Bennelongia
Environmental Consultants

Iron Ore Holdings Ltd

Iron Valley Project: Subterranean Fauna Assessment

Final Report

Prepared for Iron Ore Holdings Ltd
by Bennelongia Pty Ltd

September 2012
Report 2012/81

Iron Valley Project: Subterranean Fauna Assessment

Bennelongia Pty Ltd
5 Bishop Street
Jolimont WA 6014
www.bennelongia.com.au
ACN 124 110 167

September 2012

Report 2012/81

Cover photo: Iron Valley

Client – Iron Ore holdings Limited

Report	Version	Prepared by	Checked by	Submitted to Client	
				Method	Date
Draft report	Vers. 1	Andrew Trotter	Stuart Halse	email	12.vii.10
Final report		Andrew Trotter	Stuart Halse	email	20.x.10
	Vers. 1	Andrew Trotter Michael Curran	Stuart Halse	email	22.ii.12
	Vers. 2	Stuart Halse		email	1.iii.12
	Vers. 3	Andrew Trotter	Stuart Halse	email	31.vii.12
	Vers. 4	Andrew Trotter		email	6.ix.12

K:\Projects\B_URS_02\Iron Valley Report\Iron Valley Final\Sep 12 Final_ BEC_Iron Valley Report_final_6.ix.12

EXECUTIVE SUMMARY

Iron Ore Holdings Ltd (IOH) is planning to mine iron ore at the Iron Valley Project within IOH's Central Pilbara tenements. The Iron Valley Project is 86 km north-northwest of Newman in the Pilbara region of Western Australia (WA).

This subterranean fauna report presents results of troglofauna and stygofauna surveys conducted in 2009 and 2011 (the latter sampling at the request of the Department of Environment and Conservation) and provides an assessment of the likely impacts of mining on subterranean fauna at the Iron Valley Project. The sampling effort completed meets the requirements laid out in Environmental Protection Authority (EPA) Guidance Statement No. 54a, with a total of 98 troglofauna and 84 stygofauna samples being collected from bores inside the impact zone of the proposed mine.

The troglofauna sampling yielded 112 troglofaunal animals, representing seven Classes, 11 Orders and 16 species. Two arachnid Orders were recorded: Pseudoscorpionida (1 species) and Schizomida (1 species). The only crustacean Order collected was Isopoda (3 species). Chilopoda were represented by one species of an unknown Order (a partial and damaged specimen prevented identification based on morphology). Diplopoda were represented by Polyxenida (1 species) and Symphyla by Cephalostigmata (1 species). There were five Orders of hexapods (Entognatha/Insecta): Diplura (2 species), Blattodea (2 species), Hemiptera (2 species), Coleoptera (1 species) and Diptera (1 species).

Eleven of the 16 troglofauna species recorded at the Iron Valley Project were recorded within the proposed mine pits. Of these 11 species, 10 species are known to occur in reference areas outside the mine pits or at deposits elsewhere in the Pilbara. One species of troglofauna (Chilopoda sp.) is currently known only from within the proposed mine pits at the Iron Valley Project. Chilopoda sp. was recorded as a singleton. The conservation status of this species is very difficult to quantify because it was damaged and its identification could not be taken further and, therefore, its range could not be determined. Based on the geology of the Iron Valley Project and the distribution of other Chilopoda in the Pilbara, it is expected that this species occurs beyond the Iron Valley mine pits.

Stygofauna sampling yielded 2,153 specimens consisting of at least 23 species of at least eight Orders, including Tubificida (3 species), Hydracarina (1 species), Ostracoda (3 species), Copepoda (4 species), Syncarida (3 species), Amphipoda (7 species), Isopoda (1 species) and nematodes of unknown order/s. Copepods were the numerically dominant group at the Iron Valley Project, with species of oligochaetes, amphipods and syncarids also relatively abundant.

Twenty-two of the 23 stygofauna species recorded at Iron Valley were recorded from within the proposed drawdown cone, importantly all but two of these species are known from elsewhere. The remaining two species potentially have more localised ranges. These species, the ostracod *Meridiescandona* sp. BOS 171 and, to a lesser extent, the syncarid *Bathynella* sp. may be potentially threatened by drawdown. *Meridiescandona* sp. BOS 171 was collected from five drill holes within the Iron Valley Project, while *Bathynella* sp. was collected from a single hole. However, it is likely that both species exploit the habitat connectivity between the Project and surrounding areas in the same way as demonstrated by most of the stygofauna species at Iron Valley.

CONTENTS

LIST OF FIGURES

LIST OF TABLES

1. INTRODUCTION

Iron Ore Holdings Ltd (IOH) is planning to mine iron ore at the Iron Valley Project within IOH's Central Pilbara tenements. The Iron Valley Project is 86 km north-northwest of Newman in the Pilbara region of Western Australia (WA) (Figure 1.1). The Iron Valley Project encompasses the following tenements: Exploration Licence E 47/1385 and M47/1439. IOH proposes to commence construction in Quarter 3, 2013, with operations commencing in Quarter 1, 2014. The life of the Project is expected to be approximately seven years. Decommissioning and closure is expected to occur between years 2021 and 2023, and closure would continue for a further 10 years until 2033.

Key mining components and activities of the proposed Project include:

- Mining of the ore deposit by conventional open pit methods over a 7 year mine life. Mining will only take place above the water table. This will involve drilling and blasting, digging and loading using hydraulic excavators and front-end loaders, and transport by haul trucks.
- Processing of ore on-site, with waste dumps located outside of the pit;
- Supporting infrastructure including an accommodation village, mine site offices and utilities; and
- Water supply borefield for potable and non-potable water.

The proposed area of mine pits at the Iron Valley Project is expected to total approximately 245 ha with a maximum depth of 70 m (depending on the water table). The watertable lies at approximately 6-18 m below ground surface to the south of the dyke and up to 70 m north of the dyke. Although the area of impact is small relative to the ranges of most restricted species, the pit excavation and drawdown (for water supply) proposed for the Iron Valley Project may potentially threaten highly restricted species of subterranean fauna, if they occur within the vicinity of the Project.

A high proportion of subterranean species are short-range endemics (SREs – defined by Harvey 2002 as species with ranges of <10,000 km^2). Consequently, the Environmental Protection Authority (EPA) usually require that the risks to subterranean fauna are considered when assessing proposed mine developments where subterranean fauna are likely to occur (EPA 2003). The very limited ranges of subterranean fauna species means they are particularly vulnerable to extinction as a result of anthropogenic activities and, therefore, they are a focus of conservation policy. About 70% of stygofauna in the Pilbara meet the criterion for being an SRE species (Eberhard *et al*. 2009) and the proportion of troglofauna that are SREs is likely to be even higher (see Lamoreux 2004).

The specific aims of the troglofauna survey at the Iron Valley Project were to:

1. Document the subterranean fauna communities of the Project area and their constituent species.
2. Determine the likely impact of the Iron Valley Project on the subterranean fauna community.

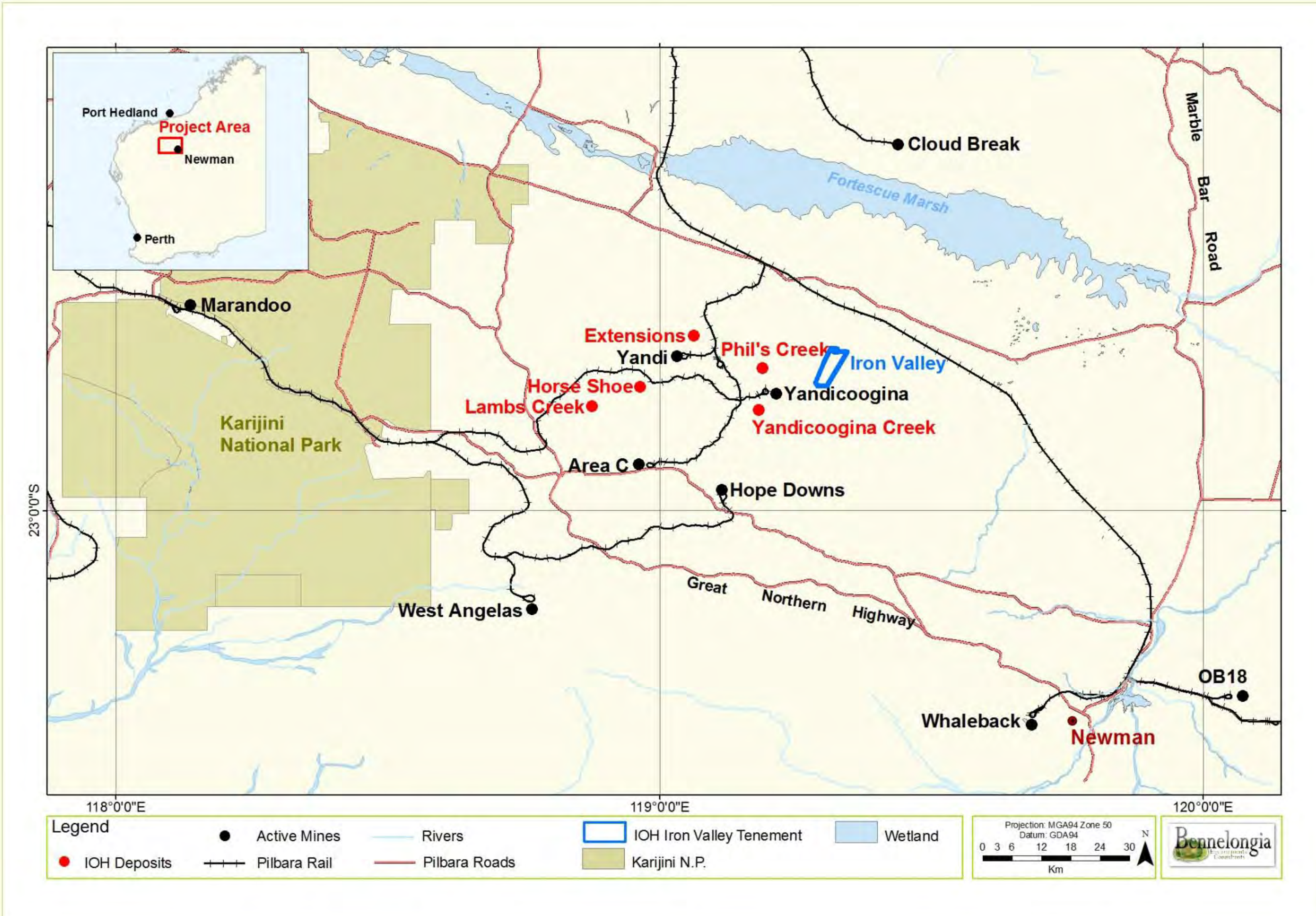


Figure 1.1. Location of the Iron Valley Project.

2. HYDROGEOLOGY

The iron ore deposit proposed to be mined by the Iron Valley Project is located in a southwards-inclined anticline of Brockman Iron Formation in the Hamersley Range (Appendix 1). Most of the mineralisation is on the eastern side of this anticline and is confined to the Upper Joffre Member. However, additional mineralisation occurs within the core of the anticline in the Dales Gorge Member. Much of the mineralisation is overlain with Quaternary Detritals (alluvium and colluvium). Although not fully characterised, existing data suggest in broad terms that geology is similar both inside and outside the proposed mine pits of the Iron Valley Project and the proposed pit boundaries reflect the extent of economic grade ore rather than prospective subterranean fauna habitat.

The local aquifer system at the Iron Valley Project extents to a depth of at least 170 m and the system comprises three main aquifers:

- Alluvium, colluvium and Tertiary detritals
- Weathered and fractured bedrock of the Brockman Iron Formation and Weeli Wolli Formation
- Mineralised zones that comprise the orebody within the Brockman Iron Formation

Hydrology of the Iron Valley Project is complex. The Project lies on the western side of a valley containing Weeli Wolli Creek. Groundwater levels typically reflect surface elevation and so are higher in the scarp to the west than in the valley and creek line. However, the Iron Valley deposit is bisected by a dolerite dyke, which runs east/west. The dyke is part of a regional feature approximately 150 km in length (Appendix 2) and interrupts the northwards flow of groundwater towards the mouth of Weeli Wolli Creek. The interruption of flow appears to be a localised feature, with the watertable being approximately 40 m higher to the south of the dyke than downstream on the northern side (Appendix 3). Around the dyke, gradients are affected by local topography and creek lines. Thus, it is likely that the southern pit, and much of the Iron Valley deposit, is separated from the regional aquifer. In contrast, the northern pit and northern section of the deposit are probably linked to the regional aquifer.

3. EXISTING INFORMATION ON SUBTERRANEAN FAUNA

There are two kinds of subterranean fauna: stygofauna and troglofauna. Stygofauna are aquatic and occur in groundwater. Troglofauna are air-breathing and occur in underground cavities, fissures and interstitial spaces above the watertable. Nearly all subterranean fauna are invertebrates, although both stygofaunal fish and troglofaunal reptiles have been recorded in WA (Whitely 1945; Aplin 1998).

The Pilbara is recognised as a global hotspot for stygofauna (Eberhard *et al*. 2009) and emerging evidence suggests the same is true for troglofauna (see Biota 2005a, 2006; Subterranean Ecology 2007; Bennelongia 2008a, b, c, 2009a, b).

3.1. Troglofauna

While the earliest work on troglofauna was focussed on their occurrence in caves, surveys during the past five years have shown that troglofauna are widespread in the landscape matrix of the Pilbara and are represented by many invertebrate groups, including isopods, palpigrads, spiders, schizomids, pseudoscorpions, harvestmen, millipedes, centipedes, pauropods, symphylans, diplurans, silverfish, cockroaches, bugs, beetles and fungus-gnats. Although abundance and diversity of troglofauna appear to be greatest in the Pilbara, at a regional scale troglofauna are ubiquitous in WA outside caves and have been recorded from the Kimberley (Harvey 2001), Cape Range (Harvey *et al*. 1993), Barrow Island (Biota 2005b), Mid-West (Ecologia 2008) and Yilgarn (Bennelongia 2009c), and South-West (Biota 2005a).

Much of the focus of troglofauna survey for environmental assessment has been in areas of pisolite and banded iron ore. The micro-habitats that troglofauna occupy within these lithologies are still being determined but it is inferred that they utilise the fissures and voids associated with weathering, enrichment and faulting (see Section 2.0). There is relatively little information about the occurrence of troglofauna outside mineralized habitats because mine development has been the primary reason for most of the sampling programs. However, it has been shown that troglofauna also occur in calcrete and alluvium in the Pilbara (Edward and Harvey 2008; Rio Tinto 2008), Yilgarn (Barranco and Harvey 2008; Platnick 2008; Bennelongia 2009c) and elsewhere (Biota 2005a, b).

3.2. Stygofauna

Survey of stygofauna in the Pilbara began in the 1990s (Humphreys 1999), with a rapid increase in knowledge over the last decade as a result of the systematic stygofauna sampling during the Pilbara Biological Survey (see Eberhard *et al*. 2005, 2009). It has been estimated that the Pilbara has between 500 and 550 stygofauna species, with the density of species being relatively uniform across the region (Eberhard *et al*. 2009). Alluvium and calcrete are usually considered to be the most productive habitats for stygofauna, although mafic volcanics may support rich populations and stygofauna occur in moderate abundance in banded iron formations (Halse *et al*. in prep.).

4. PROJECT IMPACTS

Activities that cause direct *habitat loss* are considered to be the primary impacts likely to lead to extinction of subterranean species. At the Iron Valley Project these primary impacts are:

1. *Pit excavation*. Removal of troglofauna habitat is likely to lead to significant risk to restricted troglofauna species.
2. *Groundwater drawdown.* Drawdown of aquifers to for potable and non-potable water supply is likely to lead to some risk to restricted stygofauna species due to loss of habitat.

The ecological impacts of activities that reduce the quality of subterranean fauna habitat have been little studied in Australia (or elsewhere) but it is considered that these impacts are more likely to reduce population size than cause species extinction (see Scarsbrook and Fenwick 2003; Masciopinto *et al*. 2006). Therefore, these impacts are considered to be of secondary importance.

Mining activities at the Iron Valley Project that may result in secondary impacts to subterranean fauna include:

1. *Groundwater drawdown below troglofauna habitat*. The impact of a lowered water table on subterranean humidity and, therefore, the quality of troglofauna habitat is poorly studied, but it may represent risk to troglofauna species in some cases. The extent to which humidity of the vadose[1] zone is affected by depth to the watertable is unclear. Given that pockets of residual water probably remain trapped throughout areas drawn-down and keep the overlying substrate saturated with water vapour, drawdown may have minimal impact on the humidity in the unsaturated zone. In addition, troglofauna may be able to avoid undesirable effects of a habitat drying out by moving deeper into the substrate if suitable habitat exists at depth. Overall,

[1] The zone between the surface and groundwater

drawdown outside the proposed mine pits is not considered to be a significant risk to troglofauna.

2. *Percussion from blasting*. Impacts on both stygofauna and troglofauna may occur through the physical effect of explosions. Blasting may also have indirect detrimental effects through altering underground structure (usually rock fragmentation and collapse of voids) and transient increases in groundwater turbidity. The effects of blasting are often referred to in grey literature but are poorly quantified and have not been related to ecological impacts. Any effects of blasting are likely to dissipate rapidly with distance from the pit and are not considered to be a significant threat to either stygofauna or troglofauna outside the proposed mine pits.
3. *Overburden stockpiles and waste dumps*. These artificial landforms may cause localised reduction in rainfall recharge and associated entry of dissolved organic matter and nutrients because water runs off stockpiles rather than infiltrating through them and into the underlying ground. The effects of reduced carbon and nutrient input are likely to be expressed over many years and are likely to be greater for troglofauna than stygofauna (because lateral movement of groundwater should bring in carbon and nutrients). The extent of impacts on troglofauna will largely depend on the importance of chemoautotrophy[2] in driving the subterranean system compared with infiltration-transported surface energy and nutrients. Stockpiles are unlikely to cause species extinctions, although population densities of species may decrease.
4. *Aquifer recharge with poor quality water*. Quality of recharge water declines during, and after, mining operations as a result of rock break up and soil disturbance (i.e. Gajowiec 1993; McAuley and Kozar 2006). Impacts can be minimised through management of surface water and installing drainage channels, sumps and pump in pits to prevent of recharge though the pit floor.
5. *Contamination of groundwater by hydrocarbons*. Any contamination is likely to be localised and may be minimised by engineering and management practices to ensure containment.

5. METHODS

5.1. Survey Rationale

The subterranean fauna survey at Iron Valley was conducted in accordance with the principles laid out in EPA Guidance Statements Nos 54 and 54a (EPA 2003, 2007).

The impact area for troglofauna, as a result of proposed mining at the Iron Valley Project, was defined as the area to be excavated for the mine pits (Figure 5.1). Reference bores, sampled to show the wider distribution of the troglofauna species collected in the mine pits, were located outside the pits but within the Iron Valley Project tenement (Figure 5.1). Troglofauna were also collected from other sampling programs at nearby IOH iron ore deposits, namely the Extension tenement (26 km west-northwest of the Iron Valley Project), Phil's Creek tenement (12 km west) and Horse Shoe tenement (34 km west-southwest) to show wider distribution of species (Figure 1.1).

The impact area for stygofauna, as a result of proposed mining at the Iron Valley Project, is defined as the area which would be drawn-down for potable and non-potable water supply and was set as groundwater drawdown of greater than 2 m. This is above the natural seasonal variation of about 2 m (Johnson and Wright 2001) has typically been accepted as beginning to have the potential to impact on stygofauna in the Pilbara. It should be noted that the groundwater drawdown at the Iron Valley Project is expected to have a maximum depth of only 8 m.

[2] Microbial oxidation of inorganic compounds as an energy source

5.2. Troglofauna

5.2.1. Sampling Effort

A total of 86 impact and 82 reference samples were collected during three sampling rounds from 115 drill holes within the Iron Valley Project (Table 5.1, Figure 5.1). Round 1 sampling was conducted from 13 to 18 May 2009 (scraping and setting traps) and on 8 and 9 July 2009 (retrieving traps). Round 2 sampling was conducted from 3 to 6 November 2009 (scraping and setting traps) and between 11 and 13 January 2010 (retrieving traps). Round 3 sampling was conducted at the request of the Department of Environment and Conservation (DEC) on the 11 October 2011 (scraping and setting traps). Traps were retrieved on 6 December 2011. The purpose of the sampling was to make further efforts to collect species previously known only from within the mine pit. A list of bores sampled is given in Appendix 4.

Table 5.1. Numbers of troglofauna samples collected from Iron Valley.

Round 1	Impact	Reference
Scrape	47	27
S Trap	32	20
D Trap	14	7
Samples	*47**	*27*
Round 2		
Scrape	38	22
S Trap	25	17
D Trap	14	5
Samples	*39**	*22*
Round 3		
Scrape		33
S Trap		25
D Trap		8
Samples		*33*
Total Samples	**86**	**82**

Samples consisted of a scrape and trapping event with one or two traps, S trap, one trap; D trap, two traps (shallow and deep). *In two cases, either a trap or scrap was not collected owing to sampling difficulties. Calculation of total sampling effort is based on all sampling (i.e. scrape alone or a scrape with trap/s) during a visit to a site being considered as one sample.

5.2.2. Sampling Methods

In nearly all cases, each troglofauna sample was collected using two separate techniques that provided separate subsamples. The two techniques were trapping and scraping.

1. *Trapping*. Custom made cylindrical PVC traps (270 x 70 mm, entrance holes side and top) were used for trapping. Traps were baited with moist leaf litter (sterilised by microwaving) and lowered on nylon cord to within a few metres of the watertable or end of the drill hole. In every fourth hole, a second trap was set mid-way down the hole. Drill holes were sealed while traps were set to minimise the ingress of surface invertebrates. Traps were retrieved seven or eight weeks later and their contents (bait and captured fauna) were emptied into a zip-lock bag and road freighted to the laboratory in Perth.
2. *Scraping*. Prior to setting traps, holes were scraped. This was done by lowering a troglofauna net (weighted net, 150 µm mesh with variable aperture according to diameter) to the bottom of the drill hole, or to the watertable, and scraping back to the surface along the walls of the hole. Each scrape comprised four drop and retrieve sequences with the aim of scraping any troglofauna on the walls into the net. After each scrape, the contents of the net were transferred to a 125 ml vial and preserved in 100% ethanol.

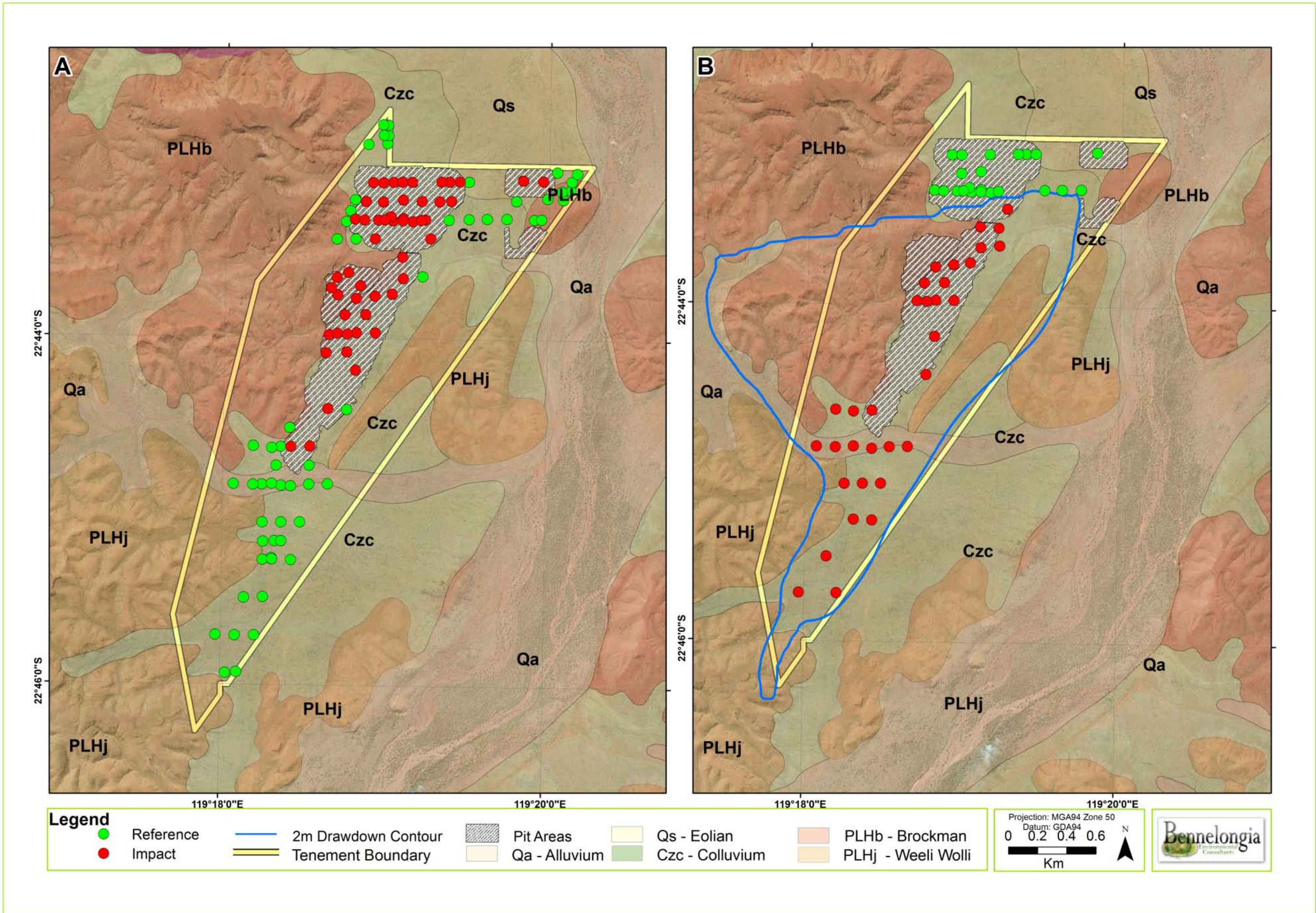


Figure 5.1. Locations of drill holes sampled for troglofauna (A) and stygofauna (B) at the Iron Valley Project.

5.2.3. Sample Sorting and Species Identification

Troglofauna caught in traps were extracted from the leaf litter using Berlese funnels under halogen lamps. Light drives troglofauna and soil invertebrates out of the litter into the base of the funnel containing 100% ethanol (EPA 2007). After about 72 hours, the ethanol and its contents were removed and sorted under a dissecting microscope. Litter from each funnel was also examined under a microscope for any remaining live or dead animals.

Preserved scrapes were elutriated to separate animals from heavier sediment and sieved into size fractions (250, 90 and 53 µm) to remove debris and improve searching efficiency. Samples were then sorted under a dissecting microscope.

All fauna picked from samples were examined for troglomorphic characteristics (lack of eyes and pigmentation, well developed sensory organs, elongate appendages, vermiform body shape). Surface and soil-dwelling species were identified only to Order level. Troglofauna were identified to species or morphospecies level, unless damaged, juvenile or the wrong sex for identification (EPA 2007). Identifications were made under dissecting and/or compound microscope, with specimens being dissected as necessary. Unpublished and informal taxonomic keys were used to assist identification of taxa for which no published keys exist.

Representative animals will be lodged with the WA Museum after the assessment process has been completed.

5.3. Stygofauna

5.3.1. Sampling Effort

A total of 49 impact and 35 reference samples were collected from within the Iron Valley Project (Table 5.2, Figure 5.1). Round 1 sampling was conducted from 13 to 15 May 2009 and Round 2 sampling was conducted between 3 and 6 November 2009. A complete list of bores sampled is given in Appendix 5. To comply with DEC's request that further stygofauna sampling should be conducted outside the expected extent of groundwater drawdown, a further 27 bores were sampled at IOH's Yandicoogina, Boundary and Phil's Creek deposits in the Weeli Wolli catchment between 10 and 13 October 2011. These deposits are 15, 44 and 12 km from Iron Valley (Figure 1.1). Sampling details are not provided because no relevant stygofauna species were collected and the sampling occurred in tenements that are not the subject of this assessment. The purpose of the sampling was to demonstrate wider distribution of stygofauna species currently known only from Iron Valley. A list of bores sampled is given in Appendix 5.

Table 5.2. Numbers of stygofauna samples collected from Iron Valley.

	Impact	Reference
Round 1	21	20
Round 2	28	15
Total Samples	**49**	**35**

5.3.2. Sampling Methods

Stygofauna sampling followed the methods outlined in Eberhard *et al*. (2005) and recommended by the EPA (2007). At each bore, six net hauls were collected using a weighted plankton net. After the net was lowered to the bottom of the bore it was jerked up and down briefly to agitate benthic and epibenthic stygofauna into the water column prior to a slow retrieve of the net. Contents of the net were transferred to a 125 ml polycarbonate vial after each haul and the contents were preserved in 100% ethanol. Nets were washed between bores to minimise contamination between sites. Three hauls were taken using a 50 µm mesh net and three with a 150 µm mesh net.

Electrical conductivity (used to infer salinity), pH, and temperature were measured at each bore using a Yeo-Cal water quality analyser.

5.3.3. Species Sorting and Identification

In the laboratory, samples were elutriated to separate out heavy sediment particles and sieved into size fractions using 250, 90 and 53 µm screens. All samples were sorted under a dissecting microscope. Sorted animals were identified to species or morphospecies using available keys and species descriptions. When necessary, animals were dissected and examined under a compound microscope. Morphospecies determinations were based on characters used in species keys.

5.4. Compiling Species Lists

Identifications of animals that could not be identified to species/morphospecies level (i.e. family level identification of a specimen that was immature or damaged) were included in calculations of species richness only if the specimens could not belong to species already recorded. For example, specimens of *Draculoides* sp. and *Draculoides* sp. B04 were treated as a single species because it was likely that the animals identified to genus *Draculoides* were, in fact, those already recorded as *Draculoides* sp. B04. The purpose of this criterion was to prevent higher level identifications falsely inflating species richness.

5.5. Personnel

Fieldwork was undertaken by Sean Bennett, Jim Cocking, Mike Scanlon, Dean Main and Andrew Trotter. Sample sorting was done by Jane McRae, Lucy Gibson, Jeremy Quartermaine, Sean Bennett, Mike Scanlon, Jim Cocking, Heather McLetchie, Grant Pearson, Dean Main and Andrew Trotter. Identifications were made by Jane McRae, Mike Scanlon and Stuart Halse.

5.6. Other Sampling

Both troglofauna captured as by-catch from stygofauna sampling and stygofauna captured during troglofauna sampling are included in species lists and interpretations of species distributions.

6. RESULTS

6.1. Troglofauna

6.1.1. Troglofauna Occurrence and Abundance

Sampling at Iron Valley yielded 112 troglofaunal animals, representing seven Classes, 11 Orders and 16 species (Table 6.1, Table 6.2). Two arachnid Orders were recorded: Pseudoscorpionida (1 species) and Schizomida (1 species). The only crustacean Order collected was Isopoda (3 species). Chilopoda were represented by one species of an unknown Order (the damaged specimen could not be further identified morphologically). Diplopoda were represented by Polyxenida (1 species) and Symphyla by Cephalostigmata (1 species). There were five Orders of hexapods (Entognatha/Insecta): Diplura (2 species), Blattodea (2 species), Hemiptera (2 species), Coleoptera (1 species) and Diptera (1 species). (Table 6.1, Figure 6.1).

Table 6.1. Troglofauna species recorded at the Iron Valley Project with known distribution indicated.

Higher Groups		Species	Number of individuals		Known from outside impact area
			Impact	**Reference**	
Arachnida					
	Pseudoscorpionida				
		Lagynochthonius sp. B02	1		Yes, known from IOH Yandicoogina tenement; and elsewhere in the Hamersley Range[1,2]
	Schizomida				
		Draculoides sp. B04	2	1	Yes
Crustacea					
	Isopoda				
		Armadillidae sp. B04	1		Yes, known elsewhere in the Hamersley Range[2]
		Troglarmadillo sp. B26	5		Yes, known elsewhere in the Hamersley Range[2]
		nr *Andricophiloscia* sp. B03		1	Yes, from reference bores only
Chilopoda					
		Chilopoda sp.	1		Uncertain
Diplopoda					
	Polyxenida				
		Lophoproctidae sp. B01	3		Yes - very widespread species[1]
Symphyla					
	Cephalostigmata				
		Symphyella sp. B05		1	Yes, from reference bore and from Phil's Creek[2]
Entognatha					
	Diplura				
		Projapygidae sp. B02		1	Yes, from reference bore only
		Japygidae sp. B04	1		Yes - very widespread species[1]
Insecta					
	Blattodea				
		Nocticola sp. B01	3		Yes - very widespread species[1]
		Nocticola sp. B09	2	1	Yes
	Hemiptera				
		Meenoplidae sp.		6	Probably - one of two widespread species[1]
		Hemiptera sp. B01	1		Yes - very widespread species[1]
	Coleoptera				
		Staphyliinidae sp. B01		43	Yes, from reference bores only
	Diptera				
		Sciaridae sp. B01	8	22	Yes - very widespread species[1]

[1]Bennelongia 2009a; [2]Bennelongia unpublished data.

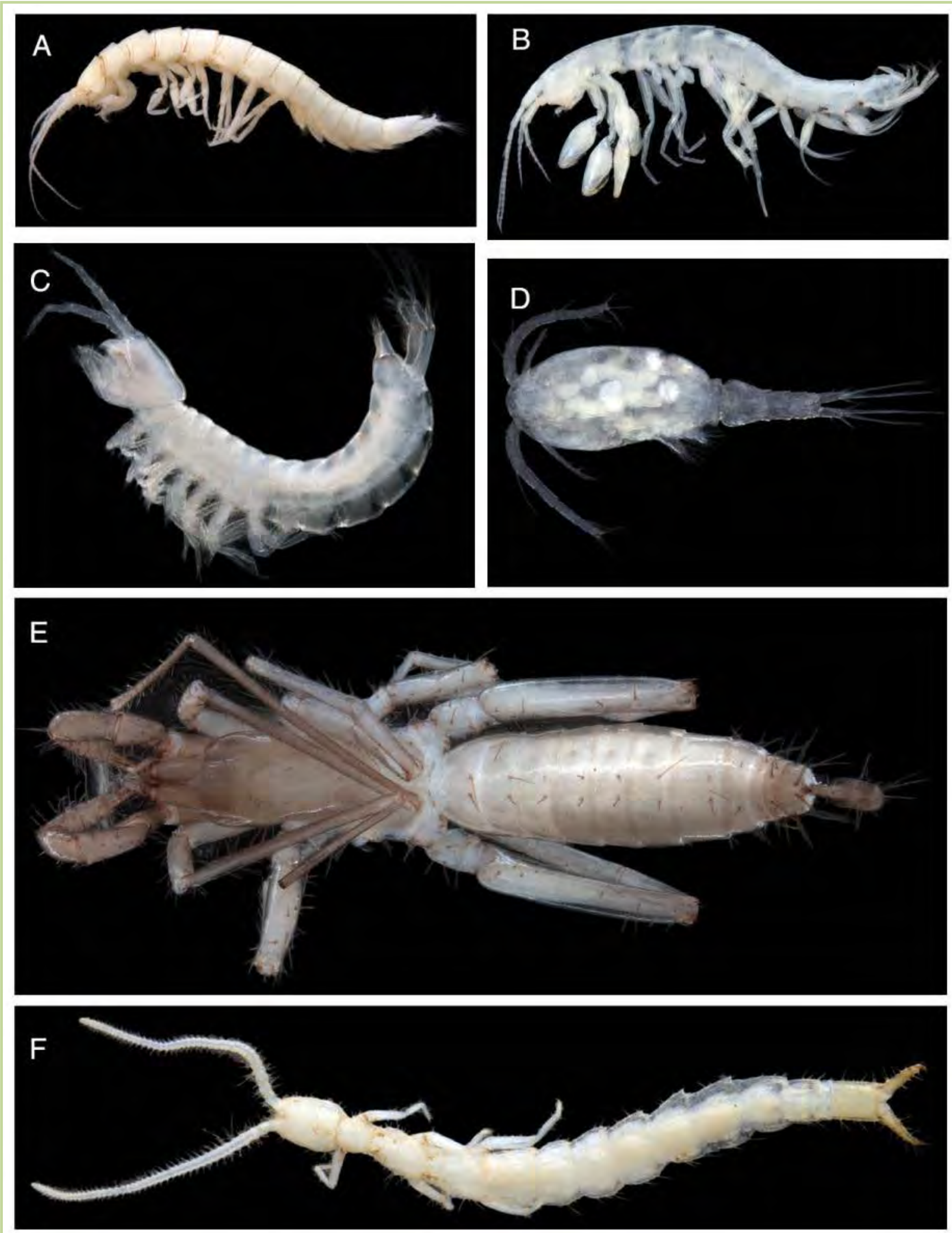


Figure 6.1. Stygofauna (A-D) and troglofauna photographs (E-F).
(A) *Pygolabis* sp. B06 (B) *Maarrka weeliwollii* (C) nr *Billibathynella* sp. B01 (D) *Thermocyclops aberrans* (E) *Draculoides* sp. B04 (F) Japygidae sp. B04.

Table 6.2. Higher level identifications (immature or incomplete specimens).

