REPORT

CORUNNA DOWNS PROJECT

TERRESTRIAL SRE INVERTEBRATE FAUNA IMPACT ASSESSMENT

Prepared for Atlas Iron Limited

November 2016

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Executive Summary

Atlas Iron Limited (Atlas) commissioned MWH (formally Outback Ecology), to conduct a terrestrial short-range endemic (SRE) invertebrate fauna assessment (this Assessment) of the Corunna Downs Project (the Project), located approximately 33 km south-west of Marble Bar by road in the Pilbara region of Western Australia.

Three areas were given consideration in compiling this assessment:

- the **Study Area** which encompasses a 18,845 hectare (ha) parcel of land;
- the **Development Envelope**, which encompasses 2,263.19 ha of land that occurs entirely within the Study Area; and
- the indicative **Disturbance Footprint**, a 423.14 ha parcel of land which occurs entirely within the Development Envelope.

Within the Development Envelope, the indicative Disturbance Footprint has been considered for the purposes of assessing potential impacts. The indicative Disturbance Footprint occurs entirely within the Development Envelope; however, the exact alignment of the indicative Disturbance Footprint is yet to be confirmed. Although the Development Envelope totals 2,263.19 ha, Atlas have committed to clearing no more than 423.14 ha for the development of the Project.

The overarching objective of this Assessment was to assess the potential impacts of the Project on terrestrial SRE invertebrate fauna and invertebrate fauna habitats. The assessment was informed by data obtained during a terrestrial SRE invertebrate fauna trapping survey conducted between March and May 2014. This survey was supplemented by collection of specimens from broad fauna habitats during a two phase vertebrate fauna trapping survey conducted in February/March 2014 (Phase 1) and during September/October 2016 (Phase 2). For local and regional context, this report also presents a summary of results from previous terrestrial SRE invertebrate fauna surveys that have been conducted in the Study Area and surrounds.

In total, the combined surveys comprised 4,420 wet trap nights, 2,800 dry/funnel trap nights, 51 hours of targeted searching, the collection of 39 soil samples and 39 leaf litter samples. Additionally, SRE invertebrate fauna habitat assessments were conducted over the Study Area, which involved characterising habitat according to condition, complexity and suitability for invertebrate taxa prone to short-range endemism. Drawing on EPA Guidance Statement No 20, MWH's previous experience in the Pilbara and subsequent consultation with invertebrate SRE specialists, the following invertebrate groups prone to short-range endemism were targeted during this assessment: mygalomorph spiders, selenopid spiders, scorpions, pseudoscorpions, millipedes, slaters and terrestrial snails.

Eleven broad habitats were identified across the Study Area. These habitats were categorised as having a high, medium or low potential to support terrestrial SRE taxa based on the presence of microhabitats, whether the habitat was restricted, isolated, widespread and/or well connected in the landscape. Based on these criteria, two habitats, Rocky Ridge and Gorge and Granite Outcrops, have a high potential to support SRE species, and one habitat, Drainage Lines, has a medium potential.

Approximately 14.1 % of Rocky Ridge and Gorge habitat and 11.1 % of Drainage Line habitat within the Study Area occurs within the Development Envelope and therefore, has potential to be directly impacted by the Project. None of the Granite Outcrop habitat occurs within the Development Envelope and consequently, this habitat will not be impacted by the Project. No invertebrate habitat was found to be restricted exclusively to the proposed Development Envelope. The Development Envelope largely comprises habitats with a low potential to support SRE species, namely Spinifex Stony Plains, Ironstone Ridgetops and Stony Rises.

The survey of the Study area resulted in the collection of 761 invertebrate specimens (from targeted groups) from 31 species. Slaters were the most diverse group to be collected (514 specimens from 9 species), followed by scorpions (147 specimens from 6 species), pseudoscorpions (80 specimens from 8 species), snails (8 specimens from 2 species), selenopid spiders (8 specimens from 3 species), mygalomorph spiders (3 specimens from 2 species) and millipedes (1 specimen). The desktop study identified a further three species with potential to occur comprising of two millipede species and one snail species.

Within the Study Area, two species were considered to be Confirmed SRE species, three as Likely SRE species and 13 as Potential SRE species. Of these, two taxa considered Likely and six considered Potential SRE species were recorded within the Development Envelope (**ES Table 1**).

ES Table 1: SRE species recorded within the Development Envelope

SRE Status	Taxa	Group
Likely	Buddelundiinae 'mw'	Slater
	Philosciidae 'corunna'	Slater
Potential	*Karaops* sp. 'indet. 2'	Selenopid spider
	Rhagada sp. 'nov'	Snail
	Lychas 'bituberculatus complex'	Scorpion
	Lychas 'hairy tail complex'	Scorpion
	Buddelundia '11'	Slater
	Buddelundia '86'	Slater

Land clearing is likely to be the largest impact on SRE invertebrate fauna and habitat within the Study Area. Atlas have committed to clearing no more than 423.14 ha within the 2,263.19 ha Development Envelope. None of the Likely or Potential SRE species were collected exclusively from within the Development Envelope. All species collected within the Development Envelope for the Project have also been collected outside the Development Envelope, either locally or regionally. As such development of the Project is unlikely to have a significant impact to any of the aforementioned species.

Atlas Iron Limited

Corunna Downs Project
Terrestrial SRE Invertebrate Fauna Impact Assessment

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1 Introduction

1.1 Project Background and Location

Atlas Iron Limited (Atlas) is looking to develop the Corunna Downs Project (the Project), located approximately 33 kilometres (km) south-west of Marble Bar by road in the Pilbara region of Western Australia (**Figure 1-1**). Atlas commissioned MWH (formally Outback Ecology), to conduct a terrestrial short-range endemic (SRE) invertebrate fauna assessment (this Assessment) of an 18,845 ha parcel of land associated with the Project (the Study Area), and to assess potential impacts of the Project within. Atlas require this Assessment to facilitate future environmental approvals for the Project, which will involve the construction and operation of an iron ore mine and associated supporting infrastructure (**Figure 1-2**).

Three areas were given consideration in compiling this assessment (**Figure 1-2**):

- the **Study Area** which encompasses a 18,845 hectare (ha) parcel of land;
- the **Development Envelope**, which encompasses 2,263.19 ha of land that occurs entirely within the Study Area; and
- the indicative **Disturbance Footprint**, a 423.14 ha parcel of land which occurs entirely within the Development Envelope.

Within the Development Envelope, the indicative Disturbance Footprint has been considered for the purposes of assessing potential impacts. The indicative Disturbance Footprint occurs entirely within the Development Envelope, however the exact alignment of the indicative Disturbance Footprint is yet to be confirmed. Although the Development Envelope totals 2,263.19 ha, Atlas have committed to clearing no more than 423.14 ha for the development of the Project.

1.2 Scope and Objectives

The specific objectives of this terrestrial SRE invertebrate fauna assessment were to:

- assess the occurrence and likely distribution of SRE invertebrate fauna within the Study Area;
- identify, describe and map fauna habitat with potential to support SRE invertebrate fauna and any significant habitat within the Study Area;
- assess survey findings in the regional context by comparisons with available data from other localities within the Pilbara bioregion; and
- assess the potential impacts of the Project on terrestrial SRE invertebrate fauna and habitat in the Study Area.

The survey was designed and conducted in accordance with:

- WA Environmental Protection Authority (EPA; 2009) Guidance No. 20, *Sampling of Short-range Endemic Invertebrate Fauna for Environmental Impact Assessment in Western Australia*;
- EPA (2004) Guidance No. 56, *Terrestrial Fauna Surveys for Environmental Impact Assessment in Western Australia*; and
- EPA (2003) Position Statement No. 3, *Terrestrial Biological Surveys as an Element of Biodiversity Protection*.

The field sampling methodology used during the surveys was endorsed previously by the, then, Department of Conservation (now Department of Parks and Wildlife, DPaW).

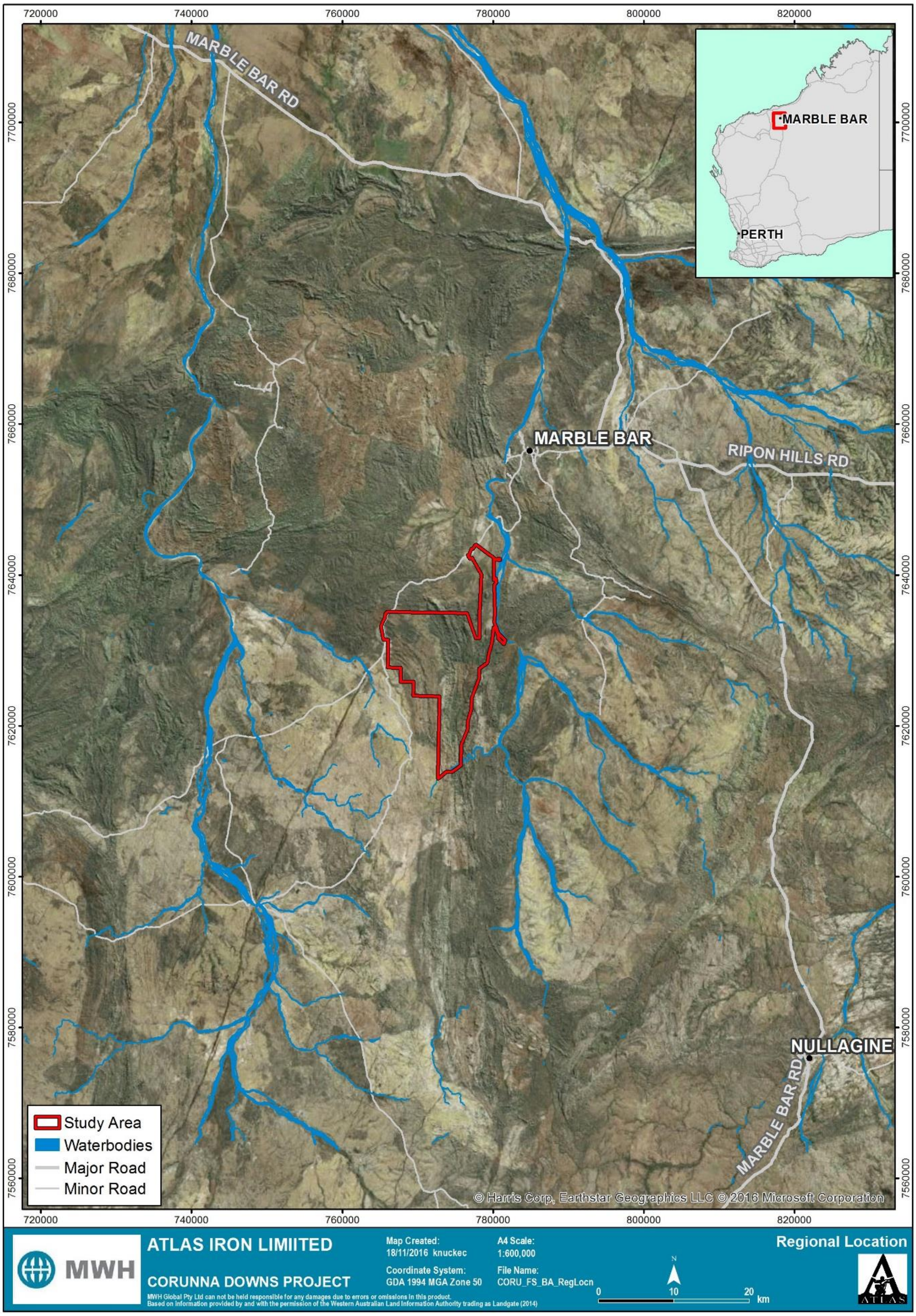

Figure 1-1: Regional Location of the Study Area

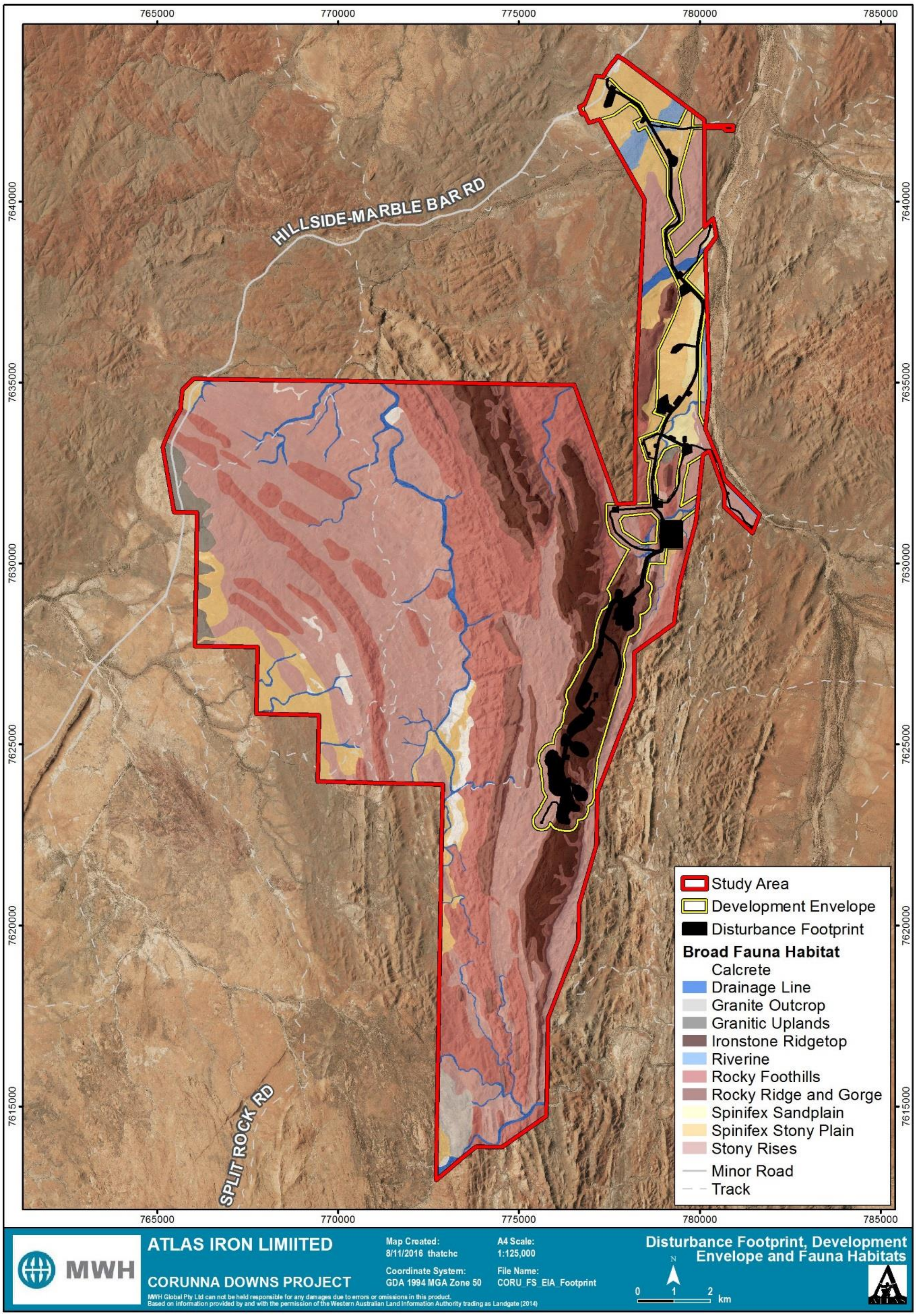

Figure 1-2: The Study Area, Development Envelope and indicative Disturbance Footprint

1.3 Short-Range Endemic Invertebrate Taxa

Endemism refers to the restriction of a species to a particular area, at a continental, national or local scale (Allen *et al.* 2002). Harvey (2002) defines a restricted range as a species with a maximum range of 10,000 km². Comprehensive systematic reviews of different faunal groups often reveal the presence of SRE invertebrate species (Harvey 2002). Some better known SRE species have been listed under State or Commonwealth legislation. However, the majority of SRE species have not been listed under legislation, often due to lack of taxonomic knowledge (EPA 2009). SRE invertebrates in general are considered relevant to environmental impact assessment as habitat loss and degradation can decrease their prospects for persistence (EPA 2009).

The SRE invertebrate fauna of WA is typically associated with sheltered and mesic microhabitats, such as the southeast aspect of slopes, trees, boulders and rock piles, outcrops, mesas, drainage systems, deep gorges, natural springs and fire refuges (EPA 2009). In WA, many terrestrial SRE invertebrate species have Gondwanan origins and are relics of previously widespread species common to the continents of the southern hemisphere during the mesic climates of the Miocene (Harvey 2002). The subsequent aridification of Australia during the Miocene through to the Pleistocene resulted in the fragmentation and contraction of once common mesic habitats. Consequently, populations dependent on these mesic habitats were also fragmented, resulting in the evolution of SRE invertebrate fauna (Harvey 2002).

A combination of intrinsic and extrinsic factors, such as dispersal capabilities or opportunities, habitat preferences, life history attributes, physiological attributes, habitat availability, biotic and abiotic interactions and historical factors, determine not only the geographic distribution of a taxon, but its propensity for population differentiation and speciation (Ponder and Colgan 2002). Taxa prone to short range endemism tend to share several ecological and life-history characteristics, such as poor powers of dispersal, confinement to discontinuous habitats, highly seasonal activity patterns and low fecundity (Harvey 2002).

Invertebrate groups prone to short-range endemism that have potential to occur within the Pilbara and are regularly targeted during SRE surveys include: mygalomorph spiders, selenopid spiders, scorpions, pseudoscorpions, millipedes, slaters and terrestrial snails. Additional invertebrate groups have potential to include SRE species (see Harvey 2002), however, such groups are generally considered beyond the requirements of fauna surveys for EIA. This is because endemism is not as common throughout the species-group, there is a lack of taxonomic resolution and/or there is a lack of regional information on the group available to inform an Environmental Impact Assessment (EPA 2009, Harvey 2002).

Taxonomists (i.e. Western Australian Museum [WAM] and Phoenix Environmental) have developed criteria for explaining the degree of certainty surrounding the SRE status of a specimen where specific knowledge gaps exist, such as:

- unknown geographic distribution of a species due to patchy/limited sampling;
- limited taxonomic resolution due to limited knowledge of a particular group or a lack of specialist skills; and
- specimens are of an inappropriate life stage or sex to allow for accurate identification to species level.

These categories will be used to provide context to specimens collected during surveys (**Table 1-1**).

Table 1-1: Categories for status with respect to short-range endemism

Status	Criteria
Western Australian Museum	
Confirmed	• A known distribution of < 10 000 km2. • The taxonomy is well known. • The group is well represented in collections and / or via comprehensive sampling.
Potential	• Patchy sampling has resulted in incomplete knowledge of the geographic distribution of the group. • Incomplete taxonomic knowledge. • The group is not well represented in collections. • This category is most applicable to situations where there are gaps.
Widespread	• A known distribution of > 10 000 km2. • The taxonomy is well known. • The group is well represented in collections and / or via comprehensive sampling.
Unknown	• Specimens belonging to known SRE groups, that cannot be accurately identified to species level due to an inappropriate sex or life stage.
Phoenix Environmental	
Confirmed	• Confirmed or almost certainly SRE; taxonomy of the group is well known (but not necessarily published). • Group well represented in collections, in particular from the region in question. • High levels of endemism in documented species i.e. *Antichiropus* millipedes (Paradoxosomatidae) and scorpions in the genus *Aops* (Urodacidae). • Inference is often possible from immature specimens.
Likely	• Taxonomically poorly resolved group. • Unusual morphology for the group (i.e. some form of troglomorphism). • Often singleton in survey and few, if any, regional records. • Opiliones in the genus *Dampetrus*.
Potential	• Taxonomically poorly resolved group. • Often common in certain microhabitats in SRE surveys (i.e. litter dwellers), but no other regional records. • Congeners often widespread. • Specimens belonging to known SRE groups, that cannot be accurately identified to species level due to an inappropriate sex or life stage.
Widespread	• Taxonomically well resolved (but often not published) and demonstrated wide distribution (i.e. > 10,000 km2).

2 Existing Environment

2.1 Biogeographic Region

The Interim Biogeographic Regionalisation for Australia (IBRA) is a bioregional framework that divides Australia into 89 bioregions and 419 subregions on the basis of climate, geology, landforms, vegetation and fauna (Thackway and Cresswell 1995).

The Study Area is located within the Pilbara bioregion (**Figure 2-1**), which encompasses approximately 178,500 km^2 of land in northern Western Australia (McKenzie *et al.* 2009). The Pilbara bioregion has a semi-desert tropical climate, with active drainage in the Fortescue, De Grey and Ashburton river systems (McKenzie *et al.* 2003). A combination of invasive weeds, altered fire regimes, feral predators and grazing by introduced herbivores has resulted in ecosystem degradation, and consequently a loss of vegetation and native species. The Pilbara bioregion is further classified into four sub-regions – Chichester, Roebourne, Fortescue Plains, and Hamersley (McKenzie *et al.* 2003). The Study Area is located within the Chichester subregion (**Figure 2-1**). The Chichester subregion is the largest of the four, encompassing 47% (83,700 km^2) of the Pilbara bioregion (McKenzie *et al.* 2009).

The Chichester subregion is characterised by undulating Archaean granite and basalt plains with substantial areas of basalt ranges (Kendrick and McKenzie 2001). The basalt plains host a shrub steppe of *Acacia inaequilatera* over *Triodia* spp. hummock grasslands, while tree steppes of *Eucalyptus leucophloia* occur on the ranges (Kendrick and McKenzie 2001). The northern part of the Chichester subregion is relatively flat and undulating, dominated by large alluvial floodplains associated with the De Grey River system and its tributaries (McKenzie *et al.* 2003).

The Study Area contains landscape and habitat features typical of the Chichester subregion. The local area is dominated by an approximately north-south ironstone range, elevated above low, rolling hills, stony plains dominated by *Triodia* spp hummock grasslands and drainage systems. Broadly speaking, the Study Area is influenced by those same ecological and landscape processes that characterise the Chichester subregion. That is, the flora and fauna are typically semi-arid inhibiting, adapted to alternating wet and dry seasonal patterns of rainfall (Leighton 2004b), with fire being one of the principal determinants of habitat and vegetation structure. The Study Area is subject to those same threatening processes found throughout the subregion, in particular being grazing by introduced herbivores and the effects of introduced predators (Kendrick and McKenzie 2001).

Figure 2-1: Location of the Study Area with respect to IBRA bioregions and sub-bioregions

2.2 Climate

The Study Area is located in the northern section of the Pilbara bioregion, which experiences a semi-arid climate characterised by hot summers and relatively warm, dry winters (Leighton 2004a). Tropical cyclones can occur between January and April, bringing sporadic, drenching rainfall events (Leighton 2004a). For a detailed account of climate in the Pilbara, see Leighton (2004a). The closest Bureau of Meteorology (BoM) weather station to the Study Area is located at Marble Bar (station 004106; previously station 004020), 25 km to the north-east (BOM 2016).

Summer in the Pilbara occurs from November to February when the mean maximum temperature for Marble Bar is 41.5°C and the mean minimum temperature is 25.5°C (**Figure 2-2**). Marble Bar averages 98 days above 40°C per year (Leighton 2004a). Winter occurs from June to August when the mean maximum temperature for Marble Bar is 29.6°C and the mean minimum temperature is 11.7°C (**Figure 2-2**).

Rainfall at Marble Bar occurs mainly in the first half of the year, with a mean average annual rainfall of 357 mm (BOM 2016). Rainfall within the region can be highly localised and unpredictable (Leighton 2004a), with substantial fluctuations occurring from year to year (BOM 2016). Generally, invertebrates in the Pilbara are more active during the wetter times of the year, making the cyclonic period from November to April the optimum period for invertebrate surveys (EPA 2009).

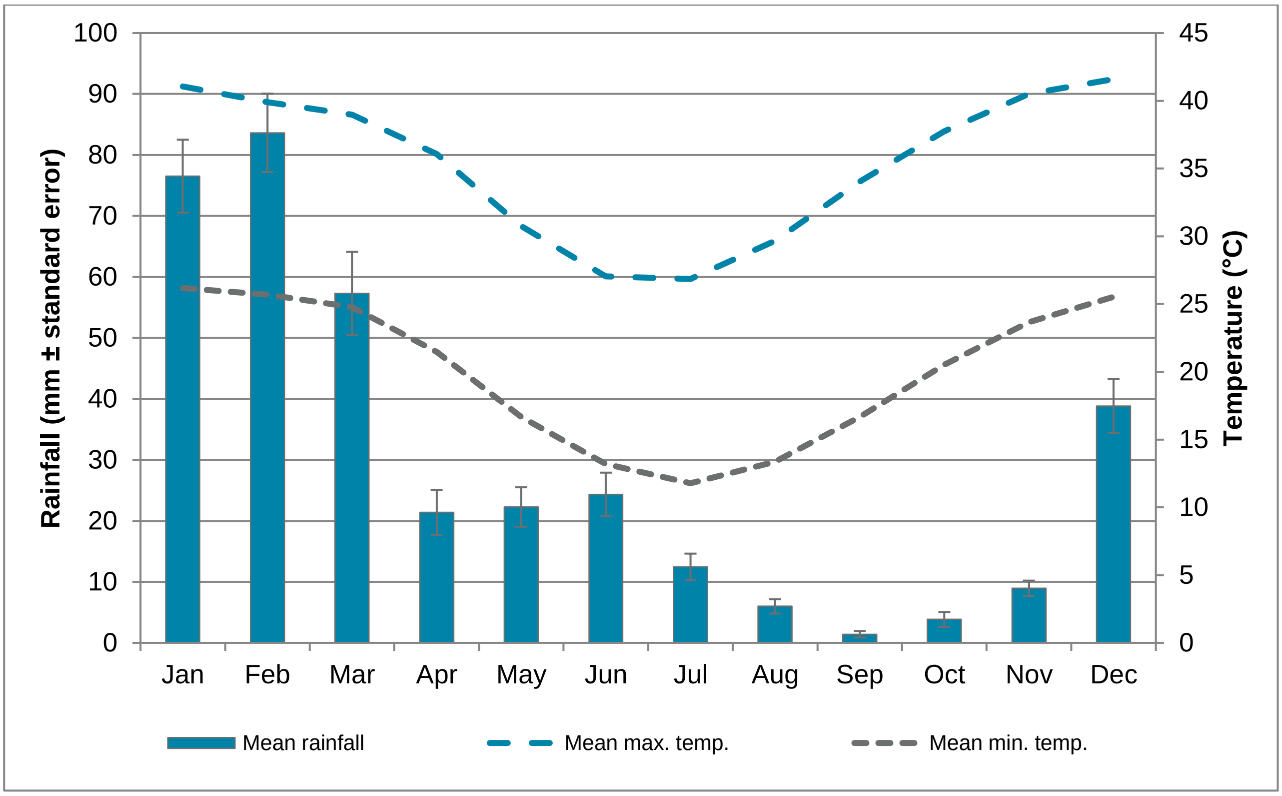

Figure 2-2: Climate data recorded at Marble Bar

Source: (BOM 2016). Data are from stations 004020 and 004106, collected between 1895-2014 for rainfall and 1901-2016 for temperature

2.3 Land Systems

A regional land survey was undertaken in the Pilbara region between 1995 and 1999, by the, then, Department of Agriculture (now the Department of Agriculture and Food) and the then Department of Land Administration (now Landgate). The objective of the survey was to develop a comprehensive description of biophysical resources and assess the vegetation composition and soil condition within the region. This information was used by Van Vreeswyk *et al.* (2004) to classify and map the land systems of the Pilbara region according to landform, soil, vegetation, geology and geomorphology.

