Vertebrate Fauna Assessment of the Iron Valley Project Area

Rocky hills within the Iron Valley Project Area

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EXECUTIVE SUMMARY

Iron Ore Holdings Ltd (IOH) proposes to develop an iron ore mine within its Iron Valley tenement (the Project Area) located in the Eastern Pilbara Region of Western Australia. As part of the Environmental Impact Assessment (EIA) for the Project, Bamford Consulting Ecologists (BCE) was commissioned to conduct a Fauna Assessment and investigation of the vertebrate fauna within the Project Area. BCE uses an impact assessment process with the following components:

- The identification of fauna values:
  - Assemblage characteristics: uniqueness, completeness and richness;
  - Recognition of ecotypes or vegetation and substrate associations (VSAs) that provide habitat for fauna; particularly those that are rare, unusual and/or support significant fauna;
  - Patterns of biodiversity across the landscape;
  - 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.

The Project Area is located within in an extensively-surveyed area with several operating iron ore mines nearby. Based on the available information from previous surveys, a standard Level 2 trapping survey was not required for the Iron Valley Project. Instead, the Office of the Environmental Protection Authority agreed to field investigations to target conservation significant species and identify key fauna environments and ecological processes that maintain the fauna assemblage. Conservation significant species were targeted during field surveys if they were considered likely to occur in the Project Area based on previous records and/or presence of suitable habitat.

Field investigations included walking transects to look for evidence of significant species, Elliott trapping, cave searching, raking, use of motion-sensitive cameras, bat surveys, spotlighting, opportunistic observations and habitat assessment.

The desktop assessment of the Project Area identified 293 species, including: five frog, 105 reptile, 138 bird and 36 native mammal and nine introduced mammal species. A total of 21 conservation significant species is considered likely to occur within the Project Area, including

two reptile, 11 bird and eight mammal species. A total of 97 fauna species was recorded during the field surveys. This comprised one frog, 25 reptile, 58 bird, 11 native mammal and two introduced mammal species.

Five conservation significant fauna species were recorded during the field surveys: the Rainbow Bee-eater (commonwealth-listed); the Mulgara (commonwealth-listed); the Western Pebble-mound Mouse and Australian Bustard (both priority-listed by the WA Department of Environment and Conservation); and the Rufous-crowned Emu-wren (not listed but locally significant). These species could be residents within the Project Area, or move through the Project Area regularly.

Three major VSAs were identified during the field investigations:

1. Drainage Lines – characterised by mixed *Acacia* shrubs, *Triodia* and Buffel grass over clay soils (Boolgeeda land system);
2. Plains – comprising of flat plains of *Triodia* and mixed shrubland (Mulga) over clay loam soils with varying fire ages, with the occasional low stony rise in the landscape (Boolgeeda land system); and
3. Rocky Hills – Stony rocky hills dominated by *Triodia* on gravelly soils and rock outcrops. Lower slopes with scattered smooth barked eucalypts, shrubs and *Triodia* over pebbles and stones (Newman land system).

The Drainage Lines VSA may be most impacted by the Project as it is restricted in the region and likely to support conservation significant fauna. Any changes to hydrology have the potential to impact significantly upon this VSA and local fauna populations. The Plains VSA is likely to experience a moderate impact by the project due to its widespread distribution in the region and potential to support conservation significant fauna. The Rocky Hills VSA is well-represented outside the Project Area, although may still be sensitive to landscape-scale impacts such as hydrological change and altered fire regimes.

Among the fauna species of conservation significance that may occur in the area, impacts on most species are expected to be negligible or minor. Species where impacts may be of concern are:

- Pilbara Olive Python – species at low population density, restricted in habitat selection such as drainage lines and sensitive to roadkill;
- Night Parrot – species very poorly known so impact hard to predict; species is highly significant, although unlikely in the Project Area;
- Mulgara – species present at a location adjacent to the Project Area; the only recent record from the south side of the Fortescue Marshes. There is limited suitable habitat within the Project Area but extensive habitat to the north and north-west. The species may be sensitive to cumulative habitat loss from multiple development projects in the

region, and to landscape scale processes such as fire regimes, livestock grazing and feral predators.

- Bush Stone-curlew – species at low population density and sensitive to roadkill and feral predators;
- Lakeland Downs Mouse – species not recorded, however highly variable and may be present; and
- Pebble-mound Mouse – species present in Project Area and sensitive to habitat loss.

Of the impacting ecological processes, concerns can be summarised as follows:

- Loss of habitat leading to population decline – possibly some concern in the Boolgeeda land system within the Project Area. Cumulative impacts with other mining in the region need to be considered;
- Loss of habitat leading to population fragmentation – may be a concern along the Boolgeeda land system as the project may lead to fragmentation and disrupt fauna movement;
- Increased mortality – of concern for some fauna species, especially Pilbara Olive Python, Australian Bustard and Bush Stone-curlew;
- Hydrological changes – downstream effects along the River land system of Weeli Wolli Creek, potentialimpacts to local fauna populations if hydrological changes not avoided;
- Species interactions – such interactions are already occurring. There is potential for both negative and positive impacts from the proposed project upon feral species;
- Dust, noise, light and disturbance – impacts uncertain but some precautions are advised; and
- Changes in fire regime – a major ecological factor in the region's fauna with potential for both negative and positive impacts from the proposed project.

Impacts were generally considered to be minor because most of the VSAs and fauna habitats are contiguous and well-represented outside the Project Area. However, the fauna are likely to rely on the hydrological situation remaining intact and changes to this process (and the VSA Drainage Lines) may result in potentially significant changes to local fauna populations. Management recommendations are made concerning minimising habitat loss and mortality, protecting landscape permeability, hydrological management, fire management and control of feral species.

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1.1 Background

Iron Ore Holdings Ltd (IOH) proposes to develop an iron ore mine within its Iron Valley tenement (the Project Area) located in the Eastern Pilbara Region of Western Australia. As part of the Environmental Impact Assessment (EIA) for the Project, Bamford Consulting Ecologists (BCE) was engaged to conduct a Fauna Assessment of the vertebrate fauna within the Project Area. Based on the available information from previous surveys in the vicinity of the Project Area (see Section 1.6), a standard Level 2 trapping survey was not required for the Iron Valley Project, as agreed to in consultation with the Office of the Environmental Protection Authority (OEPA). Instead, the OEPA agreed to field investigations to target conservation significant species and identify key fauna environments and ecological processes that maintain the fauna assemblage.

1.2 General Approach to Fauna 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 ecotypes or vegetation and substrate associations (VSAs) that provide habitat for fauna; particularly those that are rare, unusual and/or support significant fauna;
  - Patterns of biodiversity across the landscape;
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  - 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.

In the present report, the identification of fauna values includes the results of the desktop assessment and baseline surveys conducted in May 2011 (autumn) and September 2011 (spring). The review of impacting ecological processes and recommendations to mitigate impacts are provided in the final sections of the report. Descriptions and background information on the above fauna values, conservation significance levels and ecological processes can be found in Appendices 1 to 4. Based on this impact assessment process, the objectives of the investigations

are therefore to: identify fauna values; review impacting processes with respect to these values and the proposed development; and provide recommendations to mitigate these impacts.

1.3 Location and Project Description

The Project Area is located within the Marillana Pastoral Station in the Hamersley Range of the Eastern Pilbara Region of Western Australia. The Project is located approximately 1100 km north-east of Perth and 90 km north-west of Newman (Figure 1). The Project occurs within Mining Lease M47/1439 in the Shire of East Pilbara. IOH also holds an Exploration tenement (E47/1385) located directly to the west of the Project Area.

The Iron Valley tenement lies on the lower slopes and low hills of a broad valley adjacent to Weeli Wolli Creek. The Project Area is separated from Weeli Wolli Creek by a hilly range, with the creek spreading out across a plain before entering the Fortescue Marsh approximately 20 km north of the Project Area.

IOH proposes to mine iron ore at Iron Valley, ore will be crushed and screened on-site prior to sale, with waste rock being stored on-site, and mining will take place above the water table only..

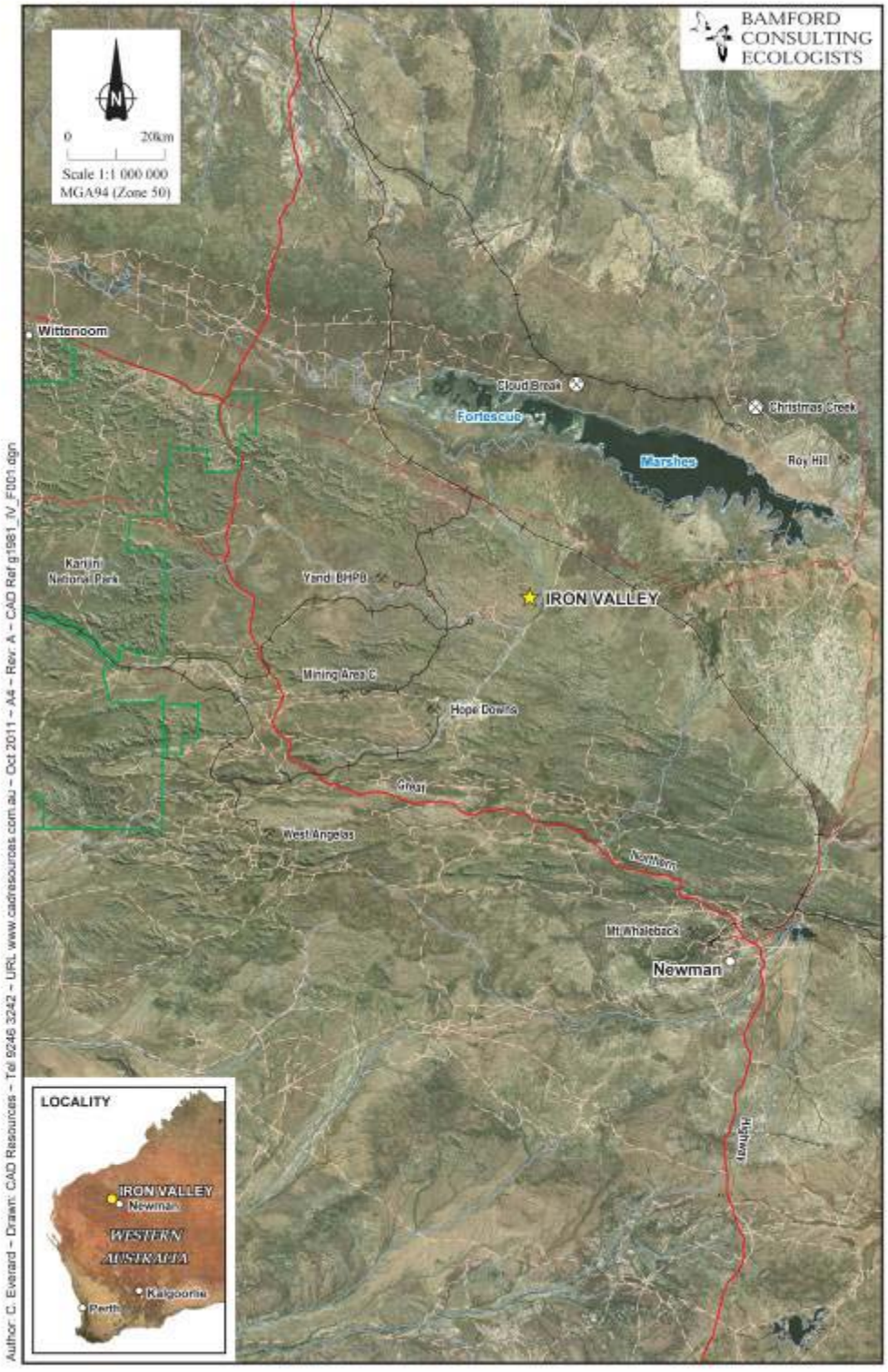

Figure 1. Location of the Iron Valley Project Area

1.4 Regional Description

The Project Area lies within the Hamersley subregion of the Pilbara Bioregion (Figure 2). The regions are described by the Interim Biogeographical Regionalisation for Australia (IBRA) classification system (Environment Australia 2000; McKenzie *et al.* 2003). The Pilbara Bioregion falls within the Bioregion Group 2 classification (EPA 2004). Bioregions within Group 2 have been described as areas of "native vegetation that is largely contiguous but is used for commercial grazing". The Project is located in the north-eastern corner of the Hamersley subregion, and abuts the Fortescue Plains. This subregion contains the Fortescue Marshes and is considered an important area for faunal biodiversity.

The general features of the Hamersley subregion are summarised by Kendrick 2001. The subregion has an area of approximately 6,215,092 ha, consisting largely of Proterozoic sedimentary ranges and plateaux, dissected by gorges (basalt, shale and dolerite). It is characterised by Mulga low woodland over bunch grasses on fine textured soils in valley floors, and *Eucalyptus leucophloia* over *Triodia brizoides* on skeletal soils of the ranges (Kendrick 2001). The climate of the region is semi desert tropical, with an average rainfall of 300 mm, falling mainly in summer cyclonic events. The dominant land uses in this subregion include grazing, Crown reserves and mining.

Kendrick 2001 notes that 7.75% of the Pilbara IBRA Region is under some form of conservation tenure (reservation class 3). Within the bioregion, PIL3 (Hamersley subregion) has 14.10% of the land area under conservation management, which is the highest in the Pilbara Region, with Kendrick 2001 recommending that a higher priority for reservation is appropriate to include riverine systems and wetlands. This subregion contains most of the Karijini National Park and parts of the Cane River Conservation Park. Note that while the Project Area appears to be adjacent to the PIL2 Fortescue subregion (see Figure 2), it lies within the PIL3 Hamersley subregion and its landscape is strictly that of the Hamersley subregion and not of the Fortescue marshes.

Figure 2. IBRA Subregions in Western Australia. Note the Project Area lies in PIL3: Hamersley subregion.

1.5 Land Types and Land Systems

Land types and systems in the Pilbara have been classified and mapped by van Vreeswyk *et al.* (2004). Land types are classified according to similarities in landform, soil, vegetation, geology and geomorphology. There are three major land types in the vicinity of the Project Area, with two land types occurring within the Project Area (Table 1).

Land types are further divided into land systems based on similarities of vegetation, landform and soil. The land systems in the region provide an indication of the fauna habitats present and are indicated in Table 1. The Project Area occurs within the Newman and Boolgeeda land systems, while the River land system is present in the Weeli Wolli creek area outside of the Project Area to the south and east (Figure 3). The McKay land system lies in close proximity to the Project Area but is not located within the Project Area.

The western section of the Project Area is dominated by the Newman land system, which comprises rugged jaspilite plateaux's with ridges supporting hard spinifex grasslands. The rocky ridges extend west beyond the tenement boundary and form part of the greater Hamersley Range. The eastern part of the Project Area consists of the Boolgeeda land system, including stony lower slopes and plains with spinifex grasslands or mulga shrublands.

The Weeli Wolli Creek flows parallel along the eastern boundary of the Project Area before draining into the Fortescue Marsh and contains the River land system, which is characterised by active flood plains and major rivers supporting grassy eucalypt woodlands, tussock grasslands and soft spinifex grasslands (van Vreeswyk *et al.* 2004). The Project Area is separated from the Weeli Wolli Creek system by a hilly range.

Table 1. Land Types and Systems represented within the region (from van Vreeswyk *et al.* 2004).

Land Type Code	Land Type Description	Land Systems
1- RGENEW	Hills and ranges with spinifex grasslands (occurs within the Project Area)	Newman
8-RGEBGO	Stony Plains with spinifex grasslands (occurs within the Project Area)	Boolgeeda
17-RGERIV	River plains with grassy woodlands and shrublands, and tussock grasslands (adjacent to the Project Area)	River

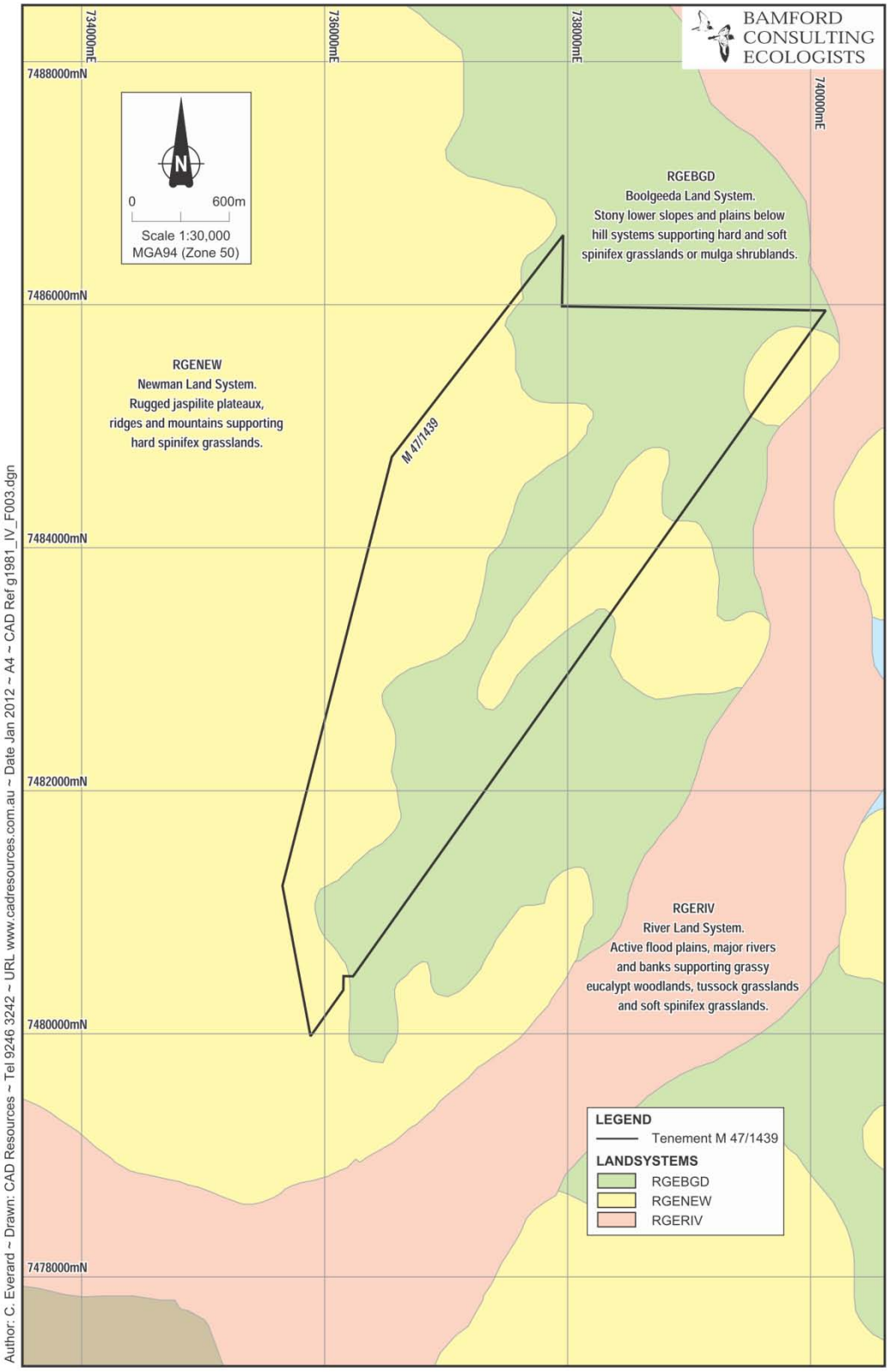

Figure 3. Land Systems within the Project Area (see map or Table 1 for Land System codes).

1.6 Previous Fauna Surveys

The Iron Valley Project Area is located in close proximity to a number of operating iron ore mines, including Fortescue Metals Group's (FMG) Cloudbreak operation, Rio Tinto Iron Ore's Yandicoogina operation and BHP Billiton Iron Ore's Yandi operation. Brockman Resources also has a proposed project located a few km north-west of the Project Area. Recent (2011) fauna surveys involving detailed trapping have previously been undertaken in the tenements for these companies (within approximately 20 km of the Project Area), including another Project for IOH located 20 km to the west (Kurrajura tenement; BCE 2011b) and FMG's Nyidinghu tenement (abuts Iron Valley to the north; BCE 2011a). Older fauna surveys in the area, dating back to the early 2000s, 1990s and even early 1980s, have also been undertaken within the vicinity of the Project Area. Some of these survey sites are located within one km of the Project Area and are located within similar land systems. Details of previous fauna surveys conducted in the area are listed in Table 2.