Higher Groups		Taxa	Number of individuals		Probable species
			Impact	Reference	
Arachnida					
	Schizomida				
		Draculoides sp.		2	*Draculoides* sp. B04
Entognatha					
	Diplura				
		Diplura sp.	1		Projapygidae sp. B02 or Japygidae sp. B04
Insecta					
	Blattodea				
		Nocticola sp.	2	3	*Nocticola* sp. B01 or *Nocticola* sp. B09

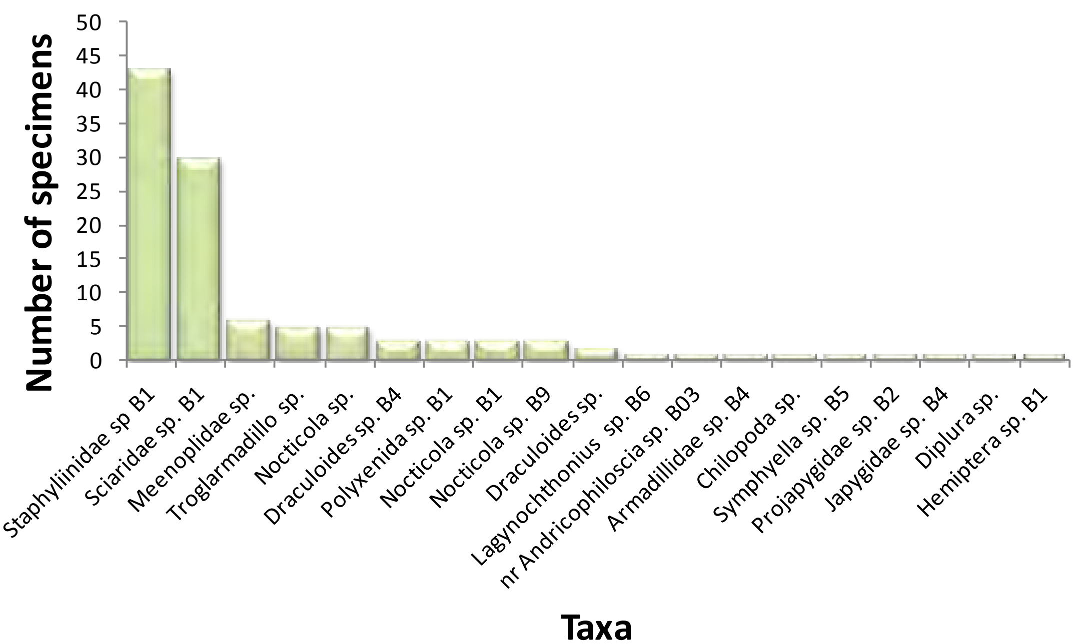


Figure 6.2. Capture abundance of each troglofauna species at the Iron Valley Project.

Seven animals were collected that did not appear to represent additional species, but which could not be properly identified to species level because they were damaged, juvenile or the wrong sex (Table 6.2). All are likely to belong to species in Table 6.1.

Staphyliinidae sp. B01 and Sciaridae sp. B01 were the numerically dominant species within the Iron Valley Project (Table 6.1, Figure 6.2). Nearly all other species were collected in low abundance (≤5 specimens) and eight species were recorded as singletons, i.e. only one animal of that species was collected during the study (Table 6.1; excluding unidentifiable specimens). Three of these singleton species (Japygidae sp. B04, *Symphyella* sp. B05 and Hemiptera sp. B01) have been previously recorded elsewhere in the central Pilbara (Table 6.1, Bennelongia 2009a, b, unpublished data).

The number of troglofaunal specimens collected per sample was about three times higher from reference bores than impact bores (Table 6.3). However, the number of species per sample was essentially the same for reference and impact bores (Table 6.3). The number of species collected within the mine pit (11) was higher than in the reference area (8) (Table 6.3).

Table 6.3. Summary statistics of troglofauna sampling at the Iron Valley Project.

Bore type	No. of Samples	Total Specimens	Mean specimens per sample	No. of Species	Mean species per sample
Impact	86	31	0.36	11	0.20 ± 0.06
Reference	82	81	0.99	8	0.20 ± 0.02

6.1.2. Troglofauna Species of the Proposed Mine Pits

Eleven of the 16 species recorded at the Iron Valley Project were recorded within the proposed mine pits (i.e. the impact area) (Table 6.1). Of these 11 species, 10 species are known to occur in reference areas outside the mine pits or at deposits elsewhere in the Pilbara. One species, Chilopoda sp. (recorded as a singleton based on a damaged specimen) is only known from the proposed mine pit (Figure 6.3). The taxonomy of this specimen cannot be taken further and, therefore, its range cannot be determined.

6.1.3. Troglofauna Distributions

Overall, about two-thirds of the troglofauna species collected are known from outside the Project area. Given that three species are known only from their singleton records at Iron Valley and most animals occurred in low abundance, making it likely their ranges are under-estimated; it appears that the troglofauna community of Iron Valley is not restricted to the Project area.

For example, five species (Lophoproctidae sp. B01, Japygidae sp. B04, *Nocticola* sp. B01, Hemiptera sp. B01 and Sciaridae sp. B01) are very widespread and known from many locations in the Pilbara (Table 6.1, Bennelongia 2009a, b). A sixth species, Meenoplidae sp. (represented by five nymphs from a reference hole), probably belongs to one of two species that are very widespread in the Pilbara (Table 6.1, Bennelongia 2009a). A seventh species, *Symphyella* sp. B5, is known from Phil's Creek approximately 12 km from the Iron Valley Project and an additional three species, *Lagynochthonius* sp. B02, Armadillidae sp. B04 and *Troglarmadillo* sp. B26, are known more locally in the Hamersley Range (Table 6.1).

6.1.4. Sampling Efficiency

Documenting the composition of troglofauna communities and the distribution of the species within them is difficult because a high proportion of troglofauna species occur in low abundance. At the Project site, 13% of all troglofaunal animals represented two-thirds of all species. Only two species were represented by more than five animals (Figure 6.2).

Despite the low abundance of most individual species, the average number of troglofaunal animals caught at the Iron Valley Project was 0.66 per sample, which is well above the historical capture rate of 0.25 for the Pilbara (Subterranean Ecology 2007). Capture rates were higher in the reference area than impact area (0.99 specimens per sample versus 0.36, in Table 6.3). Scraping and trapping gave similar yields but reference bores yielded better than impact bores (Figure 6.4).

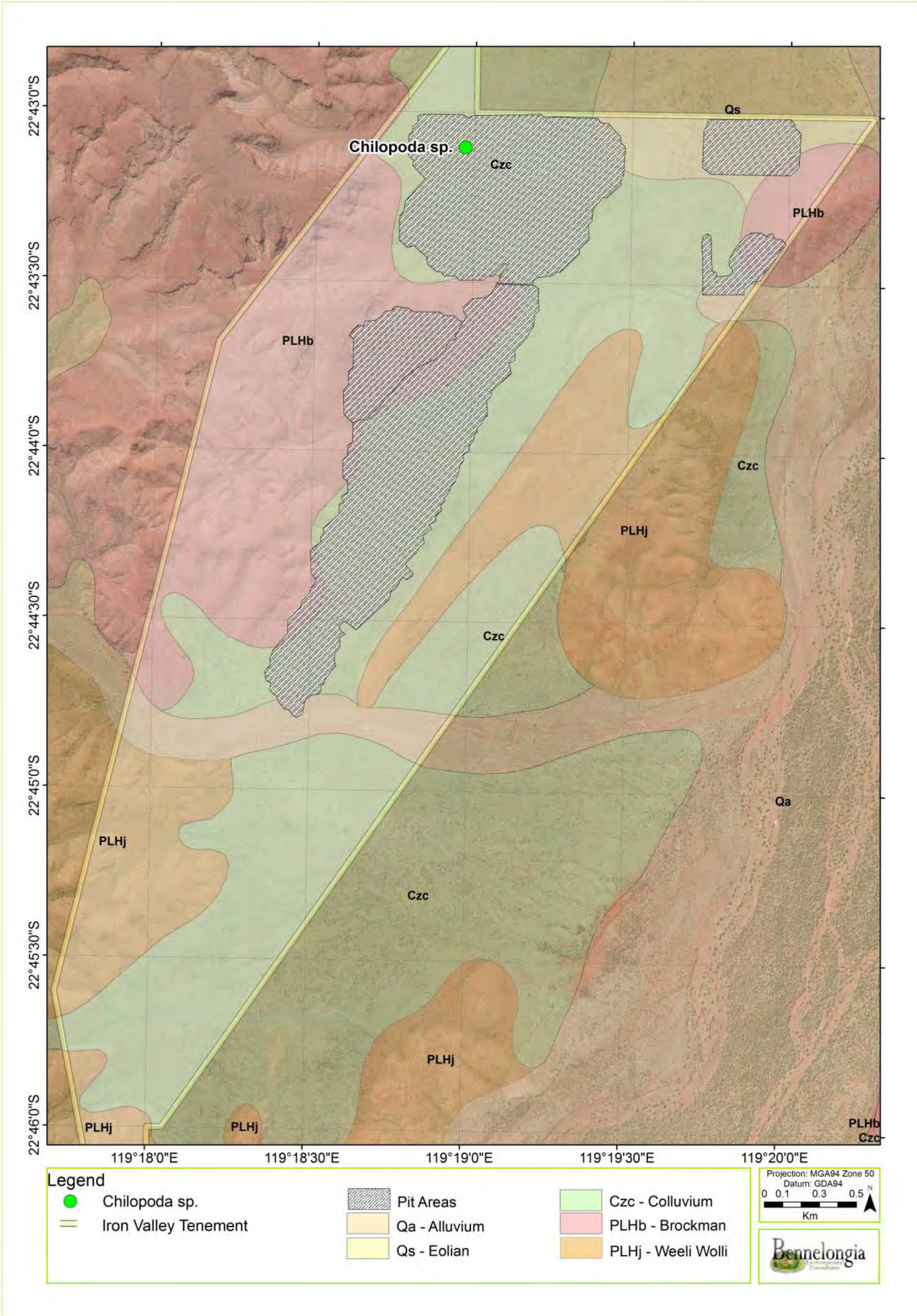


Figure 6.3. Locations of specimens of troglofauna species collected only from impact bores.

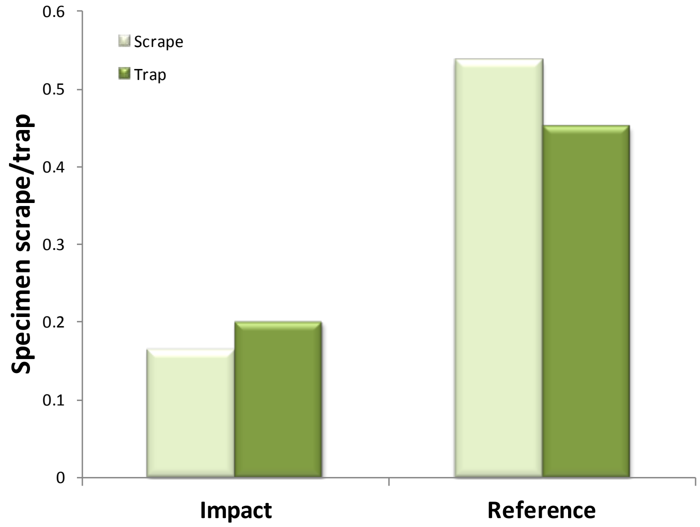


Figure 6.4. Comparison of capture rates between scraping and trapping.

6.2. Stygofauna

6.2.1. Stygofauna Occurrence and Abundance

Stygofauna sampling yielded 2,153 specimens of at least 23 species of eight Orders, including Tubificida (3 species), Hydracarina (1 species), Ostracoda (3 species), Copepoda (4 species), Syncarida (3 species), Amphipoda (7 species), Isopoda (1 species) and nematodes of unknown order/s (Table 6.4, Figure 6.1).

Copepods were the numerically dominant group within the Iron Valley Project, with species of oligochaetes, amphipods and syncarids also relatively abundant (Table 6.4, Figure 6.5). *Diacyclops humphreysi humphreysi*, *Thermocyclops aberrans* and nr *Billibathynella* sp. B01 were the most numerous species (Table 6.4, Figure 6.5). The majority of taxa were collected at low abundance with the most abundant third of the species accounting for 91% of all the animals collected and the least abundant third only 1% (Figure 6.5).

The number of stygofaunal specimens collected per sample was about three times higher from impact bores than bores reference (Table 6.6). While, the number of species per sample was about double that in impact bores compared to reference bores (Table 6.6). The number of species collected from impact bores (22) was higher than that from reference bores (13) (Table 6.6).

6.2.2. Species Identification Issues

Some stygofauna could not be identified to species level (Table 6.3). It is probable that all belong to species in Table 6.4 but in most cases the animals were too juvenile or damaged for identification below Family or Order level. Table 6.4 contains one species identified only to genus level (*Bathynella* sp.).

The taxonomy of *Bathynella* in Australia is poorly resolved and Iron Valley specimens cannot be compared reliably with specimens from elsewhere in the Pilbara, although it is considered that a single species occurs at Iron Valley. The taxonomy of *Chydaekata* sp. has been the subject of considerable genetic research and it is believed a single species of *Chydaekata* in present within the Weeli Wolli/Marillana catchment (see Finston and Johnson 2004; Finston *et al*. 2007). This species has been recorded from a number of locations on Weeli Wolli Creek and the Fortescue Marsh, with the closest record to Iron Valley being 6.5 km away.

Table 6.4. Stygofauna species recorded from the Iron Valley Project.
All specimens collected from impact area. Number of animals and whether species are known from outside impact area are shown.

Higher Groups		Species	Impact	Reference	Known from outside of impact
Nematoda					
		Nematoda sp.	15		Not assessed in EIAs, widespread in the Pilbara
Oligochaeta	Tubificida				
		Phreodrilid with dissimilar ventral chaetae	27		Yes, Pilbara-wide[1]
		Phreodrilid with similar ventral chaetae	23		Yes, Pilbara-wide[1]
		Enchytraeus Pilbara sp. 1	126	6	Yes, Pilbara-wide[1]
Acariformes					
	Hydracarina				
		Recifella sp. P1 (nr *umala*)	1		Yes, central Pilbara[1]
Crustacea	Ostracoda				
		Humphreyscandona 'janeae'		3	Reference are only, and widespread in the Fortescue catchment[1]
		Meridiescandona lucerna	9	31	Yes, and also more widely in the Fortescue catchment[1]
		Meridiescandona sp. BOS 171	47		No
	Copepoda				
		Microcyclops varicans	158		Yes, Pilbara-wide and beyond[2]
		Diacyclops cockingi	1	33	Yes, Pilbara-wide[3]
		Diacyclops humphreysi humphreysi	617	178	Yes, Pilbara-wide and beyond[4]
		Thermocyclops aberrans	223	100	Yes, central Pilbara[5]
	Syncarida				
		Bathynella sp.	3		Uncertain
		nr *Billibathynella* sp. B01	298		Yes, known from lower Weeli Wolli and Marillana Creeks[6]
		Atopobathynella sp. B07	2		Yes, known from Marillana Creek[6]
	Amphipoda				
		Maarrka weeliwollii	2	1	Yes, widespread in Weeli Wolli/Marillana catchment[6,7]
		Chydaekata sp. E	9	1	Yes, widespread in Weeli Wolli/Marillana catchment[6,8]
		Paramelitidae Genus 2 sp. B01	87	6	Yes, lower Weeli Wolli Creek[2]
		Paramelitidae Genus 2 sp. B02	30	7	Yes, widespread in Weeli Wolli/Marillana catchment[6]
		Paramelitidae sp. B16	44	1	Yes, known from lower Weeli Wolli and Marillana Creeks[6]
		Paramelitidae sp. B03	2	1	Yes, widespread in Weeli Wolli/Marillana catchment[6]
		Paramelitidae sp. B26	3	10	Yes, known from southern floodplain of the Fortescue Marsh[6]
	Isopoda				
		Pygolabis sp. B06	11		Yes, known from lower Weeli Wolli and Marillana Creeks[6]

[1]Halse *et al*. unpublished data; [2]Sars (1863); [3]Karanovic (2006); [4]Pesce and De Laurentiis (1996); [5]Lindberg (1952); [6]Bennelongia unpublished data; [7]Finston *et al*. (2011); [8]Finston *et al*. (2009).

Table 6.5. Higher level stygofauna identifications (immature or incomplete specimens).
Number of animals collected and probable species is shown.

Higher Groups	Taxa	Impact	Reference	Probable species
Oligochaeta				
Tubificida				
	Enchytraeidae sp.	12	1	*Enchytraeus* Pilbara sp. 1
Crustacea				
Ostracoda	Ostracoda sp.	2		One of the three ostracods in Table 6.4
Copepoda				
	Diacyclops sp.		2	*Diacyclops humphreysi humphreysi* or *Diacyclops cockingi*
	Thermocyclops sp.	2		*Thermocyclops aberrans*
Amphipoda				
	Amphipoda sp.	1	3	One of the amphipods in Table 6.4
	Paramelitidae sp.	10	3	One of the paramelitid in Table 6.4
Isopoda				
	Pygolabis sp.	1		*Pygolabis* sp. B06

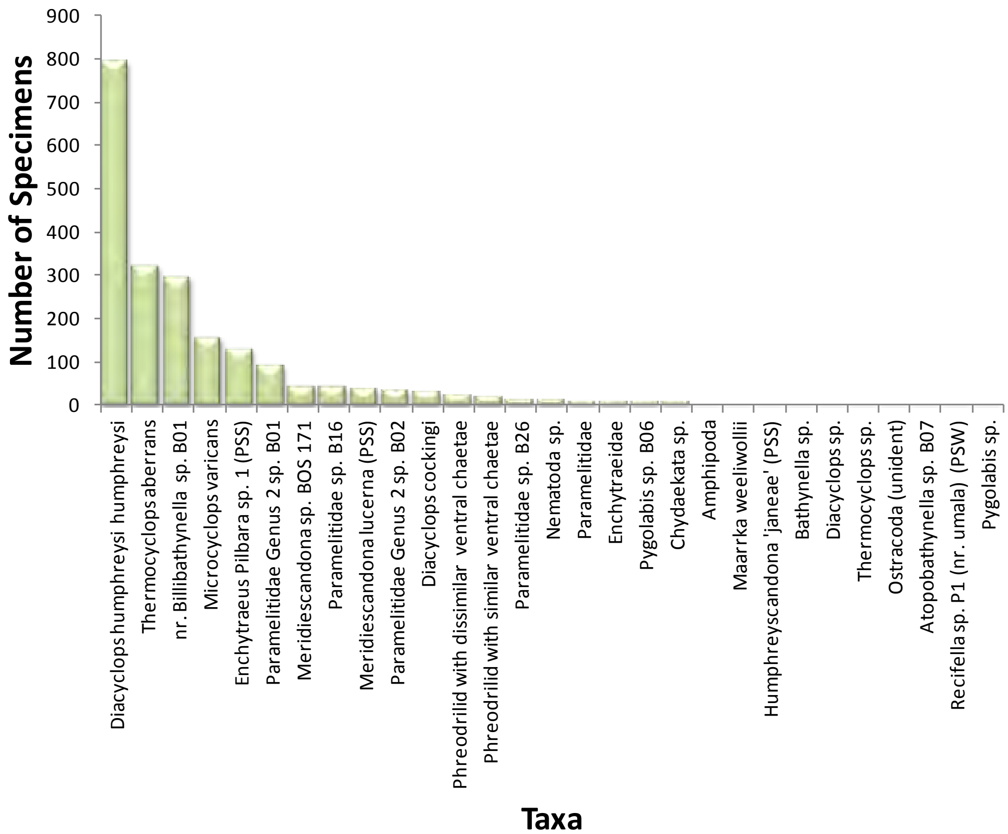


Figure 6.5. Capture abundance of each stygofauna species at the Iron Valley Project.

Table 6.6. Summary statistics of stygofauna sampling at the Iron Valley Project.

Bore type	No. of Samples	Total Specimens	Mean specimens per sample	No. of Species	Mean species per sample
Impact	49	1764	36	22	1.77 ± 0.27
Reference	35	389	11.1	13	0.71 ± 0.12

6.2.3. Stygofauna Species of the Proposed Drawdown Cone

Twenty-two stygofauna species were recorded from within the proposed drawdown cone and all but two of these species are known from elsewhere (Table 6.4). The remaining two species potentially have more localised ranges (Figure 6.6). The ostracod *Meridiescandona* sp. BOS 171 has to date been collected only from the area that will be impacted by groundwater drawdown, where it has been found in five drill holes. The syncarid *Bathynella* sp. has also been collected only from the area that will be impacted by groundwater drawdown (twice at bore WW010). However, it is uncertain if *Bathynella* sp. is a new species (due to the genus level identification) and these specimens may be conspecific with specimens of *Bathynella* that have been previously collected about seven kilometres south-west of the Iron Valley Project (Figure 6.7).

6.2.4. Stygofauna Distributions

Seven of the stygofauna species collected at the Iron Valley Project are very widespread, either known from throughout the Pilbara or beyond (Table 6.4). Four species are known to have relatively extensive ranges in the central Pilbara/Fortescue catchment. Ten species are known from either the Weeli Wolli/Marillana catchment or the southern floodplain of the Fortescue Marsh (Table 6.4).

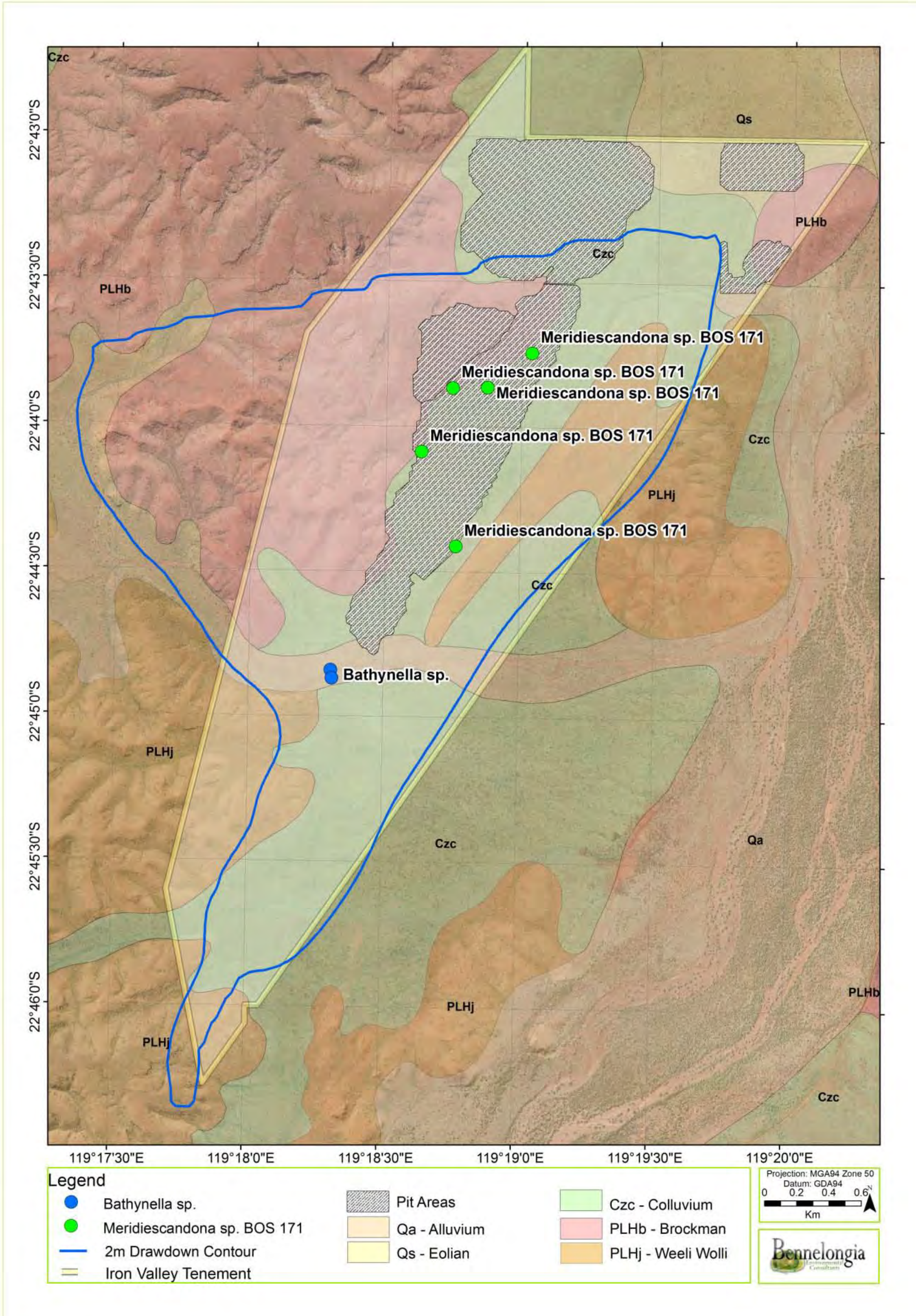


Figure 6.6. Locations of stygofauna species collected only from bores at the Iron Valley Project.
Drawdown cones are expected to extend beyond all of the bores indicated.

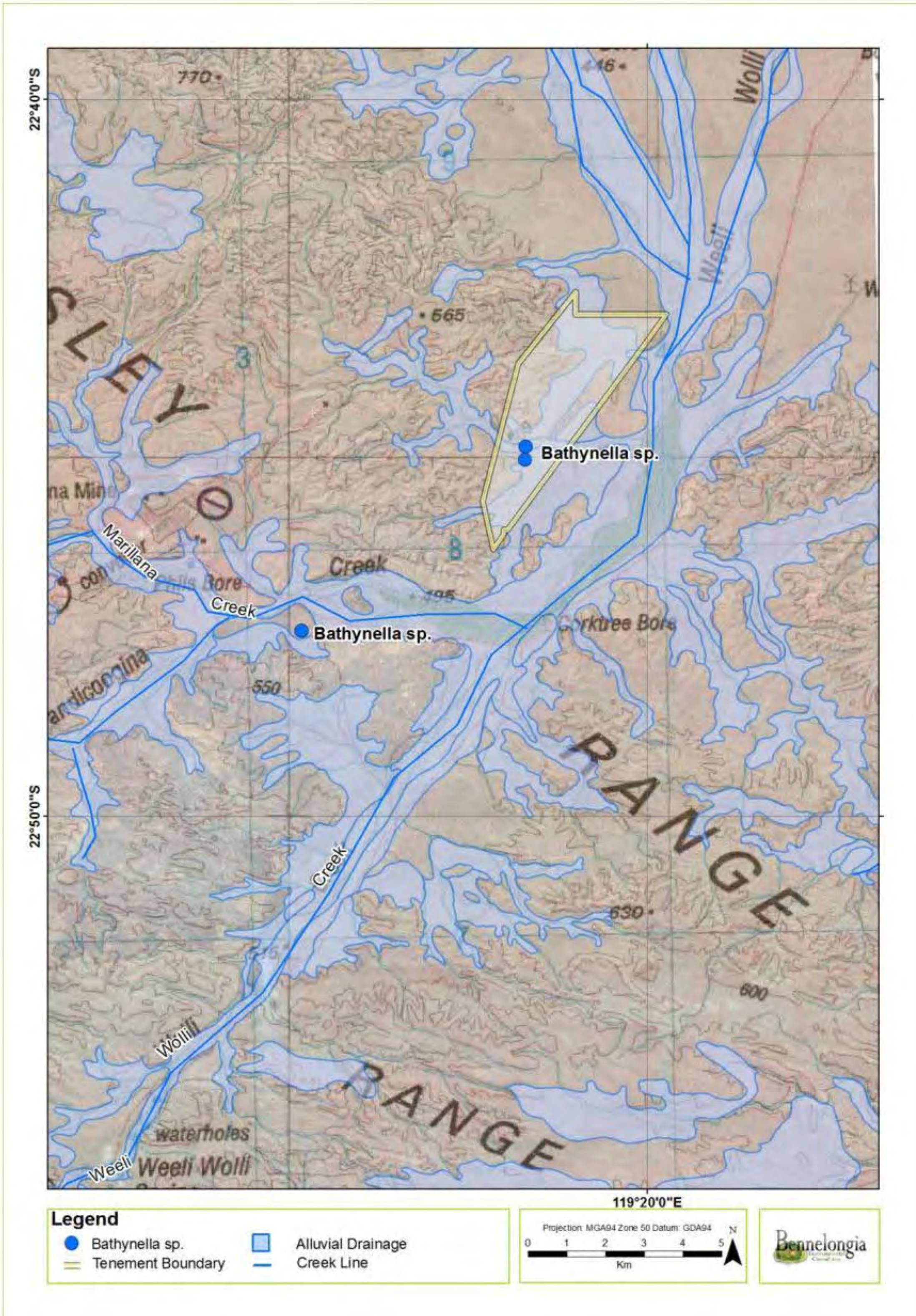


Figure 6.7. Locations of *Bathynella* specimens in the vicinity of the Iron Valley Project.
Specimens from outside the Iron Valley Project were collected during the Pilbara Stygofauna Survey (Halse *et al*. in prep.). Species level relationships are uncertain.

7. DISCUSSION

7.1. Troglofauna

7.1.1. Troglofauna Distributions and Conservation Risks for Species

The range characteristics of different troglofaunal groups in WA are not yet fully described. Troglofauna survey and research has typically focussed on taxonomy and, for the purpose of conservation, the presence or absence of species at particular localities. Little focus has been placed on documenting distributions and the most comprehensive studies to date have been on schizomids, where quite variable (although mostly small) ranges have been identified). Harvey *et al*. (2008) reported that six species of schizomid in the Robe Valley were each tightly restricted to single mesas (the largest only 989 ha), whereas one species (*Draculoides vinei*) in the Cape Range had a linear range of about 50 km.

Many of the troglofauna collected at Iron Valley are known more widely in the Pilbara (Table 6.1). Extensive distributions suggest that species have moderately high dispersal ability, either through possessing a surface dispersal phase in their life cycles or because they inhabit well connected subterranean habitats. Whether very widely dispersed species are obligate troglofauna is sometimes questioned and many such species probably have a surface dispersal phase. However, there seems little doubt that the arachnid species *Draculoides* sp. B04 is a troglobiont. *Draculoides* sp. B04 was found in both impact and reference bores at Iron Valley, suggesting that subterranean habitats within the impact and reference areas are connected. In fact, the true range of *Draculoides* sp. B04 may be considerably greater than demonstrated, owing to the confined distribution of the sampling at the Iron Valley Project and subterranean habitat connections may extend well outside the Iron Valley Project into surrounding areas (see Section 7.1.3).

One species of troglofauna (Chilopoda sp.) is currently known only from within the proposed mine pits at the Iron Valley Project. Chilopoda sp. was recorded as a singleton. The conservation status of this species cannot be quantified because the specimen was too damaged for species identification. It should be noted, however, that:

- All species of Chilopoda collected by Bennelongia in the Pilbara have been collected at very low abundance (110 specimens from over 10,000 troglofauna samples), which makes determination of range very difficult.
- In the rare cases where multiple records for a Chilopoda species exist, they have indicated the species have relatively wide ranges for troglofauna. *Cryptops* sp. B7 and *Cryptops* sp. B10 have been shown to have linear ranges of at least 27 and 90 km, respectively (Bennelongia unpublished data).

7.1.2. Habitat Characterisation

The occurrence of troglofauna is dependent on geology and, if no fissures or voids are present in the strata, no troglofauna will occur. If subterranean spaces are present, the pattern of their occurrence will largely determine the density and distribution of troglofauna. Vertical connectivity with the surface is important for supplying carbon and nutrients to maintain populations of different species (plant roots are an important surface connection), while lateral connectivity of voids is crucial to underground dispersal. Geological features such as major faults and dykes may block off the continuity of habitat and act as barriers to dispersal leading to species having highly restricted ranges.

Although not fully characterised, existing data suggest that, in broad terms, geology is similar both inside and outside the proposed mine pits of the Iron Valley Project. The proposed pit boundaries reflect the extent of economic grade ore rather than prospective subterranean fauna habitat (see Section 2, Appendix 1). The dolerite dyke that transects the Project trending in an east/west direction does not appear to represent a barrier to troglofauna because four species recorded at the Project site are known from both sides of the dyke (Appendix 6). Two of these species are very widespread (Lophoproctidae sp. B01 and Sciaridae sp. B1) and may not be obligate troglofauna but *Nocticola* sp. B09 and *Draculoides* sp. B04 are troglobites.

7.1.3. Iron Valley Troglofauna Community

The 16 species collected from 168 troglofauna samples indicate that the Iron Valley troglofauna community is moderately species rich by Pilbara standards. Large areas such as the Jirrpalpur and Packsaddle Ranges are substantially richer, having about 80 species in total; the larger Cape Preston area is also richer with at least 29 species; while the similar sized Bonnie Creek area south of Nullagine has comparable richness (18 species). The Pardoo area (12 species) and a section of the Chichester Ranges (9 species) seem to have fewer species (Subterranean Ecology 2007; Bennelongia 2008d, 2009a, b).

Abundance at the Iron Valley Project (0.66 animals per sample, impact and reference data combined) was similar to that observed for many areas of the Pilbara. Some previous rates of collection are 0.64 specimens per sample at Ore Body 24 in the Opthalmia Range, 0.70 in the Jirrpalpur Range, 0.87 at the Packsaddle Range, 0.95 at Phil's Creek and 1.1 in the Bonnie Creek area south of Nullagine (Bennelongia 2008b, c, 2009a, c).

Abundance was considerably greater in reference than impact holes within the Iron Valley Project (Table 6.3). This appears to suggest that surrounding habitat at the Iron Valley Project is more favourable for troglofauna than the commercial grade ore of the pit areas, but reference hole abundance was boosted by high capture of two species (Staphyliinidae sp. B01 and Sciaridae sp. B01).

7.2. Stygofauna

7.2.1. Stygofauna Distributions and Conservation Risk for Species

Most of the stygofauna species collected are known to, or probably, occur beyond the Iron Valley Project. On the basis of existing data, one species appears to be possibly threatened by Project development (the ostracod *Meridiescandona* sp. BOS 171), while the status of syncarid species identified only to genus (*Bathynella* sp.) is unclear and it is must also be regarded as potentially impacted. Existing information about the likely ranges and conservation significance of both species is discussed below:

1. *Meridiescandona* sp. BOS 171 is known only from the Iron Valley Project (Figure 6.6), which lies within the small area where *Meridiescandona* has radiated (see Karanovic 2007; Reeves *et al*. 2007). *Meridiescandona* sp. BOS 171 was collected from five bores within the Iron Valley Project. The presence of large stygofauna such as *Maarrka weeliwollii* and *Pygolabis* sp. B06 (the largest Pilbara stygofauna species), both in the Project impact area and more widely in Weeli Wolli/Marillana Creek, suggests that considerable habitat continuity exists in the alluvial drainage channels around the Project (see Appendix 7). It is likely that the much smaller *Meridiescandona* sp. BOS 171 makes use of such habitat connectivity and is not restricted to the Project area, although it is yet to be collected outside the Project area.

2. *Bathynella* sp. represents a genus level identification because of the absence of a satisfactory taxonomic foundation for recognizing boundaries of Australian species. Whether *Bathynella* sp. is known only from the Project area is unclear. The occurrence of larger stygofauna species such as *Maarrka weeliwollii* and *Pygolabis* sp. B06 more widely in the Marillana/Weeli Wolli Creek catchment (see Appendix 7) suggests it is unlikely that the small *Bathynella* sp. would be restricted to the Project area. Therefore, *Bathynella* sp. found at Iron Valley may be the same as the *Bathynella* species that was collected seven kilometres away in previous surveys (Figure 6.7). The only evidence suggesting that the species may be different is that two-thirds of known syncarid species have linear ranges of <10 km (Camacho and Valdecasas 2008).

When the 8 m drawdown cone is put into context of the total depth of the local aquifer system (at least 170 m deep, see Section 2 and Appendix 3), drawdown probably does not represent a significant threat to stygofauna species, unless such species are further restricted to particular units of the local aquifer system.

7.2.2. Habitat Characterisation

The dolerite dyke that transects the Project trending in an east/ west direction would appear to be a potential barrier to stygofauna movements because of the hydraulic discontinuity it represents (groundwater level is about 40 m lower on the northern side of the dyke). However, the distribution of stygofauna species suggests the dyke is not a barrier with three amphipods, a copepod and an ostracod found on both sides of the dyke (Paramelitidae Genus 2 sp. B01, Paramelitidae sp. B16, Paramelitidae sp. B26, *Diacyclops humphreysi humphreysi* and *Meridiescandona lucerna*) (Appendix 6).

7.2.3. Iron Valley Stygofauna Community

The number of stygofauna species collected from the Iron Valley Project (22 species from 84 samples) is relatively modest by Pilbara standards. For example, 34 species from 17 samples were recorded in the upper Fortescue area near Newman (Ethel Gorge community, Halse *et al*. unpublished data) and the wider Fortescue marsh area yielded 55 species in an extensive sampling program (Bennelongia 2007).

8. CONCLUSION

8.1. Troglofauna

The 168 samples on which this report was based met EPA guidelines for troglofauna assessment and the following conclusions can be drawn:

- The troglofauna community at the Iron Valley Project consists of 11 Orders and 16 species. Two arachnid Orders were recorded: Pseudoscorpionida (1 species) and Schizomida (1 species). The only crustacean Order collected was Isopoda (3 species). Chilopoda were represented by one species of an unknown Order (a partial and damaged specimen prevented identification based on morphology). Diplopoda were represented by Polyxenida (1 species) and Symphyla by Cephalostigmata (1 species). There were five Orders of hexapods (Entognatha/Insecta): Diplura (2 species), Blattodea (2 species), Hemiptera (2 species), Coleoptera (1 species) and Diptera (1 species).
- Eleven of the 16 species recorded at the Iron Valley Project were recorded within the proposed mine pits (i.e. the impact area) (Table 6.1). Of these 11 species, 10 species are known to occur in reference areas outside the mine pits or at deposits elsewhere in the Pilbara.

- One species of troglofauna (Chilopoda sp.) is currently known only from within the proposed mine pits at the Iron Valley Project. Chilopoda sp. was recorded as a singleton. The conservation status of this species cannot be quantified because the specimen was too damaged for species identification.

8.2. Stygofauna

The 84 samples on which this report was based meet the EPA requirement for stygofauna assessment. The following conclusions are drawn from the survey:

- Stygofauna sampling yielded 2,153 specimens consisting of at least 23 species of at least eight Orders, including Tubificida (3 species), Hydracarina (1 species), Ostracoda (3 species), Copepoda (4 species), Syncarida (3 species), Amphipoda (7 species), Isopoda (1 species) and nematodes of unknown order/s.
- Many species of stygofauna collected in the Iron Valley Project area (including the largest species *Pygolabis* sp. B01) are known to occur in surrounding areas of the Weeli Wolli/Marillana Creek drainage channel and, therefore, it is inferred that habitat connections exist between Iron Valley and these areas.
- To date the ostracod *Meridiescandona* sp. BOS 171 and, possibly, the syncarid *Bathynella* sp. have been collected only from the Iron Valley Project impact footprint.
- Consequently, the ostracod *Meridiescandona* sp. BOS 171 and, to lesser extent, the syncarid *Bathynella* sp. are possibly threatened by Project development. However, it is likely that both species exploit the habitat connectivity between the Project and surrounding areas in the same way as demonstrated by most of the stygofauna species at Iron Valley.

