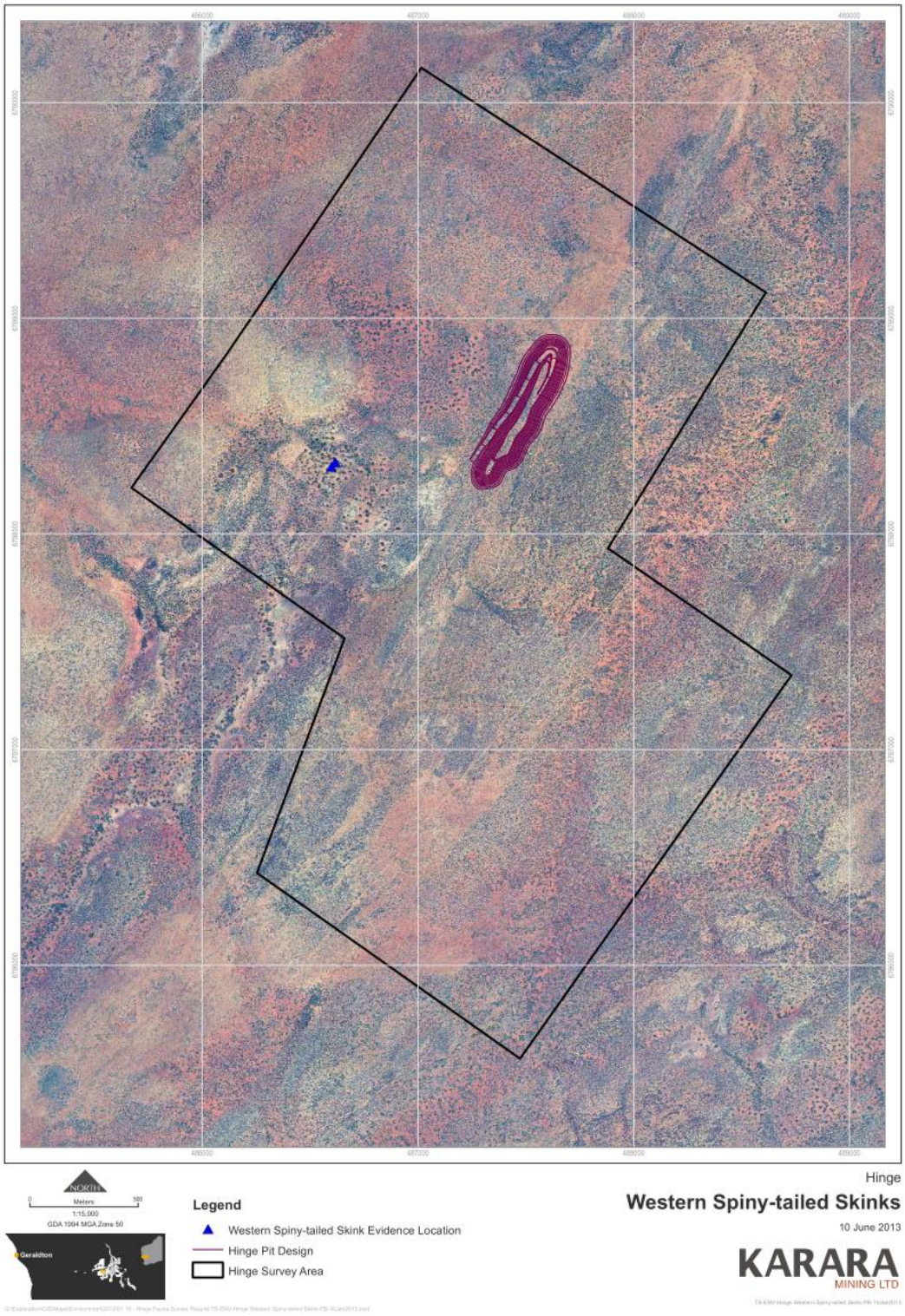

Figure 9. Records of Western Spiny-tailed Skink latrine sites identified during 2012 survey.

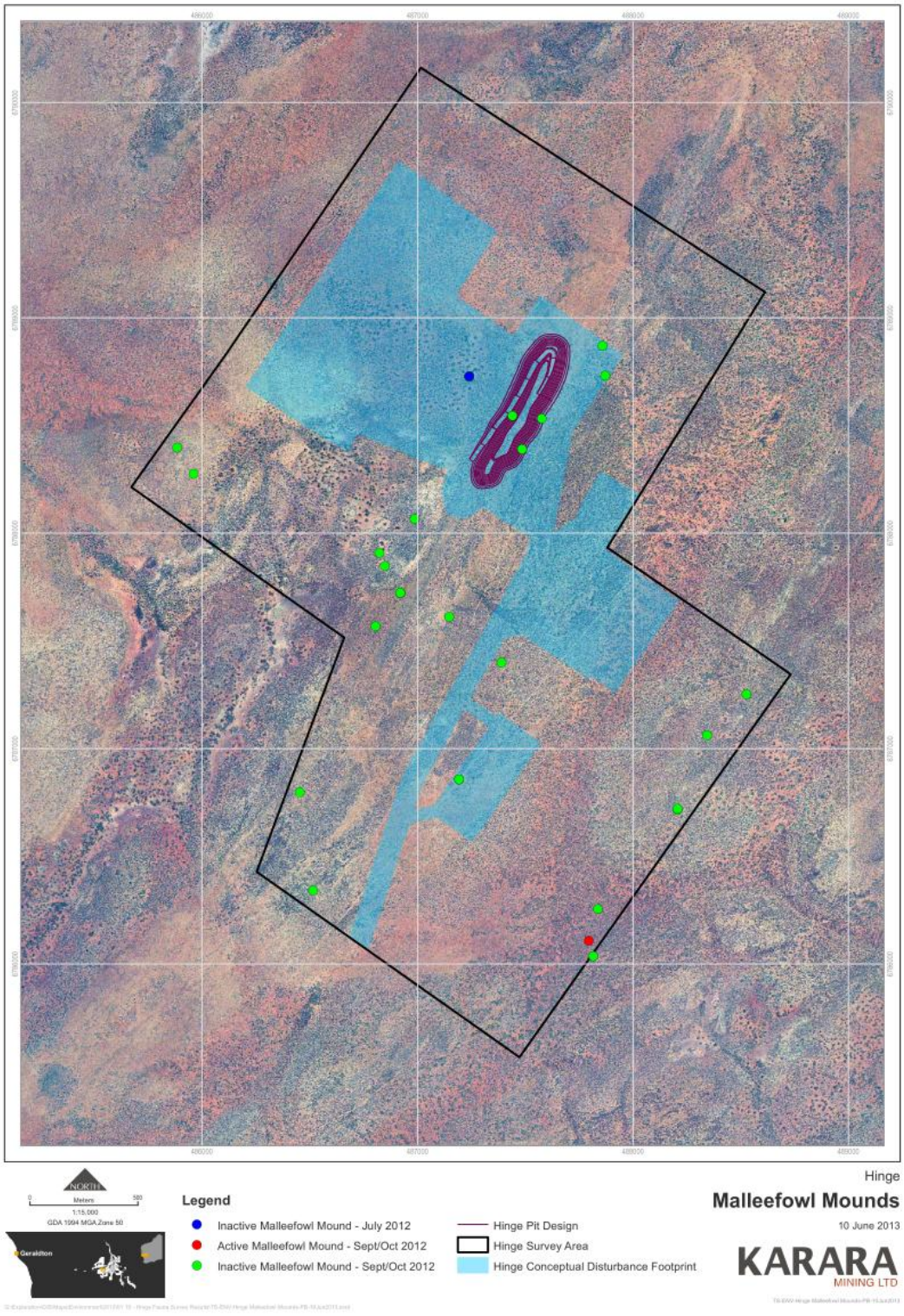

Figure 10: Locations of Malleefowl mounds recorded at Hinge in 2011and 2012.

Red dot is active mound identified in September/October 2012. Blue dot is inactive mound recorded in July 2012. Green dots are inactive mounds identified September/October 2012. Figure 5 outlines areas surveyed.

Figure 11: Active Malleefowl mound recorded at Hinge in 2012.

Figure 12. Malleefowl footprint seen during the July 2012 survey.

Figure 13: Inactive Malleefowl mound recorded at Hinge, showing some vegetative growth in the crater.

Figure 14: Inactive Malleefowl mound showing some recent diggings.

4.4.3 Shield-backed Trapdoor Spider

Overview

Out of 152 quadrats surveyed in 2011 and 2012, 38 quadrats contained spider burrows, with 144 active spider burrows recorded (Figures 15; Appendix 6). The maximum number of burrows found within a quadrat was 16. Several quadrats contained one or more matriarchal clusters, comprising one large adult burrow surrounded by numerous burrows of emergent and juvenile spiders. Six more opportunistic burrows were sighted on the ridgetop in the proposed pit area.

As with previous studies conducted on the spider in the Karara area (see Huang and Bamford 2011), spider burrows were generally found from the lower to upper slopes of the Hinge ridge and a smaller rise to the south (see Figure 15), and appeared to favour soils of cobbles with gravel and loam, or with rock outcropping. The spiders were closely associated with Acacia shrubs, with majority of burrows having fans constructed from *Acacia* (e.g. *A. ramulosa*) phyllodes (Figure 16 and 17). Within the project area they are virtually absent from the western and eastern plains away from the central ridge, except for the northeastern corner (Figure 15).

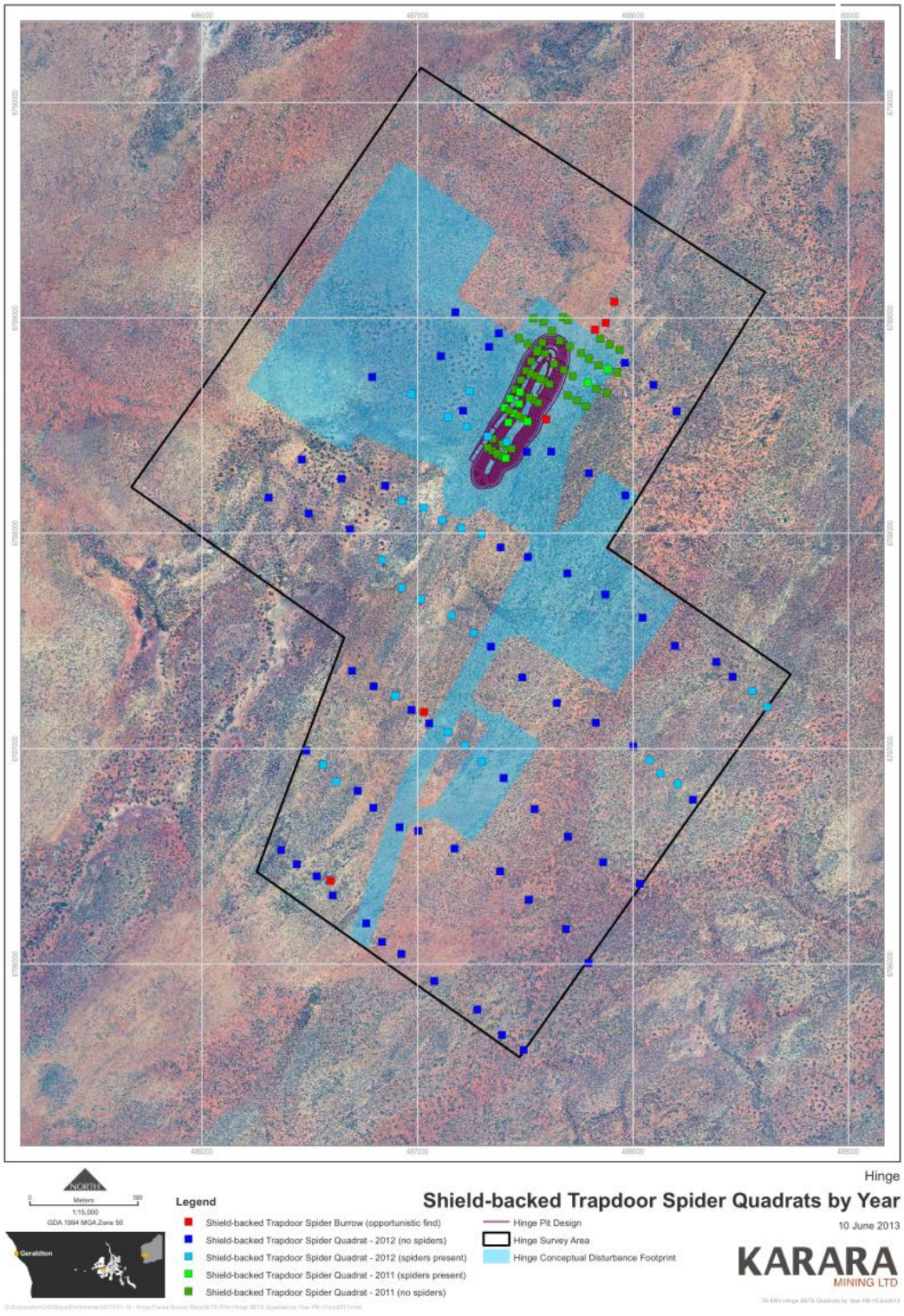

Figure 15: Locations of Shield-backed Trapdoor Spider quadrats and burrows recorded at Hinge in 2011 and 2012.

Figure 16: Shield-backed Trapdoor Spider burrow recorded at Hinge in 2012

Figure 17: Shield-backed Trapdoor Spider burrow recorded at Hinge in 2012

Population estimate

Quadrats were surveyed either for abundance or presence/absence of spiders, and were arranged at regular intervals along transects across a ridge and out onto the adjacent plains. This layout made it possible to define the distribution of the species on the Hinge ridge. The limits of distribution were defined by the quadrats furthest from the ridge that contained burrows, and by interpretation of slope, soils and vegetation. The approach used is explained in detail by Bamford (2013). Furthermore, the abundance surveys recorded the total number of burrows within 10m by 10m quadrats, thus providing a density estimate of the number of active burrows per ha.

The distribution on Hinge is restricted to the lower to upper slopes of the main ridge (approximately 105 ha) and to the smaller hill to the east (approximately 20 ha) giving a total of 125ha (Figure 18). Of this, the proposed pit covers 34 ha and 1000 m of the proposed roads (10 ha) is within the occupied habitat (Figure18).

Abundance of spiders on Hinge were calculated using methods outlined in a recent report on the distribution and abundance of spiders on ironstone ridges throughout the Karara area produced in 2011 (see Huang and Bamford 2011). A total of 144 spider burrows was recorded in 152 10 x 10 m quadrats, a survey area of 15,200 m^2 or 1.52 ha, which equates to 95 spiders per ha. However, spiders are restricted to the ridge and slopes that only cover 125 ha of the Hinge project area. Of the quadrats surveyed, 99 are within the predicted distribution, giving a total survey area of 9900 m^2 (0.99 ha). Therefore, within the predicted distribution, spider populations are estimated to be 145 spiders per ha or a total of 18,125 spiders.

However, spider densities are not uniform across the predicted distribution. Most of the proposed pit is within the predicted distribution (Figure 18), and 52 quadrats were surveyed in this area. Of these, 12 contained a total of 29 spiders, which equates to 56 spiders per ha or an estimated 1,904 spider where the pit is proposed. This low density may be due to the northern sector of the pit area having almost no spiders in an area of sparse shrubland. The rest of the Hinge ridge contains 71 ha of predicted distribution, with 65 quadrats surveyed and 86 spiders recorded; a density of 132 spiders/ha and a total of 9,372 spiders. The 20 ha of habitat to the east accommodate approximately 8,285 spiders at a high density of 414/ha. This gives a total spider population at hinge of 19,561 (Tables 14 and 15).