In total, eight land systems are mapped across the Study Area (**Table 2-1**; **Figure 2-3**) (van Vreeswyk *et al.* 2004). The Rocklea and Capricorn land systems occupy most (81%) of the Study Area, defined broadly by rolling hills and steep rugged ridges, respectively (**Table 2-1**; **Figure 2-3**). Two land systems occurring within the Study Area are likely to contain habitat suitable for SRE invertebrate taxa, however, both are contiguous with extents that occur outside the Study Area:

- Capricorn: conspicuous ironstone and sandstone ridges may contain cliff faces and gorges which are likely to create mesic micro-habitats within the land systems; and
- Granitic: granite outcrops and tors provide fire refuge and micro-habitats.

Table 2-1: Land systems occurring within the Study Area

Land system	Brief Description	Extent in Study Area	
		Ha	%
Rocklea	Basalt hills, plateaux, lower slopes and minor stony plains supporting hard (and occasionally soft spinifex) grasslands	11,124	59
Capricorn	Hills and ridges of sandstone and dolomite supporting low shrublands or shrubby spinifex grasslands	4,058	22
Talga	Hills and ridges of greenstone and chert and stony plains supporting hard and soft spinifex grasslands	2,191	12
Boolgeeda	Stony lower slopes and plains below hill systems supporting hard and soft spinifex grasslands or mulga shrublands	482	3
Satirist	Stony plains and low rises supporting hard spinifex grasslands, and gilgai plains supporting tussock grasslands	340	2
Granitic	Rugged granitic hills supporting shrubby hard and soft spinifex grasslands	294	2
River	Narrow, seasonally active flood plains and major river channels supporting moderately close, tall shrublands or woodlands of acacias and fringing communities of eucalypts sometimes with tussock grasses or spinifex	293	2
Macroy	Sandy/Stony plains and occasional tor fields based on granite supporting hard and soft spinifex shrubby grasslands	64	0.3
	Total	**18,845**	**100**

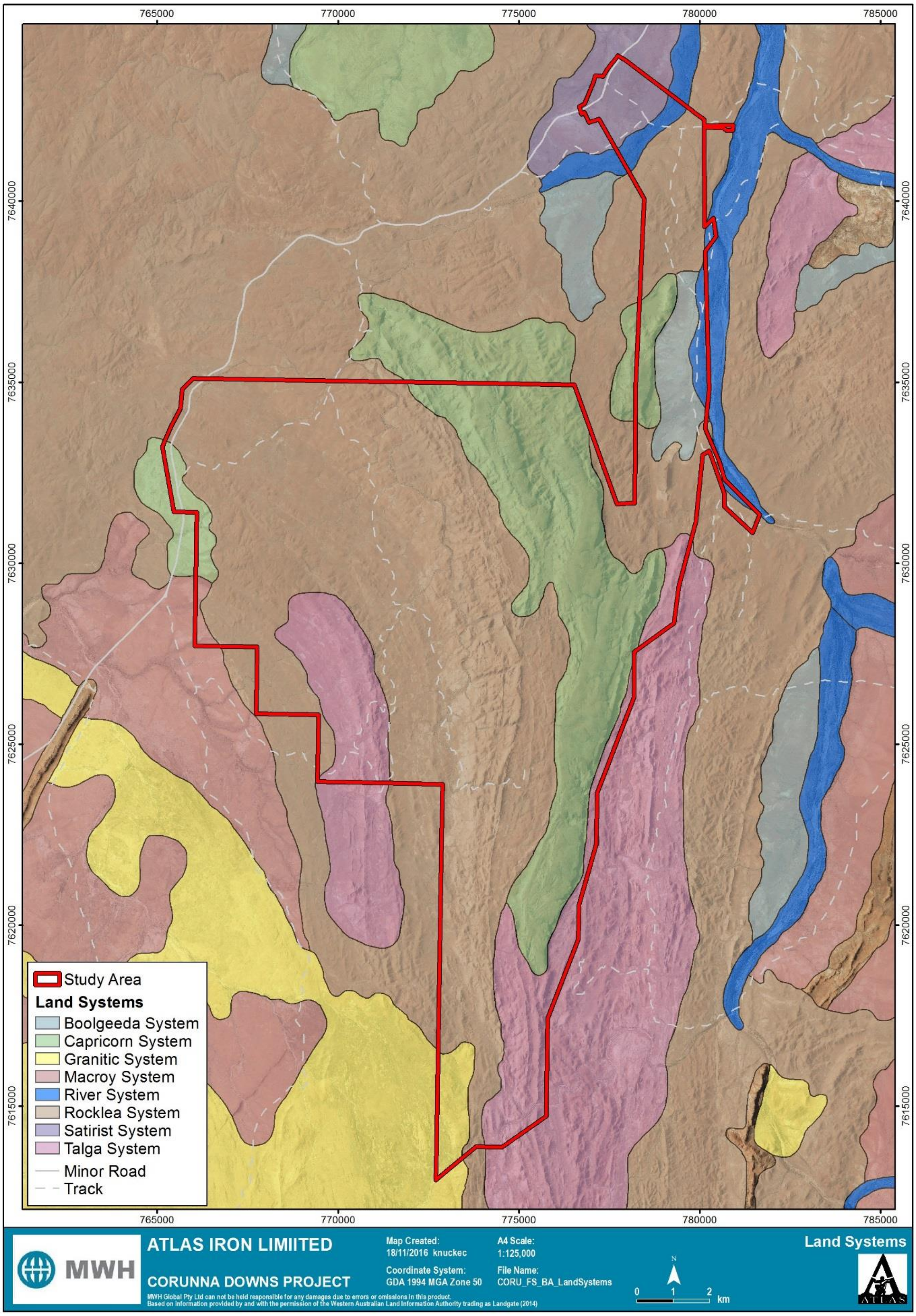

Figure 2-3: Land systems occurring across the Study Area

2.4 Pre-European Vegetation

Vegetation types reflect changes in geology, landform, soil type and hydrology, all of which are likely factors in governing the distribution of SRE taxa (EPA 2009). The Study Area is located within the Fortescue District of the Eremaeum botanical province (Beard 1990). The Fortescue botanical district is characterised by tree (*Eucalyptus* spp. and *Corymbia* spp.) and shrub (*Acacia* spp., *Hakea* spp., *Grevillea* spp. and *Senna* spp.) steppe communities and *Triodia* spp. hummock grasslands (Beard 1990).

The Pilbara region was mapped by Beard (1975) at a scale of 1:1,000,000. These vegetation systems have since been updated by Shepherd *et al*. (2002) to conform to National Vegetation Information System (NVIS) standards (ESCAVI 2003). The Study Area is located within the Abydos Plain and George Ranges (**Table 2-2**, **Figure 2-4**).

Table 2-2: Pre-European Vegetation Association Systems within the Study Area

System	System code	Description	Extent in Study Area	
			Ha	%
Abydos Plain	93	Hummock grasslands, shrub steppe; kanji over soft spinifex	1,026	5
Georges Ranges	82	Hummock grasslands, low tree steppe; snappy gum over *Triodia wiseana*	14,238	76
	587	Mosaic: Hummock grasslands, open low tree-steppe; snappy gum over *Triodia wiseana* / Hummock grasslands, shrub-steppe; kanji over *Triodia pungens*	3,277	17
	619	Medium woodland; river gum (*Eucalyptus camaldulensis*)	305	2
		Total	**18,845**	**100**

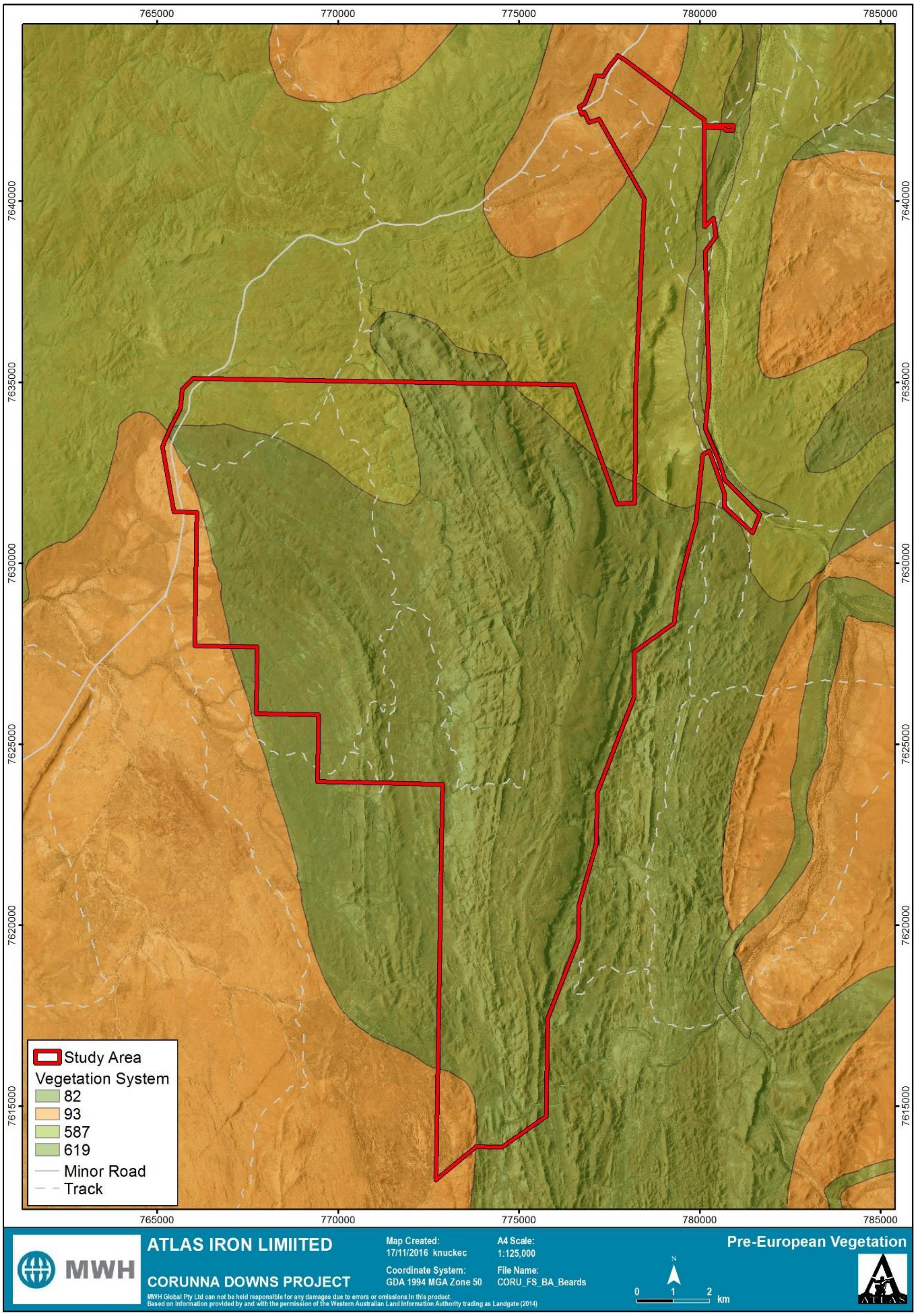

Figure 2-4: Pre-European vegetation associations occurring across the Study Area

2.5 Land Use

Land tenure in the Pilbara consists primarily of pastoral leases, with other crown reserves, such as Aboriginal reserves, and leasehold reserves (McKenzie *et al.* 2003). National parks and reserves, and unallocated crown land are the other major land use categories present in the region (McKenzie *et al.* 2003). In the Chichester subregion, the dominant land uses are pastoralism (i.e. grazing of native pasture by cattle), Aboriginal lands and reserves, vacant crown land and crown reserves, conservation, and mining (Kendrick and McKenzie 2001). The Chichester subregion has 6.6% of its land surface reserved under some form of conservation tenure, including the Abydos-Woodstock reserve (60 km west of the Study Area), Millstream-Chichester National Park (190 km west), Mungaroona Range Nature Reserve (116k m south-west) and Meentheena ex-pastoral lease (54 km east) (Kendrick and McKenzie 2001).

The majority of the Study Area lies within the Panorama (90%) and Eginbah Pastoral Stations (1%) and the remaining (9%) comprises Unallocated Crown Land (**Figure 2-5**). Evidence of pastoral activity is widespread in the Study Area, with cattle frequently observed, land degradation around water holes and drainage lines apparent and introduced pasture grasses such as Buffel Grass (*Cenchrus ciliaris*) being present in a number of habitat types.

The first mining exploration in the Pilbara commenced in the early 1800s, and currently this area provides the majority of Western Australia's petroleum, gas and iron ore exports, (RDA 2013). Historically, mining activity has been highly active in the vicinity of the Study Area. The Study Area, particularly in the western portion, possess a legacy of tracks, clearings, small mining camps and abandoned shafts associated with mining and exploration activities having degraded the fauna habitat locally (**Figure 2-5**).

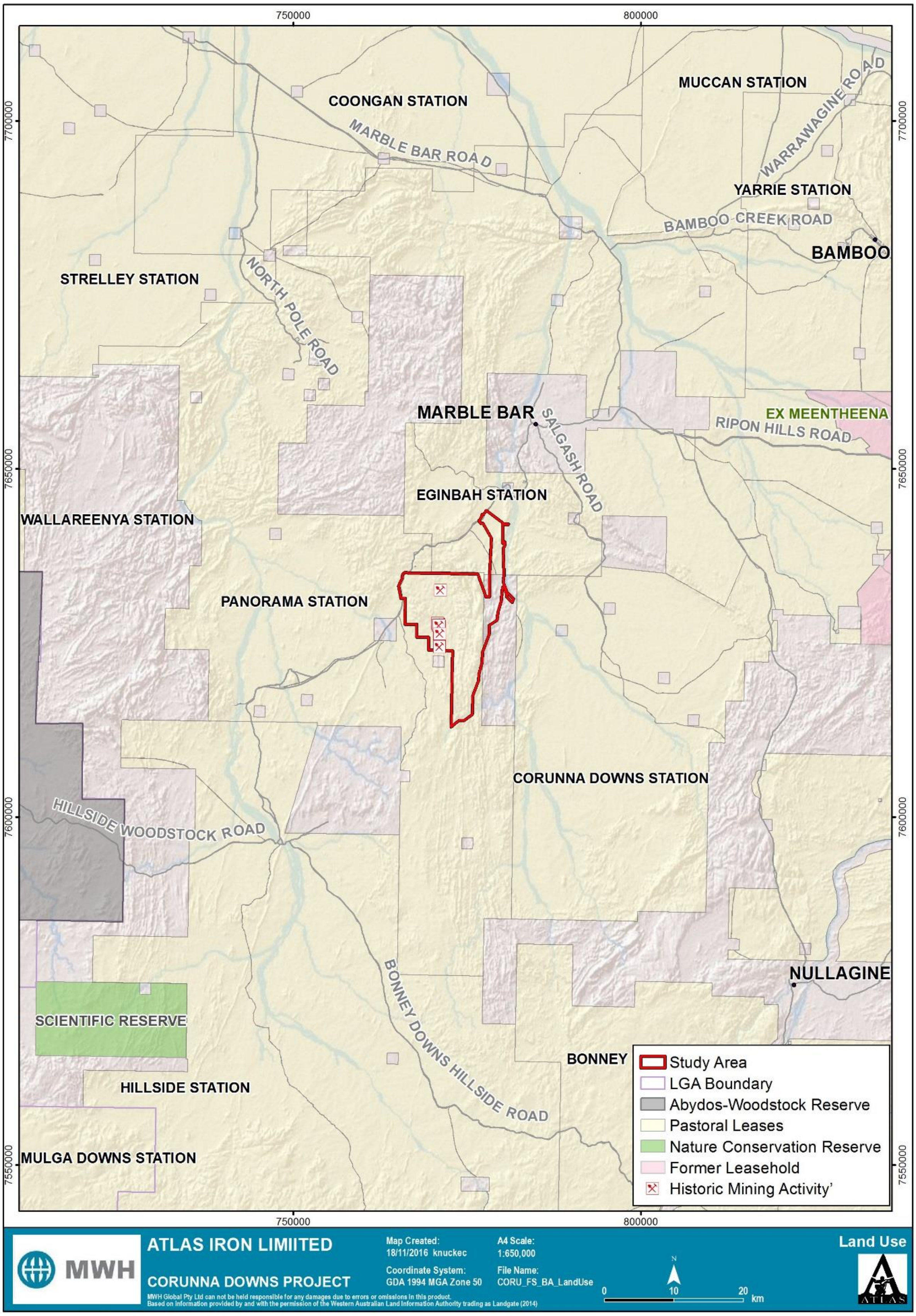

Figure 2-5: Land use in the Study Area and surrounds

3 Desktop Study

A search of relevant databases and a literature review was undertaken prior to the field surveys in order to:

- identify whether any SRE species have been previously collected within the Study Area or have potential to occur;
- determine the SRE taxa and SRE species groups that have been previously collected in the region;
- facilitate the identification of SRE habitat within the region and the Study Area; and
- assist with the assessment of the conservation significance of the invertebrate species collected during the survey by placing them in the context of regional collection records.

This information was used to refine appropriate survey methods to be applied during the survey.

3.1 Database Searches

The following databases were searched for SRE and conservation significant invertebrate collection records using a central co-ordinate of 772687 mE and 7627386 mN (GDA94, UTM 50K; **Table 3-1**). Search buffers differed due to the technical capabilities of individual databases, as well as features surrounding the Study Area relevant to different species groups.

Table 3-1: Databases searched

Database	Custodian	Date obtained	Search area buffer (km)
Arachnid and Diplopod Database	(Western Australian Museum 2014a)	8/04/2014	square 300 x 300 km
Terrestrial Mollusc Database	(Western Australian Museum 2014b)	20/01/2014	square 300 x 300 km
Threatened and Priority Fauna Database	(DPaW 2016b)	21/10/2016	50
NatureMap	(DPaW 2016a)	11/10/2016	40
Protected Matters Search Tool	(DoE 2016)	11/10/2016	40

It should be noted that the WAM is no longer able to conduct SRE specific database searches. Consequently results from database searches presented here are from the database search of the Study Area conducted in 2014. Additionally, SRE specific database searches are not available for SRE Isopods (slaters).

3.2 Literature Review

The literature review considered ten previous SRE invertebrate fauna surveys conducted in the vicinity of the Study Area (**Table 3-2**, **Figure 3-1**). Each of these studies involved detailed SRE fauna field surveys, the results of which are presented in in **Section 3.3** and provide context to the results of this study.

Table 3-2: Previous Surveys Conducted within the Vicinity of the Study Area

Reference		Survey Details	Proximity to Survey Area*	Methods	Habitats	Number of invertebrates recorded	Number of SRE invertebrates recorded*	Comments
A	Outback Ecology (2014)	Project: McPhee Creek Mine and Rail Project: SRE Invertebrate Fauna Survey Client: Atlas Iron Limited Survey type: Level 1 Targeted SRE Survey Survey date: February 2014	35 km south	• Targeted searching • Leaf litter collection • Soil sieving	• Spinifex sandplain • Granite uplands • Rocky Foothills • Acacia, spinifex on sandplain • Spinifex stony plain • Stony rise • Drainage line • Hard spinifex on calcrete • Riverine • Granite outcrop • Dolerite ridge • Rocky ridge and gorge • Disturbance • Riverine shrubland • Sandstone ridge top.	117 invertebrate specimens from 20 identifiable species.	Five potential SRE species; • Buddelundia '11' • *Karaops* 'sp. indet' • *Synsphyronus* ''7/3 short' • *Buddelundia* '86'	Species recorded at the East-west Transport Corridor have potential to occur in the Application Area because many of the habitats that have a high potential to support SRE taxa are well connected between the Application Areas.
B	Outback Ecology (2013a)	Project: Abydos Iron Ore Project Client: Atlas Iron Limited Survey type: Level 2 Survey and EIA Survey date: March – July 2010	60 km north-west	• Wet pitfall trapping • Targeted searching • Leaf litter collection • Soil sieving	• Rocky ridge and gorge • Riverine • Drainage depression • Ridge top • Drainage line • Spinifex sand plain • Spinifex stony plain	1,453 invertebrate specimens from 43 identifiable species	Six potential SRE species: • *Aops* 'pilbara 2' • *Tyrannochthonius* 'near aridus' • *Buddelundia* 'sp. 11' • *Buddelundia* 'sp. 18' • 'Gen. nov.' sp. nov.' (snail) • *Antichiropus* 'DIP005'	Habitat is typical of the Pilbara region and represents that found within the Application Area. However, species recorded at the Abydos Project are unlikely to occur in the Application Area due to the distance between the projects and a lack of connectivity between habitats likely to support SRE taxa.
C	Outback Ecology (2012b)	Project: Mt Webber Iron Ore Project Client: Atlas Iron Limited Survey type: Level 2 Survey and EIA Survey date: March 2010 – March 2012	45 km south-west	• Wet pitfall trapping • Targeted searching • Leaf litter collection • Soil sieving	• Rocky foothills • Rocky ridge and gorge • Stony rise • Granite uplands • Spinifex stony plain • Acacia, spinifex sandplain • Spinifex sandplain • Riverine • Drainage line • Uplands drainage • Hard spinifex on calcrete • Granite outcrop • Riverine shrubland	1,189 invertebrate specimens from 25 identifiable species.	Eight potential SRE species; • *Kwonkan* `MYG200`; • *Karaops* 'Mt Webber' • *Karaops* 'SEL001' • Karaops 'SEL002' • *Buddelundia* sp. 'nov. 11' • *Buddelundia* sp. 'nov. 18' • 'Gen. nov.' 'sp. nov. B' (slater) • *Quistrachia turneri*	Habitat is typical of the Pilbara region and represents that found within the Application Area. However, species recorded at the Mt Webber Project are unlikely to occur in the Application Area due to the distance between the projects and a lack of connectivity between habitats likely to support SRE taxa.
D	Outback Ecology (2010a)	Project: Turner River Hub Project: Southern Haul Road Client: Atlas Iron Limited Survey type: Level 2 Survey Survey date: March – May 2010	50 km West	• Wet pitfall trapping • Targeted searching • Leaf litter collection • Soil sieving	A number of habitats were identified in the Project due to the extensive survey area. Of these six were of significance to SRE invertebrate fauna; • Granite outcrop • Rocky ridge and gorge • Riverine • Drainage depression • Drainage lines • Calcrete breakaway	4,863 invertebrate specimens from 62 identifiable species.	Eight potential SRE species; • *Aname* 'MYG208' • *Aname* 'MYG209' • *Karaops*' sp. 'Wodgina' • *Karaops* 'sp. Mt Webber' • *Urodacus* 'pilbara 13' • *Barrowdillo* 'sp. nov. 2' • *Buddelundia* 'sp. 11' • *Laevophiloscia* sp.	Habitat is typical of the Pilbara region and represents that found within the Application Area. However, species recorded at the Turner River Project are unlikely to occur in the Application Area due to the distance between the projects and a lack of connectivity between habitats likely to support SRE taxa
E	ecologia (2011)	Project: Mt Webber Iron Ore Project Client: Giralia Resources Survey type: Level 2 Survey Survey date: March 2010	50 km west	• Wet pitfall trapping • Targeted searching • Leaf litter collection • Soil sieving	Habitat was not assessed in this report.	371 invertebrate specimens from 19 identifiable species	Four potential SRE species; • *Aname* 'MYG001' • *Kwonkan* 'MYG002' • *Synothele* sp. • *Buddelundia* 'sp. 11'	Habitat is typical of the Pilbara region and represents that found within the Application Area. However, species recorded at the Mt Webber Project are unlikely to occur in the Application Area due to the distance between the projects and a lack of connectivity between habitats likely to support SRE taxa.

Reference		Survey Details	Proximity to Survey Area*	Methods	Habitats	Number of invertebrates recorded	Number of SRE invertebrates recorded*	Comments
F	Outback Ecology (2012d)	Project: Turner River Hub Project Southern Haul Road Realignment Client: Atlas Iron Limited Survey type: Level 2 Survey Survey date: March – May 2011	70 km West	• Wet pitfall trapping • Targeted searching • Leaf litter collection • Soil sieving	• Rocky foothills • Rocky ridge • Stony rise • Granite outcrop • Spinifex stony plain • Spinifex sandplain • Riverine • Drainage line • Drainage depression • Clay depression	281 invertebrate specimens from 31 identifiable species	Five potential SRE species; • *Karaops* sp. • *Feaella* 'PSE017' • *Buddelundia* sp. 'nov. 11' • *Buddelundia* sp. 'nov. 20' • Gen. nov.' 'sp. nov. B' (slater)	Habitat is typical of the Pilbara region and represents that found within the Application Area. However, species recorded at the Southern Haul Deviation Project are unlikely to occur in the Application Area due to the distance between the projects and a lack of connectivity between habitats likely to support SRE taxa.
G	Outback Ecology (2012e)	Project: McPhee Creek Iron Ore Project Client: Atlas Iron Limited Survey type: Level 2 Survey Survey date: February – March 2012	55 km Southeast	• Wet pitfall trapping • Targeted searching • Leaf litter collection • Soil sieving	• Rocky foothills • Spinifex stony plain • Rocky ridge and gorge • Sandstone ridge • Ironstone ridge • Drainage line • Calcrete plain • Channel iron deposit	380 invertebrate specimens from 21 identifiable species.	Six potential SRE species; • *Beierolpium* 'sp. 8/4 lge' • Genus '7/4 sp. nov' • *Xenolpium* `PSE063' • *Antichiropus* 'DIP026'' • *Buddelundia* 'sp. 11' • *Buddelundia* 'sp. 18'	Habitat is typical of the Pilbara region and represents that found within the Application Area. However, species recorded at the McPhee Creek Project are unlikely to occur in the Application Area due to the distance between the projects and a lack of connectivity between habitats likely to support SRE taxa.
H	Outback Ecology (2010b)	Project: Sulphur Springs Copper - Zinc Project Client: Venturex Resources Limited Survey type: Targeted survey and EIA Survey date: January 2010	55 km Northwest	• Targeted searching • Leaf litter collection • Soil sieving	Only drainage features were assessed. Five drainage features were identified; • Gorge • Creek Line • Riverine • Drainage Line • Floodplain	153 invertebrate specimens from 13 identifiable species	Four potential SRE species: • *Antichiropus* 'DIP005' • *Antichiropus* 'DIP034' • *Buddelundia* 'sp. 11' • *Feaella* 'PSE007.	Habitat is typical of the Pilbara region and represents that found within the Application Area. However, species recorded at Spinifex Ridge Project are unlikely to occur in the Application Area due to the distance between the projects and a lack of connectivity between habitats likely to support SRE taxa.
I	ecologia (2012)	Project: North Star Project Client: Fortescue Metals Group Survey type: Level 2 Survey and EIA Survey date: March 2012	75 km Northwest	• Wet pitfall trapping • Targeted searching • Leaf litter collection	Habitats were not assessed in this report.	450 invertebrate specimens from 31 identifiable species	Four potential SRE species: • *Buddelundia* 'sp. 11' • *Buddelundia* 'sp. 18' • *Succinea* sp. • *Antichiropus* sp.	Habitat is typical of the Pilbara region and represents that found within the Application Area. However, species recorded at the North Star Project are unlikely to occur in the Application Area due to the distance between the projects and a lack of connectivity between habitats likely to support SRE taxa.