9. REFERENCES

Aplin, K.P. (1998) Three new blindsnakes (Squamata, Typhlopidae) from north western Australia. *Records of the Western Museum,* **19,**

Barranco, P. and Harvey, M.S. (2008) The first indigenous palpigrade from Australia: a new species of *Eukoenenia* (Palpigradi:Eukoeneniidae). *Invertebrate Systematics* **22,** 227-233.

Bennelongia (2007) Assessment of stygofauna values at the Cloud Break Project, 2007. Report 2007/16. Bennelongia Pty Ltd, Jolimont, 25 pp.

Bennelongia (2008a) Troglofauna survey of the Orebody 18 Mine Modification. Report 2008/27. Bennelongia Pty Ltd, Jolimont, 21 pp.

Bennelongia (2008b) Orebody 24/25 Upgrade Project: troglofauna assessment. Report 2008/40. Bennelongia Pty Ltd, Jolimont, 25 pp.

Bennelongia (2008c) Subterranean Fauna Assessment, BC Iron Nullagine Project. Report 2008/55. Bennelongia Pty Ltd, Jolimont, 27 pp.

Bennelongia (2008d) Appendix D. Subterranean fauna sampling at Balmoral South Iron Ore Project and adjacent areas. *In* Balmoral South Public Environmental Review. GHD and Australasian Resources, Perth.

Bennelongia (2009a) Area C Mining Operation Environmental Management Plan (Revision 4) A, D, P1 and P3 Deposits: Troglofauna Assessment. Report 2008/48. Bennelongia Pty Ltd, Jolimont, 65 pp.

Bennelongia (2009b) Jimblebar Iron Ore Project: Troglofauna Assessment. Report 2009/61. Bennelongia Pty Ltd, Jolimont, 55 pp.

Bennelongia (2009c) Yilgarn Iron Ore Project: Carina Deposit, Subterranean Fauna Assessment. Report 2009/69. Bennelongia Pty Ltd, Jolimont, 24 pp.

Biota (2005a) Ludlow Mineral Sands Project. Biota Environmental Sciences, Leederville, pp. 14.

Biota (2005b) Barrow Island Gorgon gas development. Biota Environmental Sciences, North Perth, pp. 34 +.

Biota (2006) Mesa A and Robe Valley mesas troglobitic fauna survey. Project No. 291. Biota Environmental Sciences, Leederville, pp. 74++.

Camacho, A.I. and Valdecasas, A.G. (2008) Global diversity of syncarids (Syncarida; Crustacea) in freshwater. *Hydrobiologia,* **595,** 257-266.

Eberhard, S.M., Halse, S.A. and Humphreys, W.F. (2005) Stygofauna in the Pilbara region, north-west Western Australia: a review. *Journal of the Royal Society of Western Australia*, **88**, 167-176.

Eberhard, S.M., Halse, S.A., Williams, M.R., Scanlon, M.D., Cocking, J.S. and Barron, H.J. (2009) Exploring the relationship between sampling efficiency and short range endemism for groundwater fauna in the Pilbara region, Western Australia. *Freshwater Biology* **54**, 885–901.

Ecologia (2008) Koolanooka – Blue Hills Direct Shipping Ore (DSO) Mining Project, Troglofauna Biological Assessment. Ecologia Environment, West Perth, 22 pp.

Edward, K.L. and Harvey, M.S. (2008) Short-range endemism in hypogean environments: the pseudoscorpion genera *Tyrannochthonius* and *Lagynochthonius* (Pseudoscorpiones: Chthoniidae) in the semiarid zone of Western Australia. *Invertebrate Systematics* **22,** 259–293.

EPA (2003) Guidance for the assessment of environmental factors: consideration of subterranean fauna in groundwater and caves during environmental impact assessment in Western Australia. Guidance Statement 54. Environmental Protection Authority, Perth, pp. 12.

EPA (2007) Sampling methods and survey considerations for subterranean fauna in Western Australia (Technical Appendix to Guidance Statement No. 54). Guidance Statement 54A. Environmental Protection Authority, Perth, pp. 32.

Finston, T.L., Francis, C.J. and Johnson, M.S. (2009) Biogeography of the stygobitic isopod Pygolabis (Malacostraca: Tainisopidae) in the Pilbara, Western Australia: Evidence for multiple colonisations of the groundwater. *Molecular Phylogenetics and Evolution* **52**, 448–460.

Finston, T.L., and Johnson, M.S. (2004) Geographic patterns of genetic diversity in subterranean amphipods of the Pilbara, Western Australia. *Marine and Freshwater Research* **55**, 619-628.

Finston, T., Johnson, M.S., Eberhard, S.M, Cocking, J.S., McRae, J.M., Halse, S.A and Knott, B. (2011) New genus and species of groundwater paramelitid amphipods from the Pilbara, Western Australia: a combined molecular and morphological approach. *Records of the Western Australian Museum* **26**, 154-178.

Finston, T.L., Johnson, M.S., Humphreys, W.F., Eberhard, S.M., and Halse, S.A. (2007) Cryptic speciation in two widespread subterranean amphipod genera reflects historical drainage patterns in an ancient landscape. *Molecular Ecology* **16**, 355-365.

Gajowiec, B. (1993) Impact of lead/zinc ore mining on groundwater quality in Trzebionika mine (southern Poland). *Mine Water and the Environment* **12**, 1-10.

Halse, S.A., Scanlon, M.D., Cocking, J.S., Barron H.J. and Eberhard, S.M. (in preparation) Pilbara stygofauna: deep groundwater of an ancient landscape contains globally significant radiation of biodiversity.

Harvey, M.S., Gray, M.R., Hunt, G.S. and Lee, D.C. (1993) The cavernicolous Arachnida and Myriopoda of Cape Range, Western Australia. *Records of the Western Australian Museum Supplement* **45,** 129-144.

Harvey, M.S. (2001) New cave-dwelling schizomids (Schizomida: Hubbardiidae) from Australia. *Records of the Western Australia Museum Supplement* **64,** 171-185.

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

Harvey, M.S, Berry O. Edward K.L. and Humphreys G. (2008) Molecular and morphological systematics of hypogean schizomids (Schizomida : Hubbardiidae) in semiarid Australia. *Invertebrate Systematics* **22**, 167–194.

Humphreys, W .F (1999) Relict stygofaunas living in sea salt, karst and calcrete habitats in arid northwestern Australia contain many ancient lineages. In: The other 99%. The conservation and biodiversity of invertebrates (eds W Ponder and D Lunney). Surrey Beatty, Sydney, pp. 219.227.

Johnson, S.L., and Wright, A.H. (2001) Central Pilbara groundwater study, Western Australia. HG8, Water and Rivers Commission, Perth.

Karanovic, I. (2007) Candoninae (Ostracoda) from the Pilbara region in Western Australia. *Crustaceana Monographs*, **7**, 1-432

Karanovic, T. (2006) Subterranean copepods (Crustacea, Copepoda) from the Pilbara region in Western Australia. *Records of the Western Australian Museum Supplement* 70, 1-239.

Lamoreux, J. (2004) Stygobites are more wide-ranging than troglobites. *Journal of Cave and Karst Studies* **66**, 18-19.

Lindberg, K. (1952). Cyclopoides (Crustacés Copépodes) du Royaume du Cambodge. *Bulletin de Institut royal des Sciences naturelles de Belgique* **28**:1-16.

McAuley, S.D., and Kozar, M.D. (2006) Groundwater quality in unmined areas and near reclaimed surface coal mines in the northern and central Appalachian coal regions, Pennsylvania and West Virginia. US Geological Survey, Reston, Virginia, 57 pp.

Masciopinto, C., Semeraro, F., La Mantia, R., Inguscio, S., and Rossi, E. (2006) Stygofauna Abundance and Distribution in the Fissures and Caves of the Nardò (Southern Italy) Fractured Aquifer Subject to Reclaimed Water Injections *Geomicrobiology Journal* **23**, 267-278.

Pesce, G. L. and De Laurentiis, P. (1996) Copepods from ground waters of Western Australia, III. *Diacyclops humphreysi* n.sp. and comments on the *Diacyclops crassicaudis* complex (Copepoda, Cyclopoidae). *Crustaceana* **69**: 524-531

Platnick, N.I. (2008) A new subterranean ground spider genus from Western Australia (Araneae:Trochanteriidae). *Invertebrate Systematics* **22,** 295–299.

Reeves J., De Deckker P. and Halse S.A. (2007) Groundwater ostracods from the arid Pilbara region of northwestern Australia: distribution and water chemistry. *Hydrobiologia*, 585, 99–118.

Rio Tinto (2008) Public environmental review, Marandoo mine phase 2. Rio Tinto, Perth, 235 pp. (http://www.riotintoironore.com/documents/Marandoo_Mine_Phase_2_PER.pdf).

Sars, G.O. (1863). Oversigt af de indenlandske Ferskvandscopepoder. *Forhandlinger I Videnskabs-Selskabet I Christiana* **Aar 1862**: 212-262

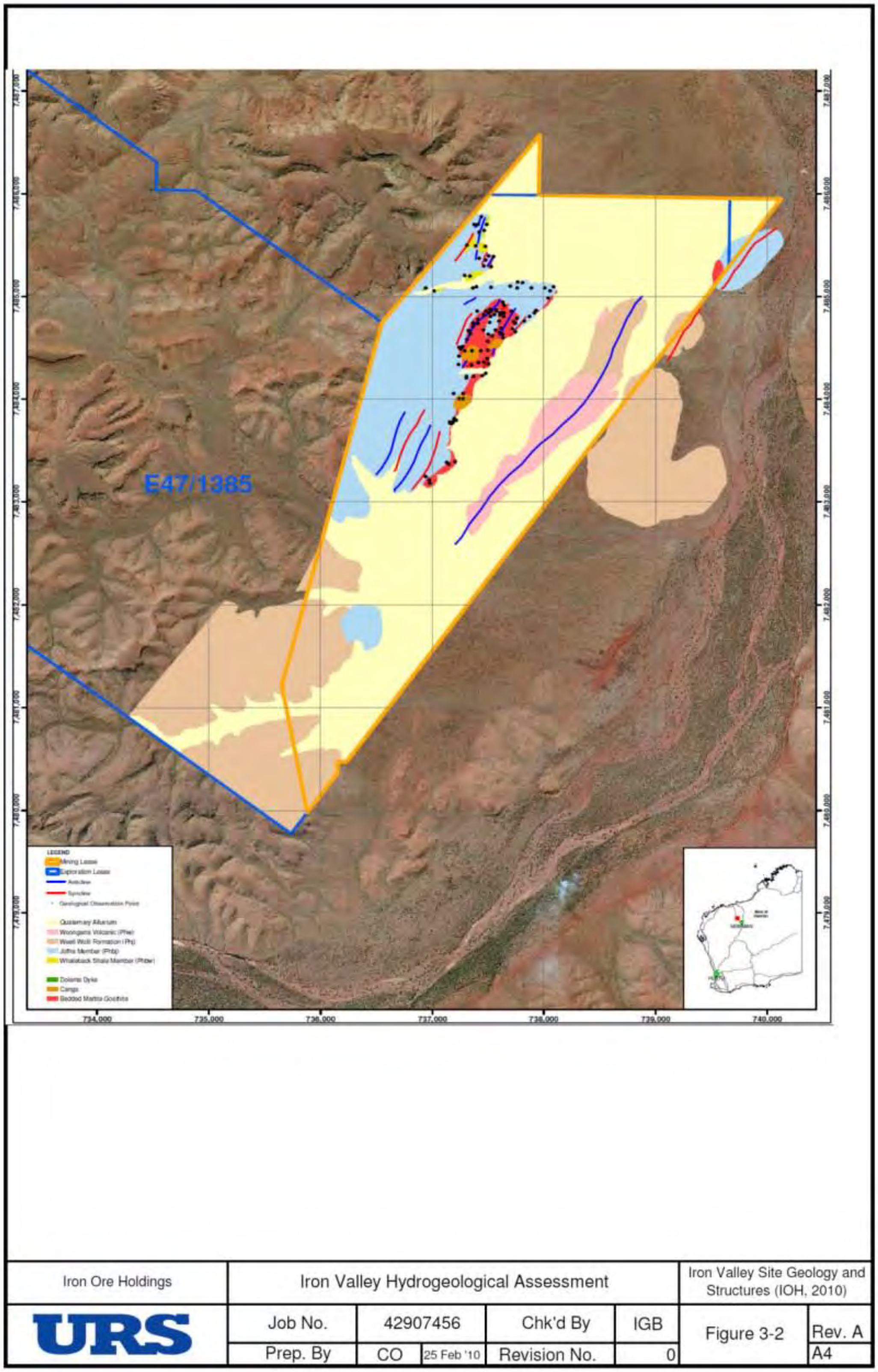
Scarsbrook, M.R., and Fenwick, G.D. (2003) Preliminary assessment of crustacean distribution patterns in New Zealand groundwater aquifers. *New Zealand Journal of Marine and Freshwater Research* **37**, 405-413.

Subterranean Ecology (2007) Pardoo DSO Project. Troglofauna survey. Phase 2 and 3 results. Subterranean Ecology, Greenwood, pp. 91.

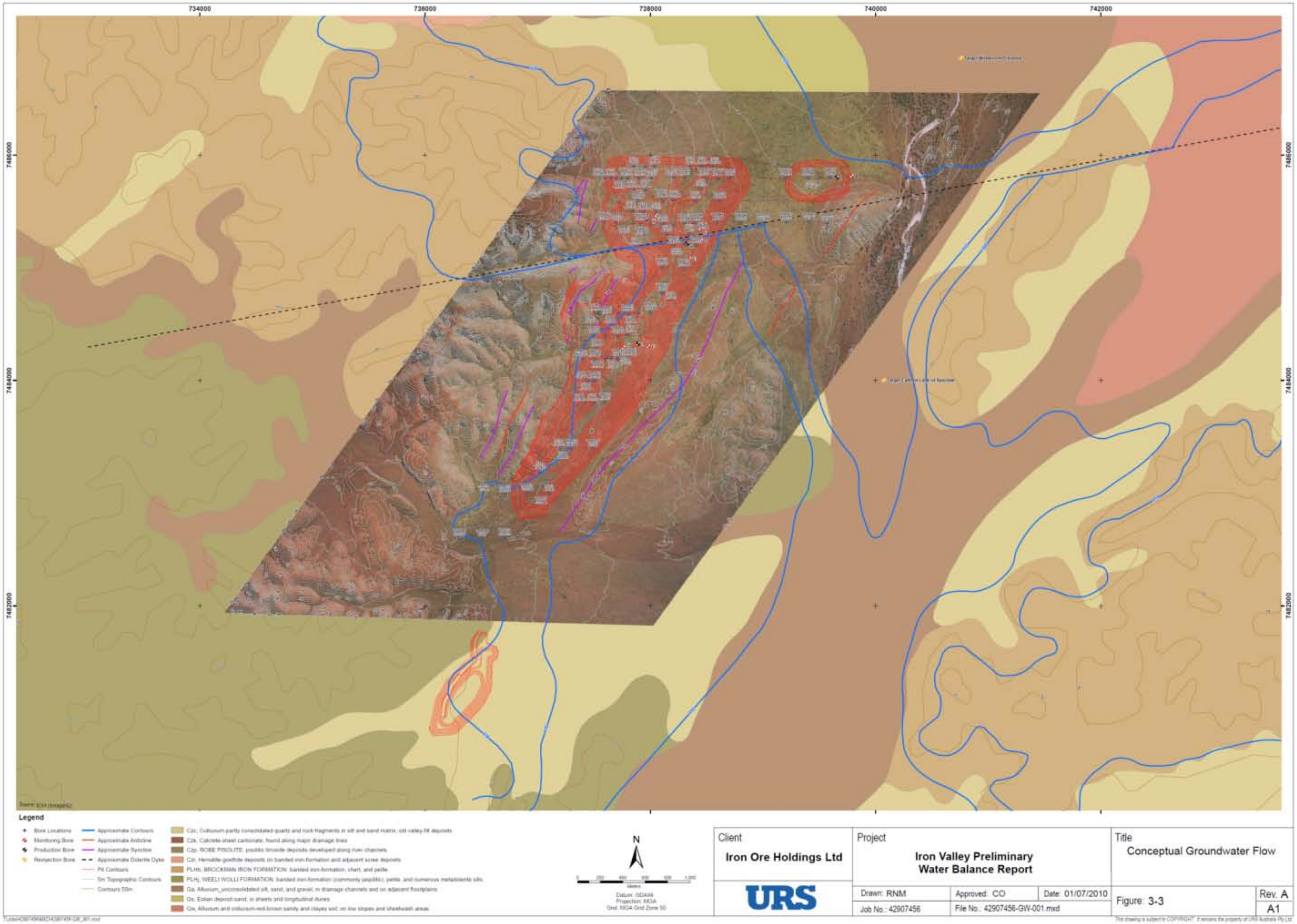
Whitely, P.G. (1945) New sharks and fishes from Western Australia. Part 2. *Australian Zoologist,* **11,** 1-45.

10. APPENDICES

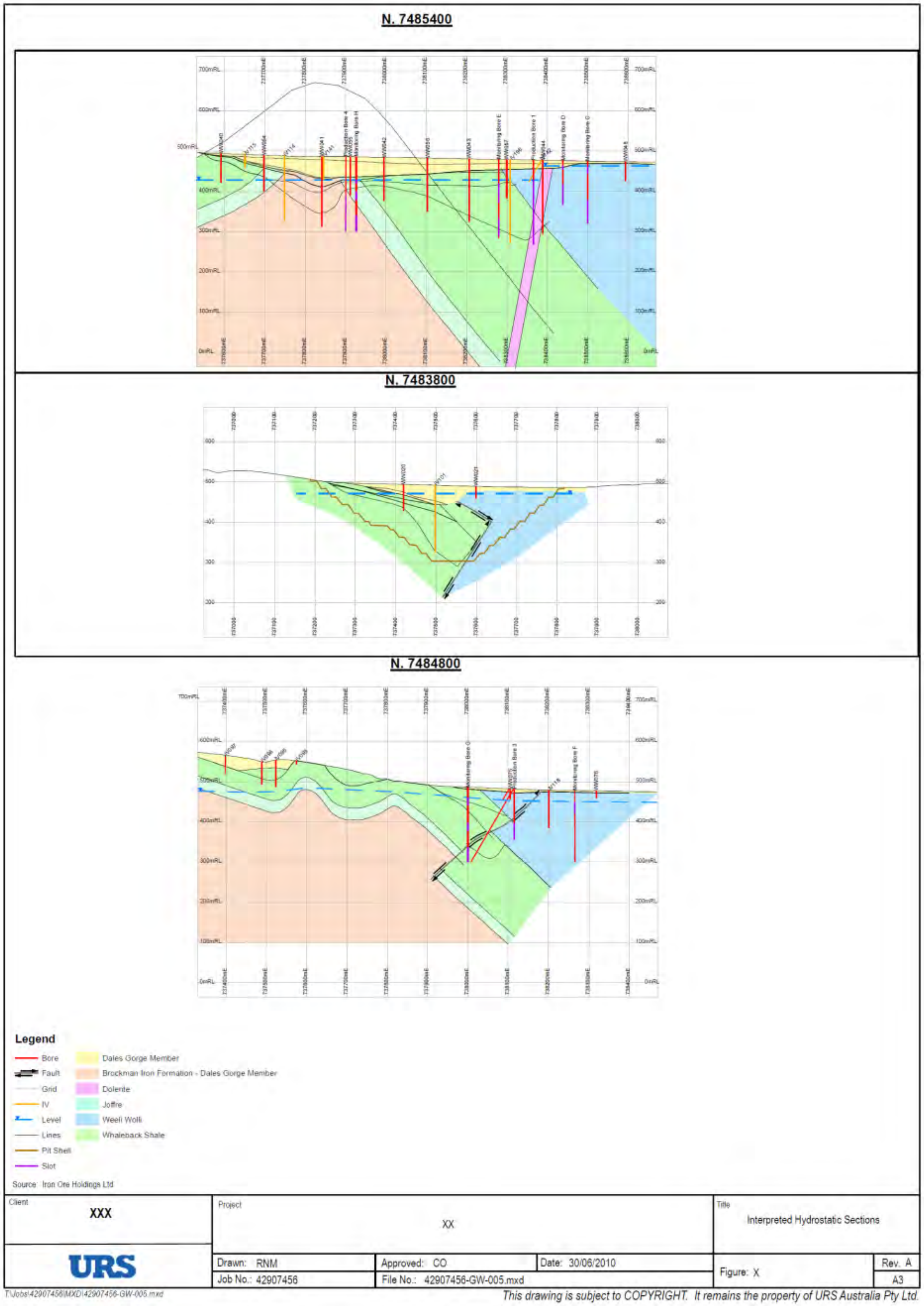
Appendix 1: Geology of the Iron Valley Project



Appendix 2: Conceptual Groundwater Flow (historical figure)



Appendix 3: Interpreted Hydrostatic Sections



Appendix 4: Co-ordinates of Bores Sampled for Troglofauna at the Iron Valley Project

Bore Code	Site type	Latitude	Longitude
WW022	Reference	-22.7619	119.2994
WW023	Reference	-22.7619	119.3014
WW024	Reference	-22.7619	119.3034
WW026	Reference	-22.7583	119.3043
WW025	Reference	-22.7583	119.3023
WW028	Reference	-22.7547	119.3071
WW027	Reference	-22.7546	119.3051
WW013	Reference	-22.751	119.308
WW011	Reference	-22.7511	119.3041
WW012	Reference	-22.7511	119.306
WW007	Reference	-22.7473	119.3108
WW006	Reference	-22.7474	119.3088
WW005	Reference	-22.7476	119.307
WW010	Reference	-22.7474	119.305
WW009	Reference	-22.7475	119.3031
WW004	Reference	-22.7474	119.3011
WW014	Reference	-22.7438	119.3031
WW015	Reference	-22.7439	119.305
WW016	Impact	-22.7438	119.3069
WW017	Impact	-22.7438	119.3089
WW019	Reference	-22.7402	119.3126
WW018	Impact	-22.7401	119.3107
WW021	Impact	-22.7364	119.3135
WW082	Impact	-22.7347	119.3126
WW081	Impact	-22.7348	119.3104
WW001	Impact	-22.7329	119.3116
WW029	Impact	-22.7329	119.3126
WW002	Impact	-22.7328	119.3136
WW051	Impact	-22.7295	119.3135
WW052	Impact	-22.7293	119.3154
WW080	Impact	-22.7311	119.3145
WW079	Impact	-22.7311	119.3123
WW077	Impact	-22.7255	119.3182
WW003	Impact	-22.7328	119.3155
WW053	Impact	-22.7291	119.3172
WW076	Reference	-22.7274	119.3203
WW075	Impact	-22.7276	119.3183
WW068	Impact	-22.7237	119.3211
WW048	Reference	-22.7219	119.3229
WW044	Impact	-22.7219	119.3205
WW074	Impact	-22.7201	119.3232
WW073	Impact	-22.7201	119.322
WW036	Reference	-22.7182	119.325
WW062	Impact	-22.7182	119.324
WW045	Impact	-22.7218	119.3182
WW046	Impact	-22.7216	119.3169
WW047	Reference	-22.7217	119.3289

Bore Code	Site type	Latitude	Longitude
WW050	Reference	-22.7218	119.3269
WW049	Reference	-22.7218	119.325
WW037	Impact	-22.7181	119.3326
WW038	Impact	-22.718	119.3306
WW039	Impact	-22.718	119.3306
WW061	Impact	-22.7183	119.3221
WW033	Impact	-22.7183	119.3191
WW059	Impact	-22.7183	119.3181
WW035	Impact	-22.7182	119.323
WW032	Impact	-22.7183	119.3172
WW058	Impact	-22.7184	119.3161
WW031	Impact	-22.7184	119.3151
WW069	Impact	-22.7202	119.3144
WW070	Impact	-22.7202	119.3161
WW071	Impact	-22.72	119.3182
WW072	Impact	-22.7201	119.3201
WW057	Impact	-22.7219	119.3201
WW043	Impact	-22.7221	119.3193
WW056	Impact	-22.722	119.3182
WW042	Impact	-22.722	119.3172
WW055	Impact	-22.7219	119.3163
WW041	Impact	-22.722	119.3157
WW054	Impact	-22.722	119.3142
WW040	Impact	-22.7219	119.3133
WW065	Impact	-22.7238	119.3154
WW063	Reference	-22.7238	119.3114
WW064	Reference	-22.7238	119.3134
IV135	Impact	-22.733	119.3107
IV095	Impact	-22.727	119.3126
IV097	Impact	-22.7275	119.3115
IV098	Impact	-22.7283	119.3139
IV100	Impact	-22.7285	119.3109
IV099	Impact	-22.7292	119.3116
IV182	Reference	-22.7221	119.3123
IV209	Reference	-22.7218	119.3318
IVUNK01	Reference	-22.7218	119.3325
IV207	Reference	-22.72	119.3299
IV208	Reference	-22.72	119.3299
IV204	Reference	-22.7198	119.3331
IV453	Reference	-22.7198	119.3348
IV454	Reference	-22.7189	119.3355
IV464	Reference	-22.719	119.3346
IV460	Reference	-22.7181	119.3356
IV452	Reference	-22.7172	119.3341
IV463	Reference	-22.7173	119.3361
IV444	Reference	-22.7146	119.3165
IV448	Reference	-22.7147	119.3145
IV445	Reference	-22.7139	119.3166
IV449	Reference	-22.7138	119.3161

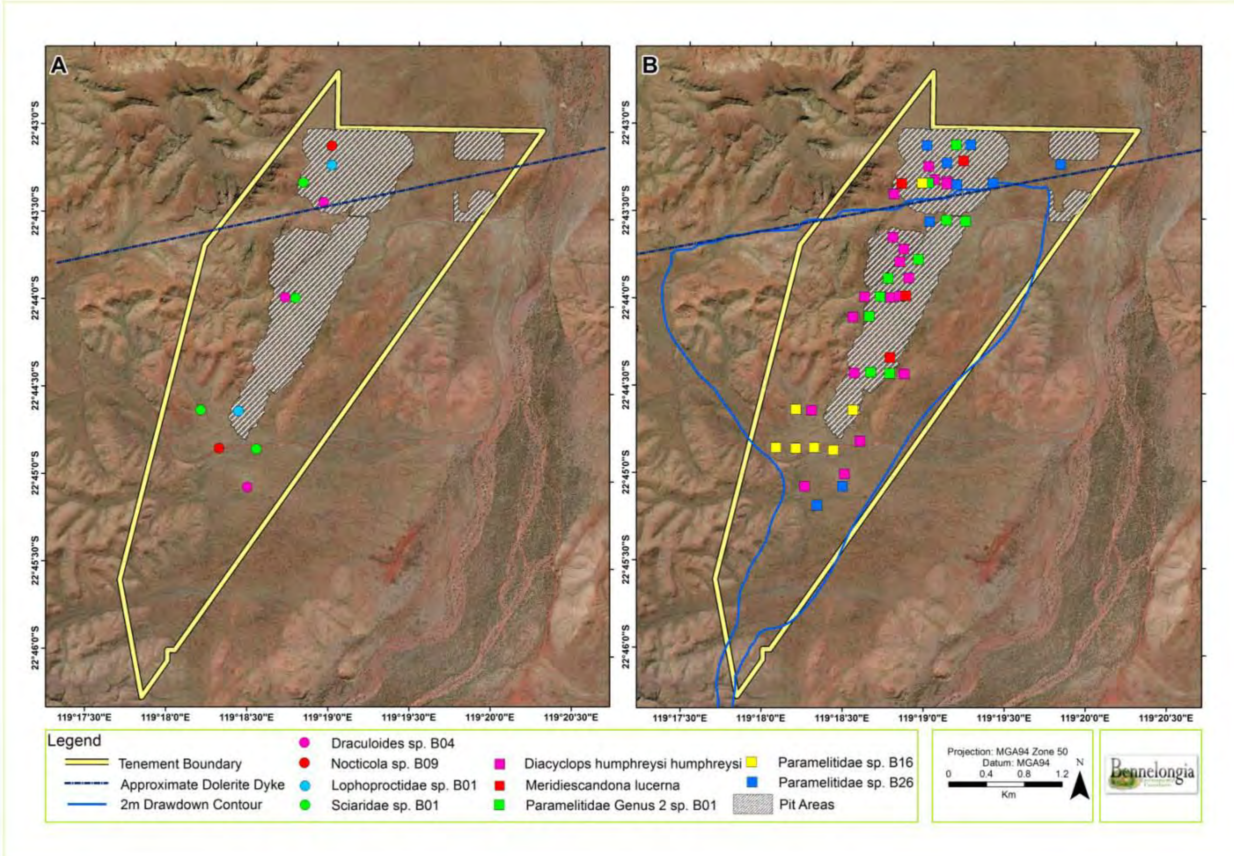
Bore Code	Site type	Latitude	Longitude
IV446	Reference	-22.7129	119.3165
IV450	Reference	-22.7128	119.316
IV109	Reference	-22.7201	119.3133
IV367	Reference	-22.7211	119.3128
IV344	Reference	-22.742	119.3068
IV338	Reference	-22.7438	119.3059
IV247	Reference	-22.7656	119.3004
IV248	Reference	-22.7655	119.3016
IV223	Reference	-22.7546	119.3051
IV273	Reference	-22.7547	119.3042
IV276	Reference	-22.7529	119.3061
IV275	Reference	-22.7529	119.3054
IV274	Reference	-22.7529	119.3042
IV244	Reference	-22.7475	119.306
IV242	Reference	-22.7475	119.304
IV241	Reference	-22.7456	119.3089
IV235	Reference	-22.7456	119.3054
IV239	Reference	-22.7545	119.3051

Appendix 5: Co-ordinates of Bores Sampled for Stygofauna at the Iron Valley Project

Bore code	Site type	Latitude	Longitude
WW024	Impact	-22.7619	119.3034
WW025	Impact	-22.7583	119.3023
WW028	Impact	-22.7547	119.3071
WW027	Impact	-22.7546	119.3051
WW013	Impact	-22.751	119.308
WW011	Impact	-22.7511	119.3041
WW012	Impact	-22.7511	119.306
WW007	Impact	-22.7473	119.3108
WW006	Impact	-22.7474	119.3088
WW005	Impact	-22.7476	119.307
WW010	Impact	-22.7474	119.305
WW009	Impact	-22.7475	119.3031
WW004	Impact	-22.7474	119.3011
WW001	Impact	-22.7329	119.3116
WW029	Impact	-22.7329	119.3126
WW002	Impact	-22.7328	119.3136
WW051	Impact	-22.7295	119.3135
WW052	Impact	-22.7293	119.3154
WW080	Impact	-22.7311	119.3145
WW079	Impact	-22.7311	119.3123
WW077	Impact	-22.7255	119.3182
WW045	Reference	-22.7218	119.3182
WW046	Reference	-22.7216	119.3169
WW047	Reference	-22.7217	119.3289
WW050	Reference	-22.7218	119.3269
WW049	Reference	-22.7218	119.325
WW038	Reference	-22.718	119.3306
WW061	Reference	-22.7183	119.3221
WW033	Reference	-22.7183	119.3191
WW035	Reference	-22.7182	119.323
WW058	Reference	-22.7184	119.3161
WW070	Reference	-22.7202	119.3161
WW057	Reference	-22.7219	119.3201
WW043	Reference	-22.7221	119.3193
WW056	Reference	-22.722	119.3182
WW042	Reference	-22.722	119.3172
WW055	Reference	-22.7219	119.3163
WW054	Reference	-22.722	119.3142
WW040	Reference	-22.7219	119.3133
WW031	Reference	-22.7184	119.3151
WW071	Reference	-22.72	119.3182
WW022	Impact	-22.7619	119.2994
WW024	Impact	-22.7619	119.3034
WW025	Impact	-22.7583	119.3023
WW013	Impact	-22.751	119.308
WW011	Impact	-22.7511	119.3041
WW007	Impact	-22.7473	119.3108

Bore code	Site type	Latitude	Longitude
WW005	Impact	-22.7476	119.307
WW010	Impact	-22.7474	119.305
WW004	Impact	-22.7474	119.3011
WW014	Impact	-22.7438	119.3031
WW015	Impact	-22.7439	119.305
WW016	Impact	-22.7438	119.3069
WW019	Impact	-22.7402	119.3126
WW021	Impact	-22.7364	119.3135
WW001	Impact	-22.7329	119.3116
WW029	Impact	-22.7329	119.3126
WW002	Impact	-22.7328	119.3136
WW080	Impact	-22.7311	119.3145
WW079	Impact	-22.7311	119.3123
WW003	Impact	-22.7328	119.3155
WW053	Impact	-22.7291	119.3172
WW052	Impact	-22.7293	119.3154
WW051	Impact	-22.7295	119.3135
WW077	Impact	-22.7255	119.3182
WW076	Impact	-22.7274	119.3203
WW075	Impact	-22.7276	119.3183
WW068	Impact	-22.7237	119.3211
WW045	Reference	-22.7218	119.3182
WW046	Reference	-22.7216	119.3169
WW057	Reference	-22.7219	119.3201
WW043	Reference	-22.7221	119.3193
WW042	Reference	-22.722	119.3172
WW055	Reference	-22.7219	119.3163
WW041	Reference	-22.722	119.3157
WW054	Reference	-22.722	119.3142
WW040	Reference	-22.7219	119.3133
WW070	Reference	-22.7202	119.3161
WW078	Impact	-22.7256	119.3202
WW062	Reference	-22.7182	119.324
WW061	Reference	-22.7183	119.3221
WW058	Reference	-22.7184	119.3161
WW033	Reference	-22.7183	119.3191
WW035	Reference	-22.7182	119.323

Appendix 6: Locations of Troglofauna (A) and Stygofauna (B) Species in Relation the Dolerite Dyke that Transects the Iron Valley Project



Appendix 7: Locations of Isopods and Amphipods

Pygolabis spp., *Chydakata* sp. and *Maarrka weeliwollii* specimens collected at the Iron Valley Project (outlined in black) and nearby. Source of data outside the Project: *Pygolabis* sp. = *Pygolabis* sp. B06 (Finston *et al*. 2009); *Maarrka weeliwollii* (Halse *et al*. unpublished data); *Chydaekata* sp. (Halse *et al*. unpublished data, Bennelongia unpublished data).

Vertebrate Fauna Assessment of the Iron Valley Project Area

Rocky hills within the Iron Valley Project Area

Prepared for: Iron Ore Holdings Ltd
Level 1, 1 Altona Street
West Perth WA 6005

Prepared by: Cameron Everard, Mike Bamford, Natalia Huang and Tim Gamblin
Bamford Consulting Ecologists
23 Plover Way
Kingsley
WA 6026

13th September 2012

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.

CONTENTS

LIST OF TABLES

LIST OF FIGURES

1 Introduction

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;
  - 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.

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

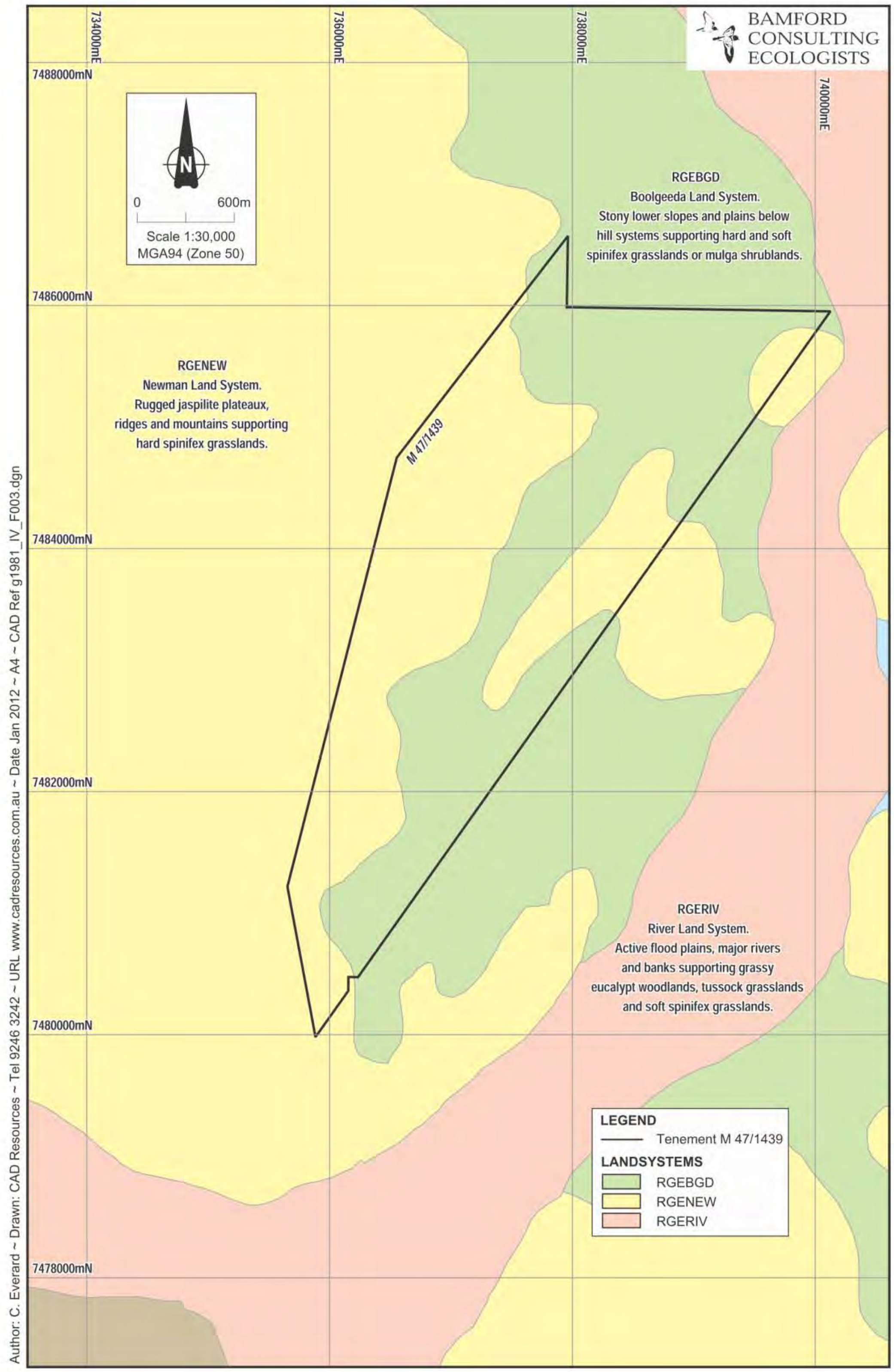


Figure 3. Land Systems within the Project Area (see map or Table 1 for Land System codes).