Table 14: Abundance of burrows per ha at Hinge and other sites in Karara

Site	Survey year	Number of burrows	Number quadrats bounded within predicted distribution	Number burrows per ha
Karara	2008	221	67	330
Karara	2009	172	63	273
Mungada	2009	68	23	296
Shine	2011 only	230	80	288
Shine	2011 and 2012	262	97	270
Hinge predicted distribution	**2011 and 2012**	**144**	**99**	**145**
Hinge proposed pit	**2011 and 2012**	**52**	**12**	**56**
Hinge ridge outside of proposed pit	**2011 and 2012**	**86**	**65**	**132**
Small hill to east	**2012**	**29**	**7**	**414**

Table 15: Estimated population size at Hinge

Site	Average number of burrows per ha	Extent of predicted distribution (ha)	Estimated population size
Shine	270	165	44,550
Shine disturbance area	270	81	21,870
Hinge predicted distribution	145	125	18,125
Hinge proposed pit	56	34	1,904
Hinge ridge outside of proposed pit	132	71	9,372
Small hill to east	414	20	8,285
Total estimated population at Hinge			19,561

Compared with Karara, Mungada and Shine ridges, Hinge has a lower density of spiders (Table 14). At other ridges in the Karara area, estimated population sizes ranged from approximately 20,000 spiders to 230,000 spiders on each ridge, depending on the ridge size. These estimates were calculated from the average abundance of 297 burrows per ha (the average of Karara, Mungada and Shine) and the predicted distribution at each site, an area based on spider records, contours and prospect boundaries.

The proposed pit site at Hinge does not appear to contain a high density of spiders. The proposed disturbance area may directly impact upon approximately 15% of the spider population in the Hinge area based on predicted occupied habitat. Predicted distribution to the south and east of the pit recorded more burrows per ha than in the area to be mined and therefore almost certainly support higher densities of the species. This provides an opportunity to reduce the impact to Shield-backed Trapdoor spiders by locating other infrastructure and development away from these areas of spider habitat.

However and in contrast, population sizes in the Crosslands (2009) and ecologia (2009) surveys further north and east were estimated at a few hundred animals on some ridges. A population estimate of just over 2000 on one ridge was claimed to be the largest known for the species (ecologia 2009). In contrast, the population sizes Bamford and Turpin (2009), working in the same area, calculated a population on one ridge of 14,994, including about 6,900 adult spiders.

Therefore, the population at Hinge, although lower than Karara, Mungada and Shine is typical of other ridges in the Karara region. Cumulative impacts need to be taken into account however when assessing new ridges for mining. It must be noted that with Karara, Blue Hills and Terapod ridges currently being mined and Shine under evaluation, the loss of each new ridge increases the cumulative impacts on specialised species such as Shield-backed Trapdoor Spiders at a population level. This makes each new ridge within the predicted distribution of the species important. It is also unknown whether there are genetic differences between this population and those of ridges in the Karara area.

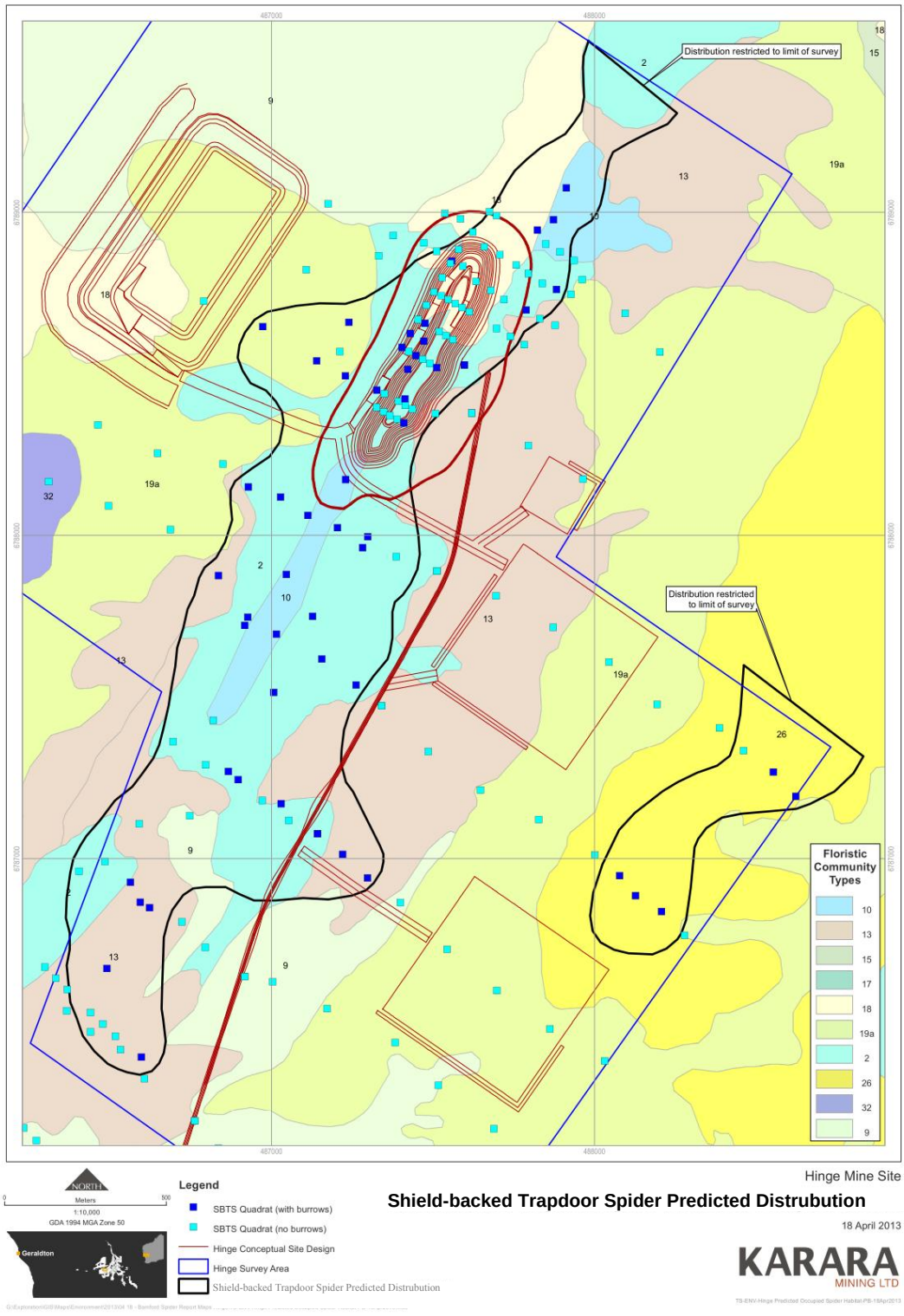

Figure 18: Results of quadrat surveys for the Shield-backed Trapdoor Spider in the Hinge area, indicating predicted distribution.

5 IMPACT ASSESSMENT

5.1 Overview of Impacts

The development of the Hinge project may adversely impact upon fauna in a number of ways. While some impacts upon fauna are unavoidable during a development project, of concern are long-term, deleterious impacts upon biodiversity. Impacts expected from this project may include the following:

- Death/injury/displacement/disturbance of fauna during clearing and impacts with vehicles/machinery.

- Loss of habitat
  - clearance, removal or degradation of native vegetation;
  - weed invasion displacing native vegetation;
  - hydrological changes altering or removing fauna habitat;
  - loss of local resources.

- Degradation of fauna habitat
  - increased levels of disturbance to fauna habitats and local fauna;
  - increased weed invasion degrading or removing fauna habitat;
  - increased levels of artificial chemicals, nutrients, heavy metals entering the proposed project area;
  - increased incidence of fire.

- Obstructions to the movements of terrestrial fauna.

- Altered hydrological processes
  - resulting in habitat removal or modification;
  - impacts to surface and groundwater flows (through vegetation clearing, interception of the ground water table, alterations to natural flows, drainage diversions), affecting the breeding biology of fauna species, particularly amphibians.
  - increased erosion due to clearing. Muddy runoff from roads and other cleared areas can have detrimental impacts on surrounding Shield-backed Spider Burrows.

- Disturbance of fauna in nearby areas.

- Changes in the abundance of feral species.

Potential impacts from the project upon fauna are considered under the categories outlined in Section 3.5.1: impacts to VSAs, conservation significant fauna and ecological processes that may affect the fauna assemblage. These are discussed in the following sections.

5.2 Vegetation and Substrate Associations

The significance of impacts upon VSAs is related to the fauna they support and the degree of impact from the proposed development. The main VSAs in the project area are described in Section 4.1 above.

The extent and impact on each VSA type can be summarised as follows:

1. **Banded Ironstone Ridges.**

- Representation. A linear ironstone ridge extends north-south through the project area. It supports mixed shrubland and low woodland of *Acacia, Allocasuarina* and *Myrtaceae* growing in generally shallow rocky-loam soils. This VSA extends outside of the project area to the north. Uncommon in the region and is likely to support habitat specialist species.
- Conservation Significance for Fauna. Due to its restricted occurrence, it is likely to support restricted populations of fauna. Supports the conservation significant Malleefowl (CS1), Gilled Slender Blue-tongue (CS1), Shield-backed Trapdoor Spider (CS1) and Woolley's Pseudantechinus (CS3) and is likely to support SRE invertebrates (see Section 3.2.3 and Appendix 1 for definitions of Conservation Significance levels). Woolley's Pseudantechinus, the Shield-backed Trapdoor Spider, SRE invertebrates (such as the millipede *Antichiropus sp. nov.* "Karara") and possibly the Gilled Slender Blue-tongue are likely to be dependent on habitat occurring within the proposed disturbance footprint (i.e. rocky habitat along the Hinge ridge). The Malleefowl is present but also widespread in surrounding VSAs.
- Impact. The conservation significant species mentioned above are likely to suffer habitat loss and some habitat fragmentation as a result of the project.
- Impact Assessment. Impacts to this VSA are considered of moderate to high significance due to the nature of impact (direct), presence of conservation significant fauna, the restricted occurrence of the VSA and the cumulative impact of ridges within the region being disturbed.

2. **Foothills and slopes.**

- Representation. This flanks the main Hinge ridge and a smaller hill to the east. It supports a tall and dense shrubland of acacia (dominated by *Acacia ramulosa*) and melaleuca on gravelly-loam soils. Concentration of runoff from ironstone ridges is an important factor in the development of this habitat. Some areas of very dense shrubland occur on the steeper eastern slopes of the ridge. A restricted VSA that is uncommon in the region and is likely to support habitat specialist species.
- Conservation Significance for Fauna. Several conservation significant fauna species are reliant upon the slopes of the ironstone ridges with gravelly loam soils and associated dense vegetation. These include Malleefowl (CS1), Western Yellow Robin (CS3), White-browed Babbler (CS2), Redthroat (CS3), Golden Whistler (CS3), Shield-backed Trapdoor Spider (CS1) and potentially Gilbert's Whistler (CS3). A large population of Shield-backed Trapdoor Spider was recorded on the slopes of the Hinge ridge and neighbouring hills and along with 17 inactive Malleefowl mounds.

- Impact. Areas of this VSA are expected to be impacted. The slopes of the Hinge ridge are likely to be mined or used for stockpiles, including on the steeper eastern slopes.
- Impact Assessment. Impacts to this VSA are considered of moderate to high significance due to the nature of impact (direct), presence of conservation significant fauna, the restricted occurrence of the VSA and cumulative impacts from mining in the region.

3. Red-loam Plains.

- Representation. Plains of red loam soils, supporting mixed Acacia species at variable densities occur adjacent to the Hinge ridge. Emergent eucalypts are a significant component of this landform, and generally occur close to the foothills and in low-lying areas where water may concentrate.
- Conservation Significance for Fauna. Supports a low number of conservation significant fauna when compared to the surrounding ridges. However Malleefowl may create mounds in areas of dense vegetation, an active mound was identified in the southeastern courner and the Bush Stone-curlew is likely to occur.
- Impact. Unknown as only the proposed pit area was provided at the time of writing the report. However the majority of this VSA may lie outside the proposed area of disturbance.
- Impact Assessment. Impacts to this VSA are considered of minor significance due to the reduced presence of conservation significant fauna and the extent of the VSA within the region.

4. Minor Drainage Lines.

- Representation. Numerous minor and incised drainage tracts traverse the project area. These areas generally support very dense Acacia shrubland.
- Conservation Significance for Fauna. Similar to the dense vegetation on the slopes of the Hinge ridge, several conservation significant fauna species are reliant upon the associated dense vegetation. These include Malleefowl (CS1), Western Yellow Robin (CS3), White-browed Babbler (CS2), Redthroat (CS3), Golden Whistler (CS3), Shield-backed Trapdoor Spider (CS1) and potentially Gilbert's Whistler (CS3).
- Impact. Unknown. Impacts to this VSA should be avoided where possible.
- Impact Assessment. Impacts to this VSA are considered of moderate significance due to the potential presence of conservation significant fauna.

5. Eucalypt woodland.

- Representation. Two large areas of Eucalypt woodland occur to the east and west of the Hinge ridge. This VSA has a restricted occurrence in the region.
- Conservation Significance for Fauna. Three conservation significant fauna species occur within this VSA in the Karara area. These are the Major Mitchell's Cockatoo (CS1), Western Spiny-tailed Skink (CS1) and Reticulated Velvet Gecko (CS3). Western Spiny-tailed Skinks were recorded in the woodland to the west of the ridge and Major Mitchell's Cockatoos were seen in the area. Major Mitchell's Cockatoo has a broad distribution across inland Australia but there are few regions where it is now common. The Karara area appears to be one such region. The Western Spiny-tailed Skink has a scattered

distribution and is confined to the southern Murchison and northern Wheatbelt, so the population at Hinge would be of particular significance. The Reticulated Velvet Gecko is widespread in suitable habitat (woodlands of smooth-barked eucalypts). Additionally, this VSA is likely to contain tree hollows suitable for further conservation significant fauna and a significant resource for local fauna.

- Impact. Unknown. Impacts to this VSA should be avoided where possible.
- Impact Assessment. Impacts to this VSA are considered to be moderate to high due to the presence of conservation significant fauna and the restricted occurrence of the VSA regionally.

Significant VSAs are areas of soils, vegetation types and/or landform that are important for significant species or biodiversity. They are often small in extent and as a general rule, rare VSAs are likely to be of particular interest with respect to impact assessment compared with common or widespread habitats. Within the Hinge project area, several VSAs are identified as significant, with impacts from the project likely to be moderate. These are:

- Ironstone ridges;
- Foothills and slopes;
- Drainage lines (if impacted); and
- Eucalypt woodlands (if impacted).

5.3 Conservation Significant Species

Impacts on conservation significant species are considered to be mostly of minor significance, with impacts considered to be potentially moderate for a few species largely reliant on environments on the ridge that are within the impact area (Table 16). Several conservation significant species are expected to occur at Hinge, however six are of particular importance, as they occur, or are expected to occur, in resident populations or are in restricted habitats. Many of these species occur in the Karara area in habitats similar to those found at Hinge. These include habitat specialist or restricted species:

- Malleefowl (CS1, one active mound and two sets of prints recorded but these, and most mounds, outside the impact area);
- Shield-backed Trapdoor Spider (CS1, a population of approximately 19,561 expected within the project area and 1,904 (9.7%) expected within the proposed pit area; unknown what other areas will be disturbed);
- Western Spiny-tailed Skink (CS1, two areas of scats recorded west of the Hinge ridge and outside the proposed pit impact area)
- Gilled Slender Blue-tongue (CS1, may occur on Hinge ridge);
- Woolley's Pseudantechinus (CS3, may occur on the Hinge ridge)
- Western Yellow Robin (CS3, recorded on slopes the of Hinge ridge);
- Golden Whistler (CS3, recorded on Hinge on the ridge); and
- Short range endemic invertebrates (CS3, expected to occur on Hinge ridge).