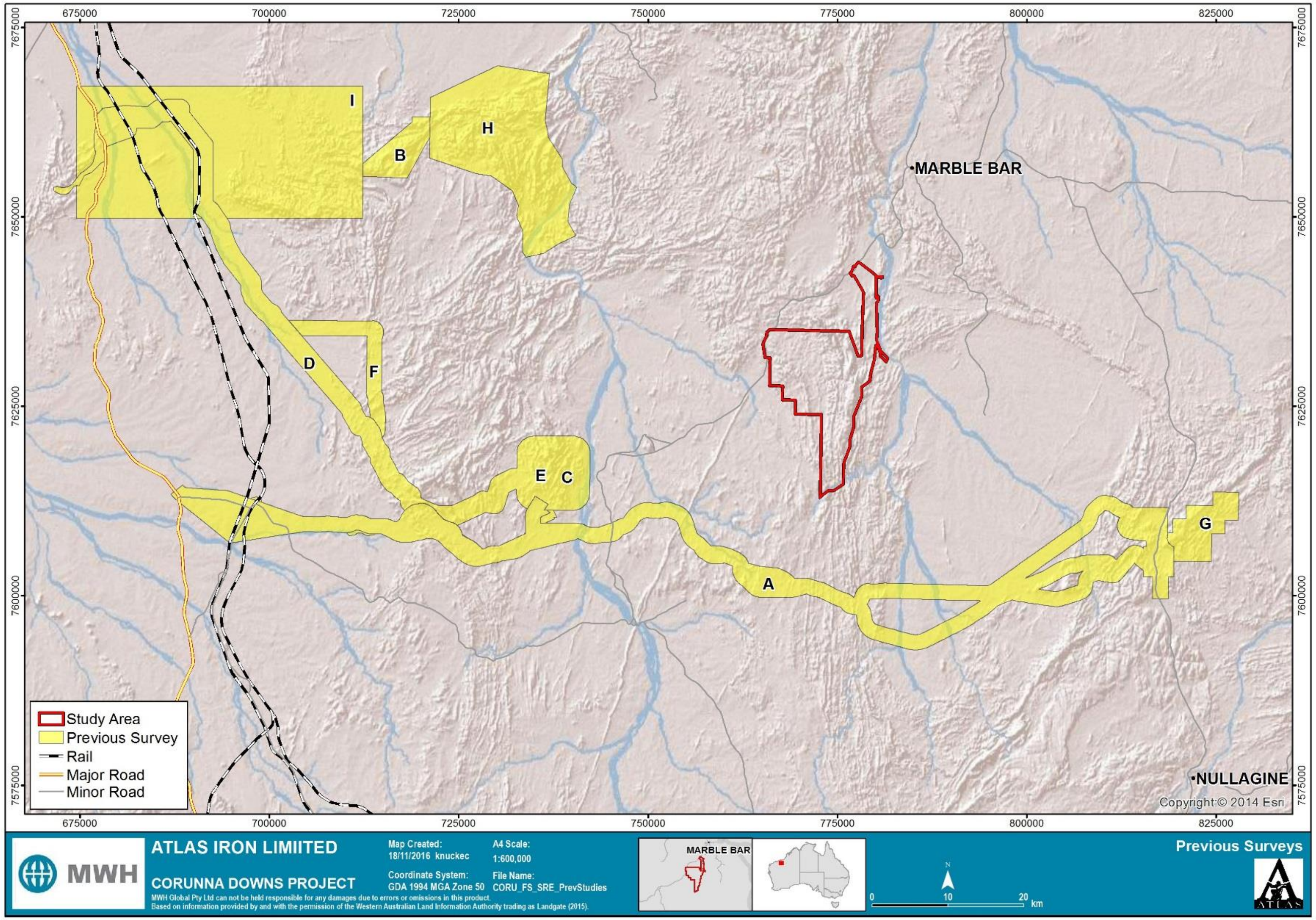

Figure 3-1: Previous Surveys Conducted within the Vicinity of the Study Area

3.3 Desktop Study Results

Database searches and a literature review yielded a total of 48 terrestrial SRE invertebrate species from target groups that have been collected within a 100 km radius of the Study Area. Only specimens identified to species or morphospecies are presented in this section, as it is not possible to determine species distribution based on genus only.

These species were ranked as having a high, medium or low potential to occur in the Study Area depending on the availability of habitat and the proximity of the collection record in relation to the Study Area. Of the 48 species identified in the desktop study, one species, *Antichiropus* `DIP038', was considered to have a high potential of occurring in the Study Area as it has been collected within 10 km of the Study Area and was collected from similar habitat as what occurs in the Study Area (**Table 3-3**; **Figure 3-2**). A further three species were considered to have a medium potential of occurring in the Study Area as they have previously been recorded within 10 km and 30 km from the Study Area and within similar habitats as what occurs in the Study Area (**Table 3-3**; **Figure 3-2**). The remaining 46 species had low potential to occur in the Study Area and are listed in **Appendix A**. No existing specimens have previously been collected from within the Study Area. Even if these species were found to occur within the Development Envelope for this Project, the presence of regional records suggests that the Project is unlikely to affect the long term survival of the species.

Table 3-3: Records of SRE invertebrates returned by the database searches and literature review

Species Name	Taxa	Source	Reference	Habitat(s)	Likelihood of occurrence in the Study Area	Reason for Likelihood	
						Habitat present in Study Area	Closest record to Study Area
Antichiropus \`DIP038\`	Millipede	WA Museum	(Western Australian Museum 2014a)	Drainage line	High	Yes	1 km west
Antichiropus \`DIP034\`	Millipede	WA Museum	(Western Australian Museum 2014a)	Urban (natural habitat unknown)	Medium	Possible	23 km northeast
Buddelundia sp. 11	Slater	McPhee Creek Mine and Rail Project: East-west Transport Corridor	(Outback Ecology 2014)	Rocky Ridge and Gorge, Granite Outcrop, Rocky Foothills, Drainage Line, Channel Iron Deposit, Stony Rise, Spinifex Stony Plain	Medium	Yes	15 km south
		McPhee Creek Iron Ore Project	(Outback Ecology 2012e)				
		Mt Webber DSO Project	(Outback Ecology 2012b)				
		Abydos DSO Project	(Outback Ecology 2013a)				
Rhagada richardsonii	Snail	WA Museum	(Western Australian Museum 2014b)	Rocky ridge and gorge	Medium	Yes	20 km east

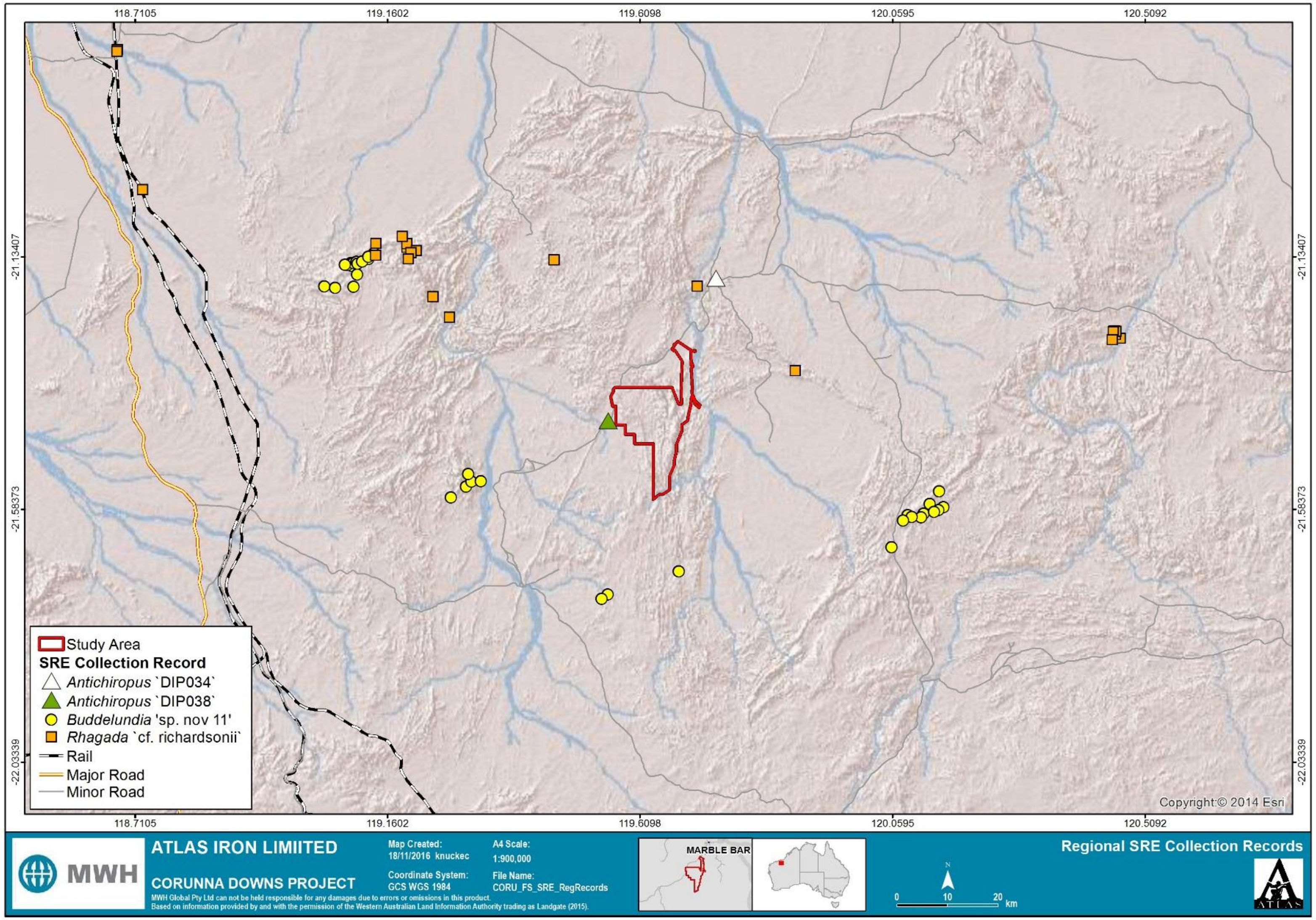

Figure 3-2: SRE invertebrates identified from the desktop study with a medium to high potential to occur in the Study Area

4 Terrestrial SRE Invertebrate Fauna Field Survey

This Assessment is based on the findings of a desktop study and a trapping survey within habitats with potential to support SRE taxa, hereon referred to as the SRE trapping survey. Additionally, the collection of specimens was supplemented by dry pitfall trapping in broad fauna habitats during two fauna trapping surveys; hereon referred to as the Phase 1 and Phase 2 fauna surveys, respectively. Additionally, during the Phase 2 fauna survey, targeted search effort for SRE taxa was incorporated into the survey design to supplement the existing SRE survey effort within the Study Area.

The SRE survey was undertaken between 12th and 19th March 2014, with wet pitfall traps open until the 19th May 2014. The Phase 1 fauna survey was undertaken between 24th February and 7th March 2014 and the Phase 2 fauna survey was undertaken between 22nd September and 5th October 2016 (MWH 2016a). For local and regional context, this report also presents a summary of results from previous terrestrial SRE invertebrate fauna surveys that have been conducted in the region surrounding the Study Area.

4.1 Field Survey Timing and Weather

The SRE trapping survey was conducted between 12th March and 19th May 2014. Wet pitfall traps were deployed, habitat assessments conducted and soil and leaf litter were collected between 12th March and 19th March 2014. Wet pitfall traps were collected between the 16th May and 19th May 2014. The Phase 1 fauna survey was conducted between 24th February and 7th March 2014. The Phase 2 fauna survey was undertaken between 22nd September and 5th October 2016.

The records from the Marble Bar weather station were considered when assessing the weather conditions over the survey periods (see **Section 2.2**). During the SRE trapping survey, the daily maximum temperatures recorded at the Marble Bar ranged between 24.8 ºC and 43.2 ºC, with minimum temperatures ranging between 15.7 ºC and 28.5 ºC. A mean maximum and minimum temperature of 25.7 ºC and 39.7 ºC at Marble Bar was recorded over the survey period which is similar to the long term average of the region (BOM 2016).

In the six weeks prior to the survey, 111.6 mm of rain was recorded at the Marble Bar Weather Station which is in line with the long term average for the same period (BOM 2016)(**Figure 4-1**). However, during the eight week survey period when wet pitfall traps were open, only 8.2 mm of rainfall was experienced over a total of four rain days, which is well below the long-term average for the period (BOM 2016). No rainfall occurred during the Phase 1 fauna survey and a total of 8.8mm was recorded during the Phase 2 fauna survey (BOM 2016).

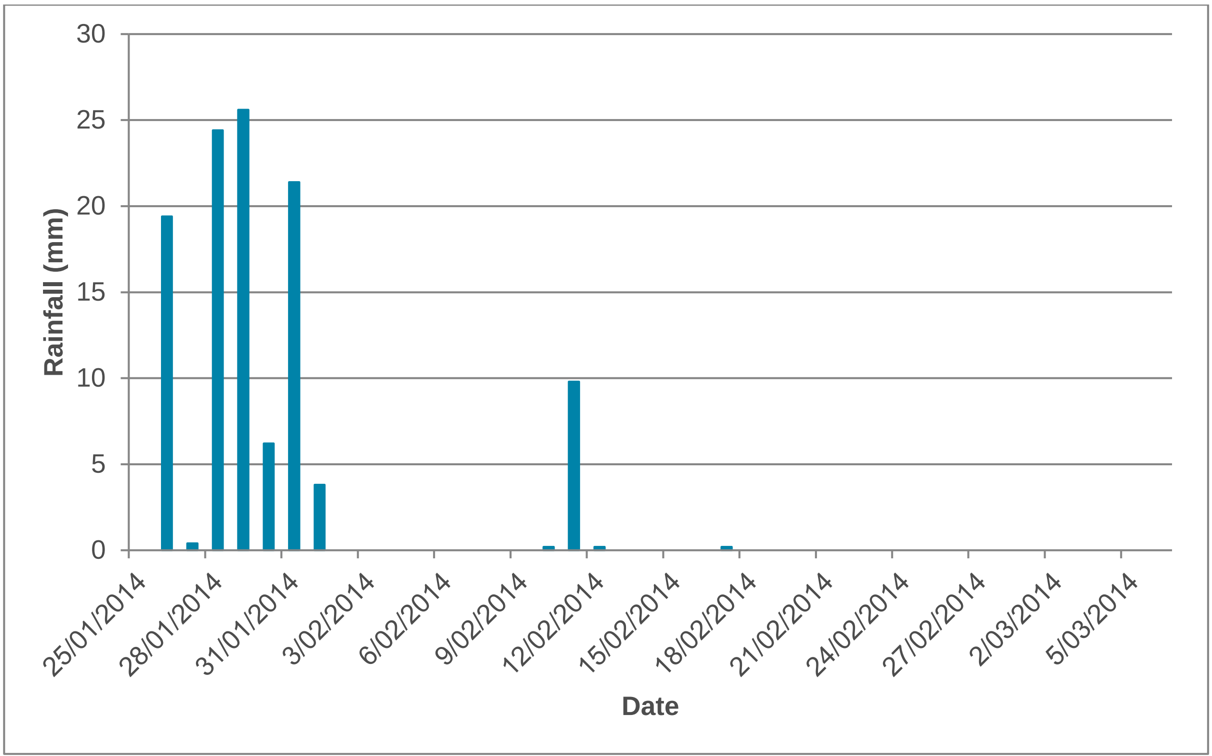

Figure 4-1: Rainfall Recorded Six Weeks Prior to the Survey

Source: BOM (2016). Rainfall data are from station 00410

4.2 Survey Sites

Prior to the survey, a set of prospective survey sites were selected via a desktop analysis of aerial imagery and after a reconnaissance survey of the Study Area (Outback Ecology 2013b). These sites were then ground-truthed in the field and the optimal sites selected based on the potential for those habitats to support SRE taxa and vehicle accessibility at the time of survey.

A total of 13 systematic survey sites were established during the survey (**Figure 4-2, Appendix B**). Invertebrate collection methods employed at these sites included wet pitfall trapping, targeted searching, soil sieving and litter collection, for use in Tullgren funnels (**Section 4.4.4**). Targeted searching was also undertaken at an additional six sites (TAR 1-6) to gain improved geographical coverage during the survey. Site descriptions for each systematic and targeted survey site are presented in **Appendix C**. Additionally, specimens from SRE taxa were collected during the Phase 1 and Phase 2 vertebrate fauna surveys of the broad habitats that occur in the Study Area (MWH 2016a) (**Figure 4-2,**). The vertebrate fauna traps were open for seven nights. Additionally, targeted searches for SRE taxa was undertaken during the Phase 2 vertebrate fauna survey (**Figure 4-2**).

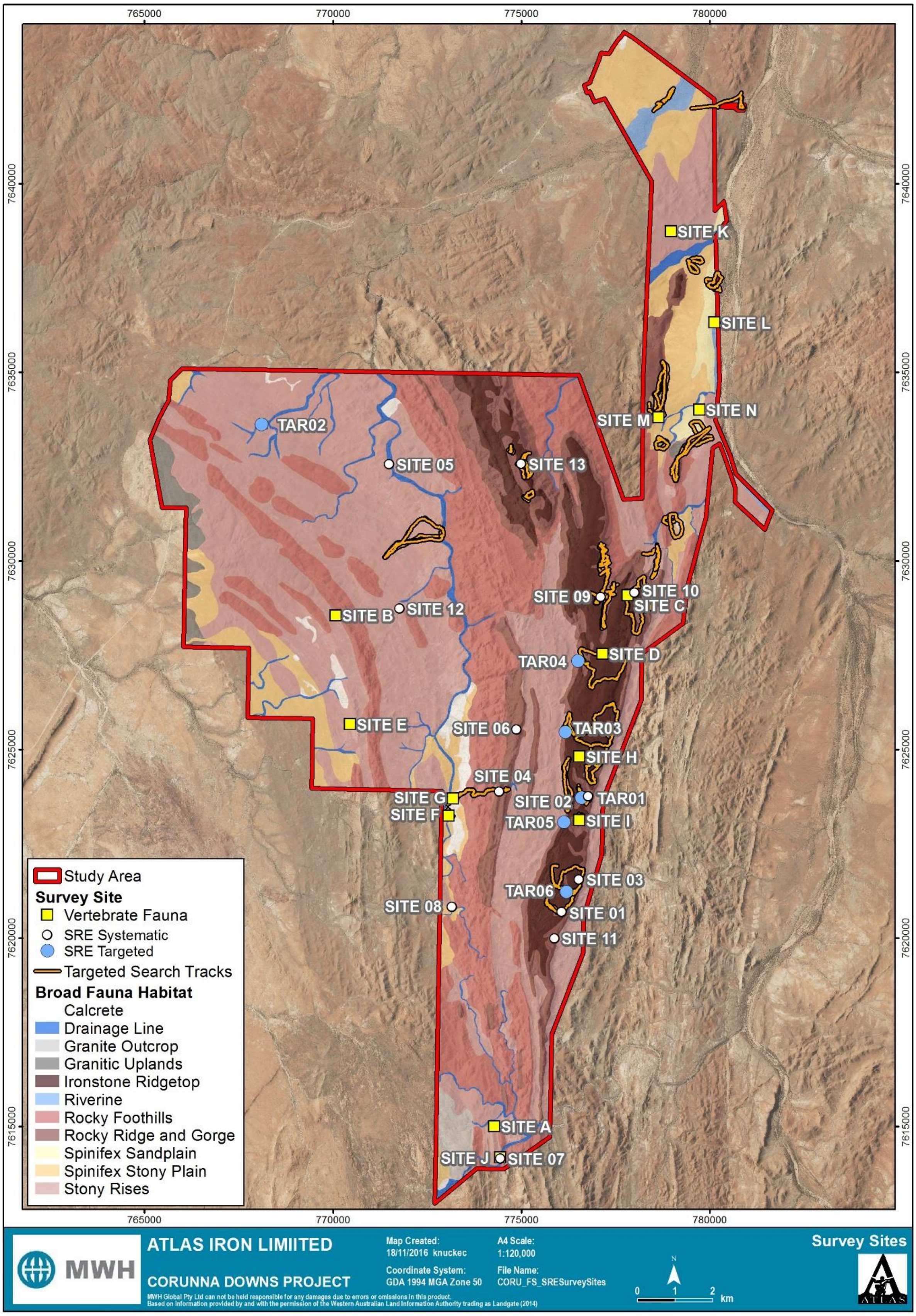

Figure 4-2: Location of systematic and targeted survey sites sampled during the survey

4.3 Habitat Assessment

Habitat assessments form an important part of terrestrial SRE invertebrate fauna surveys. This is because a risk based approach that uses habitat as a surrogate to infer a species distribution may be required in situations where SRE species are only recorded from planned impact areas. A risk based approach will be considered by the EPA (2009) under the following conditions:

- a potential SRE taxon is represented by one or few specimens from only within proposed development areas;
- contextual data on the wider distribution and status of the taxon is unavailable from the WAM or the DPaW; and
- additional targeted surveys appear unlikely to yield results in a reasonable timeframe.

Habitats with potential to support SRE fauna within the Study Area were identified and assessed in terms of complexity, quality, connectivity, landscape position, outcropping, soil type, broad vegetation type, litter cover, existing disturbance, extensiveness and physical connectivity within the landscape. These assessments were conducted at each of the ten targeted SRE survey sites over an area of approximately 50 m x 50 m. Additionally, habitat assessments were conducted at each of the fourteen survey sites associated with vertebrate fauna pitfall trapping.

There are no prescriptive guidelines for identifying habitats with the potential to support SRE fauna, although the most prospective habitats tend to be those that are sheltered, isolated or both (EPA 2009, Harvey 2002). Many SRE species are associated with sheltered environments that are pockets of relictual habitat (Harvey 2002). In the Pilbara, sheltered habitats and microhabitats include: deep gorges, ridges and slopes with southeast facing aspects, riparian vegetation along drainage systems and fire refuge areas. Isolated habitats are more likely to support SREs in comparison to extensive swathes of contiguous habitat that enable species to have broader distributions. Habitat isolates in the Pilbara include individual *Ficus* trees, mountains, outcrops and mesas surrounded by plains (EPA 2009). Information resulting from the habitat assessment of the Study Area has been incorporated into the descriptions of each broad habitat and used to create habitat mapping (**Section 5.1**). Habitats were categorised as having a high, medium or low potential to support terrestrial SRE taxa based on the presence of microhabitats, whether the habitat was restricted or widespread in the landscape, and whether the habitat formed isolates or was well connected in the landscape

4.4 Collection Techniques

The techniques used for collecting SRE taxa during the surveys included: wet pitfall trapping: targeted searches, habitat assessments and soil and leaf litter collection (**Table 4-1**). These techniques are aligned with the EPA (2009) specifications and endorsed by invertebrate SRE specialists of the WAM and DPaW. Supplementary sample methods used during the Phase 1 and Phase 2 vertebrate fauna surveys included: dry pitfall traps, funnel traps, and a habitat assessment at each trapping site (MWH 2016a).

Table 4-1: Summary SRE sampling methods and effort for the invertebrate fauna survey

Sampling technique	Sampling effort per site	Total effort
Targeted searching (systematic)	3 hours per site (13 systematic sites)	39 hours
Targeted searching (targeted)	2 hours per site (6 targeted sites)	12 hours
Litter collection	3 samples per site (13 sites)	39 samples
Soil sieving	3 samples per site (13 sites)	39 samples
Wet pitfall trapping	5 traps per site (13 sites) (over 68 nights)	4,420 trap nights
Dry pitfall trapping (Phase 1)	10 traps per site (10 sites) (over seven nights)	700 trap nights
Funnel trapping (Phase 1)	20 traps per site (10 sites) (over seven nights)	1,400 trap nights
Dry pitfall trapping (Phase 2)	10 traps per site (10 sites) (over seven nights)	700 trap nights
Funnel trapping (Phase 2)	10 traps per site (10 sites) (over seven nights)	700 trap nights

4.4.1 Targeted Searching

Three person hours of targeted searching was conducted at each systematic survey site, and two person hours was expended at each SRE targeted site (**Table 4-1**). Additionally 125 person hours of targeted searching was expended during the Phase 2 vertebrate fauna survey which included searches for SRE taxa. Targeted searches focused on microhabitats that occurred within broader habitat types that had potential to support SRE taxa. These microhabitats included areas of: leaf litter, beneath logs, bark and rocks, crevices, at the bases of shrubs and trees and beneath spinifex hummocks. Where leaf litter accumulates in large areas, it was passed through a 0.1-1.0 cm fraction sieve to remove course material and then inspected for small invertebrate taxa, such as pseudoscorpions, millipedes, snails and scorpions. Burrows suspected to be those of mygalomorph spiders or scorpions were excavated and occupants were collected.

4.4.2 Wet Pitfall Trapping

Wet pitfall trapping for terrestrial SRE taxa is a more effective sampling method than dry pitfall trapping due to the longer trapping period. The longer trapping period increases the probability of trapping species that are active only briefly or sporadically, such as those that become active during periods of rainfall. Each of the 13 systematic sites consisted of five wet pitfall traps left open for 68 nights, equating to a total trapping effort of 4,420 trap nights (**Table 4-1**).