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.

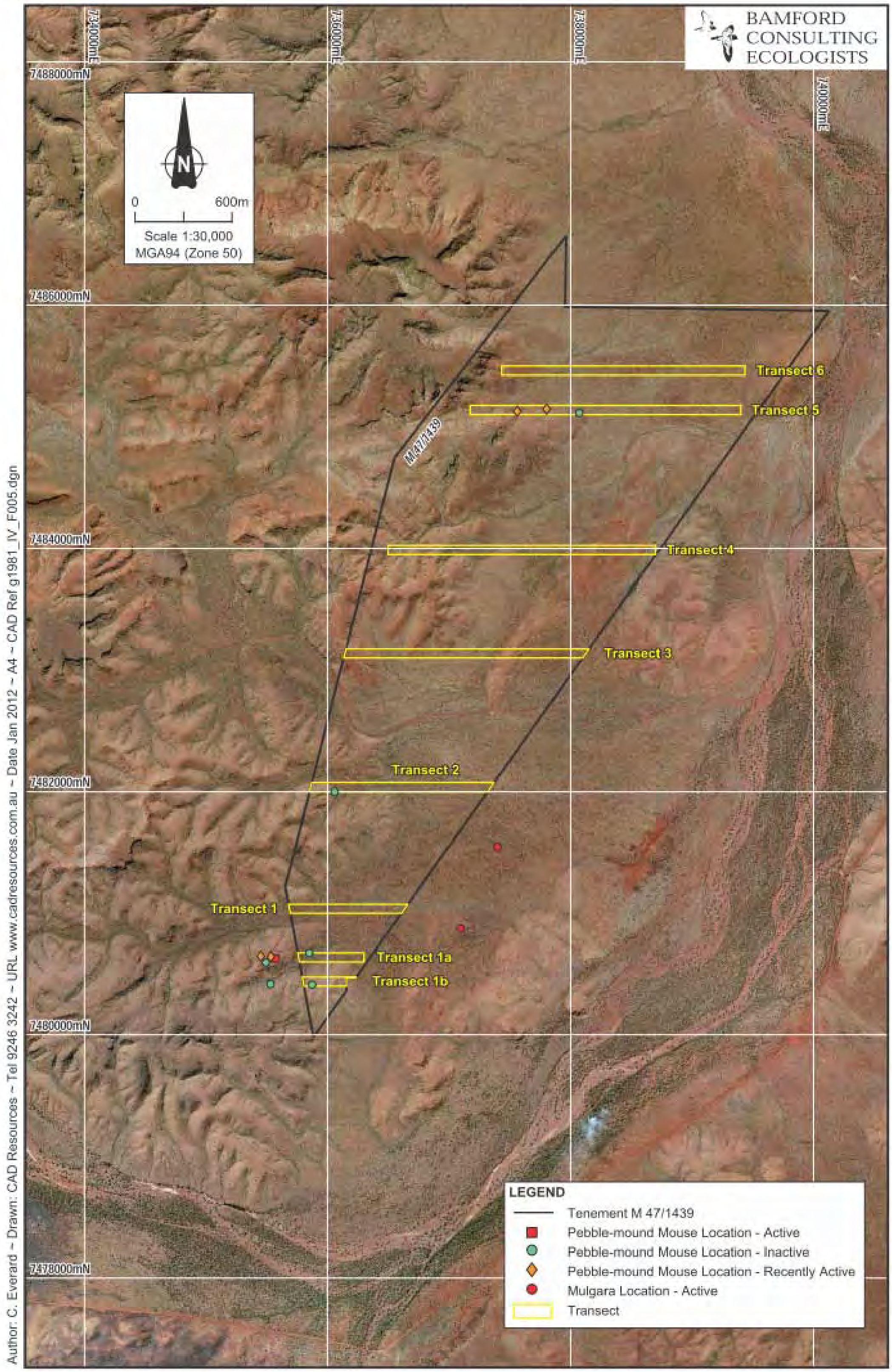


Figure 4. Locations of Western Pebble-mound Mouse and Mulgara transects and burrows. Tenement M 47/1439 indicates boundary of Project Area.

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

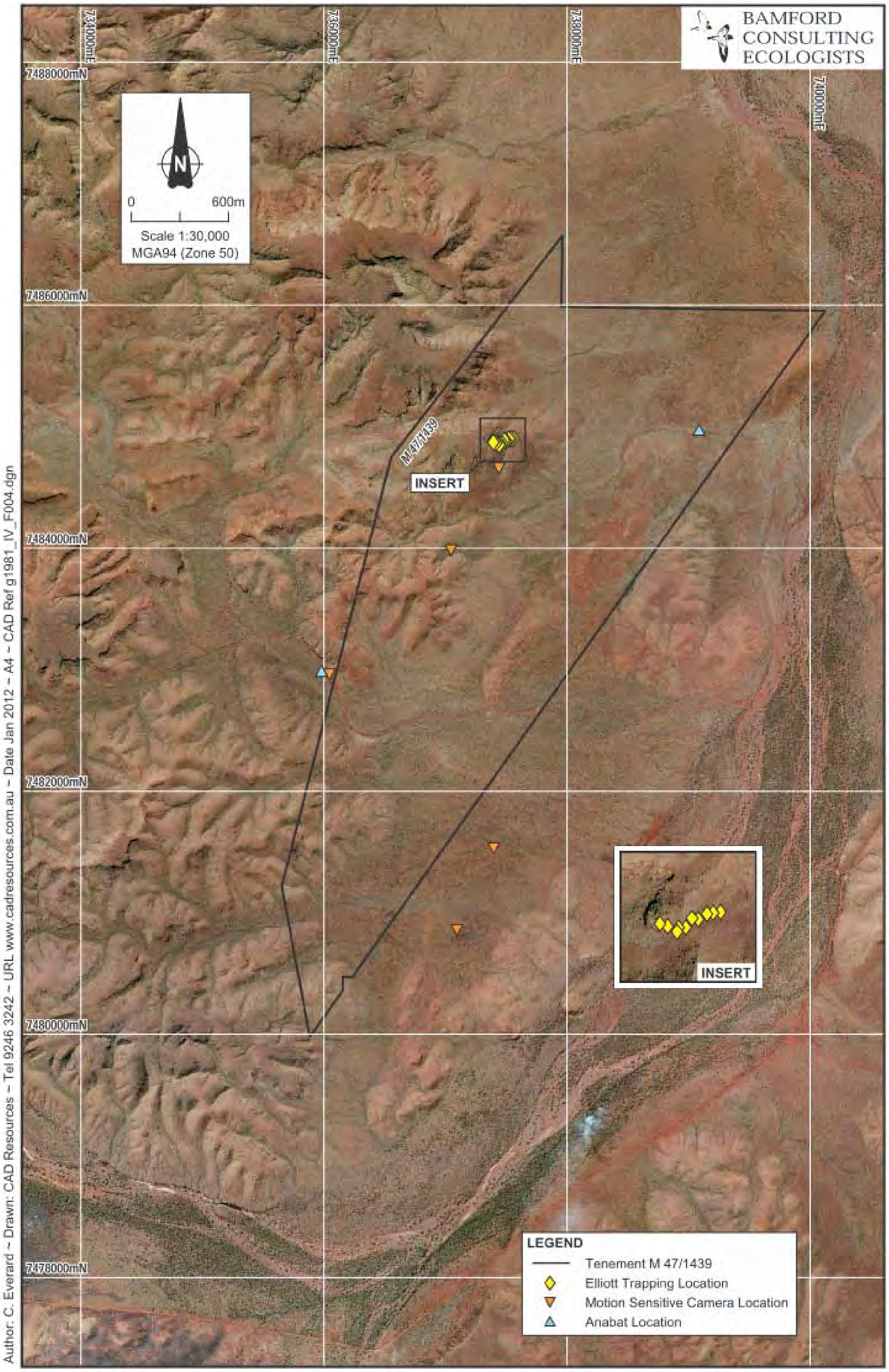


Figure 5. Location of Elliott traps, motion-sensitive cameras and AnaBat surveys. Tenement M 47/1439 indicates boundary of Project Area.

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.

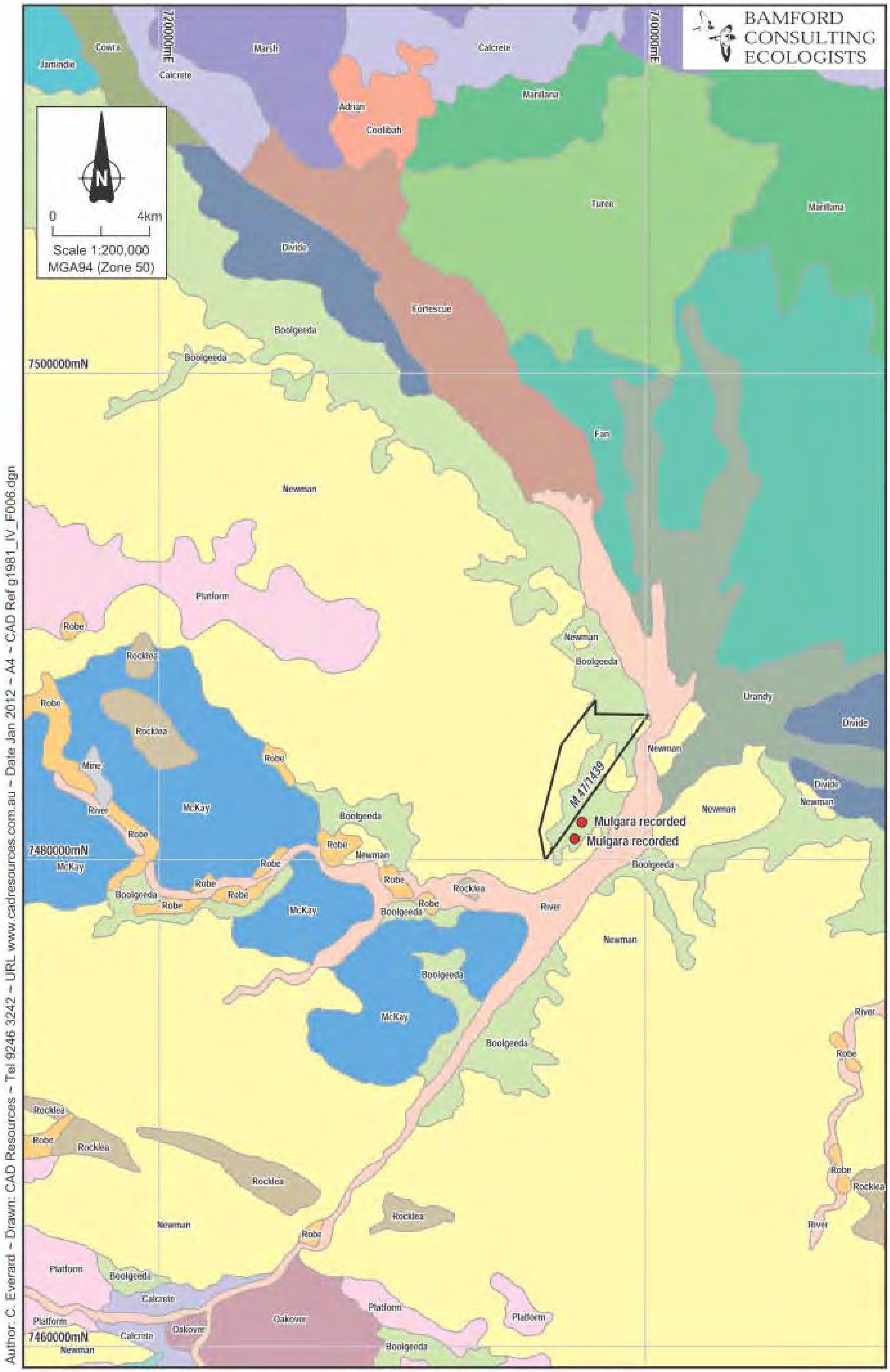


Figure 6. The Iron Valley Project Area, showing the extent of the Boolgeeda Land System (habitat for the Mulgara) and the location of Mulgara records near the Project Area.

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.

<u>Bilby (*Macrotis lagotis*)</u>

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.

6 References

Allen, G. R., Midgeley, S. H. and Allen, M. (2002), *Field Guide to the Freshwater Fishes of Australia.*, Western Australian Museum, Perth, Western Australia.

Aplin, K. P. (1998), 'Three New Blind Snakes (Squamata: Typhlopidae) from Northwestern Australia.' *Records of the Western Australian Museum*, vol. 19, pp. 1-12.

Armstrong, K.N. and Anstee, S.D. (2000), The ghost bat in the Pilbara: 100 years on. *Australian Mammalogy* 22: 93–101.

Bamford Consulting Ecologists (2005), Fauna Survey of Proposed Cloudbreak Mine. Prepared for the Fortescue Metals Group Ltd, June 2005.

Bamford Consulting Ecologists (2010), Report on December 2009 search for Night Parrot. A Fortescue Metals Group Project. Report prepared for the Fortescue Metals Group, July 2010.

Bamford Consulting Ecologists (2011a), Fauna Assessment FMG Nyidinghu Iron Ore Project. Prepared for the Fortescue Metals Group August 2011.

Bamford Consulting Ecologists (2011b), Vertebrate Fauna Assessment of the Kurrajura Tenement Area. Prepared for Iron Ore Holdings November 2011. (In preparation).

Barrett, G., Silcocks, A., Barry, S., Cunnningham, R. and Poulter, R. (2003), *The New Atlas of Australian Birds.* Royal Australasian Ornithologists Union, Melbourne.

Biota Environmental Sciences (2005), 'Fauna Habitats and Fauna Assemblages of the Proposed F Stage B Rail Corridor and Mindy Mindy, Christmas Creek, Mt Lewin and Mt Nicholas Mine Areas.' Fortescue Metals Group Pty. Ltd.

Biota Environmental Sciences (2009), Yandicoogina Targeted Northern Quoll Survey. Prepared for Rio Tinto Iron Ore, December 2009.

Biota Environmental Sciences (2010), Yandicoogina Junction South West and Oxbow Fauna Survey. Prepared for Rio Tinto Iron Ore, December 2010.

Biota Environmental Sciences (2011), Hope Downs Project Life of Mine Targeted Fauna Survey. Prepared for Rio Tinto Iron Ore, January 2011.

Birds Australia (2011). Bird Data, Birds Australia Database. Available at:

www.birdata.com.au

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

Bureau of Meteorology (2011) Climate Statistics for Newman. Accessed online on the 9 October 2011 from: http://www.bom.gov.au

Burbidge, A. A., Fuller, P. J. and McKenzie, N. L. (1995), 'Vertebrate Fauna.' in *The Biological Survey of the Eastern Goldfields of Western Australia; Part 12: Barlee - Menzies Study Area.* , W.A. Museum,, Perth, Western Australia.

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

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

Churchill, S. K. (2008), *Australian Bats. 2nd Edition.*, Allen and Unwin, NSW.

Covacevich, J. (1995), 'Lakeland Downs Mouse *Leggadina Lakedownensis.*' in R. Strahan (ed.), *The Mammals of Australia*, Reed, Chatswood, N.S.W., pp. 556 - 557.

Davis, R.A. and Metcalf, B.M. (2008). The Night Parrot (*Pezoporus occidentalis*) in northern Western Australia: a recent sighting from the Pilbara region. Emu, 108: 233-36.

Davis, R., Wilcox, J. A., Metcalf, B. M. and Bamford, M. J. (2005), 'Fauna Survey of Proposed Iron Ore Mine, Cloud Break. '

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

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

Duncan, A., Baker, G.B. and Mongomery, N. (1999), *The Action Plan for Australian Bats*. Environment Australia, Canberra.

Department of Environment and Conservation (DEC) (2011). NatureMap Database. Accessed online, 19 September 2011 at: www.naturemap.dec.wa.gov.au

Department of Sustainability, Environment, Water, Population and Communities (DSEWPaC) (2011a), *Environment Protection and Biodiversity Conservation Act 1999 referral guidelines for the endangered northern quoll*, Dasyurus hallucatus. EPBC Act policy statement 3.25. Commonwealth of Australia 2011.

DSEWPaC (2011b), SPRAT Threatened Species Database. Accessed online, 19 September 2011 at: http://www.environment.gov.au/cgi-bin/sprat/public/publicspecies.pl?taxon_id=174

DSEWPaC (2011c). Survey guidelines for Australia's threatened mammals. EPBC Act survey guidelines 6.5. [Online]. EPBC Act policy statement: Canberra, ACT: DSEWPAC. Available from: http://www.environment.gov.au/epbc/publications/threatened-mammals.html.

Ecologia (2009), Marillana Iron Ore Project Vertebrate Fauna Assessment. Prepared for Brockman Resources Limited, June 2009.

Ecologia (2010), Christmas Creek Terrestrial Vertebrate Fauna Desktop Assessment. Prepared for Fortescue Metals Group Ltd, October 2010.

Environment Australia (2000), *Revision of the Interim Biogeographic Regionalisation for Australia (IBRA) and Development of Version 5.1 - Summary Report. Environment Australia*, Department of Environment and Heritage, Canberra, Australian Capital Territory.

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

EPA (2004), *Guidance for the Assessment of Environmental Factors: Terrestrial Fauna Surveys for Environmental Impact Assessment in Western Australia. No. 56*, Environmental Protection Authority, Perth, Western Australia.

Higgins, P.J. (1999). *Handbook of Australian, New Zealand and Antarctic Birds. Vol. 4 Parrots to Dollarbird*. Oxford University Press, Melbourne.

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

Johnson, K. A. (1995), 'Bilby *Macrotis Lagotis*', in R. Strahan (ed.), *The Mammals of Australia*, Reed, Chatswood, N.S.W., pp. 186 - 188.

Johnstone, R. E. and Storr, G. M. (1998), *The Handbook of Western Australian Birds Vol. 1 – Non-Passerines (Emu to Dollarbird).* Western Australian Museum, Perth.

Johnstone, R. E. and Storr, G. M. (2004), *Handbook of Western Australian Birds. Vol 2: Passerines (Blue-Winged Pitta to Goldfinch).* Western Australian Museum, Perth, Western Australia.

Kendrick, P. (2001), 'Pilbara 3 (Pil3 – Hamersley Subregion).' in *A Biodiversity Audit of Western Australia's 53 Biogeographical Subregions in 2002.*, Department of Conservation and Land Management, Western Australia, Kensington, Western Australia.

Lavery, H. J. and Kirkpatrick, T. H. (1997), 'Field Management of the Bilby *Macrotis Lagotis* in an Area of South-Western Queensland.' *Biological Conservation*, vol. 79, pp. 271-281.

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

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

Menkhorst, P. and Knight, F. (2001), *A Field Guide to the Mammals of Australia*, Oxford University Press, Melbourne.

Moseby, K. E. and O'Donnell, E. (2003), 'Reintroduction of the Greater Bilby, *Macrotis Lagotis* (Reid) (Marsupialia: Thylacomyidae) to Northern South Australia: Survival, Ecology and Notes on Reintroduction Protocols.' *Wildlife Research*, vol. 30, pp. 15-27.

Ninox Wildlife Consulting (2009), A Vertebrate Fauna Survey of The Proposed Hope Downs 4 Option 6 Infrastructure Corridor. Prepared for Pilbara Iron Company (Services), August 2009.

Payne, A.L., Mitchell, A.A., and Holman, W.F. 1988, An inventory and condition survey of rangelands in the Ashburton River catchment, Western Australia, Technical Bulletin No. 62, revised edition, Western Australian Department of Agriculture, South Perth.

Pearson, D. (2003), Giant Pythons of the Pilbara. Landscope. 19(1).

Simpson, K. and Day, N. (2004), *Field Guide to Australian Birds.*, Penguin Books Australia, Melbourne.

Slater, P., Slater, P. and Slater, R. (2003), *The Slater Field Guide to Australian Birds.*, Weldon Publishing, Sydney.

Start, A. N. and Kitchener, D. J. (1995), 'Western Western Pebble-mound Mouse *Pseudomys Chapmani*.' in R. Strahan (ed.), *The Mammals of Australia.*, Reed Books, Sydney, pp. 590 - 592.

Storr, G. M., Smith, A. D. and Johnstone, R. E. (1999), *Lizards of Western Australia. I. Skinks. Revised Edition.*, W.A. Museum, Perth, Western Australia.

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

Storr, G. M., Smith, L. A. and Johnstone, R. E. (1990), *Lizards of Western Australia. Iii. Geckoes and Pygopodids.*, W.A. Museum, Perth, Western Australia.

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

Strahan, R. (1995), *The Australian Museum Complete Book of Australian Mammals.*, Angus and Robertson, Sydney.

Strahan, R. (2004), *The Mammals of Australia.*, Reed New Holland, Sydney.

Tyler, M. J. and Doughty, P. (2009), *Field Guide to Frogs of Western Australia. 4th Edition.*, W.A. Museum, Perth, Western Australia.

Van Dyck, S. and Strahan, R. (2008), *The Mammals of Australia, Third Edition.*, Reed New Holland, Sydney.

Van Vreeswyk, A. M. E., Payne, A. L., Leighton, K. A. and Hennig, P. (2004), *Technical Bulletin No. 92: An Inventory and Condition Survey of the Pilbara Region, Western Australia.* Department of Agriculture Western Australia.

Western Wildlife (2009), *Phil's Creek Project Area Fauna Survey*. Prepared for Iron Ore Holdings. May 2009.

Wilson, S. and Swan, G. (2008), *Reptiles of Australia. 2nd Edition.*, Princeton University Press, Australia.

Woolley, P. A. (1995), 'Mulgara *Dasycercus Cristicauda*.' in R. Strahan (ed.), *The Mammals of Australia*, Reed Books, Sydney, pp. 55 - 56.

Woolley, P. A. and Valente, A. (1986), 'Reproduction in *Sminthopsis Longicaudata* (Marsupialia, Dasyuridae) - Laboratory Observations.' *Australian Wildlife Research*, vol. 13, pp. 7-12.

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%)

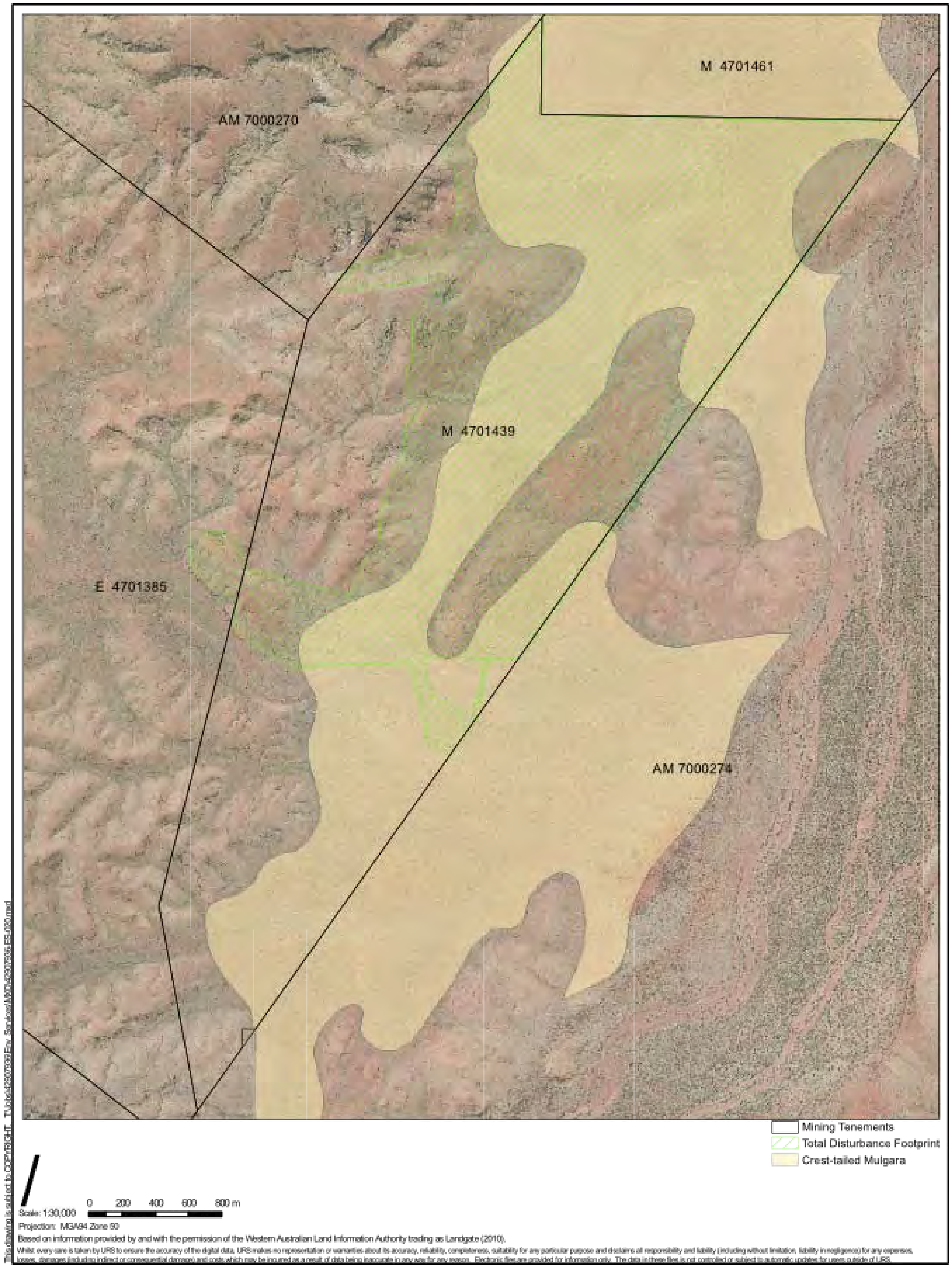


Figure 1. Interpreted habitat of Crest-tailed Mulgara.

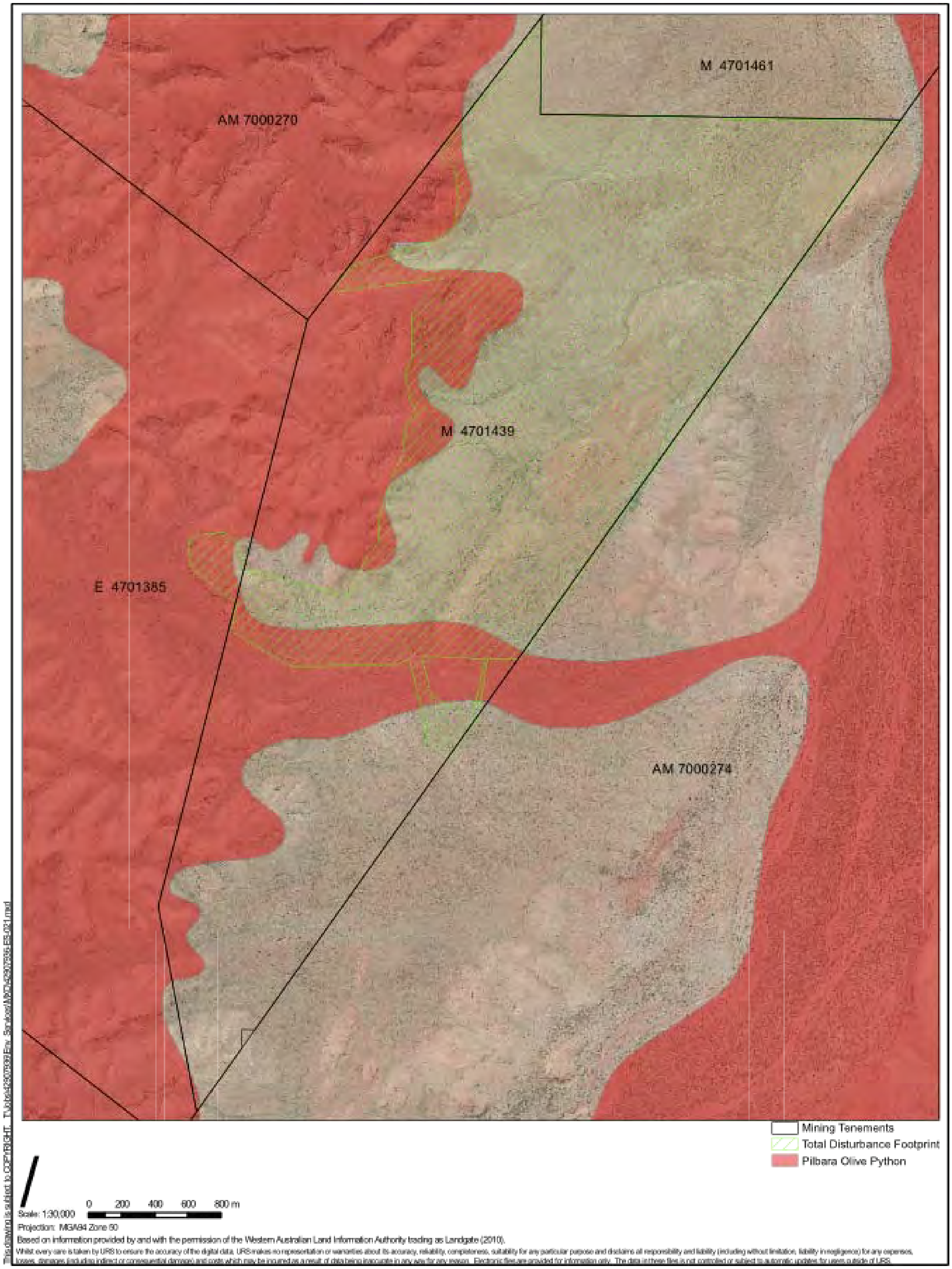


Figure 2. Interpreted habitat of Pilbara Olive Python.

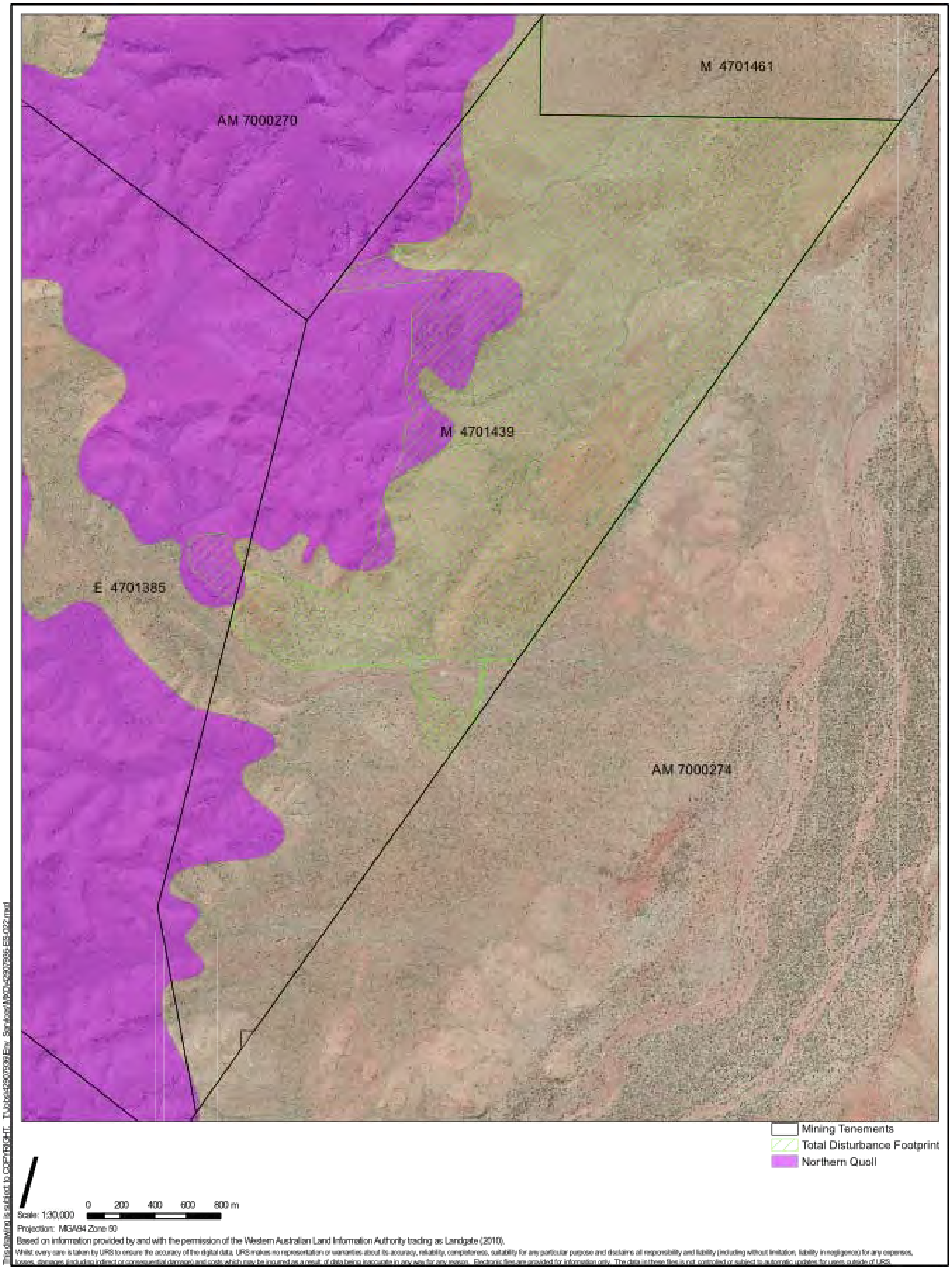


Figure 3. Interpreted habitat of Northern Quoll.

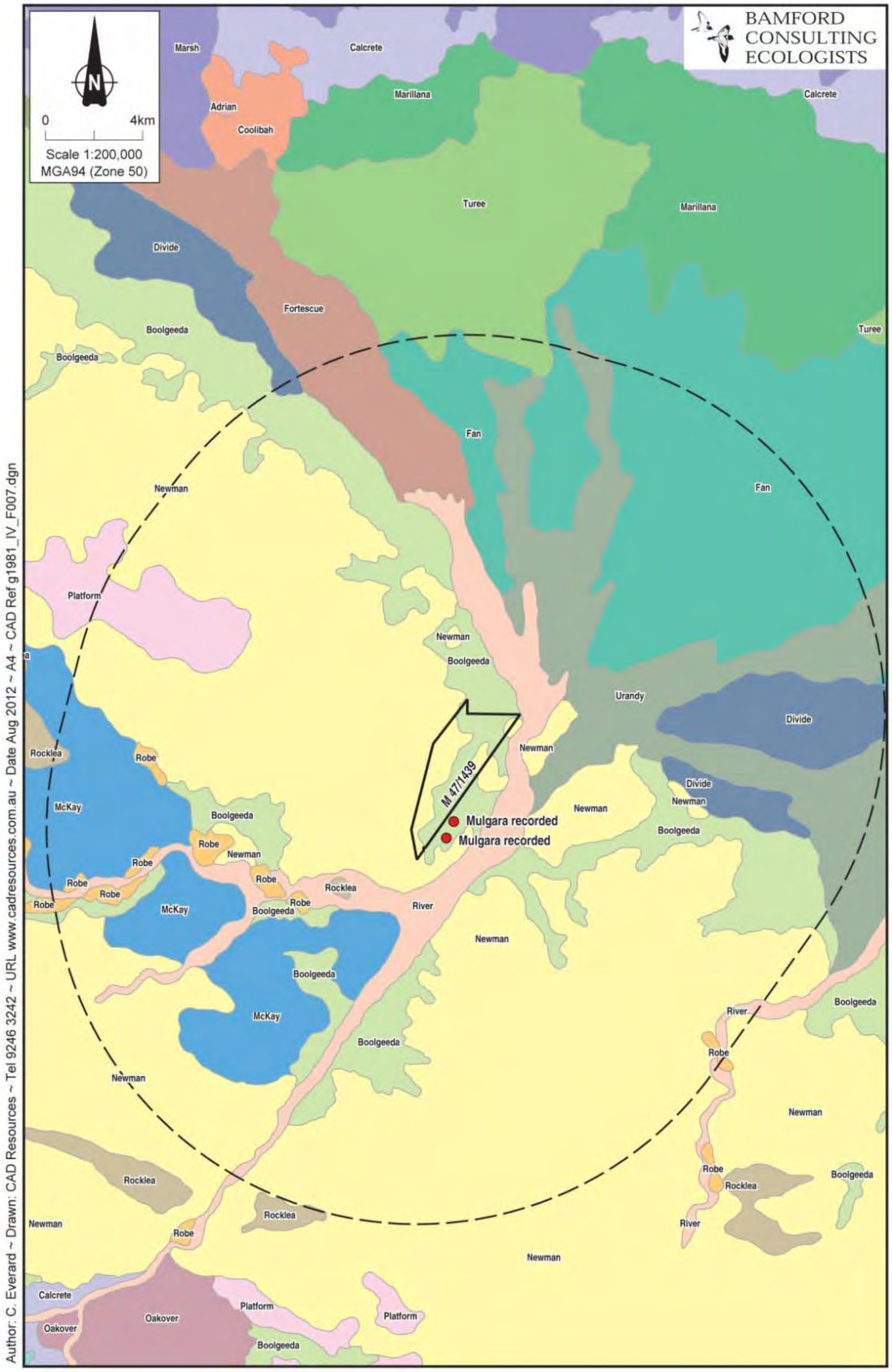


Figure 4. Land systems within 15km of the Iron Valley lease area, upon which local land system areas calculated.