A summary of the potential impacts upon the conservation significant species expected to occur at Hinge and actions that may minimise these impacts are detailed in Table 16.

Table 16: Potential impacts upon conservation significant species expected to occur in the Hinge project area

Criteria for significance of impact as outlined in Section 3.5.2. Actions required for the Malleefowl, Western Spiny-tailed Skink and Shield-backed Trapdoor Spider are guided by the KML management procedures for each species.

Species Name	Nature and significance of likely impact		Action required
	Nature of impact	Significance	
Species of concern with moderate likely impact			
Malleefowl	Loss of habitat and disturbance, loss of breeding sites (mounds). Species known to be sensitive to roadkill from increased traffic.	Minor – (resident population of Malleefowl likely be impacted, however disturbance area is small and mounds have been found across adjacent Shine and Badja Station, with habitat extensive in local area. Increased traffic limited to a few roads).	Design project to minimise disturbance to species and habitat. Minimise habitat loss and avoid disturbance to Malleefowl mounds. Minimise loss of active and recently active mounds. Signage on roads near mounds to minimise roadkill. Conduct ongoing monitoring to determine impacts on local population. Feral predator control programs across Badja Station could benefit the regional Malleefowl population.
Shield-backed Trapdoor Spider	Loss of habitat and disturbance	Minor (About 15% of resident population of spiders likely to be impacted assuming impacts are lagely limited to proposed pit area; cumulative regional impacts need consideration).	Design project to minimise disturbance to species and habitat. Place associated works away from the ridge and hill to the east. Avoid disturbance to drainage lines and the ironstone ridge. Minimise habitat loss. Conduct ongoing monitoring to determine impacts on local population.
Western Spiny-tailed Skink	Habitat loss, disturbances to breeding (removal of habitat trees and logs)	Minor (occurs in fragmented populations in the region but resident population identified in project area lies outside proposed pit impact area. Impact woulkd have to be reviewed if infrastruxture were to impact upon where the species was recorded. Individuals may also disperse through project area).	Design project to minimise disturbance to species and habitat. Place associated works outside of Eucalypt Woodland particularly to the west of the ridge to avoid impact on Western Spiny-tailed Skink habitat.
Gilled Slender Blue-tongue	Habitat loss and disturbance. Loss and fragmentation of ridge top habitat.	Moderate (occurs in fragmented populations in the region, may occur in project area and likely to be restricted to high in the landscape where most impact occurs).	Minimise loss of suitable habitat.
Woolley's Pseudantechinus	Loss and fragmentation of habitat.	Moderate (occurs in fragmented populations in the region, may occur in project area).	Minimise disturbance footprint, minimise impact to breakaways and rocky ridges.

Western Yellow Robin, Golden Whistler	Loss of habitat, some localised population loss through disturbance.	Moderate (Most CS3 species are at the limit of their range and patchily distributed in the Murchison. Also restricted distribution in the project area).	Minimise disturbance footprint in areas of suitable habitat, dence vegetation in drainage lines and foothills and slopes.
Species of less concern with minor/negligible likely impact			
Carpet Python	Loss of habitat, potential for roadkill.	Minor (occurs in fragmented populations in the region, but project area may be outside range).	Minimise disturbance footprint, avoid disturbance of tree hollows.
CS3 Reptiles (Mulga Dragon, Reticulated Velvet Gecko)	Loss of habitat, some localised population loss through disturbance.	Minor (loss of habitat, fragmentation of populations).	Minimise disturbance footprint.
Slender-billed Thornbill	Potential for loss of habitat	Negligible (suitable habitat not present in project area, unlikely to occur)	None.
Peregrine Falcon	Potential loss of habitat and disturbance	Negligible (likely in project area as occasional visitor but unlikely to be affected by clearing of a small amount of vegetation).	Avoid disturbance to large trees (possible nesting / roosting sites). Minimise disturbance footprint.
Major Mitchell's Cockatoo	Loss of breeding habitat (tree hollows)	Minor (relies mainly on Eucalypt Woodlands which are mostly outside impact areas).	Minimise loss of suitable habitat including large trees.
Rainbow Bee-eater	Potential loss of habitat and disturbance	Negligible (likely to occur as an occasional visitor).	None.
Fork-tailed Swift	Potential loss of habitat	Negligible (likely to occur as rare visitor but not reliant on terrestrial environments).	None.
Crested Bellbird (southern)	Habitat loss and fragmentation	Minor (locally widespread and may be transistional with non-significant race)	Minimise disturbance footprint.
White-browed Babbler (western wheatbelt)	Habitat loss and fragmentation	Minor (locally widespread and may be transistional with non-significant race)	Minimise disturbance footprint.
Rufous Fieldwren (western wheatbelt)	Potential loss of habitat	Negligible (suitable habitat not likely to be present in project area)	None.
Australian Bustard	Loss of habitat. Risk of roadkill.	Negligible (likely only as an occasional visitor and limited suitable habitat in project area).	Minimise disturbance footprint, minimise habitat loss. Monitor and manage increased mortality.
Bush Stone-curlew	Loss of habitat. Risk of roadkill.	Minor (minor loss of habitat, widespread species present in small numbers).	Avoid disturbance to drainage lines. Minimise habitat loss and manage hydrological impacts. Minimise disturbance footprint. Monitor and manage increased mortality.

Grey Falcon	Potential loss of habitat and disturbance	Negligable (likely in project area as occasional visitor).	Avoid disturbance to large trees (possible nesting / roosting sites). Minimise disturbance footprint.
Other CS3 Birds	Loss of habitat, some localised population loss through disturbance.	Minor (Most CS3 species are at the limit of their range and patchily distributed in the Murchison. Also restricted distribution in the project area).	Minimise disturbance footprint in areas of suitable habitat.
Kultarr	Loss of habitat, feral predation	Minor (species probably widespread at low density)	Minimise disturbance footprint; feral predator management.
Common Brushtail Possum	Loss of habitat, potential for roadkill	Minor (species probably widespread at low density)	None. Note that main threatening process for species in region is probably feral predators.
SRE Invertebrates	Potential for habitat loss	Moderate (Most species likely to be restricted to the ridge and seasonally moist sites where runoff is concentrated, making them vulnerable to habitat loss and hydrological change).	Minimise disturbance to suitable habitat; conduct additional surveys targeting SRE species.

5.4 Ecological Processes

Many of the potential impacts of the proposed development upon fauna can be related to ecological processes (Appendices 2 and 4). There are currently 17 key threatening processes listed by the federal Department of Sustainability, Environment, Water, Population and Community (SEWPC 2011, see Appendix 4). Several of these processes may be applicable to the Hinge project area:

- Land clearance;
- Loss of climatic habitat caused by anthropogenic emissions of greenhouse gases;
- Predation by the Feral Cat;
- Predation by the European Red Fox;
- Competition and land degradation by feral Rabbits; and
- Competition and land degradation by feral Goats.

There are common themes through the ecological processes outlined by Soule *et al.* (2004), the key threatening processes listed by SEWPC 2011 and some of the impacts discussed with respect to threatened species (see Appendix 4). Potential impacts of the proposed exploration upon the fauna assemblage in the project area are discussed under the headings of ecological processes below.

5.4.1 Increased mortality

Direct mortality of common species during clearing is unavoidable but can be minimised (see recommendations below). In general, areas to be cleared are small within the context of the regional landscape so mortality during clearing is likely to represent only small proportions of regional populations. However, the viability of species that occur at low population densities in areas adjacent to the project area may be compromised by ongoing mortality. Roadkill may be a significant threat to species such as the Malleefowl and Bush Stone-curlew.

5.4.2 Loss of habitat affecting population survival

The loss of significant habitat may be detrimental to local fauna populations. Of particular significance may be impacts to the ironstone ridge and drainage lines within the project area (see Section 5.2). These VSAs are expected to support a higher number of conservation significant species, species with restricted ranges, specialist species and potentially short-range endemic fauna. To minimise loss of significant fauna species, impacts to the rocky ridge and drainage line VSAs should be minimised.

Additionally, disturbance to breeding habitat of conservation significant species should be avoided. One active Malleefowl mound is known to occur within the Hinge project area; where practical, efforts should be made to minimise disturbances to mounds, particularly those that are active or recently active.

As noted above, the project area lies within a region with a complex of ironstone hills so fauna species occurring within the Hinge project area can be expected to be more

widespread than the impact area. The distribution of even SRE invertebrates is likely to be greater than the impact area. Despite this, the abundance of some species in the region may depend upon populations in small areas that may be impacted. For example, species largely dependent upon well-developed ironstone ridges and well-developed dense vegetation in the lower slopes of the ridges may be significantly impacted by the project. This is particularly the case when you take into account the cumulative impact of mining and exploration within the region. Intensive surveys over surrounding hills would be required to quantify this impact.

5.4.3 Loss of habitat affecting population movements and gene flow

Connectivity of habitat can be a major concern with resource development projects in fragmented landscapes. While the project area supports almost continuous habitat and therefore disruption of connections across the landscape should not be a major concern, there are some linear habitats that the development could fragment. This is mainly an issue with the ironstone ridges where mining may leave isolated areas of habitat. There may also be a concern with stockpiles or waste dumps alongside the ridges disrupting fauna movements between low and high parts of the landscape.

5.4.4 Species interactions, including predators and other feral species

Feral species are a major conservation concern in general but are a small component of the fauna of the project area, although the Feral Cat, Goat, Rabbit and Fox were recorded during the survey and are likely to occur throughout the project area. With development, they are likely to increase in numbers in the area. These can be attracted by permenant water, food scraps or deliberately encouraged by some staff. They can also gain improved access to habitat along tracks and roads.

Predation by introduced species has contributed to the local extinction of some mammal species and may also affect the Malleefowl, Bush Stone-curlew and Brush-tailed Possum. Given the presence of species thought to be sensitive to feral predators, measures to avoid encouraging Foxes and Cats, and possibly control measures, should be considered. Control of feral species as part of the development may have a positive impact upon native fauna in the region, including the Malleefowl, affected by feral predators.

Control of Feral Goats in particular as well as Rabbits would also improve the suitability of surrounding habitat, which has been, and continues to be, severly degraded by these introduced herbivores. Liaison with local DEC should be undertaken to develop and implement a feral goat control program.

Additionally, weed invasion poses a significant threat to the fauna and flora values of the project area. Several weed species occur in the region, and they can replace native species and degrade fauna habitats. Vehicles, earthworks and road construction can spread weeds and should be managed properly.

5.4.5 Hydroecology

Interruptions of hydroecological processes are a concern where disturbances are associated with the major rivers and riparian vegetation. It is not known if there will

be localised or broad scale impacts from the project, or no impacts at all, but this needs to be investigated. Changes in groundwater levels may affect any groundwater dependent ecosystems, which may consequently impact on fauna utilising such areas. Impacts to the drainage lines in the project area may have impacts of moderate significance as this VSA is likely to support specialist species.

Increased erosion due to clearing of roads and larger areas can negatively impact adjacent areas. This is particularly relevant to Shield-backed Trapdoor Spiders whose burrows can be flooded and/or filled with mud due to changed runoff patterns and soil movment. Erosion control should be undertaken, particularly for disturbance on ridges and slopes.

5.4.6 Changes in fire regime

Some conservation significant fauna are particularly susceptible to fire. The incidences of fire may increase with development in an area, and local fauna populations may be impacted upon without proper fire management. Proper fire management may have a positive impact on fauna populations in the area and could be undertaken as part of development and management of the Hinge and Karara area.

5.4.7 Dust, light, noise and disturbance

The proposed development will introduce light, noise and other sources of disturbance to an area where there is currently very little human activity. Impacts under such circumstances are poorly documented, but the introduction of light may attract fauna to the area and alter species interactions. Vibration may impact on the population of Shield-backed Trapdoor Spiders; further studies are required to determine any impacts of such disturbance on local fauna populations.

5.5 Summary of impacts

Impacts are summarised in Tables 17 and 18. Impacts upon fauna values are generally considered to be minor, even upon the majority of significant species (see Table 16) because of the relatively small footprint (Table 17). Impacts upon VSAs may be of moderate significance as they are restricted, with similar VSAs throughout the region declining due to mining. Conservation significant species that may experience a moderate level of impacts are generally susceptible to increased mortality and increased feral predation. These impacts are of concern because they can affect the same suite of significant species that occur in low numbers (therefore fragile populations) and species that are sensitive to roadkill and predation by feral species.

Most ecological processes are expected to have only minor impacts, the exceptions being increased mortality (such as roadkill), loss of habitat affecting population survival (such as loss restricted VSAs impacting specialist species), and increased feral predation, which may experience moderate levels of impacts (Table 18).

Table 17: Summary of impacts upon fauna assemblage, VSAs and kwy conservation significant species

Fauna Value	Impacts from proposal	Significance of impacts
Fauna assemblage	Loss of some significant habitat.	Minor
VSAs	Some loss of significant and restricted VSAs.	Moderate
Malleefowl	Some population loss and habitat loss. Loss of breeding sites (Malleefowl mounds) and important thicket vegetation on slopes. Possible increase in predation and risk of roadkill. Sensitive to these impacts as present only in small numbers, but species is widespread in surrounding area and impacts are localised.	Minor
Shield-backed Trapdoor Spider	Some population loss and habitat loss. Restricted habitat. Potential disturbances from vibration associated with drilling and runoff from cleared areas. Widespread in the Karara area but restricted elsewhere.	Minor
Western Spiny-tailed Skink	Some population loss and habitat loss. Restricted habitat and population within the region. Possible increase in predation by feral predators. Potential decrease in habitat quality due to feral goats.	Minor
Gilled Slender Blue-tongue	Some population loss and habitat loss.	Moderate
Golden Whistler	Some possible loss of habitat, disturbance and increased predation pressure.	Moderate
Western Yellow Robin	Some possible loss of habitat, disturbance and increased predation pressure.	Moderate
Woolley's Pseudantechinus	Loss of habitat in restricted VSA, disturbance and increased predation pressure.	Moderate
SRE invertebrates	Loss of habitat in restricted VSA; possibly hydrological change	Moderate

Table 18: Summary of impacts upon ecological processes

Impacting process	Impact
Increased mortality leading to population decline	Moderate. With an increase in vehicular traffic, there may be an increased risk of roadkill of significant species that occur in very low numbers in the area, particularly Malleefowl and Bush Stone-curlew.
Loss of habitat affecting population survival	Minor. Loss of significant VSAs will occur within the proposed disturbance area. Localised habitat loss leading to the local loss of Malleefowl, Shield-backed Trapdoor Spiders and Western Spiny-taile Skink is anticipated. This can be reduced through placement of associated disturbance areas such as waste dumps, etc.
Loss of habitat affecting population movements and gene flow	Minor. Habitat fragmentation will result from the proposed project and will reduce connectivity of fauna habitats through the landscape.
Species interactions due to feral or over-abundant native species	Moderate. There is potential for changes in the abundance of some predators, notably the Dingo, Fox and feral Cat, and this could affect species sensitive to such predators. Feral Goats also decrease habitat health. Feral control programs could reduce this impact to Minor.
Habitat degradation due to weed invasion	Minor. Low risk of weed invasion beyond the current, provided management measures are in place.
Hydrological change	Minor. Impacts to hydrology are largely unknown, but impacts to drainage lines should be avoided.
Changes in fire regime	Minor. There should be little risk of a change in the fire regime, provided management measures are in place.
Dust, light, noise and disturbance	Minor. Some disturbance may result from the effects of dust, light and vibration, but are mostly unknown. Efforts should be made to minimise disturbance on the local Malleefowl and Shield-backed Trapdoor Spider populations.