Each wet pitfall trap comprised a plastic container that slots into a buried cylindrical PVC pipe (100 mm x 250 mm). Care was taken to ensure that the top of the container was flush with the top of the PVC pipe and the ground surface. The container was filled with approximately 500 millilitres (ml) of a preserving agent (100% propylene glycol) and a cover was suspended approximately 20 mm above the trap to reduce vertebrate by-catch and to limit rain entering the trap. To increase the effectiveness of the pitfall trap, two drift fences (flywire mesh) measuring approximately 75 centimetres (cm) in length and 15 cm in height were set on each side of the trap, with the base of the fence buried into the ground. Traps were placed at 5 to10 metre (m) intervals where possible.

Upon the completion of the field survey, wet pitfall traps were removed, all holes back-filled and containers collected and sent back to the MWH laboratory. The contents of wet pitfall traps were examined using a dissecting microscope in the MWH laboratory before being sorted and sent to the corresponding specialists for taxonomic identification.

4.4.3 Dry Pitfall and Funnel Trapping

Dry Pitfall trapping and funnel trapping was conducted as part of a standard trapping grid at ten sites across the Study Area in Phase 1 and across ten sites in Phase 2 (MWH 2016a). Each trapping grid consisted of two drift fences, which were 40 cm high and 50 metres long, set into the substrate. Two types of pit trap were installed along the drift fences: five standard 20 litre (L) PVC buckets and five PVC pipe traps 15 cm in diameter and 50 cm deep. The pit traps were set flush with the surface of the ground, with the drift fence running across the middle. All traps were left open overnight and checked early the following morning, for seven consecutive nights. The total dry pitfall trapping effort for the Phase 1 and Phase 2 fauna survey totaled 1,400 trap nights and the total funnel trapping effort for the Phase 1 and Phase 2 fauna survey totaled 2,800 trap nights. All specimens from SRE invertebrate groups collected in these dry pitfall traps have been included in this Assessment.

4.4.4 Soil Sieving and Leaf Litter Collection

Three samples of concentrated leaf litter and soil, where available, were collected from each targeted SRE survey site, with a total of 30 samples taken during the survey. The samples were collected by scraping back the top layer of litter to reveal the layer of decomposition above the soil (where present). Leaf litter along with the top layer of soil was passed through a two layered sieve with openings of four mm and ten mm. Material that passed through the four millimetre layer was searched in the field for pseudoscorpions, slaters, snails and millipedes. The remaining concentrated litter sample (material collected from between the four mm and ten mm particle size) was sealed in plastic bags, kept cool and subsequently transported to the MWH laboratory.

Tullgren funnels were used to extract invertebrates from the concentrated litter samples. Tullgren funnels use light and heat to create a temperature gradient over the leaf little sample, where the top has a higher temperature than the bottom of the sample. Invertebrates that occur within the sample move away from the higher temperature, where eventually they exit the funnel and fall into a container of 100 % ethanol. Invertebrate groups targeted using this method include pseudoscorpions, slaters and millipedes. Samples were left in the Tullgren funnels for at least 72 hours. After this time, the collection containers beneath the Tullgren funnels were examined for invertebrates using a binocular microscope. The material remaining in the funnels was searched for large invertebrates such as snails, scorpions and spiders using x2 magnification.

4.4.5 Specimen Preservation

All specimens were preserved in a way that allowed genetic analysis if required (Western Australian Museum 2014c). Large mygalomorph spiders and scorpions were placed in 75% ethanol, after their third left leg had been removed and stored in 100 % ethanol. Pseudoscorpions and slater specimens were stored in 100% ethanol. Active live land snails had a sample taken from the rear of the foot and stored in 100% ethanol. The specimen was then drowned in freshwater for up to one hour which caused them to become extruded from their shell to assist with morphological identification. Once dead, the specimen was stored in 75% ethanol. Dormant snails could usually be made active by initiating the drowning process. The mollusc department of the WAM has requested that shells of dead snails are no longer submitted to the WAM for identification, and that snail specimens be identified using genetic analysis in preference to morphological identification. Specimens belonging to all taxa prone to short-range endemism were delivered to taxonomists for identification and registered with the WAM.

4.5 Survey Teams, Taxonomic Specialists and Licencing

4.5.1 Licencing

All components of the field survey were conducted under the following licences to Take Fauna for Scientific Purposes (DPaW, Regulation 17 Licence). The SRE survey was conducted under Licence No: SF009657, issued on 13/01/2014 and valid from 15/01/2014 - 30/06/2014. The Phase 1 fauna survey was conducted under Licence No: SF009676, issued on 29/01/2014 and valid from 10/02/25014 – 4/04/2014. The Phase 2 fauna survey was conducted under a license 01-000059-1, issued on 22/09/2016 and valid from 22/09/2016 – 05/10/2016.

4.5.2 Survey Team

The SRE field survey and vertebrate fauna pitfall survey of the Study Area were conducted by experienced MWH staff and sub-contractors (**Table 4-2**).

Table 4-2: Study team for the field survey of the Study Area

Person	Qualifications	Position
SRE Trapping Survey		
Paul Bolton	BSc (Marine Biol/Zoology) (Hons)	Principal Ecologist
Matthew Quinn	BSc (Env Sci and Marine Sci)	Zoologist
Phase 1 Fauna Survey		
Mark Gresser	BSc (Biol Sci/Cons & Wildlife Biol) (Hons)	Senior Zoologist
Mark Carter	BSc (Econ Sci) (Hons) PGDip (Ecotourism)	Senior Zoologist
Chris Knuckey	BSc (Env Mgmt) (Hons)	Senior Zoologist
Briana Wingfield	BSc (Cons & Wildlife Biol, Env Sc) (Hons)	Zoologist
Arnold Slabber	BSc (Aquatic Sci) (Hons)	Ecologist
Jen Wilcox	BSc (Biol Sci/Env Sci)	Senior Zoologist
Phase 2 Fauna Survey		
Paul Bolton	BSc (Marine Biol/Zoology) (Hons)	Principal Zoologist
Chris Knuckey	BSc (Env Mgmt) (Hons)	Senior Zoologist
Briana Wingfield	BSc (Cons & Wildlife Biol, Env Sc) (Hons)	Zoologist
Megan Stone	BSc (Cons & Wildlife Biol) (Hons)	Ecologist
Mike Brown	BSc (Environmental Science)	Senior Zoologist
Andre Schmitz	BSc (Environmental Management)	Senior Zoologist

4.5.3 Taxonomic specialists

Invertebrate specimens collected during the survey were identified by taxonomic specialists from Phoenix Environmental, the WAM and independent consulting taxonomists (**Table 4-3**).

Table 4-3: Invertebrate taxonomists and their specialisation

Invertebrate Group	Taxonomist	Organisation
SRE trapping survey & Phase 1 Fauna Survey		
Spiders and millipedes	Volker Framenau	Phoenix Environmental
Scorpions and pseudoscorpions	Erich Volschenk	Phoenix Environmental
Slaters	Simon Judd	Phoenix Environmental
Snails	Gaynor Dolman (molecular genetics), Corey Whisson and Lisa Kirkendale	WAM
Phase 2 Fauna Survey		
Spiders and Snails	Gaynor Dolman (molecular genetics), Corey Whisson and Lisa Kirkendale	WAM
Scorpions	Erich Volschenk	Alacran Environmental Science
Slaters	Simon Judd	Independent taxonomist

5 Results and Discussion

5.1 Terrestrial Invertebrate Fauna Habitats

A total of eleven broad habitats were identified in the Study Area on the basis of location, landform, substrate, and vegetation community (**Table 5-1**, **Figure 5-1**). These habitats were categorised as having a high, medium or low potential to support terrestrial SRE taxa (**Section 4.3**). Although a variety of survey methods and extensive sampling was undertaken during the Survey, the cryptic nature and sporadic seasonal activity of many groups means that it is unlikely that all SRE species will be collected on any one survey. For this reason it is important to consider habitat and to consider habitat as part of this Assessment.

Two habitats within the Study Area, Rocky Ridge and Gorge and Granite Outcrops, have a high potential to support SRE species. The Rocky Ridges and Gorges contains features such as ridges (southerly or easterly aspect), gorges and deep gullies which tend to form sheltered habitat isolates that are protected from fire and are uncommon in the wider landscape. Within the Study Area, there were a number of locations where these microhabitats had running water which supported stands of large *Melaleuca*, groves of *Ficus* and ferns. These micro-habitats also function as fire refuges, which by definition, are not affected by the broad-scale fires that are common in many habitats of the Pilbara. Some invertebrate taxa that occur within these micro-habitats have restricted distributions as they cannot survive and disperse into the less protected surrounding environments. Rocky Ridge and Gorge habitat occurs as a band in the eastern portion of the Study Area. This habitat was comprehensively surveyed as it is the habitat most likely to support SRE taxa.

Granite Outcrops also have a high potential for supporting SRE species as they tend to form habitat isolates and have the potential to create fire refuges. The large areas of exposed rock on Granite Outcrops can also divert water into crevices and depressions, which accumulate soil and leaf litter, creating mesic micro-habitats likely to support SRE taxa (Main 2000). Additionally, large areas of bare rock can also serve as barriers to fire creating fire refuges for vegetation (Main 2000). As with species from Rocky Ridge and Gorge habitat, some invertebrate taxa that occur within these micro-habitats can have restricted distributions as they cannot survive and disperse into surrounding less-mesic environments. Granite Outcrop habitat was located in the south-west corner of the Study Area and was not surveyed as it occurs in excess of seven km south of the Development Envelope for the Project, and is consequently unlikely to be impacted by the proposed development.

One habitat, Drainage Lines, has a medium potential to support SRE taxa as it provides a sheltered environment compared to the surrounding landscape, and tends to contain a higher soil moisture content. Additionally, the only record of the SRE millipede *Antichiropus* \`DIP038\` was made from this habitat approximately 1 km west of the Study Area (**Section 3.3**). Drainage Lines consist of minor watercourses (less than 20 m in width) with sand or stony banks which support intermittent areas of dense riparian vegetation which provide increased shelter and retain water for longer periods than the surrounding plains. Invertebrate taxa which utilise these areas of riparian vegetation can generally passively disperse along the drainage line during seasonal water flow. Drainage Lines occur in the central northern and southern portions of the Study Area as tributaries of the Coongan River.

The eight other habitats in the Study Area have a low potential to support SRE taxa. Such habitats are considered widespread in the region, as determined by broad scale land systems pre-European mapping (**Section 2.3**) and previous studies conducted within the region (**Section 3.2**), and contain limited microhabitats suitable for SRE habitation.

Table 5-1: Assessment of habitats within the Study Area

Broad Fauna Habitat	Likelihood of supporting SRE Taxa	Rational for classification			Survey Effort	Plate	Land systems	Vegetation and Substrate	Study Area (ha)	Study Area (%)
		Micro-habitats present	Extent within landscape	Connectivity						
Stony Rise	**Low**	No	Widespread	Well connected	• SRE Systematic Sites 8, 12 • Phase 1 trapping Site A, E • Phase 2 trapping Site K	5.1	Major component of the Talga and Rocklea land systems	Stony undulating plain with occasional *Acacia* spp and *Hakea* spp over hummock grassland of *Triodia* spp on stony red loam	7, 703	41
Rocky Foothills	**Low**	No	Widespread	Well connected	• Phase 1 trapping Site B • Phase 2 trapping Site M	5.2	Major component of the Talga and Rocklea land systems	Sparse shrubland of occasional *Acacia* spp and *Eucalyptus* spp over *Triodia* spp on stony red clay loam	4, 458	24
Spinifex Stony Plain	**Low**	No	Widespread	Well connected	Not surveyed	5.5	Minor component of the Rocklea land system	Sparse woodland of *Corymbia hamersleyana* over mixed open shrubland of *Acacia pyrifolia*, *Acacia* spp, *Senna* spp and *Grevillia wickhamii* over hummock grassland of *Triodia* spp and herbs on reddish brown sandy loam	1, 876	10
Rocky Ridge and Gorge	**High**	Yes	Limited	Isolated	• SRE Systematic Sites 1, 2, 3, 4, 6, 9, 10, 11, 13 • SRE Targeted Sites 1, 3, 4, 5, 6 • Phase 1 trapping Site I • Phase 2 trapping Site I	5.4	Major component of the Capricorn land system	Open stands of *Acacia* spp and *Eucalyptus leucophloia* over *Triodia* spp and other native grasses on stony red sandy loams. Sheltered gorges and deep gullies within this broader habitat occasionally had running water which supported stands of large *Melaleuca* sp trees, groves of *Ficus* sp trees and ferns.	1,766	9
Ironstone Ridgetop	**Low**	No	Limited	Isolated	• Phase 1 trapping Sites C, D, H • Phase 2 Trapping Sites C, D, H	5.3	Major component of the Capricorn land system	Sparse shrubland of occasional *Eucalyptus leucophloia* and *Acacia* spp over *Triodia* spp on red-brown ironstone	1, 543	8
Drainage Line	**Medium**	Yes	Limited	Well connected	• SRE Systematic Sites 5, 7 • SRE Targeted Site 2 • Phase 1 trapping Sites G, J • Phase 2 trapping Sites G	5.6	This habitat does not align with any particular land system	*Acacia* spp and *Eucalyptus* spp with scattered *Melaleuca* spp over dense grassland of *Triodia* spp, *Cenchrus ciliaris* and other grasses on river sand and alluvial loam	502	3
Granitic Uplands	**Low**	Yes	Widespread	Well connected	Not surveyed	5.7	Aligns with the Capricorn land system	Open shrubland of slender *Acacia* spp over *Triodia* spp on shallow sandy soils over sheets and outcropping of granite stones and boulders	238	1
Calcrete	**Low**	No	Widespread	Well connected	• Phase 1 trapping Site F • Phase 2 trapping Site F	5.8	Minor occurrence within the Rocklea land system	Open shrubland with *Acacia* spp over hummock grassland of *Triodia* spp on clay-loam with calcrete	235	1
Spinifex Sandplain	**Low**	No	Widespread	Well connected	• Phase 2 trapping Site N	5.10	Minor occurrence within the Boolgeeda land system	Very open shrubland of *Acacia* spp. over *Triodia* sp. hummock grassland on sandy loam.	195	1
Riverine	**Low**	Yes	Widespread	Well connected	• Phase 2 trapping Site L	5.11	Aligns with the River land system	Woodland of large *Eucalyptus camaldulensis*, *Eucalyptus victrix* with occasional *Melaleuca argentea*, a midstory of and *Acacia* spp. and *Grevillea pyramidalis* over grasses comprising heavily grazed *Cenchrus ciliaris* (Buffel) on banks of loam with river sand in the main channel.	167	1
Granite Outcrop	**High**	Yes	Limited	Isolated	Not surveyed	5.9	Minor occurrence within the Granitic land system	Very sparse open woodland of *Eucalyptus* spp with dense pockets of *Acacia* spp woodland over shrubland of *Acacia* spp and *Triodia* spp hummock grassland on stony red sand, interspersed with substantial granite boulder piles	163	1
								Total	18,845	100

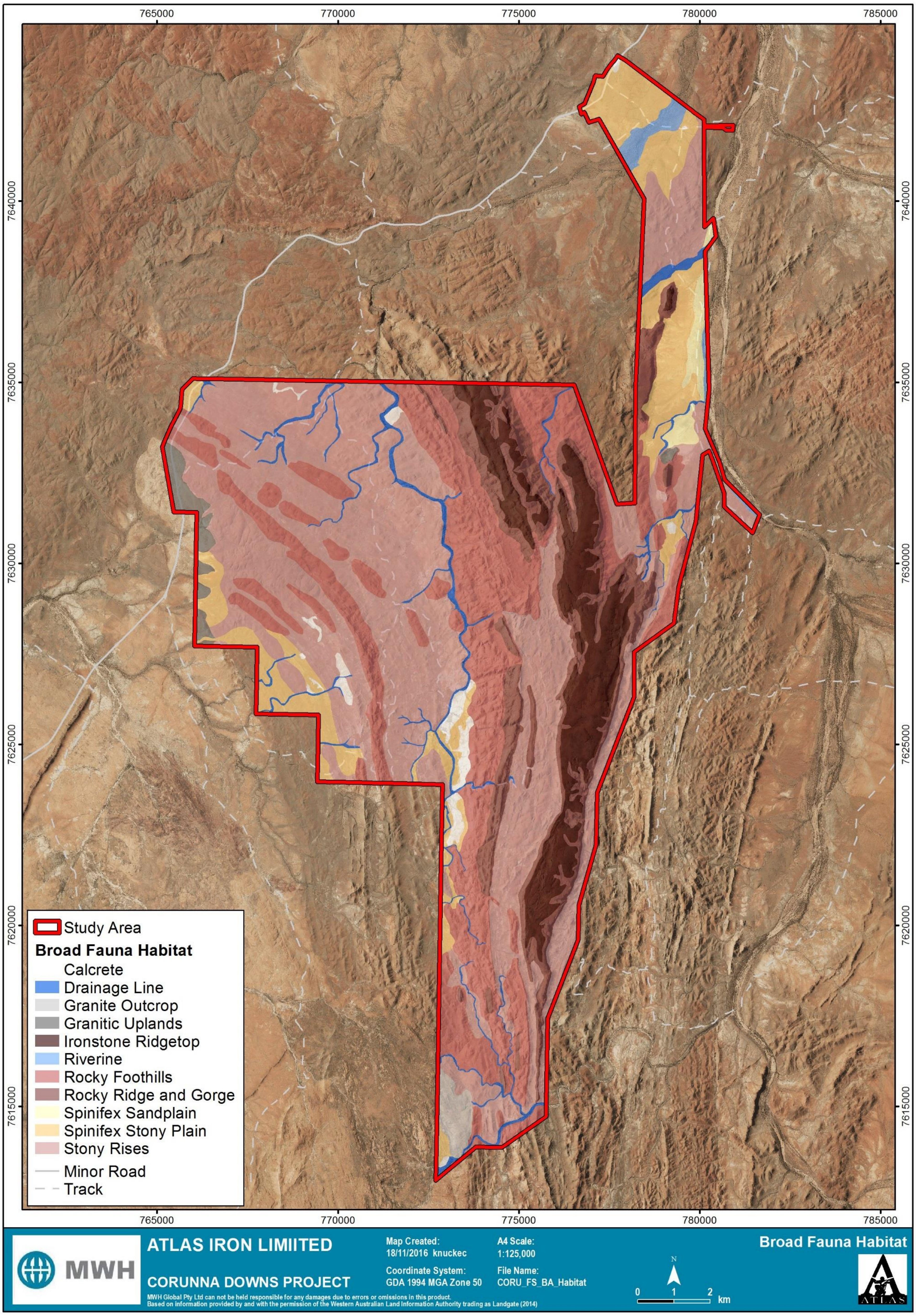

Figure 5-1: Habitat Types within the Study Area

Plate 5-1: Example of Stony Rise habitat

Plate 5-2: Example Rocky Foothills habitat

Plate 5-3: Example of Spinifex Stony Plain habitat

Plate 5-4: Example of Rocky Ridge and Gorge habitat

Plate 5-5: Example of Ironstone Ridgetop habitat

Plate 5-6: Example of Drainage Line habitat

Plate 5-7: Example of Granitic Uplands habitat

Plate 5-8: Example of Calcrete habitat

Plate 5-9: Example of Spinifex Sandplain habitat

Plate 5-10: Example of Riverine habitat

Plate 5-11: Example of Granite Outcrop habitat

5.2 SRE Collection Records

The surveys, combined, yielded a total of 761 invertebrate specimens from 31 species. A number of specimens from each target group were not able to be identified to species, as they were of an inappropriate sex or life stage. For these specimens it is difficult to draw conclusions on their distributions without undertaking comparative genetic analysis with reference collections. Slaters were the most speciose group to be collected during the survey, followed by pseudoscorpions and scorpions (**Table 5-2**). Selenopid spiders, mygalomorph spiders, selenopid spiders, snails and millipedes were represented by low numbers of species.

Table 5-2: Summary of the terrestrial SRE invertebrates collected during the surveys

Group	Specimens	Species
Mygalomorph spiders	3	2
Selenopid spiders	8	3
Pseudoscorpions	80	8
Scorpions	147	6
Slaters	514	9
Millipede	1	1
Snails	8	2
TOTAL	761	31

Based on current taxonomy and known species distributions (**Appendix D - Appendix G**), two species collected in the Study Area were *confirmed* SRE species, three were *likely* SRE species and 12 were *potential* SRE species as follows:

- *confirmed* SRE species:
  - pseudoscorpion: *Feaella* sp. nov.;
  - millipede: Paradoxosomatidae sp. indet.
- *likely* SRE species:
  - slaters: *Acanthodillo* sp. indet., Buddelundiinae 'mw', Philosciidae 'corunna'; and
- potential SRE species:
  - selenopid spiders: *Karaops* sp. indet.1, and *Karaops* sp. indet.2;
  - mygalomorph spiders: *Aurecocrypta* sp. indet., and *Aname* sp. indet.;
  - scorpions: *Lychas* 'gracilimanus complex', *Lychas* 'bituberculatus complex', *Lychas* 'hairy tail complex', *Urodacus* 'pilbara 16', and *Urodacus* sp. indet.;
  - slaters: *Buddelundia* '11', *Buddelundia* '86'; and
  - snails: *Rhagada* '*convicta* complex' and *Rhagada* sp. 'nov'.

It should be noted that a number of these taxa could not be identified to species level and classified as indeterminate ('indet') (See **Section 1.3** for SRE criteria). Indeterminate taxa have the potential to represent SRE species as they are from genera that are known to include species with restricted ranges. Similarly, four indeterminate taxa have been assigned as members of species complexes where separate molecular studies have revealed some forms appear to represent SRE species. However, without molecular analysis to compare the genetic makeup of the indeterminate specimens with the WAM reference records, their true status remains uncertain.

Ten species (highlighted orange within **Table 5-3**), were only collected from habitats with a high or medium potential to support SRE taxa. The remaining seven potential SRE species were collected from habitats that have a low potential to support SRE taxa. This suggests that the potential SRE status of these species may not represent restricted distributions but rather a lack of taxonomic resolution and/or regional records. The location and number of specimens collected of these species is summarised in **Table 5-3**, and detailed taxonomic and molecular reports are included in **Appendix D - Appendix G**.

Table 5-3: SRE Species, collection location, number of specimens and associated habitat. Shading denotes species only recorded from habitats with high or medium potential to support SRE species

Habitat	Likelihood of supporting SRE Taxa	Site	Number of specimens collected																		
			Confirmed		Likely			Potential													
			Feaella sp. nov.	Paradoxosomatidae sp. indet.	*Acanthodillo* sp. indet.,	*Buddelundiinae* 'mw'	*Philoscidae* 'corunna'	*Karaops* 'sp. indet. 1'	*Karaops* 'sp. indet. 2'	*Aurecocrypta* sp. indet.	*Aname* sp. indet.	*Lychas* 'gracilimanus complex'	*Lychas* 'bituberculatus complex'	*Lychas* 'hairy tail complex '	*Urodacus* 'pilbara 16'	*Urodacus* sp. indet	*Buddelundia* '11'	*Buddelundia* '86'	*Rhagada* 'convicta complex'	*Rhagada* sp. 'nov'
Stony Rise	Low	8											2				85			
		12											5	1						
		A																7		
		E																		
		K																		
Rocky Foothills	Low	B											1							
		M																2		
Ironstone Ridgetop	Low	C																		
		D																21		
		H															1			
Rocky Ridge and Gorge	High	1				3	1						2							
		2				2			2*				6	5						2
		3							1				12	9						
		4				1							8	7			13			
		6				5							8	3			10			
		9				12							6							
		10											5	3						
		11				5	1						1	7						
		13				16					1		11	1						
		Tar-1																		
		Tar-3																		
		Tar-4																		

Habitat	Likelihood of supporting SRE Taxa	Site	Number of specimens collected																	
			Confirmed		Likely			Potential												
			Feaella sp. nov.	Paradoxosomatidae sp. indet.	*Acanthodillo* sp. indet.,	*Buddelundiinae* 'mw'	*Philosciidae* 'corunna'	*Karaops* 'sp. indet. 1'	*Karaops* 'sp. indet. 2'	*Aurecocrypta* sp. indet.	*Aname* sp. indet.	*Lychas* 'gracilimanus complex'	*Lychas 'bituberculatus complex*	*Lychas 'hairy tail complex '*	*Urodacus* 'pilbara 16'	*Urodacus* sp. indet	*Buddelundia* '11'	*Buddelundia* '86'	*Rhagada* 'convicta complex'	*Rhagada* sp. 'nov'
		Tar-5																		
		Tar-6											1							
		I							1											
		Opp 1				8			1											
		Opp 2															1			
		Opp 4							1											
Spinifex Stony Plain	Low	-																		
Drainage Line	Medium	5	1	1	2												3		7	
		7																		
		Tar-2																		
		G													1	1				
		J																		
		Opp 3															1			
Granite Uplands	Low	-																		
Calcrete	Low	F						1		1		3	2			1	2	2		
Granite Outcrop	High	-																		
Riverine	Low	L																		
Spinifex Sandplain	Low	N																2		

* only one of the two *Karaops* specimens from this site successfully amplified for molecular analysis, however, given that both specimens were collected at the same location, the specimens are likely to represent the same species.

5.2.1 Confirmed SRE Species

***Feaella* sp. nov.**

A single female pseudoscorpion from the genus *Feaella* was collected from Drainage Line habitat during the survey (**Table 5-3**, **Figure 5-2**). This specimen is morphologicallt distinct from two other undescribed but confirmed SRE species of *Feaella* that are known from the Pilbara. It is therefore considered by taxonomists to be a confirmed SRE species also (**Appendix D**). The other specimens from this genus collected in the Pilbara were also from Drainage Line habitats (Outback Ecology 2012c, d). The collection of this specimen from a habitat with a medium potential to support SRE species supports the notion that this specimen represents a SRE species.

Paradoxosomatidae sp. indet.

A dry fragment of a millipede from the family Paradoxosomatidae was collected from a single site within Drainage Line habitat (**Table 5-3**, **Figure 5-2**). In Western Australia, this family is represented by genera that typically have restricted ranges, including the highly speciose genus *Antichiropus,* of which almost all species have restricted ranges (**Appendix D**).

The collection of this specimen from a habitat with medium potential to support SRE species supports the notion that this specimen represents a SRE species. Additionally, the SRE species from this family; *Antichiropus* \`DIP038\` and *Antichiropus* \`DIP034\` have been collected in close proximity to the Study Area (1 km west and 23 km northeast of the Study Area, respectively) (**Section 3.3**). It is possible that this specimen represents one of these species, however confirmation via genetic analysis was not possible as the specimen was dead upon collection.