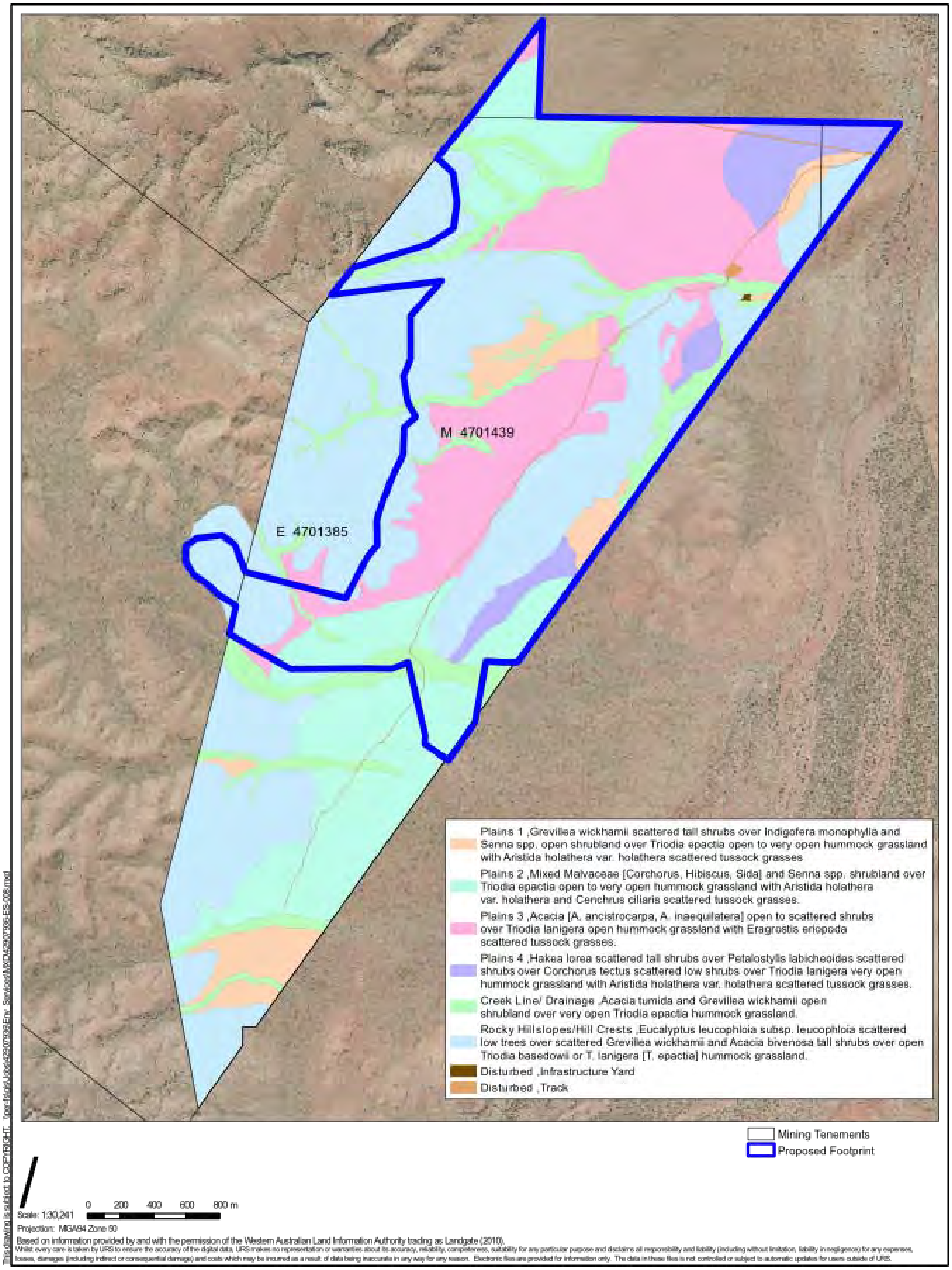


Figure 5. Vegetation types and proposed impact footprint within Iron Valley lease area.

Iron Ore Holdings Ltd – Iron Valley Project

Targeted Terrestrial Short-Range Endemic Invertebrate Fauna Survey

Prepared for URS Australia Pty Ltd

August 2012

Dalcon Environmental Pty Ltd
3 Yeeda Way, Malaga, WA 6090, Australia

Phone: (08) 9271 6776 (Int. +61 8 9271 6776)
Fax: (08) 9248 9120 (Int. +61 8 9248 9120)
Email: contact@dalconenvironmental.com.au
Webpage: http://www.dalconenvironmental.com.au

dalcon environmental

DOCUMENT STATUS					
			Approved for Issue		
Rev.	Author	Reviewer/s	Name	Distributed To	Date
A	M. Heath R. Gordon	S. Helleren R. Gordon	S. Helleren	H. Fletcher	23/09/2011
B	R. Gordon S. Helleren	S. Helleren R. Gordon	S. Helleren	H. Fletcher	9/01/2012
FINAL	R. Gordon S. Helleren	S. Helleren R. Gordon	S. Helleren	H. Fletcher	27/01/2012
FINAL AMENDMENT - A					
	R. Gordon	R. Gordon	R. Gordon	H. Fletcher	18/07/2012
FINAL AMENDMENT - B					
	R. Gordon	R. Gordon	R. Gordon	H. Fletcher	27/08/2012

Author: Mark Heath, Ross Gordon
Dalcon Environmental Pty Ltd
3 Yeeda Way, MALAGA WA 6090
Phone: +61 (0)8 9271 6776
Fax: +61 (0)8 9248 9120
Email: contact@dalconenvironmental.com.au
Website: www.dalconenvironmental.com.au

Cover Images
Top Left: Mygalomorph trapdoor spider *Missulena* "MYG045".
Mid Left: Scorpion *Urodacus* "megamastigus short" fluorescing under ultraviolet light.
Bottom Left: Male Mygalomorph trapdoor spider *Aganippe* "MYG086", rearing up in a typical aggressive posture.

Images courtesy of Ross Gordon, Dalcon Environmental Pty Ltd

Disclaimer, Confidentiality and Copyright Statement

Dalcon Environmental undertook the work and prepared this document, according to the scope of services, as defined by the Client with regards to specific instructions, time and budgetary requirements. The conclusions and recommendations stated in this document are based on those instructions and requirements, and they could change if such instructions and/or requirements change or are in fact inaccurate or incomplete.

The findings, observations and recommendations expressed by Dalcon Environmental in this report are based upon the professional opinion of Dalcon Environmental according to the data and information supplied to Dalcon Environmental (this includes verbal communications) by the Client for which the work has been undertaken (as stated in this report) and/or information obtained from the examination of documents accessed from the public record these sources of information have been identified in the report wherever possible and reasonable care has been taken by Dalcon Environmental to verify such information however, unless stated otherwise, this may not have been possible. No warranty or guarantee, whether express or implied, is made with respect to the findings, observations, conclusions and/or recommendations expressed in this report and Dalcon Environmental does not represent such findings, observations, conclusions and/or recommendations as true or accurate, and disclaims all liability with respect to the use of such findings, observations, conclusions and/or recommendations

This document was intended for the sole use of the Client and only for the use for which it was prepared, which is stated in this document. Any representation in the document is made only to the Client. Dalcon Environmental disclaims all liability with respect to the use of this document by a third party, and with respect to the use of and reliance upon this document by any party, including the Client for a purpose other than the purpose for which it was prepared. This document is intended to be read in its entirety, and sections or parts of the document should therefore not be read and relied on out of context.

Dalcon Environmental has conducted environmental field monitoring and/or testing for the purpose of preparing this document. The type and extent of monitoring and testing is described in the document.

All sites, display a degree of variation in the vertical and horizontal environmental conditions. Due to these inconsistencies, no monitoring, testing or sampling technique can completely eliminate the possibility that the results obtained through monitoring or testing are not entirely representative of the environmental conditions on the site. Any conclusions based on the findings only serve as an indication of the environmental condition of the site (including the presence or otherwise of contaminants, or biota) at the time of preparing this document.

It should be noted that site conditions, including the exact location, extent and concentration of contaminants, or biota, could change with time. Subject to the limitations imposed by the instructions and requirements of, the monitoring and testing have been undertaken in a professional manner, according to generally accepted practices and with a degree of skill and care which is ordinarily exercised by reputable environmental consultants in similar circumstances. Dalcon Environmental makes no other warranty, express or implied.

Acknowledgements

Dalcon Environmental would like to acknowledge the cooperation of URS Australia Pty Ltd staff with whom we have liaised prior to and during the field program and during the reporting phase of this Project, in particular Hannah Fletcher. Thanks also to Iron Ore Holdings Ltd staff at the Iron Valley site for their assistance in the field.

We would also like to thank Volker Framenau of Phoenix Environmental Sciences Pty Ltd for their services identifying the survey's Mygalomorph trapdoor spiders, Erich Volshenk for Scorpion identifications and Barbara Main of Curtin University for her assistance with the identification of the *Aganippe* trapdoor spiders.

Executive Summary

Dalcon Environmental, on behalf of URS Australia Pty Ltd (URS), undertook a targeted Short Range Endemic (SRE) invertebrate fauna survey of the Iron Valley Project (Iron Ore Holdings Ltd) in June 2011, specifically targeting the Mygalomorph trapdoor spider genus *Aganippe* and scorpion genus *Urodacus* at the request of the Department of Environment and Conservation (DEC). This target survey was subsequent to an extensive SRE survey undertaken by Dalcon Environmental in 2010 (Dalcon Environmental 2011).

Iron Ore Holdings Ltd proposes to develop an iron ore mine on its Iron Valley tenement in the Eastern Pilbara Region of Western Australia (WA). Two associated surveys were conducted initially during May and June 2010 (Dalcon Environmental 2011), with this third targeted SRE survey occurring in June 2011. The targeted SRE survey in June 2011 was conducted within Iron Ore Holdings Ltd tenement M47/1439 and adjoining Rio Tinto Iron Ore's tenement M274/SA for the purpose of obtaining more specimens of potential SRE fauna collected in the previous surveys, in the expectation that the taxonomy of these species can be further resolved and their SRE status determined.

Methods appropriate to the targeted collection of SRE invertebrates were employed, including dry pitfall traps with drift net fences, leaf litter collection, hand foraging, night surveys and burrow excavation.

Six specimens of the Mygalomorph spider previously identified from the 2010 surveys as *Aganippe* "sp. (fem)" (Dalcon Environmental 2011) were collected. Five out of the six specimens were identified to species level as *Aganippe* 'MYG086'; the sixth specimen was a juvenile but is considered to belong to the same species as the other five specimens. Three of the *Aganippe* "MYG086" specimens were each recorded at survey sites IOH Site 01 and RIO Site 02. *Aganippe* "MYG086" is only known from the three surveys of the Iron Valley Project as well as a survey at Roy Hill Station, ca. 80 km southeast of Iron Valley. As these two recorded occurrences of *Aganippe* "MYG086" fall within the currently accepted SRE definition of fauna exhibiting home ranges less than 100,000 km^2 (Harvey 2002), it is reasonable to consider *Aganippe* "MYG086" as potentially SRE fauna.

The target *Urodacus* sp. found in the previous survey of the area was discovered to be *Urodacus* 'megamastigus short' which is not an SRE (Volschenk 2010).

Table of Contents

List of Figures

List of Tables

1. INTRODUCTION

In May 2010 Dalcon Environmental was commissioned by URS Australia Pty Ltd (URS) on behalf of Iron Ore Holdings Ltd (IOH) to undertake a Short Range Endemic (SRE) invertebrate fauna survey at the Iron Valley Project (the Project) in the Pilbara Region of Western Australia. As a result of this survey (Dalcon Environmental 2011), two potential SRE taxa were recorded but neither could be identified to species level and hence their SRE status could not be determined. These potential SRE taxa were a species of scorpion, *Urodachus* sp. juv, and a Mygalomorph (trapdoor) spider, *Aganippe* sp. (fem).

Only a single juvenile specimen of the *Urodachus* was found in the 2010 survey (in a wet pitfall trap on the gravel plains of the "long transect" (Figure 1), and adults are required for identification to species level. Eleven female *Aganippe* trapdoor spiders were excavated from burrows also on the gravel plains of the "long transect" (Figure 1) in the 2010 survey, and male spiders are required for identification to species level and subsequent determination of SRE status.

This report documents the Project background and the methods and results of a targeted survey for the Mygalomorph trapdoor spider genus *Aganippe* and scorpion genus *Urodacus*, which was undertaken during June 2011.

1.1. Project Background

IOH proposes to develop an iron ore mine on its Iron Valley tenement in the Eastern Pilbara Region of Western Australia (WA), for the Iron Valley Project (Figure 2). The Iron Valley deposit lies within Mining Lease M47/1439.

Initial drilling has been undertaken at the Iron Valley deposit since 2008. The Project Area has been previously undisturbed by mining, and has been used by the Marillana Station pastoralists for cattle grazing.

The Project Area is located approximately 90 km north-west of Newman and 150km east of Tom Price and located in close proximity to a number of operating iron ore mines including Rio Tinto Iron Ore's (RTIO) Yandicoogina operation, BHP Billiton Iron Ore's (BHPBIO) Yandi operation and Fortescue Metals Group (FMG) Cloudbreak operation.

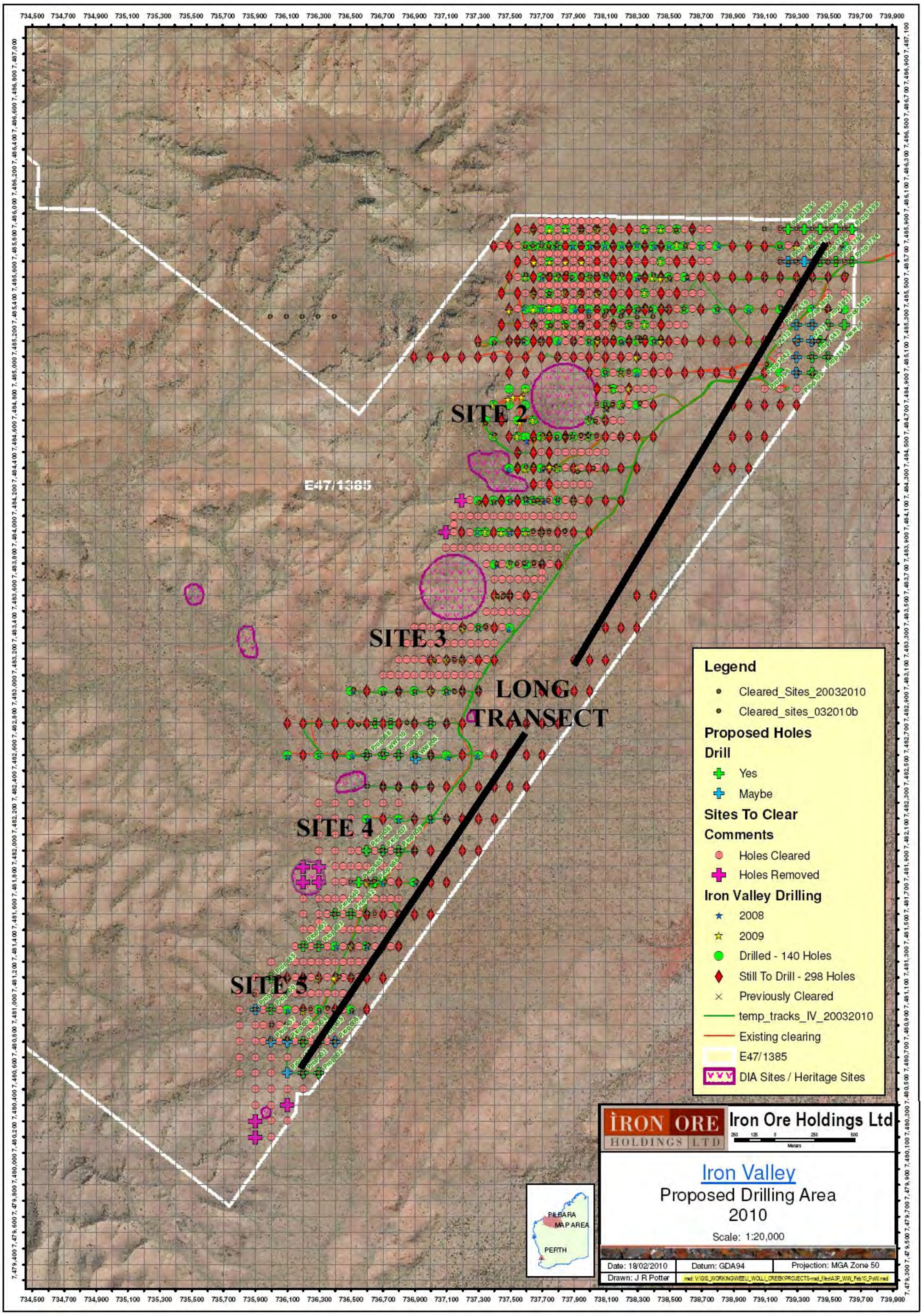


***Figure 1:** Long transect line from the Dalcon Environmental 2010 SRE Survey at IOH.*

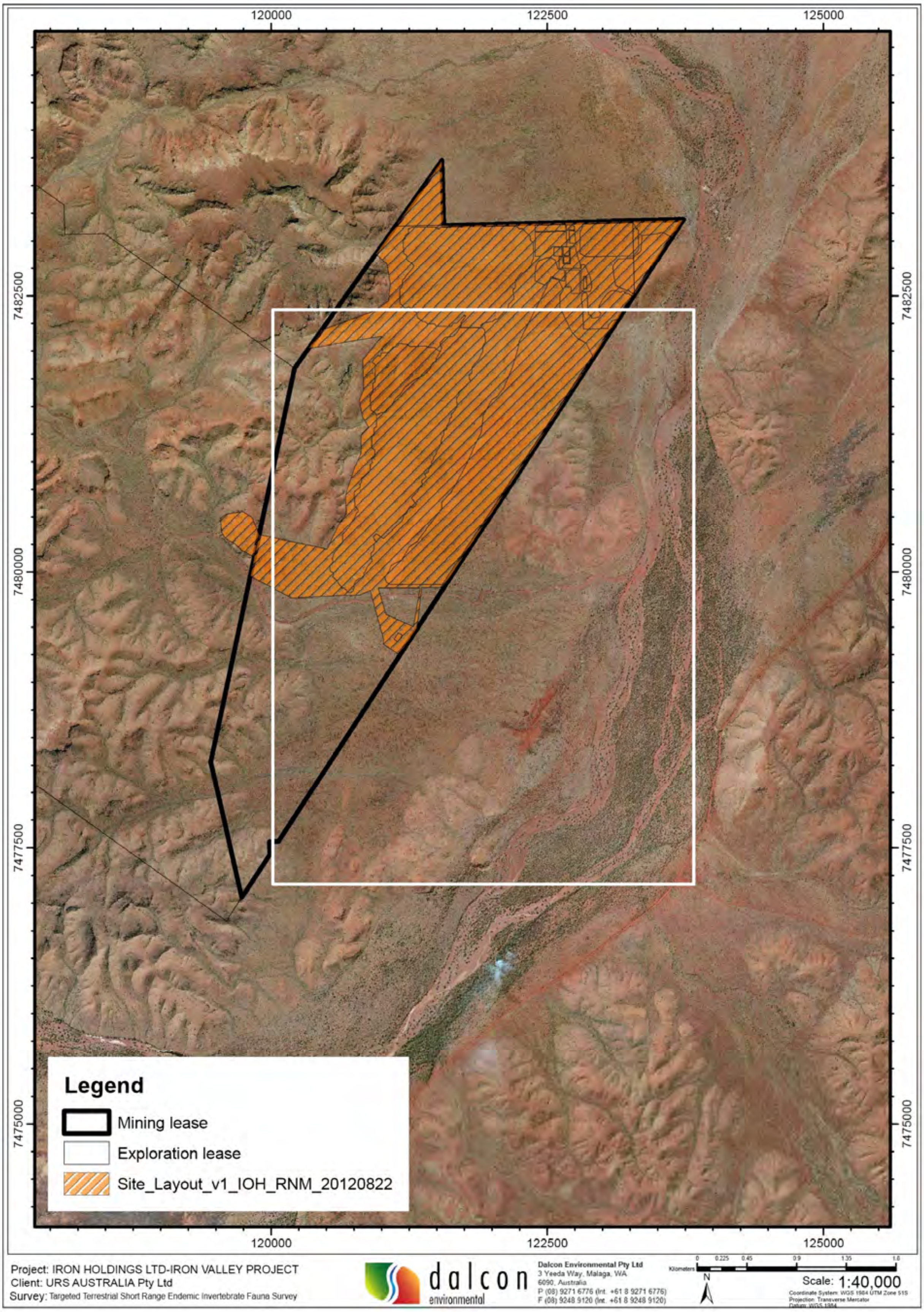


Figure 2: *Key mining components and activities of the proposed Project. White rectangle indicates area depicted in Figure 5.*

1.2. Objectives

This targeted survey was undertaken as a result of discussions with the Department of Environment and Conservation (DEC) in regards to the findings of the 2010 SRE survey (Dalcon Environmental, 2011), which highlighted the taxonomic uncertainty of the potential SRE taxa *Aganippe* sp. (fem) and *Urodachus* sp. (juv). The response from the DEC outlined the need to obtain mature male specimens for both these taxa so that their SRE status could be determined along with specific habitat information. The collection of male specimens would provide much greater taxonomic certainty and combined with habitat information, should help to address the uncertainty regarding the risk to these taxa from the Project, by demonstrating that these species are found in habitat that is widespread.

The DEC recommended that a targeted survey be undertaken using active searching techniques (such as hand foraging, burrow inspections and excavations, collection of leaf litter and night surveys) and dry pitfall trapping. The targeted survey should be undertaken at locations within the Project Area where these species are known to occur (based on the previous survey) as well where known to occur (based on the previous survey) in areas of similar habitat beyond the Project (impact) Area (Figure 5, 7, 8, 18), with the objective of capturing male specimens of the taxa listed above. In addition to this, habitat descriptions should be recorded of the locations where the targeted taxa are found, which can then be used to provide some risk based assessment. This combined approach should provide adequate data for the DEC to further assess the Project's impact on invertebrate/SRE fauna, as advised by the DEC.

The objectives of this survey therefore are:

1) Undertake a targeted survey for male specimens of the trapdoor spider *Aganippe* sp. (fem) at sites recorded in the 2010 survey and from similar habitat within and beyond the Project Area;
2) Describe the preferred habitat in which the burrows of the trapdoor spider *Aganippe* sp. (fem) as recorded in the 2010 survey occur;
3) Extrapolate the extent of preferred *Aganippe* sp. (fem) habitat throughout the Project Area to the best extent possible in order to estimate distribution and locate new *Aganippe* sp. populations;

4) Undertake a targeted survey for male specimens of the scorpion *Urodachus* sp. (juv) at sites recorded in the 2010 survey and from similar habitat within and beyond the Project Area;
5) Describe the habitat in which the burrows of the scorpion *Urodachus* sp. (juv) as recorded in the 2010 survey occur;
6) Extrapolate the extent of this preferred *Urodachus* sp. (juv) habitat throughout the Project Area.

This survey was conducted as a targeted SRE survey as per the EPA's Guidance Statement No. 20, Sampling of SRE Invertebrate Fauna for Environmental Impact Assessment in WA (EPA, 2009) and the DEC recommendations (Durant B 2011, pers. comm., 15 April) focusing on:

1. Identifying areas in which vegetation is under threat of being cleared or irrevocably damaged in a way which would directly affect SRE fauna habitat.
2. Identifying areas sensitive to and likely subjected to changes in hydrology, fire regimes, introduction of weed or soil pathogens which would directly affect SRE fauna habitat.
3. Identify any other potential impacts which would directly affect SRE fauna habitat.

Permission was granted for Dalcon Environmental to conduct sampling and vegetation surveys in the adjacent Rio Tinto tenement (Best D 2011, pers. comm., 29 May) to find areas similar to IOH sites containing the targeted SRE in the hopes of finding target SRE fauna outside IOH tenement.

2. PROJECT AREA

2.1. Regional Setting

The Project is situated within the Pilbara Region of WA within the Hamersley Range. It lies within the Weeli Wolli Catchment which drains into the Fortescue River Basin (known as the Fortescue Marsh). The Hamersley Range contains large deposits of iron ore and is a source of a high percentage of the iron ore mined in Australia (Department of the Environment, Water, Heritage and the Arts 2001 – now known as Department of Sustainability, Environmental, Water, Population and Communities). It is a mountainous area of Proterozoic (545-2500 million years ago) sedimentary ranges and plateaux, reaching an elevation of 1250 m above sea level (Durrant *et al*., 2010).

The Project is within the Pilbara Bioregion which consists of mountainous ranges and plateaus with cliffs and deep gorges, alluvial/granite/basalt plains with an arid subtropical climate, mild winters and summer rain. The Pilbara Bioregion is dominated by hummock grasslands (spinifex) with some Acacia shrub land. The region is extensively grazed by cattle (Department of the Environment, Water, Heritage and the Arts, 2001).

Cyclones and local thunderstorms cause major flows in river systems almost every year between December and April. These rivers are generally dry between August and November with only occasional flows (Department of the Environment, Water, Heritage and the Arts, 2001).

2.2. Regional Climate

Climate for the region was collected from the Bureau of Meteorology (BOM) Newman Aerodrome weather station, approximately 90 km north-west of the Project Area. A weather station is present at Marillana Station, however, it is only equipped to record temperature and data is inconsistent (Bureau of Meteorology, 2011b).

The Project Area experiences an arid tropical climate characterised by hot wet summers and mild dry winters. Annual average rainfall of 309.6 mm (200 – 350 mm) occurs between December and June (Figure 3) but can vary widely (Department of the Environment, Water, Heritage and the Arts, 2001). Highest average temperature of 37 °C occurs between November to February, declining to median temperature of 25 °C during winter months (Figure 3) (Department of the Environment, Water, Heritage and the Arts, 2001). Effect of climate upon potential short-range endemic invertebrate yields is discussed in Section 4.1 and Section 4.2.

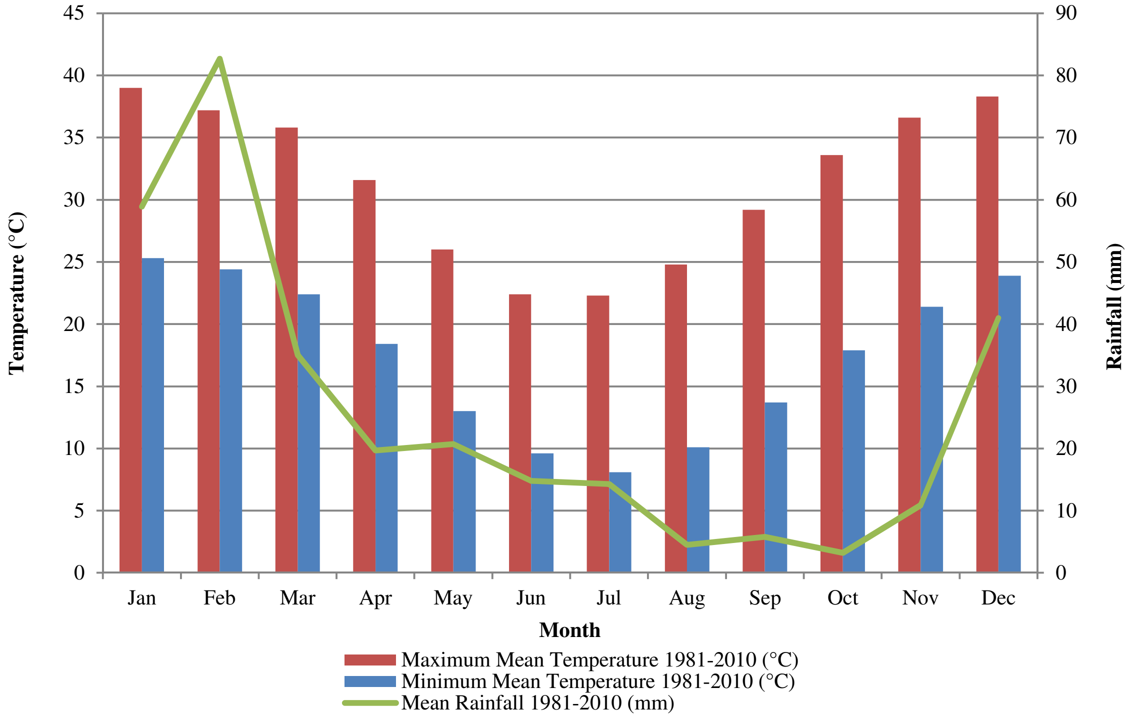


Figure 3: *Average Temperature and Rainfall 1981 – 2010 from Newman Airport weather station (Station ID: 001176) (Bureau of Meteorology, 2011a).*

2.3. Project Setting

IOH proposes to clear up to 674 ha of vegetation for the Project (excluding any future transport corridors). The Project Area has historically been used for pastoral activities and in the past several years, mineral exploration has also been undertaken within the Project Area. Dalcon observed that a recent fire had occurred within the Project Area, in early 2009.

The Project Area occurs within the Hamersley Plateau Botanical District, which is grouped within the Eremaean Botanical Province (Beard, 1979). The vegetation condition and assemblage, including the presence of any weed species within the Project Area, has been assessed during the flora and vegetation assessments undertaken as part of the EIA for the Project.

The Project is located within the Eastern Pilbara Region and is dominated by the Hamersley Plateau (Van Vreeswyk *et al.,* 2004). The geology in the region comprises lower Proterozoic shale, chert, mudstone, sandstone and dolomite (Van Vreeswyk *et al.,* 2004). The Project Area is located within the Boolgeeda and Newman Land systems which is not prone to soil erosion, or land degradation (Van Vreeswyk *et al.,* 2004). This land system comprises of hills, ridges, plateaux remnants and breakaways of meta-sedimentary and sedimentary rocks, supporting hard Spinifex and predominantly supports hard Spinifex vegetation. The soils generally encountered within the McKay land system comprise stony soils, red deep loamy duplex with minor shallow loams and red loamy earths with river bed soil in channels (Van Vreeswyk *et al.,* 2004). Although not favoured by livestock (Van Vreeswyk *et al.,* 2004), the Project Area has historically been used for pastoral use, and is currently a pastoral station (Marillana Station).

It was evident that the southern part of the tenement had recently been subject to wildfire, with the wildfire occurring in early 2009. The area burnt was south of the creek line (a tributary of Weeli Wolli Creek) which runs in an east-west direction across the southern part of the tenement. This burning had altered the structure of the vegetation community and removed all of the Spinifex and most of the ground cover and litter. The effect this has had on the invertebrate community is largely unknown (see Section 3) and beyond the scope of this survey. Different invertebrate groups respond differently to fire, however there were some differences in the invertebrate communities observed in this burnt region and these will be discussed in Section 6.2, and Section 6.4.

2.4. Legislative Framework

The *Environmental Protection Act 1986* (EP Act) was developed to provide for the formation of an EPA. The Act allows the EPA to carry out measures "for the prevention, control and abatement of pollution and environmental harm, for the conservation, preservation, protection, enhancement and management of the environment and for matters incidental to or connected with the foregoing". The object and principles of the EP Act are outlined in Section 4a of the Act. This section of the Act lists five principles that are necessary to ensure that the objectives of the Act are maintained. Three of these principles relate to native fauna and flora:

1) The Precautionary Principle

Where there are threats of serious or irreversible damage, lack of full scientific certainty should not be used as a reason for postponing measures to prevent environmental degradation.

In the application of the precautionary principle, decisions should be guided by:

a) Careful evaluation to avoid, where practicable, serious or irreversible damage to the environment; and
b) An assessment of the risk-weighted consequences of various options.

2) The Principles of Intergeneration Equity

The present generation should ensure that the health, diversity and productivity of the environment is maintained or enhanced for the benefit of future generations.

3) The Principle of the Conservation of Biological Diversity and Ecological Integrity

Conservation of biological diversity and ecological integrity should be a fundamental consideration.

Environmental Impact Assessment projects require the assessor(s) to follow EPA guidelines. With regards to this Project there are three applicable guidelines:

- Guidance Statement No. 56: Terrestrial Fauna Surveys for Environmental Impact in Western Australia (EPA, 2004); and
- Position Statement No. 3: Terrestrial Biological Surveys as an element of Biodiversity Protection (EPA, 2002) ; and
- Position Statement No. 20: Sampling of Short Range Endemic Invertebrate Fauna for Environmental Impact Assessment in Western Australia (EPA, 2009).

In relation to SRE Fauna, EPA Guidance Statement No. 56 states:

> "*Comprehensive systematic reviews of different faunal groups often reveal the presence of short-range endemic species (Harvey, 2002). Among the terrestrial fauna there are numerous regions that possess short-range endemics. Mountainous terrains and freshwater habitats often harbour short-range endemics, but the widespread aridification and forest contraction that has occurred since the Miocene has resulted in the fragmentation of populations and the evolution of many new species. Particular attention should be given to these types of species in environmental impact assessment because habitat loss and degradation will further decrease their prospects for long-term survival.*
>
> *Harvey (2002) considered that although there were occasional short-range endemics among the vertebrates and insects, there were much higher numbers among the molluscs, earthworms, some spider groups (especially the mygalomorphs), millipedes, and some groups of crustaceans. Short-range endemics generally possessed similar ecological and life history characteristics, especially poor powers of dispersal, confinement to discontinuous habitats, slow growth and low fecundity.*
>
> *Some better known short-range endemic species have been listed as threatened or endangered under State or Commonwealth legislation but the majority have not. Often the lack of knowledge about these species precludes their consideration for listing as threatened or endangered. Listing under legislation should therefore not be the only conservation consideration in environmental impact assessment. The State is committed to the principles and objectives for the protection of biodiversity as outlined in* The National Strategy for the Conservation of Australia's Biological Diversity *(Commonwealth of Australia, 1996). The EPA expects that environmental impact assessment will consider impacts on conservation of short-range endemics in accordance with these principles and objectives*."

Western Australian native fauna are currently protected under Federal and State Acts, the Commonwealth *Environmental Protection and Biodiversity Conservation Act 1999* (EPBC Act) and the WA *Wildlife Conservation Act 1950* (WC Act) respectively.

The EPBC Act was created to protect native species, to prevent extinction and promote recovery of threatened species, and aid in the conservation of migratory species. Section 3 of the EPBC Act lists a number of key objectives in order to achieve this, some of which include:

- Provide for the protection of the environment, especially those aspects of the environment that are matters of national environmental significance;
- Promote ecologically sustainable development through the conservation and ecologically sustainable use of natural resources;
- Promote the conservation of biodiversity; and
- Provide for the protection and conservation of heritage.

Section 3a of the EPBC Act states "decision-making processes should effectively integrate both long-term and short-term economic, environmental, social and equitable considerations" in addition to the ecologically sustainable development principles listed in Section 4a of the EP Act.

The WC Act is applicable to Western Australian wildlife only, and states that all native flora and fauna and migratory species are to be protected at all times.

This survey was undertaken in accordance with all of the principles and objectives detailed above.

3. SHORT RANGE ENDEMIC FAUNA - BACKGROUND

Previously the use of invertebrates in biodiversity surveys has been regarded as problematic due to the high numbers of species involved (Harvey, 2002). In response to this problem Main (1996) suggested that research be conducted specifically on relict species assemblages to determine their habitat requirements. The concept of recognising the major groups which contained a high number of narrow range relictual species was proposed by Harvey (2002), who called these relictual species SREs. An SRE species is defined as having a naturally small distribution of less than 10 000 km^2 (100 km x 100 km) (Harvey, 2002). SREs were found to display certain ecological and life history traits:

- Poor dispersal ability (e.g. most spiders can disperse by ballooning, but trapdoors [Mygalomorphs] do not use this method and many are SREs);
- Confinement to discontinuous habitats;
- Highly seasonal activity patterns, often only active during cooler and moister periods, which, typically based on rain variations, can be restricted to certain periods; and
- Lower ability to reproduce offspring, or offspring produced in lower numbers.

The existence of SREs is a result of climatic and vegetation changes that have occurred over geological time. Australia used to be part of a super land mass called Gondwanaland and was thickly vegetated with tropical rainforest. The fragmentation of Australia from Gondwana, and its drift northwards, resulted in a decrease in rainfall, resulting in aridification (Main, 1996; 1997). Invertebrate species that used to be common while the land was covered with rainforest found themselves squeezed into the reduced rainforest areas, and today these relictual species are only found in moist and shaded areas. These areas typically include habitats that are isolated by geographical barriers which impedes dispersal and gene flow. A classic example is islands, where the terrestrial environment is surrounded by a marine environment which prevents dispersal to other islands. In this respect, caves and mesas are like islands, possessing environmental conditions that are totally different to the surrounding landscape. Large landform features, like the Devonian Reef system in the Kimberley Region, host a large number of SREs because they act as a barrier, resulting in speciation as a result of fragmentation of populations.

Typical habits that often contain SRE species include:

- Vine thickets and rainforest patches (usually in the Kimberley and tropics);
- Areas of high rainfall with short summer drought;
- Boulder and rock piles especially if water is shed from rocks;
- Isolated hills and mesas especially if subject to frequent mist, cloud or drizzle;
- Areas where vegetation can harvest water from fog or cloud;
- Vegetated gullies with deep leaf litter;
- Permanent freshwater pools, rivers and wetlands; swamps; springs;
- Areas of impeded groundwater flow;
- South facing slopes of hills and ranges which are sheltered from summer heat;
- Mouths of caves, inside of caves;
- Mountainous terrain and gorges;
- Islands;
- Granite outcrops (Main, 1997);
- Ridges that create a barrier (e.g. Devonian Reef in the Kimberley); and
- Palaeodrainage channels (Raven, 2008).

Each of these habitats would support a small and spatially isolated population, which would be further restricted due to SRE low dispersal power (Main, 1996; Harvey, 2002).

The process of aridification and rainforest reduction has resulted in the fragmentation of invertebrate populations and a tendency for the evolution of new species with small distribution (EPA, 2009). Due to SREs being restricted to specialized microhabitats they are very vulnerable to anthropogenic disturbances and will often be unable to recover from disturbance and thus face the prospect of extinction. These disturbances can be due to agriculture, mineral extraction, roading and housing developments. Fire can also be a threat because an entire population may be restricted to a single microhabitat (EPA, 2009).