Table 2. Previous fauna surveys within the vicinity of the Iron Valley Project Area.

Consultant	Date	Report
Bamford Consulting Ecologists	2011	Fauna Assessment FMG Nyidinghu Iron Ore Project
Biota Environmental Sciences	2011	Hope Downs Project Life of Mine Targeted Fauna Survey
Biota Environmental Sciences	2010	Yandicoogina Junction South West and Oxbow Fauna Survey
Ecologia	2010	Christmas Creek Terrestrial Vertebrate Fauna Desktop Assessment
Bamford Consulting Ecologists	2010	Report on December 2009 search for Night Parrot. A Fortescue Metals Group Project
Biota Environmental Sciences	2009	Yandicoogina Targeted Northern Quoll Survey
Ninox Wildlife Consulting	2009	A Vertebrate Fauna Survey of The Proposed Hope Downs 4 Option 6 Infrastructure Corridor
Ecologia	2009	Marillana Iron Ore Project Vertebrate Fauna Assessment
Western Wildlife	2009	Phil's Creek Project Area Fauna Survey
Bamford Consulting Ecologists	2005	Fauna Survey of Proposed Cloudbreak Mine
Biota Environmental Sciences	2005	Fauna Habitats and Fauna Assemblage of the Proposed FMG Stage B Rail Corridor

2 Methods

2.1 Desktop Assessment

2.1.1 Sources of Information

Information on the fauna assemblage of the Project Area was drawn from a wide range of sources. These included State and Commonwealth government databases, BCE's local database and results of other recent baseline vertebrate fauna studies (see Section 1.6).

Furthermore, BCE undertook a desktop assessment and a comprehensive Level 2 trapping program at IOH's nearby Kurrajura tenement (located approximately 20 km north-east of Iron Valley). These surveys were conducted concurrently with the Iron Valley field surveys in May and September 2011 (BCE 2011b). Note that at the time of writing the Kurrajura tenement was no longer held by IOH, but the results of the survey and impact assessment have been used by BCE to support the findings at the Iron Valley Project.

Databases accessed by BCE include the Department of Environment and Conservation's (DEC) Naturemap (incorporating the Western Australian Museum's FaunaBase and the DEC Threatened and Priority Fauna Database), Birds Australia's Atlas Database (BA), Commonwealth EPBC Protected Matters Search Tool, Atlas of Living Australia database and BCE's local database (Table 3).

Information from the above sources was supplemented with species expected in the area based on general patterns of distribution from BCE's experience and broader literature. Sources of information used for these general patterns included:

- Allen *et al.* (2002) - freshwater fish;
- Tyler and Doughty (2009) - frogs;
- Storr *et al.* (1983); Storr *et al.* (1990); Storr *et al.* (1999); Storr *et al.* (2002) and Wilson and Swan (2008) - reptiles;
- Blakers *et al.* (1984); Johnstone and Storr (1998, 2004) and Barrett *et al.* (2003) - birds; and
- Strahan (1995); Menkhorst and Knight (2001); Strahan (2004); Churchill (2008); and Van Dyck and Strahan (2008) - mammals.

Table 3. Details of literature and database search.

Database	Type of records held on database	Area searched
NatureMap (DEC 2011)	Records in the WA Museum and DEC databases. Includes historical data and records on Threatened and Priority species in WA.	Point search from: 22°44' 5'' S, 119°18' 27'' E. Plus 40 km radius.
Birds Australia Atlas Database	Records of bird observations in Australia, 1998-2011.	Species list for the 1 degree grid cell containing: 22°44' 5'' S, 119°18' 27'' E.
EPBC Protected Matters Search Tool	Records on matters protected under the Commonwealth EPBC Act, including threatened species and conservation estate.	Point search from: 22°44' 5'' S, 119°18' 27'' E. Plus 10 km radius.
Atlas of Living Australia Database	Records of species distributions and mapping tools.	General area search: Pilbara Bioregion

2.1.2 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 *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.

2.1.3 Interpretation of Species Lists

Species lists generated from the review of information sources 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 habitat types 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 during field investigations.

Interpretation of species lists generated through the desktop review included assigning an expected status to species of conservation significance that are likely to be present) within the Project Area. This is particularly important for birds that may naturally be migratory or nomadic, and for some mammals that can also be highly mobile or irruptive (or 'boom and bust' populations). The status categories used within this report are:

- Resident: species with a population permanently present in the Project Area;
- Regular migrant or visitor: species that occurs within the Project Area regularly in at least moderate numbers, such as part of an annual cycle;
- Irregular Visitor: species that occurs 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 utilises the Project Area in at least moderate numbers and for some time, such as weeks or months.
- Vagrant: species that occurs within the Project Area on an unpredictable basis, in small numbers and/or for very brief periods. Therefore, the Project Area is unlikely to be an important home range for the species; and
- Locally extinct: species that have not been recently recorded in the local area and for which adequate searches have been undertaken; therefore almost certainly no longer present in the Project Area.

2.2 Field Surveys

2.2.1 Overview

The field survey included several components:

1. targeted searching for conservation significant fauna including Western Pebble-mound Mouse and Mulgara transects, Elliott trapping for Northern Quoll, cave searching for Northern Quoll scats, and raking (raking through piles of loose soil and turning over fallen vegetation principally for reptiles);
2. use of motion-sensitive cameras;
3. bat surveys;
4. spotlighting;
5. opportunistic observations; and
6. habitat assessment.

The sampling methodology outlined in the Commonwealth Guidelines for the Northern Quoll was taken into consideration during the survey (DSEWPaC 2011a). A summary of survey techniques used during the May and September field surveys is provided in Table 4.

Table 4. Details of survey techniques used in May and September surveys

Survey Techniques	First Survey Period 9-19 May 2011	Second Survey Period 29-30 September 2011
Targeted Western Pebble-mound Mouse and Mulgara transects	X	X
Elliott trapping (Northern Quoll)	X	
Targeted cave searches	X	X
Motion-sensitive cameras (Northern Quoll)	X	
Motion-sensitive cameras (Mulgara)	X	X
AnaBat surveys	X	X
Spotlighting	X	
Opportunistic observations and searching	X	X

2.2.2 Survey Timing and Weather Conditions

The timing of field surveys was determined by Guidance Statement 56 (EPA 2004), which states: "fauna and faunal assemblage surveys conducted for baseline information should be multiple surveys conducted in each season appropriate to the bioregion and the faunal group. The most important seasonal activity times for many faunal groups is related to rainfall and temperature. Thus, a survey in the season that follows the time of maximum rainfall is generally the most productive and important survey time. In some cases there may also be a need to time surveys according to the seasonal activity patterns of particularly important species (such as Specially Protected Fauna or Priority species) or particular assemblages (e.g. amphibians [and migratory birds])". The two surveys were undertaken in May 2011, following summer rain, and in September 2011, following winter rain.

The first field survey was conducted between the 9th and 19th May 2011. During this period the weather was generally cool for the region with some light rainfall (approximately 8 mm, recorded at Marillana Meteorological Station during the survey period). The daily maximum temperatures recorded at Newman Meteorological Station during the survey period ranged from 18.8°C to 28.4°C (Bureau of Meteorology 2011).

The second field survey was conducted on the 29th and 30th of September 2011, when conditions were warm to hot. Daily maximum temperatures ranged from 34.2°C to 34.7°C (Bureau of Meteorology 2011). These periods are considered a suitable time for maximising trap captures in the north-west of Western Australia.

2.2.3 Personnel and Licences

Field work was conducted by:

- Dr Mike Bamford (B.Sc. Hons. Ph.D.)
- Natalia Huang (B.Sc. Hons.)
- Ian Harris (B.Sc. Hons.)
- Brendan Metcalf (B.Sc. Hons.)
- Robert Browne-Cooper (B.Sc.)
- Peter Smith (Dip. Ag.)
- Sarah Smith (B.Sc.)
- Gillian Basnett (B.Sc. MSc.)
- Dr John Scanlon (B.Sc. Hons. Ph.D. [Ecoscape])
- Claudia McHarrie (B.Sc. Hons. [Ecoscape])
- Cameron Everard (B.Sc.)

This document was prepared by Cameron Everard, Mike Bamford, Natalia Huang and Tim Gamblin (B.Sc.). The field surveys were conducted under DEC Regulation 17 licence number SF007970.

2.2.4 Conservation Significant Species Targeted

Significant fauna species identified during the desktop assessment include several species that can be found by targeted searching for evidence of their activities (e.g. scats, tracks, diggings and burrows), and opportunistic observations of these were recorded throughout the surveys. Species were targeted if they were considered likely to occur in the Project Area based on previous records and/or presence of suitable habitat.

The species targeted were:

- Pilbara Olive Python (*Liasis olivaceus barroni*);
- Northern Quoll (*Dasyurus hallucatus*);
- Bilby (*Macrotis lagotis*);
- Western Pebble-mound Mouse (*Pseudomys chapmani*);
- Mulgara (*Dasycercus cristicauda*)*;
- Ghost Bat (*Macroderma gigas*); and
- Pilbara Leaf-nosed Bat (*Rhinonicteris aurantia*).

*Note there was historical taxonomic confusion between the Crest-tailed Mulgara and the similar Brush-tailed Mulgara (*D. blythi*). This means that the distribution of the two Mulgara species is presently unclear, with even the identity of museum specimens being uncertain. The Brush-tailed Mulgara is listed as Priority 4 by the DEC in WA, but is not recognised under EPBC legislation (whereas the Crest-tailed Mulgara is). BCE has taken a precautionary approach in this instance and determined that the species that may occur within the Project Area is the Crest-tailed Mulgara that is listed under the EPBC Act (see Section 3.5.4). In a recent publication (DSEWPaC 2011c), it is stated that the Crest-tailed Mulgara does not occur in WA, but as the EPBC Act stands now, DSEWPaC would consider any Mulgara to be *D. cristicauda*.

2.2.5 Western Pebble-mound Mouse and Mulgara Transects

Targeted searches were carried out for the Western Pebble-mound Mouse (burrow systems) and Mulgara (burrows, foraging holes, tracks and scats) as there was suitable habitat for both species within and adjacent to the Project Area. Searching was approached systematically by walking with 2-3 personnel in a line, spaced about 20 m apart, so that a transect of a known length and width (and therefore area) was searched. Eight transects were carried out within the Project Area (Figure 5). A total area of 88 ha was surveyed by transects. All personnel involved in searching were familiar with the evidence of each species, or were trained by experienced personnel on site. All observations and locations of fauna were recorded. Transects were carried out throughout the Project Area in various habitat types (Figure 4). In addition, opportunistic observations of the Western Pebble-mound Mouse and Mulgara were recorded throughout the surveys, including in suitable habitat immediately outside the Project Area.

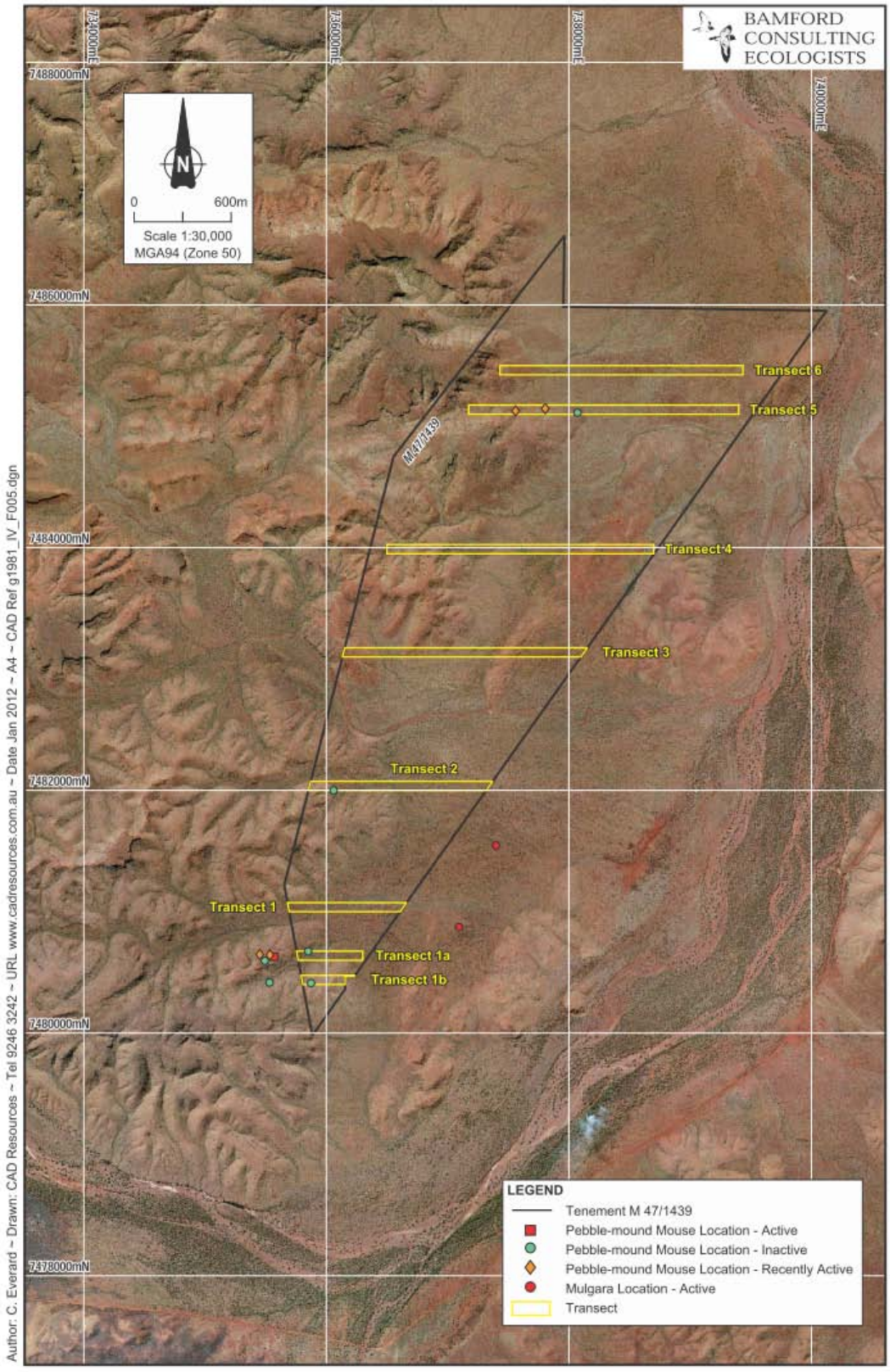

Figure 4. Locations of Western Pebble-mound Mouse and Mulgara transects and burrows. Tenement M 47/1439 indicates boundary of Project Area.

2.2.6 Elliott Traps and Cave Searches

A transect of ten Elliott traps was set in a rocky area where Northern Quoll were considered likely to occur. Elliott traps was spaced approximately 25 m apart and were set for five nights in May and were baited with universal bait (rolled oats, peanut paste and sardines). Locations of each Elliott trap are provided in Appendix 5 and shown in Figure 5. Targeted searches in potential suitable cave habitat were carried out in the Project Area and focused on locating possible roosts sites of conservation significant bat species such as the Pilbara Leaf-nosed Bat and Ghost Bat, as well as any evidence of the Northern Quoll (e.g. scats).

2.2.7 Motion-sensitive Cameras

It was considered likely that the Northern Quoll may occur in the rocky environments of the Project Area (located on the western and eastern boundaries of the Project Area). This species can be difficult to detect but can be recorded using motion-sensitive cameras. These operate in daylight or at night, and were set in suitable rocky habitat with universal bait within the camera detection zone. Three cameras were set for four or eight nights in May in rocky areas to target the Northern Quoll (Table 5, Figure 5). Two cameras were also set in habitat considered suitable for Mulgara (low spinifex over sand); one camera was set for two nights in May and one camera was set for one night in September (Table 5, Figure 5). These locations were outside the Project Area (about 300 m east) and were selected on the basis of opportunistic evidence that the Mulgara was present. All species photographed were identified.

Table 5. Details of motion-sensitive camera surveys

Camera No.	Start Date	Finish Date	Survey Nights	Easting	Northing
BC2	14-5-2011	18-5-2011	4 nights	737045	7483998
BC4	14-5-2011	18-5-2011	4 nights	737440	7484672
BC6	10-5-2011	18-5-2011	8 nights	736045	7482976
Aud1	16-5-2011	18-5-2011	2 nights	737094	7480873
Aud5	29-9-2011	30-9-2011	1 night	737397	7481545

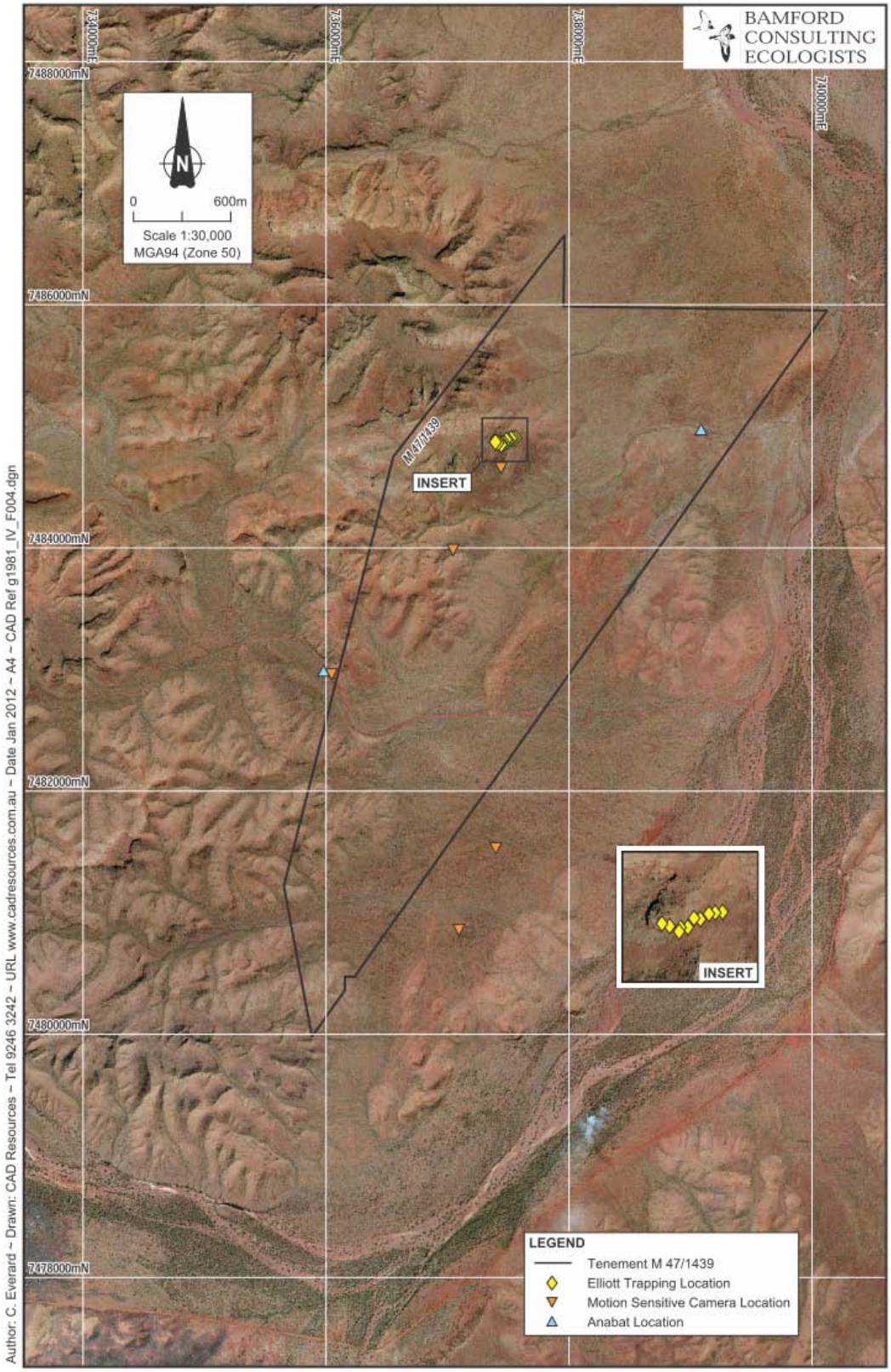

Figure 5. Location of Elliott traps, motion-sensitive cameras and AnaBat surveys. Tenement M 47/1439 indicates boundary of Project Area.