5.2.2 Likely SRE Species

***Acanthodillo* sp. indet.**

Two female specimens from the slater genus *Acanthodillo* were collected from a single site within Drainage Line habitat (**Table 5-3**, **Figure 5-2**). These specimens could not be designated a morphospecies name as male specimens are required for conclusive taxonomic identification. They are regarded as likely to represent a SRE species as the genus contains many SRE species and these specimens are morphologically distinct from others collected in the region at Abydos, Mt Webber, McPhee Creek and the Southern Haul Road component of the Turner River Hub Project (**Appendix D**). The collection of this specimen from a habitat with a medium potential to support SRE species supports the notion that this specimen represents a SRE species.

Buddelundiinae 'mw'

Fifty-two (52) slater specimens from the subfamily Buddelundiinae 'mw' were collected from eight sites within Rocky Ridge and Gorge habitat (**Table 5-3**, **Figure 5-2**). Buddelundiinae 'mw' is regarded as a SRE species as it is only known to occur at Corunna Downs and at Mt Webber (**Appendix D**, **Appendix F**; **Figure 5-4**). At Mt Webber, this species (named Gen nov. sp. nov B) was also only collected from

Rocky Ridge and Gorge habitat (Outback Ecology 2013c). The consistent collection of this species from Rocky Ridge and Gorge habitat, a habitat with a high potential to support SRE species, supports the notion that it is a SRE species.

Philosciidae 'corunna'

Two slater specimens (one male and one female) of Philosciidae 'corunna' were collected from two sites within Rocky Ridge and Gorge habitat (**Table 5-3**, **Figure 5-2**). Philosciidae 'corunna' is considered likely to be a SRE species as is distinct from other species in the genus (**Appendix D**). The collection of this species from a habitat with a high potential to support SRE species further supports the notion that Philosciidae 'corunna' represents a SRE species.

5.2.3 Potential SRE Species – From SRE Habitats

***Karaops* 'sp. Indet 2'**

Six juvenile specimens of the selenopid spider, *Karaops* 'sp. Indet 2' were collected during the survey from Rocky Ridge and Gorge habitat (**Table 5-3**). Three of the specimens (along with one specimen of *Karaops* 'sp. Indet 1') were originally unable to be identified to species level based on morphology and were assigned the suffix 'sp. indet' (**Appendix D**). However, molecular analysis has since revealed that the specimen belongs to a lineage only represented by specimens collected during this survey of the Study Area (**Appendix G**). Given that all specimens of *Karaops* 'sp. Indet 2' have been collected from Rocky Ridge and Gorge habitat within the Study Area, it appears likely that this species is a SRE.

***Aname* sp. indet**

A single juvenile specimen of mygalomorph spider from the genus *Aname* was collected from Rocky Ridge and Gorge habitat (**Table 5-3**, **Figure 5-3**). This specimen could not be identified to species level as adult male specimens are required. It is considered to have potential to represent a SRE as many other species of this genus are known to have restricted ranges (**Appendix D**). Given that this specimen was collected from Rocky Ridge and Gorge habitat, there is potential that this specimen could represent a SRE species.

***Urodacus* 'pilbara 16'**

A single male specimen of the scorpion *Urodacus* 'pilbara 16' was collected from a site in Drainage Line habitat (**Table 5-3**, **Figure 5-3**). This specimen is the only known record of this species. Given that it is from a genus which is represented by both widespread and SRE species, it is considered to be a potential SRE species (**Appendix D**). Given that this specimen was collected from Drainage Line habitat, a habitat with medium potential to support SRE, there is potential for this specimen to represent a SRE species.

***Rhagada convicta* complex**

Seven specimens from terrestrial snail were collected from a site within Drainage Line habitat (**Table 5-3**, **Figure 5-3**). Genetic analysis at the WAM has revealed that these specimens belong to a species complex, which is currently known as *Rhagada convicta*. Specimens from this complex have been collected as far away as Karratha (270 km northwest of the Study Area). Currently this complex is considered a single species, however, genetic variation within the group mirrors levels of genetic divergence observed between different species of *Rhagada* which may indicate the presence of cryptic species (**Appendix E**). Given the uncertainty regarding this species' distribution, these specimens have been considered to have potential to represent a SRE species (**Appendix E**). Drainage Line habitat has a medium potential to support SRE species and based on this, there is potential for these specimens to represent a SRE species.

***Rhagada* sp. 'nov'**

A single specimen of the snail Rhagada sp. 'nov' was collected from Rocky Ridge and Gorge habitat (**Table 5-3**, **Figure 5-3**). Genetic analysis conducted by the WAM has revealed that this specimen has a COI DNA sequence that closely aligns with two other specimens from the WAM collection. This close alignment strongly suggests that the specimens are all of the same species. One of the specimens was collected 31 km south of Pannawonica, approximately 350 km west of the Project; and the other specimen was collected approximately 25 km northwest of the Woodie Woodie minesite, 145 km east of the Project. Although the linear geographic separation of these three specimens is approximately 493 km, the tendency for this species to be associated with sheltered habitats (drainage lines, riparian zones and gorges) means that it has potential to represent a SRE species (**Appendix E**). This specimen was collected from Rocky Ridge and Gorge habitat which has a high potential to represent SRE species and based on this habitat association, there is potential for this species to have a restricted distribution to more mesic habitats in the landscape. However the large distance between records suggests that the species is not restricted in its distribution.

5.2.4 Potential SRE Species – From Widespread Habitats

The following potential SRE species were recorded from habitats with low potential to support SRE species. Consequently, their identification as potential SRE species may represent a lack of regional records or a lack of taxonomic resolution or molecular knowledge. Each is discussed with respect to current taxonomic knowledge, habitat associations and collection records.

***Karaops* 'sp. Indet 1'**

A single juvenile specimen of the selenopid spider, *Karaops* 'sp. Indet 1' was collected during the survey from Calcrete habitat (**Table 5-3**). This specimen originally was unable to be identified to species level based on morphology and was assigned the suffix 'sp. indet' (**Appendix D**); however, molecular analysis has since revealed that the specimen belongs to a lineage which includes at least two other specimens (**Appendix G**). The two other specimens of *Karaops* 'sp. Indet 1' were previously collected approximately 35 km west of the Study Area (**Figure 5-4**). Although the distribution means that the species could represent a SRE species, the occurrence within Calcrete habitat suggests that the species may have a wider distribution in similar habitats in the landscape.

***Aurecocrypta* sp. indet.**

A single specimen of mygalomorph spider from the genus *Aurecocrypta* was collected from Calcrete habitat (**Table 5-3**, **Figure 5-3**). This specimen could not be identified to species level as adult male specimens are required for accurate identification. It is considered to have potential to represent a SRE as many other species of this genus are known to have restricted ranges (**Appendix D**). Given that this specimen was collected from Calcrete habitat, a habitat with a low potential to support SRE species, it would appear that this specimen is unlikely to represent a SRE species.

***Lychas* 'gracilimanus complex'**

Three specimens of the scorpion *Lychas* 'gracilimanus' were collected from a single site within the Calcrete habitat type (**Table 5-3**, **Figure 5-3**). *Lychas* 'gracilimanus' was considered a well-defined morphospecies that has a very patchy distribution in the Pilbara (**Appendix D**); however it is now considered part of a species complex that appears to comprise at least two broad populations: a Robe Valley group and an Eastern Pilbara group, but may also comprise smaller cryptic species in association with restricted habitats (E. Volschenk *pers comm* 26/10/2016). Given that the specimens were all from the same site, it is likely that they are of the same form. Additionally, given that the habitat is unlikely to support SRE species, it would appear that these specimens are unlikely to represent a SRE species.

***Lychas* 'bituberculatus complex'**

Seventy (70) specimens of scorpions from the *Lychas* 'bituberculatus complex' were collected from four habitats within the Study Area (**Table 5-3**, **Figure 5-3**). The majority of these specimens were collected from sites within Rocky Ridge and Gorge habitat (10 sites) with the remaining specimens collected from Stony Rise (2 sites), Rocky Foothills (1 site) and Calcrete (1 site) habitats. This complex was previously thought to involve a single widespread species (**Appendix D**), however it is now considered to represent a species complex, with some forms appearing to have restricted distributions that may represent potential SRE species (E. Volschenk *pers comm* 26/10/2016). Within the Study Area, specimens were collected from sites well distributed across the Study Area, mostly in association within Rocky Ridge and Gorge habitat. Although the relatedness between these specimens is not certain; specimens collected from a single habitat, such as Rocky Ridge and Gorge, are considered likely to represent the same form within the species complex.

***Lychas* 'hairy tail complex'**

Thirty-six (36) specimens of scorpion from the *Lychas* 'hairy tail complex' were collected from two habitats within the Study Area (**Table 5-3**, **Figure 5-3**). The majority of these specimens were collected from Rocky Ridge and Gorge habitat (7 sites) with the remaining single specimen collected from Stony Rise habitat (1 site). This complex was previously thought to involve a single widespread species (**Appendix D**), however it is now considered to represent a species complex, with some forms appearing to have restricted distributions that may represent potential SRE species (E. Volschenk *pers comm* 26/10/2016). Within the Study Area, specimens were collected from sites well distributed across the Study Area, almost exclusively from Rocky Ridge and Gorge habitat. Given that the majority of these specimens were recorded from a single habitat, Rocky Ridge and Gorges, it is likely that these specimens represent a single form of the species complex.

***Urodacus* sp. indet**

Two juvenile specimens of scorpions from the genus *Urodacus* were recorded from Drainage Line and Calcrete habitats (**Table 5-3**, **Figure 5-3**). The juvenile specimens is likely to represent *Urodacus* 'Pilbara 8' (E. Volschenk *pers comm* 26/10/2016) which has also been collected in the Study Area but is not considered a SRE species (**Appendix D**).

***Buddelundia* '11'**

One hundred and sixteen (116) specimens of *Buddelundia* '11' were recorded across four habitats within the Study Area: Stony Rise (1 site), Ironstone Ridgetop (1 site), Rocky Ridge and Gorge (3 sites), Drainage Line (2 sites) and Calcrete (1 site) (**Table 5-3**, **Figure 5-3**). Specimens of *Buddelundia* '11' have previously been recorded at the Abydos DSO Project (approximately 50 km Northwest of the Study Area) and at the Mt Webber DSO Project (approximately 30 km west of the Study Area) (**Appendix D**, **Appendix F**, **Figure 5-4**). Specimens of *Buddelundia* '11' have also been recorded at McPhee Creek (approximately 50 km east of the Study Area), however there exists some variation in morphology when compared to the other sites (Outback Ecology 2012a). *Buddelundia* '11' is considered a potential SRE based on its known distribution where it is well represented both within and outside the Study Area and across a variety of habitats (**Figure 5-4**).

***Buddelundia* '86'**

Thirty-four (34) specimens of *Buddelundia* '86' were recorded across five habitats within the Study Area: Stony Rise (1 site), Rocky Foothills (1 site), Ironstone Ridgetop (1 site), Calcrete (1 site) and Spinifex Sandplain (1 site) (**Table 5-3**, **Figure 5-3**). Specimens of *Buddelundia* '86' have previously been recorded at the Mt Webber DSO Project (approximately 30 km west of the Study Area) and along the McPhee Creek East West Transport Corridor (approximately 50 km west of the Study Area and 45 km southeast of the Study Area) (**Appendix D**, **Appendix F**, **Figure 5-4**). *Buddelundia* '86' is considered a potential SRE based on its known distribution where it is well represented both within and outside the Study Area and across a variety of habitats (**Figure 5-4**).

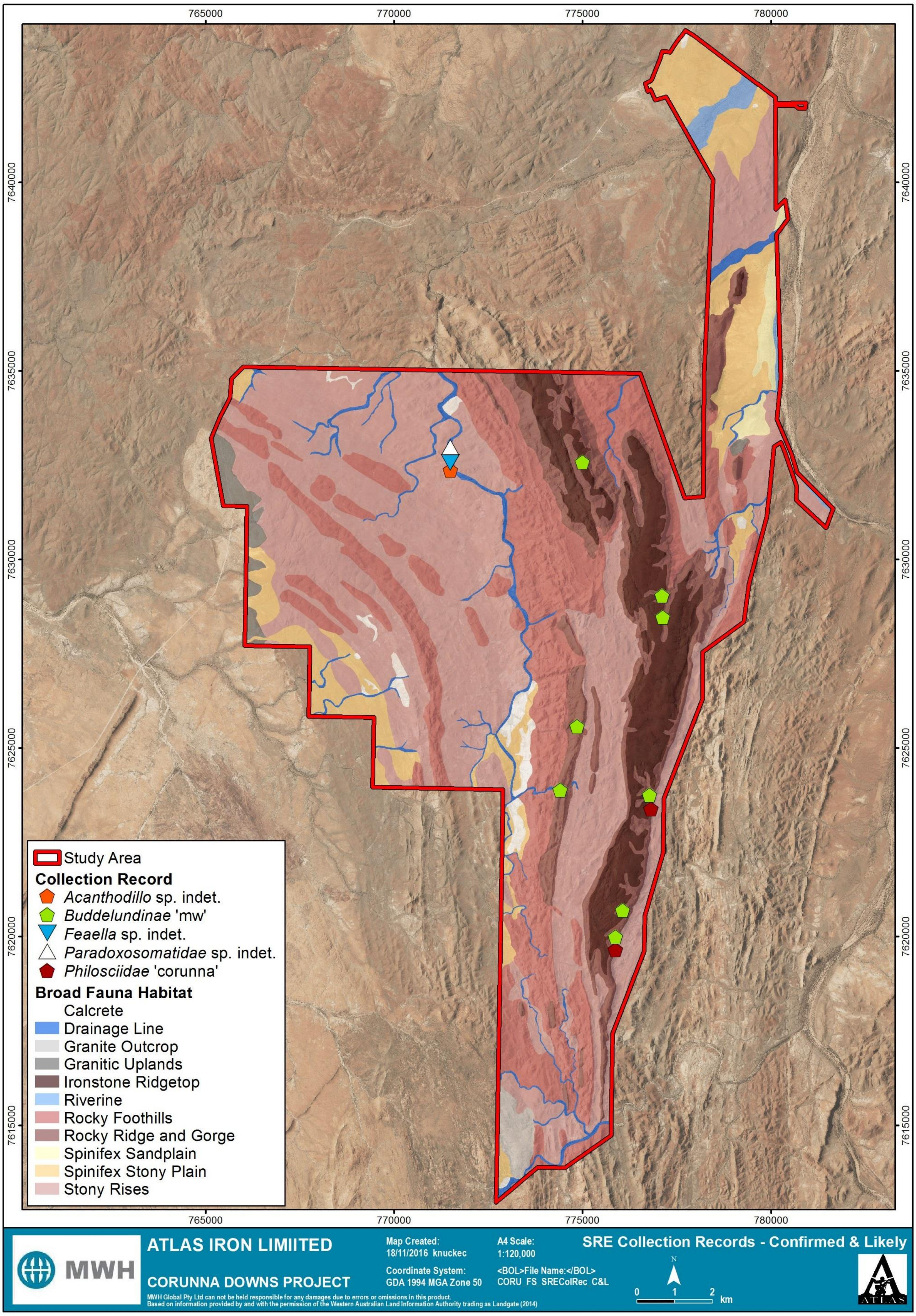

Figure 5-2: Collection locations of Confirmed and Likely SRE species from the Study Area

Note: some symbols are offset slightly to show all species collected at a given location

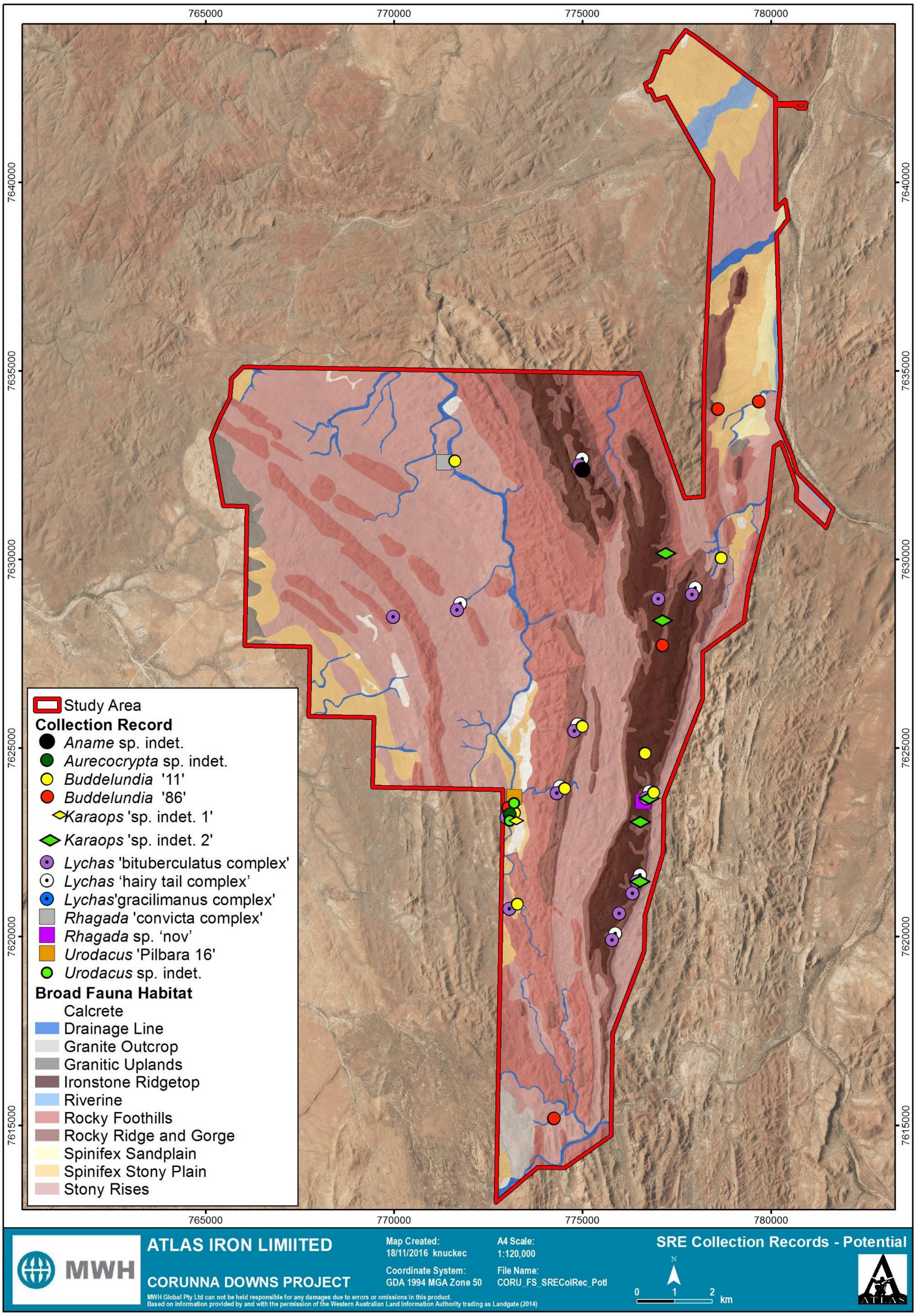

Figure 5-3: Collection locations of Potential SRE species from the Study Area

Note: some symbols are offset slightly to show all species collected at a given location

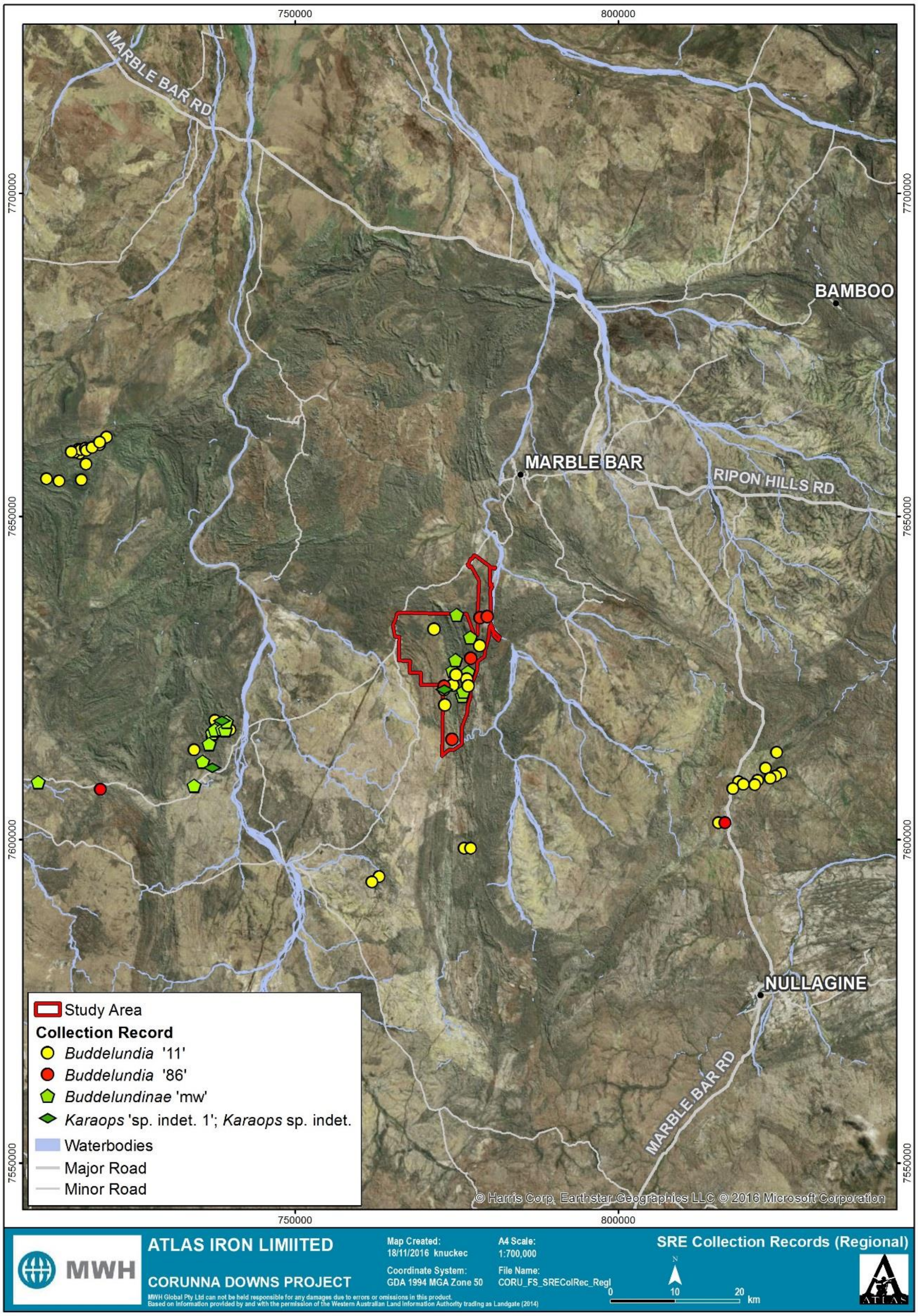

Figure 5-4: Collection records of the slaters *Buddelundiinae* 'mw', Buddelundia '11' Buddelundia '86' and Karaops 'sp. Indet 1' with respect to the Study Area

6 Survey Limitations and Constraints

The EPA (2004) lists possible limitations and constraints that can impinge on the adequacy of a fauna survey (**Table 6-1**). All fauna surveys are limited to some degree by time and seasonal factors and in an ideal situation several surveys would be undertaken over a number of years during different seasons. Nevertheless, all potential limitations and constraints identified by the EPA (2004) were considered and satisfied.

Table 6-1: Summary of potential survey limitations and constraints

Aspect	Constraint	Current surveys
Competency / experience of consultants	No	Members of the survey team have a combined total of over 15 years of experience undertaking terrestrial SRE invertebrate fauna surveys of this kind in WA. Invertebrate specimens were identified by recognised taxonomists.
Scope	No	Terrestrial SRE invertebrate fauna were assessed using established and standardised sampling techniques which have been endorsed by the WAM and DPaW.
Proportion of fauna identified, recorded and/or collected	No	The survey of the Study Area yielded a total of 761 invertebrate specimens from 31 identifiable species. The relative success of each survey method is compared in **Section 6.1**, with respect to the number of specimens collected and the number of SRE species collected. This section highlights the importance of using a variety of survey methods to successful understand the occurrence of SRE species in the Study Area. All specimens collected from groups prone to short-range endemism were submitted to the WAM or relevant taxonomists for identification. Specimens were identified down to the lowest taxonomic level possible. However, identifications could not always be made to the species level if the taxonomy of the group was not well resolved or if the life stage or sex required for identification were not collected. Database searches identified a total of 48 terrestrial SRE species that have been identified within 100km of the Project. Evaluation of habitats types, connectivity of habitats in the landscape and the proximity of the previous records suggests that only a few of these species actually have potential to occur. The survey was designed to maximise the collection of specimens belonging to target groups, however, it is recognised that surveys across years and seasons may be necessary to collect the majority of species in an area.
Sources of information (e.g. previously	No	Previously available data relevant to this survey was obtained via a desktop study comprising database searches and a literature review (**Section 3**).

Aspect	Constraint	Current surveys
available data as distinct from new data)		
Proportion of task achieved, and further work which might be needed	No	Systematic survey sites and/or vertebrate trapping sites were established in all habitats considered to have the potential to support SRE species occurring in the Study Area. The only exception is the Granite Outcrop habitat which comprises a small portion of the Study Area (1.0 %) that is unlikely to be affected by the Project. All specimens from target groups were identified by relevant taxonomic experts.
Timing, weather, season, cycle	No	The SRE trapping survey was conducted between 12 March and 19 May 2014 and the Phase 1 fauna survey was conducted between 24 February and 7 March 2014. These dates are largely between the optimal survey time of November and April which is recommended for invertebrate surveys in the Pilbara by the EPA (2009). Generally, invertebrates in the Pilbara are more active during the wetter times of the year, making the cyclonic period from November to April the optimum period for invertebrate surveys (EPA 2009). The Phase 2 fauna survey, although outside the optimal timeframe, it did provide a good opportunity to supplement existing specimen records and extend survey coverage. The temperature during the survey was typical of the time of year, however rainfall was lower that long-term averages with only 8.2 mm of rainfall falling over a total of four rain days while the wet pitfall traps were open (**Section 4.1**).
Disturbances	No	Evidence of a large recent fire event (late 2013) was present in the Study Area. This fire affected approximately 14,098 ha (74.8 %) of the Study Area (**Figure 6-1**). Although large portions of most habitats were affected by the fire, those habitats with high and medium potential to support SRE species tended to have fire refuge areas that were not affected by the fire. Evidence of these refuges was prevalent in the Rocky Ridge and Gorge habitat which contain sheltered microhabitats. These comprise gorges, deep gullies and steep ridges which support vegetation vulnerable to fire such as *Ficus* sp along with large stands of melaleuca, ferns and dense grasses. Sheltered unburned areas were also found along the more thickly vegetated sections of the Drainage Line habitat. Because many SRE species are dependent upon sheltered fire refuge areas, the survey was able to be conducted by targeting these refuges without causing a major limitation to the survey. Only three targeted survey sites (TAR 1, 3, 5) were located in areas that were partially affected by fire. All other sites were located within fire refuges that were not affected by the 2013 fire (**Appendix A**). These refuges were isolated from each other in the Study Area.