Not all taxa are characterised by a large number of SREs. Although there are insects which could be described as SRE, no insect Orders have a high percentage of SRE. This is mainly because insects are winged and usually highly mobile. Some flightless insects could be considered SREs as their range is limited, but no Order is made up of a high percentage of flightless individuals (Yeates *et al*., 2002).

Harvey (2002) has identified certain taxa that contain a high proportion of SREs in Australia, these are:

- Mollusca - Gastropoda (land snails);
- Annelida - Oligochaeta (earthworms);
- Onychophora (velvet worms);
- Arachnida - Scorpionida (scorpions);
- Arachnida - Araneae (mostly Mygalomorphae [trapdoor] spiders);
- Arachnida – Pseudoscorpionida (pseudoscorpions);
- Arachnida – Schizomida (schizomids);
- Malacostraca – Isopoda (slaters/woodlice); and
- Diplopoda – Chordeumatida (millipedes).

It should be noted that the identification of known SREs in WA is based on the identification provided by the WA Museum. Due to the poor current state of knowledge of the taxonomy of groups like Isopods (woodlice) they are currently mostly identified to morphospecies level, and as a result SRE identification cannot be achieved. For this reason it is possible that SRE species do occur at a project site but taxonomic difficulties make their complete identification impossible.

From the Iron Valley survey in the Pilbara, it is unlikely that Velvet worms (Onychophora) would be recorded as they are usually found in the moister south-west of WA, avoiding the arid areas of the state (Monge-Najera, 1994). Schizomids are true troglobites found in deep crevices of mesas and are unlikely to be found in the Project Area because of the lack of sufficiently deep caves. Earthworms (Annelida – Oligochaeta) could occur but currently there is no standard acceptable method to survey them. Consequently the groups to be surveyed at the Iron Valley site were landsnails, trapdoor spider, pseudoscorpions, slaters/woodlice and millipedes (Gastropoda, Scorpionida, Mygalomorphae, Pseudoscorpionida, Isopoda and Diplopoda).

It is important to recognise that the potential SRE groups listed above are not exhaustive, and that invertebrates generally are understudied and poorly understood with most species lacking a formal description. Reliable taxonomic evaluation of many species has only recently been commenced and thus there is very little literature relevant to SREs in peer reviewed journals. Bearing these facts in mind, it is important to adhere to the precautionary principle, as adopted by the EPA/DEC under section 4a of the EP Act.

3.1. **Potential Threats to Short Range Endemic Populations**

A small distribution range of a particular species may be completely natural and stable, or it may represent a historical fragmentation of range or loss of habitat due to past or continuing threats. It is therefore essential to carefully interpret the range patterns of any species and determine any causes for the restricted range before any conservation management is carried out (New and Sands, 2002).

Issues that need to be considered are dispersal ability, habitat preferences, life history attributes, physiological attributes, habitat availability and biotic/abiotic interactions. Due to their relictual nature, any loss or fragmentation of habitat can cause the extinction of a local SRE (Ponder and Colgan, 2002). Threats to habitats suitable to SREs include (Australian Biological Resource Assessment, 2002):

- Clearing of native vegetation;
- Inappropriate and changed fire regimes (altered fire regimes may act to promote premature drying of mesic refuge habitats for SREs);
- Mineral extraction;
- Road and housing development;
- Grazing; and
- Changed hydrology.

SREs are especially vulnerable to anthropogenic activity due to limited dispersal ability and specific habitat requirements (Eberhard *et.al.*, 2009). Their limited dispersal capabilities make any land degradation likely to fragment their habitat and results in a decrease in population numbers, inbreeding and loss of genetic fitness. Thus if a loss of habitat occurs in only a part of their range this could be highly significant due to fragmentation and the consequent inability to exchange genes between the fragments.

4. METHODS

4.1. Survey Timing

The targeted survey was conducted between the 31st May 2011 and 10th June 2011 with dry pitfall traps deployed and additional invertebrate sampling conducted between the 3rd and 8th of June 2011. The timing of the survey was just outside the preferred timing stated in EPA Guidance Statement No. 20 (EPA, 2009), as this Guidance Statement recommends that terrestrial invertebrate fauna (particularly SRE) surveys in the Pilbara should be conducted from November to April (coinciding with the cyclone season as many SRE species are only found during this wet season). During discussions with the DEC in early 2011 (Durant B 2011, pers. comm., 15 April), the DEC recommended that the survey commence sooner rather than later, and that the proposed timing of late May-June was acceptable (Durant B 2011, pers. comm., 15 April) Fortunately, out of season rainfall between the 4th and 10th June 2011 which significantly increased the yield of SRE Mygalomorph spiders in the targeted survey areas.

4.2. Weather During the Survey Period

Data from the Newman Aerodrome weather station (Station ID 001176, located approximately 90 km south east of the Project Area) indicates that temperature during the survey period ranged from 0.3 ºC minimum to 28.6 ºC maximum. The monthly rainfall total of 9.4 mm was recorded from 5th to 8th June, with the majority, 8.2 mm falling on the 7th June. (BOM, 2011). However, it was noted by the field team that the survey area experienced continuous drizzle to rain for the majority of the survey period with numerous heavy rain events, so it is likely that the rainfall for the survey area was greater than that recorded from the Newman Airport weather station.

Daily maximum and minimum temperatures, as well as rainfall, recorded from the Newman Airport weather station during the targeted survey month of June 2011 are presented in Figure 4.

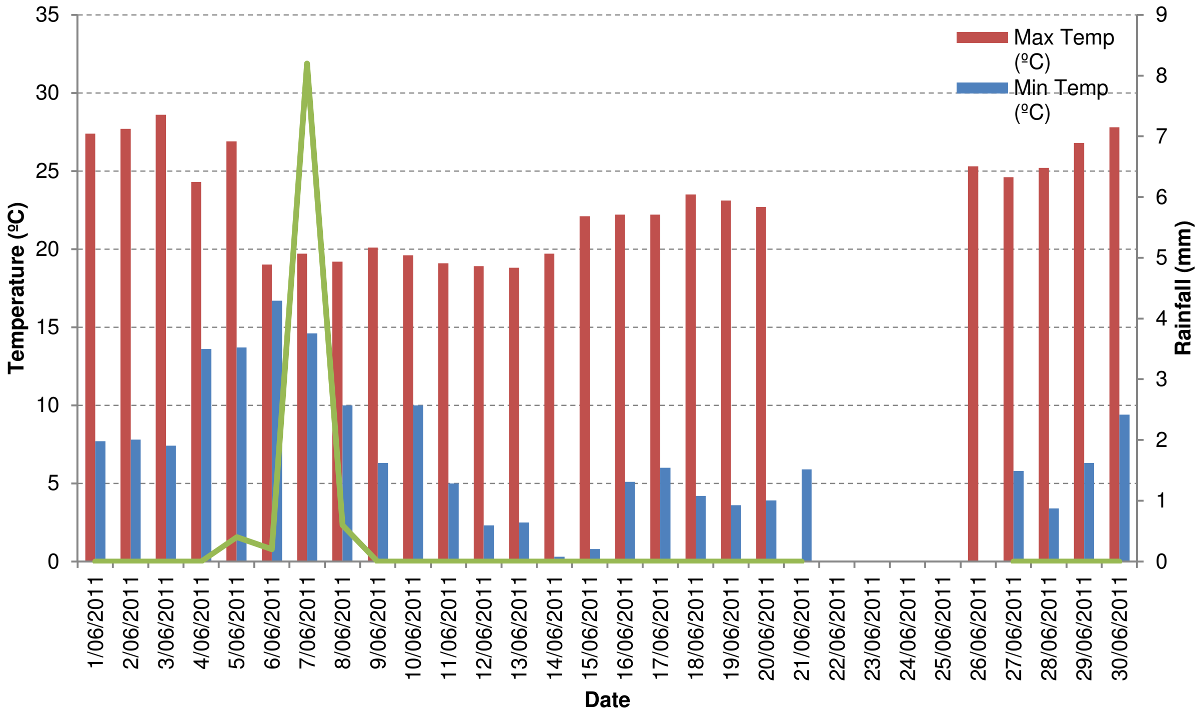


Figure 4: *Daily minimum and maximum temperature and rainfall from the Newman Airport weather (Station ID 001176) in June 2011 (BOM, 2011).*

4.3. Site Selection

Due to the targeted nature of the current survey, site selection was based upon data collected during previous surveys. Sites were allocated at and around GPS waypoints of previous sites which had recorded instances of the Mygalomorph spider *Aganippe* sp. and scorpions *Urodachus* sp. on the flat plains, around drilling pads and the proposed pit areas (Figure 5). At these targeted sites a grid pattern deployment was utilized to ensure the most comprehensive sampling of the habitat.

As requested by the DEC, sites beyond the Project impact area (the Iron Valley tenement boundary) were also surveyed. Approval was granted to locate sites on Rio Tinto Iron Ore's North Billard tenure (Best D 2011, pers. comm., 29 May) with similar habitats found in the Iron Valley tenement area that is known to contain *Aganippe* and *Urodachus* burrows (Figure 5, 7 and 8).

Rio Tinto survey sites were selected by examining aerial photographs and selecting areas of vegetation exhibiting either: 1) similarities to the Iron Valley Project sites where SRE fauna had been collected previously in the 2010 survey (Dalcon Environmental, 2011), or 2) vegetation complexes with high probability of containing SRE fauna based on previous Dalcon Environmental surveys and unpublished data, extensive literature review and correspondence with short-range endemic specialists (Harvey, 2002). These potential sites were then verified via ground reconnaissance prior to commencing the surveying (Figure 5, 6, 7 and 8).

Figure 5 displays a distribution overview all site locations associated with the targeted SRE survey. Red icons indicate survey points within the IOH tenement and are expanded upon in Figure 6. Green icons indicate survey points within the adjacent Rio Tinto tenement and are expanded upon in Figure 7 and Figure 8

Figure 6 displays a distribution overview of all sampling sites within the IOH tenement. Two sampling sites, IOH tenement Site 01 (IOHS01 – Figure 6) and IOH tenement Site 02 (IOHS02 – Figure 6) are present. IOHS01 contained 20 dry pitfall traps (Section 4.4.1) in a five-by-four sampling grid matrix. IOHS02, adjacent to IOHS01 contained 10 dry pitfall traps (Section 4.4.1) in a three-by-three sampling grid matrix with one trap positioned at the end of the final sampling row in suitable potential SRE habitat.

Rio Tinto tenement Site 01 (RIOS01 – Figure 7) and Rio Tinto tenement Site 02 (RIOS02 – Figure 8) contained 15 dry pitfall traps (Section 4.4.1) in a five-by-three sampling grid matrix each to standardise sampling methodology.

Total of 60 dry pitfall traps (Section 4.4.1.) were deployed during the targeted survey.

Four vegetation and habitat assessment sites (RIOVEG 01 to 02) were selected in Rio Tinto tenement in areas considered to best represent the vegetation complexes along the tenement boundary line as well as provide suitable habitat for potential SRE fauna (Figure 5).

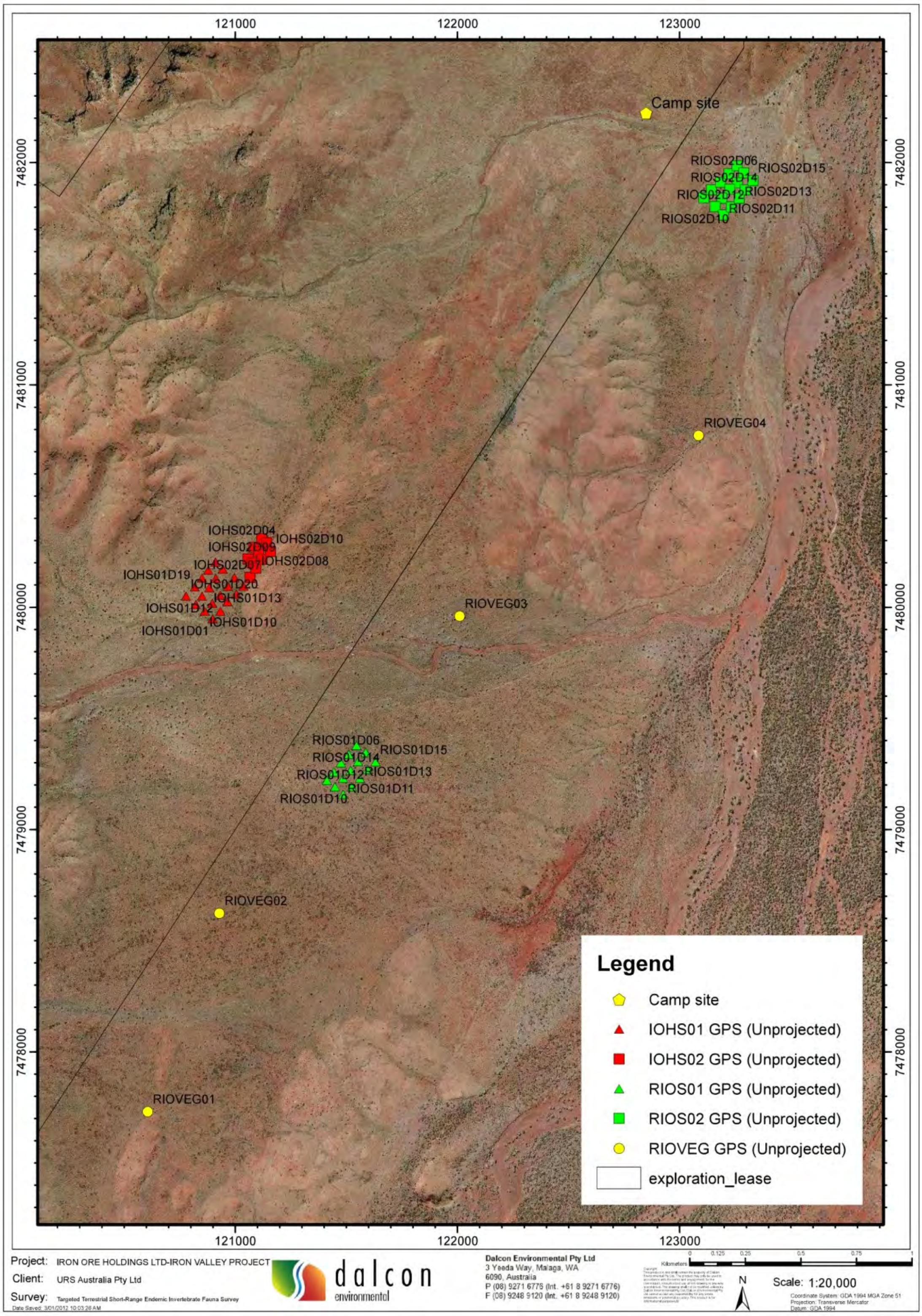


Figure 5: *Site locations within the Iron Valley (IOH – left side of tenement boundary) and Rio Tinto (RIO – right side of tenement boundary) for the targeted SRE survey.*

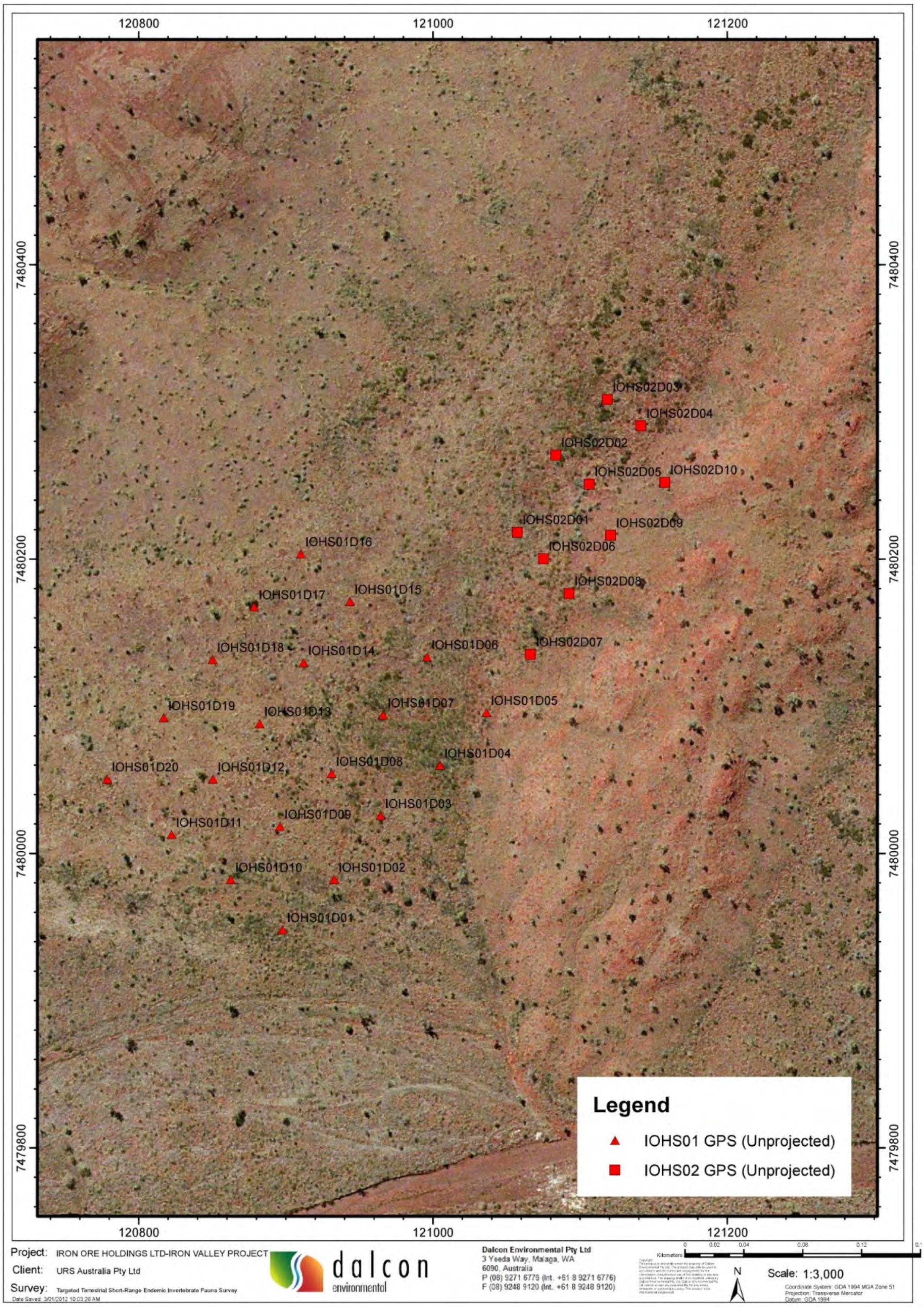


Figure 6: *Sites One and Two within the Iron Valley tenement (IOHS01 & IOHS02) for the targeted SRE survey.*

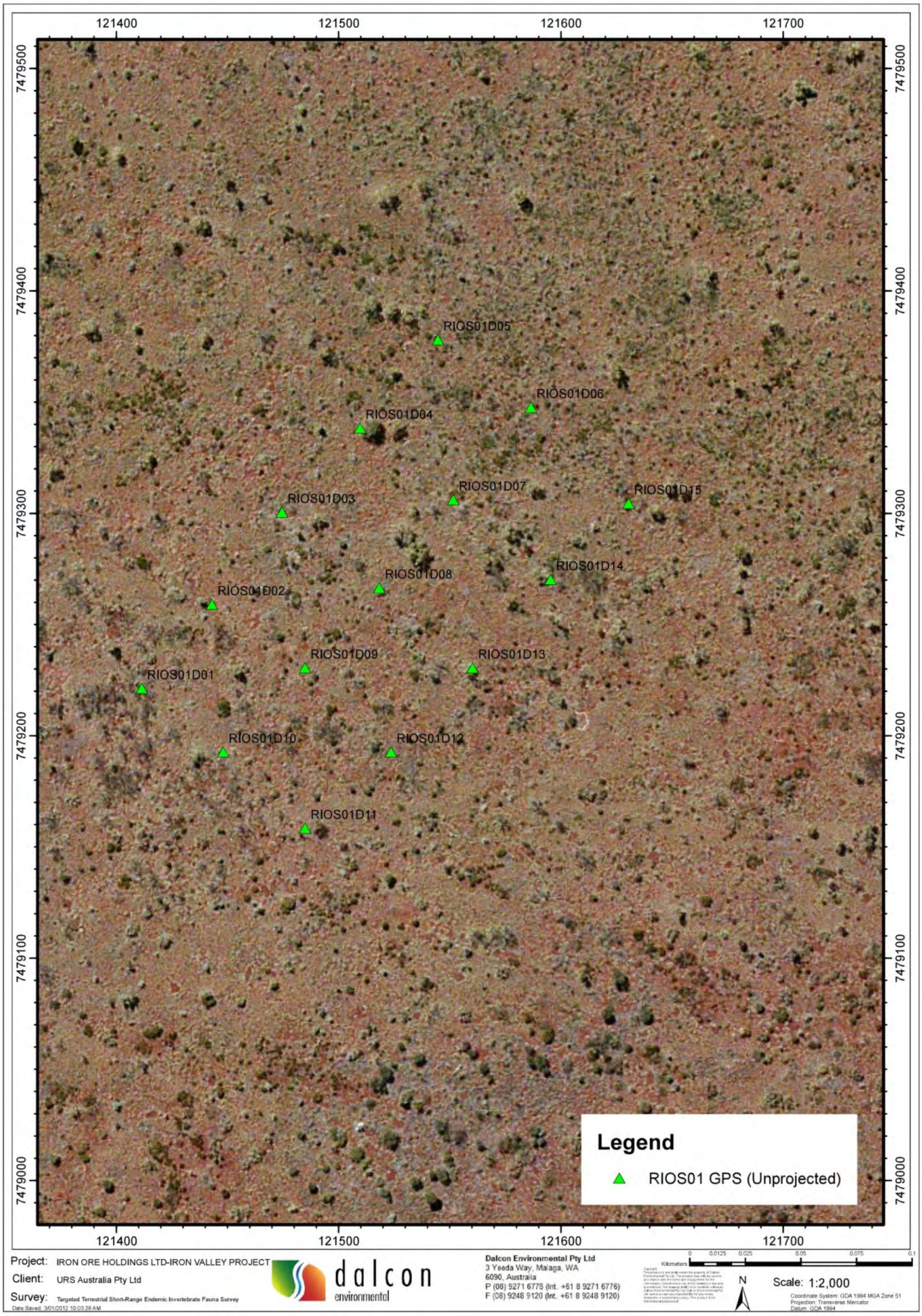


Figure 7: *Rio Tinto Site One locations within the Rio Tinto Iron Ore's tenement (RIOS01).*

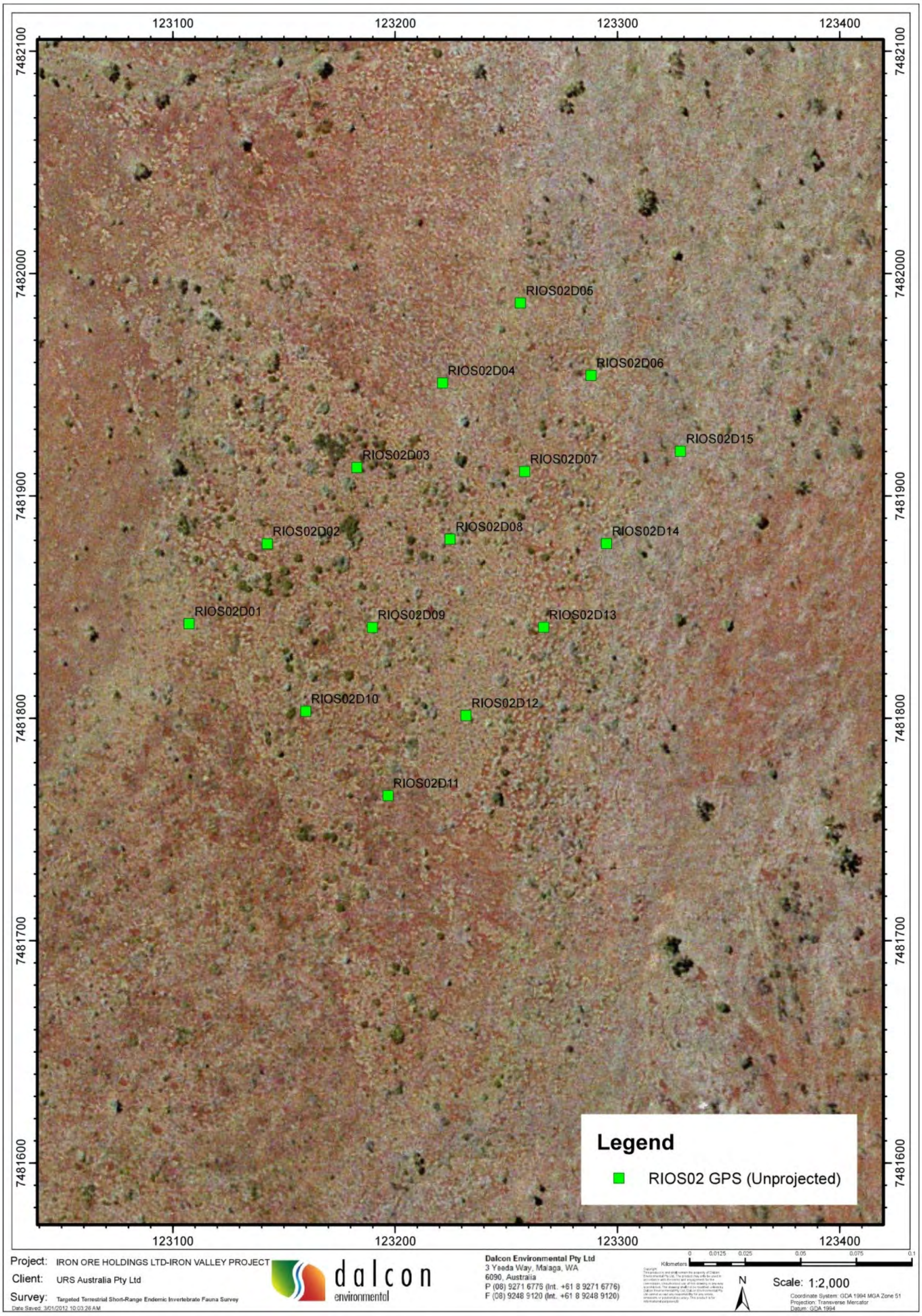


Figure 8: *Rio Tinto Site Two locations within the Rio Tinto Iron Ore's tenement (RIOS02).*

4.4. Sampling Methodology

Several sampling methodologies were employed for this targeted survey based on the principles outlined in EPA Guidance Statement No. 20: *Sampling of Short Range Endemic Invertebrate Fauna for Environmental Impact Assessment in Western Australia* (EPA, 2009). This survey focussed on several foraging methodologies (discussed in the following sections) intended to target SRE taxa. Dalcon Environmental presented the DEC with a complete proposed methodology prior to applying for a Regulation 17 License to take (i.e. capture, collect, disturb, study) fauna for scientific purposes (Bradley D 2011, pers. comm., 15 April). These methods were accepted and consequently a Regulation 17 License was awarded to Dalcon Environmental prior to the survey commencing (License No. SF007419).

4.4.1. Dry Pitfall Traps with Drift Net Fencing

Total of 60 dry pitfall traps were deployed during this survey. Dry pitfall traps comprised of a two litre bucket (160 mm diameter, 145 mm depth) dug flush into the ground. To increase sampling efficiency, three drift net fences (metal fly screen, 2 m length, 30 cm height) extending out in a ‘Y’ configuration (120 degrees apart) each side of the bucket were dug into the ground and ends secured using stakes (Figure 9). Lids were fashioned from the bucket lids and secured by metal pegs to 30 mm above ground level to reduce large vertebrate by catch.

Dry pitfall traps were checked every morning for six days. Potential SRE taxa were collected and vertebrate by-catch carefully released nearby. Dry pitfall traps were constructed in accordance to the regulations imposed by Environmental Protection Authority (2009).

Although recognised that dry pitfall traps have limited success sampling SRE fauna in comparison to other collection methods, their ability to capture fauna live reducing vertebrate by-catch mortality is extremely attractive (Environmental Protection Authority, 2009). Dry pitfall traps have proven very successful in sampling scorpion and mygalomorph fauna during favourable weather conditions (Harvey, 2002).

Figure 9: *A typical dry pitfall Trap without a lid and with two drift net fences.*

4.4.2. **Scorpion Trapping**

Targeted scorpion trapping was deployed at each site using plastic cups as small dry pitfall traps, located in close proximity to verified scorpion burrows. Close proximity was standardised by setting the small dry pitfall trap directly in front of and 30 cm away from the scorpion burrow exit. If vegetation or other factors prevented deployment directly in front of the burrow, the trap was deployed 30 cm away from the burrow exit and offset 45 degrees from it. It was the aim of these traps to directly intercept scorpion fauna entering and exiting the burrows for foraging outside of their burrow.

4.4.3. **Hand Foraging**

Foraging was undertaken by a three person team at all sites for a minimum of three hours each. Hand foraging included turning over rocks, looking under bark and sifting through leaf litter targeting: Araneae (spiders), Scorpiones (scorpions), Pseudoscorpiones (pseudoscorpions), Gastropoda (snails), Isopoda (woodlice) and Diplopoda (millipedes). An organised search pattern following the layout of the trapping regimen at the site and targeted searches under areas of interest (ie. ideal areas of potential SRE habitat) was utilised.

Any specimens collected were carefully picked up and transferred to plastic jars containing 100% ethanol for preservation. A waterproof label was placed in the jar indicating the site location and collection method.

4.4.4. **Collection of Leaf Litter**

Leaf litter was sparse over much of the Project Area and therefore could not be collected quantitatively. Where available, leaf litter was collected and “double bagged” into large plastic garbage bags. A waterproof label was placed into each bag indicating the site the leaf litter was collected from. These bags were kept in a dark cool place in order to prevent desiccation, and then transported back to the laboratory. Upon arrival at the laboratory, each litter sample was placed into a Tullgren Funnel to extract the invertebrates. Tullgren Funnels are a widely used technique (Upton, 1991) to separate the invertebrates from the leaf litter collected. Leaf litter is placed into a large funnel underneath a heat and light source (in this case a 100W incandescent light globe) for a set duration, commonly two weeks. As the invertebrates move downward through the litter to avoid the heat they eventually fall out of the funnel into a jar containing 100% Glycol to preserve specimens. These jars were then sorted and specimens collected, labelled and preserved in vials containing 100% ethanol pending analysis.

4.4.5. **Burrow Excavation**

The ground at all sites was examined visually for the presence of Mygalomorph spider burrows. When these were located, the burrows were documented, photographed and Mygalomorph spider presence and sex verified by using a milliscope. Female spiders rearing young were left undisturbed, however, if no other burrows were found within the site, a singular spider would be excavated for identification purposes. A limited number of females and males were excavated from each site (depending on occurrence) so as to avoid causing unrecoverable damage of the local Mygalomorph population, with the preference to collect male spiders for accurate identification purposes. A representative of each species present would be collected if possible. Excavated spiders were collected, labelled and preserved in vials containing 100% ethanol. Figure 10 illustrates the locating and excavation of a Mygalomorph trap door spider burrow.

Burrow descriptions and photographs of the Mygalomorph specimens collected are presented in Section 5.1.

4.4.6. **Night Surveys**

Night surveys were conducted using a large ultra violet (UV) blacklight lamp. Scorpions fluoresce under UV light and this method is an excellent technique to find them, as many species of scorpion are nocturnal. This is a standard technique for surveying scorpions (Lowe *et al*., 2003). Scorpions located were carefully picked up and transferred to labelled jars containing 100% ethanol.

4.5. **Laboratory Methods**

Upon return to the laboratory, each sample collected during the surveys was entered into Dalcon Environmental's proprietary job track and sample analysis software to record where each sample was collected and a unique numeric sample ID was allocated. An adhesive label was printed out with the sample ID and stuck to the outside of each sample jar.

Samples were processed at varying magnifications under an Olympus SZX7 Zoom Stereo Microscope. Potential SRE taxa were placed into individual vials each labelled with the sample ID.

Figure 10: *Locating and excavating spider burrows. The scale bar below the "lids" of the Mygalomorph spider burrow = 2.5 cm, the silk-lined tunnels of the excavated burrows extended to a depth of about 30 – 40 cm (May/June 2010 survey).*

These samples were passed on to the WA Museum (and other agencies where required) for taxonomic verification together with a database of information including (for each unique sample ID) the date of collection, the site codes, GPS coordinates and the name of the collector(s).

4.6. Habitat Assessment Methodology

Habitat assessment (see Section 6) involved recording at each site:

- Broad SRE habitat type;
- Landscape position;
- Broad vegetation type (including vegetation indicative of suitable SRE habitat);
- Presence of rocky outcrops;
- Suitable soil substrate;
- Leaf litter coverage;
- Presence of SRE fauna;
- Habitat disturbance;
- Habitat physical connectivity.

Dominant vegetation present at each site was labelled and identified by a botanist for vegetation complex comparison. Short-range endemic habitat assessment sheets for all sites are found in Appendix 3.

4.7. Curation and Species Identification

As stated above, taxa belonging to invertebrate groups known to contain SRE species (see Section 3) were forwarded to people from various agencies that have the relevant expertise to identify them to the lowest taxonomic level. The level of taxonomic resolution is dependent upon both the current state of knowledge on a particular taxon and the level of expertise currently available. The experts used for taxonomic verification are presented in Table 1.

Table 1: *List of expertise used for taxonomic verification of potential SRE taxa found throughout the survey.*

Taxon	Expert	Institution
Aganippe trapdoor spider	Barbara Main	University of Western Australia
Mygalomorph spiders	Volker Framenau	WA Museum
Scorpions	Erich Volshenk	Scorpion ID

5. RESULTS AND DISCUSSION

As per the targeted nature of this survey, invertebrates representing two groups known to contain potential SRE taxa were collected:

- Araneae (mostly Mygalomorphae [trapdoor] spiders);
- Scorpionida (scorpions);

A list of the potential SRE taxa recorded, SRE significance and location collected is presented in Table 2. Results for each of the potential SRE invertebrate groups are discussed in results and discussion.

Table 2: *List of the potential SRE taxa recorded for the targeted SRE survey, SRE significance and which site location they were found.*

TAXON	Genus/Species	Significance	Site	Total
ARACHNIDA				
Araneae				
Idiopidae	*Aganippe* sp.	Juvenile	RIO Site 02	**1**
	Aganippe 'MYG086'	Potentially SRE	IOH Site 01	**3**
	Aganippe 'MYG086'	Potentially SRE	RIO Site 02	**2**
			Total	**6**

5.1. Arachnida

5.1.1. Araneae, Mygalomorphae (Mygalomorph Spiders)

5.1.1.1. Overview

Mygalomorphae are an important group of spiders, many of which are SRE. These spiders have become a focus group in environmental assessment surveys, particularly in recent SRE surveys (Durrant *et al*., 2010). Their high conservation status is demonstrated by the listing of several mygalomorphs on Schedule 1 (fauna likely to become extinct) of the Wildlife Conservation (Specially Protected Fauna) Notice 2010 by the Western Australian Government. The WA Mygalomorph fauna has impressive biodiversity and is still taxonomically poorly understood with many families and many new species being regularly collected (Durrant *et al*., 2010).

Spiders can be divided into two groups: the aerially active spiders; and those that live and disperse on the ground. The aerially active spiders use ballooning to disperse their young in the air, and are typically short lived (usually survive one year). They are highly invasive and recolonise quickly after habitat disturbance. Due to their practice of ballooning they tend to be widespread and of no significance regarding SRE. In contrast the Araenomorphae (ground hunters) and Mygalomorphae (trapdoor and funnel-web spiders) are limited to earth bound activity and the young disperse by walking. As a result populations often tend to be very clumped and entire populations can be missed due to the logistical and ethical constraints of wet pitfall trapping programs which limit the number of traps placed (Raven, 2008). Mygalomorphae generally live much longer, up to 20 years old, and are very habitat specific not moving very far from their habitat even if it is under threat. Mygalomorphs are therefore also a useful indicator of the history of disturbance in an area (Raven, 2008).

Raven (2008) has argued that in the Pilbara, Mygalomorph spiders are found where palaeodrainage basins occur, rather than on south facing slopes as suggested by Harvey (2002). Raven bases this argument on the fact that the Pilbara is part of the Western Shield which developed during the Precambrian (600-400 million years ago), has the oldest land surface in the world, and has never been glaciated or submerged. Calcrete channels formed during the Eocene and Oligocene (37-30 million years ago) when the rivers stopping flowing as a result of the dryer conditions, leaving behind the palaeodrainage channels (Karonovic, 2007). For this reason Mygalomorph spiders have had over 200 million years to evolve and adapt to the harsh conditions of the Pilbara. Their main adaptation is the use of burrows, which can extend to a depth of 700 mm (Main, 1982). This Project (and many other iron ore operations in the Pilbara Region) is situated on a Channel Iron Deposit (CID [Iron Ore Holdings Ltd, 2010]). These CIDs are iron-rich fluvial sedimentary deposits which occupy the meandering palaeochannels of the region dating back to the Early to Mid-Tertiary period.

Raven further argues that in the very open country of the Pilbara the gullies are dry and hot by 8am, even in mid-winter and, as a result, may not provide suitable habitat for Mygalomorph spiders. He argues that Mygalomorph spiders will tend to be more common on the flatter areas with more soil, especially those areas associated with palaeodrainage basins. Both Harvey and Raven present valid arguments, and Dalcon Environmental is not in a position to validate one or the other as our experience indicates that both arguments have merit depending upon the nature of the site being surveyed.

Harvey's argument can be considered to refer to SREs in general, which do prefer habitats where they are sheltered from the heat of the day (such as south facing slopes) whereas the argument of Raven is specific to Mygalomorph spiders.

The argument presented by Raven, particularly with respect to Mygalomorph spiders being more common on the flatter areas with more soil in areas associated with palaeodrainage basins (as is the case for this Project), appears to have been confirmed in this survey with Mygalomorph burrows only being located on the flat ground on the 'long transect' (Figure 1). Mygalomorph burrows are cryptic, however and may have not been present but not observed in the rockier terrain throughout the Project during the initial 2010 short-range endemic and 2011 targeted short-range endemic surveys.