2.2.8 Bat Surveys

Bat echolocation calls were recorded using the AnaBat system (Titley Electronics, Ballina, NSW), where calls were recorded through the AnaBat II Bat Detector onto an audio recorder. At a later stage the recorded calls were assessed using AnaBat software to analyse the call characteristics. AnaBat detectors were set at two locations (14th May 2011: 736045E, 7482976N and 29th September 2011: 739087E, 7484960N; see Figure 4) within the Project Area. AnaBat recordings were analysed by Kyle Armstrong of Specialised Zoological and Brenden Metcalf (BCE). All species recorded were identified.

2.2.9 Spotlighting

Spotlighting was conducted both on foot, using head-torches (referred to as head-torching), and from a vehicle using the vehicle headlights and a hand-held spotlight. Where necessary, animals were captured for identification purposes and then released. Spotlighting was conducted during evenings on the 14th, 15th and 17th of May (three nights) when conditions were considered most suitable (on warm clear evenings).

2.2.10 Opportunistic Observations and Searching

Throughout both survey periods, opportunistic observations of fauna that contributed to the accumulation of information about the fauna of the Project Area were recorded. These included such casual observations as birds or reptiles seen while travelling through the site. Opportunistic searching for fauna, such as raking through leaf-litter and turning over logs, was also carried out throughout the Project Area. Such raking/searching involved about 10 person-hours of effort in the May survey.

2.2.11 Habitat Assessment

Vegetation and substrate associations (VSAs) were assessed during the desktop assessment and as part of the field survey investigations. A VSA combines broad vegetation types, soils or other substrate with which they are associated, and landform (see Appendix 1). This information on VSAs is supplemented in the Pilbara Region by a Land Systems Analysis (van Vreeswyk *et al.* 2004) that provides information on the regional distribution, abundance and management of these VSAs. In the context of fauna assessment, VSAs are the environments that provide habitats for fauna. Within the 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.

2.2.12 Summary of Field Effort

Across the May and September field trips, survey effort can be summarised as follows:
Field time: 60 person-days (estimated as some time shared between Iron Valley and Kurrajura).
Elliott traps 50 trapnights
Motion-sensitive cameras 19 camera-nights
Anabat recording 6 unit-nights
Cave searching 5 person-hours
Searching by raking 10 person-hours (May only)
Transect searching for burrows and tracks 20 person hours (estimated)
Spotlighting 3 nights

2.3 Impact Assessment

2.3.1 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 4.3. 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.

2.3.2 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 6). Population change can be the result of direct habitat loss and/or impacts upon ecological processes.

Table 6. Criteria for impact assessment

Impact Category/Significance Level	Observed Impact
Negligible	No population decline
Minor	Short-term population decline (recovery after end of project) within survey area, no change in viability of conservation status of population
Moderate	Permanent population decline, no change in viability of conservation status of population
Major	Permanent population decline resulting in change in viability or conservation status of population
Critical	Taxon extinction

2.4 Limitations of Investigations

The EPA Guidance Statement 56 (EPA 2004) outlines a number of limitations that may arise during surveying of fauna. These survey limitations are discussed in the context of the BCE fauna survey at the Project Area, and detailed in Table 7.

Table 7. Survey limitations as outlined by EPA (2004).

EPA Limitation	BCE Comment
Level of survey.	The targeted survey approach was deemed adequate by the OEPA to identify significant fauna and habitats occurring in the Project Area, when combined with information from similar surveys undertaken in the region.
Competency/experience of the consultant(s) carrying out the survey.	The authors and project personnel have had extensive experience in conducting fauna assessments in the Pilbara Region.
Scope (What faunal groups were sampled and were some sampling methods not able to be employed because of constraints?).	The survey focussed on significant species (reptiles, mammals, bats and birds). A range of survey methods were undertaken.
Proportion of fauna identified, recorded and/or collected.	All vertebrate fauna observed (including from trapping etc) were 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 region and databases (BCE, Naturemap, BA, DEC, ALA and EPBC).
The proportion of the task achieved and further work which might be needed.	The targeted survey is complete (two season survey).
Timing/weather/season/cycle.	Seasonal surveys were conducted from the 9th to 19th May and 29th to 30th September 2011. Conditions were cool during the May survey, which may have affected the presence and/or abundance of some species. Conditions were good (warm to hot) during the September survey.
Disturbances (e.g. fire, flood, accidental human intervention etc.), which affected results of survey.	No disturbances affected the survey. Recent fires may have affected the abundance and distribution of species such as the Mulgara.
Intensity (In retrospect, was the intensity adequate?).	Survey intensity was adequate to record conservation significant fauna and habitats.
Completeness (e.g. was relevant area fully surveyed).	Targeted survey is complete, but as noted above, some species not recorded may be present under different seasonal conditions, but the habitat assessment allows such species to be considered.
Resources (e.g. degree of expertise available in animal identification to taxon level).	All vertebrate species have been identified to species (sometimes sub-species) level. All survey personnel are adequately trained and deemed competent to conduct animal identification to taxon level.

EPA Limitation	BCE Comment
Remoteness and/or access problems.	No access problems were experienced.
Availability of contextual (e.g. biogeographic) information on the region.	Extensive regional information was available (including from another IOH survey conducted at the same time) and was consulted during the desktop assessment and results analysis.

3 Results

3.1 Threatened Ecological Communities

No Threatened Ecological Communities (TECs) were identified within the vicinity of the Project Area during the desktop review.

3.2 Vegetation and Substrate Associations

Three major VSAs were identified during the field investigations and are listed below from low to high in the landscape (see Plates 1 and 2).

1. Drainage Lines – characterised by mixed *Acacia* shrubs, *Triodia* and Buffel grass over clay soils (Boolgeeda land system);
2. Plains – comprising of flat plains of *Triodia* and mixed shrubland (Mulga) over clay loam soils with varying fire ages, with the occasional low stony rise in the landscape (Boolgeeda land system); and
3. Rocky Hills – Stony rocky hills dominated by *Triodia* on gravelly soils and rock outcrops. Lower slopes with scattered smooth bark Eucalypts, shrubs and *Triodia* over pebbles and stones (Newman land system).

Within the Project Area, the VSA Drainage Lines is likely to be most significant for fauna as it supports a key ecological process (hydrology) that maintains the fauna assemblage in the Project Area (see Section 3.6). The rocky hills also consisted of several steep cliffs and small caves with occasional Eucalypts over *Triodia*. These specialised habitats are important for significant species (e.g. Northern Quoll) and were the focus of targeted searches, Elliott trapping and motion-sensitive cameras.

Plate 1. Plains of *Triodia* over clay loam soils with rocky hills in the background.

Plate 2. Rocky hills with *Triodia* over rock and gravelly soils.

3.3 Vertebrate Fauna

3.3.1 Overview and Characteristics of Fauna Assemblage

The vertebrate fauna with the potential to occur (including those also recorded) in the Project Area is presented in Appendix 6. These lists are based largely upon known species distributions and available habitats, and exclude species that may have appeared in databases but are obviously likely on the site only as vagrants, such as seabirds, or for which the site has no suitable habitat, such as marine mammals (see Section 2.1.3).

The desktop assessment identified 293 vertebrate species potentially occurring in the Project Area, including: five frog, 105 reptile, 138 bird, 36 native mammal and nine introduced mammal species (Table 8). A total of 21 conservation significant species is considered likely to occur within the Project Area (either as a resident or as a visitor on seasonal basis, see Table 8). This includes two reptile (1 CS1, 1 CS2), 11 bird (5 CS1, 4 CS2, 2 CS3) and eight mammal (4 CS1, 4 CS2) species.

A total of 97 fauna species was recorded during the field survey. This comprised 1 one frog, 25 reptile, 58 bird, 11 native mammal and two introduced mammal species (Table 8 and Appendix 6). Five conservation significant fauna species were recorded during the field surveys (Appendix 6). Details of each conservation significant species expected to occur in the survey area are provided in Table 9, with details of conservation significance categories provided in Appendix 3.

Overall, the assemblage of vertebrate fauna expected to occur within the Project Area reflects the community structure of the Pilbara Region of Western Australia. The fauna assemblage is not considered unique, with the environment widespread in the region, and the assemblage considered typical of the region. In terms of completeness, the overall assemblage is lacking a few of the usual mammals but is otherwise substantially complete. Fauna expected include a number of terrestrial fauna that are unique to the region, such as the Pilbara Leaf-nosed Bat (*Rhinonycteris aurantius*), the Pilbara Olive Python (*Liasis olivaceus barroni*) and the blind snake *Ramphotyphlops ganei*, and some more diverse representatives of northern and arid Australia. As a result, a diverse fauna assemblage is expected to occur across the Project Area where ranges of species with predominantly Torresian (tropical Australian) and Eyreaen (Inland Australian) distributions overlap.

Table 8. Composition of vertebrate fauna expected to occur and recorded within the Project Area

Taxon	Number of species expected	Number recorded	Significant fauna expected	Significant fauna recorded
Frogs	5	1	-	-
Reptiles	105	25	2	0
Birds	138	58	11	3
Native Mammals	36	11	8	2
Introduced Mammals	9	2	-	-
Total	**293**	**97**	**21**	**5**

Note: Survey focussed on targeting significant species and habitats compared to a usual Level 2 trapping program.

Table 9. Conservation significant fauna species expected to occur in the Project Area (conservation categories as defined in Appendix 3).

Species are considered likely to occur in the Project Area based on database searches, literature and authors' experience.

Species		***EPBC Act 1999***	***WA Wildlife Conservation Act 1950***	**DEC Priority**
Conservation Significance Level 1				
Pilbara Olive Python	*Liasis olivaceus barroni*	Vulnerable	Schedule 1	
Peregrine Falcon	*Falco peregrinus*		Schedule 4	
Night Parrot	*Pezoporus occidentalis*	Endangered	Schedule 1	
Fork-tailed Swift	*Apus pacificus*	Migratory	Schedule 3	
Rainbow Bee-eater	*Merops ornatus*	Migratory	Schedule 3	
Fork-tailed Swift	*Apus pacificus*	Migratory	Schedule 3	
Eastern Great Egret	*Ardea modesta*	Migratory	Schedule 3	
Northern Quoll	*Dasyurus hallucatus*	Endangered	Schedule 3	
Crest-tailed Mulgara	*Dasycercus cristicauda*	Vulnerable	Schedule 1	
Greater Bilby	*Macrotis lagotis*	Vulnerable	Schedule 1	
Pilbara Leaf-nosed Bat	*Rhinonicteris aurantius*	Vulnerable		
Conservation Significance Level 2				
Blind snake	*Ramphotyphlops ganei*			Priority 1
Australian Bustard	*Ardeotis australis*			Priority 4
Bush Stone-curlew	*Burhinus grallarius*			Priority 4
Grey Falcon	*Falco hypoleucos*			Priority 4
Star Finch	*Neochmia ruficauda subclarescens*			Priority 4
Western Pebble-mound Mouse	*Pseudomys chapmani*			Priority 4

Species		***EPBC Act 1999***	***WA Wildlife Conservation Act 1950***	**DEC Priority**
Lakeland Downs Mouse	*Leggadina lakedownensis*			Priority 4
Long-tailed Dunnart	*Sminthopsis longicaudata*			Priority 4
Ghost Bat	*Macroderma gigas*			Priority 4
Conservation Significance Level 3				
Rufous-crowned Emu-wren	*Stipiturus ruficeps*			
Striated Grasswren	*Amytornis striatus*			

3.3.2 Western Pebble-mound Mouse and Mulgara Transects

Western Pebble-mound Mouse

Two recently active and four inactive Western Pebble-mound Mouse burrow systems (mounds) were recorded within the Project Area (Table 10, Figure 4). There were additional mounds observed opportunistically just outside (<500 m) the Project tenement boundary (Figure 4). Western Pebble-mound Mouse mounds were recorded in the northern and southern parts of the Project Area on the gravelly slopes of rocky hills. Most of the Pebble-mound Mouse activity and suitable habitat appeared to be outside the Project Area.

Table 10. Details of Western Pebble-mound Mouse mounds recorded

Western Pebble-mound Mouse mounds	**Active mounds**	**Recently active mounds**	**Inactive mounds**	**Total number of mounds**
Mounds recorded within the Project Area	0	2	4	6
Mounds recorded adjacent to the Project Area (<500m)	1	2	2	5

Mulgara

A single active Mulgara burrow was recorded just outside the south eastern tenement boundary in May 2011, on the flat *Triodia* plain with clay-loam soil (Zone 50, 737094E, 7480873N) (Figure 4). A motion-sensitive camera located next to this burrow system did not record any Mulgara. Opportunistic searching in the same area conducted in September 2011 identified a second active Mulgara burrow (Zone 50, 737397E, 7481545N). A Mulgara was recorded by a motion-sensitive camera at this burrow (see Section 3.3.4). These two burrows and the confirmed Mulgara were in the flat *Triodia* plains typical of the Boolgeeda land system, and lay about 300m from the boundary of the Project Area. Some of this land system is present in the Project Area, but it is more extensive to the north and north-west (Figure 6).

3.3.3 Elliott Traps and Cave Searches

No Northern Quoll or other mammal species were recorded from the Elliott trapping conducted in the rocky hills of the Project Area. Several cave systems throughout the Project Area were searched for signs of fauna activity, however most were considered too small for bats. Several Common Sheathtail Bats (*Taphozous georgianus*) were recorded in one cave. No Northern Quoll activity (scats and tracks) were observed during cave searches.

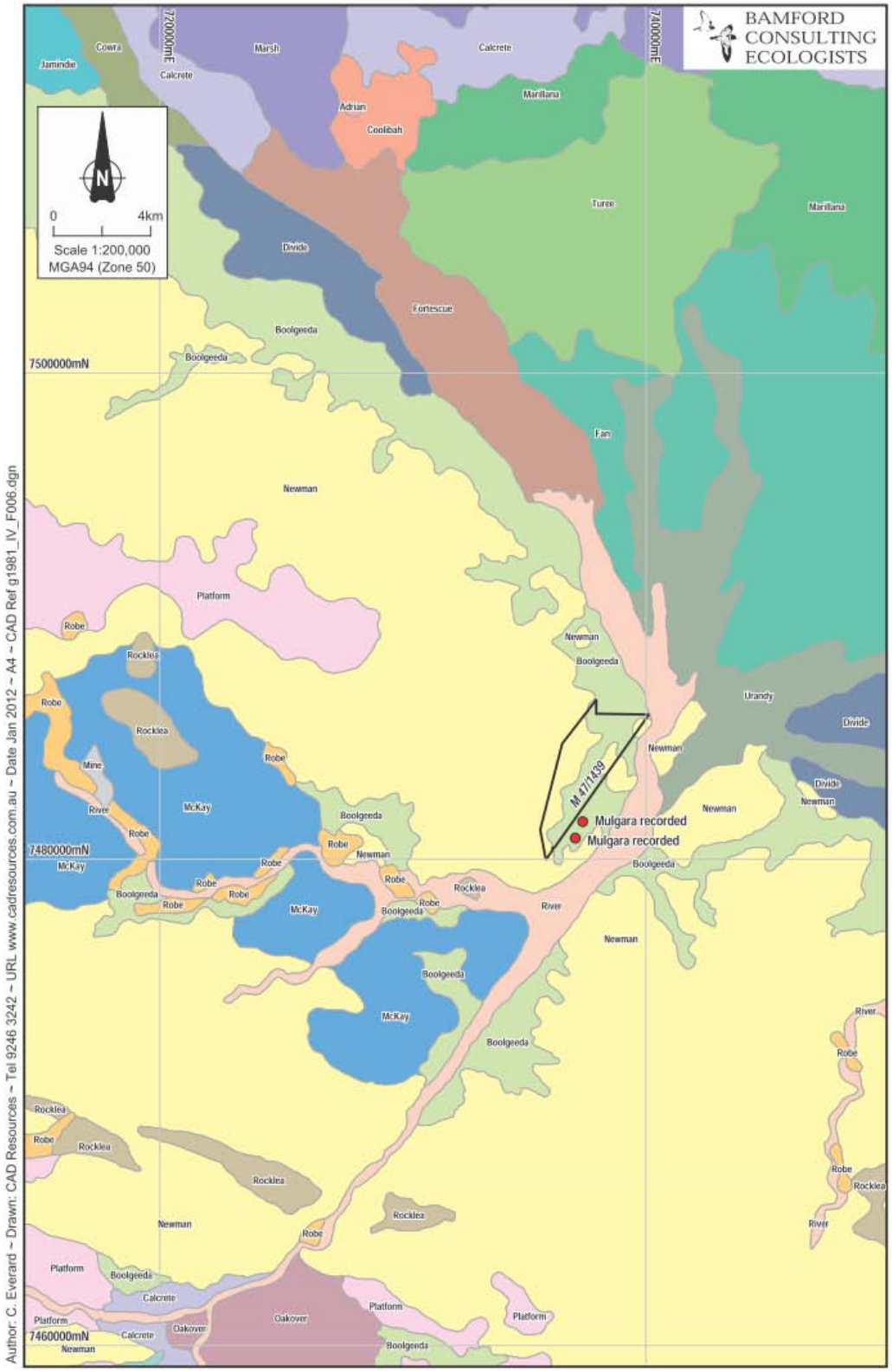

Figure 6. The Iron Valley Project Area, showing the extent of the Boolgeeda Land System (habitat for the Mulgara) and the location of Mulgara records near the Project Area.

3.3.4 Motion-sensitive Cameras

The Mulgara was recorded on a motion-sensitive camera, with no other species recorded (Plates 3 and 4). The individual was recorded at a burrow system found opportunistically (see Section 3.3.2). Although this record is located approximately 300 m outside the Project tenement boundary, it confirms the presence of Mulgara in the local area.

Plates 3 and 4. Mulgara confirmed outside of Project tenement boundary with motion-sensitive camera.

3.3.5 Bat Surveys

Six bat species were recorded through the AnaBat system from the Project Area during the two surveys and included: Yellow-bellied Sheathtail Bat *Saccolaimus flaviventris, Chaerephon jobensis,* Common Sheathtail Bat *Taphozous georgianus*, Gould's Wattled Bat *Chalinolobus gouldii, Scotorepens greyii* and *Vespadelus finlaysoni*. None of these species is of conservation significance. No calls of either the Ghost Bat or the Pilbara Leaf-nosed Bat were recorded.

3.3.6 Spotlighting

Eleven reptile species and 33 individuals (29 geckoes, one skink, one dragon and two snakes) were recorded while spotlighting (Appendix 6). All species observed are common to the region.

3.3.7 Opportunistic Observations

During the investigation, 96 species were opportunistically recorded including:

- One frog species;
- 25 reptile species;
- 12 mammal species (includes two introduced species); and
- 58 bird species.

Of the 25 reptile species observed, there were two dragons, 11 geckoes, seven skinks, two legless lizards and three snakes identified. All species recorded during the assessment are indicated in Appendix 6.

3.4 Patterns of Distribution and Abundance

Overall, the composition of the vertebrate fauna observed is as expected for the region (see Section 3.3.1). A number of general trends in the distribution and abundance of fauna can be drawn from the data.

As with the reptile assemblage, all of the birds recorded were expected. Many of the expected species not recorded during the survey are associated with environments (such as wetlands, large cave systems and deeply incised gorges), that are not present in the Project Area. In addition, a number of bird species expected but not recorded are likely to be either regular or intermittent visitors to the area.

Almost all the species that were confirmed are widespread, and despite targeted approaches being used to locate conservation significant-listed mammals such as the Bilby, Mulgara, Northern Quoll, Ghost Bat and Pilbara Leaf-nosed Bat, only two significant mammal species (the Mulgara and Western Pebble-mound Mouse) were recorded. This may in part be due to the lack of suitable habitat for some of these species. For example, the Bilby prefers a light sandy substrate and vegetation with different fire ages, while the Ghost Bat and Pilbara Leaf-nosed Bat prefer large, humid cave systems. Both habitat types were limited or absent within the Project Area, thus the two bat species might forage through the area (since they occur regionally) but are highly unlikely to have important roost sites within the Project Area. The rocky habitat appeared suitable for Northern Quoll, but the species was not recorded and the results of other surveys in the region indicate that the species is very scarce in this part of the Hamersley Ranges.