Aspect	Constraint	Current surveys
		Parts of the Study Area were disturbed by clearing and drilling activities associated with resource exploration. Evidence of grazing pressure from cattle was observed on the Spinifex Stony Plain, Drainage Line and Riverine habitats within the Study Area. Rocky Ridge and Gorge, and Granite Outcrop habitat that occurred within the Study Area was considered to be important to terrestrial SRE taxa. These habitat types were relatively undisturbed by the above activities.
Intensity	No	The SRE trapping survey of habitats more likely to support SRE taxa involved the following collection methods (wet pitfall traps, targeted searching, soil and litter collection) employed at 13 sites. A further six sites were subjected to target searching. In total, the SRE trapping survey comprised 4,320 trapping nights, 39 hours of targeted searching, the sieving of 39 soil samples and the collection of 39 leaf litter samples. Additional trapping effort of broad fauna habitats was undertaken during the Phase 1 and Phase 2 vertebrate fauna survey at ten survey sites during each phase. Methods used to collect SRE taxa included funnel traps and pitfall traps which totalled 2,100 trap nights for each phase. Additional targeted searching and collection of SRE invertebrate taxa was also undertaken during the Phase 2 fauna survey.
Completeness	No	All potential invertebrate habitats within the Study Area were adequately surveyed with the exception of the Granite Outcrop habitat. The Granite Outcrop habitat was not surveyed as it comprises a small portion (1 %) of the Study Area that is unlikely to be affected by the Project. All remaining broad fauna habitats were surveyed for SRE invertebrates via the collection of specimens during the Phase 1 and Phase 2 vertebrate fauna survey.
Resources	No	Resources were adequate to complete the survey. Survey participants were competent in the collection of invertebrates and identification of the habitats encountered during the survey.
Remoteness and access problems	No	Access was adequate for a large portion of the Study Area, however some areas in the north of the Study Area and the Granite Outcrop in the south-west were inaccessible by vehicle and could not be reached on foot. These areas are outside proposed impact areas for the Project.
Availability of contextual information	No	Contextual information on the occurrence of SRE species in the region was available and sourced through the WAM Database, NatureMap Database, Threatened and Priority Fauna Database, Protected Matters Search Tool, and through a literature review of regional SRE invertebrate fauna surveys.

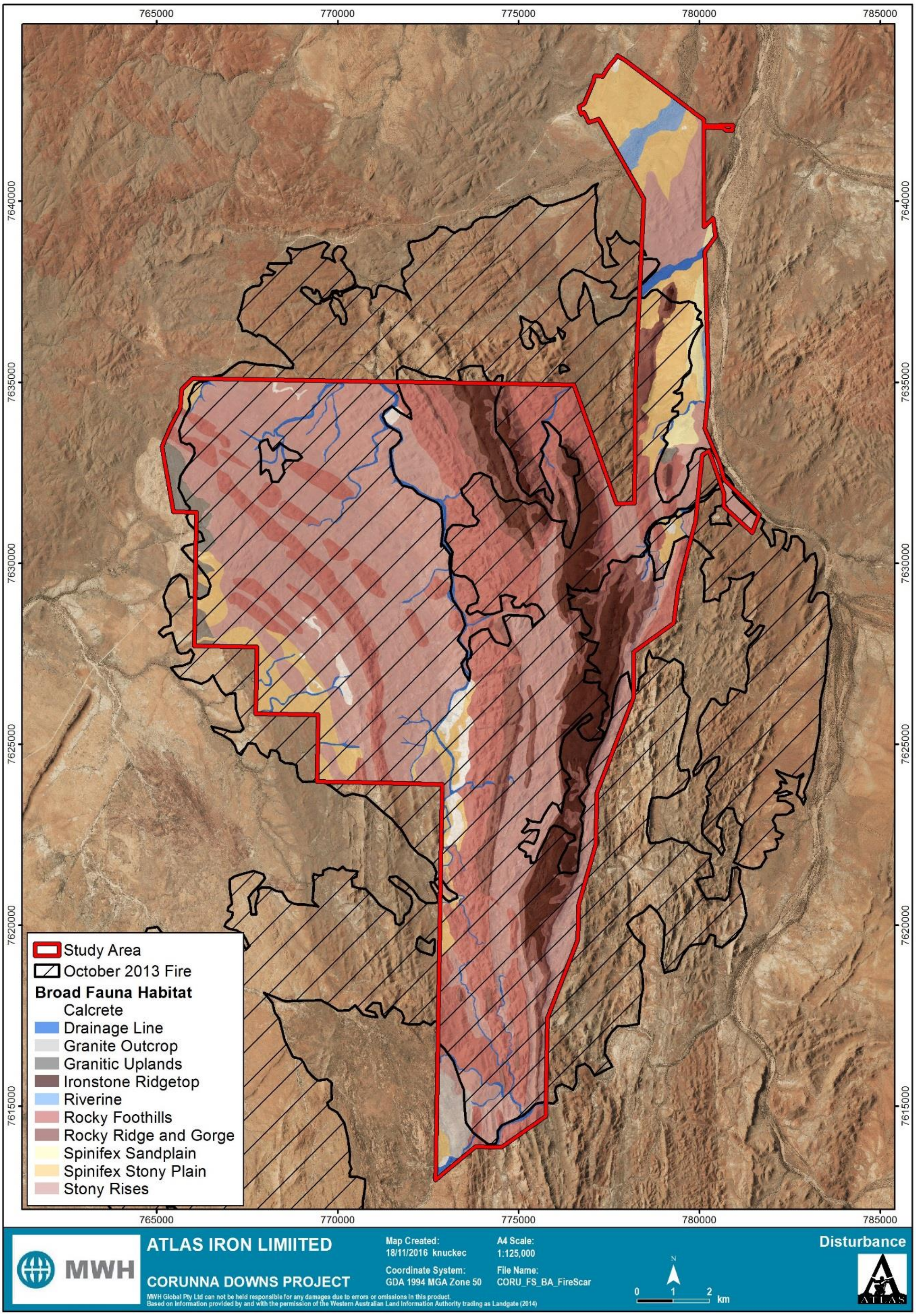

Figure 6-1: Extent of the October 2013 fire event as it relates to habitats in the Study Area

6.1 Survey methods and specimens collected

Different survey methods can influence which SRE groups are collected and the diversity of SRE species collected. Survey information for each method is summarised below:

- Number of specimens from each SRE group (**Table 6-2**); and
- Number of specimens from each SRE species (confirmed, likely or potential) (**Table 6-3**).

Wet pitfall trapping during the SRE trapping survey resulted in the highest number of invertebrate specimens collected from SRE groups (547 specimens from five targeted groups) and resulted in the collection of all groups except millipedes and snails (**Table 6-2**). However, dry pitfall/funnel trapping during the Phase 1 fauna survey and targeted searching during the SRE trapping survey resulted in the highest number of SRE species being collected (eight SRE species from 35 specimens and eight SRE species from 33 specimens, respectively)(**Table 6-3**).

Importantly, 11 of the 18 SRE species were only collected by a single collection method, with different methods being successful for the collection of different groups. Five species were only collected during the targeted searching component of the SRE trapping survey, six species were only collected by dry pitfall trapping (Phase 1 and 2 fauna surveys combined), and only one species was only collected by wet pitfall trapping. These results demonstrate the importance of using a variety of collection methods during a survey and highlights the comprehensive approach employed for this Assessment. Additionally, it is worth noting that survey methods, particularly passive methods such as pitfall traps, are likely to vary in their success depending on activity levels of target groups i.e. depending on whether rainfall occurs during the trapping period.

Table 6-2: Number of specimens from SRE groups by each collection method

Survey	Collection Method	Number of specimens from SRE groups							Total
		Mygalomorph spiders	Selenopid spiders	Scorpions	Pseudo-scorpions	Slaters	Snails	Millipede	
SRE Trapping Survey	Wet Pitfall Trapping	1	4	94	14	434	-	-	547
	Targeted Searching	-	-	11	64	29	8	1	113
	Litter in Tullgren Funnels	-	-	-	2	1	-	-	3
Phase 1 Fauna Survey	Dry Pitfall/Funnel Trapping	1	1	32	-	50	-	-	84
Phase 2 Fauna Survey	Dry Pitfall/Funnel Trapping	-	1	10	-	48	-	-	59
	Targeted Searching	1	2	-	-	10	-	-	13

Table 6-3: Number of specimens of SRE species collected by each collection method

Survey	Collection method	Number of specimens collected																		
		Confirmed		Likely			Potential													Total
		Feaella sp. indet.	Paradoxosomatidae sp. indet.	*Acanthodillo* sp. indet.	*Buddelundiinae* 'mw'	*Philosciidae* 'corunna'	*Karaops* 'sp. indet. 1'	*Karaops* 'sp. indet. 2'	*Aurecocrypta* sp. indet.	*Aname* sp. indet.	*Lychas* 'gracilimanus complex'	*Lychas* 'bituberculatus complex	*Lychas* 'hairy tail complex'	*Urodacus* 'pilbara 16'	*Urodacus* sp. indet	*Buddelundia* '11'	*Buddelundia* '86'	*Rhagada* 'convicta complex'	Rhagada sp. 'nov'	
SRE Trapping Survey	Wet Pitfall Trapping	-	-	2	44	-	-	3	-	1	-	58	36	-	-	100	-	-	-	**244**
	Targeted Searching	1	1	-	-	2	-	-	-	-	-	9	1	-	-	11	-	7	1	**33**
	Litter in Tullgren Funnels	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	**0**
Phase 1 Fauna Survey	Dry Pitfall/Funnel Trapping	-	-	-	-	-	-	1	1	-	1	2	2	1	-	3	24	-	-	**35**
Phase 2 Fauna Survey	Dry Pitfall/Funnel Trapping	-	-	-	-	-	1	-	-	-	2	1	-	-	2	-	20	-	-	**26**
	Targeted Searching	-	-	-	8	-	-	2	-	-	-	-	-	-	-	2	-	-	-	**12**

7 Impact Assessment

Threatening processes specifically associated with the Project can be categorised as either direct or indirect impacts. Direct impacts primarily occur through land clearing, whereas indirect impacts include inappropriate fire regimes, introduced flora and changes to surface hydrology (EPA 2009), increased noise, vibration, artificial light, and impacts of dust. The threatening processes that are potentially associated with the development of the Project are discussed below.

7.1.1 Land Clearing

Land clearing is likely to be the largest potential impact on SRE invertebrate fauna and habitat. Atlas have committed to clearing no more than 423.14 ha within the 2,263.19 ha Development Envelope (**Table 7-1**, **Figure 7-1**). Land clearing for the Project will directly remove habitat available to SRE invertebrate fauna resulting in habitat contraction, and may potentially result in habitat fragmentation which is likely to increase the impact of additional threatening processes.

By definition, SRE species have poor dispersal capabilities (Harvey 2002) and are therefore unable to emigrate from land as it is being cleared. Consequently, land clearing could result in the direct loss of SRE populations that occur within the Disturbance Footprint. Additionally, land clearing is likely to result in habitat fragmentation increasing degradation through edge effects (Fahrig 2003) such as by introducing of increasing the abundance of introduced flora (Keighery 2010) and altering the richness and assemblages of prey and predators (Saunders *et al.* 1991) of invertebrate fauna. Clearing of habitats with the potential to support SRE species (**Section 5.1**) should be limited where practicable.

7.1.2 Altered Fire Regimes

The development and operation of the Project may alter fire regimes within the Study Area through the introduction of unplanned fire resulting from vehicle movements and/or other Project activities such as hot work. Fire may impact fauna via direct contact, or indirectly by long-term habitat modification brought about by inappropriate fire frequency and intensity (Gill *et al.* 1999).

Short-range endemic invertebrate habitats, such as outcrops, are often fire refuges (EPA 2009) which may not be burnt with the frequency of the surrounding landscape. Rocky Ridge and Gorge and Granite Outcrop habitats have the potential to provide fire refuges within the Study Area (**Table 5-1**, **Figure 5-1**). Increasing fire frequency in fire refuges, such as in these habitats, is likely to have detrimental impacts to the SRE species within, and the supporting vegetation such as *Ficus* sp. trees which often occur in irregularly burnt habitats (Woinarski *et al.* 2004). The impact of inappropriate fire regimes may be reduced through the implementation of an appropriate fire management plan.

7.1.3 Introduced Flora

Environmental weeds already present in the Development Envelope may be spread due to increased vehicle usage. In addition, new weed species may be brought into the Development Envelope by mobile equipment during construction and operation of the Project. Weed invasion is widely recognised as having a negative impact on ecological communities, with the ability to fundamentally alter the composition and structure of native vegetation communities (Cowie and Werner 1993, Gordon 1998) and in the extreme, entire ecosystems can be modified (Sodhi and Ehrlich 2010), and increase fuel loads in some systems which may in-turn alter the local fire regime (Miller *et al.* 2010).

Fundamental changes to the composition and structure of vegetation communities is likely to have a negative impact on SRE species (EPA 2009). Invasion by non-native species typically results in a decline in native plant species richness (Grice 2006). Buffel grass (*Cenchrus ciliaris*) was already documented as being extensive within the Riverine habitat and also occurred along the Drainage Line habitat (**Section 5.1**), however, other weed species are also likely to occur. It is important to implement management strategies to reduce the occurrence and spread of weeds during mining operations.

7.1.4 Changes to Hydrology

The Project is likely to result in changes to surface hydrology in the Study Area which may in-turn affect SRE habitat. Changes to surface hydrology such as drainage control structures may divert natural water flow away from areas that were previously moist environments (such as Gorges and Drainage Lines), thereby reducing the quality of SRE habitat and the health of vegetation in these areas. Alternatively, drainage control structures may increase sediment loading or cause temporary flooding of SRE habitat downstream or adjacent to mining areas.

Changes in groundwater hydrology may influence the health and persistence of groundwater dependent vegetation which may support SRE habitats and species. Additionally, changes to groundwater hydrology may influence the flow of springs and seeps that support vegetation within gorges and drainage lines and, in turn affect the ability of those habitats to support SRE species.

7.1.5 Noise and Vibration

Noise and vibration from the Project will be associated with blasting, crushing and screening, vehicle movements, diesel power generation and general machine operation necessary for mine operation. Information on the potential effects of noise and vibration on SRE species-groups is limited. A trial that tests the effect of exploration drilling on the SRE Shield-backed trapdoor spider has been conducted at Jack Hills in the Murchison by Crosslands Resources (Department of Mines and

Petroleum 2010). In the trial, spiders were observed in their burrows while vibration simulating drilling was produced at varying distances from the source of vibration. Results suggested that the effects of vibration on spiders may be limited, however, the intrusion of the burrows by endoscopic camera may also have influenced spider behaviour. Raven (2008), suggests that vibrations created by blasting and heavy earthmoving equipment may actually attract spiders and other arachnids, which subsequently places these individuals at risk of direct contact with mining activities. There may also be a significant impact of vibration from heavy vehicles on scorpions as they use vibration for prey detection, navigation and courting (Volschenk 2011). Without further research, it is not possible to predict and quantify the noise and vibration impacts on SRE species. However, in the absence of species-specific data, such impacts should be controlled and where possible, avoid habitats prone to supporting SRE taxa.

7.1.6 Artificial Light

The Project will result in an increase in the exposure of SRE invertebrate fauna to artificial light. Most SRE invertebrate fauna in the Pilbara are active during the hours of darkness and it is possible that artificial light will influence feeding and breeding behaviour. To reduce possible impacts of artificial light on SRE fauna, lighting should be designed to illuminate only the necessary operational areas and avoid illuminating the surrounding landscape, particular within or near habitats known to support SRE taxa.

7.1.7 Dust Emissions

The Project will potentially result in an increase in dust pollution resulting from blasting, the movement of light and heavy vehicles and the general use of equipment on site. Dust pollution may lead to the degradation of surrounding vegetation and high levels may reduce plant growth resulting in the degradation of the overall ecosystem and the increased risk of disease in plants (Farmer 1993). Studies in semi-arid regions of Western Australia have however failed to prove negative effects of dust on arid-zone flora, suggesting that the impact of dust emissions within such ecosystems is not as prominent as witnessed in other systems (Matsuki *et al.* 2016). Adequate dust suppression measures should be implemented to reduce the effects of dust on potential SRE habitats and SRE species.

7.2 Impact on SRE Habitat

A maximum of 423.14 ha of fauna habitat within the Development Envelope will be removed for the Project within the 2,263.19 ha Development Envelope, and is likely to pose the largest threat of the Project on SRE species (**Table 7-1**, **Figure 7-1**). Habitat loss is listed as a key threatening process under the EPBC Act, however, it is recognised that this is a necessary and typical outcome for the development of the Project. The removal of SRE habitat within the Development Envelope will result in the loss of SRE populations that reside in those habitats.

Eleven broad habitats were identified in the Study Area. Of these habitats; Rocky Ridge and Gorge, and Granite Outcrop habitats were considered to have a high potential to support SRE species. Drainage Line habitat was identified as having a medium potential to support SRE species. Approximately 249.26 ha (14.1 %) of Rocky Ridge and Gorge and 55.72 ha (11.1 %) of the Drainage Line habitat is located within the Development Envelope (**Table 7-1**). No Granite Outcrop habitat occurs within the Development Envelope for the Project (**Table 7-1**). Together these two habitats comprise a total of 304.98 ha (12.5%) of the Development Envelope (**Table 7-1**).

The remaining habitats were considered to have a low potential to support SRE species. The development of the Project will largely impact habitats unlikely to support SRE species, namely the Spinifex Stony Plains, Ironstone Ridgetops and the Stony Rises.

Table 7-1: Extent of habitat within the Development Envelope

Broad Fauna Habitat	Likelihood of supporting SRE Taxa	Extent within* (ha)		
		Study Area (ha)	Development Envelope	Disturbance Footprint
Stony Rise	Low	7,703	532.74 (6.9%)	79.10 (1.0%)
Rocky Foothills	Low	4,458	76.27 (1.7%)	11.04 (0.2%)
Spinifex Stony Plain	Low	1,876	607.97 (32.4%)	99.66 (5.3%)
Rocky Ridge and Gorge	High	1,766	249.26 (14.1%)	42.29 (2.4%)
Ironstone Ridgetop	Low	1,543	537.93 (34.9%)	167.03 (10.8%)
Drainage Line	Medium	502	55.72 (11.1%)	2.70 (0.5%)
Granitic Uplands	Low	238	0.17 (0.1%)	-
Calcrete	Low	235	7.79 (3.3%)	6.71 (19.2%)
Spinifex Sandplain	Low	195	157.60 (80.8%)	12.86 (6.6%)
Riverine	Low	167	37.72 (22.6%)	1.73 (1.0%)
Granite Outcrop	High	163	-	-
	Total	**18,845**	**2,263.19**	**423.12**

*percentages denote extent of that habitat type as a proportion of that habitat existing within the Study Area

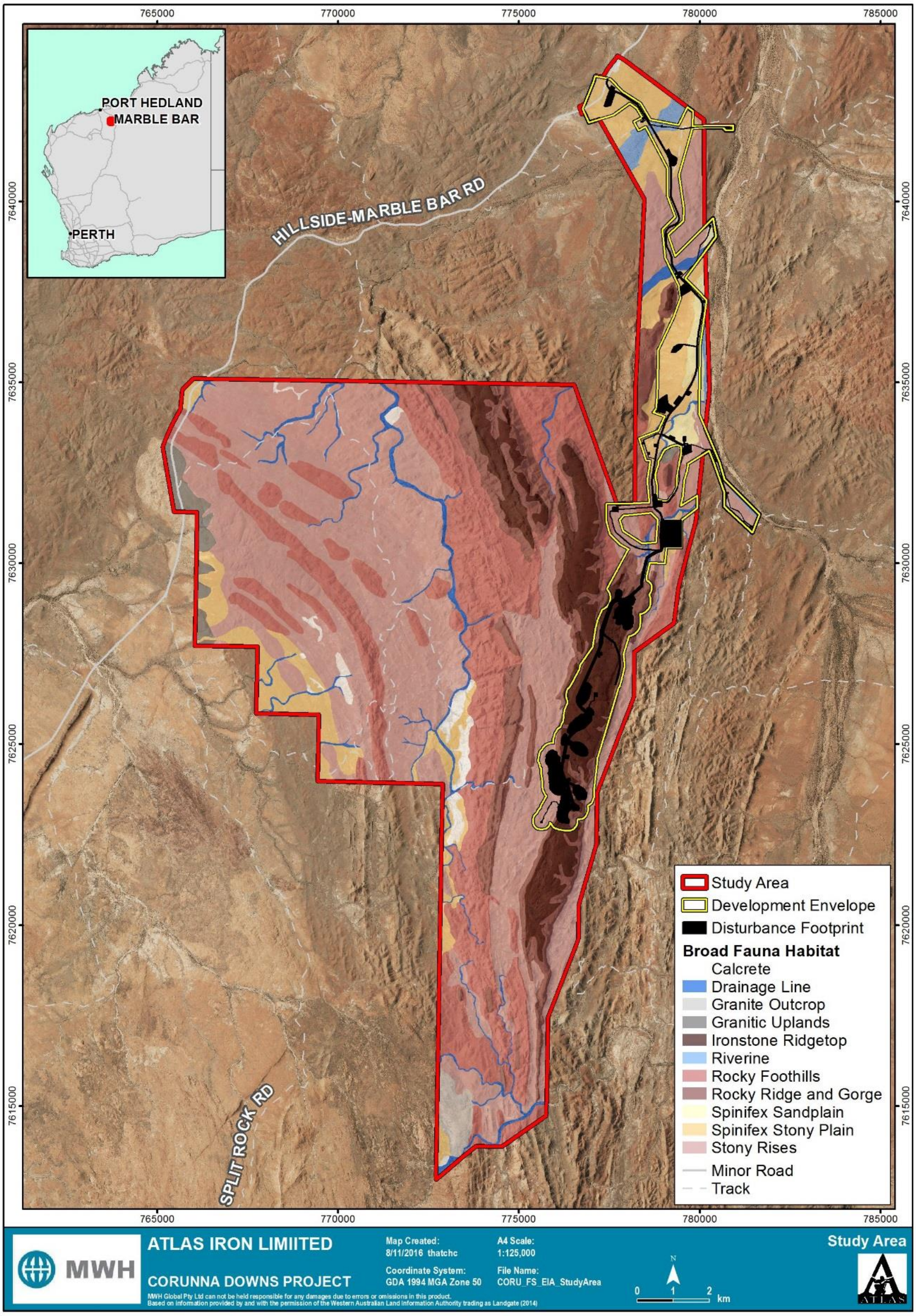

Figure 7-1: Broad habitat in relation to the Development Envelope and the Study Area

7.3 Impacts on Terrestrial SRE Invertebrate Fauna

The desktop study and field surveys identified two Confirmed SRE species, three Likely SRE species and 12 Potential SRE species. Of these, no confirmed, two Likely and six potential SRE species were collected from within the Development Envelope (**Table 7-2**). None of these species were collected exclusively from within the Development Envelope and all species were collected outside the Development Envelope.

For brevity, only confirmed, likely and potential SRE species recorded within the Development Envelope are discussed in the following sections (**Sections 7.3.1 - 7.3.3**). Those species only recorded outside the Development Envelope are not discussed further in this report. Indeterminate species (yellow highlight in **Table 7-2**) are species that could not be identified to species level using morphology. These species may represent SRE taxa however molecular testing wold be required for confirmation. Molecular testing of these specimens was not pursued as they were collected outside the Development Envelope for the Project.

Table 7-2: SRE species in relation to the Development Envelope

Group	Taxa	SRE status	Recorded within Development Envelope?	Recorded outside Development Envelope?
Selenopid spiders	*Karaops* 'sp. indet.1'	Potential	No	Yes
	Karaops 'sp. indet.2'	Potential	Yes	Yes
Mygalomorph spiders	*Aurecocrypta* sp. indet	Potential	No	Yes
	Aname sp. indet.	Potential	No	Yes
Scorpions	*Lychas* 'gracilimanus complex'	Potential	No	Yes
	Lychas 'bituberculatus complex'	Potential	Yes	Yes
	Lychas 'hairy tail complex'	Potential	Yes	Yes
	Urodacus 'pilbara 16'	Potential	No	Yes
	Urodacus sp. indet.	Potential	No	Yes
Pseudoscorpions	*Feaella* sp. 'nov'	Confirmed	No	Yes
Slaters	*Acanthodillo* sp. indet.	Likely	No	Yes
	Buddelundiinae 'mw'	Likely	Yes	Yes
	Philosciidae 'corunna'	Likely	Yes	Yes
	Buddelundia '11'	Potential	Yes	Yes
	Buddelundia '86'	Potential	Yes	Yes
Millipedes	Paradoxosomatidae sp. indet.	Confirmed	No	Yes
Terrestrial Snails	*Rhagada* 'convicta complex'	Potential	No	Yes
	Rhagada sp. 'nov'	Potential	Yes	Yes

* *Yellow highlight:* Species not identified to species or morphospecies

7.3.1 Likely SRE species

Buddelundiinae 'mw'

Fifty-two (52) specimens of slater from the family Buddelundiinae 'mw' were collected from eight sites within Rocky Ridge and Gorge habitat during the survey (**Section 5.2.2**). Impacts to this species are likely to be minimal as only one of those sites occurs within the Development Envelope (**Figure 7-2**). Furthermore, the species is known to have a regional distribution that extends well outside of the Study Area away from potential impacts of the Project (**Figure 5-4**).

Philosciidae 'corunna'

Two specimens (one male and one female) of slater from the family Philosciidae 'corunna' were collected from two sites within Rocky Ridge and Gorge habitat (**Section 5.2.2**). Although one specimen was collected within the Development Envelope, the Project is unlikely to affect the long term survival of Philosciidae 'corunna' as the other specimen was collected more than 2.5 km outside the Development Envelope (**Figure 7-2**).

7.3.2 Potential SRE species – SRE habitats

***Karaops* 'sp. indet.2'**

Six specimens of the selenopid spider *Karaops* 'sp. Indet 2' have been identified from five sites within Rocky Ridge and Gorge habitat (**Section 5.2.3**). The Project is unlikely to affect the long term survival of the species as only two of these sites occur within the Development Envelope. Additionally, the Rocky Ridge and Gorge habitat extends north and south of the Project outside the proposed mining area (**Figure 7-2**).