Seven Mygalomorph spiders were collected over the duration of the targeted survey. Six of these belong to the genus *Aganippe* and one to genus *Missulena*. Twelve *Aganippe* sp. (fem) specimens were collected during the 2010 short-range endemic IOH survey, however, no similarity can be drawn between 2011 targeted survey yields and the initial 2010 survey as the original 2010 survey specimens were unidentifiable due to incorrect sex (absent sufficient taxonomic features for species identification. The singular *Misulena* specimen collected during the targeted survey (2011) was not previously found during the initial 2010 short-range endemic IOH survey.

5.1.1.2. *Aganippe* 'MYG086' - (Family Idiopidae)

The Mygalomorph family Idiopidae are common throughout Australia and are considered 'typical' trapdoor spiders; spiders that close their burrow with a hinged door. The genus *Aganippe* is common throughout Western Australia with fourteen species described in Australia and many new species awaiting descriptions (Main, 1985). Six specimens of *Aganippe* were collected during the targeted survey, with five of the six specimens accurately identified as *Aganippe* 'MYG086' and one as an unidentifiable juvenile. Three specimens were recorded at IOH Site 01 and two specimens, as well as the juvenile *Aganippe* sp. (which is believed to be the same species as *Aganippe* 'MYG086'), at RIO Site 02. Figure 11 shows a typical example of ideal *Aganippe* Mygalomorph trapdoor spider habitat: open soil area in spinifex grasslands under stands of Acacia which provide leaf litter for trap door construction.

Aganippe 'MYG086' (Figures 12 and 13) is only known from two locations, the two surveys of the Iron Valley Project (May/June 2010 and June 2011) and from Roy Hill Station, approximately 80 km southeast of the Iron Valley Project. As these two recorded occurrences of *Aganippe* 'MYG086' fall within the currently accepted SRE definition of fauna exhibiting home ranges less than 10,000 km^2, it is reasonable to consider *Aganippe* 'MYG086' as potentially SRE fauna.

Figure 11: *Habitat of RIO Site 02, showing the location of an excavated Aganippe 'MYG086' burrow.*

Due to the diversity of *Aganippe* species known throughout Western Australia, it is difficult to generalise the characteristics of the burrows and trapdoors of the genus. However, *Aganippe* 'MYG086' found throughout the survey exhibited a preference to burrowing in open patches of soil under Acacia stands with only a moderate amount of leaf litter around the base (Figure 11). This enables the *Aganippe* 'MYG086' to use the leaf litter to construct an extremely cryptic door (Figure 14 and 15), while exploiting the increase in open area to better ambush prey. *Aganippe* 'MYG086' burrows excavated during the survey were typically 2 to 3 cm in diameter and 30 to 60 cm deep.

Figure 12: *Aganippe 'MYG086' in a typical Mygalomorph aggressive posture (front).*

Figure 13: *Aganippe 'MYG086' in a typical Mygalomorph aggressive posture (dorsal).*

Figure 14: *Aganippe 'MYG086' trapdoor burrow (closed).*

Figure 15: *Aganippe 'MYG086' trapdoor burrow (open).*

5.1.1.3. *Missulena* 'MYG045' - (Family Actinopodidae)

A single specimen of *Missulena* 'MYG045' (Figures 16 and 17) was collected in a dry trap within the Rio Tinto Iron Ore tenement Site 02 (See Appendix 1 for coordinates). *Missulena* are commonly referred to as 'Mouse Spiders' with *M.* 'MYG045' being widely distributed throughout the Hamersley subregion of the Pilbara and possibly further south according to the WA Museum database collections (Durrant *et al.* 2010). Because of this it is not considered a SRE. No burrow was found in the location of the dry trap where the *Missulena* 'MYG045' was collected during hand foraging due to mygalomorph burrows being cryptic in nature; therefore, no burrow description or images are available.

Figure 16: *Missulena 'MYG045' (lateral).*

Figure 17: *Missulena 'MYG045' (front).*

5.1.2. **Scorpiones (Scorpions)**

5.1.2.1. **Overview**

Scorpions are found throughout Australia but are particularly common in arid areas. These species excavate deep spiral burrows from which they emerge at night to catch prey. Scorpions are often found under logs and rocks (Harvey and Yen, 1989). Scorpions are represented in WA by two families, Buthidae and Urodacidae.

The family Buthidae is the most widespread of all scorpion families, and in WA are represented by the genera *Isometrus*, *Isometroides* and *Lychas*. The taxonomy of the species making up these genera is problematic as each genus contains numerous undescribed species, this is especially true for *Lychas*. Most Australian Buthidae appear to have wide distributions, however, few taxa have confirmed SRE distributions (Volschenk, 2010).

The family Urodacidae is endemic to Australia where it is represented by the genera *Urodachus* and *Aops*. The greatest issue confronting *Urodachus* taxonomy is the large number of undescribed species being recognised as a result of current ongoing research on the group. At present there are 22 species of *Urodachus*, but this may represent only 20% of the real diversity in Australia. *Urodachus* is most diverse in WA and only a few species are recorded east of the Great Dividing Range in eastern Australia (Volschenk, 2010).

Two species of scorpion were recorded during the targeted SRE survey totalling four specimens collected. Specimens from both the Buthidae and Urodacidae families were collected. One specimen of Lychas "multipunctatus" (from the Buthidae family) was recorded at IOH site 01. Two specimens of *Urodacus* "megamastigus short" (from the Urodacidae family) were recorded at IOH Site 01 and a singular specimen at RIO Site 01. The only specimen of *Lychas* "multipunctatus" was recorded at IHO Site 01.

5.1.2.2. *Lychas* **'multipunctatus' - (Family Buthidae)**

The genus *Lychas* is widespread throughout Australia and suffers from a lack of taxonomic work. While also represented in Africa, India and eastern Asia, all known Australian taxa are considered endemic. While *Lychas* have wide distributions, however, a small number are known to be SRE.

One specimen of *Lychas* 'multipunctatus' was found during the targeted SRE survey at IOH Site 01. This undescribed species is one of the most common and widely distributed scorpions throughout the Western Australia Pilbara region. The species *Lychas* 'multipunctatus' is considered non-SRE (Volschenk, 2011). (Note: Lychas 'multipunctatus' is a well-defined and clearly identified unpublished morphospecies[1]).

5.1.2.3. *Urodacus* **'megamastigus short' - (Family Urodacidae)**

Urodacus is the most diverse scorpion genus in Western Australia and contains both widespread and SRE species. Three specimens of *Urodacus* 'megamastigus short' were collected during the survey, two at IOH Site 01 and one at RIO Site 02. This undefined species as been recorded throughout the greater Pilbara bioregion and all subregions, and therefore is considered non-SRE. (Volschenk, 2011).

---

[1] Morphospecies: A taxonomic species based wholly on morphological differences from related species (Merriam-Webster 2012a)

It is believed that the unidentifiable *Urodacus* sp. collected in the previous survey (May/June 2010) is conspecific with *Urodacus* 'megamastigus short' and therefore considered to be non-SRE.

5.2. Results Summary

A list of all invertebrates recorded and numbers found for each sampling method is presented in Table 3, with SREs found only in the Mygalomorph family Idiopidae, species *Aganippe* 'MYG086'. The majority of taxa listed here are non-SRE taxa but have been included as additional information.

Table 3: *Table of all invertebrate groups and individuals collected during the targeted SRE survey.*

TAXON	Genus/Species	Significance	Site	Method	Total
ARACHNIDA					
Araneae					
Actinopodidae	*Missulena* 'MYG045'	Not SRE, Widespread	RIO Site 02	Dry Pitfall	**1**
Idiopidae	*Aganippe* sp.	Juvenile	RIO Site 02	Excavation	**1**
	Aganippe 'MYG086'	Potentially SRE	IOH Site 01	Dry Pitfall	**3**
	Aganippe 'MYG086'	Potentially SRE	RIO Site 02	Dry Pitfall	**2**
ARACHNIDA					
Scorpiones					
Urodacidae	*Urodacus* 'megamastigus short'	Not SRE, Widespread	IOH Site 01	UV Lamp	**2**
	Urodacus 'megamastigus short'	Not SRE, Widespread	RIO Site 01	UV Lamp	**1**
Buthidae	Lychas 'multipunctatus'	Not SRE, Widespread	IOH Site 01	UV Lamp	**1**

Total	**11**

6. VEGETATION ASSESSMENT

6.1. Vegetation Assessment and Collection Methods

As requested by the DEC for the Targeted SRE survey, a habitat assessment of major flora was undertaken at each site (Durrant B 2011, pers. comm. 15 April). This was undertaken to enable comparison between different survey areas in order to better determine the likelihood of target SRE fauna being present.

The habitat assessment consisted of observing the sites and recording

- Broad habitat type
- Specialised habitat type
- Vegetation complex assemblage
- Substrate analysis
- Presence of geological and topographic points of interest suitable as SRE habitat
- Leaf litter cover and composition
- Level and type of habitat disturbance
- Area physical connectivity and extent
- Visual confirmation during site hand foraging (Section 4.4.3.) of the presence or absence of Mygalomorph trap door spider and scorpion fauna burrows.

The vegetation assemblage at IOH Site 01 and 02 are considered 'floristic control sites' to compare the other site vegetation assemblages recorded during the study as these sites already contain target SRE fauna from the previous IOH survey collections (Dalcon Environmental 2011). A comprehensive flora assessment was conducted at IOH Site 01 and 02, however, due to the increased thoroughness (more samples collected) of the vegetation assessment conducted, it is difficult to directly compare vegetation complexes directly due the non-standardised sampling methodology used at the other sites. Vegetation present at each site was collected, labelled and pressed to be identified by a flora taxonomic specialist.

The vegetation boundaries and types indicated on the vegetation map (Figure 18) are drawn using visual differences in perceived vegetation assemblages while in the field and using high resolution aerial photography in the laboratory, not data collected from the vegetation assessment. This map is for reference only and should by no means be considered an official map of the vegetation complexes occurring within the site.

The objective of vegetation mapping was to provide further certainty ‘that neither species is at risk from the Project. To address this uncertainty more specific habitat information should be provided illustrating that the species are found in habitat that is widespread and not conductive to SREs’ (Durrant B 2010, pers. comm. 15 April). However this habitat information, while indicating that the risk to the species is potentially low, there is however, a risk that it won’t (Durrant B 2010, pers. comm. 15 April).

Although it is confirmed that potential SRE taxa are in habitat that is located in the adjacent Rio Tinto tenement, these taxa still fall within the 10,000 km^2 restricted population distribution which defines the taxa as a potential SRE (Harvey 2002). As Dalcon Environmental cannot confirm the long term security of SRE populations on the Rio Tinto tenement, these taxa are potentially still at risk.

Vegetation map creation was aided by the vegetation map produced by Astron Environmental Services vegetation and flora survey report (Astron Environmental Services 2011).

Vegetation type 1 is indicative of rocky hillocks and crests containing low *Eucalyptus leucophloia* subsp. *leucophloia* trees with *Grevillea wickhamii* subsp. *hispidula* and *Acacia bivenoso* shrubs over *Triodia* sp. hummock grassland.

Vegetation type 2 is indicative of creek and drainage lines predominated by *Grevillea wickhamii* subsp. *hispidula* over wide and open *Triodia* sp. hummock grassland.

Vegetation type 3 is indicative of family Malvaceae flora including numerous *Corchorus* species, *Hibiscus coatesii* and *Sida* species collected. Vegetation type 3 is also characterised by *Triodia* sp. open grassland, however, there are scattered stands of *Aristida holathera* var. *holathera* and the weed grass *Cenchrus cillaris*.

Vegetation type 4 is indicative of vegetation adjacent creek and drainage areas by *Grevillea wickhamii* subsp. *hispidula* over open *Triodia* sp. hummock grassland with scattered *Indigofera monophylla* and *Senna* species. This vegetation type is a mix between Vegetation type 2 and Vegetation type 3 although is different enough in assemblage and age to warrant its own vegetation type allocation.

Vegetation type 5 is indicative of scattered *Hakea lorea* subsp. *lorea* over *Petalostylis labicheoides* over open *Triodia* species grassland.

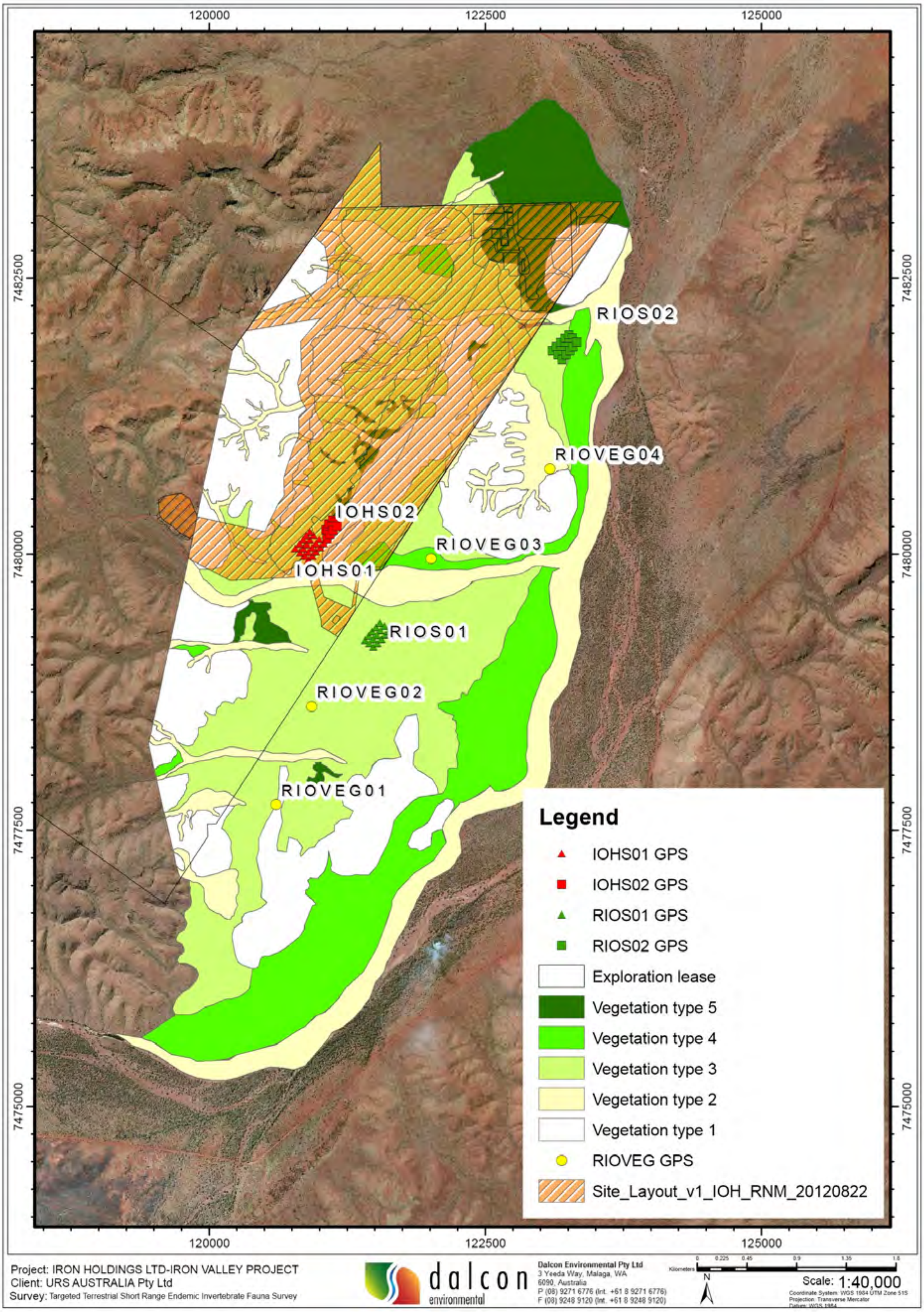


***Figure 18:** Representational vegetation map of the survey area using visual differences in vegetation assemblages to distinguish perceived floral borders.*

6.2. Results of Habitat Assessment – IOH Sites

Due to their close proximity and identical biology and geography, IOH Site 01 (IOH-S01) and IOH Site 02 (IOH-S02) were combined for the vegetation assessment. These two sites were surveyed due to the likelihood of containing the SRE fauna the survey was specifically targeting.

The two IOH sites are broadly characterised as spinifex grassland with open ground scattered Eucalyptus over-storey and Acacia under-storey, transitioning to open grasslands towards the elevated terrain to the west (Figure 19). The substrate is suitable for Mygalomorph spiders and scorpions as it consists of loosely compacted red soil with scattered rocks and pebbles (35% coverage) with spinifex clumps providing shelter and microhabitat. Leaf litter coverage was minimal within both sites. However, in the south west corner of IOH Site 02, young vegetation recovering from previous fires formed thick stands with up to 60 % leaf litter coverage. The north east corner of IOH Site 02 exhibits a transition area in geography, with ground substrate consisting of 15 % small pebbles, 85 % large rocks as the site progressed into a nearby rocky ridgeline. This impenetrable rocky habitat is unsuitable for the burrow dwelling Mygalomorph trapdoor spiders and scorpion fauna. This vegetation type is broadly represented in Figure 18 as Vegetation Type 3, however, IOH Site 02 also passes briefly into Vegetation type 5.

IOH Site 01 and IOH Site 02 are located within the proposed disturbance area for the project, with drill lines, drill pads and severe soil disturbance already present throughout the sites. The IOH sites are also heavily eroded in areas by artificial drainage lines created from exploration disturbances. Evidence of cattle grazing, anthropogenic disturbances and weed invasion are also present (Astron Environmental Services 2011).

A total of 54 flora species were collected during the vegetation assessment at both IOH sites (see Appendix 2).

Figure 19: *IOH Site 01 and 02 - Typical vegetation complex.*

6.3. Results of Habitat Assessment - RIO Sites

6.3.1. RIO Site 01

Rio Tinto Iron Ore Site 01 (RIO-S01) is characterised by spinifex grassland with open soil patches and sparse Eucalyptus over-storey (Table 5, Appendix 3). Soil substrate is suitable for Mygalomorph trapdoor and scorpion fauna to burrow in, although slightly more compacted then the IOH sites. Overall leaf litter coverage throughout the site is minimal, however, a moderate to high amount of leaf litter was present under localised Acacia stands which are ideal for Mygalomorph trapdoor spiders as they commonly use leaf litter in the construction of burrow doors. This vegetation type is broadly represented in Figure 18 as Vegetation Type 3. Mygalomorph trapdoor spiders and scorpions were present at the site (refer to SRE fauna collected in Table 2).

Fire is the dominant disturbance observed at RIO-S01 and is likely responsible for the age and composition of the vegetation assemblage present. Minor signs of cattle grazing and runoff erosion are also present. Twenty two representative flora species were collected at RIO-S01, exhibiting the highest percentage similarity in comparison to both the IOH sites at 41 %. Only two species of RIO-S01 are unique to the site.

6.3.2. **RIO Site 02**

Rio Tinto Iron Ore Site 02 (RIO-S02) is a flat plain situated adjacent land subjected to inundation associated with the seasonal flow of Weeli Wolli Creek. Vegetation complex is characterised by spinifex grassland with a mixed Acacia woodland over-storey (Table 5, Appendix 3). The open areas of this site have medium compacted soil between clumps of spinifex which are ideal for SRE Mygalomorph trapdoor spiders and scorpion fauna. The medium to high concentrations (60 – 100 %) of leaf litter under Acacia stands are also ideal for SRE Mygalomorph trapdoor spiders and scorpion fauna, despite overall leaf litter coverage of the site being insignificant. This vegetation type is broadly represented in Figure 18 as Vegetation Type 3 and Vegetation Type 4. Mygalomorph trapdoor spiders were present in RIO-S02 under the Acacia stands, however, no scorpion burrows were found.

Eleven flora species dominated the vegetation complex present at Rio Tinto Iron Ore Site 02 (Table 5). Of these eleven species, three percent were unique to the site: *Acacia colei* var. ileocarpa and *Velleia connata*. The site, however, exhibits a 16 % similarity in species composition with IOH Sites 01 and 02.

6.4. **IOH and RIO Vegetation Assessment Site Comparisons**

Due to their close proximity and identical flora complex and geography, IOH Site 01 (IOH-S01) and IOH Site 02 (IOH-S02) were combined for the vegetation assessment. In contrast, the Rio Tinto Iron Ore vegetation assessment sites were sufficiently isolated by distance and contain unique floristic complexes that they are discussed separately here.

Only six species were present in all four Rio Tinto tenement vegetation assessment sites (Table 4). It is important to note that no SRE fauna sampling regimen was deployed at the RIO vegetation assessment sites

Table 4: *The six flora species present in all RIO Vegetation Assessment Sites.*

Name	Family
Corchorus lasiocarpus subsp. *lasiocarpus*	Malvaceae
Corchorus sidoides subsp. *sidoides*	Malvaceae
Petalostylis labichieoides	Fabaceae
Ptilotus exaltatus	Amaranthaceae
Ptilotus helipteroides	Amaranthaceae
Senna artemisioides subsp. *helmsii*	Fabaceae

On average, the RIO vegetation survey sites exhibit 18 % to 27 % floristic uniqueness in comparison to both the IOH survey sites. An average of 18 species were collected to represent the dominant vegetation complexes present per site, however, there is only 25 – 43% species composition similarity between the four vegetation assessment sites.

Flora species composition and similarities between the IOH and the four RIO vegetation survey sites is displayed in Table 5.

Table 5: *Flora species present at IOH and Rio Tinto Iron Ore vegetation assessment sites.*

Name	Site				
	IOH	RIOVEG-1	RIOVEG-2	RIOVEG-3	RIOVEG-4
Acacia adoxa var. *adoxa*	X	X			
Acacia ancistrocarpa	X				X
Acacia colei var. *ileocarpa*		X			
Acacia dictyophleba					X
Acacia hilliana	X	X			X
Acacia inaequilatera	X		X	X	
Acacia pachyachra	X		X	X	X
Acacia pruinocarpa	X			X	
Acacia pyriformis				X	
Acacia spondylophylla				X	
Acacia tumida var. *pilbarensis*	X	X		X	X
Aristida holathera var. *holathera*	X			X	
**Cenchrus ciliaris*	X			X	X
Corchorus lasiocarpus subsp. *lasiocarpus*		X	X	X	X
Corchorus sidoides subsp. *sidoides*	X	X	X	X	X
Corymbia hamersleyana	X				X
Dicrastylis cordifolia		X	X	X	
Eragrostis setifolia		X		X	
Eucalyptus gamophylla	X			X	
Gomphrena cunninghamii				X	
Goodenia microptera	X	X			
Gossypium robinsonii	X	X			X
Grevillea wickhamii subsp. hispidula	X		X	X	
Hakea chordopylla			X	X	X
Hakea lorea subsp lorea	X		X	X	X
Paraneurachne muellerii	X	X			
Petalostylis labichieoides	X	X	X	X	X
Ptilotus calostachyus	X	X	X		
Ptilotus exaltatus	X	X	X	X	X
Ptilotus helipteroides	X	X	X	X	X
Ptilotus obovatus	X			X	
Salsola austrlalis				X	
Scaevola parvifolia					X
Senna artemisioides subsp. *helmsii*		X	X	X	X
Sida echinocarpa	X	X	X	X	
Solanum phlomoides	X	X			
Trianthema pilosa	X				X

* indicates weed species

6.4.1. **RIO Vegetation Assessment Site 01**

Vegetation of RIO vegetation assessment Site 01 (RIOVEG-1, Figure 18) consisted entirely of herbaceous species with no discernable living over-storey due to previous fire. A total of 18 dominant flora species were collected during the survey (Table 5). Only nine percent of the species collected are shared with the IOH tenement sites, with 44 % being unique to the site (see Appendix 2).

RIOVEG-1 is a plain landscape, sparse in features with few undulations and hillocks. Rocky outcrops may be suitable for harbouring SRE Gastropods (snails), and while being absent from the site, may be substituted by the presence of the rocky hillocks which in some cases can provide suitable habitat. Soil substrate is ideal for burrowing SRE fauna, however, the evidence of fire having removed all leaf litter has reduced the potential areas of refuge, habitat and construction materials for Mygalomorph trapdoors. This vegetation type is broadly represented in Figure 18 as Vegetation Type 1 flanked either side by Vegetation Type 2.

No scorpion or trapdoor spider burrows were found and no specimens collected during the site visual assessment. No sampling regime was deployed at RIOVEG-1.

6.4.2. **RIO Vegetation Assessment Site 02**

RIO Site 02 (RIOVEG-2, Figure 18) vegetation consists entirely of herbaceous species due to previous fire, as all previous over-storey vegetation is deceased. Fourteen species were collected, 57% of which are unique to RIOVEG-2 (see Table 5, Appendix 2). Four of the total fourteen species are shared with the IOH sites (7 % similarity).

RIOVEG-2 is a plain flanked by small ranges on either side. Soil substrate is suitable for Mygalomorph spider and scorpion fauna, however, presence of either is unconfirmed. Leaf litter is absent from the site due to pervious fire. This vegetation type is broadly represented in Figure 18 as the broad Vegetation Type 3; however, the site does cross into Vegetation Type 5. No scorpion or trapdoor spider burrows were found and no specimens collected during the site visual assessment. No sampling regime was deployed at RIOVEG-2.

6.4.3. RIO Vegetation Assessment Site 03

RIO vegetation Site 03 (RIOVEG-3, Figure 18) is characterised by spinifex grasslands with scattered herbs and Eucalyptus over-storey. The spinifex grasslands transitions to general grasslands and towards a creek line which flows near the site (Figure 18). The soil substrate is suitable for SRE fauna, however, no evidence of Mygalomorph trapdoor spider or scorpion burrows or species were found. This may be contributed to some extent by the lack of over-storey and leaf litter throughout the site. This vegetation type is broadly represented in Figure 18 as Vegetation Type 4.

Twenty four species were collected during the vegetation assessment, the greatest diversity exhibited by any of the RIO vegetation assessment sites. Thirty three percent of the 24 flora species collected are unique to RIOVEG-3, only nine species are shared with the IOH sites (16 %) (see Appendix 2).

No scorpion or trapdoor spider burrows were found and no specimens collected during the site visual assessment. No sampling regime was deployed at RIOVEG-3.

6.4.4. RIO Vegetation Assessment Site 04

The vegetation of RIO vegetation Site 03 (RIOVEG-4, Figure 18) is characterised by spinifex grassland with Acacia shrub level over-storey with areas of open soil and scattered Eucalyptus (Table 5, Appendix 3). While rocky outcrops are ideal for SRE Gastropods (snails), this species was absent within the survey area, although they were present in the surrounding rocky hills. Substrate was suitable for SRE trapdoor spider and scorpion burrow building, especially between grass and spinifex clumps present under Eucalyptus and Acacia stands where elevated levels (40 – 60 %) of leaf litter coverage provides ample habitat construction materials and camouflage. Overall, however, there was minimal leaf litter covering the site. Although no evidence of Mygalomorph trapdoor spider or scorpion burrows or species were found, it is highly likely that they are present within the area. Existing disturbances are localised with depressions and drainage lines running throughout the survey site accompanied by evidence of seasonal or periodic inundation and heavy runoff into the nearby Weeli Wolli Creek catchment area.

Visually, RIOVEG-4 is very similar to RIO Site 01. This vegetation type is broadly represented in Figure 18 as the broad Vegetation Type 1 and differs however from RIO Site 01 due to be restricted to areas of increased soil moisture, inundation and drainage.

A total of 18 species were collected at RIOVEG-4 during the vegetation (see Appendix 2). Fourteen of the 18 species collected (24 %) are present at both RIOVEG-4 and the IOH sites, with only five species (9 %) being unique to the site. These results of similarity and uniqueness are identical to that of RIO vegetation assessment site 01. Both sites (RIOVEG-1 and RIOVEG-4) vegetation complexes are represented by 18 species, of which over 55 % (10 species) are common.

No scorpion or trapdoor spider burrows were found and no specimens collected during the site visual assessment. No sampling regime was deployed at RIOVEG-4.

7. SURVEY ADEQUACY AND LIMITATIONS

The main potential limitation of this survey was that the timing was later in the year than optimal, as stated in EPA Guidance Statement No. 20, which recommends that SRE surveys in the Pilbara region be conducted during the wet season (November – April) (EPA, 2009). However, Department of Environment and Conservation advised that the May and June survey period was acceptable (Durrant B 2011, pers. comm., 15 April).

Durant *et al.* (2010) has stated that Pilbara rainfall is very unreliable and highly variable, with these rainfall events largely driving the activity of the local fauna. Extended periods of dry conditions and inappropriate rainfall can induce torpor[2], however, SRE assemblages respond very quickly to appropriate isolated rainfall events. The 12 month period prior to the survey had less than average rainfall and although there was good rainfall recorded on site during April immediately before this survey (Bureau of Meteorology 2011a), rainfall during the survey periods themselves (May and June) was below average (Table 6). This would have potentially effected specimen yields as SREs, specifically mygalomorphs, which known to be active immediately prior to, during and after rainfall events (Main BY 2011, pers. comm., July).

Ultimately, the precise rainfall requirements which are most favourable for sampling SRE taxa (and their subsequent capture) are not known and there are many mitigating circumstances which affect the suitability of these rain events (i.e. soil type, topography, vegetation, SRE species). Because of this it cannot be said categorically that the lower than average rainfall in the 12 months prior to the survey and the months of the survey itself resulted in reduced SRE mobility and capture but it must be considered herein as a potential limitation to the survey.

Marillana station weather station is not equipped with rainfall measuring equipment (Bureau of Meteorology 2011b), therefore, although rain was present during the survey it is unable to be locally quantified and weather data at Newman Airport is the most accurate rainfall data available.

---

[2] Torpor: A state of physiological lowered activity typically characterized by reduced metabolism, heart rate, respiration, and body temperature that occurs in varying degrees especially in hibernating and estivating animals (Merriam-Webster 2012b).

Table 6: *Newman Aerodrome weather station monthly average rainfall (mm) over the period 1981 – 2010, running monthly total for 2011 and monthly differences.*

	Duration		**Difference**
	1981-2010	**2011**	**2011**
Month	**Mean for 30 yrs**	**Monthly**	**Monthly**
January	58.9	59	0.1
February	82.7	145.8	63.1
March	35	26	-9
April	19.7	31.4	11.7
May	20.7	5.6	-15.1
June	14.8	9.4	-5.4
July	14.3	32.2	17.9
August	4.5	0	-4.5
September	5.8	-	-
October	3.2	-	-
November	10.9	-	-
December	41	-	-
TOTAL	**311.5**	**309.4**	

Lack of habitat diversity per site during the targeted SRE survey is not considered a limitation of this study as the targeted nature of the survey restricted sampling sites to areas which SRE specimens had been collected in the previous SRE survey in the Iron Valley Project and similar habitats where the target fauna may occur.

Although part of the survey area had been burnt (refer Section 2.3), Dalcon Environmental does not consider this to have been a limitation to the survey as it does not seem to have affected the abundance of any of the SRE taxa recorded when compared to unburnt sites. This is due to collections of the Mygalomorphae trap door spider *Aganippe* 'MYG086' and the scorpion *Urodacus* 'megamastigus short' from both IOH and RIO survey areas (Table 3).

As discussed in Section 6.1 the comprehensive floristic assessment conducted at IOH sites 01 and 02 in comparison to the Rio Tinto Iron Ore sites makes a direct floral comparison between sites difficult due to the non-standardised sampling methodology used at all sites. Future flora assessments should have methodology to ensure similar sampling regimes between sites. It is possible with an identical scope of flora surveying at RIO sites as was conducted at the IOH sites, an increased number of flora samples may have been identified and vegetation complexes between sites increase or decrease in similarity in respect to the values presented in this report. However, considering that the objective of the flora assessment was to define SRE habitat as the basis of a risk assessment, rather than make direct floristic comparisons between sites (see Section 8), Dalcon Environmental considers the assessment to be adequate.

8. CONCLUSIONS

The targeted short-range endemic invertebrate survey conducted in June 2011, consisted of a total of four sampling sites within the Iron Ore Holdings Ltd Iron Valley M47/1439 mining lease and the adjacent Rio Tinto M274/SA tenement. Total of 60 dry pitfall traps were deployed in the project area: 30 dry pitfall traps within between two IOH tenement sampling sites and 30 dry pitfall traps between two RIO tenement sampling sites. Extensive hand foraging was also conducted at each sampling site as well as UV night surveys specifically to sample for scorpion fauna. Four vegetation and habitat assessment sites were situated along the length of the adjacent Rio Tinto M274/SA tenement boundary to access the extent of potentially suitable SRE habitat outside the IOH project area.

Recommendations made by the Department of Environment and Conservation (Durrant B 2011, pers. comm. 15 April) and the Environmental Protection Authority guidance statement 20 (Sampling of Short Range Endemic Invertebrate Fauna for Environmental Impact Assessment in Western Australia; EPA, 2009) were used as a guideline in determining the most appropriate sampling regime to selectively sample the target short-range endemic invertebrates. The deployment of dry pitfall traps (EPA, 2009) was deemed the best survey method over time to survey in conjunction with extensive hand foraging (Durrant B 2011, pers. comm. 15 April; EPA 2009) for target burrows of mygalomorphs and scorpions. Due to the range of area in the Rio Tinto tenement, vegetation assessments were conducted at regular intervals to determine the extent of suitable SRE habitat and composition similarity to IOH sites (Durrant B 2011, pers. comm. 15 April; EPA, 2009).

A total of 11 specimens were yielded over five species, with a single potential SRE identified (Table 3).

A singe *Aganippe* species, *Aganippe* ‘MYG086’ was collected within the project area (Table 3). *Aganippe* ‘MYG086’ is considered to be a potential SRE (Section 5.1.1.2). *Aganippe* ‘MYG086’ is only known from the Iron Valley Project (May/June 2010 and June 2011) and from Roy Hill Station, approximately 80 km southeast of the Project area.

Aganippe ‘MYG086’ is present within the Iron Valley tenement (IOH Site 01) and the adjoining Rio Tinto Iron Ore tenement (RIO Site 02). This may indicate a larger population of *Aganippe* ‘MYG086’ in the area which may be unlikely to be adversely impacted upon by Iron Valley infrastructure development. This conclusion is dependent upon the long term security of habitats in the adjacent Rio Tinto Iron Ore.

Although these two *Aganippe* 'MYG086' populations may be unrelated and may experience no interconnectivity (i.e. due to topographical and habitat barriers, lack of population dispersal) due to the definition of SRE fauna stating that populations range less than 10 000 km^2, the significance of these localised populations is still relevant. Based on the current known distribution of this species (only known at the Project and 80 km southeast), Dalcon Environmental cannot assume that this species is widespread, but can infer that at least within the region of the IOH/RIO tenements, that it may be present within areas that have been defined as suitable habitat (see Section 5.1.1, Section 6, Figure 18). This is only verifiable by further targeted surveys conducted throughout the two tenements and is complicated by the vegetation condition of the RIO Site 02.

The vegetation complex currently present at RIO Site 02 has been directly influenced by a recent fire event. There is evidence surrounding the burnt area at RIO Site 02 that suggests that a different vegetation type once existed within the site than was present during the survey.

As the area recovers from the fire event (date unknown, possibly in early 2009) the surrounding vegetation complex will recolonise the area with its assemblage making it less synonymous with the vegetation present at IOH Site 01 and 02. While it is inevitable that RIO Site 02 will share some flora species present at IOH sites, between the two sites there are currently differences in:

- Flora composition complexity (primarily of understory species);
- Flora age;
- Flora stability (flora composition will continue to change while colonising species die off and are replaced over time with more permanent species);
- Soil dynamics and burrowing suitability;
- Leaf litter composition and percent coverage;
- Percent open bare soil;
- Food sources.

SRE fauna experience difficulty dispersing (Harvey 2002) rendering them vulnerable to rapid re-colonisation of damaged and disturbed areas by flora and habitat changes. For example, Mygalomorph trap door spiders will burrow and inhabit only one burrow for the entirety of their life, rendering them extremely susceptible to habitat changes over time (Main BY 2011, pers. comm., July). Locally restricted species tend to have a high conservation status because they are more vulnerable to extinction following habitat destruction and environmental change (Eberhard *et al*., 2009; Ponder and Colgan, 2002). SRE migration from the older stable IOH habitat to the burnt transitional habitat at RIO Site 2 is extremely unlikely.

A single *Urodacus* species, *Urodacus* 'megamastigus short', was collected during UV night survey's at IOH Site 01 and RIO Site 02 (Table 3). *Urodacus* 'megamastigus short' is widespread and not a SRE (Section 5.1.2.3) (Volschenk, 2010, 2011).

It is important to note concerning possible SRE distributions and populations within the potential suitable habitat zones within the IOH and adjacent RIO tenements, as per Figure 18 that without a survey to physically confirm population presence that the known populations in the IOH tenement may still be at risk. This is because the IOH tenement populations are known where the extent of possible RIO tenement populations is not. Any future plans to develop the RIO tenement is unknown by Dalcon Environmental casting uncertainty about the future of potential SRE populations present and increasing the importance of SRE populations found within the IOH project area.

9. RECOMMENDATIONS

9.1. General recommendations

In order to limit the impacts on *Aganippe* 'MYG086' present within the Project area, Dalcon recommends that:

- Clearing of native vegetation should be kept to a minimum. This applies particularly to any spinifex grasslands.
- Habitat that is likely to contain *Aganippe* 'MYG086', such as spinifex grasslands with acacia over-storeys, should not be disturbed if possible. It is apparent that much of the *Aganippe* 'MYG086' habitat on the IOH tenement occurs within areas that are proposed to be disturbed as a result of the Project. Whilst suitable *Aganippe* 'MYG086' habitat was found on the adjacent Rio Tinto Iron Ore tenement, this habitat was in a state of flux as a result of previous fire with the vegetation community which is likely to change over time, and as a result, may become less conducive habitat for *Aganippe* 'MYG086'. Any possible future development within this tenement is unknown.
- Any areas that will be cleared should be rehabilitated by plants endemic to the area as immediately after use to encourage SRE (and general) floral and faunal recolonisation.
- To minimise the danger of increased fire frequency as a result of the Project, a fire prevention strategy should be implemented. Fire is a recognised threat to spinifex grasslands (Kendrick, 2001).
- Every effort is taken to ensure vehicles do not introduce or spread any weeds (i.e. implement a weed management strategy) or soil pathogens which will impact potential SRE habitat.