The Western Pebble-mound Mouse was found on the rocky hills and gravelly slopes of the Newman land system which occupies about half the Project Area (Figure 3), although not all the land system may be suitable for the species. Records were confined to the south of the Project Area despite searching more widely across the area.

As discussed, transect searching and motion-sensitive cameras confirmed the presence of Mulgara just outside the eastern part of the tenement within the flat *Triodia* plains of the Boolgeeda land system. This system occurs within the Project Area but is more extensive outside (to the north and west, see Figure 6). Numerous bird species including the Australian Bustard and Rainbow Bee-eater are also likely to forage throughout this area adjacent to the Project Area. Several frog and bird species are likely to use the drainage lines of the Boolgeeda and River and system to the east of the Project Area. The Pilbara Olive Python (if present), may also frequent the drainage lines in times of flooding to move through the Project Area in search of prey.

3.5 Conservation Significant Species

3.5.1 Overview

Of the 21 species of conservation significance expected to occur within the Project Area (Table 9), five species were recorded. These include the:

- Australian Bustard (CS2);
- Rainbow Bee-eater (CS1);
- Rufous-crowned Emu-wren (CS3)
- Mulgara (CS1); and
- Western Pebble-mound Mouse (CS2).

Conservation significant species can be difficult to detect and may not always be present for several reasons. Significant species that were recorded, their habitat and expected status (presence/absence) in the Project Area are presented in Table 11. Significant species are further discussed below under each taxon. Impacts upon significant species and management recommendations are discussed in Section 4. Appendix 7 presents additional information on areas of land systems and vegetation types both within the lease area and within 15km of the lease area. Proportional impacts on vegetation types within the lease area and on land systems within 15km are indicated, and the importance of each vegetation type and land system to each significant species is considered.

Table 11. Status of conservation significant species likely to occur in the Project Area.

Preferred habitat derived from literature (Section 2.1.1).

Species	Recorded in Project Area	Habitat	Expected status in Project Area
Conservation Significance Level 1			
Pilbara Olive Python *Liasis olivaceus barroni*		Generally associated with riverine woodland areas, gorges and large rock holes and swamps.	Likely resident
Peregrine Falcon *Falco peregrinus*		Habitat generalist favouring areas with cliffs and abandoned nests in tall, wooded forests.	Likely resident
Night Parrot *Pezoporus occidentalis*		Mature spinifex grasslands and chenopod Shrublands, particularly where the two are closely juxtaposed. Fortescue Marsh is a current hotspot for the species.	Uncertain; may be cryptic resident or irregular visitor
Fork-tailed Swift *Apus pacificus*		Nomadic aerial forager following low pressure storm systems, with no reliable reports of them coming to land.	Irregular visitor
Rainbow Bee-eater *Merops ornatus*	Recorded	Any habitat suitable for hawking for insects. Breeds in a wide variety of sandy habitats.	Regular migrant
Eastern Great Egret *Ardea modesta*		Extensive wetlands of the Fortescue Marshes, however no wetlands in the Project Area but individuals may visit nearby Weeli Wolli Creek.	Irregular visitor
Northern Quoll *Dasyurus hallucatus*		Rocky and broken country in open Eucalypt forest.	Irregular visitor
Crest-tailed Mulgara *Dasycercus cristicauda*	Recorded nearby	Mature Spinifex grasslands on sandy substrates.	Irregular visitor

Species	Recorded in Project Area	Habitat	Expected status in Project Area
Bilby *Macrotis lagotis*		Woodlands and grasslands on sandplains and dunefields, often close to drainage systems.	Probably locally extinct
Pilbara Leaf-nosed Bat *Rhinonicteris aurantius*		Roosts in warm humid caves, likely to forage throughout Project Area	Regular visitor
Conservation Significance Level 2			
Blind snake *Ramphotyphlops ganei*		Uncertain; may prefer moist gorges and gullies or grasslands, Shrublands and woodlands.	Resident
Australian Bustard *Ardeotis australis*	Recorded	Open or lightly-wooded grasslands and shrublands.	Resident
Bush Stone-curlew *Burhinus grallarius*		Grassy woodlands with minimal to no human disturbance.	Resident
Grey Falcon *Falco hypoleucos*		Habitat generalist including shrubland, grassland and wooded watercourses.	Resident
Star Finch *Neochmia ruficauda subclarescens*		Grasslands near water.	Regular visitor
Western Pebble-mound Mouse *Pseudomys chapmani*	Recorded nearby	Hummock grassland on skeletal soils containing an abundance of small pebbles on spurs and the lower slopes of ridges.	Resident
Lakeland Downs Mouse *Leggadina lakedownensis*		Cracking clays and adjacent habitats in open shrublands and hummock and tussock grasslands.	Uncertain
Long-tailed Dunnart *Sminthopsis longicaudata*		Scree slopes surrounding rock hills and mesas.	Likely Resident
Ghost Bat *Macroderma gigas*		Roosts in warm humid caves, likely to forage throughout Project Area	Regular visitor

Species		Recorded in Project Area	Habitat	Expected status in Project Area
Conservation Significance Level 3				
Rufous-crowned Emu-wren	*Stipiturus ruficeps*	Recorded	Spinifex, often including at least some long-unburnt	Resident
Striated Grasswren	*Amytornis striatus*		Spinifex, often including at least some long-unburnt	Resident

3.5.2 Reptiles

Two conservation significant reptile species are expected to occur in the Project Area. Neither of these species was recorded during the surveys.

Conservation Significance Level 1 (CS1)

Pilbara Olive Python (*Liasis olivaceus barroni*)

The Pilbara Olive Python is listed as Schedule 1 (Vulnerable) under the WA Wildlife Conservation Act and Vulnerable under the Commonwealth's EPBC Act. This subspecies is restricted to ranges within the Pilbara Region and is often recorded near waterholes (Wilson and Swan 2008). In some locations this species is considered stable and in sizeable numbers (Pearson 2003).

Pilbara Olive Pythons occur in rocky areas such as gorges, caves and rock crevices, and can also burrow beneath rocks or shelter in hollow logs. They are often associated with water and may also search for prey in grassy areas surrounding rocky outcrops (DSEWPaC 2011b). The Pilbara Olive Python has been recorded from the Weeli Wolli Creek area (DEC 2011) and may move through the river system through the Project Area. It is therefore likely to be present along major drainage lines in times of flooding and rocky habitats throughout the Project Area.

Conservation Significance Level 2 (CS2)

Ramphotyphlops ganei

The blind snake *Ramphotyphlops ganei* is listed as Priority 1 by DEC. Only described as a new species in 1998 (Aplin 1998), virtually nothing of the ecology or biology of *Ramphotyphlops ganei* is known. Wilson and Swan (2008) suggest that it may be associated with moist gorges and gullies. The species is known only from a small number of voucher specimens collected from the region (DEC 2011). This species has also been recorded from ironstone ridge slopes and crests (BCE database). It is considered likely that the species is present in the Project Area, but is difficult to detect due to its cryptic nature.

3.5.3 Birds

Eleven conservation significant bird species are expected to occur in the Project Area, with three of these recorded during the field surveys.

Conservation Significance Level 1 (CS1)

Rainbow Bee-eater (*Merops ornatus*) - Recorded

The Rainbow Bee-eater is listed as Migratory under the Commonwealth's EPBC Act. It was recorded within the Project Area during the surveys. It is likely to be a breeding visitor (spring to autumn) to the Project Area as suitable breeding habitat exists. It is found in almost any habitat suitable for hawking for insects, but is usually restricted to the better-watered regions (Johnstone and Storr 1998). The Rainbow Bee-eater breeds in a wide variety of sandy habitats across much of the state, in the north Kimberley, on the Swan Coastal Plain and in the south west and east as far as Twilight Cove (Johnstone and Storr 1998). Although the Rainbow Bee-eater is listed under the EPBC Act as Migratory and recognised by the Japan-Australia Migratory Bird Agreement (JAMBA), this is a widespread species that is opportunistic in its use of habitat. The Rainbow Bee-eater was observed within the Boolgeeda land system of the Project Area.

Peregrine Falcon (*Falco peregrinus*)

The Peregrine Falcon is listed as Schedule 4 (Other Specially Protected Fauna) under the WA Wildlife Conservation Act. This species occurs in a variety of habitats, and may breed in the Project Area, possibly utilising tree hollows in ephemeral riverine habitat or cliff ledges along gullies and hills (Johnstone and Storr 1998). This species was recorded during the Kurrajura tenement area survey (located approximately 20 km north-west of Iron Valley), which was undertaken concurrently with the Iron Valley survey, and may be nesting in the area in nearby cliff-faces.

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 2011). The Peregrine Falcon mates for life with pairs maintaining a home range of about 20-30 km^2 throughout the year. Blakers *et al.* (1984) consider that Australia is one of the strongholds of the species, since it has declined in many other parts of the world. The Peregrine Falcon has also been recorded in the general vicinity of the Project Area (Birds Australia 2011).

Night Parrot (*Pezoporus occidentalis*)

The Night Parrot is listed as Schedule 1 (critically endangered) under the WA Wildlife Conservation Act, and as endangered under the Commonwealth's EPBC Act. This is a poorly-known species with very few recent records in Australia. The only recent verified record of this species in the Pilbara Region is from the northern side of the Fortescue Marsh on Mulga Downs

Station, some 40km from the Project Area (Davis and Metcalf 2008). Little is known of the species' habitat requirements, however many recent records come from Spinifex grasslands and chenopod shrublands (Birds Australia 2011), although Higgins (1999) lists a wide range of vegetation types utilised by the species. Several surveys by BCE and other consultants to locate this species have been unsuccessful. This species is considered a likely resident or regular nomadic visitor within the Fortescue Marsh, and may be an irregular visitor to the Project Area.

Fork-tailed Swift (*Apus pacificus*)

The Fork-tailed Swift is listed as Migratory under the Commonwealth's EPBC Act. This is a largely aerial species that occurs independent of terrestrial habitat types and is likely to be an irregular visitor to the Project Area.

Eastern Great Egret (*Ardea modesta*)

The Fortescue Marshes situated approximately 30 km north of the Project Area are important for migratory waterbirds, but in general the Project Area does not provide suitable habitat for these species. The Eastern Great Egret is one species that may occasionally forage up minor watercourses and thus could occur in the Project Area, but only as an irregular visitor in small numbers.

Conservation Significance Level 2 (CS2)

Australian Bustard (*Ardeotis australis*) - Recorded

The Australian Bustard is listed as Priority 4 by the DEC and inhabits grasslands. This species was recorded in the Project Area in the flat *Triodia* plains and is likely to vary in abundance seasonally and annually. The Australian Bustard is considered common in the Pilbara, with suitable habitat being widespread. It is likely to be a resident in the Project Area.

Bush Stone-curlew (*Burhinus grallarius*)

This species is listed as Priority 4 by the DEC. In the Pilbara, the Bush Stone-curlew it is often associated with woodlands and shrublands along ephemeral or permanent watercourses (M. Bamford pers. obs.). Although not recorded during the surveys, this species may be present within the Project Area, but is notoriously cryptic when not calling; furthermore, the calling season can be unpredictable. The Bush Stone-curlew has been recorded north of the Project Area (approximately 30 km) in the vicinity of the Fortescue Marsh (DEC 2011, BCE database).

Grey Falcon (*Falco hypoleucos*)

The Grey Falcon is listed as Priority 4 by the DEC. It appears to have a distribution centred around ephemeral or permanent drainage lines and may breed in the Project Area, utilising old nests of other species situated in the tallest trees along drainage systems (Garnett and Crowley 2000). The Grey Falcon has been recorded on the northern side of the Fortescue Marsh (BCE

database), and is very likely to be resident along major river systems (such as Weeli Wolli Creek) in the region.

Star Finch (*Neochmia ruficauda subclarescens*)

This species is listed as Priority 4 by the DEC. The western race of the Star Finch is generally found in and around grassland near water (Slater *et al*. 2003, Simpson and Day 2004, Slater *et al.* 2003). The Star Finch has been recorded approximately ten km south-west of the Iron Valley Project at Rio Tinto's Yandicoogina operations (Biota 2010). Due to a lack of suitable riparian grasslands and rushes in the Project Area, this species is likely to be only an occasional visitor.

Conservation Significance Level 3 (CS3)

Rufous-crowned Emu-wren (*Stipiturus ruficeps*)

Striated Grasswren (*Amytornis striatus*)

The Rufous-crowned Emu-wren and Striated Grasswren have a scattered distribution in the Pilbara and are associated with long-unburnt spinifex. When found they are often only present in low numbers. Their presence in the Project Area would be of conservation interest due to their patchy distribution and reliance on rare habitat.

3.5.4 Mammals

Eight conservation significant mammal species are expected to occur in the Project Area, with two of these recorded during the field surveys.

Conservation Significance Level 1 (CS1)

Northern Quoll (*Dasyurus hallucatus*)

The status of the Northern Quoll has recently been upgraded to Endangered under the Commonwealth's EPBC Act. This change in status is due to the negative impact of the Cane Toad *Bufo marinus* in the north and east of the Northern Quoll's range, and the threat of Cane Toads in the west of its range.

This species inhabits rock crevices, tree hollows and termite mounds. The Northern Quoll is often associated with rocky areas in the Pilbara but also occurs along watercourses. The Northern Quoll formerly occurred across much of northern Australia from the Pilbara to Brisbane, but now occurs in a number of fragmented populations across its former range (DSEWPaC 2011b).

Opportunistic searching, Elliott trapping and the use of motion-sensitive cameras for the Northern Quoll did not detect any evidence of the species within the Project Area. There are very few confirmed records of the species in the Hamersley Ranges south of the Fortescue Marshes (DEC 2011), and therefore it is expected only as an occasional visitor in the Project Area even though there is suitable habitat present, with no evidence of resident and substantial populations. The species has been recorded approximately 25 km south of the Project Area near Hope Downs (Biota 2011) with several unconfirmed sightings at Rio Tinto's Yandicoogina operations ten km away (Biota 2010).

Crest-tailed Mulgara (*Dasycercus cristicauda*)

The Crest-tailed Mulgara is listed as Vulnerable under the Commonwealth's EPBC Act. The Crest-tailed Mulgara prefers mature spinifex grasslands on sandy substrates across the arid zone of Western Australia (Woolley 1995). Suitable mulgara habitat is present in the eastern section of the Project Area (lower parts of the landscape) and outside the Project Area/tenement. Although not recorded inside the Project Area, two active Mulgara burrows and a confirmed sighting (by motion-sensitive camera) were recorded outside the south eastern boundary of the

Project Area. There is more extensive habitat (Boolgeeda Land System) to the north and north-west of the Project Area. It is expected that this species persists in low numbers throughout the region. Note that the record from near the Project Area is the only recent confirmation of the species on the south side of the Fortescue Marshes. There are several recent (e.g. 2009) database records from the north side of the Fortescue Marshes.

There may be a certain "boom and bust" nature to the lifestyle of the Mulgara, with populations contracting to core habitat during poor seasons for resources such as low rainfall, and expanding rapidly when the conditions improve (Woolley 1995). Further, Woolley (1995) cites examples of local populations disappearing for several years before being re-invaded and repopulated by Mulgara in subsequent years.

Note that there is uncertainty regarding the distribution of the Crest-tailed Mulgara and the similar Brush-tailed Mulgara (*D. blythi*). For most of the last 30 years only the Crest-tailed Mulgara was recognised. More recently, Woolley (2005, 2006) re-assigned the species to the Brush-tailed Mulgara and Crest-tailed Mulgara. The historical taxonomic confusion means that the distribution of the two Mulgara species is unclear (Woolley 2005, 2008) and even museum specimens need to be reviewed. However, both species have suffered significant population reduction and fragmentation over the past 80 years (Woolley 2008). The Brush-tailed Mulgara is listed as Priority 4 by the DEC in WA, but is not recognised under EPBC legislation (whereas the Crest-tailed Mulgara is). As the specimen was recorded by motion-sensitive camera only, and could not be identified to species level, BCE has taken a precautionary approach, and determined that the species is the Crest-tailed Mulgara that is listed under the EPBC Act. Under the current EPBC list, any Mulgara found in WA is considered to be *D. cristicauda* by DSEWPaC. However, a recent publication by DSEWPaC (2011c) does recognise the revised taxonomy and states that *D. cristicauda* does not occur in WA. This does not alter the EPBC listing but the situation should be discussed with DSEWPaC.

Bilby (*Macrotis lagotis*)

The Bilby is listed as Vulnerable under the Commonwealth's EPBC Act and Schedule 1 under the WA Wildlife Conservation Act. It is also listed as Vulnerable (VU C2a) by the IUCN Red List. Once very widespread, the Bilby is now confined to northern and mostly inland locations of Australia, particularly sandy deserts where they have an affinity for dunefields (Moseby and O'Donnell 2003) and *Acacia* shrublands associated with paleo-drainage systems (M. Bamford pers. obs.). Johnson (1995) suggests that populations of the species in central Australia are still declining and fragmenting, and Lavery and Kirkpatrick (1997) suggest that very small populations may leave traces that incorrectly suggest much larger numbers and healthier populations exist than is actually the case. There are some historic (early 1980s) records of the Bilby on Marillana Station (N. Dunlop pers. comm.) but the species is probably locally extinct. It is quite an easy species to locate when present because of its distinctive tracks, burrows and foraging holes, however is unlikely to occur in the Project Area on the basis of lack of suitable habitat and confirmed records.

Pilbara Leaf-nosed Bat (*Rhinonicteris aurantius*)

The Pilbara Leaf-nosed Bat is classified as Vulnerable by Duncan *et al*. (1999), the Commonwealth's EPBC Act and the WA Wildlife Conservation Act. The Pilbara Leaf-nosed Bat has very specific requirements for roosting caves, which need to provide a stable, hot (28 – 32 ºC) and very humid (96 – 100%) environment. There was no evidence of such caves within the Project Area, but the species is likely to be a foraging visitor and transient animals may even roost overnight in crevices and tree hollows, with such habitats present in rocky areas and along drainage lines in the Project Area.

Lakeland Downs Mouse (*Leggadina lakedownensis*)

This species is listed as Priority 4 by the DEC and listed as Low Risk / Near Threatened (LR/NT) by the IUCN Red List. Covacevich (1995) notes that this species is secretive and apparently rare, yet notes that the only two known voucher collections were made at sites where the mice were common enough to be hand-captured. This suggests that the species persists in a "boom-bust" life cycle. Biota (2005) cite a forthcoming publication that states the number of records of the species has increased, and note most of their captures have been made on cracking clays and adjacent habitats in open shrublands and hummock and tussock grasslands. This species was not recorded during the surveys but may be a resident (but highly variable in abundance) in the area.

Conservation Significance Level 2 (CS2)

Western Pebble-mound Mouse (*Pseudomys chapmani*) - Recorded

The status of the Western Pebble-mound Mouse has recently been downgraded from Schedule 1 under the WA Wildlife Conservation Act to DEC Priority 4. The Western Pebble-mound Mouse inhabits hummock grassland areas of *Triodia, Cassia, Acacia* and *Ptilotus* on skeletal soils containing an abundance of small pebbles (Start and Kitchener 1995). These conditions are most common on spurs and the lower slopes of ridges within the Project Area. Transect surveys identified two recently active and four inactive Western Pebble-mound Mouse burrow systems within the Project Area, confirming this species as present and resident. A further one active, two recently active and inactive burrow systems were identified outside (<500m) the Project boundary.

Long-tailed Dunnart (*Sminthopsis longicaudata*)

The Long-tailed Dunnart is listed as Priority 4 by the DEC. This species occupies scree slopes surrounding rock hills and mesas, but little is known of their biology (Burbidge *et al*. 1995). Four specimens from the Pilbara, all from areas in the south of the biogeographical region, have been lodged with the Western Australian Museum. The closest specimens were recorded just west of Newman (DEC 2011) and also at Mt Nicholas, east of the Fortescue Marshes (Biota 2010). Current understanding of the breeding biology (Woolley and Valente 1986) suggests that they probably exhibit a "boom-bust" lifestyle. This species may be a resident within the

Boolgeeda land system and may occur throughout the Hamersley Ranges, including within the Project Area.