***Rhagada* sp. 'nov'**

A single specimen of the snail *Rhagada* sp. 'nov' was collected from Rocky Ridge and Gorge habitat during this survey (**Section 5.2.3**). The specimen was collected from a location within the Development Envelope (**Figure 7-2**), however other specimens of the species have been collected approximately 350 km west and 145 km east of the Project (**Section 5.2.3**). Although the species is considered a potential SRE species as it is only known from habitats with limited distributions in the landscape (drainage lines, riparian zones and gorges), its large range suggests that the Project is unlikely to affect the long term survival of the species.

7.3.3 Potential SRE species – Widespread habitats

***Lychas* 'bituberculatus complex'**

Seventy (70) scorpion specimens from the *Lychas* 'bituberculatus complex' were collected from ten sites within Rocky Ridge and Gorge habitat, two sites in Stony Rise habitat, one site in Rocky Foothills and one site in Calcrete habitat (**Section 5.2.4**). Only two of these sites were located within the Development Envelope, both within Rocky Ridge and Gorge habitat (**Figure 7-3**). Although relatedness between the specimens collected within the Study Area is not certain, it is probable that the same form within the complex occurs across the Rocky Ridge and Gorge sites. Given that six of the Rocky Ridge and Gorge sites occur outside the Development Envelope, it is unlikely that the Project will affect the long term survival of the species.

***Lychas* 'hairy tail complex'**

Thirty-six (36) scorpion specimens from the *Lychas* 'hairy tail complex' were collected from seven sites within Rocky Ridge and Gorge habitat and a single specimen was collected from a site within Stony Rise habitat (**Section 5.2.4**). Only two of these sites were located within the Development Envelope, both within Rocky Ridge and Gorge habitat (**Figure 7-3**). Although relatedness between the specimens collected within the Study Area is not certain, it is likely that the same form within the complex occurs across the Rocky Ridge and Gorge sites. Given that five of the Rocky Ridge and Gorge sites occur outside the Development Envelope, it is unlikely that the Project will affect the long term survival of the species.

***Buddelundia* '11'**

One hundred and sixteen (116) specimens of *Buddelundia* '11' were recorded from three sites within Rocky Ridge and Gorge habitat, two sites in Drainage Line habitat, and one site in each of Stony Rise, Ironstone Ridgetop and Calcrete habitats (**Section 5.2.4**). Given that only three of these eight sites occur within the Development Envelope, it is unlikely that the Project will affect the long term survival of the species (**Figure 7-3**). Furthermore, the species is known to have a regional distribution that extends well outside of the Study Area away from potential impacts of the Project (**Figure 5-4**).

***Buddelundia* '86'**

Thirty-four (34) specimens of *Buddelundia* '86' were recorded across single sites in the Stony Rise, Rocky Foothills, Ironstone Ridgetop, Calcrete and Spinifex Sandplain habitats (**Section 5.2.4**). Given that only two of these five sites occur within the Development Envelope, it is unlikely that the Project will affect the long term survival of the species (**Figure 7-3**). Furthermore, the species is known to have a regional distribution that extends well outside of the Study Area away from potential impacts of the Project (**Figure 5-4**).

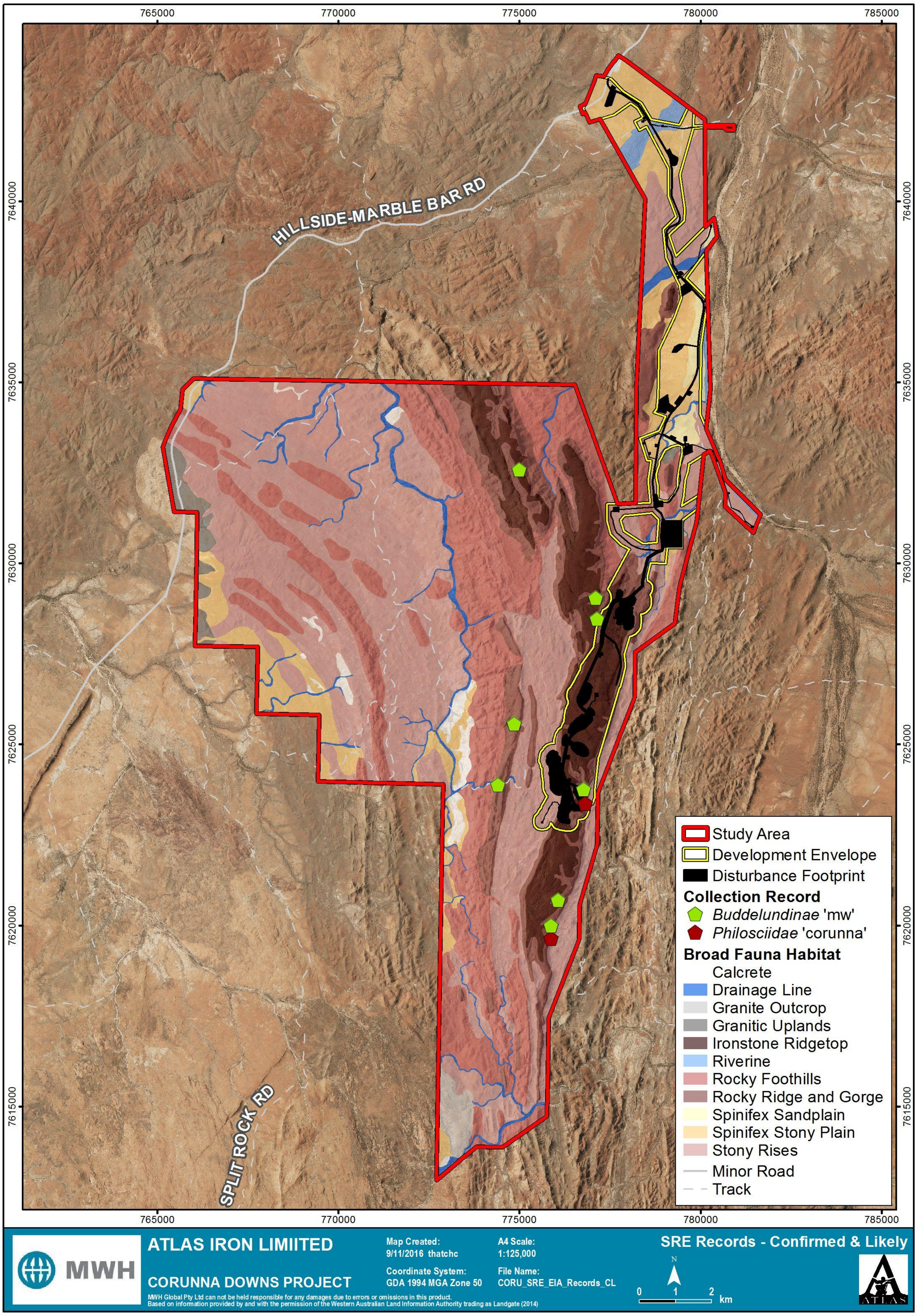

Figure 7-2: Likely SRE species that occur within the Development Envelope

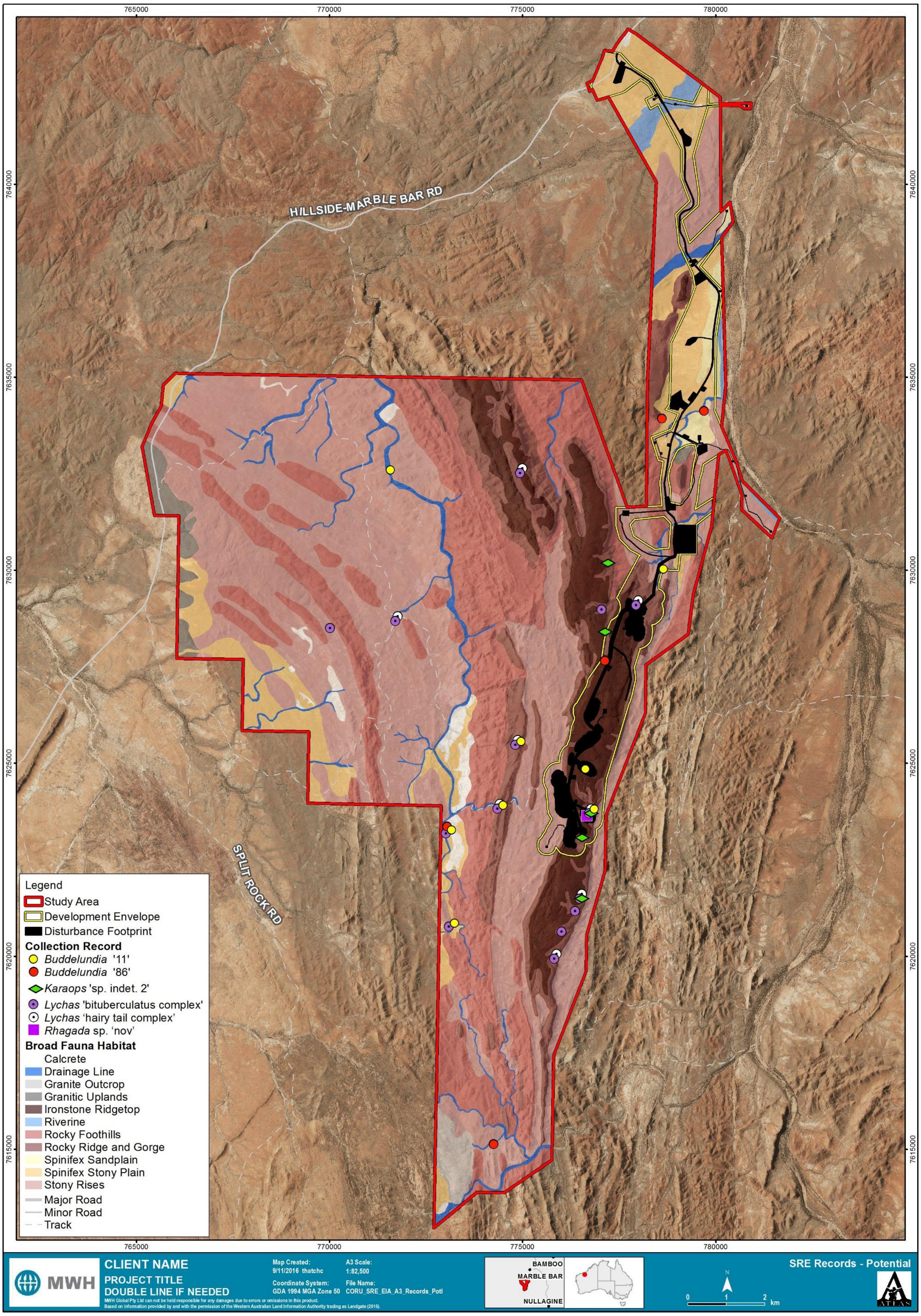

Figure 7-3: Potential SRE species that occur within the Development Envelope

8 Conclusion

The survey of the Study Area recorded 31 species from target SRE groups. Based on current scientific knowledge of species collected within the Study Area, two species were considered by experts as Confirmed SRE species, three as Likely SRE species and 13 as Potential SRE species.

The two confirmed SRE species were:

- *Feaella* sp. nov. (pseudoscorpion)
- Paradoxosomatidae sp. indet. (millipede)

The three likely SRE species were:

- *Acanthodillo* sp. indet. (slater)
- Buddelundiinae 'mw' (slater)
- *Philosciidae* 'corunna' (slater)

Of these species, two Likely and six Potential SRE species were collected from within Development Envelope. However, none of these species have been collected exclusively from within the Development Envelope with all species collected outside the Development Envelope, either locally or regionally.

The desktop study identified one species, the millipede *Antichiropus* `DIP038' with a high potential to occur; and an additional two species, the millipede *Antichiropus* `DIP034` and snail *Rhagada richardsonii* have a medium potential to occur in the Study Area. Even if these species were found to occur within the Development Envelope for this Project, the presence of regional records suggests that the Project is unlikely to affect their long term survival.

Eleven broad habitats were identified within the Study Area. Two of these habitats, Rocky Ridge and Gorge and Granite Outcrops, have a high potential to support SRE species. Additionally, one habitat, Drainage Lines, has a medium potential to support SRE species.

Approximately 249.26 ha (14.1 %) of Rocky Ridge and Gorge and 55.72 ha (11.1 %) of the Drainage Line habitat is located within the Development Envelope. No Granite Outcrop habitat occurs within the Development Envelope for the Project. Together these two habitats comprise a total of 304.98 ha (12.5%) of the Development Envelope. The Development Envelope largely comprises habitats with a low potential to support SRE species, namely Spinifex Stony Plains, Ironstone Ridgetop and Stony Rise. It is unlikely that any SRE taxa recorded during this Survey is likely to be adversely impacted by development of the Project. Habitat clearing poses the largest threat of the Project to SRE and as such, clearing should, where possible, avoid habitats considered of High or Medium likelihood to support SRE taxa.

9 References

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Appendices

Appendix A Potential Terrestrial SRE Invertebrate Species Identified in the Desktop Study

Species Name	Taxa	Source	Reference	Habitat(s)	Likelihood of occurrence in the Study Area	Reason for Likelihood	
						Similar habitat present in Study Area?	Closest record to Study Area
Antichiropus \`DIP038\`	Millipede	WA Museum	(Western Australian Museum 2014a)	Drainage line	High	Yes	1 km west
Buddelundia sp. 11	Slater	McPhee Creek Mine and Rail Project: East-west Transport Corridor	(Outback Ecology 2014)	Rocky Ridge and Gorge, Granite Outcrop, Rocky Foothills, Drainage Line, Channel Iron Deposit, Stony Rise, Spinifex Stony Plain	Medium	Yes	15 km south
		McPhee Creek Iron Ore Project	(Outback Ecology 2012e)				
		Mt Webber DSO Project	(Outback Ecology 2013c)				
		Abydos DSO Project	(Outback Ecology 2013a)				
Rhagada richardsonii	Snail	WA Museum	(Western Australian Museum 2014b)	Rocky ridge and gorge	Medium	Yes	20 km east
Antichiropus \`DIP034\`	Millipede	WA Museum	(Western Australian Museum 2014a)	Urban (natural habitat unknown)	Medium	Possible	23 km north-east
Buddelundiinae 'mw'	Slater	Mt Webber DSO Project	(Outback Ecology 2013c)	Rocky Ridge and Gorge, Granite Outcrop, Rocky Foothills,	Low	Yes	32 km west
Buddelundia sp. nov 18	Slater	McPhee Creek Iron Ore Project	(Outback Ecology 2012e)	Spinifex Stony Plain, Rocky Ridge and Gorge, Channel Iron Deposit	Low	Yes	32 km west
		Mt Webber DSO Project	(Outback Ecology 2013c)				
		Abydos DSO Project	(Outback Ecology 2013a)				

Species Name	Taxa	Source	Reference	Habitat(s)	Likelihood of occurrence in the Study Area	Reason for Likelihood	
						Similar habitat present in Study Area?	Closest record to Study Area
Buddelundia '86'	Slater	McPhee Creek Mine and Rail Project: East-west Transport Corridor	(Outback Ecology 2014)	Rocky foothills Stony Rise	Low	Yes	50 km west
Quistrachia turneri	Snail	WA Museum	(Western Australian Museum 2014b)	Rocky ridge and gorge	Low	Yes	32 km south-west
		Mt Webber DSO Project	(Outback Ecology 2013c)				
Rhagada radleyi	Snail	WA Museum	(Western Australian Museum 2014b)	Spinifex sand plain	Low	Yes	30 km north-west
Missulena `MYG110`	Mygalomorph spider	WA Museum	(Western Australian Museum 2014a)	Spinifex sand plain	Low	Yes	40 km east
Antichiropus `DIP026`	Millipede	WA Museum	(Western Australian Museum 2014a)	Rocky ridge and gorge, drainage line	Low	Yes	40 km east
Kwonkan `MYG200`	Mygalomorph spider	WA Museum	(Western Australian Museum 2014a)	Rocky footslope	Low	Yes	32 km west
		Mt Webber DSO Project	(Outback Ecology 2013c)				
Karaops `aurizon`	Araneomorph spider	WA Museum	(Western Australian Museum 2014a)	Rocky footslope, Granite outcrop	Low	Yes	80 km west
Karaops `BD1 (juvenile)`	Araneomorph spider	WA Museum	(Western Australian Museum 2014a)	Rocky ridge and gorge	Low	Yes	85 km south
Karaops feedtime	Araneomorph spider	WA Museum	(Western Australian Museum 2014a)	Stony plain	Low	Yes	85 km south
Karaops forteyi	Araneomorph spider	WA Museum	(Western Australian Museum 2014a)	Rocky footslope, Stony plain	Low	Yes	90 km south-west

Species Name	Taxa	Source	Reference	Habitat(s)	Likelihood of occurrence in the Study Area	Reason for Likelihood	
						Similar habitat present in Study Area?	Closest record to Study Area
Karaops kariyarra	Araneomorph spider	WA Museum	(Western Australian Museum 2014a)	Rocky ridge and gorge	Low	Yes	70 km west
Karaops nyamal	Araneomorph spider	WA Museum	(Western Australian Museum 2014a)	Rocky ridge and gorge	Low	Yes	32 km west
		Mt Webber DSO Project	(Outback Ecology 2013c)				
Opopaea durranti	Araneomorph spider	WA Museum	(Western Australian Museum 2014a)	Stony plain	Low	Yes	60 km south
Spinasteron woodstock	Araneomorph spider	WA Museum	(Western Australian Museum 2014a)	Granite outcrop	Low	Yes	60 km west
Wesmaldra \`learmonth?\`	Araneomorph spider	WA Museum	(Western Australian Museum 2014a)	Spinifex sand plain	Low	Yes	70 km south-east
Aname \`armigera group?\`	Mygalomorph spider	WA Museum	(Western Australian Museum 2014a)	Spinifex sand plain	Low	Yes	70 km west
Aname \`MYG368-DNA\`	Mygalomorph spider	WA Museum	(Western Australian Museum 2014a)	Acacia woodland	Low	Yes	80 km south-east
Aname \`MYG371-DNA\`	Mygalomorph spider	WA Museum	(Western Australian Museum 2014a)	Drainage line	Low	Yes	40 km west
Aname \`MYG372-DNA\`	Mygalomorph spider	WA Museum	(Western Australian Museum 2014a)	Drainage line	Low	Yes	85 km north-west
Anidiops \`MYG083\`	Mygalomorph spider	WA Museum	(Western Australian Museum 2014a)	Drainage line, stony plain, sand dune	Low	Yes	98 km south-west
Anidiops \`MYG308-DNA\`	Mygalomorph spider	WA Museum	(Western Australian Museum 2014a)	Spinifex sand plain	Low	Yes	90 km south-west

Species Name	Taxa	Source	Reference	Habitat(s)	Likelihood of occurrence in the Study Area	Reason for Likelihood	
						Similar habitat present in Study Area?	Closest record to Study Area
Aurecocrypta `MYG318-DNA`	Mygalomorph spider	WA Museum	(Western Australian Museum 2014a)	Rocky ridge and gorge	Low	Yes	55 km north-west
Conothele `MYG282-DNA`	Mygalomorph spider	WA Museum	(Western Australian Museum 2014a)	Spinifex sand plain	Low	Yes	125 km south-west
Synothele `MYG114`	Mygalomorph spider	WA Museum	(Western Australian Museum 2014a)	Spinifex sand plain	Low	Yes	45 km south-east
Synothele `MYG193`	Mygalomorph spider	WA Museum	(Western Australian Museum 2014a)	Spinifex sand plain	Low	Yes	70 km south-east
Synothele `MYG334`	Mygalomorph spider	WA Museum	(Western Australian Museum 2014a)	Rocky footslope	Low	Yes	50 km north-east
Oratemnus `PSE018`	Pseudoscorpion	WA Museum	(Western Australian Museum 2014a)	Drainage line	Low	Yes	52 km west
Synsphyronus `PSE006`	Pseudoscorpion	WA Museum	(Western Australian Museum 2014a)	Acacia woodland	Low	No	90 km south
Synsphyronus `PSE008`	Pseudoscorpion	WA Museum	(Western Australian Museum 2014a)	Granite outcrop	Low	Yes	80 km north-west
Synsphyronus `PSE012`	Pseudoscorpion	WA Museum	(Western Australian Museum 2014a)	Rocky ridge and gorge	Low	Yes	90 km west
Xenolpium `PSE063`	Pseudoscorpion	WA Museum	(Western Australian Museum 2014a)	Rocky ridge and gorge	Low	Yes	50 km east
Antichiropus `DIP005`	Millipede	WA Museum	(Western Australian Museum 2014a)	Drainage line, rocky ridge and gorge	Low	Yes	45 km north-west
Antichiropus `DIP011 ?`	Millipede	WA Museum	(Western Australian Museum 2014a)	Drainage line	Low	Yes	52 km north

Species Name	Taxa	Source	Reference	Habitat(s)	Likelihood of occurrence in the Study Area	Reason for Likelihood	
						Similar habitat present in Study Area?	Closest record to Study Area
Antichiropus \`DIP012\`	Millipede	WA Museum	(Western Australian Museum 2014a)	Drainage line	Low	Yes	83 km south-west
Antichiropus \`DIP013\`	Millipede	WA Museum	(Western Australian Museum 2014a)	Drainage line	Low	Yes	90 km south-west
Antichiropus \`DIP031\`	Millipede	WA Museum	(Western Australian Museum 2014a)	Drainage line	Low	Yes	90 km south
Dampetrus \`aurizon\`	Harvestman	WA Museum	(Western Australian Museum 2014a)	Rocky footslope	Low	Yes	80 km west
Feaella \`PSE007\`	Pseudoscorpion	WA Museum	(Western Australian Museum 2014a)	Gully	Low	Yes	50 km west
Lychas \`bituberculatus group\`	Scorpion	WA Museum	(Western Australian Museum 2014a)	Rocky ridge and gorge	Low	Yes	90 km west
Urodacus \`cloudbreak\`	Scorpion	WA Museum	(Western Australian Museum 2014a)	Spinifex sand plain	Low	Yes	95 km south
Urodacus \`nullagine dark\`	Scorpion	WA Museum	(Western Australian Museum 2014a)	Spinifex sand plain	Low	Yes	80 km south
Leichhardtia sisurnius	Snail	WA Museum	(Western Australian Museum 2014b)	Rocky ridge and gorge	Low	Yes	60 km north-east

Appendix B Surveys sites sampled during the survey

Systematic and targeted SRE survey sites and vertebrate fauna surveys sites sampled during the survey

Site	Survey type	Habitat	Site location: Coordinates (GDA 94 MGA 50K) Easting	Northing
1	SRE Systematic	Rocky Ridge and Gorge	776069	7620695
2		Rocky Ridge and Gorge	776778	7623754
3		Rocky Ridge and Gorge	776534	7621547
4		Rocky Ridge and Gorge	774412	7623883
5		Drainage Line	771494	7632568
6		Rocky Ridge and Gorge	774876	7625530
7		Drainage Line	774441	7614150
8		Stony Rise	773155	7620821
9		Rocky Ridge and Gorge	777108	7629038
10		Rocky Ridge and Gorge	778001	7629154
11		Rocky Ridge and Gorge	775878	7619992
12		Stony Rise	771767	7628739
13		Rocky Ridge and Gorge	774997	7632578
TAR 1	SRE Targeted	Rocky Ridge and Gorge	776816	7623722
TAR 2		Drainage Line	768321	7633617
TAR 3		Rocky Ridge and Gorge	776384	7625465
TAR 4		Rocky Ridge and Gorge	776723	7627344
TAR 5		Rocky Ridge and Gorge	776343	7623077
TAR 6		Rocky Ridge and Gorge	776419	7621227
A	Phase 1 Fauna	Stony Rises	774282	7615008
B		Rocky Foothills	770070	7628561
C		Ironstone Ridgetop	777821	7629088
D		Ironstone Ridgetop	777157	7627542
E		Stony Rises	770456	7625676
F		Calcrete	773076	7623244
G		Drainage Line	773188	7623701
H		Ironstone Ridgetop	776543	7624814
I		Rocky Ridge and Gorge	776540	7623125
J		Drainage Line	774445	7614177
Site C	Phase 2 Fauna	Ironstone Ridgetop	777821	7629088
Site D		Ironstone Ridgetop	777157	7627542
Site F		Calcrete	773076	7623244
Site G		Drainage Line	773188	7623701
Site H		Ironstone Ridgetop	776543	7624814
Site I		Rocky Ridge and Gorge	776540	7623125
Site K		Stony Rises	778971	7638743
Site L		Riverine	780130	7636330
Site M		Rocky Foothills	778638	7633811
Site N		Spinifex Sandplain	779725	7634010

Appendix C Site Descriptions

Site 3	**Co-ordinates:** 50K 776534 7621547

Broad Habitat Type:	Rocky Ridge and Gorge
Landform:	Ridge face (eastern aspect)
Soil Type:	Sandy loam
Disturbance:	Nil
Leaf Litter Cover:	5%
Vegetation Structure:	Mixed *Acacia* and *Eucalyptus* woodland over a grassland dominated by *Eragrostis* sp. in the sheltered areas and *Triodia* sp. in more open areas. Four large *Ficus* tress were present in sheltered area.
Micro-habitats Present:	Isolated sheltered micro-habitats formed by the east-facing ridge face (approximately 10 m high).

Site 4	**Co-ordinates:** 50K 774412 7623883

Broad Habitat Type:	Rocky Ridge and Gorge
Landform:	Gorge
Soil Type:	Silt loam/Sandy clay
Disturbance:	Cattle
Leaf Litter Cover:	5% - 10%
Vegetation Structure:	Dense *Melaleuca* woodland located in areas containing soil substrate, grass species dominated by *Eragrostis* sp. located in between rocky substrate.
Micro-habitats Present:	Gorge varies between relative open to highly incised areas, the latter offering better shelter. *Melaleuca* thickets may potential create micro-habitats.

Site 5	**Co-ordinates:** 50K 771494 7632568

Broad Habitat Type:	Drainage Line
Landform:	Drainage line
Soil Type:	Sandy clay
Disturbance:	Buffel Grass and Cattle
Leaf Litter Cover:	5%
Vegetation Structure:	Mixed *Acacia*, *Eucalyptus* and *Melaleuca* woodland over Buffel grass.
Micro-habitats Present:	Some sheltered micro-habitats created by riparian vegetation.

Site 6	**Co-ordinates:** 50K 774879 7625573

Broad Habitat Type:	Rocky Ridge and Gorge
Landform:	Gorge
Soil Type:	Sandy
Disturbance:	Nil
Leaf Litter Cover:	5%
Vegetation Structure:	Closed *Melaleuca* woodland located in areas containing soil substrate, grass species dominated by *Eragrostis* sp. located in between rocky substrate.
Micro-habitats Present:	Deeply incised gorge creates sheltered micro-habitat, *Melaleuca* thickets may potential create micro-habitats.