10. STUDY TEAM

The Iron Valley Project Targeted Short Range Endemic Invertebrate Fauna Survey detailed in this document was planned, coordinated and executed by Dalcon Environmental Pty Ltd in close consultation with URS Australia Pty Ltd and Iron Ore Holdings Pty Ltd.

The Project team, their responsibilities and qualifications were as follows:

Stuart Helleren BSc (Hon), MSc

Principal Scientist/Director/Project Management

Phillip Mark Heath BSc (Hon)

Senior Environmental Scientist/Invertebrate Zoologist/Field Program

Sabrina Arkile BSc (Hon)

Senior Environmental Scientist/Field Program

Ray Mielens BSc

Environmental Scientist/Field Program

Mitchel Ranger BSc

Environmental Scientist/Field Program

Ross Gordon BSc (Hon)

Environmental Scientist/Invertebrate Zoologist/Field Program

We would also like to thank the taxonomic experts listed in Table 1 for the identification of potential SRE taxa.

11. REFERENCES

Antunes, S., Curado, N., Castro, B. & Goncalves, F. (2009) Short term recovery of soil functional parameters and edaphic macroarthropod community after a forest fire. *Journal of Soil and Sediments* 9(3): 267-278

Astron Environmental Services 2011, *Iron Ore Holding Ltd – Iron Valley Project (Phase 2) – Vegetation and Flora Survey, July/August 2011*, Astron Environmental Services, Western Australia.

Beard, J.S. (1979) Vegetation Survey of Western Australia Pilbara. Explanatory Notes to Sheet 5. The Vegetation of the Pilbara Area, University of Western Australia Press, Western Australia.

Beard, J.S. (1990) Plant Life of Western Australia. Kangaroo Press: Kenhurst, Australia

Brand, R.H. (2006) The influence of prescribed burning on spiders and pseudoscorpions: known predators of woodland litter springtails. *Transactions of the Illinois State Academy of Science* 99(3-4).

Bureau of Meteorology (2011a). *Latest Weather Observations for Newman Airport*, Commonwealth of Australia.
http://www.bom.gov.au/products/IDW60801/IDW60801.94317.shtml.

Bureau of Meteorology (2011b) *Daily Rainfall Marillana Station*, Commonwealth of Australia,
http://www.bom.gov.au/jsp/ncc/cdio/weatherData/av?p_nccObsCode=136&p_display_type=dailyDataFile&p_stn_num=005009&p_startYear=.

Dalcon Environmental (2011) Short Range Endemic Survey – Iron Ore Holdings Ltd Iron Valley Project. *Dalcon Environmental Pty Ltd*.

Dawes-Gromadski, T. (2007) Short term effects of low intensity fire on soil macroinvertebrate assemblages. *Austral Ecology* 32:663-668

Department of Environment and Conservation (2001) Forestcheck. Department of Environment and Conservation, Western Australia. Accessed at http://www.dec.wa.gov.au/content/view/5605/2290/1/5/

Department of Environment and Conservation (1986). Environmental Protection Act 1986, Department of Environment and Conservation, Western Australia

Department of Environment and Conservation (1950). Wildlife Conservation Act 1950, Department of Environment and Conservation, Western Australia

Department of the Environment, Sports and Territories (1996). National Strategy for the Conservation of Australia's Biological Biodiversity, Department of the Environment, Sports and Territories, Canberra

Department of the Environment, Water, Heritage and the Arts (now known as Department of Sustainability, Environmental, Water, Population and Communities), National Land and Water Resources Audit (2001). National Australian Natural Resources Atlas 2001. Department of the Environment, Water, Heritage and the Arts, Canberra Accessed at: http://www.anra.gov.au/topics/rangelands/overview/wa/ibra-pil.html

Department of Sustainability, Environment, Water, Population and Communities (1999) Environment Protection and Biodiversity Act 1999, Department of Sustainability, Environment, Water, Population and Communities, Canberra

Durrant, B.J., Harvey, M.S., Framenau, V.W., Ott, R. & Waldock, J.M. (2010) Patterns in the composition of ground-dwelling spider communities in the Pilbara bioregion, Western Australia. *Records of the Western Australian Museum*, Supplement 78:185-204.

Eberhard, S.M., Halse, S.A., Williams, M.R., Scalon, M.D., Cockling, J., Barron, H.J. (2009) Exploring the relationship between sampling efficiency and short range endemism for groundwater fauna in the Pilbara Region, *W.A. Freshwater Biology*, 54:885-201

EPA, (2009) Guidance for the Assessment of Environmental Factors: Sampling of Short Range Endemic Invertebrate Fauna for Environmental Impact Assessment in Western Australia Guidance Statement No 20, Environmental Protection Authority, Canberra

EPA, (2004) Guidance for the Assessment of Environmental Factors: Terrestrial Fauna Surveys for Environmental Impact Assessment in Western Australia Guidance Statement No 56, Environmental Protection Authority, Canberra

EPA, (2002) Terrestrial Biological Surveys as an Element of Biodiversity Protection EPA Position Statement No 3, Environmental Protection Authority, Canberra

Framenau, V. (2010) Volker.framenau@museum.wa.gov.au, IOH Mygalomorphs, 23/08/2010

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

Harvey, M.S. & Yen, A.L. (1989) Worms to Wasps: An Illustrated Guide to Australia's Terrestrial Invertebrates. Oxford University Press, Auckland

Herbison-Evans, D & Crossley, (2011). Website, "Families of Moths in Australia." Accessed at http://lepidoptera.butterflyhouse.com.au/moths.html

Hosie, A. (2010) Andrew.hosie@museum.wa.gov.au, Isopods, 11/10/2010

Iron Ore Holdings Ltd (2010) Comparable transactions highlight favourable valuation anomaly – Initiation of Coverage. http://www.ironoreholdings.com/documents/321.pdf. Accessed December 2, 2010.

Karonovic, I. (2007) Preface and Introduction in Candorinae (Ostracoda) from the Pilbara region of WA, Koniklijke Brill, Leiden, Netherlands

Kendrick, P. (2001) A Biodiversity Audit of Western Australia's 53 Biogeographical Subregions: Pilbara 3, Hamersley Subregion, Department of Conservation and Land Management, Western Australia

Koch, L.E. (1985) Pincushion Millipedes (Diplopoda: Polyxenida): Their Aggregation and Identity in Western Australia. *Western Australian Naturalist*, 16(2/3): 30-32

Lowe, G., Kutcher, S.R. & Edwards, D. (2003) A Powerful New Light Source for Ultraviolet Detection of Scorpions in the Field. *Euscorpius* 8: 1-7

Main, B.Y. (1982) Adaptations to arid habitats by Mygalomorph spiders. In: Barker, W.R. & Greenslade, P.J.M. (Ed.) Evolution of the Fauna and Flora of Arid Australia. Peacock Publications, Frewville, South Australia, pp273-283.

Main, B.Y. (1985). Further studies on the systematics of ctenizid trapdoor spiders: a review of the Australian genera (Araneae: Mygalomorphae: Ctenizidae). *Australian Journal of Zoology, Supplement Series*, 108: 184

Main, B.Y. (1996) Terrestrial Invertebrates in south-west Australian forests: the tole of relict species and habitats in reserve design. *Journal Royal Society Western Australia* 79(4): 277-280

Main, B.Y. (1997) Granite Outcrops: A Collective Ecosystem, *Journal of the Royal Society of Western Australia* 80:113-122

Merriam-Webster (2012a), Morphospecies - Definition and more from the free Merriam-Webster Dictionary, Merriam-Webster Incorporated. http://www.merriam-webster.com/dictionary/morphospecies. Accessed: February 20, 2012.

Merriam-Webster (2012b), Torpor - Definition and more from the free Merriam-Webster Dictionary, Merriam-Webster Incorporated. http://www.merriam-webster.com/dictionary/torpor. Accessed: February 22, 2012.

Monge-Najera, J. (1994) Ecological Biogeogeography of Phylum Onychophora, *Biogeographica* 70(3): 111-123

New, T.R. & Sands, P.A. (2002) Narrow-range endemicity and conservation status: interpretation for Australian butterflies, *Invertebrate Systematics* 16(4):665-670

Ninox Wildlife Consulting (2009) A vertebrate Fauna Survey of the Proposed Hope Downs 4 Infrastructure Corridor Option 1, prepared for Mattiske consulting on behalf of Pilbara Iron Company.

Poinar, G.O. (1998) Arthropod Phoresy involving Pseudoscorpions in the Past and Present *Acta Arachnologica* 47:2; pp79-96

Ponder, W. & Colgan, D.J. (2002) What makes a narrow range taxon? Insights from Australian freshwater snails, *Invertebrate Systematics* 16:571-582

Raven, R. (2008) Endemicity of Mygalomorphs in the Pilbara Region, Western Australia. A report prepared for BHP Billiton and included in the BHP Billiton Iron Ore Orebody 24/25 Upgrade Terrestrial Invertebrate Short-range Endemic Assessment Oct 2008, Outback Ecology Services

Slatyer, C., Ponder, W., Rosauer, D. & Davis, L. (2007) Between a rock and a dry place: land snails in Australia. In: Dickman, C., Lunney, D. & Burgin, S. (Ed.) Animals of Arid Australia: out on their own, Royal Zoological Society of NSW, Mosman, NSW, Australia pp 273-283.

Solem, A. (1988) Maximum in the Minimum: biogeography of land snails from the Ningbing Ranges and Jeremiah Hills, northeast Kimberley, Western Australia. *Journal of the Malacological Society of Australia* 9:59-113

Solem, A. (1997) Camaenid land snails from Western and Central Australia (Mollusca: Pulmonata: Camaenidae). VII Taxa from Dampierland through the Nullabor. *Records WA Museum Supplement* 50:1461-1906

Thompson, S.A. & Thompson, G.G. (2008) Vertebrate by-catch in invertebrate wet pitfall traps. *Journal of the Royal Society of Western Australia* 91:237-241.

Upton, M.S. (1991) Methods for Collecting, Preserving and Studying Insects and Related Forms. Australian Entomological Society, Brisbane

URS Australia Pty Ltd, (2009) Balmoral South Iron Project. Public Environmental Review, EPA Assessment No 1677

Van Vreeswyk, A.M.E., Payne, A.L., Leighton, K.A. and Hennig, P., (2004) An Inventory and Condition Survey of the Pilbara Region, Western Australia. Technical Bulletin in No. 92, Department of Agriculture, South Perth

Volschenk, E. (2010) Scorpion Identification Report DA:201011 prepared for Dalcon Environmental.

Volschnek, E. (2011) Scorpion Identification Report DA.ION.072011 prepared for Dalcon Envrionmental.

Yeates, D.K., Bouchard, P. & Monteith, G.B. (2002) Patterns and levels of endemism in the Australian wet tropics rainforest: evidence from flightless insects. *Invertebrate Systematics* 16(4): 605-619.

York, A., Bell, T., Christie, J. & Brennan, K. (2006) Forests, fire and ecological processes In: *Life in a Fire Prone Environment, Bushfire Conference*, Brisbane.

12. Appendix 1 – GPS Coordinates

12.1. IOH Site 01 GPS Coordinates

IOH Site 01	Position (WSG 84)		
Trap Number	Lat/Long	UTM	Notes
IOHS01D01	S22 44 43.1 E119 18 34.1	50 K 737165 7482824	
IOHS01D02	S22 44 42.1 E119 18 35.3	50 K 737201 7482857	
IOHS01D03	S22 44 40.7 E119 18 36.5	50 K 737234 7482899	
IOHS01D04	S22 44 39.6 E119 18 37.9	50 K 737276 7482932	
IOHS01D05	S22 44 38.5 E119 18 39.1	50 K 737309 7482966	
IOHS01D06	S22 44 37.2 E119 18 37.7	50 K 737270 7483006	
IOHS01D07	S22 44 38.5 E119 18 36.6	50 K 737239 7482967	
IOHS01D08	S22 44 39.7 E119 18 35.3	50 K 737202 7482929	
IOHS01D09	S22 44 40.9 E119 18 34.1	50 K 737166 7482895	
IOHS01D10	S22 44 42.0 E119 18 32.9	50 K 737131 7482860	
IOHS01D11	S22 44 41.0 E119 18 31.5	50 K 737092 7482892	
IOHS01D12	S22 44 39.8 E119 18 32.5	50 K 737122 7482928	
IOHS01D13	S22 44 38.6 E119 18 33.7	50 K 737155 7482965	
IOHS01D14	S22 44 37.3 E119 18 34.7	50 K 737186 7483005	
IOHS01D15	S22 44 35.9 E119 18 35.9	50 K 737220 7483045	
IOHS01D16	S22 44 34.9 E119 18 34.7	50 K 737188 7483079	
IOHS01D17	S22 44 36.0 E119 18 33.6	50 K 737154 7483044	
IOHS01D18	S22 44 37.1 E119 18 32.6	50 K 737125 7483010	
IOHS01D19	S22 44 38.4 E119 18 31.4	50 K 737090 7482971	
IOHS01D20	S22 44 39.7 E119 18 30.0	50 K 737050 7482931	
IOHS01S01	S22 44 41.2 E119 18 35.7	50 K 737212 7482885	Scorpion Burrow
IOHS01S02	S22 44 41.1 E119 18 35.6	50 K 737210 7482886	Scorpion Burrow
IOHS01S03	S22 44 40.7 E119 18 35.9	50 K 737219 7482897	Scorpion Burrow
IOHS01S04	S22 44 40.4 E119 18 36.8	50 K 737243 7482908	Scorpion Burrow
IOHS01S05	S22 44 38.5 E119 18 37.9	50 K 737275 7482967	Scorpion Burrow
IOHS01S06	S22 44 38.3 E119 18 37.6	50 K 737268 7482971	Scorpion Burrow
IOHS01S07	S22 44 38.3 E119 18 37.7	50 K 737271 7482972	Scorpion Burrow
IOHS01S08	S22 44 39.7 E119 18 35.3	50 K 737202 7482929	Scorpion Burrow
IOHS01S09	S22 44 37.7 E119 18 37.0	50 K 737251 7482989	Scorpion Burrow
IOHS01S10	S22 44 38.6 E119 18 36.6	50 K 737239 7482962	Scorpion Burrow
IOHS01S11	S22 44 38.8 E119 18 36.4	50 K 737232 7482958	Scorpion Burrow
IOHS01S12	S22 44 39.7 E119 18 35.6	50 K 737211 7482931	Scorpion Burrow
IOHS01S13	S22 44 40.1 E119 18 35.3	50 K 737200 7482918	Scorpion Burrow
IOHS01TD01	S22 44 39.5 E119 18 37.7	50 K 737269 7482935	Trapdoor
IOHS01TD02-03	S22 44 38.3 E119 18 33.5	50 K 737152 7482974	Trapdoor 02 and 03 close together

Note: 'IOH' indicates site location within the Iron Valley Project (IOH tenement). '$S0_X$' indicates site number. 'D_{XX}' indicated dry pitfall Trap number. 'S_{XX}' indicates Scorpion burrow number found on site. '$TD0_X$' indicates trapdoor number found on site.

12.2. **IOH Site 02 GPS Coordinates**

IOH Site 02	Position (WSG 84)		
Trap Number	**Lat/Long**	**UTM**	**Notes**
IOHS02D01	S22 44 34.5 E119 18 39.9	50 K 737335 7483088	
IOHS02D02	S22 44 32.8 E119 18 40.9	50 K 737363 7483139	
IOHS02D03	S22 44 31.6 E119 18 42.1	50 K 737400 7483175	
IOHS02D04	S22 44 32.2 E119 18 42.9	50 K 737422 7483156	
IOHS02D05	S22 44 33.5 E119 18 41.6	50 K 737385 7483118	
IOHS02D06	S22 44 35.1 E119 18 40.5	50 K 737352 7483069	
IOHS02D07	S22 44 37.2 E119 18 40.1	50 K 737340 7483004	
IOHS02D08	S22 44 35.9 E119 18 41.1	50 K 737369 7483045	
IOHS02D09	S22 44 34.6 E119 18 42.1	50 K 737398 7483083	
IOHS02D10	S22 44 33.5 E119 18 43.4	50 K 737436 7483117	
IOHS02S01	S22 44 34.9 E119 18 39.1	50 K 737312 7483077	Scorpion Burrow

Note: 'IOH' indicates site location within the Iron Valley Project (IOH tenement). '$S0_X$' indicates site number. 'D_{XX}' indicated dry pitfall Trap number. 'S_{XX}' indicates Scorpion burrow number found on site.

12.3. RIO Site 01 GPS Coordinates

RIO Site 01	Position (WSG 84)		
Trap Number	Lat/Long	UTM	Notes
RIOS01D01	S22 45 07.1 E119 18 51.4	50 K 737648 7482078	
RIOS01D02	S22 45 05.9 E119 18 52.6	50 K 737681 7482115	
RIOS01D03	S22 45 04.6 E119 18 53.7	50 K 737714 7482155	
RIOS01D04	S22 45 03.4 E119 18 55.0	50 K 737751 7482191	
RIOS01D05	S22 45 02.2 E119 18 56.2	50 K 737787 7482229	
RIOS01D06	S22 45 03.2 E119 18 57.7	50 K 737828 7482197	
RIOS01D07	S22 45 04.5 E119 18 56.4	50 K 737791 7482157	
RIOS01D08	S22 45 05.8 E119 18 55.2	50 K 737757 7482119	
RIOS01D09	S22 45 06.9 E119 18 54.0	50 K 737722 7482085	
RIOS01D10	S22 45 08.1 E119 18 52.7	50 K 737683 7482048	
RIOS01D11	S22 45 09.2 E119 18 53.9	50 K 737719 7482013	
RIOS01D12	S22 45 08.2 E119 18 55.3	50 K 737759 7482045	
RIOS01D13	S22 45 07.0 E119 18 56.6	50 K 737797 7482081	
RIOS01D14	S22 45 05.7 E119 18 57.9	50 K 737834 7482120	
RIOS01D15	S22 45 04.6 E119 18 59.2	50 K 737870 7482152	
RIOS01S01	S22 45 05.3 E119 18 53.6	50 K 737712 7482133	Scorpion Burrow
RIOS01S02	S22 45 05.0 E119 18 53.8	50 K 737716 7482142	Scorpion Burrow
RIOS01S03	S22 45 04.3 E119 18 54.1	50 K 737726 7482164	Scorpion Burrow
RIOS01S04	S22 45 06.5 E119 18 54.1	50 K 737724 7482097	Scorpion Burrow
RIOS01S05	S22 45 06.2 E119 18 53.3	50 K 737702 7482107	Scorpion Burrow
RIOS01S06-07	S22 45 06.5 E119 18 55.1	50 K 737754 7482097	Scorpion Burrow
RIOS01S08	S22 45 06.7 E119 18 55.2	50 K 737756 7482090	Scorpion Burrow
RIOS01S09	S22 45 06.9 E119 18 56.6	50 K 737797 7482083	Scorpion Burrow
RIOS01S10	S22 45 07.4 E119 18 54.8	50 K 737744 7482068	Scorpion Burrow
RIOS01S11	S22 45 06.7 E119 18 48.9	50 K 737576 7482094	Scorpion Burrow
RIOS01TD01	S22 45 08.9 E119 18 52.9	50 K 737688 7482024	Trapdoor
RIOS01TD02	S22 45 10.4 E119 18 52.9	50 K 737689 7481976	Trapdoor
RIOS01TD03	S22 45 10.1 E119 18 55.0	50 K 737749 7481986	Trapdoor

Note: 'RIO' indicates site location within Rio Tinto Iron Ore's tenement (adjacent to the Iron Valley Project). '$S0_X$' indicates site number. 'D_{XX}' indicated dry pitfall trap number. 'S_{XX}' indicates Scorpion burrow number found on site. '$TD0_X$' indicates trapdoor number found on site.

12.4. **RIO Site 02 GPS Coordinates**

RIO Site 02	Position (WSG 84)		
Trap Number	**Lat/Long**	**UTM**	**Notes**
RIOS02D01	S22 43 43.4 E119 19 53.0	50 K 739447 7484626	
RIOS02D02	S22 43 42.3 E119 19 54.3	50 K 739483 7484660	
RIOS02D03	S22 43 41.2 E119 19 55.7	50 K 739525 7484693	
RIOS02D04	S22 43 40.0 E119 19 57.1	50 K 739565 7484729	
RIOS02D05	S22 43 38.9 E119 19 58.4	50 K 739601 7484764	
RIOS02D06	S22 43 40.0 E119 19 59.5	50 K 739632 7484730	
RIOS02D07	S22 43 41.3 E119 19 58.4	50 K 739600 7484688	
RIOS02D08	S22 43 42.3 E119 19 57.2	50 K 739566 7484659	
RIOS02D09	S22 43 43.6 E119 19 55.9	50 K 739529 7484621	
RIOS02D10	S22 43 44.8 E119 19 54.8	50 K 739498 7484584	
RIOS02D11	S22 43 46.0 E119 19 56.1	50 K 739533 7484545	
RIOS02D12	S22 43 44.9 E119 19 57.4	50 K 739569 7484580	
RIOS02D13	S22 43 43.6 E119 19 58.6	50 K 739606 7484618	
RIOS02D14	S22 43 42.4 E119 19 59.6	50 K 739636 7484654	
RIOS02D15	S22 43 41.1 E119 20 00.8	50 K 739671 7484694	
RIOS02S01	S22 43 43.8 E119 19 52.5	50 K 739431 7484615	Scorpion Burrow
RIOS02S02	S22 43 43.3 E119 19 53.3	50 K 739454 7484631	Scorpion Burrow
RIOS02S03	S22 43 39.2 E119 19 57.5	50 K 739577 7484753	Scorpion Burrow
RIOS02S04	S22 43 38.7 E119 19 58.7	50 K 739610 7484769	Scorpion Burrow
RIOS02TD01	S22 43 44.9 E119 19 55.0	50 K 739501 7484579	Trapdoor
RIOS02TD02	S22 43 43.5 E119 19 53.9	50 K 739473 7484624	Trapdoor
RIOS02TD03	S22 43 45.1 E119 19 54.2	50 K 739479 7484576	Trapdoor

Note: ‘RIO’ indicates site location within Rio Tinto Iron Ore’s tenement (adjacent to the Iron Valley Project). ‘$S0_X$’ indicates site number. ‘D_{XX}’ indicated dry pitfall trap number. ‘S_{XX}’ indicates Scorpion burrow number found on site. ‘$TD0_X$’ indicates trapdoor spider number found on site.

12.5. RIO Site 02 GPS Coordinates

	Position (WSG 84)		
Trap Number	Lat/Long	UTM	Notes
RIOVEG01	S22 45 54.8 E119 18 21.9	50 K 736783 7480624	Vegetation Assessment point
RIOVEG02	S22 45 26.2 E119 18 34.0	50 K 737141 7481501	Vegetation Assessment point
RIOVEG03	S22 44 43.6 E119 19 13.0	50 K 738274 7482792	Vegetation Assessment point
RIOVEG04	S22 44 18.1 E119 19 51.3	50 K 739380 7483560	Vegetation Assessment point

Note: 'RIO' indicates site location within Rio Tinto Iron Ore's tenement (adjacent to the Iron Valley Project). '$S0_X$' indicates site number. 'D_{XX}' indicated dry pitfall trap number. 'S_{XX}' indicates Scorpion burrow number found on site. '$TD0_X$' indicates trapdoor spider number found on site.

13. Appendix 2 – Vegetation Survey Results

Name	Site						
	IOH	RIO-S01	RIO-S02	RIOVEG-1	RIOVEG-2	RIOVEG-3	RIOVEG-4
Acacia adoxa var. *adoxa*	X			X			
Acacia ancistrocarpa	X		X				X
Acacia bivenosa	X		X				
Acacia colei var. *ileocarpa*			X	X			
Acacia dictyophleba							X
Acacia hilliana	X			X			X
Acacia inaequilatera	X	X			X	X	
Acacia pachyachra	X				X	X	X
Acacia pruinocarpa	X					X	
Acacia pteraneura	X	X					
Acacia pyriformis						X	
Acacia spondylophylla						X	
Acacia tumida var. *pilbarensis*	X			X		X	X
Aristida holathera var. *holathera*	X	X				X	
**Cenchrus ciliaris*	X	X	X			X	X
Cleome viscosa	X	X	X				
Corchorus lasiocarpus subsp. *lasiocarpus*		X		X	X	X	X
Corchorus sidoides subsp. *sidoides*	X	X		X	X	X	X
Corymbia hamersleyana	X						X
Cucumis maderaspatanus	X						
Dicrastylis cordifolia				X	X	X	
Dysphania kalparri	X						
Eragrostis setifolia				X		X	

Eremophila forrestii subsp. *forrestii*	X	X					
Eremophila longifolia	X						
Eucalyptus gamophylla	X		X			X	
Eucalyptus ?leucophloia subsp. *leucophloia*	X						
Euphorbia australis	X	X					
Gomphrena cunninghamii						X	
Goodenia microptera	X			X			
Gossypium robinsonii	X			X			X
Grevillea wickhamii subsp. hispidula	X		X		X	X	
Hakea chordopylla		X			X	X	X
Hakea lorea subsp lorea	X	X			X	X	X
Heliotropium pachyphyllum	X						
Hibiscus coatesii	X	X					
Indigofera monophylla	X	X					
Oldenlandia crouchiana	X						
Paraneurachne muellerii	X	X		X			
Petalostylis labichieoides	X		X	X	X	X	X
Phyllanthus erwinii	X						
Polycarpea corymbosa	X						
Portulaca oleracea	X						
Ptilotus astrolasius	X						
Ptilotus auriculifolius	X						
Ptilotus calostachyus	X	X		X	X		
Ptilotus exaltatus	X	X		X	X	X	X
Ptilotus helipteroides	X	X		X	X	X	X
Ptilotus macrocephalus	X	X					
Ptilotus obovatus	X					X	
Salsola austrlalis						X	

Scaevola parvifolia							X
Senna artemisioides subsp. *helmsii*				X	X	X	X
Senna ferraria	X	X	X				
Senna glutinosa subsp.x *luerssenii*	X	X					
Senna glutinosa subsp.pruinosa	X	X					
Sida echinocarpa	X	X		X	X	X	
Sida fibulifera	X						
Sida Spiciform Panicles (E. Leyland s.n. 14/8/90)	X						
Solanum phlomoides	X			X			
Solanum sturtianum	X	X					
Trianthema pilosa	X	X					X
Trichodesma zeylanicum var. *zeylanicum*	X		X				
Triodia pungens	X						
Triodia sp.	X						
Velleia connata			X				
Yakirra australiensis	X						

14. Appendix 3 – Habitat Assessment Sheets

14.1. IOH Site 01 and 02 – Habitat Assessment Sheet

SHORT-RANGE ENDEMIC ASSESSMENT - HABITAT ASSESSMENT SHEET

GENERAL INFORMATION

Location: IOHS01 & IOHS02
Date: 2-Jun-11
Surveyor: Heath.M

GPS (Easting/Northing): 50K 737165 7482824
Site #: S01 & S02
Photo #:

Broad SRE Habitat Type: Spinifex grassland w/h open ground. Transitional grassland
Landscape Position: Plain between ridges

VEGETATION

Broad Vegetation Type: Spinifex, grass, scattered Eucalyptus spp. & Acacia spp.

Vegetation indicative of SRE habitat (eg. Ficus, ferns) — Present [X] Absent [ ]

Spinifex Grassland

SUBSTRATE

Rock outcrop which may harbour land snails — Present [ ] Absent [X]

-

Substrate suitable for Mygalomorph spiders or scorpions — Present [X] Absent [ ]

Loose compacted soil w/h scattered rock & spinifex clumps. Open bare ground.

Litter Cover — Low (0-40%) [X] Moderate (40-60%) [ ] High (60-100%) [ ]

-

EVIDENCE OF TARGET SRE GROUPS

Presence of Mygalomorph spider/scorpion burrows — Present [X] Absent [ ]

Trapdoor burrows present. Scorpion burrows present.

HABITAT

Area of Habitat (based on aerial photographs):

Existing Disturbance — Present [X] Absent [ ]

Drilling lines, road, minimal cattle sign (inc. grazing), drainage lines, disturbance specialist pioneer vegetation present.

Phyisical Connectivity: Continuous vegetation type throughout plain between ridges.

Extent of Habitat: Similar habitat for +4 km as per walked during previous year survey.

Other Comments: Final transect of IOHS02 (D07-10) in rocky area at foot of hill - Rock cover 80-100%

14.2. **RIO Site 01 – Habitat Assessment Sheet**

SHORT-RANGE ENDEMIC ASSESSMENT - HABITAT ASSESSMENT SHEET

GENERAL INFORMATION

Location	RIOS01	Date	3-Jun-11	Surveyor	Mark.H
GPS (Easting/Northing)	50K 737648 7482078	Site #	RIOS01		
		Photo #			
Broad SRE Habitat Type	Spinifex grassland w/h open soil patches	Landscape Position	v.large open plain between two ranges		

VEGETATION

Broad Vegetation Type: Spinifex grassland w/h sparse Eucalpytus spp. overstorey

Vegetation indicative of SRE habitat (eg. Ficus, ferns) — Present [ ] Absent [X]

-

SUBSTRATE

Rock outcrop which may harbour land snails — Present [X] Absent [ ]

There are patches of rocky cobble possibly suitable - v.unlikely however.

Substrate suitable for Mygalomorph spiders or scorpions — Present [X] Absent [ ]

Open sandy areas between spinifex clumps - soil burrowable. Good Myg habitat under scattered Acacia spp. stands w/h leaf litter.

Litter Cover — Low (0-40%) [X] Moderate (40-60%) [ ] High (60-100%) [ ]

Mainly under overstorey vegetation & shurbs. No loose litter.

EVIDENCE OF TARGET SRE GROUPS

Presence of Mygalomorph spider/scorpion burrows — Present [X] Absent [ ]

Scorpion & Myg burrows present & excavated. Scorpion & myg's collected.

HABITAT Area of Habitat (based on aerial photographs):

Existing Disturbance — Present [X] Absent [ ]

Fire, v.minor drainage erosion, major cattle sign

Phyisical Connectivity:

Extent of Habitat:

Other Comments:

14.3. RIO Site 02 – Habitat Assessment Sheet

SHORT-RANGE ENDEMIC ASSESSMENT - HABITAT ASSESSMENT SHEET

GENERAL INFORMATION

Location: RIOS02 | Date: 3-Jun-11 | Surveyor: Mark.H

GPS (Easting/Northing): 50K 739447 7484626

Site #: RIOS02

Photo #:

Broad SRE Habitat Type: Spinifex grassland w/h mixed Acacia spp. woodland overstorey

Landscape Position: Plain adjacent creekline

VEGETATION

Broad Vegetation Type: Spnifex grassland w/h mixed Acacia spp. woodland overstorey

Vegetation indicative of SRE habitat (eg. Ficus, ferns) — Present [ ] Absent [X]

V.suitable under/around Acacia spp. stands

SUBSTRATE

Rock outcrop which may harbour land snails — Present [ ] Absent [X]

-

Substrate suitable for Mygalomorph spiders or scorpions — Present [X] Absent [ ]

Open soil patches between Spinifex. Perfect under Acacaia spp. stands in Leaf.L

Litter Cover — Low (0-40%) [X] Moderate (40-60%) [ ] High (60-100%) [ ]

Overall low, however, moderate-high under Acacia spp. stands

EVIDENCE OF TARGET SRE GROUPS

Presence of Mygalomorph spider/scorpion burrows — Present [X] Absent [ ]

Scorpion burrows absent. Myg PRESENT, found under Acacia spp. stands.

HABITAT

Area of Habitat (based on aerial photographs):

Existing Disturbance — Present [ ] Absent [X]

-

Phyisical Connectivity: Plain. fringes adjoining creek land vegetation and flooding area of Weeli Wollie Creek

Extent of Habitat:

Other Comments:

14.4. RIO Vegetation Assessment Site 01 – Habitat Assessment Sheet

SHORT-RANGE ENDEMIC ASSESSMENT - HABITAT ASSESSMENT SHEET

GENERAL INFORMATION

Location	RIOVEG01	Date	8-Jun-11	Surveyor	Mark.H
GPS (Easting/Northing)	50K 736783 7480624	Site #	RIOVEG01		
		Photo #			
Broad SRE Habitat Type	Herbs and open areas fire affected	Landscape Position	Plain - Minor undulations & Hillocks		

VEGETATION

Broad Vegetation Type: Herbs

Vegetation indicative of SRE habitat (eg. Ficus, ferns) — Present [ ] Absent [X]

-

SUBSTRATE

Rock outcrop which may harbour land snails — Present [ ] Absent [X]

Rocky hillocks possibly suitable

Substrate suitable for Mygalomorph spiders or scorpions — Present [X] Absent [ ]

Easily burrowable

Litter Cover — Low (0-40%) [X] Moderate (40-60%) [ ] High (60-100%) [ ]

Evidence of fire which would have burnt leaf litter off

EVIDENCE OF TARGET SRE GROUPS

Presence of Mygalomorph spider/scorpion burrows — Present [ ] Absent [X]

-not checked, vegetation assessment only-

HABITAT Area of Habitat (based on aerial photographs):

Existing Disturbance — Present [X] Absent [ ]

Fire, minor cattle sign

Phyisical Connectivity	Plain runing between two ranges running length of transect.
Extent of Habitat	
Other Comments	

14.5. RIO Vegetation Assessment Site 02 – Habitat Assessment Sheet

SHORT-RANGE ENDEMIC ASSESSMENT - HABITAT ASSESSMENT SHEET

GENERAL INFORMATION

Location: RIOVEG02 | Date: 8-Jun-11 | Surveyor: Mark.H

GPS (Easting/Northing): 50K 737141 7481501 | Site #: RIOVEG02 | Photo #:

Broad SRE Habitat Type: Open herb plain | Landscape Position: Plain between two ranges

VEGETATION

Broad Vegetation Type: Herbs - Less flowering that RIOVEG01 & less species

Vegetation indicative of SRE habitat (eg. Ficus, ferns) Present [ ] Absent [X]

-

SUBSTRATE

Rock outcrop which may harbour land snails Present [ ] Absent [X]

-

Substrate suitable for Mygalomorph spiders or scorpions Present [ ] Absent [ ]

Litter Cover Low (0-40%) [X] Moderate (40-60%) [ ] High (60-100%) [ ]

Fire would have burnt leaf litter off. Herbs not contributing to litter cover.

EVIDENCE OF TARGET SRE GROUPS

Presence of Mygalomorph spider/scorpion burrows Present [ ] Absent [X]

-not checked, vegetation assessment only-

HABITAT Area of Habitat (based on aerial photographs):

Existing Disturbance Present [X] Absent [ ]

Fire, minor cattle signs

Phyisical Connectivity:

Extent of Habitat:

Other Comments:

14.6. RIO Vegetation Assessment Site 03 – Habitat Assessment Sheet

SHORT-RANGE ENDEMIC ASSESSMENT - HABITAT ASSESSMENT SHEET

GENERAL INFORMATION

Location	RIOVEG03
Date	8-Jun-11
Surveyor	Mark.H
GPS (Easting/Northing)	50K 738274 748297
Site #	RIOVEG03
Photo #	
Broad SRE Habitat Type	Spinifex grassland
Landscape Position	Open drainage area near creek surrounded by hills

VEGETATION

Broad Vegetation Type: Spinifex grassland with herbs & Eucalyptus spp

Vegetation indicative of SRE habitat (eg. Ficus, ferns) — Present [ ] Absent [X]

-

SUBSTRATE

Rock outcrop which may harbour land snails — Present [ ] Absent [X]

Substrate suitable for Mygalomorph spiders or scorpions — Present [X] Absent [ ]

Soil is suitable

Litter Cover — Low (0-40%) [X] Moderate (40-60%) [ ] High (60-100%) [ ]

EVIDENCE OF TARGET SRE GROUPS

Presence of Mygalomorph spider/scorpion burrows — Present [ ] Absent [X]

None observed

HABITAT

Area of Habitat (based on aerial photographs):

Existing Disturbance — Present [ ] Absent [X]

None observed

Phyisical Connectivity: Part of plain running EW between ranges

Extent of Habitat:

Other Comments:

14.7. RIO Vegetation Assessment Site 04 – Habitat Assessment Sheet

SHORT-RANGE ENDEMIC ASSESSMENT - HABITAT ASSESSMENT SHEET

GENERAL INFORMATION

Location	RIOVEG04	Date	9-Jun-11	Surveyor	Mark.H
GPS (Easting/Northing)	50K 739380 7483560	Site #	RIOVEG04	Photo #	
Broad SRE Habitat Type	Spinifex & Acacia spp. w/h Open Soil Patches	Landscape Position	Transitional zone between 2 hills & riverbed		

VEGETATION

Broad Vegetation Type: Spinifex & Grassland with Acacia spp. & Eucalpytus spp. overstorey

Vegetation indicative of SRE habitat (eg. Ficus, ferns) — Present [ ] Absent [X]

-

SUBSTRATE

Rock outcrop which may harbour land snails — Present [ ] Absent [X]

Not in area sampled - POSIBILITY in surrounding rocky hills

Substrate suitable for Mygalomorph spiders or scorpions — Present [X] Absent [ ]

Soil Suitable for burrowing, open areas of soil between trees & grass/spinifex clumps

Litter Cover — Low (0-40%) [X] Moderate (40-60%) [ ] High (60-100%) [ ]

Mainly below overstorey flora

EVIDENCE OF TARGET SRE GROUPS

Presence of Mygalomorph spider/scorpion burrows — Present [ ] Absent [X]

No visual confirmation. Low/Med posibility of Myg/Scorpions. Looks good though…

HABITAT

Area of Habitat (based on aerial photographs):

Existing Disturbance — Present [X] Absent [ ]

Drainage lines, v.minor cattle sign, areas (small) of depressions w/h evidence of seasonal/periodical inundation

Phyisical Connectivity	-See landscape position above- Catchment area flowing into nearby Weeli Wollie Creek
Extent of Habitat	
Other Comments	Looks v.similar to RIOS01 - Potential for Mygs