Ghost Bat (*Macroderma gigas*)

The Ghost Bat is listed as Priority 4 by the DEC, Vulnerable by the IUCN, and Lower Risk (near threatened) by Duncan *et al*. (1999). The Ghost Bat formerly occurred over a wide area of central, northern and southern Australia, however has declined significantly in the southern parts of its range in the last 200 years (DSEWPC 2011b). It now occurs in only a few highly disjunct sites across northern Australia and in Western Australia is now confined to the Kimberley and Pilbara.

The distribution of Ghost Bats is influenced by the availability of suitable caves and mines for roost sites. The preferred roosting habitats of Ghost Bats in the Pilbara are deep, complex caves beneath bluffs of low rounded hills composed of Marra Mamba geology, Brockman Iron Formations, granite rock-piles and abandoned mines (Armstrong and Anstee 2000). Churchill (2008) notes that the Ghost Bat has a preference for caves with warm and humid microclimates (27°C, 80% humidity).

The Ghost Bat is carnivorous, feeding on large insects, spiders, termites and many types of small vertebrates, including birds, reptiles and other bats (Churchill 2008). It forages over an area of approximately 60 ha, within a radius of approximately two km from its roost, with up to 20 bats having overlapping ranges (Armstrong and Anstee 2000). However, BCE (unpubl data) caught a Ghost Bat (mist-net) flying over the samphire of the Fortescue Marshes (probably >5 km from the nearest possible roost). The Ghost Bat is also known from the Hope Downs rail corridor, West Angeles and Weeli Wolli Springs (Biota 2005). There is unlikely to be suitable habitat for the species to roost within the Project Area, but it may be a regular foraging visitor.

3.6 Ecological Processes upon which Fauna depend

There are several ecological processes upon which fauna and ecosystems depend, with certain processes making ecosystems more sensitive to change than others (see Appendix 4). Within the Iron Valley Project Area, the key ecological process of importance to the fauna assemblage is considered to be hydrology. The fauna are likely to rely on the hydrological situation remaining intact and changes to this process (and the VSA Drainage Lines) may result in potentially significant changes to local fauna populations. Potential impacts on ecological processes relevant to the Project are discussed in the following section.

4 Impact Assessment

Potential impacts from the Project upon fauna are assessed in accordance with EPA Guidance Statement No. 56 (EPA 2004) and considered under the categories outlined in Section 2.3.1: impacts to VSAs, conservation significant fauna and ecological processes that may affect the fauna assemblage. These are discussed in the following sections.

4.1 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 3.2 above. Potential impacts and significance of each VSA within the Project Area is discussed in Table 12. Appendix 7 gives details of how the proposed disturbance to VSAs in the project area may affect conservation significant species on a local scale.

Habitats and VSAs of conservation significance tend to be those that are both rare across the landscape and that are important for significant species and/or for biodiversity. In particular, one VSA within the Project Area is regionally restricted, supports high proportions of conservation significant fauna and may be highly susceptible to impacts from the Project. This VSA is:

- Drainage Lines – characterised by mixed *Acacia* shrubs, *Triodia* and Buffel grass over clay soils (Boolgeeda land system).

The Drainage Lines VSA may be particularly sensitive to changes in surface hydrology, with any changes potentially leading to significant impacts to local fauna populations. Impacts to this VSA are considered to be minor to moderate (Table 12). The Plains VSA is expected to experience a minor to moderate impact from the Project due to habitat loss and fragmentation (Table 12). It is widespread in the region but may support conservation significant fauna. Impacts on the Rocky Hills VSA are expected to be minor with little of such habitat present in the impact area (Table 12). Cumulative impacts with other mining projects in the region also need to be considered. Table 13 compares the areas of all local land systems and the land systems found within the project area. In the case of the Boolgeeda land systems, 5.2% of this system present within 15km of the lease area falls within the lease. In comparison, only 1.4% of the only other land system represented in the lease area, Newman, lies within the lease area.

Table 12. Potential impacts and significance of VSAs within Project Area

VSA	Representation	Conservation Significance	Possible Impacts	Significance of Impact
Drainage Lines - characterised by mixed *Acacia* shrubs, *Triodia* and buffel grass over clay soils. Boolgeeda land system	Restricted in region. Drainage lines feed into the Weeli Wolli Creek east of the Project Area.	Potentially supports a rich fauna, including significant fauna, and may provide nesting habitat for conservation significant fauna.	Project Area extends across several creeklines and has the potential to cause some hydrological disruptions to surface flow, including loss and fragmentation of important fauna habitat.	Minor to Moderate. Habitat fragmentation and changes to hydrology may impact fauna; also loss of large habitat trees may impact breeding of some species.
Plains – comprising of flat plains of *Triodia* and mixed shrubland over clay loam soils with varying fire ages, with the occasional low stony rise. Boolgeeda land system	Patchily distributed although widespread regionally, although the majority is in good condition. Covers the northern, central and south-eastern parts of the Project Area.	Has a diverse vertebrate fauna and is likely to provide core habitat to several conservation significant fauna, including Mulgara (confirmed), Lakeland Downs Mouse (unconfirmed) and Australian Bustard (confirmed).	Considerable loss and fragmentation of this VSA.	Moderate to minor. VSA is restricted and patchy outside impact areas, and represents a large component of the proposed development footprint. Habitat fragmentation may impact some conservation significant fauna.
Rocky Hills – Stony rocky hills dominated by *Triodia* on gravelly soils and rock outcrops. Lower slopes with scattered Eucalypts, shrubs and *Triodia* over pebbles and stones Newman land system	Widespread in the region and the majority in good condition. Mostly confined to the western and southern parts of the Project Area, and extending into the ridges of the Hamersley Ranges outside the Project Area.	Has the most depauperate fauna association within the Project Area, but with potentially some habitat specialist conservation significant fauna such as the Northern Quoll, Ghost Bat and Pilbara Leaf-nosed Bat.	Some loss of this VSA, however most is outside the impact area.	Minor as little direct impact. VSA is widespread outside Project Area, and only represents a small part of the project footprint.

Table 13. Area of local (15km radius) land systems and land systems found within Project Area

Land System	Area Within 15km Radius of Boundary (ha)	Area Within Lease M47/1439 (ha)
Adrian	31.04	0
Boolgeeda	10473.06	540.41
Calcrete	7805.11	0
Coolibah	1453.90	0
Cowra	234.83	0
Divide	6241.71	0
Fan	19726.86	0
Fortescue	5714.53	0
Marillana	13248.25	0
Marsh	5415.55	0
McKay	8809.62	0
Newman	39881.75	546.38
Oakover	2515.82	0
Pindering	18.68	0
Platform	3738.23	0
River	6366.60	0
Robe	1031.81	0
Rocklea	2130.24	0
Turee	10885.97	0
Urandy	10495.97	0

4.2 Conservation Significant Species

Among the fauna species of conservation significance, impacts on most species are expected to be negligible or minor (Table 14). Potential impacts on conservation significant species expected to occur in the Project Area are discussed in Table 14. Species where impacts may be of concern are:

- Pilbara Olive Python – recorded from Weeli Wolli Creek, species at low population density, restricted in habitat selection such as drainage lines and sensitive to roadkill;
- Night Parrot – species very poorly known so impact hard to predict; species is highly significant, although unlikely in the Project Area;
- Mulgara – species present adjacent to the Project Area with limited suitable habitat within the Project Area. There is probably a low density population throughout suitable habitat (Boolgeeda Land System) in the region, and this may be sensitive to a range of impacting processes such as cumulative habitat loss from multiple development projects in the region, altered fire regimes, livestock grazing and feral predators;
- Bush Stone-curlew – species at low population density and sensitive to roadkill and feral predators;
- Lakeland Downs Mouse – species not recorded, however highly variable and may be present; and
- Pebble-mound Mouse – species present in Project Area and sensitive to habitat loss.

Appendix 7 examines the proportional impact of the proposed development upon habitat of each species of conservation significance. Habitat is not necessarily the same for each species, and was initially defined based upon land systems and vegetation types that corresponded with the known habitat preferences (Appendix 7; Table 1). Vegetation type correlates most closely with preferred habitat, but for proportional impacts (within a 15km radius of the project area), the habitat for each species within the clearing footprint, based on land system or vegetation type, can only be compared with the total area of corresponding land system, since vegetation mapping for the greater area is not available. This correlation is not exact for each species but it does provide a sense of scale of the extent of preferred habitat being cleared within the wider area. The percentage impacts are presented in Appendix 7 and also in Table 14. Whichever approach is taken percentage impacts are low; most below 1% but for a few species reliant upon the Boolgeeda land system as high as 3.82%.

For key species of conservation interest (listed under the EPBC Act: Crest-tailed Mulgara, Northern Quoll and Pilbara Olive Python), habitat was also defined through interpretation of the preferred habitat with respect to land systems and vegetation types. For each of these species,

preferred habitat within and immediately adjacent to the tenement is illustrated in Appendix 7. This approach allows for a different calculation of proportional impact within a 15km radius of the project area.

For each species, area of habitat within disturbance footprint is calculated in three ways: based upon land systems, based upon vegetation type and based upon an interpretation of both vegetation type and land system that reflects the known habitat preference of the species (interpreted habitat). Proportional local impacts within 15km radius (in parenthesis) are based upon land systems as only these are mapped outside the lease area.

These proportional impacts are provided in Table 2 of Appendix 7. Proportional impacts using habitat areas based upon the interpretation of land systems and vegetation types are low. For the three species of greatest conservation interest, percentage impacts are as follows:

Crest-tailed Mulgara – 3.36% (based on vegetation type) to 3.82% (based on land system or interpreted habitat) of habitat within 15km falls within the clearing footprint;

Pilbara Olive Python – 0.13% (based on vegetation type) to 0.6% (based on land system) of habitat within 15km falls within the clearing footprint;

Northern Quoll – 0.17% (based on interpreted habitat) to 0.7% (based on land system) of habitat within 15km falls within the clearing footprint.

Table 14. Potential impacts on conservation significant species expected to occur in the Project Area

Descriptions of each species are given in Section 3.5. Potential impacts include threatening processes as listed in Appendix 2. Impact assessment criteria as defined in Section 2.3.2. Proportional impacts on preferred habitat within 15km of the project area are presented in parentheses, where different methods of interpreting habitat result in different proportional impacts the higher value is used, for all values see Appendix 7.

Species		Potential impacts	Impact Assessment
Conservation Significance Level 1			
Pilbara Olive Python	*Liasis olivaceus barroni*	Some loss and fragmentation of habitat. Potential roadkill. (0.6%)	Minor. Suitable habitat is outside Project Area.
Peregrine Falcon	*Falco peregrinus*	Possibility of loss of a nest site. (0.7%)	Negligible
Night Parrot	*Pezoporus occidentalis*	Possibly some loss of habitat and possibility of increased mortality on roadsides. (~1.35%)	Minor. Status of species in Project Area is not known, however unlikely to be present regularly in the Project Area.
Fork-tailed Swift	*Apus pacificus*	None as mainly aerial species. (1.35%)	Negligible
Rainbow Bee-eater	*Merops ornatus*	Some localised loss of breeding habitat. (2.45%)	Minor. Species very widespread.
Eastern Great Egret	*Ardea modesta*	Impact unlikely due to lack of suitable habitat (wetlands) in the Project Area, although may use drainage lines intermittently. (0.94%)	Negligible
Northern Quoll	*Dasyurus hallucatus*	Low possibility of some loss of habitat. (0.7%)	Minor. Core habitat is outside the Project Area and population in region not confirmed.
Crest-tailed Mulgara	*Dasycercus cristicauda*	The species is sensitive to landscape scale impacts such as fire regimes, livestock grazing and feral species, which are not directly related to the proposal. There may also be cumulative impacts due to habitat loss from multiple resource development projects in the region. (3.82%)	Minor-Moderate. Species may utilise habitats within and outside the Project Area, and is susceptible to several impacts. The individuals located are probably part of a low density population across the Boolgeeda Land System in the region. The impact of the proposed

Species		Potential impacts	Impact Assessment
			development is Minor to Moderate because only a small amount of suitable habitat will be directly impacted.
Bilby	*Macrotis lagotis*	Impact unlikely as species probably locally extinct. If present, could lose some habitat and be affected by roadkill, altered fire regimes and changes in abundance of feral species. (3.93%)	Minor. Species probably locally extinct. Fire management and feral control as part of environmental stewardship could benefit species.
Pilbara Leaf-nosed Bat	*Rhinonicteris aurantius*	Some loss of foraging habitat. No roosting habitat expected in Project Area. (0.7%)	Minor. Core roosting habitat is outside the Project Area.
Conservation Significance Level 2			
blind snake	*Ramphotyphlops ganei*	Some loss and fragmentation of habitat. (2.45%)	Minor. Status of species is uncertain.
Australian Bustard	*Ardeotis australis*	Some loss of habitat and possibility of increased mortality on roadsides. (3.82%)	Minor. Species is widespread and versatile in natural and altered habitats.
Bush Stone-curlew	*Burhinus grallarius*	Some loss of breeding habitat, feral predation and possibility of increased mortality on roadsides. (2.38%)	Minor. Species is widespread but generally in low numbers.
Grey Falcon	*Falco hypoleucos*	Low possibility of loss of a nest site. (0.94%)	Negligible
Star Finch	*Neochmia ruficauda subclarescens*	Some loss of habitat. (0.94%)	Minor. Species is widespread and suitable habitat in Project Area is limited.
Western Pebble-mound Mouse	*Pseudomys chapmani*	Some loss of habitat. (0.7%)	Moderate. Habitat is also outside the Project Area but project will contribute to cumulative habitat loss for this species.
Lakeland Downs Mouse	*Leggadina lakedownensis*	Habitat loss, fragmentation and feral predation. (2.45%)	Minor. Habitat is also outside the Project Area but project will contribute to cumulative habitat loss for this species.
Long-tailed Dunnart	*Sminthopsis*	Low possibility of some loss of habitat. (0.7%)	Minor. Core habitat is outside the

Species		Potential impacts	Impact Assessment
	longicaudata		Project Area.
Ghost Bat	*Macroderma gigas*	Some loss of foraging habitat. No roosting habitat expected in Project Area. (0.7%)	Minor. Core habitat is outside the Project Area.
Conservation Significance Level 3			
Rufous-crowned Emu-wren	*Stipiturus ruficeps*	Habitat loss and fragmentation. (3.93%)	Minor. Habitat exists outside of Project Area.
Striated Grasswren	*Amytornis striatus*	Habitat loss and fragmentation. (3.93%)	Minor. Habitat exists outside of Project Area.

4.3 Ecological Processes

4.3.1 Loss of Habitat Leading to Population Decline

The proposed development lies on land that may be broadly categorised as undeveloped, and has previously been used for rangelands pastoralism. These areas constitute native vegetation that will be affected by the proposed development, and the extent to which these areas will be impacted is uncertain. Since the area is surrounded by similar VSAs and land systems that will remain unaffected by this project, the proportional loss of fauna habitats will generally be low. However, cumulative impacts may also need to be considered. Of the VSAs identified, the Boolgeeda land system is extensively targeted for mining and while generally low in biodiversity, is favoured by the Pebble-mound Mouse and Mulgara. Therefore substantial disturbance in the region could result in some population declines.

4.3.2 Loss of Habitat Leading to Population Fragmentation

The Project Area lies on the Newman and Boolgeeda land systems and therefore the extent of fragmentation will depend initially upon the amount of vegetation disturbed and the pattern in which this disturbance is undertaken. If small blocks are excised from the surrounding landscape without disruption, then the impact on fragmentation will be low. If the landscape is disturbed in a mosaic pattern of disturbance then the impact will be higher. The effectiveness of rehabilitation may or may not mitigate these impacts. Mining within the central region of the Project Area may fragment fauna which is restricted to the Boolgeeda land system between the northern and south-eastern parts, although this may not be an issue. It should be noted that numerous other mining projects are proposed for the region from companies such as FMG, BHP Billiton and Rio Tinto, which may lead to further fragmentation of habitat.

4.3.3 Increased Mortality

Mortality of fauna during clearing and other operations is inevitable, but ongoing mortality may be significant for larger species that may have low population sizes. The major source of ongoing mortality is likely to be roadkill affecting mammals such as kangaroos, Bilby (if present), and Mulgara, and larger reptiles such as monitor lizards and snakes (potentially including Pilbara Olive Python). The Australian Bustard and Bush Stone-curlew are also sensitive to roadkill but individuals are highly mobile and therefore localised mortality is unlikely to have a significant impact on their populations.

4.3.4 Hydrological changes

Changes in hydrology within the landscape may result from the Project, particularly where drainage lines are affected, and may lead to significant impacts to the local fauna. The area of greatest concern is the ephemeral creek lines located within the flat spinifex plains of the Boolgeeda land system and the Weeli Wolli Creek (River land system) located to the south and east of the Project Area (Figure 2). Roads,

mining pits, waste dumps and other infrastructure from the project may alter both surface and sub-surface hydrology. Stormwater diversion and drainage from the project may alter the current flow regime, increase infiltration into new areas and decrease waterflow in other areas downstream. Changes to hydrology may impact fauna that use the drainage lines for breeding, such as amphibians and some conservation significant species.

4.3.5 Species Interactions, including Predation and Competition

The fauna assemblage in the Project Area and region includes species sensitive to predation by feral species such as the Fox and Feral Cat. In addition, feral species such as the Rabbit can affect rehabilitation. Vegetation degradation by cattle overgrazing can make fauna more vulnerable to additional impacts, particularly in vegetation along the drainage lines. Feral species often increase in abundance due to disturbance and human activities, but the project also provides opportunities for the control of feral species (see Section 5).

4.3.6 Dust, Noise, Light and Disturbance

Impacts of dust, noise, light and disturbance upon fauna are difficult to predict, but some experience from existing mines in the South-West (Worsley and Alcoa operations), and other operations in the Pilbara (BHP Billiton Nimingarra, Cattle Gorge, Sunrise Hill) suggest that fauna, including fauna of conservation significance, are tolerant of these forms of disturbance. Exceptions include species that have very specific refugial habitat requirements, such as the Pilbara Leaf-nosed Bat and the Ghost Bat, but neither of these species is expected to have major roosts within the Project Area due to a lack of suitable habitat. Generally, impacts of such disturbances are poorly documented, but the introduction of light has the potential to attract fauna to the area and alter species interactions or lead to increased roadkill.

4.3.7 Changes in Fire Regime

The Project is likely to increase the potential for bushfire in the region because of ignition sources from machinery and increased human activity. Van Vreeswyk *et al.* (2004) suggest that the Newman and Boolgeeda land systems are naturally subject to fire, and therefore they may be at high risk of increased fire events and intensity as a result of the development. Changing fire regimes have direct (*i.e.* loss of individuals) and indirect (*i.e.* population depression) effects on the fauna of the Project Area, particularly some conservation significant taxa, and it is important that this risk be recognised and managed. In addition to the impacts of fire, van Vreeswyk *et al.* (2004) note that these land systems are subject to increased erosion if the vegetation is removed (either directly or by fire).

4.3.8 Summary of Impacts to Ecological Processes

Of the impacting processes, concerns can be summarised as follows:

- Loss of habitat leading to population decline – possibly some concern in the Boolgeeda land system within the Project Area. Cumulative impacts with other mining in the region need to be considered;
- Loss of habitat leading to population fragmentation – may be a concern along the Boolgeeda land system as the project may lead to fragmentation and disrupt fauna movement;
- Increased mortality – of concern for some fauna species, especially Pilbara Olive Python, Australian Bustard and Bush Stone-curlew;
- Hydrological changes – possible downstream effects along the River land system of Weeli Wolli Creek and potential impacts to local fauna populations, but effects expected to be limited to local changes in surface hydrology.;
- Species interactions – such interactions are already occurring. There is potential for both negative and positive impacts from the proposed project upon feral species;
- Dust, noise, light and disturbance – impacts uncertain but some precautions are advised; and
- Changes in fire regime – a major ecological factor in the region's fauna with potential for both negative and positive impacts from the proposed project.