5.6 Summary by EPA Guidance

According to criteria set out in the EPA Guidance Statement No. 56, the impacts of the development upon fauna in the Hinge project area can be summarised as given in Table 19.

Table 19: Potential impacts to fauna of the proposal as assessed following the guidance of the EPA's Guidance Statement No. 56.

(Terrestrial fauna surveys for environmental impact assessment in Western Australia, EPA 2004)

Factor	**Impact and explanation**
Degree of habitat degradation or clearing within the local area or region.	Minor (Project area is in region where very little clearing has taken yet place).
Size/scale of proposal/impact.	Major (>50ha of remnant native vegetation may be disturbed - Bioregion Group 2).
Rarity of vegetation and landforms.	Major (impacted vegetation and landforms include some that are limited in distribution, notably the ironstone hills).
Refugia.	Major (Ironstone hills are refugia for a range of species).
Fauna protected under international agreements or treaties, Specially Protected or Priority Fauna.	Major (faunal assemblage includes species of high conservation significance).
Size of remnant and condition/intactness of habitat and faunal assemblage.	Minor (project area is in a largely undisturbed environment).
Ecological linkage.	Moderate (the project area may provide linkage because it supports linear rare habitats that may link other refuge habitats across the landscape).
Heterogeneity or complexity of the habitat and faunal assemblage.	Major (project area has high habitat heterogeneity and a complex faunal assemblage).

6 RECOMMENDATIONS

The Hinge project area supports a rich fauna assemblage, with habitat specialist species such as the Shield-backed Trapdoor Spider and Western Spiny-tailed Skink present. Previous work by BCE in the Karara area has shown habitats targeted for development support significant populations of fauna, including conservation significant species. Ironstone ridges and adjacent slopes are especially important for conservation significant fauna. Fauna is therefore likely to be impacted largely through loss of habitat, although there are other considerations such as increased mortality through mining operations and increased feral predation.

Based on the impact assessment conducted in the above sections, several recommendations for the Hinge project area are made and are presented below. These are guided by the KML management procedures for the Western Spiny-tailed Skink, Malleefowl and Shield-backed Trapdoor Spider.

Recommendation 1:
Minimise chance of roadkill through speed limits (especially in areas of high wildlife activity such as close to Malleefowl mounds, water sources and at watercourse crossings). Install signage in areas where species such as Malleefowl are regularly seen. Educate personnel on significance of conservation significant species in the area.
Reason:
The populations of some significant fauna may be vulnerable to roadkill from traffic. Reduce mortality of fauna due to collisions, particularly threatened fauna species.

Recommendation 2:
Minimise disturbance footprint. Limit loss of habitat by minimising clearance of all native vegetation. Limit loss of habitat by restricting vegetation clearance and land disturbance to previously disturbed and degraded areas to a maximum possible level. Retain areas of native vegetation that maintain linkages to adjacent vegetation. Maximise the use of existing tracks.
Reason:
Retain as much habitat as possible, in the best condition possible. This will help retain the fauna values already present at the site, minimise impacts to conservation significant species and facilitate rehabilitation.

Recommendation 3:
Minimise disturbance of significant habitats, particularly linear and restricted habitat. Significant habitat includes the banded ironstone ridge, drainage lines and Eucalypt woodland. This s being done by placing associated works in areas adjacent to the Hinge ridge and away from Eucalypt Woodland with large trees and logs and the hill to the east of the site.
Reason:
These habitats provide shelter and refuge for a number of conservation significant species particularly Shield-backed Trapdoor spiders and Western Spiny-tailed Skinks, and provided opportunities for fauna movement and gene flow.

Recommendation 4:
Avoid disturbance to Malleefowl mounds. At least one active Malleefowl mound is known to occur within the project area. While loss of some mounds may be inevitable, the number of mounds impacted should be minimised. Mining infrastructure and activities should avoid active and recently active mounds.
Reason:
The Malleefowl is a conservation significant species listed under the EPBC Act. Disturbances to the breeding cycles of this species should be avoided.

Recommendation 5:
Conduct a monitoring program for the Malleefowl, Western Spiny-tailed Skink and Shield-back Trapdoor Spider in surrounding areas.
Reason:
Monitoring these species will assist the impact assessment on conservation significant species occurring within the Hinge area and region.

Recommendation 6:
Feral fauna, particularly Cats, Foxes and Goats, should be discouraged and managed. Implement feral animal control program across Hinge area and the Karara region. Liaise with DEC to develop and implement a goat control program throughout Karara as they are currently the feral animal having the greatest impact on biodiversity in the region.
Reason:
Feral predators can have significant impacts to fauna and often increase in abundance with development. A feral predator control program could have beneficial impacts to regional populations such as that of Malleefowl. The high goat numbers at the time of surveying are causing severe habitat degradation in the region and their removal from the area can have beneficial impacts on the vegetation and fauna population.

Recommendation 7:
Manage hydrology carefully. Impediments to surface hydrology and flows, and any effects on groundwater or surface hydrology should be minimised. Avoid disturbance to drainage lines.
Reason:
Hydrological changes can have far-reaching consequences on surrounding ecosystems. Habitats along drainage lines and those associated with seasonal waterbodies and run-off are locally significant for fauna and can support a high number of conservation significant fauna. Changes in hydrology may impact on the densely vegetated habitats associated with drainage from the ironstone hills and the fauna that utilise them. Previous surveys in disturbed areas occupied by Shield-backed Trapdoor Spiders have revealed negative impacts through runoff from roads and other cleared areas. Mud and silt block up burrows, rendering them unuseable

Recommendation 8:
Implement a proper fire management program in consultation with experts and based on ecological principles.
Reason:
The incidence of fire can increase with development and excessive fire can severely degrade habitats. Some species may also rely upon their habitat being burnt regularly.

Recommendation 9:
Rehabilitate where possible. After land disturbance, appropriate revegetation of all unused disturbed areas should be carried out, using locally collected seed.
Reason:
Insofar as possible, return disturbed areas into habitat that can support a faunal assemblage similar to those that occurred there before the disturbance.

7 REFERENCES

Adams, M., Reardon, T. R., Baverstock, P. R. and Watts, C. H. S. (1988). Electrophoretic resolution of species boundaries in Australian Microchiroptera. IV. The Molossidae (Chirpotera). Aust Journal Biological Science 41: 315-326.

Bamford, M. J. (2006). Gindalbie Metals N.L. and Midwest Corporation: Mt Karara/Mungada Haul Road; Fauna Assessment. Report prepared for Woodman Environmental Consulting by Bamford Consulting Ecologists, Kingsley, WA.

Bamford, M.J. (2008). Surveys for mounds of the Malleefowl *Leipoa ocellata* in the Karara area, July 2008. Unpubl. Report to Karara Mining Limited by Bamford Consulting Ecologists, Kingsley.

Bamford, M.J. (2013). Approach to mapping the extent of habitat of the Shield-backed Trapdoor Spider in the Karara region. Unpubl. report for: Karara Mining Ltd, GBG and Exploration by Bamford Consulting Ecologists, Kingsley.

Bamford, M.J. and Bancroft, W. (2011). Assessment for the Shield-backed Trapdoor Spider in the Hinge, Jasper Hills and Spyder Prospects. Unpubl. report to Karara Mining Limited by Bamford Consulting Ecologists, Kingsley.

Bamford, M.J. and Metcalf, N. (2008). Karara Mining Limited; Karara Iron Ore Project. Report into investigations into the status of Woolley's Pseudantechinus and the Shield-back Trapdoor Spider. Unpublished report to Gindalbie Metals by Bamford Consulting Ecologists, Kingsley.

Bamford, M. and Turpin, J. (2009). Report into investigations into the distribution and abundance of the Shield-backed Trapdoor Spider at Karara and Mungada; July 2009. Unpubl. report to KML by Bamford Consulting Ecologists, Kingsley.

Bamford, M. and Wilcox, J. (2004). Blue Hills fauna assessment. Unpubl, report by Bamford Consulting Ecologists to ATA Environmental, Perth.

Benshemesh, J. (2005). National Recovery Plan for Malleefowl 2006-2010. Department of Environment Water Heritage and the Arts, Adelaide.

Birds Australia (2008). BirdLife Australia Database. www.birdsaustralia.com.au (accessed January 2008).

Blakers, M., Davies, S.J.J.F. and Reilly, P.N. (1984). The Atlas of Australian Birds. Royal Australasian Ornithologists Union. Melbourne University Press.

Burbidge, A.A. and McKenzie, N.L. (1989). Patterns in the modern decline of Western Australia's vertebrate fauna: causes and conservation implications. Biol. Cons. 50: 143-198.

Burbidge, A.A. (2004). Threatened Animals of Western Australia. Department of Conservation and Land Management, Perth.

Bush, B., Maryan, B., Browne-Cooper R., and Robinson D. (2007) Reptiles and frogs in the bush: southwestern Australia. University of Western Australia Press.

Calver, M., Lymbery, A., McComb, J. and Bamford, M. (2009). Environmental Biology. Cambridge University Press, Melbourne.

Christidis, L. and Boles, W.E. (2008). Systematics and Taxonomy of Australian Birds. CSIRO Publishing, Australia.

Churchill, S. (1998). Australian Bats. Reed New Holland, Sydney, NSW.

Clevenger, A. P. and Waltho, N. (2000). Factors Influencing the Effectiveness of Wildlife Underpasses in Banff National Park, Alberta, Canada. *Conservation Biology* **14**: 1-11

Cogger, H. G. (2000). Reptiles and Amphibians of Australia. Reed New Holland, Sydney, Australia.

Crosslands (2009). Jack Hills mine expansion: Shield-backed Trapdoor Spider *Idiosoma nigrum* targeted survey. Unpubl. report to Crosslands by Phoenix Environmental, Balcatta.

Department of Environment and Conservation (2008). Threatened and Priority Fauna Database. Accessed November 2007.

Department of Environment and Conservation (2012). NatureMap Database. Accessed November 2012.

Department of Sustainability, Environment, Water, Population and Communities (2011a). Threatened Species Profiles. Available at: http://www.environment.gov.au/cgi-bin/sprat/public/publicspecies.pl?taxon_id=66699

Department of Sustainability, Environment, Water, Population and Communities (2011) *Protected Matters Database Search Tool*.

DEH. (2008). SpeciesBank. Department of the Environment and Heritage. http://www.deh.gov.au/biodiversity/abrs/online-resources/species-bank/index.html

Doughty, P. and Maryan, B. (2010a). Checklist of the Amphibians of Western Australia. Department of Terrestrial Zoology, Western Australian Museum, Welshpool, Western Australia.

Doughty, P. and Maryan, B. (2010b). Checklist of the Reptiles of Western Australia. Department of Terrestrial Zoology, Western Australian Museum, Welshpool, Western Australia.

Dufty, A.C. (1989). Some Population characteristics of *Perameles gunnii* in Victoria. Wildlife Research: **18** (3) 355 – 365.

ecologia (2009). The Shield-Back Spider Idiosoma nigrum Targeted Survey: Weld Range. Unpubl. report to Sinosteel Midwest Corporation.

Environmental Protection Authority (2002). Terrestrial Biological Surveys as an Element of Biodiversity Protection. Position Statement No. 3. Environmental Protection Authority, Perth, Western Australia.

Environmental Protection Authority (2004). Guidance for the assessment of environmental factors: Terrestrial fauna surveys for environmental impact assessment in Western Australia. No. 56. Environmental Protection Authority, Perth, Western Australia.

Environment Australia (2000). Revision of the Interim Biogeographic Regionalisation for Australia (IBRA) and Development of Version 5.1 -

Summary Report. Environment Australia, Department of Environment and Heritage, Canberra, Australian Capital Territory.

Frith, H.J., (1976). Reader's Digest Complete Book of Australian Birds. Reader's Digest Services Pty Ltd.

Garnett, S. and Crowley, G. (2000). The Action Plan for Australian Birds. Environment Australia and the Royal Australasian Ornithologists Union.

Garnett, S., Szabo, J.K. and Dutson, G. (2010). The Action Plan for Australian Birds 2010. Birds Australia. CSIRO Publishing, Collingwood, Victoria.

Harrington, R. (2002). The effects of artificial watering points on the distribution and abundance of avifauna in an arid and semi-arid mallee environment. Doctoral dissertation, University of Melbourne, Department of Zoology.

Harris, I and Bamford, M. (2008). *Surveys for Western Spiny-tailed Skinks Egernia .stokesii badia.* Report prepared by Bamford Consulting Ecologists for Karara Mining Limited: Karara Iron Ore Project.

Harvey, M. S. (2002). Short-range endemism among the Australian fauna: some examples from non-marine environments. Invertebrate Systematics 16: 555-570.

Harvey, M. S. (2006). The Short-Range Endemic Invertebrate Fauna from Karara Station, Western Australia. Unpubl. report to Bamford Consulting Ecologists by the Department of Terrestrial Invertebrates, WA Museum, Welshpool.

How, R. A., & Hillcox, S. J. (2000). Brushtail possum, Trichosurus vulpecula, populations in south-western Australia: demography, diet and conservation status. *Wildlife Research* **27**: 81-89.

How, R. A., Cooper, N. K. and Bannister, J. L. (2009). Checklist of the Mammals of Western Australia. Department of Terrestrial Zoology, Western Australian Museum, Welshpool, Western Australia.

How, R. A., Dell, J. and Robinson, D. (2003). The Western Spiny-tailed Skink, *Egernia stokesii badia*: declining distributing of a habitat specialist. Western Australian Naturalist 24: 138-146.

Huang, N. and Bamford, M. (2011). Review of distribution and abundance of the Shield-backed Trapdoor Spider in Karara Iron Ore Project area: Surveys conducted from 2007 to August 2011. Unpublished report to Karara Mining Limited, Perth.

IUCN. (2001). IUCN Red List Categories and Criteria, Version 3.1. IUCN Species Survival Commission, IUCN, Gland, Switzerland and Cambridge, UK.

Jackson, S. D. and Griffin, C. R. (2000). A Strategy for Mitigating Highway Impacts on Wildlife. Pp. 143 – 159, In Messmer, T. A and B. West, (eds) Wildlife and Highways: Seeking Solutions to an Ecological and Socio – economic Dilemma. The Wildlife Society.

Johnstone, R. E. and Storr, G. M. (1998). Handbook of Western Australian birds. Volume 1: Non-passerines (Emu to Dollarbird). Western Australian Museum, Perth, Western Australia.

Johnstone, R. E. and Storr, G. M. (2004). Handbook of Western Australian birds. Volume 2: Passerines (Blue-winged Pitta to Goldfinch). Western Australian Museum, Perth, Western Australia.

Jones, M.E. (2000). Road upgrade, road mortality and remedial measures: impacts on a population of eastern quolls and Tasmanian devils. *Wildl Res* **27**: 289 – 296.

Kofoed, P. (1998). A wizard with wavelengths. *Ecos* **96**. CSIRO.

Letnic, M., Dickman, C.R., Tischler, M.K., Tamayo, B. and Beh, C.L. (2004). The responses of small mammals and lizards to post-fire succession and rainfall in arid Australia. *Journal of arid environments* **59** (1): 85-114.

Mace, G. and Stuart, S. (1994). Draft IUCN Red List Categories, Version 2.2. Species; Newsletter of the Species Survival Commission. IUCN - The World Conservation Union. 21-22: 13-24.