The Project has the potential to impact most significantly upon the hydrology in the area, with any changes to hydrology considered to have the greatest impact upon local fauna populations.

4.4 Summary by EPA Guidance

According to criteria set out in the EPA Guidance Statement No. 56, the impacts of the project upon fauna in the survey area can be summarised as given in Table 15.

Table 15. Summary of potential impacts of the Project on fauna as assessed following the guidance of the EPA's Guidance Statement No. 56.

Factor	Scale and Nature of Impact (EPA No. 56)	Explanation
Degree of habitat degradation or clearing within the local area or region	Low	Project Area is largely undisturbed, so project will introduce disturbance into the local area where there is little current disturbance. The VSAs proposed for disturbance are not regionally restricted, however they could provide potential core habitat for multiple conservation significant fauna. Fragmentation is unlikely to impart ongoing impacts.
Size/scale of proposal/impact	Low	Project is comparatively small within the region.
Rarity of vegetation and landforms	Low	The project proposes to disturb the Newman and Boolgeeda land systems, which are regionally common.
Refugia	Low	Typical refugial habitat (e.g. cliffs and gorges) are also common outside of the Project Area. Some of the habitats with the Project Area, such as large trees, may provide important habitat for species.
Fauna protected under international agreements or treaties, Specially Protected or Priority Fauna	Moderate	Several species of conservation significance may be impacted; of greatest interest to the project are the Northern Quoll, Mulgara, Pebble-mound Mouse and Pilbara Olive Python.
Size of remnant and condition/intactness of habitat and faunal assemblage	Low	Remnants are mostly large and contiguous within and outside the Project Area. Fragmentation is unlikely to impart ongoing impacts.
Ecological linkage	Low	Many of the conservation significant fauna within the habitats are not particularly susceptible to fragmentation impacts. Fragmentation is unlikely to impart ongoing impacts.
Heterogeneity or complexity of the habitat and faunal assemblage	Moderate	Habitats are complex.

5 Management Recommendations

The impact assessment (Section 4) identified a range of impacts upon fauna that could result from the proposed development. Management strategies are recommended below to reduce these potential impacts on fauna species.

5.1 Loss of Habitat

The loss of habitat from vegetation clearing should be minimised where possible, for example, by avoiding clearing/disturbance of native vegetation where possible, minimising the disturbance footprint, clearly delineating the permitted clearing area and progressively rehabilitating disturbed areas as soon as practical.

5.2 Fragmentation of Habitat

Habitat fragmentation is a concern because while the landscape consists mainly of flat plains and rocky hills, there are some linear environments such as the distribution of the Boolgeeda land system through the centre of the Project Area and the Weeli Wolli Creek system (although located outside the Project Area). The fauna in these linear environments may be particularly sensitive to fragmentation. Areas of particular concern are the northern, central and south-eastern regions of the Project Area as these areas are within the proposed mine pits.

Potential effects of fragmentation can be minimised by limiting footprint size and by planning the disturbance areas in discrete blocks, rather than in a mosaic pattern that results in many small, discontinuous fragments. Furthermore, infrastructure such as roads and even pipelines can affect fauna movements. Placement of such infrastructure should be considered to avoid dividing blocks of contiguous habitat. Roads should be unbunded where possible, since even this may be enough to disrupt the movement of small animals (including conservation significant fauna such as the Mulgara and Lakeland Downs Mouse), while pipelines can be raised or buried to avoid limiting movement of small, terrestrial species. Rehabilitation can be used selectively to facilitate linkage.

5.3 Increased Mortality during Operations

Some mortality is inevitable during operations and sources of ongoing mortality could include collision with vehicles or striking infrastructure. Fauna may be attracted into mine areas in search of food, such as dead insects underneath lights. Mortality from collision with vehicles can be reduced through education of mine personnel (inductions), and implementing minimum speed limits (for example, some mine-sites have speed limits of 60 to 80 km/h during the day, and 50 km/h during the evening and night). In areas of known wildlife activity signs should be placed to alert drivers.

5.4 Hydrological Changes

Hydrological changes have the potential for impacts of minor to moderate significance, with changes potentially leading to impacts upon local fauna populations, including conservation significant species. Efforts should be made to avoid significantly changing the hydrology of the area. Such efforts could include the usage of waste dumps and drainage sumps. It is understood that the project will not

require de-watering. The potential for impacts upon hydrology along drainage lines needs to be investigated, especially surrounding the Weeli Wolli Creek to the south and east of the Project Area.

5.5 Species Interactions

Factors that are likely to attract feral species or lead to increases in local populations of feral species should be minimised, for example, by implementing standard waste management measures for foodstuffs to limit introduced species' access to food resources. The presence of feral species, such as the feral Cat, Fox and Cattle, should be discouraged. It is recommended that a feral fauna control program should be established in consultation with the Western Australian Agriculture Department and the Department of Environment and Conservation (DEC).

5.6 Dust, Noise, Light and Disturbance

Disturbances from these factors are poorly understood, but a precautionary approach is recommended. Management strategies to reduce possible impacts on fauna from disturbances could include directing lighting away from areas of native vegetation, and implementing dust suppression and traffic management strategies.

5.7 Changes in Fire Regime

The Project should not become a source of unplanned fires which will require a system of fire-awareness and management. This should be development in consultation with a fire management specialist. Note there is potential for conservation benefits from a fire management plan that aims to reintroduce something approaching the natural fire regime that probably consisted of frequent but small less-intense fires.

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

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

Species listed under the EPBC Act are assigned to categories recommended by the International Union for the Conservation of Nature and Natural Resources (IUCN) and reviewed by Mace and Stuart (1994), or are listed as migratory. Migratory species are recognised under international treaties such as the China Australia Migratory Bird Agreement (CAMBA), the Japan Australia Migratory Bird Agreement (JAMBA), the Republic of South Korea Australia Migratory Bird Agreement (ROKAMBA), and/or the 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 and Jones 1999; Clevenger and Waltho 2000; Jackson and Griffin 2000).

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

Species interactions, including predation and competition

Changes in species interactions often occur with development. Introduced species, including the feral Cat, 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 and McKenzie 1989). Introduced grazing species, such as the Rabbit, Goat, Camel and domestic livestock, can also degrade habitats and deplete vegetation that may be a food source for other species.

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

Hydroecology

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

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

Fire

The role of fire in the Australian environment and its importance to vertebrate fauna has been widely acknowledged (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 and Longcore 2006). Effects can include impacts on predator-prey interactions, changes to mating and nesting behaviour, and increased competition and predation within and between invertebrates, frogs, birds and mammals.

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

Appendix 3. Categories used in the assessment of conservation status

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

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

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

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

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

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

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

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

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

Least Concern. Taxa that are not Threatened.

Schedules used in the WA Wildlife Conservation Act.

Schedule 1. Rare and Likely to become Extinct.

Schedule 2. Extinct.

Schedule 3. Migratory species listed under international treaties.

Schedule 4. Other Specially Protected Fauna.

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

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

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

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

Priority 4. Taxa in need of monitoring. Taxa which are considered to have been adequately surveyed, or for which sufficient knowledge is available, and which are

considered not currently threatened or in need of special protection, but could be if present circumstances change.

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

Appendix 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)

Appendix 5. GPS locations of Elliott traps within rocky areas of Iron Valley

Elliott Trap ID	Easting	Northing
IVE1	737560	7484903
IVE2	737540	7484901
IVE3	737523	7484898
IVE4	737499	7484883
IVE5	737482	7484886
IVE6	737465	7484861
IVE7	737445	7484860
IVE8	737441	7484849
IVE9	737415	7484864
IVE10	737394	7484871

Appendix 6. Species expected to occur (and recorded) within the Iron Valley Project Area

Expected species are based on reviews of the NatureMap (DEC), Birds Australia (BA), the EPBC Protected Matters Search Tool (EP) databases, the Bamford Consulting Ecologists (BCE) database, and of the broader literature (Lit). Species recorded during other surveys in the region (BCE 2011a and 2011b, Biota 2010 and Western Wildlife 2008) are indicated under 'Other'. Species recorded during the present May and September 2011 surveys are indicated under '2011'. Levels of conservation significance are listed under "CS"**.** Significant species that were recorded during BCE surveys are highlighted in green.

FROGS

Common Name	Species	CS	BA	DEC	EP	BCE	Lit	Other	2011
HYLIDAE									
Main's Frog	*Cyclorana maini*			x		x		x	
Waterholding Frog	*Cyclorana platycephala*					x	x	x	
Desert Tree Frog	*Litoria rubella*			x		x		x	x
MYBATRACHIDAE									
Douglas' Toadlet	*Pseudophryne douglasi*			x				x	
Russell's Toadlet	*Uperoleia russelli*			x				x	
Total Frog Species: 5									**1**

REPTILES

Common Name	Species	CS	BA	DEC	EP	BCE	Lit	Other	2011
CHELUIDAE									
Flat-shelled Tortoise	*Chelodina steindachneri*			x		x		x	
CARPHODACTYLIDAE									
	Nephrurus wheeleri			x		x		x	x
Barking Gecko	*Nephrurus milii*			x				x	
DIPLODACTYLIDAE									
Clawless Gecko	*Crenadactylus ocellatus*			x				x	
Fat-tailed Gecko	*Diplodactylus conspicillatus*			x		x		x	x
	Diplodactylus pulcher			x				x	
	Diplodactylus savagei			x				x	
	Lucasium stenodactylum			x		x		x	x
	Lucasium wombeyi			x				x	x
Marbled Velvet Gecko	*Oedura marmorata*			x				x	x
Beaked Gecko	*Rhynchoedura ornata*			x		x		x	x
	Strophurus elderi			x				x	
	Strophurus jeanae			x				x	
	Strophurus wellingtonae			x				x	
GEKKONIDAE									
	Gehyra pilbara			x				x	
	Gehyra punctata			x				x	x
	Gehyra purpurascens			x				x	x
	Gehyra variegata			x		x		x	x
Bynoe's Gecko	*Heteronotia binoei*			x		x		x	x
Desert Cave Gecko	*Heteronotia spelea*			x		x		x	x
PYGOPODIDAE									
	Delma butleri			x				x	
	Delma elegans			x				x	
	Delma haroldi			x				x	x
	Delma nasuta			x				x	
	Delma pax			x				x	
	Delma tincta			x				x	
	Lialis burtonis			x		x		x	x
	Pygopus nigriceps			x				x	
SCINCIDAE									
	Carlia munda			x		x		x	
	Carlia triacantha			x				x	
	Cryptoblepharus buchananii			x		x		x	
	Cryptoblepharus plagiocephalus			x				x	
	Cryptoblepharus ustulatus			x				x	x
	Ctenotus ariadnae			x				x	

Common Name	Species	CS	BA	DEC	EP	BCE	Lit	Other	2011
	Ctenotus duricola			x				x	
	Ctenotus grandis			x				x	
	Ctenotus hanloni			x				x	
	Ctenotus helenae			x				x	
	Ctenotus leonhardii							x	
Leopard Ctenotus	*Ctenotus pantherinus*			x		x		x	x
	Ctenotus rubicundus			x		x		x	
	Ctenotus rutilans			x				x	
Rock Ctenotus	*Ctenotus saxatilis*			x		x		x	x
	Ctenotus schomburgkii			x				x	
	Ctenotus serventyi			x				x	
	Ctenotus uber			x				x	
Slender Blue-tongue	*Cyclodomorphus melanops*			x		x		x	x
Pygmy Spiny-tailed Skink	*Egernia depressa*			x				x	
	Egernia formosa			x				x	
Narrow-banded Sand Swimmer	*Eremiascincus fasciolatus*			x				x	
Broad-banded Sand Swimmer	*Eremiascincus richardsonii*			x				x	
	Lerista amicorum			x				x	
	Lerista bipes			x				x	
	Lerista labialis			x				x	
	Lerista jacksoni			x				x	
	Lerista muelleri			x				x	
	Lerista neander			x				x	
	Lerista timida						x	x	
	Lerista zietzi			x				x	x
	Menetia greyii			x		x		x	
	Menetia surda			x				x	
	Morethia ruficauda			x		x		x	x
	Notoscincus ornatus			x				x	
	Proablepharus reginae			x				x	
Central Blue-tongue	*Tiliqua multifasciata*			x		x			x
AGAMIDAE									
	Amphibolurus longirostris			x		x		x	x
	Caimanops amphiboluroides			x				x	
	Ctenophorus caudicinctus			x		x		x	x
	Ctenophorus isolepis			x				x	
	Ctenophorus nuchalis			x		x		x	
	Ctenophorus reticulatus			x		x		x	
	Diporiphora valens			x				x	
	Pogona minor			x		x		x	
	Tympanocryptis			x				x	

Common Name	Species	CS	BA	DEC	EP	BCE	Lit	Other	2011
	cephalus								
VARANIDAE									
Spiny-tailed Monitor	*Varanus acanthurus*			x		x		x	
Short-tailed Pygmy Monitor	*Varanus brevicauda*			x		x		x	
Pilbara Mulga Monitor	*Varanus bushi*			x		x		x	
	Varanus caudolineatus			x				x	
Pygmy Desert Monitor	*Varanus eremius*			x				x	
Perentie	*Varanus giganteus*			x				x	
Bungarra or Sand Monitor	*Varanus gouldii*			x				x	
Yellow-spotted Monitor	*Varanus panoptes*			x		x		x	
Pilbara Rock Monitor	*Varanus pilbarensis*			x				x	
Racehorse Monitor	*Varanus tristis tristis*			x		x		x	
TYPHLOPIDAE									
	Ramphotyphlops ammodytes			x		x		x	
	Ramphotyphlops ganei	CS2		x			x	x	
	Ramphotyphlops grypus			x		x		x	
	Ramphotyphlops hamatus			x				x	
	Ramphotyphlops waitii			x				x	
BOIDAE									
Pygmy Python	*Antaresia perthensis*			x		x		x	
Stimson's Python	*Antaresia stimsoni*			x		x		x	
Black-headed Python	*Aspidites melanocephalus*			x		x		x	x
Pilbara Olive Python	*Liasis olivaceus barroni*	CS1		x	x		x	x	
ELAPIDAE									
Pilbara Death Adder	*Acanthophis wellsi*			x		x		x	
NW Shovel-nosed Snake	*Brachyurophis approximans*			x				x	
Yellow-faced Whipsnake	*Demansia psammophis*			x		x		x	
Rufous Whipsnake	*Demansia rufescens*			x				x	
Moon Snake	*Furina ornata*			x				x	
Monk Snake	*Parasuta monachus*			x				x	
Mulga Snake	*Pseudechis australis*			x		x		x	x
Ringed Brown Snake	*Pseudonaja modesta*			x				x	
Western Brown Snake	*Pseudonaja nuchalis*			x				x	
Rosen’s Snake	*Suta fasciata*			x				x	x
Spotted Snake	*Suta punctata*			x				x	
Pilbara Bandy-bandy	*Vermicella snelli*			x			x	x	
Total Reptile Species: 105									**25**

BIRDS

Common Name	Species	CS	BA	DEC	EP	BCE	Lit	Other	2011
CASUARIIDAE									
Emu	*Dromaius novaehollandiae*		x	x		x		x	x
PHASIANIDAE									
Brown Quail	*Coturnix ypsilophora*			x		x	x	x	
ANATIDAE									
Plumed Whistling-Duck	*Dendrocygna eytoni*		x	x		x			
Australian Shelduck	*Tadorna tadornoides*		x	x				x	
Australian Wood Duck	*Chenonetta jubata*		x	x				x	
Grey Teal	*Anas gracilis*		x	x		x		x	
Pacific Black Duck	*Anas superciliosa*		x	x		x		x	
Hardhead	*Aythya australis*		x	x					
PODICIPEDIDAE									
Australasian Grebe	*Tachybaptus novaehollandiae*		x	x			x		
Hoary-headed Grebe	*Poliocephalus poliocephalus*			x			x		
COLUMBIDAE									
Common Bronzewing	*Phaps chalcoptera*		x	x		x		x	x
Crested Pigeon	*Ocyphaps lophotes*		x	x		x		x	x
Spinifex Pigeon	*Geophaps plumifera*		x	x		x		x	x
Diamond Dove	*Geopelia cuneata*		x	x		x		x	x
Peaceful Dove	*Geopelia striata*		x	x		x		x	
PODARGIDAE									
Tawny Frogmouth	*Podargus strigoides*		x					x	
EUROSTOPODIDAE									
Spotted Nightjar	*Eurostopodus argus*		x			x		x	x
AEGOTHELIDAE									
Australian Owlet-nightjar	*Aegotheles cristatus*		x	x				x	x
APODIDAE									
Fork-tailed Swift	*Apus pacificus*	CS1			x		x	x	
ANHINIGIDAE									
Australasian Darter	*Anhinga novaehollandiae*		x	x				x	
PHALACROCORCIDAE									
Little Pied Cormorant	*Microcarbo melanoleucos*		x	x		x		x	
Little Black Cormorant	*Phalacrocorax sulcirostris*		x	x		x		x	
CICONIIDAE									
Black-necked Stork	*Ephippiorhynchus asiaticus*		x					x	
ARDEIDAE									
White-necked Heron	*Ardea pacifica*		x	x		x	x	x	x
Eastern Great Egret	*Ardea modesta*	CS1	x	x		x	x	x	

Common Name	Species	CS	BA	DEC	EP	BCE	Lit	Other	2011
White-faced Heron	*Egretta novaehollandiae*		x	x		x		x	
Little Egret	*Egretta garzetta*		x	x				x	
Nankeen Night-Heron	*Nycticorax caledonicus*					x	x	x	
THRESKIORNITHIDAE									
Straw-necked Ibis	*Threskiornis spinicollis*		x	x		x		x	
Royal Spoonbill	*Platalea regia*		x						
Yellow-billed Spoonbill	*Platalea flavipes*		x	x		x			
ACCIPITRIDAE									
Black-shouldered Kite	*Elanus axillaris*			x			x	x	
Square-tailed Kite	*Lophoictinia isura*		x			x			
Black-breasted Buzzard	*Hamirostra melanosternon*						x	x	x
Whistling Kite	*Haliastur sphenurus*		x	x		x		x	x
Black Kite	*Milvus migrans*		x	x				x	
Brown Goshawk	*Accipiter fasciatus*		x	x		x		x	
Collared Sparrowhawk	*Accipiter cirrocephalus*		x	x		x	x	x	
Spotted Harrier	*Circus assimilis*		x	x		x		x	
Swamp Harrier	*Circus approximans*			x				x	
Wedge-tailed Eagle	*Aquila audax*		x	x		x		x	x
Little Eagle	*Hieraaetus morphnoides*		x	x		x		x	x
FALCONIDAE									
Nankeen Kestrel	*Falco cenchroides*		x	x		x		x	x
Brown Falcon	*Falco berigora*		x	x		x		x	x
Australian Hobby	*Falco longipennis*		x	x		x		x	
Grey Falcon	*Falco hypoleucos*	CS2		x		x	x	x	
Peregrine Falcon	*Falco peregrinus*	CS1	x	x		x	x	x	
RALLIDAE									
Buff-banded Rail	*Gallirallus philippensis*		x						
OTIDIDAE									
Australian Bustard	*Ardeotis australis*	CS2	x	x		x	x	x	x
BURHINIDAE									
Bush Stone-curlew	*Burhinus grallarius*	CS2				x	x	x	
RECURVIROSTRIDAE									
Black-winged Stilt	*Himantopus himantopus*			x		x		x	
CHARADRIDAE									
Black-fronted Dotterel	*Elseyornis melanops*		x	x		x		x	
Red-kneed Dotterel	*Erythrogonys cinctus*			x		x		x	
TURNICIDAE									
Little Button-quail	*Turnix velox*		x	x		x		x	x
CACTUIDAE									
Galah	*Eolophus roseicapillus*		x	x		x		x	x
Little Corella	*Cacatua sanguinea*		x	x		x		x	x
Cockatiel	*Nymphicus hollandicus*		x	x		x		x	x
PSITTACIDAE									

Common Name	Species	CS	BA	DEC	EP	BCE	Lit	Other	2011
Australian Ringneck	*Barnardius zonarius*		x	x		x		x	x
Budgerigar	*Melopsittacus undulatus*		x	x		x		x	x
Bourke's Parrot	*Neopsephotus bourkii*			x		x	x		
Night Parrot	*Pezoporus occidentalis*	CS1			x	x	x		
CUCULIDAE									
Horsfield's Bronze-Cuckoo	*Chalcites basalis*		x	x		x		x	x
Black-eared Cuckoo	*Chrysococcyx osculans*			x		x		x	
Pallid Cuckoo	*Cacomantis pallidus*		x	x		x		x	x
STRIGIDAE									
Barking Owl	*Ninox connivens*			x		x	x	x	
Southern Boobook	*Ninox novaeseelandiae*		x	x		x		x	x
TYTONIDAE									
Barn Owl	*Tyto alba*			x				x	
HALCYONIDAE									
Blue-winged Kookaburra	*Dacelo leachii*		x	x		x		x	
Red-backed Kingfisher	*Todiramphus pyrrhopygia*		x	x		x		x	x
Sacred Kingfisher	*Todiramphus sanctus*		x	x		x		x	
MEROPIDAE									
Rainbow Bee-eater	*Merops ornatus*	CS1	x	x	x	x	x	x	x
PTILONORHYNCHIDAE									
Western Bowerbird	*Ptilonorhynchus guttatus*		x	x				x	
MALURIDAE									
White-winged Fairy-wren	*Malurus leucopterus*		x	x		x		x	x
Variegated Fairy-wren	*Malurus lamberti*		x	x		x		x	x
Rufous-crowned Emu-wren	*Stipiturus ruficeps*	CS3		x				x	x
Striated Grasswren	*Amytornis striatus*	CS3	x	x				x	
ACANTHIZIDAE									
Redthroat	*Pyrrholaemus brunneus*		x	x				x	
Weebill	*Smicrornis brevirostris*		x	x		x		x	x
Western Gerygone	*Gerygone fusca*		x	x		x		x	
Slaty-backed Thornbill	*Acanthiza robustirostris*			x		x	x	x	
Yellow-rumped Thornbill	*Acanthiza chrysorrhoa*			x		x	x	x	
Chestnut-rumped Thornbill	*Acanthiza uropygialis*		x	x		x		x	
Inland Thornbill	*Acanthiza apicalis*		x	x		x		x	
PARDALOTIDAE									
Red-browed Pardalote	*Pardalotus rubricatus*		x	x		x		x	x
Striated Pardalote	*Pardalotus striatus*		x	x		x		x	
MELIPHAGIDAE									
Pied Honeyeater	*Certhionyx variegatus*			x			x	x	
Singing Honeyeater	*Lichenostomus virescens*		x	x		x		x	x
Grey-headed Honeyeater	*Lichenostomus keartlandi*		x	x		x		x	x
White-plumed Honeyeater	*Lichenostomus penicillatus*		x	x		x		x	x

Common Name	Species	CS	BA	DEC	EP	BCE	Lit	Other	2011
White-fronted Honeyeater	*Phylidonyris albifrons*			x				x	
Yellow-throated Miner	*Manorina flavigula*		x	x		x		x	x
Spiny-cheeked Honeyeater	*Acanthagenys rufogularis*		x	x		x		x	
Grey Honeyeater	*Conopophila whitei*					x	x	x	
Crimson Chat	*Epthianura tricolor*		x	x		x		x	x
Orange Chat	*Epthianura aurifrons*			x		x	x	x	
Black Honeyeater	*Sugomel niger*			x				x	x
Brown Honeyeater	*Lichmera indistincta*		x	x		x		x	x
Black-chinned Honeyeater	*Melithreptus gularis*			x			x	x	
POMATOSTOMIDAE									
Grey-crowned Babbler	*Pomatostomus temporalis*		x	x		x		x	
White-browed Babbler	*Pomatostomus superciliosus*		x					x	
PSOPHODIDAE									
Chestnut-breasted Quail-thrush	*Cinclosoma castaneothorax*			x			x	x	
Chiming Wedgebill	*Psophodes occidentalis*		x	x					
NEOSITTIDAE									
Varied Sittella	*Daphoenositta chrysoptera*			x		x	x	x	
CAMPEPHAGIDAE									
Ground Cuckoo-shrike	*Coracina maxima*			x		x	x	x	
Black-faced Cuckoo-shrike	*Coracina novaehollandiae*		x	x		x		x	x
White-winged Triller	*Lalage sueurii*		x	x		x		x	x
PACHYCEPHALIDAE									
Rufous Whistler	*Pachycephala rufiventris*		x	x		x		x	x
Grey Shrike-thrush	*Colluricincla harmonica*		x	x		x		x	x
Crested Bellbird	*Oreoica gutturalis*		x	x		x		x	
ARTAMIDAE									
Masked Woodswallow	*Artamus personatus*		x	x		x		x	x
Black-faced Woodswallow	*Artamus cinereus*		x	x		x		x	x
Little Woodswallow	*Artamus minor*		x	x		x		x	x
Grey Butcherbird	*Cracticus torquatus*		x	x		x		x	
Black-backed Butcherbird	*Cracticus mentalis*							x	
Pied Butcherbird	*Cracticus nigrogularis*		x	x		x		x	x
Australian Magpie	*Cracticus tibicen*		x	x		x		x	x
RHIPIDURIDAE									
Grey Fantail	*Rhipidura albiscapa*			x		x	x	x	x
Willie Wagtail	*Rhipidura leucophrys*		x	x		x			x
CORVIDAE									
Little Crow	*Corvus bennetti*		x	x				x	
Torresian Crow	*Corvus orru*		x	x		x		x	x
MONARCHIDAE									
Magpie-lark	*Grallina cyanoleuca*		x	x		x		x	x

Common Name	Species	CS	BA	DEC	EP	BCE	Lit	Other	2011
PETROICIDAE									
Red-capped Robin	*Petroica goodenovii*		x	x		x		x	
Hooded Robin	*Melanodryas cucullata*		x	x		x		x	x
ALAUDIDAE									
Horsfield's Bushlark	*Mirafra javanica*		x	x		x		x	x
ACROCEPHLIDAE									
Australian Reed-Warbler	*Acrocephalus australis*		x					x	
MEGALURIDAE									
Rufous Songlark	*Cincloramphus mathewsi*		x	x		x		x	x
Brown Songlark	*Cincloramphus cruralis*		x	x		x		x	x
Spinifexbird	*Eremiornis carteri*			x				x	x
HIRUNDINIDAE									
Welcome Swallow	*Hirundo neoxena*		x			x			
Fairy Martin	*Petrochelidon ariel*		x	x				x	
Tree Martin	*Petrochelidon nigricans*		x	x				x	
NECTARINIIDAE									
Mistletoebird	*Dicaeum hirundinaceum*		x	x		x		x	
ESTRILDIDAE									
Zebra Finch	*Taeniopygia guttata*		x	x		x		x	x
Star Finch	*Neochmia ruficauda subclarescens*	CS2				x	x	x	
Painted Finch	*Emblema pictum*		x	x		x		x	x
MOTCILLIDAE									
Australasian Pipit	*Anthus novaeseelandiae*		x	x		x		x	
Total Bird Species: 138									**58**

MAMMALS

Common Name	Species	CS	BA	DEC	EP	BCE	Lit	Other	2011
TACHYGLOSSIDAE									
Echidna	*Tachyglossus aculeatus*					x	x	x	x
DASUYRIDAE									
Mulgara	*Dasycercus cristicauda/ D. blythi*	CS1					x		x*
Kaluta	*Dasykaluta rosamondae*			x		x		x	
Northern Quoll	*Dasyurus hallucatus*	CS1			x		x	x	
Pilbara Ningaui	*Ningaui timealeyi*			x		x		x	
Wongai Ningaui	*Ningaui ridei*			x				x	
Undescribed Pilbara planigale	*Planigale sp. 1(ingrami)*			x		x	x		
Undescribed Pilbara planigale	*Planigale sp. 2*					x			
Rory's Pseudantechinus	*Pseudantechinus roryi*						x		
Woolley's Pseudantechinus	*Pseudantechinus woolleyae*			x			x	x	
Stripe-faced Dunnart	*Sminthopsis macroura*			x		x	x	x	
Long-tailed Dunnart	*Sminthopsis longicaudata*	CS2					x	x	
THYLACOMYIDAE									
Greater Bilby	*Macrotis lagotis*	CS1		x	x		x	x	
MACROPODIDAE									
Euro	*Macropus robustus*			x		x		x	x
Red Kangaroo	*Macropus rufus*			x		x		x	x
Rothschild's Rock-Wallaby	*Petrogale rothschildi*						x	x	
MEGADERMATIDAE									
Ghost Bat	*Macroderma gigas*	CS2		x		x	x	x	
HIPPOSIDERIDAE									
Pilbara Leaf-nosed Bat	*Rhinonicteris aurantia*	CS1		x	x		x	x	
EMBALLONURIDAE									
	Taphozous georgianus			x		x		x	x
	Taphozous hilli			x			x	x	
Yellow-bellied Sheathtail Bat	*Saccolaimus flaviventris*						x	x	x
MOLOSSIDAE									
White-striped Mastiff Bat	*Tadarida australis*			x		x	x	x	
	Chaerephon jobensis			x		x		x	x
Beccari's Freetail-bat	*Mormopterus beccarii*			x			x	x	
VESPERTILLIONDAE									
Lesser Long-eared Bat	*Nyctophilus geoffroyi*			x		x		x	
Northwestern Long-eared Bat	*Nyctophilus bifax daedalus*			x			x	x	
Gould's Wattled Bat	*Chalinolobus gouldii*			x		x		x	x
Chocolate Wattled Bat	*Chalinolobus morio*			x			x	x	

Common Name	Species	CS	BA	DEC	EP	BCE	Lit	Other	2011
	Scotorepens greyii			x		x		x	x
	Vespadelus finlaysoni			x		x		x	x
MURIDAE									
Lakeland Downs Mouse	*Leggadina lakedownensis*	CS2					x	x	
House Mouse	*Mus musculus*	INT		x		x		x	
Spinifex Hopping Mouse	*Notomys alexis*			x				x	
Western Pebble-mound Mouse	*Pseudomys chapmani*	CS2		x		x	x	x	x
Desert Mouse	*Pseudomys desertor*			x		x	x	x	
Sandy Inland Mouse	*Pseudomys hermannsburgensis*			x		x		x	
Rock Rat	*Zyzomys argurus*			x		x		x	
LEPORIDAE									
Rabbit	*Oryctolagus cuniculus*	INT		x	x	x		x	
CANIDAE									
Dingo	*Canis lupus dingo*	INT		x		x	x	x	x
Fox	*Vulpes vulpes*	INT		x	x	x		x	
FELIDAE									
Cat	*Felis catus*	INT		x	x	x		x	x
EQUIDAE									
Horse	*Equus caballus*	INT		x		x	x		
Donkey	*Equus asinus*	INT		x		x		x	
CAMELIDAE									
Dromedary Camel	*Camelus dromedarius*	INT				x	x		
BOVIDAE									
European Cattle	*Bos taurus*	INT		x		x	x	x	
Total Mammal Species:45									**11 (and 2 Int)**

*Note: Mulgara recorded just outside Iron Valley tenement boundary. Depending upon taxonomy recognised, species may be *D. blythi*

Appendix 7.

Table 1. Habitat preference and likely proportion of local disturbance to all conservation significant species expected to occur (and recorded) within the Iron Valley Project Area. Habitat is based upon land systems and is refined within the lease area to vegetation types within these systems. Proportional local impacts (within 15km radius) are based upon land systems as only these are mapped outside the lease area.

Species	Coordinates	Habitat	Land Systems that correspond to habitat. Area of land system within clearing footprint in parenthesis	Veg Type within lease that corresponds to habitat. Area of veg type within clearing footprint in parenthesis	Area of land systems within 15km	Percentage of habitat within clearing footprint compared with corresponding land system within 15km	
						Based on veg type in footprint	Based on land system in footprint
Conservation Significance Level 1							
Pilbara Olive Python *Liasis olivaceus barroni*	Not recorded	Generally associated with riverine woodland areas, gorges and large rock holes and swamps.	Only Newman within the project area is likely to support resident animals, also uses River. (277.9)	Creek Line/Drainage (60.1)	46,248.35	0.13	0.6
Peregrine Falcon *Falco peregrinus*	Not recorded	Habitat generalist favouring areas with cliffs and abandoned nests in tall, wooded forests.	Newman but may forage anywhere (277.9)	Rocky Hillslopes/Hill Crests (217.9)	39,881.75	0.55	0.7

Species	Coordinates	Habitat	Land Systems that correspond to habitat. Area of land system within clearing footprint in parenthesis	Veg Type within lease that corresponds to habitat. Area of veg type within clearing footprint in parenthesis	Area of land systems within 15km	Percentage of habitat within clearing footprint compared with corresponding land system within 15km	
						Based on veg type in footprint	Based on land system in footprint
Night Parrot *Pezoporus occidentalis*	Not recorded	Mature spinifex grasslands and chenopod Shrublands, particularly where the two are closely juxtaposed. There are recent records from the Fortescue Marsh.	Unknown. (677.9; Assuming equally likely to be in any land system)	Unknown (677.9; Assuming equally likely to be in any veg type)	~50,354.81 Assuming equally likely to be in any land system	~1.35	~1.35
Fork-tailed Swift *Apus pacificus*	Not recorded	Nomadic aerial forager following low pressure storm systems, with no reliable reports of them coming to land.	Any land system (677.9)	Any veg type (677.9)	50,354.81	1.35	1.35
Rainbow Bee-eater *Merops ornatus*	Recorded, likely throughout area	Any habitat suitable for hawking for insects. Breeds in a wide variety of sandy habitats.	Boolgeeda, River, likely to forage elsewhere (400)	Creek Line/Drainage, Plains 1-4 (411.8)	16,839.66	2.45	2.38

Species	Coordinates	Habitat	Land Systems that correspond to habitat. Area of land system within clearing footprint in parenthesis	Veg Type within lease that corresponds to habitat. Area of veg type within clearing footprint in parenthesis	Area of land systems within 15km	Percentage of habitat within clearing footprint compared with corresponding land system within 15km	
						Based on veg type in footprint	Based on land system in footprint
Eastern Great Egret *Ardea modesta*	Not recorded	Extensive wetlands of the Fortescue Marshes, however no wetlands in the Project Area but individuals may visit nearby Weeli Wolli Creek.	May visit River. (0)	May visit Creek Line/Drainage (60.1)	6,366.6	0.94	Negligible
Northern Quoll *Dasyurus hallucatus*	Not recorded	Rocky and broken country in open Eucalypt forest.	Newman (277.9)	Rocky Hillslopes/Hill Crests (217.9)	39,881.75	0.55	0.7
Crest-tailed Mulgara *Dasycercus cristicauda*	Active Burrow 737094 7480873 Active Burrow + photograph 737397 7481545	Mature Spinifex grasslands on sandy substrates.	Boolgeeda (400)	Plains 1-4. (351.7)	10,473.06	3.36	3.82

Species	Coordinates	Habitat	Land Systems that correspond to habitat. Area of land system within clearing footprint in parenthesis	Veg Type within lease that corresponds to habitat. Area of veg type within clearing footprint in parenthesis	Area of land systems within 15km	Percentage of habitat within clearing footprint compared with corresponding land system within 15km	
						Based on veg type in footprint	Based on land system in footprint
Bilby *Macrotis lagotis*	Not recorded	Woodlands and grasslands on sandplains and dunefields, often close to drainage systems.	Boolgeeda (400)	Plains 1-4, Creek Line/Drainage. (411.8)	10,473.06	3.93	3.82
Pilbara Leaf-nosed Bat *Rhinonicteris aurantius*	Not recorded	Roosts in warm humid caves, likely to forage throughout Project Area	Newman (277.9)	Rocky Hillslopes/Hill Crests (217.87)	39,881.75	0.55	0.7
Conservation Significance Level 2							
Blind snake *Ramphotyphlops ganei*	Not recorded	Uncertain; may prefer gorges and gullies or grasslands, Shrublands and woodlands.	Boolgeeda, River (400)	Plains 1-4, Creek Line/ Drainage (411.76)	16,839.66	2.45	2.38

Species	Coordinates	Habitat	Land Systems that correspond to habitat. Area of land system within clearing footprint in parenthesis	Veg Type within lease that corresponds to habitat. Area of veg type within clearing footprint in parenthesis	Area of land systems within 15km	Percentage of habitat within clearing footprint compared with corresponding land system within 15km	
						Based on veg type in footprint	Based on land system in footprint
Australian Bustard *Ardeotis australis*	Recorded, likely throughout area	Open or lightly-wooded grasslands and shrublands.	Boolgeeda (400)	Plains 1-4 (351.7)	10,473.06	3.35	3.82
Bush Stone-curlew *Burhinus grallarius*	Not recorded	Grassy woodlands with minimal to no human disturbance.	Boolgeeda, River (400)	Plains 1-4 (351.7)	16,839.66	2.09	2.38
Grey Falcon *Falco hypoleucos*	Not recorded	Habitat generalist including shrubland, grassland and wooded watercourses.	River but may forage anywhere (0)	Creekline/Drainage, may forage anywhere. (60.1)	6,366.6	0.94	Negligible
Star Finch *Neochmia ruficauda subclarescens*	Not recorded	Grasslands near water.	River (0)	Creekline/Drainage (60.1)	6,366.6	0.94	Negligible

Species	Coordinates	Habitat	Land Systems that correspond to habitat. Area of land system within clearing footprint in parenthesis	Veg Type within lease that corresponds to habitat. Area of veg type within clearing footprint in parenthesis	Area of land systems within 15km	Percentage of habitat within clearing footprint compared with corresponding land system within 15km	
						Based on veg type in footprint	Based on land system in footprint
Western Pebble-mound Mouse *Pseudomys chapmani*	Inactive and very old 735849 7480674 Active 735572 7480629 Recently Active 735534 7480644 Inactive 735493 7480596 Recently Active 735451 7480648	Hummock grassland on skeletal soils containing an abundance of small pebbles on spurs and the lower slopes of ridges.	Newman (277.9)	Rocky Hillslopes/Hill Crests (217.9)	39,881.75	0.55	0.7
Lakeland Downs Mouse *Leggadina lakedownensis*	Not recorded	Cracking clays and adjacent habitats in open shrublands and hummock and tussock grasslands.	Possibly River and Boolgeeda (400)	Possibly Creekline/Drainage, Plains 1-4 (411.76)	16,839.66	2.45	2.38

Species	Coordinates	Habitat	Land Systems that correspond to habitat. Area of land system within clearing footprint in parenthesis	Veg Type within lease that corresponds to habitat. Area of veg type within clearing footprint in parenthesis	Area of land systems within 15km	Percentage of habitat within clearing footprint compared with corresponding land system within 15km	
						Based on veg type in footprint	Based on land system in footprint
Long-tailed Dunnart *Sminthopsis longicaudata*	Not recorded	Scree slopes surrounding rock hills and mesas.	Newman (277.9)	Rocky Hillslopes/Hill Crests (217.87)	39,881.75	0.55	0.7
Ghost Bat *Macroderma gigas*	Not recorded	Roosts in warm humid caves, likely to forage throughout Project Area	Newman, may forage anywhere (277.9)	Rocky Hillslopes/Hill Crests (217.87)	39,881.75	0.55	0.7
Conservation Significance Level 3							
Rufous-crowned Emu-wren *Stipiturus ruficeps*	On track near Mulgara burrows, precise coordinates not known	Spinifex, often including at least some long-unburnt	Boolgeeda (400)	Plains 1-4, Creek Line/Drainage (411.8)	10,473.06	3.93	3.82
Striated Grasswren *Amytornis striatus*	Not recorded	Spinifex, often including at least some long-unburnt	Boolgeeda (400)	Plains 1-4, Creek Line/Drainage (411.8)	10,473.06	3.93	3.82

Table 2. Habitat preference and likely proportion of local disturbance to key conservation significant species expected to occur (and recorded) within the Iron Valley Project Area. For each species, area of habitat within disturbance footprint is calculated in three ways: based upon land systems, based upon vegetation type and based upon an interpretation of both vegetation type and land system that reflects the known habitat preference of the species (interpreted habitat). Proportional local impacts within 15km radius (in parenthesis) are based upon land systems as only these are mapped outside the lease area.