Malleefowl Preservation Group (2008). Malleefowl Preservation Group website accessed in 2012 on http://www.malleefowl.com.au/

Marchant, S. and Higgins, P. J. (Eds). (1993). Handbook of Australian, New Zealand and Antarctic Birds. Volume 2: Raptors to Lapwings. Oxford University Press, Melbourne, Australia.

McKenzie, N. L., May, J. E. and McKenna, S. (2003). Bioregional Summary of the 2002 Biodiversity Audit for Western Australia. The National Land and Water Resources Audit and the Western Australian Department of Conservation and Land Management, Perth, Western Australia.

Menkhorst, P. and Knight, F. (2004). A Field Guide to the Mammals of Australia. Oxford University Press, South Melbourne.

Pavey, C. (2006). Threatened Species Of The Northern Territory: Slender-Billed Thornbill (western subspecies) *Acanthiza iredalei iredalei*. Accessed: 28/02/07. Available at: www.nt.gov.au/nreta/wildlife/threatened/pdf/birds/slenderbilled_thornbill_ex.

Payne, A.L., Van Vresswyk, A.M.E., Pringle, H.J.R., Leighton, K.A. and P. Henning (1998). An Inventory and Condition Survey of the Sandstone – Yalgoo – Paynes Find Area, Western Australia. Technical Bulletin 90. Department of Agriculture, Perth.

Priddel, D. and Wheeler, R. (2003) Nesting activity and demography of an isolated population of malleefowl (*Leipoa ocellata*). *Wildlife Research* **30**: 451-464

Rich, C. and Longcore, T. (2006). Ecological Consequences of Artificial Night Lighting. Island Press.

Saunders, D. A., & Ingram, J. (1995). Birds of southwestern Australia. An atlas of changes in the distribution and abundance of the wheatbelt fauna. Surrey Beatty and Sons, Chipping Norton. New South Wales, Australia.

Soule, M. E., Mackey, B. G., Recher, H. F., Williams, J. E., Woinarski, J. C. Z., Driscoll, D., Dennison, W. C. and Jones, M. E. (2004). The role of connectivity in Australian conservation. *Pacific Conservation Biology* **10**: 266-279.

Scheick, B.K. and Jones, M.D. (1999). Locating Wildlife Underpasses Prior To The Expansion Of Highway 64, In North Carolina. In Proceedings of the International Conference on Wildlife 1999.

Simpson, K. & Day, N. (1999). Field Guide to the Birds of Australia, Penguin, Australia.

Storr, G. M., Smith, L. A. and Johnstone, R. E. (1983). Lizards of Western Australia. II. Dragons and Monitors. Western Australian Museum, Perth, Western Australia.

Storr, G. M., Smith, L. A. and Johnstone, R. E. (1990). Lizards of Western Australia. III. Geckoes and Pygopods. Western Australian Museum, Perth, Western Australia.

Storr, G. M., Smith, L. A. and Johnstone, R. E. (1999). Lizards of Western Australia. I. Skinks. Western Australian Museum, Perth, Western Australia.

Storr, G. M., Smith, L. A. and Johnstone, R. E. (2002). Snakes of Western Australia. Western Australian Museum, Perth, Western Australia.

Strahan, R. (Ed.) (1995). The Mammals of Australia. Reed Books, Chatswood, New South Wales, Australia.

Turpin, J., Basnett, G., Bamford, M. and Huang, N. (2012). Shine Project Area Fauna Assessment. Unpubl. Report to Karara Mining Limited by Bamford Consulting Ecologists, Kingsley.

Tyler, M. J., Smith, L. A. and Johnstone, R. E. (2000). Frogs of Western Australia. Western Australian Museum, Perth, Western Australia.

Western Australian Museum (2008). Faunabase. Vertebrate Fauna Database. Accessed November 2012, available at: http://www.museum.wa.gov.au/faunabase/prod/index.htm.

Wilson, S. and Swann, G. (2003). Reptiles of Australia. Princeton University Press, Australia.

Wilson, S. and Swan, G. (2010). *A Complete Guide to Reptiles of Australia*. 2nd Edition. New Holland Publishers (Australia), Sydney.

Western Australian Museum (2009) *Checklists of the Fauna of Western Australia*. Unpublished checklist. Last updated 6 October 2009. Western Australian Museum, Perth.

8 APPENDICES

Appendix 1. Explanation of fauna values

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

Assemblage characteristics

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

Completeness. An assemblage may be complete (ie. 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 and substrate associations (VSAs)

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

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

Patterns of biodiversity across the landscape

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

Species of conservation significance

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

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

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

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

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

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

This level of significance has no legislative or published recognition and is based on interpretation of distribution information, but is used here as it may have links to preserving biodiversity at the genetic level (EPA 2002). If a population is isolated but a subset of a widespread (common) species, then it may not be recognised as threatened, but may have unique genetic characteristics. Conservation significance is applied to allow for the preservation of genetic richness at a population level, and not just at a species level. Species on the edge of their range, or that are sensitive to impacts such as habitat fragmentation, may also be classed as CS3, as may colonies of waterbirds. The Western Australian Department of Environmental Protection, now

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

Invertebrate species considered to be short range endemics (SREs) also fall within the CS3 category, as they have no legislative or published recognition and their significance is based on interpretation of distribution information. Harvey (2002) notes that the majority of species that have been classified as short-range endemics have common life history characteristics such as poor powers of dispersal or confinement to discontinuous habitats. Several groups, therefore, have particularly high instances of short-range endemic species: Gastropoda (snails and slugs), Oligochaeta (earthworms), Onychophora (velvet worms), Araneae (mygalomorph spiders), Pseudoscorpionida (pseudoscorpions), Schizomida (schizomids), Diplopoda (millipedes), Phreatoicidea (phreatoicidean crustaceans), and Decapoda (freshwater crayfish). The poor understanding of the taxonomy of many of the short-range endemic species hinders their conservation (Harvey 2002).

Introduced species

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

Ecological processes upon which the fauna depend

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

Appendix 2. Explanation of threatening processes

Potential impacts of proposed developments upon fauna values can be related to threatening processes. This is recognised in the literature and under the EPBC Act, in which threatening processes are listed (see Appendix 4). Processes that may impact fauna values with respect to mining are discussed below. Processes specific to the project are discussed in Section 5. 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. Impacting processes are outlined below.

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.

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 the Eastern Barred Bandicoot, *Peremeles gunni* ((Dufty 1989), Eastern Quoll, *Dasyurus viverrinus* and Tasmanian Devil *Sarcophilus harrisii* (Jones 2000). Increased mortality due to roadkill is often more prevalent in habitats that have been fragmented ((Scheick & Jones 1999; Clevenger & Waltho 2000; Jackson & 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, Fox and Rabbit may have adverse impacts upon native species and development can alter their abundance. In particular, some mammal species are very sensitive to introduced predators and the decline of many mammals in Australia has been linked to predation by the Fox, and to a lesser extent the feral Cat (Burbidge & 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 (e.g. Letnic *et al.* 2004). Fire is a natural feature of the environment but frequent, extensive fires may adversely impact some fauna, particularly mammals and short-range endemic species. Changes in fire regime, whether to more frequent or less frequent fires, may be significant to some fauna. Impacts of severe fire may be devastating to species already occurring at low densities or to species requiring long unburnt habitats to survive. Fire management may be considered the responsibility of managers of large tracts of land.

Dust, light, noise and vibration

Impacts of dust, light, noise and vibration upon fauna are difficult to predict. Some studies have demonstrated the impact of artificial night lighting on fauna, with lighting affecting fauna behaviour more than noise (Rich & 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 & Longcore 2006). Artificial night lighting may also lead to disorientation of migratory birds. Aquatic habitats and open habitats such as grasslands and dunes may be vulnerable to light spill.

Appendix 3. Categories used in the assessment of conservation status

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

Extinct. Taxa not definitely located in the wild during the past 50 years.

Extinct in the Wild. Taxa known to survive only in captivity.

Critically Endangered. Taxa facing an extremely high risk of extinction in the wild in the immediate future.

Endangered. Taxa facing a very high risk of extinction in the wild in the near future.

Vulnerable. Taxa facing a high risk of extinction in the wild in the medium-term future.

Near Threatened. Taxa that risk becoming Vulnerable in the wild.

Conservation Dependent. Taxa whose survival depends upon ongoing conservation measures. Without these measures, a conservation dependent taxon would be classed as Vulnerable or more severely threatened.

Data Deficient (Insufficiently Known). Taxa suspected of being Rare, Vulnerable or Endangered, but whose true status cannot be determined without more information.

Least Concern. Taxa that are not Threatened.

Schedules used in the Wildlife Conservation Act.

Schedule 1. Rare and Likely to become Extinct.
Schedule 2. Extinct.
Schedule 3. Migratory species listed under international treaties.
Schedule 4. Other Specially Protected Fauna.

DEC species (species not listed under the Conservation Act, but for which there is some concern).

Priority 1. Taxa with few, poorly known populations on threatened lands.

Priority 2. Taxa with few, poorly known populations on conservation lands; or taxa with several, poorly known populations not on conservation lands.

Priority 3. Taxa with several, poorly known populations, some on conservation lands.

Priority 4. Taxa in need of monitoring. Taxa which are considered to have been adequately surveyed, or for which sufficient knowledge is available, and which are considered not currently threatened or in need of special protection, but could be if present circumstances change.

Priority 5. Taxa in need of monitoring. Taxa which are not considered threatened but are subject to a specific conservation program, the cessation of which would result in the species becoming threatened within five years (IUCN Conservation Dependent).

Appendix 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.

(Taken from http://www.wilderness.org.au/articles/wc_science)

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 17 key threatening processes listed by the federal Department of Sustainability, Environment, Water, Population and Communities).

- Competition and land degradation by feral/unmanaged Goats (*Capra hircus*);
- Competition and land degradation by feral Rabbits (*Oryctolagus cuniculus*);
- Dieback caused by the root-rot fungus (*Phytophthora cinnamomi*);
- Incidental catch (bycatch) of Sea Turtles during coastal otter-trawling operations within Australian waters north of 28 degrees South;
- Incidental catch (or bycatch) of seabirds during oceanic longline fishing operations;
- Infection of amphibians with chytrid fungus resulting in chytridiomycosis;
- Injury and fatality to vertebrate marine life caused by ingestion of, or entanglement in, harmful marine debris;
- Land clearance;
- Loss of biodiversity and ecosystem integrity following invasion by the Yellow Crazy Ant (*Anoplolepis gracilipes*) on Christmas Island, Indian Ocean;
- Loss of climatic habitat caused by anthropogenic emissions of greenhouse gases;
- Predation by exotic rats on Australian offshore islands of less than 1000 km^2 (100,000 ha);
- Predation by feral Cats (*Felis catus*);
- Predation by the European Red Fox (*Vulpes vulpes*);

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

(taken from http://www.environment.gov.au/cgi-bin/sprat/public/publicgetkeythreats.pl)

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—other such as altered flow regimes affecting riparian vegetation; and
- Pollution.

(taken from Cork S, Sattler P and Alexandra J (2006), 'Biodiversity' theme commentary prepared for the 2006 Australian State of the Environment Committee, Department of the Environment and Heritage, Canberra, http://www.deh.gov.au/soe/2006/commentaries/biodiversity/index.html)

In addition to the above processes, the 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 will 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 will disrupt the breeding cycle of a population.
Will the proposed action modify, destroy, remove, isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline.
Will the proposed action result in introducing invasive species that are harmful to a critically endangered or endangered species becoming established in the endangered or critically endangered species' habitat.
Will the proposed action introduce disease that may cause the species to decline.
Will the proposed action will interfere with the recovery of the species.

Appendix 5: Fauna recorded or expected to occur in the Hinge project area.

These lists are derived from the results of database and literature searches and from previous field surveys conducted in the local area. Species recorded during the BCE field surveys are highlighted with (X) under Hinge. Literature and database records include NatureMap (DEC), Birds Australia records (BA) and field guides.

TABLE A – 1. Frogs Recorded or Expected in the Hinge project area. No frog species were recorded in the Hinge project area during the 2011 or 2012 surveys.

Species		Status	DEC	Karara	Hinge
HYLIDAE (Tree frogs)					
Cyclorana platycephala	Water-holding Frog				
MYOBATRACHIDAE (Ground frogs)					
Opisthodon spenceri	Spencer's Frog		**X**		
Neobatrachus centralis	Desert Trilling Frog				
Neobatrachus kunapalari	Kunapalari Frog				
Neobatrachus pelobatoides	Humming Frog				
Neobatrachus sutor	Shoemaker Frog				
Neobatrachus wilsmorei	Wilsmore's Frog		**X**		
Pseudophryne occidentalis	Western Toadlet		**X**	**X**	
Total Number of Species Expected: 8 **Total Number of Species Recorded: 0**					

NB. The Inland Tree-Frog *Litoria rubella* was found at Minjar Camp and is reported from Badja Station homestead, but is almost certainly introduced at these locations and there is no suitable habitat for the species in the Project Area.

TABLE A – 2. Reptiles Recorded or Expected in the Hinge project area.

Species		Status	DEC	Karara	Hinge
Gekkonidae (geckoes)					
Diplodactylus granariensis	Western Stone Gecko			X	
Diplodactylus pulcher				X	
Lucasium maini					
Lucasium squarossum				X	
Nephrurus vertebralis					
Oedura marmorata	Marbled Velvet Gecko				
Oedura reticulata	Reticulated Velvet Gecko	CS3		X	
Rhynchoedura ornata	Beaked Gecko		X	X	X
Strophurus assimilis	Thorn-tailed Gecko				
Underwoodisaurus milii	Barking Gecko			X	
Gehyra punctata			X		
Gehyra variegata	Variegated Dtella		X	X	
Heteronotia binoei	Bynoe's Gecko		X	X	
Pygopodidae (legless lizards)					
Delma australis				X	
Lialis burtonis	Burton's Legless Lizard			X	
Pygopus lepidopodus	Common Scaly-foot				
Pygopus nigriceps	Hooded Scaly-foot		X		
Agamidae (dragon lizards)					
Caimanops amphiboluroides	Mulga Dragon	CS3	X	X	
Ctenophorus cristatus	Ornate Crevice-Dragon				
Ctenophorus nuchalis	Central Netted Dragon				
Ctenophorus reticulatus	Western Netted Dragon		X	X	
Ctenophorus scutulatus	Lozenge-marked Dragon		X	X	X
Moloch horridus	Western Bearded Dragon				X
Pogona minor	Thorny Devil		X	X	
Varanidae (monitors or goannas)					
Varanus caudolineatus	Stripe-tailed Monitor			X	
Varanus giganteus	Perentie			X	
Varanus gouldii	Sand Goanna			X	X
Varanus tristis	Black-headed Monitor			X	
Varanus panoptes	Yellow-spotted Monitor			X	
Scincidae (skink lizards)					
Cryptoblepharus buchananii	Buchanan's snake-eyed skink		X	X	X
Cryptoblepharus plagiocephalus	Fence Skink		X	X	
Ctenotus mimetes				X	
Ctenotus schomburgkii			X	X	
Ctenotus severus			X		
Ctenotus uber			X	X	
Cyclodomorphus branchialis	Gilled Slender Blue-tongue	CS1	X	X	
Egernia depressa	Pygmy Spiny-tailed Skink		X	X	X
Egernia stokesii badia	Western Spiny-tailed Skink	CS1	X	X	X
Eremiascincus richardsonii	Broad-banded Sand-swimmer		X	X	
Lerista gerrardii				X	
Lerista kingi			X	X	
Lerista macropisthopus					
Lerista nichollsi			X		

Species		Status	DEC	Karara	Hinge
Lerista timida					
Liopholis inornata	Desert Skink				
Menetia greyii	Common Dwarf Skink		**X**	**X**	
Morethia butleri			**X**	**X**	
Morethia obscura	Dusky Morethia				
Tiliqua occipitalis	Western Blue-tongue			**X**	
Typhlopidae (blind snakes)					
Ramphotyphlops australis	Southern Blind Snake				
Ramphotyphlops hamatus				**X**	
Ramphotyphlops waitii	Beaked Blind Snake				
Boidae (pythons)					
Antaresia stimsoni	Stimson's Python			**X**	
Morelia spilota	Carpet Python	**CS1**			
Elapidae (front-fanged snakes)					
Brachyurophis semifasciata			**X**		
Demansia psammophis	Yellow-faced Whipsnake			**X**	
Furina ornata	Rosen's Snake				
Parasuta monachus	Gwardar			**X**	
Pseudechis australis	Ringed Brown Snake			**X**	
Pseudechis butleri	Yellow-spotted Mulga Snake		**X**	**X**	
Pseudonaja mengdeni					
Pseudonaja modesta	Mulga Snake		**X**	**X**	
Pseudonaja nuchalis	Monk Snake		**X**		
Simoselaps bertholdi	Moon Snake			**X**	
Suta fasciata	Jan's Banded Snake		**X**		
Total Species Expected: 65 **Total Species Recorded at Hinge: 7**			**27**	**41**	**7**

TABLE A – 3. Birds Recorded or Expected in the Hinge project area.