Species	Habitat	Land system corresponding with habitat	Hectares of land system within 15km	Hectares of land system corresponding with habitat within clearance footprint	Hectares of vegetation corresponding with habitat within clearance footprint	Hectares of interpreted habitat within clearance footprint
Crest-tailed Mulgara *Dasycercus cristicauda*	Mature Spinifex grasslands on sandy substrates.	Boolgeeda	10473.06	400 (3.82%)	351.7 (3.36%)	400 (3.82%)
Pilbara Olive Python *Liasis olivaceus barroni*	Generally associated with riverine woodland areas, gorges and large rock holes and swamps	Newman, River	46248.35	277.9 (0.6%)	60.1 (0.13%)	105 (0.23%)
Northern Quoll *Dasyurus hallucatus*	Rocky and broken country in open Eucalyptus forest.	Newman	39881.75	277.9 (0.7%)	217.9 (0.55%)	68 (0.17%)

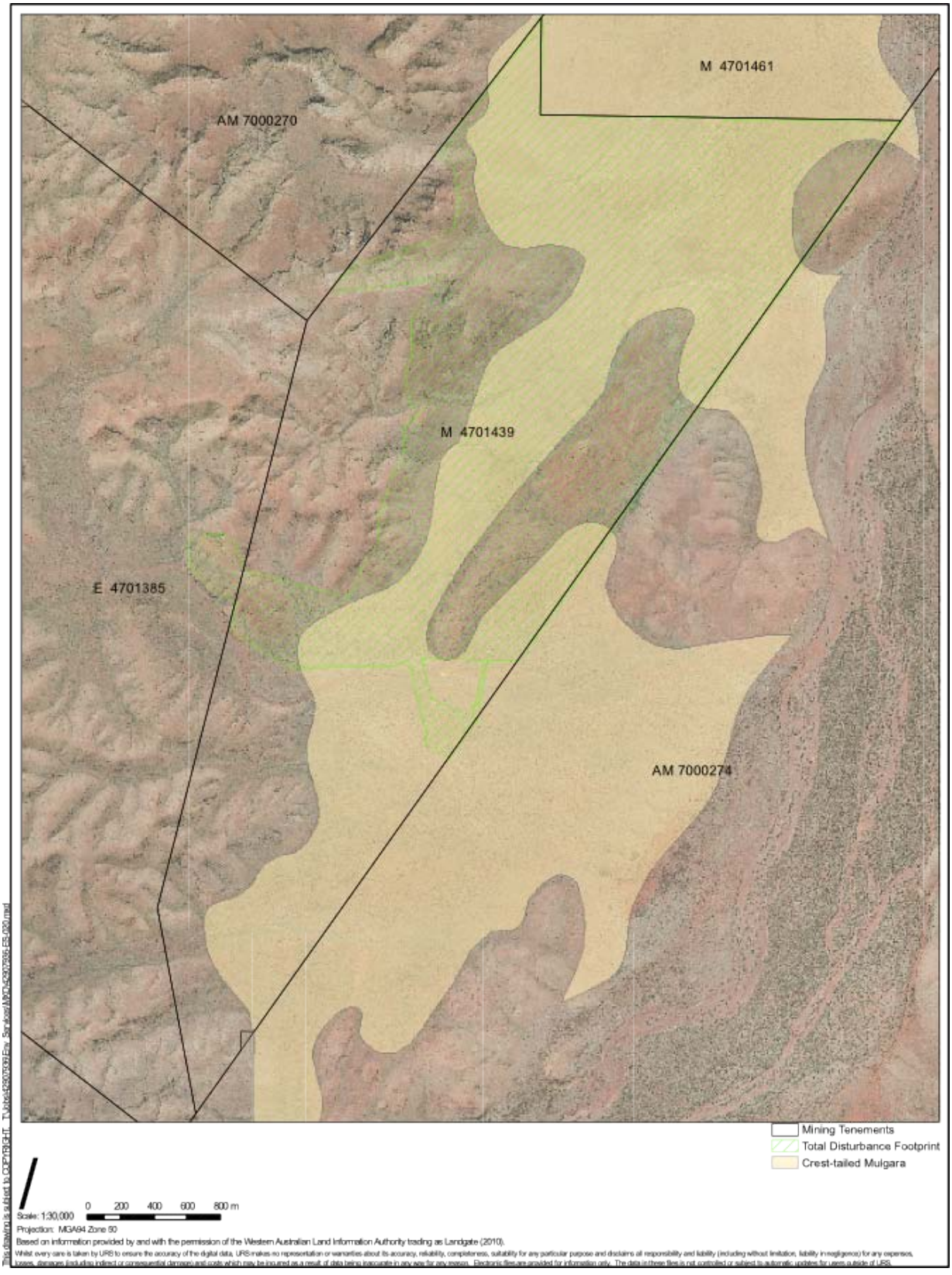

Figure 1. Interpreted habitat of Crest-tailed Mulgara.

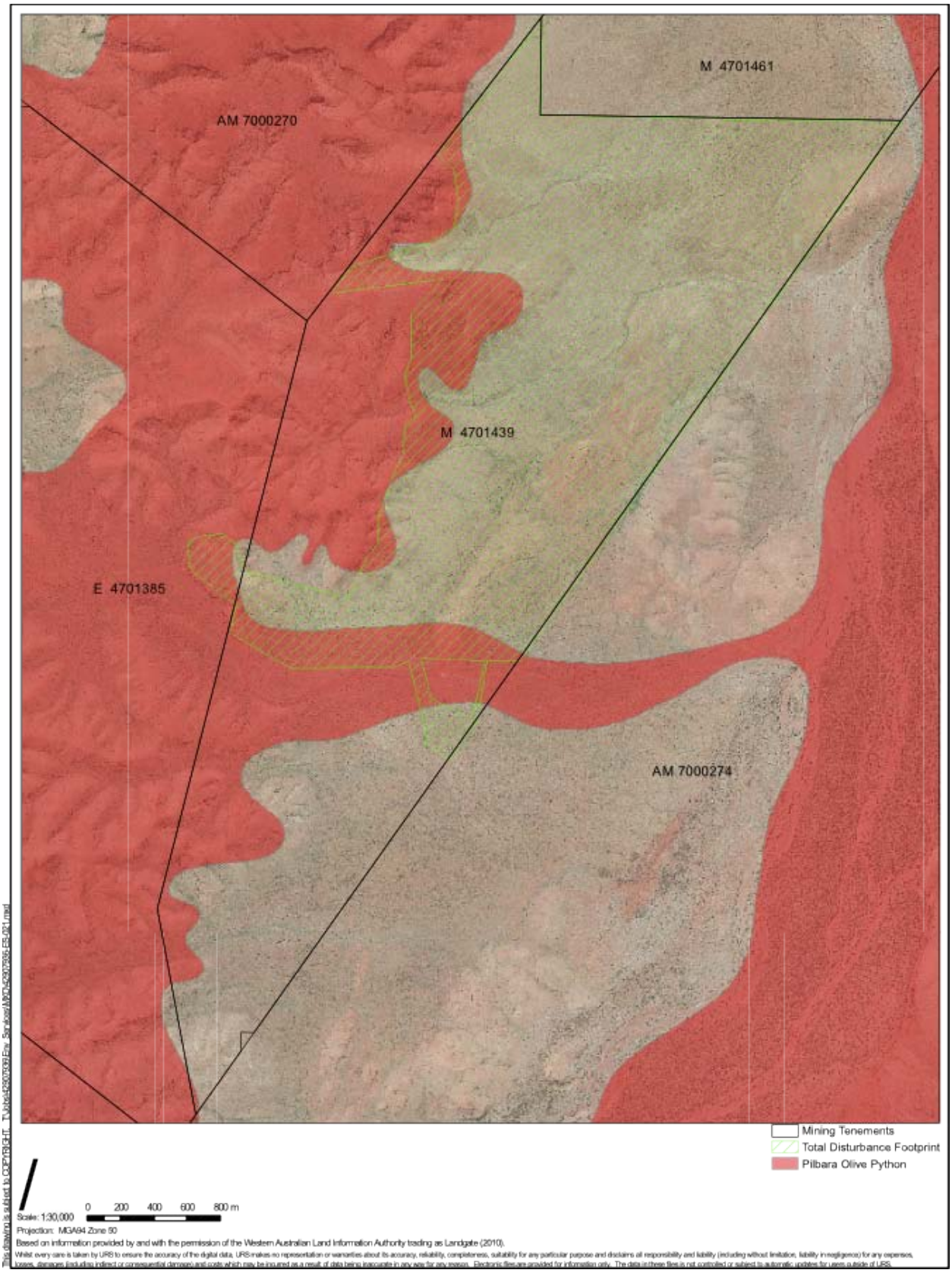

Figure 2. Interpreted habitat of Pilbara Olive Python.

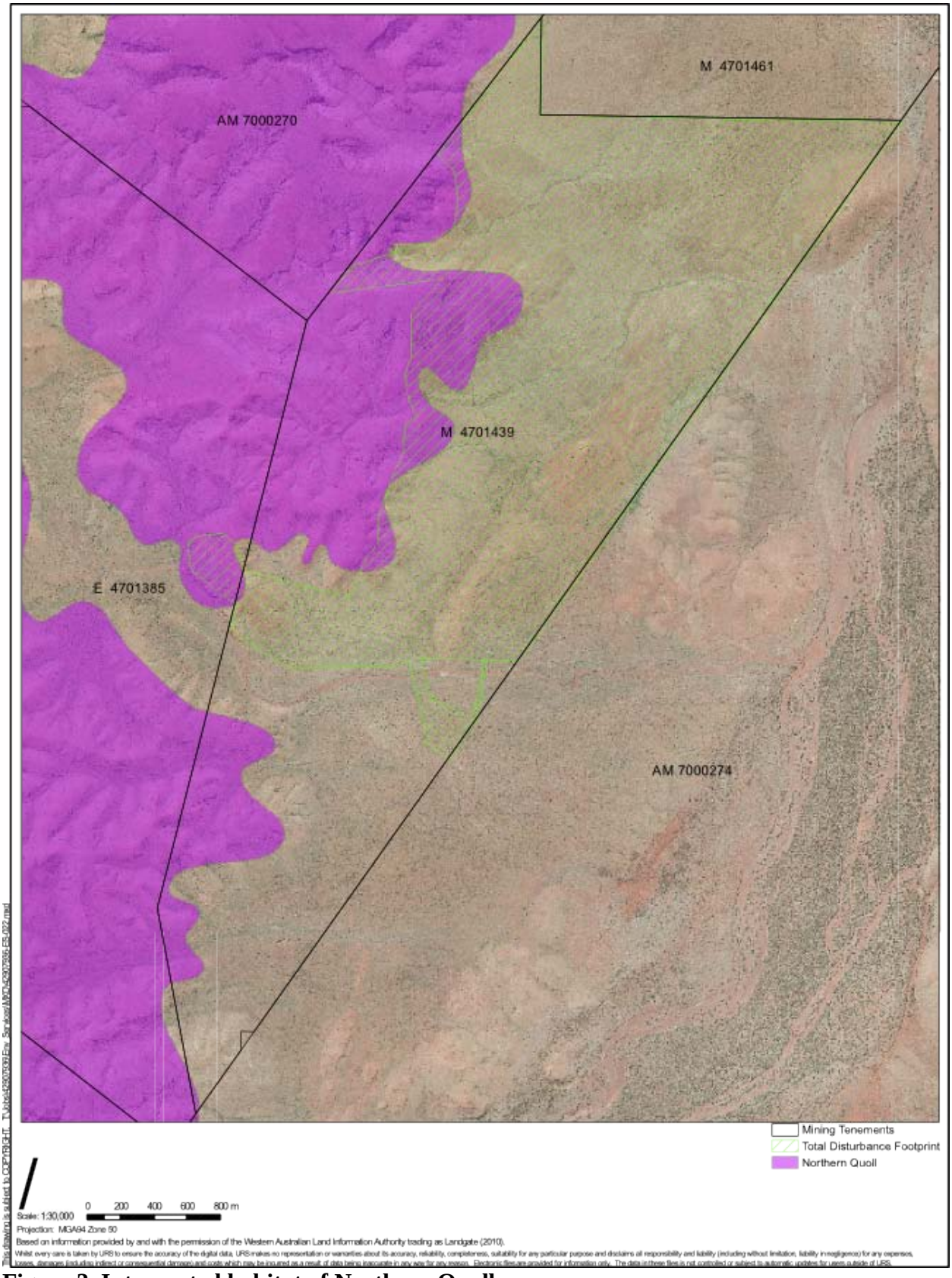

Figure 3. Interpreted habitat of Northern Quoll.

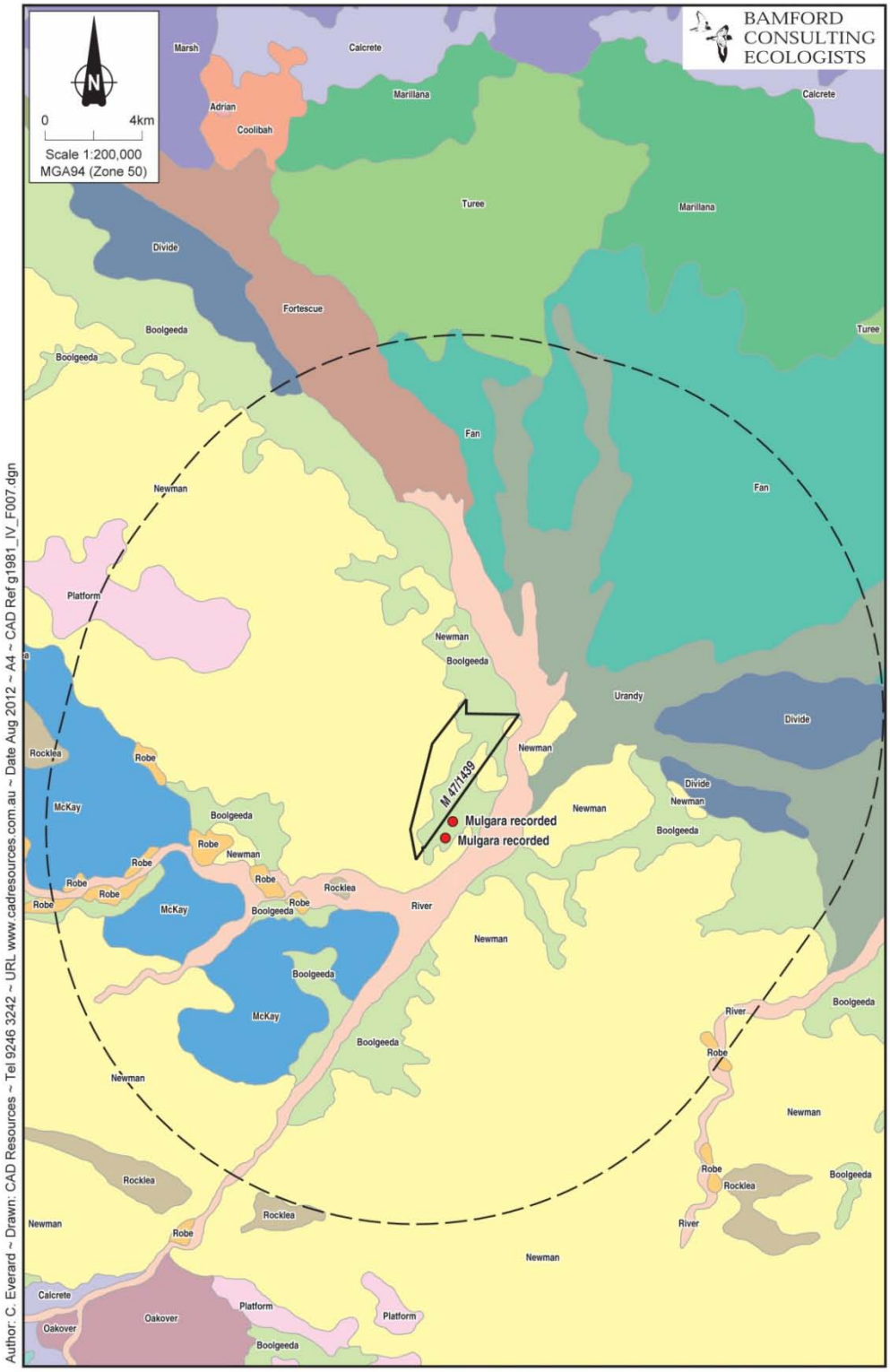

Figure 4. Land systems within 15km of the Iron Valley lease area, upon which local land system areas calculated.

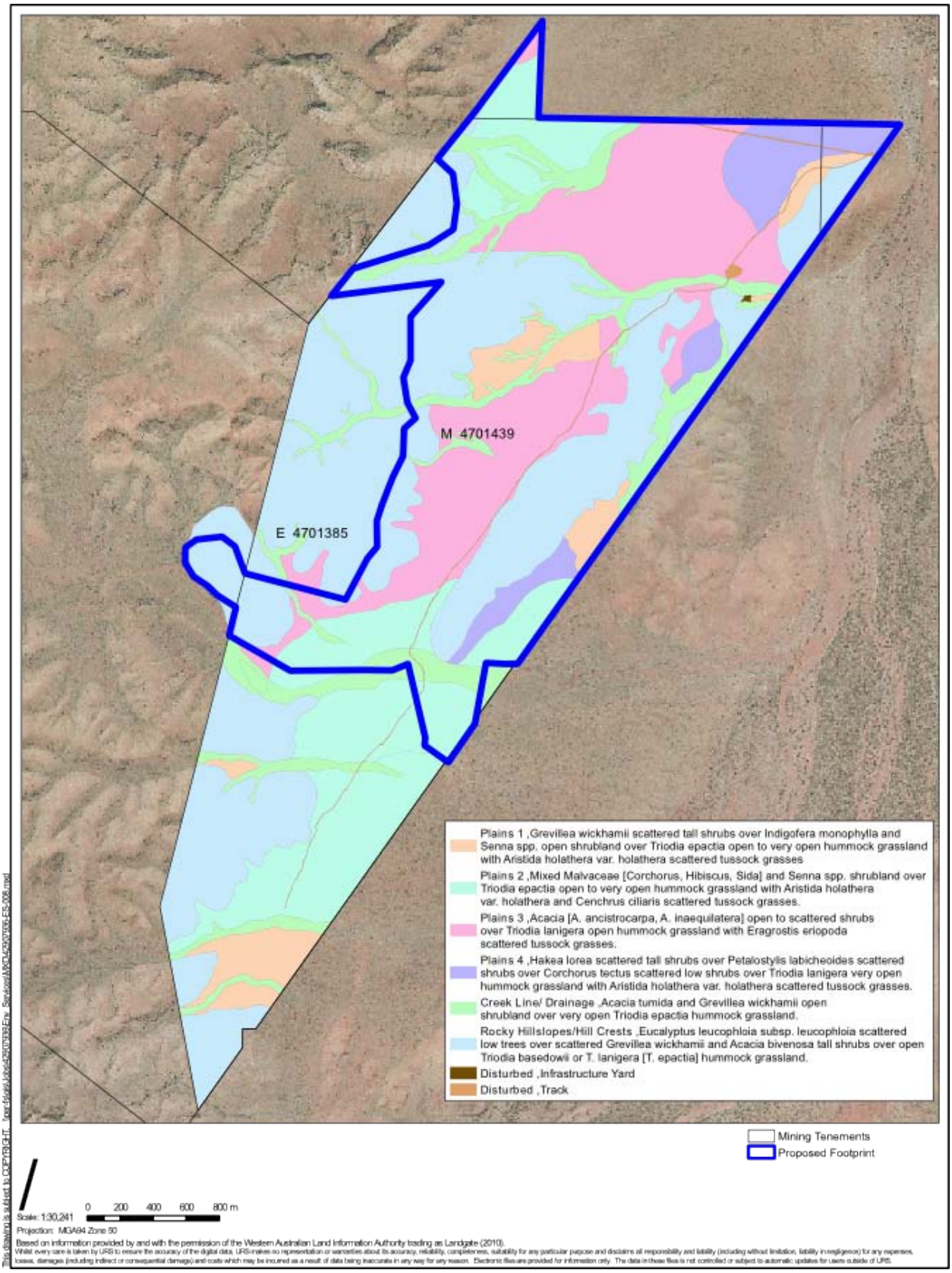

Figure 5. Vegetation types and proposed impact footprint within Iron Valley lease area.