Species		Status	DEC / BA	Karara	Hinge
CASUARIIDAE (Cassowaries and emus)					
Dromaius novaehollandiae	Emu		X	X	X
MEGAPODIIDAE (Megapodes)					
Leipoa ocellata	Malleefowl	CS1	X	X	X
PHASIANIDAE (Pheasants and allies)					
Coturnix pectoralis	Stubble Quail		X		
COLUMBIDAE (Pigeons and doves)					
Phaps chalcoptera	Common Bronzewing		X	X	X
Ocyphaps lophotes	Crested Pigeon		X	X	X
Geopelia cuneata	Diamond Dove		X	X	
PODARGIDAE (Australian frogmouths)					
Podargus strigoides	Tawny Frogmouth		X	X	
CAPRIMULGIDAE (Nightjars and allies)					
Eurostopodus argus	Spotted Nightjar		X	X	X
AEGOTHELIDAE (Owlet-nightjars)					
Aegotheles cristatus	Australian Owlet-nightjar		X	X	
APODIDAE (Typical swifts)					
Apus pacificus	Fork-tailed Swift[a]	CS1			
ACCIPITRIDAE (Osprey, hawks and eagles)					
Elanus axillaris	Black-shouldered Kite		X		
Lophoictinia isura	Square-tailed Kite			X	
Hamirostra melanosternon	Black-breasted Buzzard				
Milvus migrans	Black Kite				
Haliastur sphenurus	Whistling Kite		X		
Circus assimilis	Spotted Harrier		X	X	
Accipiter fasciatus	Brown Goshawk		X	X	X
Accipiter cirrhocephalus	Collared Sparrowhawk		X	X	
Aquila audax	Wedge-tailed Eagle		X	X	
Hieraaetus morphnoides	Little Eagle				
FALCONIDAE (Falcons)					
Falco berigora	Brown Falcon		X	X	X
Falco longipennis	Australian Hobby		X	X	
Falco hypoleucos	Grey Falcon	CS2			
Falco subniger	Black Falcon				
Falco peregrinus	Peregrine Falcon	CS1		X	
Falco cenchroides	Nankeen Kestrel		X	X	
OTIDIDAE (Bustards)					
Ardeotis australis	Australian Bustard	CS2	X		
BURHINIDAE (Stone-curlews)					
Burhinus grallarius	Bush Stone-curlew	CS2	X	(X)	
CHARADRIIDAE (Lapwings, plovers and dotterels)					
Charadrius melanops	Black-fronted Dotterel		X		
Charadrius australis	Inland Dotterel		X		
Vanellus tricolor	Banded Lapwing		X		
TURNICIDAE (Button-quails)					
Turnix velox	Little Button-quail		X	X	
Turnix varia	Painted Button-quail			X	
CACATUIDAE (Cockatoos)					
Calyptorhynchus banksii	Red-tailed Black-Cockatoo		X	X	
Eolophus roseicapilla	Galah		X	X	X
Cacatua pastinator	Western Corella				
Cacatua sanguinea	Little Corella		X		

Species		Status	DEC / BA	Karara	Hinge
Cacatua leadbeateri	Major Mitchell's Cockatoo	**CS1**	**X**	**X**	**X**
Nymphicus hollandicus	Cockatiel		**X**	**X**	**X**
PSITTACIDAE (Parrots)					
Glossopsitta porphyrocephala	Purple-crowned Lorikeet			**X**	
Polytelis anthopeplus	Regent Parrot	**CS3**	**X**	**X**	
Barnardius zonarius	Australian Ringneck		**X**	**X**	**X**
Psephotus varius	Mulga Parrot		**X**	**X**	**X**
Melopsittacus undulatus	Budgerigar		**X**	**X**	**X**
Neosephotus bourkii	Bourke's Parrot		**X**	**X**	
Neophema splendida	Scarlet-chested Parrot	**CS3**			
CUCULIDAE (Old world cuckoos)					
Cuculus pallidus	Pallid Cuckoo		**X**	**X**	
Cacomantis flabelliformis	Fan-tailed Cuckoo				
Chrysococcyx osculans	Black-eared Cuckoo		**X**	**X**	
Chrysococcyx basalis	Horsfield's Bronze-Cuckoo		**X**	**X**	
Chrysococcyx lucidus	Shining Bronze-Cuckoo			**X**	
STRIGIDAE (Hawk owls)					
Ninox novaeseelandiae	Southern Boobook			**X**	
TYTONIDAE (Barn owls)					
Tyto alba	Barn Owl				
HALCYONIDAE (Kingfishers)					
Dacelo novaeguineae	Laughing Kookaburra	**INT**			
Todiramphus pyrrhopygia	Red-backed Kingfisher		**X**	**X**	
Todiramphus sanctus	Sacred Kingfisher				
MEROPIDAE (Bee-eaters)					
Merops ornatus	Rainbow Bee-eater	**CS1**	**X**	**X**	
CLIMACTERIDAE (Australo-Papuan treecreepers)					
Climacteris rufa	Rufous Treecreeper	**CS3**	**X**	**X**	
Climacteris affinis	White-browed Treecreeper			**X**	
PTILINORHYNCHIDAE					
Ptilonorhynchus guttatus	Western Bowerbird		**X**	**X**	
MALURIDAE (Fairy-wrens, emu-wrens and grasswrens)					
Malurus splendens	Splendid Fairy-wren		**X**	**X**	**X**
Malurus lamberti	Variegated Fairy-wren		**X**	**X**	
Malurus pulcherrimus	Blue-breasted Fairy-wren				
Malurus leucopterus	White-winged Fairy-wren		**X**		
PARDALOTIDAE (Pardalotes, scrubwrens, thornbills and allies)					
Pardalotus striatus	Striated Pardalote		**X**	**X**	
Sericornis frontalis	White-browed Scrubwren		**X**	**X**	**X**
Hylacota cauta	Shy Heathwren	**CS2**			
Calamanthus campestris	Rufous Fieldwren	**CS2**			
Pyrrholaemus brunneus	Redthroat	**CS3**	**X**	**X**	**X**
Drymodes brunneopygi	Southern Scrub-robin	**CS3**			
Smicrornis brevirostris	Weebill		**X**	**X**	**X**
Gerygone fusca	Western Gerygone		**X**	**X**	
Acanthiza apicalis	Inland Thornbill		**X**	**X**	**X**
Acanthiza uropygialis	Chestnut-rumped Thornbill		**X**	**X**	**X**
Acanthiza robustirostris	Slaty-backed Thornbill		**X**	**X**	**X**
Acanthiza iredalei	Slender-billed Thornbill	**CS1**			
Acanthiza chrysorrhoa	Yellow-rumped Thornbill		**X**	**X**	
Aphelocephala leucopsis	Southern Whiteface		**X**	**X**	
MELIPHAGIDAE (Honeyeaters)					
Anthochaera carunculata	Red Wattlebird		**X**	**X**	
Acanthagenys rufogularis	Spiny-cheeked Honeyeater		**X**	**X**	**X**

Species		Status	DEC / BA	Karara	Hinge
Manorina flavigula	Yellow-throated Miner		X	X	X
Lichenostomus virescens	Singing Honeyeater		X	X	X
Lichenostomus leucotis	White-eared Honeyeater			X	
Lichenostomus penicillatus	White-plumed Honeyeater		X		
Lichenostomus plumulus	Grey-fronted Honeyeater				
Melithreptus brevirostris	Brown-headed Honeyeater			X	
Lichmera indistincta	Brown Honeyeater		X	X	
Phylidonyris albifrons	White-fronted Honeyeater		X	X	X
Phylidonyris nigra	White-cheeked Honeyeater				
Phylidonyris melanops	Tawny-crowned Honeyeater				
Conopophila whitei	Grey Honeyeater	CS3	X		
Certhionyx niger	Black Honeyeater		X		
Certhionyx variegatus	Pied Honeyeater		X	X	
Epthianura tricolor	Crimson Chat		X		
Epthianura aurifrons	Orange Chat				
Epthianura albifrons	White-fronted Chat		X		
POMATOSTOMIDAE (Babblers)					
Pomatostomus temporalis	Grey-crowned Babbler		X		
Pomatostomus superciliosus	White-browed Babbler	CS2	X	X	X
CINCLOSOMATIDAE (Quail-thrushes and allies)					
Psophodes occidentalis	Chiming Wedgebill		X		
Cinclosoma castanotum	Chestnut Quail-thrush		X	X	X
Cinclosoma castaneothorax	Chestnut-breasted Quail-thrush		X		
NEOSITTIDAE (Sitellas)					
Daphoenositta chrysoptera	Varied Sittella		X	X	
CAMPEPHAGIDAE (Cuckoo-shrikes and trillers)					
Coracina novaehollandiae	Black-faced Cuckoo-shrike		X	X	
Coracina maxima	Ground Cuckoo-shrike		X		
Lalage sueurii	White-winged Triller		X	X	X
PACHYCEPHALIDAE (Whistlers, shrike-thrushes and allies)					
Oreoica gutturalis	Crested Bellbird	CS2	X	X	X
Pachycephala inornata	Gilbert's Whistler	CS3		X	
Pachycephala pectoralis	Golden Whistler	CS3	X	X	X
Pachycephala rufiventris	Rufous Whistler		X	X	X
Colluricincla harmonica	Grey Shrike-thrush		X	X	X
ARTAMIDAE (Woodswallows, butcherbirds and currawongs)					
Artamus personatus	Masked Woodswallow		X	X	X
Artamus superciliosus	White-browed Woodswallow		X		
Artamus cinereus	Black-faced Woodswallow		X	X	X
Artamus minor	Little Woodswallow		X	X	
Cracticus torquatus	Grey Butcherbird		X	X	X
Cracticus nigrogularis	Pied Butcherbird		X	X	
Gymnorhina tibicen	Australian Magpie		X	X	X
Strepera versicolor	Grey Currawong		X	X	
DICRURIDAE (Monarchs, fantails and drongos)					
Myiagra inquieta	Restless Flycatcher				
Grallina cyanoleuca	Magpie-lark		X		
Rhipidura albiscapa	Grey Fantail		X	X	
Rhipidura f. albicauda	White-tailed Fantail			X	
Rhipidura leucophrys	Willie Wagtail		X	X	X
CORVIDAE (Crows and allies)					
Corvus coronoides	Australian Raven		X	X	X
Corvus bennetti	Little Crow		X	X	X

Species		Status	DEC / BA	Karara	Hinge
Corvus orru	Torresian Crow		**X**	**X**	
PETROICIDAE (Robins)					
Microeca leucophaea	Jacky Winter			**X**	
Petroica goodenovii	Red-capped Robin		**X**	**X**	**X**
Melanodryas cucullata	Hooded Robin		**X**		
Eopsaltria griseogularis	Western Yellow Robin	**CS3**		**X**	**X**
SYLVIIDAE (Old world warblers)					
Cinclorhamphus mathewsi	Rufous Songlark		**X**	**X**	
Cinclorhamphus cruralis	Brown Songlark		**X**		
ZOSTEROPIDAE (White-eyes)					
Zosterops lateralis	Silvereye		**X**		
HIRUNDINIDAE (Swallows and martins)					
Cheramoeca leucosternum	White-backed Swallow		**X**	**X**	
Hirundo neoxena	Welcome Swallow		**X**	**X**	
Hirundo nigricans	Tree Martin		**X**	**X**	**X**
Hirundo ariel	Fairy Martin		**X**		
DICAEIDAE (Flowerpeckers)					
Dicaeum hirundinaceum	Mistletoebird		**X**	**X**	
PASSERIDAE (Sparrows, weaverbirds, waxbills and allies)					
Taeniopygia guttata	Zebra Finch		**X**	**X**	**X**
MOTACILIDAE (Old world wagtails and pipits)					
Anthus novaeseelandiae	Richard's Pipit		**X**	**X**	
Total Species Expected: 140 **Total Species Recorded at Hinge: 42**			**105**	**90**	**42**

TABLE A – 4. Mammals Recorded or Expected in the Hinge project area.

Species	Status	DEC	Karara	Hinge
TACHYGLOSSIDAE (Echidnas)				
Tachyglossus aculeatus Echidna		**X**	**X**	**X**
DASYURIDAE (Dasyurids)				
Antechinomys laniger Kultarr	**CS3**	**X**	**(X)**	
Ningaui ridei Wongai Ningaui				
Pseudantechinus woolleyae Woolley's Pseudantechinus	**CS3**		**X**	
Sminthopsis crassicaudata Fat-tailed Dunnart				
Sminthopsis dolichura Little Long-tailed Dunnart			**X**	
MACROPODIDAE (Kangaroos, wallabies)				
Macropus fuliginosus Western Grey Kangaroo			**X**	
Macropus robustus Euro, Biggada			**X**	**X**
Macropus rufus Red Kangaroo, Marlu		**X**	**X**	
PHALANGERIDAE (brush-tailed possums)				
Trichosurus vulpecula Common Brush-tailed Possum	**CS3**		**(X)**	
BURRAMYIDAE (Pygmy possums)				
Cercartetus concinnus Western Pygmy-possum				
EMBALLONURIDAE (Sheathtail bats)				
Taphozous hilli Hill's Sheathtail-bat				
VESPERTILIONIDAE (Vespertillionid bats)				
Chalinolobus gouldii Gould's Wattled Bat			**X**	
Chalinolobus morio Chocolate Wattled Bat				
Nyctophilus geoffroyi Lesser Long-eared Bat			**X**	
Nyctophilus timoriensis Greater Long-eared Bat				
Scotorepens balstoni Inland Broad-nosed Bat				
Scotorepens greyii Little Broad-nosed Bat			**X**	
Vespadelus baverstocki Inland Forest Bat			**X**	
Vespadelus finlaysoni Finlayson's Cave Bat		**X**		
Vespadelus regulus Southern Forest Bat				
MOLOSSIDAE (Freetail bats)				
Mormopterus sp. Listed as Species 3 by Adams *et al*. (1988). Inland Freetail-bat				
Mormopterus sp. Listed as Species 4, population O by Adams *et al*. (1988). Western Freetail-bat				
Tadarida australis White-striped Freetail-bat		**X**	**X**	
MURIDAE (Rats and mice)				
Mus musculus House Mouse	**INT**		**X**	
Notomys mitchellii Mitchell's Hopping-mouse			**X**	
Pseudomys hermannsburgensis Sandy Inland Mouse			**X**	
LEPORIDAE (Rabbits and hares)				
Oryctolagus cuniculus Rabbit	**INT**		**X**	**X**
CANIDAE (Dogs and foxes)				
Canis lupus Dog/Dingo			**X**	
Vulpes vulpes Red Fox	**INT**		**X**	**X**
FELIDAE (Cats)				
Felis catus Cat	**INT**		**X**	
BOVIDAE (Horned ruminants)				
Capra hircus Goat	**INT**		**X**	**X**
Total Species Expected: 32 **Total Species Recorded: 7**		**5**	**20**	**5**

TABLE A – 5. Conservation significant invertebrates recorded or expected in vicinity of the Hinge Project Area

Species		Status	Recorded in Area	Recorded on Hinge
Shield-backed Trapdoor Spider	*Idiosoma nigrum*	CS1	X	X
Scorpion	*Urodacus* Mt Gairdner	CS3	X	
Millipede	*Antichiropus* sp. nov. 'PM1'	CS3	?	
Species recorded			**2**	**1**

TABLE A – 6. Species considered to be extinct in vicinity of the Hinge project area.

Species		Status
PSITACCIDAE (Parrots and lorikeets)		
Pezoporus occidentalis	Night Parrot	**CS1**
TYTONIDAE (Barn owls)		
Tyto novaehollandiae	Masked Owl	**CS2**
MALURIDAE (Fairy-wrens, emu-wrens and grasswrens)		
Amytornis textilis textilis	Thick-billed Grasswren (west)	**CS2**
DASYURIDAE (Dasyurids)		
Dasyurys geoffroii	Chuditch, Western Quoll	**CS1**
Phascogale calura	Red-tailed Phascogale	**CS1**
MYRMECOBIIDAE (Numbat)		
Myrmecobius fasciatus	Numbat	**CS1**
PERAMELIDAE (Bandicoots)		
Isoodon obesulus	Quenda/Southern Brown Bandicoot	**CS3**
Perameles bougainville	Western Barred Bandicoot	**CS1**
Macrotis Lagotis	Bilby	**CS1**
Chaeropus ecaudatus	Pig-footed Bandicoot	**EXTINCT**
POTOROIDAE (Potoroos and Bettongs)		
Bettongia lesuer	Burrowing Bettong	**CS1**
Bettongia penicillata	Woylie	**CS1**
MACROPODIDAE (Kangaroos, wallabies)		
Lagostrophus fasciatus	Banded Hare-wallaby	**CS1**
Lagorchestes hirsutus	Mala, Rufous Hare-wallaby	**CS1**
Macropus eugenii	Tammar Wallaby	**CS2**
Macropus irma	Brush or Black-gloved Wallaby	**CS2**
Onychogalea lunata	Crescent Nailtail Wallaby	**EXTINCT**
Petrogale lateralis	Black-footed Rock-Wallaby	**CS1**
MEGADERMATIDAE (Ghost Bat)		
Megaderma gigas	Ghost Bat	**CS2**
MURIDAE (Rats and mice)		
Notomys longicaudatus	Long-tailed Hopping-mouse	**PRESUMED EXTINCT**
Pseudomys occidentalis	Western Mouse	**CS2**
Pseudomys fieldi	Djoongari/Shark Bay Mouse	**CS1**
Rattus tunneyi	Pale Field Rat	**CS3**
Leporillus conditor	Greater Stick-nest Rat	**CS1**
Leporillus apicalis	Lesser Stick-nest Rat	**PRESUMED EXTINCT**
Total Species Expected: 25		

Appendix 6. Malleefowl Mound Descriptions

The Malleefowl Mound

Malleefowl have developed a highly sophisticated method of temperature control for egg incubation. This species constructs distinctive nests that comprise a large mound covering a central core of leaf litter. The mound is constructed out of sand, pebbles or small rocks, depending on the habitat available. Mounds have a large central depression which is filled with leaf litter and covered with soil. Eggs are laid within the mound, buried and left to incubate by the heat generated from decomposing leaf litter (Malleefowl Preservation Group, 2008). An adult pair maintains the mound temperature of 32 – 34 degrees by adjusting soil cover to either retain or expel heat from the egg chamber (Malleefowl Preservation Group, 2008).

Malleefowl are monogamous with pair bonds maintained for life (Priddel and Wheeler, 2003). The mound is constructed and maintained by an adult pair over 9 -11 months of the year (Malleefowl Preservation Group, 2008). Nest preparation occurs in autumn and the male will tend the nest through summer until temperatures begin to fall.

Malleefowl mounds vary in size and diameter, depending on age and activity, however mounds commonly span more than five metres and are up to one metre high (DEC, 2008). A pair of Malleefowl will often use the same nest over successive seasons, however nest fidelity is highly variable. Some Malleefowl pairs have been recorded using the same mound for up to nine years while others relocate seasonally between a cluster of two, three or four mounds (Priddel and Wheeler, 2003). Malleefowl mounds used over many generations can attain a diameter of over 20m (Malleefowl Preservation Group, 2008). Long inactive mounds can be reactivated for breeding (M. Bamford, pers. obs.) and are therefore important in a landscape context.

Mound construction and breeding relies heavily on rainfall. Malleefowl have been recorded abandoning mound construction or failing to use a mound during seasons of low rainfall (Priddel and Wheeler, 2003). Breeding Malleefowl tend to be sedentary, as they nest and roost in the same area year after year. Breeding males do not stray far from the nest however birds may range over several kilometres outside the breeding season (DEC, 2008). Malleefowl also require large amounts of leaf litter for egg incubation and so are generally restricted to areas of dense vegetation that have not been burnt for many years.

Established pairs generally breed annually with eggs laid from September to January. The average clutch size is 16 (but range from 5 to 30) and the incubation period lasts for between 62 and 64 days (DEC, 2008). Malleefowl chicks receive no parental care and as a result chick mortality is high due to predation and exposure (DEC, 2008).

Priddel and Wheeler (2003) studied the nesting activity of Malleefowl within an isolated remnant of mallee in central New South Wales. The maximum longevity recorded for breeding adults was 12 years with an average of 7.5 years. Over a twenty year period the population declined, with large population decreases coincident with years of low rainfall and unsuccessful breeding. The population is predicted to become extinct in the next few years.

Mound Profile

The profile of a Malleefowl Mound changes with breeding activity and age (erosion and vegetation growth). A number of profile stages are classified according to age (Benshemesh 2006) and include:

Profile 1. Typical crater with raised rims. This is the typical shape of an inactive nest. However the nest may also be active and open.

Profile 2. Nest fully dug out. The characteristic of this profile is that the crater slopes down steeply, and at the base the sides drop vertically to form a box- like structure with side usually 20 to 30 cm deep. Often, litter will have been raked into windrows, and may have started to enter the nest.

Profile 3. Nest with litter. This is the next stage after profile 2. Litter will have been raked into the nest by Malleefowl, and thick layers of litter are evident on the surface. There may or may not be sand mixed with the litter at this stage.

Profile 4. Nest mounded up (no crater). This is the typical profile of an active but unopened Malleefowl nest. The active mound is closed and dome shaped.

Profile 5. Nest a sandy crater with peak in centre. This is a typical profile of an active nest which is in the process of being closed by Malleefowl.

Profile 6. Nest low and flat without peak or crater. This mound has not been used for some time and weathering and erosion have 'flattened" the original mound.

Mound Age

When mounds were located, the location and physical details of the mound were recorded. The age of each mound was classified according to the criteria listed below (based largely upon pers. obs (J. Turpin and M.Bamford)).:

Active: Fresh scratchings, loose soil and mound dug out in preparation for the breeding season or mounded for breeding. Mounds containing abundant but weathered plant material and shell fragments have been used regularly over at least the previous few years.

Recently used (1-5 years): No signs of very recent activity, such as scratchings. Soil surface compacted and little plant material present. However, mound slopes still steep and no plants growing in mound.

Moderately old (5-20 years): No recent activity, soil compacted and no plant material. Surface of mound showing some weathering, such as loose soil and debris accumulating in central depression, and some plant colonisation possibly present.

Old (20-100 years): Mound moderately to very weathered, often with a veneer of gravel on the slopes because of removal of fine materials from the surface. Some bushes growing on mound.

Very old (100+ years): Mound very weathered, with profile low and central depression poorly defined. Bushes and even small trees growing on mound

Appendix 7. Locations of conservation significant species recorded during the 2011 and 2012 surveys

Western Spiny-tailed Skink

Recording	Easting	Northing	Details
Egernia stokesii 1	486617.6	6788332	Fresh scats at fallen logs
Egernia stokesii 2	486599.1	6788311	Fresh scats at fallen logs

Malleefowl mounds

Date		Easting	Northing	Width	Height	Dimple	Activity	Profile	Vegetation	Soils	Notes
July 2012	MM24	487240	6788728				Inactive				Very old and inactive 50+ years.
September 2012	MM1	487816	6786037	3	0.2		Inactive	slight donut	Eucalypt open wooldand over acacia tall shurbland	sandy loam with some gravel	20+ years. Some scratching in previous few months. Raised around only part of mound.
September 2012	MM2	487796	6786108	4	1.3		Active	mounded	Eucalypt open wooldand over acacia tall shurbland	Sandy-loam	Freshly scatched that day, being worked, eggshell fragments from previous year
September 2012	MM3	486517	6786342	10	0.5	0.2	Inactive		Eucalypt open wooldand over shrubs		
September 2012	MM4	486455	6786798	4.5	0.2	0.4	Inactive		Low shrubland	Gravelly-loam	Centre has been dug out in last two years, last used +20 years

Date		Easting	Northing	Width	Height	Dimple	Activity	Profile	Vegetation	Soils	Notes
September 2012	MM5	486806	6787568	3	0.4	0.4	Inactive				Old egg shell and plant material present, dug out in 2012, last used 2-3 years ago
September 2012	MM6	486921	6787723	6	0.4		Inactive				Few eggshell fragments, last used 5-10 years
September 2012	MM7	487148	6787612	10	0.5		Inactive				Large gravel rise, unused more than 50 years
September 2012	MM8	487193	6786857	6	0.8	0.2	Inactive		Acacia and mixed shurbland. Gravel in mound.	gravelly loam soil	15-20 years. Well-formed but not worked recently
September 2012	MM9	488207	6786721	12	1	0.4	Inactive				Few eggshell fragments, centre excavated in last 12 months last used 5-10 years
September 2012	MM10	487837	6786255	4.5	0.2	0.3	Inactive		Eucalypt open wooldand over acacia tall shurbland	sandy-loam	dug out within last year. 5+ years since last used. Leaf-litter layers still visible.
September 2012	MM11	487390	6787400	4.5	0.4	0.4	Inactive				Eggshell fragments and vegetation in centre, no recent activity, last used about 5 years
September 2012	MM12	488344.48	6787062.39	5	0.2	0.1	Inactive				An old gravel mound, few shrubs growing on it, last used more than 50 years ago
September 2012	MM13	488527.43	6787252.14	5	0.2	0.2	Inactive		Acacia tall shrubland		Last used more than 20 years ago
September 2012	MM14	486987.93	6788066.82	9	0.4	0.05	Inactive				Gravel mound with bushes growing across the top, last used more than 50 years

Date		Easting	Northing	Width	Height	Dimple	Activity	Profile	Vegetation	Soils	Notes
September 2012	MM15	485885.33	6788397.9	6	0.6	0	Inactive				Sandy mound no crater, plant material and shell fragments present, last used before 2006 fire .
September 2012	MM16	485962	6788276	7	0.3	0.5	Inactive			Sand and fine gravel	10-20 years old
September 2012	MM17	486824.53	6787908.65	9	0.2		Inactive				Very low rocky mound, trees and lichen across surface, last used 100 + years
September 2012	MM18	486850	6787848	12	0.8		Inactive				Dead shrubs over mound, last used more than 100 years
September 2012	MM19	487478	6788393	8	0.4	0.1	Inactive		Acacia shrubland on gravelly loam		Karara mound No. 558. On an old boodie warren, last used more than 20 years ago.
September 2012	MM20	487574	6788530	10	0.6	0.1	Inactive				Karara mound no 382. Very gravelly, trees growing over mound 50+ years
September 2012	MM21	487441	6788545	5	0.2	0.1	Inactive				Shrubs growing over mound 100+ years
September 2012	MM22	487859	6788870	8	0.6	0.3	Inactive				Loose gravel in mound but no shell fragments or plant material 20+ years
September 2012	MM23	487871	6788732	4	0.4	0.5	Inactive				Layers of vegetation and very old eggshell in crater. 5-10 years

Shield-backed Trapdoor Spider Quadrats surveyed in 2011 and 2012

December 2011

Quadrat	Easting	Northing	Burrows	Soil	Vegetation	Position
H01	487403.999	6788582.007	3	Rocky clay loam	Mixed open Acacia myrtaceous shrubland	upper slope
H02	487578.999	6788885.002	0	gravelly loam	acacia tall shrubland	upper slope
H03	487558.339	6788849.645	1	Clay loam wth gravel and occasional outcropping	Low open mixed Acacia myrtaceous shrublands with Sheoak	upper slope
H04	487553.997	6788842.006	0	Rocky clay loam with outcropping	Mixed open Acacia myrtaceous shrubland	upper slope
H05	487527.992	6788798.007	0	Rocky clay loam with outcropping	Mixed open Acacia myrtaceous shrubland	upper slope
H06	487503	6788754.008	0	Rocky clay loam with outcropping	Mixed open Acacia myrtaceous shrubland	upper slope
H07	487453.993	6788668.008	0	rock outcropping, lichen on rocks	tall acacia shrubland	top of slope
H08	487478.993	6788712.007	0	Rocky clay loam with outcropping	Mixed open Acacia myrtaceous shrubland	upper slope
H09	487428.992	6788625.003	2	Rocky clay loam with outcropping	Mixed open Acacia myrtaceous shrubland	upper slope
H10	487539.997	6788618.001	0	gravelly loam, lichen on small rocks	tall acacia shrubland over mixed shrubs	upper slope
H11	487674.994	6789002.004	0	gravelly loam	low sparse acacia shrublan	mid slope
H12	487696.995	6788990.001	0	gravelly loam	Acacia low, sparse shrubland on gravelly loam. Burnt	mid slope
H13	487632.94	6788785.899	0	Clay loam with cobbles	Sparse low Acacia Sheoak myrtaceous shrubland	upper slope
H14	487592.611	6788833.05	0	Clay loam with cobbles	Sparse Acacia Sheoak myrtaceous shrubland	upper slope

Quadrat	Easting	Northing	Burrows	Soil	Vegetation	Position
H15	487589.999	6788705.005	0	Clay loam with cobbles	Mixed open Acacia myrtaceous shrubland	upper slope
H16	487546.993	6788730.004	0	Clay loam with cobbles	Mixed open Acacia myrtaceous shrubland	upper slope
H17	487471.997	6788601.007	1	Clay loam with cobbles	Mixed open Acacia myrtaceous shrubland	mid slope
H18	487489.995	6788532	0	rocky and gravelly loam	mixed acacia shrubland	upper slope
H19	487446.998	6788556.005	1	Clay loam with cobbles	Mixed open Acacia myrtaceous shrubland	upper slope
H20	487421.996	6788514.003	1	-	-	-
H21	487413.998	6788402.008	0	Gravel clay loam	Mixed open Acacia and Grevillea shrubland	mid slope
H22	487388.998	6788359.003	0	Cobble clay loam	Mixed Acacia Melalecua shrubland	lower slope
H23	487346.998	6788383.009	0	Cobble clay loam	Mixed Acacia Melalecua shrubland	lower slope
H24	487409.993	6788348.003	2	Cobble clay loam	Mixed Acacia Melalecua shrubland	lower slope
H25	487366.998	6788371.005	0	Cobble clay loam	Low mixed Acacia shrubland	lower slope
H26	487324.996	6788396.004	0	Cobble clay loam	Mixed Acacia Melalecua shrubland	lower slope
H27	487349.997	6788439.001	0	Gravelly cobble clay loam	Mixed open Acacia myrtaceous shrubland	mid slope
H28	487392.993	6788415.005	0	Gravelly cobble clay loam	Mixed open Acacia myrtaceous shrubland	mid slope
H29	487435.997	6788391	0	Gravel clay loam	Mixed Acacia Melalecua shrubland	mid slope
H30	487510.992	6788519.003	3	Clay loam with gravel and cobbles	Mixed open Acacia myrtaceous shrubland	upper slope

Quadrat	Easting	Northing	Burrows	Soil	Vegetation	Position
H31	487467.994	6788545.005	0	Rocky clay loam	Mixed open Acacia myrtaceous shrubland	upper slope
H32	487424.997	6788569.001	0	Clay loam with cobbles	Mixed open Acacia myrtaceous shrubland	upper slope
H33	487560.994	6788606.007	0	rocky and gravelly loam	mixed acacia shrubland	upper slope
H34	487519	6788631.007	0	gravelly loam, lichen on small rocks	tall acacia shrubland over mixed shrubs	upper slope
H35	487474.998	6788656.005	0	rock outcropping	tall acacia shrubland	top of slope
H36	487474.998	6788656.005	7	gravelly loam, lichen on small rocks	tall acacia shrubland over mixed shrubs	upper slope
H37	487611.992	6788692.009	0	Clay loam with cobbles	Mixed open Acacia myrtaceous shrubland	upper slope
H38	487568.994	6788717.008	0	Clay loam with cobbles	Mixed open Acacia myrtaceous shrubland	crest
H39	487524.992	6788742.006	0	Clay loam with cobbles	Mixed open Acacia myrtaceous shrubland	crest
H40	487830.183	6788670.92	0	Clay loam with cobbles	Acacia myrtaceous shrubland with occasional York Gum	mid slope
H41	487788.538	6788698.122	1	Gravel clay loam	Open mixed Acacia Melaleuca Sheoak shrubland with occasional York Gum	upper slope
H42	487935.997	6788851.004	0	gravelly loam, rocks, lichen on small rocks	mixed acacia shrubland	upper slope
H43	487892.998	6788877.007	0	gravelly loam, lichen on small rocks	tall acacia shrubland over mixed shrubs	upper slope
H44	487848.996	6788902.006	0	gravelly loam, lichen on small rocks	tall acacia shrubland over mixed shrubs	upper slope
H45	487781.993	6788590.002	0	gravelly loam	tall acacia shrubland over sparse understorey	mid slope
H46	487882	6788761	1	very gravelly loam, lichens on small rocks	Open acacia tall shrubland over acacia shrubs	mid slope

Quadrat	Easting	Northing	Burrows	Soil	Vegetation	Position
H47	487739.999	6788616.006	0	gravelly loam	tall acacia shrubland over sparse understorey	mid slope
H48	487696.994	6788640.003	0	gravelly and rocky loam	mixed acacia shrubland	lower slope
H49	487471.706	6788905.344	0	Gravel clay loam	Open mixed Acacia myrtaceous shrubland	upper slope
H50	487511.173	6788878.855	0	Clay loam wth gravel and occasional outcropping	Sparse mixed Acacia myrtaceous shrubland with occasional emergent Corymbia	upper slope
H51	487678.577	6788758.961	0	Clay loam with cobbles	Sparse low Acacia Sheoak myrtaceous shrubland	upper slope
H52	487719.473	6788730.059	0	Clay loam with cobbles	Open mixed Acacia Sheoak myrtaceous shrubland	mid slope
H53	487878.211	6788650.587	0	Clay loam with cobbles	Acacia myrtaceous shrubland with occasional York Gum	mid slope
H54	487537	6788997	0	gravelly loam	mixed acacia shrubland	mid-slope
H55	487585	6788980	0	gravelly loam	mixed acacia shrubland	mid-slope
H56	487623	6788939	0	gravelly loam	mixed acacia shrubland	mid-slope
H57	487659	6788893	0	gravelly loam	mixed acacia shrubland	mid-slope
H58	487707	6788869	0	gravelly loam	mixed acacia shrubland	upper slope
H59	487758	6788837	0	gravelly loam	mixed acacia shrubland	upper slope
H60	487795	6788810	0	gravelly loam	melaleuca tall shrubland with little understorey and dense litter	mid slope
H61	487838	6788780	0	very gravelly loam, lichens on small rocks	Open acacia tall shrubland over acacia shrubs	mid slope
H62	487927	6788746	0	very gravelly loam, lichens on small rocks	Open acacia tall shrubland over acacia shrubs	mid slope

July 2012

Quadrat	Easting	Northing	Presence of spiders
Hinge A Spider Quadrat 1	487377.2	6788928	None
Hinge A Spider Quadrat 2	487331.7	6788865	None
Hinge A Spider Quadrat 3	487239.9	6788660	4 x 14-15mm.
Hinge A Spider Quadrat 4	487211.8	6788569	None
Hinge A Spider Quadrat 5	487107.8	6788822	None
Hinge A Spider Quadrat 6	487175.2	6789026	None

September/October 2012

Quadrat	Easting	Northing	Juvenile	Adult	Total Burrows	Vegetation and Soils	Position
1A	486762.25	6786189	0	0	0	Acacia tall, open shrubland on loam with some gravel	Plain low in landscape
1B	486835.848	6786104	0	0	0	Acacia open shrubland on loam	Plain low in landscape
1C	486926.155	6786048	0	0	0	Acacia open shrubland on loam	Plain low in landscape
1D	487078.26	6785922	0	0	0	Acacia tall, open shrubland on loam	Slight rising slope
1E	487277.193	6785789	0	0	0	Acacia tall, open shrubland on loam with some gravel	
1F	487391.899	6785672	0	0	0	Eucalypt and melaleuca open woodland over acacia tall shrubland on gravelly sandy-loam	

Quadrat	Easting	Northing	Juvenile	Adult	Total Burrows	Vegetation and Soils	Position
1G	487492.34	6785602	0	0	0	Eucalypt and sand pine open woodland over acacia tall shrubland on sandy-loam	
1H	486606.629	6786319	0	0	0	Eucalypt low woodland over low shrubland on gravelly loam	Slight slope
1I	486533.023	6786409	0	0	0	Mixed shrubland on gravelly loam	Mid slope
1J	486439.986	6786464	0	0	0	Tall acacia shrubland, gravelly loam	Mid slope
1K	486366.309	6786529	0	0	0	Mixed tall shrubland on gravelly loam	Top of low rise
2A	487793.391	6786006	0	0	0	Eucalypt low , open woodland over acaica tall open shrubland on gravelly-loam	
2B	487688.571	6786164	0	0	0	Eucalypt open woodland over acaia tall, closed shrubland on gravelly-sandy-loam	
2C	487516.405	6786299	0	0	0	Scattered sand pines over acacia tall, open shrubland on sandy loam	
2D	487382.402	6786431	0	0	0	Acacia open shrubland on loam	
2E	487172.197	6786536	0	0	0	Eucalypt open woodland over acacia tall, open shrubland on loam	
2F	487003.68	6786619	0	0	0	Acacia low shrubland on gravelly-loam	
2G	486484.148	6786991	0	0	0	Acacia tall shrubland on gravelly loam	Top of rise
2H	486562.986	6786927	7	3	10	Acacia tall shrubland, cobbles, gravel and loam, some lichen	Top of rise

Quadrat	Easting	Northing	Juvenile	Adult	Total Burrows	Vegetation and Soils	Position
2I	486622.563	6786848	0	3	3	Acacia tall shrubland, cobbles, gravel and loam, some lichen	Top of rise
2J	486722.307	6786804	0	0	0	Eucalypt and acacia tall shrubland, few cobbles, gravelly loam, no lichen	Mid slope
2K	486795.414	6786725	0	0	0	Acacia and melaleuca shrubland on gravelly loam	Low slope
2L	486916.724	6786635	0	0	0	Acacia low shrubland on gravelly-loam	Low slope
3A	487053.255	6787118	0	0	0	Mixed tall shrubland on rocks cobble gravel loam and lichen	Mid slope
3B	486970.918	6787180	0	0	0	Mixed tall shrubland on gravelly loam	Plain
3C	486897.143	6787244	0	3	3	Closed shrubland with cobbels gravel and loam	Plain
3D	486796.031	6787290	0	0	0	Low shrubland on gravelly loam	Mid slope
3E	486695.375	6787362	0	0	0	Acacia shrubland on slightly gravelly loam	Upper slope
3F	487141.898	6787077	4	3	7	Acacia shrubland on rock gravel loam, lichen present	Low slope
3G	487220.538	6787013	4	0	4	Acacia shrubland on gravelly loam	Low slope
3H	487297.531	6786940	12	4	16	Acacia tall open shrubland rocky gravelly loam, lichen	Low slope
3I	487398.866	6786864	0	0	0	Acacia low shrubland on gravelly-loam	plain

Quadrat	Easting	Northing	Juvenile	Adult	Total Burrows	Vegetation and Soils	Position
3J	487543.208	6786719	0	0	0	Eucalypt open woodland over acacia tall, open shrubland on loam	plain
3K	487697.361	6786592	0	0	0	Acacia closed shrubland on loam	Plain
3L	487862.01	6786473	0	0	0	Acacia closed shrubland on loam	Plain
3M	488031.54	6786374	0	0	0	Acacia closed shrubland on loam	Plain
4A	486926.656	6787747	0	1	1	Acacia open shrubland on gravelly loam	Upper slope
4B	487015.316	6787695	6	3	9	Mixed shrubland on cobbles gravelly loam	Mid slope
4C	487156.19	6787618	0	1	1	Acacia tall closed shrubland on gravelly loam	Low slope
4D	488278	6786763			0	Acacia shrubland, few emergent Eucalypts, gravelly loam	Plain
4E	488207	6786836	7	3	10	Acacia shrubland with rocks, cobbles, loam and lichen	Low rise
4F	488127	6786885	1		1	Acacia shrubland rocks cobbles loam and lichen	Low rise
4G	487261.334	6787537	1	1	2	Acacia closed shrubland on gravelly loam	Low slope
4H	487340.56	6787473			0	Eucalyptus open woodland over mixed shrubland on gravelly loam	Low slope
4I	487485.005	6787331			0	Acacia tall open shrubland slightly gravelly loam	Plain

Quadrat	Easting	Northing	Juvenile	Adult	Total Burrows	Vegetation and Soils	Position
4J	487646.556	6787212			0	Eucalypt and acacia open woodland over acacia low shrubland on loam	Plain
4K	487826.963	6787121			0	Eucalypt, sand pine and acacia tall shrubland on loam	Plain
4L	488000.863	6787011			0	Acacia shrubland on gravelly loam	Mid slope
4M	488077.453	6786947	9	3	12	Acacia open shrubland on cobbles, gravel loam and lichen	Upper slope
4N	486310.134	6788166	0	0	0	Acacia open shrubland on rocks cobbles gravel and loam	Low slope
4O	486495.706	6788092	0	0	0	Acacia tall open shrubland on rock cobbles gravel and loam	Low slope
4P	486687.118	6788018	0	0	0	Acacia tall shrubland on loam	Plain
4Q	486836.252	6787876	0	1	1	Acacia tall shrubland on gravel loam some cobbles and lichen	Low slope
5A	488623.092	6787193	1	3	4	Acacia tall open shrubland on gravelly loam with lichen	Plain
5B	488553.405	6787268	1	1	2	Acacia tall shrubland on gravelly loam	Low slope
5C	488461.626	6787334	0	0	0	Acacia tall shrubland on gravelly loam with lichen	Plain
5D	488386.295	6787404	0	0	0	Eucalypt woodland over acacia tall shrubland on gravelly loam	Plain
5E	488193.737	6787477	0	0	0	Eucalypt and sand pine open woodland over acacia open tall shrubland on sandy-loam	Plain

Quadrat	Easting	Northing	Juvenile	Adult	Total Burrows	Vegetation and Soils	Position
5F	488044.345	6787608	0	0	0	Eucalypt and sand pine open woodland over acacia open tall shrubland on sandy-loam	Plain
5G	487871.899	6787716	0	0	0	Acacia tall shrubland on gravelly loam	Plain
5H	487695.372	6787813	0	0	0	Acacia tall shrubland on gravelly loam	Mid slope
5I	487512.145	6787890	0	0	0	Acacia tall shrubland on gravelly loam	Mid slope
5J	487385.814	6787934	0	0	0	Acacia tall open shrubland on cobbles, gravel and loam with some lichen	Mid slope
5K	487298.116	6787996	0	1	1	Acacia and melaleuca tall shrubland on cobbles, gravel, loam	Upper slope
5L	487203.738	6788024	12	2	14	Acacia tall shrubland on cobbles, gravel, loam and lichen	Upper slope
5M	487113.047	6788062	0	1	1	Mixed shrubland with rocks cobble gravel loam lichen	Upper slope
5N	487027.786	6788119	0	1	1	Acacia closed tall shrubland with rocks cobbles gravel loam and lichen	Mid slope
5O	486928.047	6788150	0	3	3	Acacia shrubland with rocks, cobbles, loam and lichen	Low slope
5P	486849.488	6788221	0	0	0	Scattered eucalypts over acacia open shrubland on cobbles gravel and loam	Low slope
5Q	486646.924	6788254	0	0	0	Eucalypt open woodland over acacia open shrubland on cobbles and loam	Plain
5R	486462.793	6788342	0	0	0	Eucalypt very open woodland over open mixed shrubland on cobbles gravel and loam	Plain

Quadrat	Easting	Northing	Juvenile	Adult	Total Burrows	Vegetation and Soils	Position
6A	487964	6788175	0	0	0	Scattered eucalypts over acacia tall closed shrubland on loam	Plain
6B	487795	6788278	0	0	0	Acacia tall closed shrubland on gravelly loam	Low slope
6C	487620	6788379	0	0	0	Eucalypt and acacia tall shrubland on gravelly loam	Mid slope
6D	487507	6788377	0	0	0	Eucalypt and acacia tall shrubland on loam	Upper slope
6E	487413	6788423	4	1	5	Acacia shrubland on cobbles gravel and loam with lichen	Upper slope
6F	487326	6788450	1	1	2	Acacia shrubland on cobbles gravel and loam with lichen	Upper slope
6G	487229	6788494	0	1	1	Acacia shrubland on cobbles gravel and loam with little lichen	Mid slope
6H	487140	6788540	2	0	2	Acacia shrubland on cobbles gravel and loam with little lichen	Mid slope
6I	486973	6788646	1	0	1	Acacia shrubland on gravelly loam	Low slope
6J	486790	6788725	0	0	0	Eucalypt and sand pine open woodland on sandy loam	Plain
7A	487961.42	6788792	0	0	0	Acacia tall shrubland on gravel loam with some lichen	Low slope
7B	488095	6788688	0	0	0	Acacia tall shrubland on gravelly loam	Low slope
7C	488202	6788567	0	0	0	Scattered eucalypts over acacia tall open shrubland on gravelly loam	Low slope

Quadrat	Easting	Northing	Juvenile	Adult	Total Burrows	Vegetation and Soils	Position
Opportunistic	487597	6788528			1		
Opportunistic	487029.831	6787170			1		
Opportunistic	486597.205	6786386			1		
Opportunistic	487597	6788528			1		
Opportunistic	487823	6788945			1		
Opportunistic	487873	6788977			1		
Opportunistic	487913	6789075			3		