Site 7	**Co-ordinates:** 50K 774441 7614150

Broad Habitat Type:	Drainage Line
Landform:	Riverine Drainage Line
Soil Type:	Sandy
Disturbance:	Buffel Grass and Cattle
Leaf Litter Cover:	5%
Vegetation Structure:	Large River Gums (*Eucalyptus camaldulensis*) located on banks, Very open *Melaleuca* woodland present over Buffel and various other grass species (*Eragrostis* sp.)
Micro-habitats Present:	Limited shelter created by riparian vegetation, some leaf litter accumulation under *E. camaldulensis*.

Site 8	**Co-ordinates:** 50K 773155 7620821

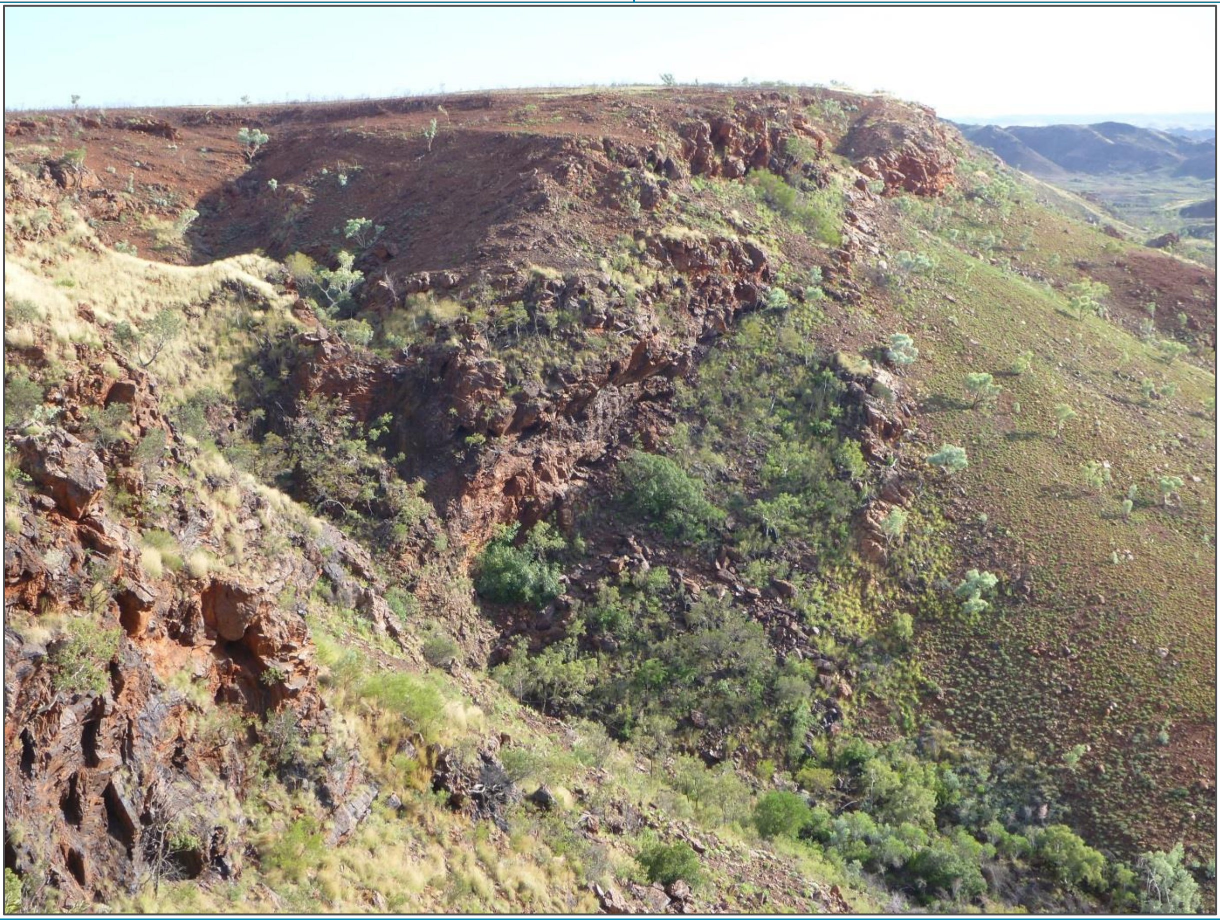
Broad Habitat Type:	Stony Rise
Landform:	Scree slope
Soil Type:	Sandy clay loam
Disturbance:	Nil
Leaf Litter Cover:	5%
Vegetation Structure:	Very spares *Eucalyptus sp.* over a closed grassland of *Triodia sp.*
Micro-habitats Present:	Nil

Site 9	**Co-ordinates:** 50K 777108 7629038
	
Broad Habitat Type:	Rocky Ridge and Gorge
Landform:	Gorge
Soil Type:	Sandy clay loam
Disturbance:	Nil
Leaf Litter Cover:	10%
Vegetation Structure:	Closed *Melaleuca* over *Acacia tumida* woodland.
Micro-habitats Present:	Isolated sheltered micro-habitat formed by surrounding ridge faces. Root mat may also create micro-habitat within the habitat type.

Site 10	**Co-ordinates:** 50K 778108 7629038

Broad Habitat Type:	Rocky Ridge and Gorge
Landform:	Open gully
Soil Type:	Sandy loam
Disturbance:	Nil
Leaf Litter Cover:	5%
Vegetation Structure:	Scattered *Eucalyptus leucophloia*, with small groves of *Acacia tumida* over a closed grassland dominated by *Triodia sp.* Three *Ficus* trees present.
Micro-habitats Present:	Very exposed gully, potential micro-habitats created where leaf litter from *Ficus* trees accumulates.

Site 11	**Co-ordinates:** 50K 775878 7619992



Broad Habitat Type:	Rocky Ridge and Gorge
Landform:	Ridge (eastern aspect)
Soil Type:	Sandy loam
Disturbance:	Nil
Leaf Litter Cover:	10%
Vegetation Structure:	Scattered Eucalyptus and Acacia woodland over grassland dominated by *Eragrostis* sp. Three *Ficus* Trees present
Micro-habitats Present:	Potential micro-habitats created where leaf litter from *Ficus* trees accumulates.

Site 12	**Co-ordinates:** 50K 771767 7628739

Broad Habitat Type:	Stony Rise
Landform:	Plain
Soil Type:	Sandy loam
Disturbance:	Historical residential dwelling
Leaf Litter Cover:	5%
Vegetation Structure:	Scattered *Eucalyptus* over an open woodland of *Acacia bivenosa* over a closed *Triodia* grassland.
Micro-habitats Present:	Nil

Site 13	**Co-ordinates:** 50K 774997 7632578

Broad Habitat Type:	Rocky Ridge and Gorge
Landform:	Gorge
Soil Type:	Sandy loam
Disturbance:	Nil
Leaf Litter Cover:	10-25%
Vegetation Structure:	Scattered *Eucalyptus leucophloia*, with small groves of *Acacia tumida* over a closed grassland dominated by *Triodia* and *Eragrostis* sp. Two *Ficus* trees present
Micro-habitats Present:	Gorge habitat was relatively well shaded by north and south facing ridges. Potential micro-habitats created where leaf litter from *Ficus* trees accumulates

Target 1	**Co-ordinates:** 50K 776816 7623722
	
Broad Habitat Type:	Rocky Ridge and Gorge
Landform:	Gorge
Soil Type:	Sandy loam
Disturbance:	Fire
Leaf Litter Cover:	5%
Vegetation Structure:	Dominated by six large *Ficus* Trees (four burnt).
Micro-habitats Present:	Potential micro-habitats created where leaf litter from *Ficus* trees accumulates

Target 2	**Co-ordinates:** 50K 768321 7633617
	
Broad Habitat Type:	Drainage Line
Landform:	Drainage line
Soil Type:	Sandy loam
Disturbance:	Buffel grass and cattle
Leaf Litter Cover:	5%
Vegetation Structure:	*Eucalyptus victrix* along the banks, open woodland of *Acacia Tumida* over a closed grassland dominated by *Eragrostis* sp. and Buffel grass
Micro-habitats Present:	Nil

Target 3	**Co-ordinates:** 50K 776384 7625465

Broad Habitat Type:	Rocky Ridge and Gorge
Landform:	Ridge top
Soil Type:	Sandy loam
Disturbance:	Fire
Leaf Litter Cover:	5%
Vegetation Structure:	Two large Ficus trees over an open woodland of *Acacia tumida* over an open grassland *Triodia* and *Eragrostis* sp.
Micro-habitats Present:	Potential micro-habitats created where leaf litter from *Ficus* trees accumulates

Target 4	**Co-ordinates:** 50K 776723 7627344

Broad Habitat Type:	Rocky Ridge and Gorge
Landform:	Gorge
Soil Type:	Sandy loam
Disturbance:	Recently burnt
Leaf Litter Cover:	5%
Vegetation Structure:	Mixed *Acacia* and *Eucalyptus* woodland over an open grassland *Triodia* and *Eragrostis* sp.
Micro-habitats Present:	Nil

Target 5	**Co-ordinates:** 50K 776343 7623077

Broad Habitat Type:	Rocky Ridge and Gorge
Landform:	Ridge (eastern aspect)
Soil Type:	Sandy loam
Disturbance:	Nil
Leaf Litter Cover:	5%
Vegetation Structure:	Scattered *Eucalyptus leucophloia*, with small groves of *Acacia tumida* over a closed grassland dominated by *Triodia* and *Eragrostis* sp.
Micro-habitats Present:	Limited sheltered created by east facing ridge face.

Target 6	**Co-ordinates:** 50K 776419 7621227

Broad Habitat Type:	Rocky Ridge and Gorge
Landform:	Gorge
Soil Type:	Sandy loam
Disturbance:	Nil
Leaf Litter Cover:	5%
Vegetation Structure:	Open *Eucalyptus leucophloia* woodland, with small groves of *Acacia tumida* over a closed grassland dominated by *Eragrostis* sp. One large *Ficus* tree present.
Micro-habitats Present:	Sheltered Gorge created by northern and southern ridge faces. Potential micro-habitats created where leaf litter from *Ficus* trees accumulates

Appendix D Identification and assessment of short range endemism of invertebrates from the Corunna Downs Survey, Western Australia

PHOENIX
ENVIRONMENTAL SCIENCES

Identification and assessment of short-range endemism of invertebrates from the Corunna Downs Survey, Western Australia

Prepared for MWH Pty Ltd

August 2014

Taxonomic Report

Identification and assessment of short-range endemism of invertebrates from the Corunna Downs Survey, Western Australia

Prepared for MWH Pty Ltd

Taxonomic Report

Authors: Erich Volschenk and Simon Judd

Reviewer: Volker Framenau

Date: 12 August 2014

Submitted to: Paul Bolton, Arnie Slabber

Chain of authorship and review			
Name	Task	Version	Date
Erich Volschenk	Draft for technical review	1.0	6 August 2014
Simon Judd	Technical review	1.2	6 August 2014
Volker Framenau	Technical review	1.3	6 August 2014
Erich Volschenk	Draft for client comments	1.4	7 August 2014
Volker Framenau	Final submitted to client	1.5	12 August 2014

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EXECUTIVE SUMMARY

In July 2014, Phoenix Environmental Sciences Pty Ltd (Phoenix) was commissioned by MWH Pty Ltd to identify terrestrial invertebrates collected from the Corunna Downs Survey, Western Australia. A total of 740 specimens in 221 samples were identified and screened for short-range endemic (SRE) invertebrate taxa.

There are uncertainties in determining the range-restrictions of many invertebrates in Western Australia due to lack of surveys, lack of taxonomic resolutions within target taxa and problems in identifying certain life stages. To account for these uncertainties Phoenix uses a three-tier categorisation for short-range endemism: confirmed SRE, likely SRE and potential SRE, in addition to widespread species.

The material included at least 28 morphospecies in 21 genera and 18 families.

The material included:

- two confirmed SRE:
  - *Feaella* sp. indet. (family Feaellidae – pseudoscorpion)
  - Paradoxosomatidae sp. indet. (Paradoxosomatidae – keeled millipede)
- three likely SREs:
  - *Acanthodillo* sp. indet. (Armadillidae – slater)
  - Buddelundiinae 'mw' (Armadillidae – slater)
  - Philosciidae 'corunna' (Philosciidae – slater)
- seven potential SREs:
  - *Karaops* sp. indet. (Selenopidae – wall crab spider)
  - *Aname* sp. indet. (Nemesiidae – wishbone trapdoor spider)
  - *Aurecocrypta* sp. indet. (Barychelidae – brush-footed trapdoor spiders)
  - *Buddelundia* '11' (Armadillidae – slater)
  - *Buddelundia* '86' (Armadillidae – slater)
  - *Lychas* 'gracilimanus' (Buthidae – scorpion)
  - *Urodacus* 'pilbara 16' (Urodacidae – scorpion).

1 Scope of works

In February 2014, Phoenix Environmental Sciences Pty Ltd (Phoenix) was commissioned by MWH Pty Ltd to identify terrestrial invertebrates collected from the East West Rail Spur Project, Western Australia. A total of 740 specimens in 221 samples were identified and screened for short-range endemic (SRE) invertebrate taxa.

2 Background

2.1.1 Short-range endemic invertebrates

Short-range endemic fauna are defined as animals that display restricted geographic distributions, nominally less than 10,000 km^2, that may also be disjunct and highly localised (Harvey 2002; Ponder & Colgan 2002). Isolating mechanisms and features such as inhospitable habitat, roads, urban infrastructure, large creek lines and ridges can act to prevent the dispersal and gene flow of the less mobile invertebrate species.

Short-range endemism in terrestrial invertebrates is believed to have evolved through two primary processes (Harvey 2002):

- **Relictual short-range endemism**: relictual SREs are thought to have had wider distributions during more mesic geological periods. Australia's aridification over the last 60 million years resulted in a contraction of the ranges of these species into relatively small habitat pockets where moist conditions persist (relictual Gondwanan habitats). Evolutionary processes over long periods of isolation typically resulted in each population developing into a distinctive species. Millipedes and slaters are typical relictual SREs and they are generally found in deep gullies often on the south-facing slopes of mountains, hills and ridges. Relictual SREs often inhabit areas with: high rainfall, areas where topography induces fog, areas with permanent water (swamps, creek lines and river systems) or deep litter beds. Sometimes habitats have various combinations of these features.
- **Habitat specialisation**: habitat specialist SREs may have settled in particular isolated habitat types by means of dispersal or phoresy (transport of one organism by another) and evolved in isolation into distinct species. Such habitat islands include rocky outcrops (pseudoscorpions in the genus *Synsphyronus* or spiders in the family Selenopidae are typical examples) or salt lakes (e.g. wolf spiders of the genus *Tetralycosa*). Unlike relictual SREs in mesic habitats, habitat specialist SREs are restricted by environmental parameters other than humidity and are often found in arid environments such as the Pilbara.

Invertebrate groups that contain SRE taxa are generally well distributed across the Australian landscape and well adapted to semi-arid environments due to a variety of behavioural and morphological features that have developed to avoid desiccation and predation. They generally possess (Harvey 2002):

- poor powers of dispersal
- confinement to discontinuous habitats
- seasonality, i.e. only active in cooler or wetter months
- slow growth
- low levels of fecundity.

2.1.2 Categories of short-range endemism

There is uncertainty in categorising a specimen as SRE which originates in a number of factors including:

- **Poor regional survey density** (sometimes taxon-specific): A regional fauna is simply not known well enough to assess the distribution of species. This factor also considers the fact that, simply because a species has not been found regionally, does not mean it is really absent; this confirmation ('negative proof') is almost impossible to obtain ('absence of proof is not proof of absence').
- **Lack of taxonomic resolution**: many potential SRE taxa (based on habitat constraints, SRE status of closely related species, or morphological peculiarities such as troglomorphism) have never been taxonomically treated and identification to species level is very difficult or impossible as species-specific character systems have not been defined. Good taxonomic resolution does not necessarily require a published revision, but generally requires a taxonomist to be actively working on this group or a well-established, preferably publicly available, reference collection (i.e. museum collection).
- **Problems of identification**: SRE surveys often recover life stages of potential SRE taxa that cannot be confidently identified based on morphological characters, even if revisions exist. These include, for example, juvenile or female millipedes, mygalomorph spiders and scorpions. Molecular techniques are increasingly being employed to overcome these identification problems.

Currently, there is no accepted system to determine the likelihood that a species is an SRE. The WA Museum has recently introduced a three tier-rating (confirmed, potential and not SRE - widespread) (Western Australian Museum 2013). In contrast, Phoenix employs a system that differentiates an additional level of short-range endemism, 'likely', which, in comparison to the WA Museum, discriminates further to facilitate setting conservation or management priorities (Table 2-1). These categories are dynamic and can change with every single survey as knowledge of SRE status is updated. For example, the millipede *Austrostrophus stictopygus* (order Spirobolida) has been shown to be widespread in the Pilbara based on material collected as part of environmental assessment studies, following its initial description from few localities (Harvey *et al.* 2011; Hoffman 2003).

Life stages of species that cannot be identified at the species level, e.g. some females and juveniles, are assessed based on the knowledge of the higher taxon they belong to, i.e. family or genus. For example, all juvenile or female *Antichiropus* millipedes would be classified as 'confirmed SRE' as all but a few of the 140+ known species in this genus are currently considered SREs (Wojcieszek *et al.* 2011).

Although the different categories of 'SRE-likelihood' may help to set conservation priorities, SRE taxa of all categories should be assessed on their merit, in order to determine appropriate conservation measures that adhere to the Precautionary Principle within environmental impact assessments. That is, "*where there are threats of serious or irreversible environmental damage, lack of full scientific certainty should not be used as a reason to postpone measures to prevent environmental degradation*" (EPA 2002).

Table 2-1 Phoenix SRE categories reflecting survey, taxonomic and identification uncertainties

SRE category	Criteria	Typical representative
Confirmed	Confirmed or almost certainly SRE; taxonomy of the group is well known (but not necessarily published); group well represented in collections, in particular from the region in question; high levels of endemism in documented species; inference is often possible from immature specimens	*Antichiropus* millipedes (Paradoxosomatidae); scorpions in the genus *Aops* (Urodacidae)
Likely	Taxonomically poorly resolved group; unusual morphology for the group (i.e. some form of troglomorphism); often singleton in survey and few, if any, regional records	Opiliones in the genus *Dampetrus*; some pseudoscorpions (*Synsphyronus*) and slaters (Philosciidae); some araneomorph spiders in the genus *Karaops* (Selenopidae)
Potential	Taxonomically poorly resolved group; often common in certain microhabitats in SRE surveys (i.e. litter dwellers), but no other regional records; congeners often widespread	Many mygalomorph spiders; some centipedes (Cryptopidae; Geophilomorpha)
Widespread	Taxonomically well resolved (but often not published) and demonstrated wide distribution (i.e. > 10,000 km^2)	

2.2 IDENTIFICATION AND PERSONNEL

All taxa were examined in 70% or 100% ethanol under Leica M80 and M205C stereomicroscopes.

The method of identification for each taxon, i.e. by taxonomic literature or comparison with type or other reference material, is indicated in the taxonomic part of this report. Phoenix personnel involved in the identification are listed in Table 2-2.

Table 2-2 Phoenix personnel involved in identification

Name	Qualifications	Taxa
Dr Erich Volschenk	Ph.D. (Zool.)	Scorpiones and Pseudoscorpiones
Dr Simon Judd	Ph. D. (Env Mgmt)	Isopoda
Dr Volker Framenau	Ph.D. (Zool.)	Araneae and Diplopoda

2.3 TAXONOMY AND NOMENCLATURE

The taxonomic nomenclature of invertebrates follows the references detailed in Table 2-3.

Morphospecies designations of undescribed species are generally adopted from the parataxonomic framework of the scientist(s) working on the group. These informal morphospecies names are given between apostrophes. These names are not valid under the International Code of Zoological Nomenclature (ICZN 1999) and therefore not written in italics.

The Phylogenetic Species Concept, as defined by Cracraft (1983) is adopted when delineating morphospecies.

Table 2-3 Nomenclatural references, morphospecies designations and reference collections for the invertebrates from the Corunna Downs Survey, Western Australia

Taxonomic group	Taxonomic reference for described species and higher taxa	Morphospecies designation and reference collection
Araneae (Araneomorphae)	Platnick (2014); Framenau (2014)	Reference collection at WAM
Araneae (Mygalomorphae)	Platnick (2014); Framenau (2014)	“MYG”- morphospecies designation developed by V.W. Framenau (WAM, Phoenix), reference collection at WAM
Pseudoscorpiones	Harvey (2011a)	“PSE”-morphospecies designation developed by M. Harvey (WAM), reference collection at WAM
Scorpiones	Fet *et al.* (2000), Glauert (1925), Koch, (1977), Kovařík (1997), Kovařík (2002), Volschenk and Prendini (2008), Volschenk *et al.* (2000) Volschenk *et al.* (2012)	Morphospecies designation developed by E.S. Volschenk (WAM, Phoenix), reference collection at WAM
Isopoda	Schmalfuss (2003); Schmidt and Leistikow (2004); Schotte *et al.* (2008)	Morphospecies designation developed by S. Judd (Phoenix), reference collection at WAM, temporarily housed at Phoenix.

2.4 SPECIMEN DEPOSITORY

The EPA guidance statement No. 20 (‘*Sampling of short-range invertebrate fauna for environmental impact assessment in Western Australia*’) (EPA 2009) recommends that all specimens representing SRE target groups are lodged with the WAM to enhance the knowledge of the distribution of putatively rare species. Phoenix adheres to this recommendation and all of the survey specimens will be lodged with the WA Museum.

The WA Museum only issues registration numbers upon lodgement of specimens. Phoenix is therefore not able to provide registration numbers for all specimens (see Appendix 1), which will be provided after lodgement.

3 RESULTS

3.1 SUMMARY

The material included at least 28 morphospecies in 21 genera and 18 families (Table 3-1; Appendix 1). The material included two confirmed SREs, three likely SRE's and seven potential SREs (Table 3-1).

Table 3-1 Status of SRE target invertebrate from the Corunna Downs Survey, Western Australia

Higher taxon	Species	SRE status	Remarks
Araneomorphae (modern spiders)			
Selenopidae	*Karaops nyangumarta*	Widespread	
	Karaops sp. indet.	Potential	Maybe *K. nyangumarta*
Trochanteriidae	Trochanteriidae sp. indet.	Widespread	
Mygalomorphae (trapdoor spiders)			
Barychelidae	*Aurecocrypta* sp. indet.	Potential	
Nemesiidae	*Aname* sp. indet.	Potential	
Pseudoscorpiones (pseudoscorpions)			
Atemnidae	*Oratemnus* sp. indet.	Widespread	
Feaellidae	*Feaella* sp. nov.	Confirmed	
Garypidae	*Synsphyronus* '8/3 pilbara'	Widespread	
Olpiidae	*Austrohorus* sp. indet.	Widespread	
	Beierolpium '8/3'	Widespread	
	Beierolpium sp. indet.	Widespread	
	Indolpium sp. indet.	Widespread	
	Xenolpium sp. indet.	Widespread	
Scorpiones (scorpions)			
Buthidae	*Lychas bituberculatus*	Widespread	
	Lychas 'gracilimanus'	Potential	
	Lychas 'hairy tail grp'	Widespread	
Urodacidae	*Urodacus* 'pilbara 16'	Potential	
	Urodacus 'pilbara 4'	Widespread	
	Urodacus 'pilbara 8'	Widespread	
Diplopoda (millipedes)			
Paradoxosomatidae	Paradoxosomatidae sp. indet.	Confirmed	
Isopoda (slaters)			
Armadillidae	*Acanthodillo* sp. indet.	Likely	
	Buddelundia '11'	Potential	
	Buddelundia '13'	Widespread	
	Buddelundia '14MW'	Widespread	

Higher taxon	Species	SRE status	Remarks
	Buddelundia '18'	Widespread	
	Buddelundia '86'	Potential	
	Buddelundiinae 'abydos'	Widespread	
	Buddelundiinae 'mw'	Likely	
Philosciidae	Philosciidae 'corunna'	Likely	

3.2 Araneae – Araneomorphae (modern spiders)

The Araneae (spiders) are characterised by a number of unique characters, including abdominal appendages modified as spinnerets, silk glands and associated spigots, cheliceral venom glands and male pedipalp tarsi modified as secondary genitalia from sperm transfer (Coddington & Levi 1991). Spiders are one of the largest and most diverse orders of arachnids with more than 40,000 described species worldwide (Platnick 2014), and approximately 3,600 species named from Australia (Framenau 2014).

In contrast to the Mygalomorphae, modern spiders are rarely targeted in SRE surveys. Araneomorphae often disperse very well, for example by wind-drift on gossamer threads (‘ballooning’) (e.g. Bell *et al.* 2005), and many species are widely distributed across the Australian landscape (Harvey 2002). This is in particular true for the members of the ground spiders (family Gnaphosidae), crab spiders (Thomisidae) and Long-spinneret bark spiders (Hersiliidae). Some of these were included in the material (Appendix 1) and are not considered to include any SREs.

3.2.1 Family Selenopidae (wall crab spiders)

Wall crab spiders are small to medium-sized dorso-ventrally flattened spiders. They are superficially similar to huntsmen spiders (family Sparassidae) and flat ground spiders (families Gnaphosidae and Trochanteriidae), but differ by their characteristic eye pattern. Wall crab spiders have a light brown mottled colouration and often strongly banded legs. They are extremely fast runners and therefore very difficult to catch.

Their flat morphology is a perfect adaptation to a life in narrow crevices and they can typically be found under exfoliating slabs of granite outcrops and under bark of trees. The preference for isolated outcrops or mountain ridges predisposes Selenopidae to short-range endemism (Crews & Harvey 2011). Selenopidae occur in tropical and subtropical regions world-wide. In Australia, a single genus, *Karaops*, is known with 37 described species (Crews 2013; Crews & Harvey 2011).

3.2.1.1 Genus *Karaops*

The genus *Karaops* differs from other genera in the family Selenopidae by the spination of the two first pairs of legs and by the absence of scopulae (brushes of dense setae) from their tarsi (Crews 2013; Crews & Harvey 2011). *Karaops* is currently known from Australia only. Sixteen species are described from the Pilbara region and its vicinity of which one, *K. martamarta* is fairly widespread. This supports a high diversity of the genus in the region and suggests restricted ranges for many of the species. Unidentifiable members of the genus are therefore categorised as potential SREs.

***Karaops nyangumarta* Crews, 2013**

Karaops nyangumarta is a widespread species and can be clearly identified by the distinct genitalia, i.e. the two ovate depressions of the female epigyne and the shape of the conductor in the male pedipalp (Crews 2013). The species was originally described based on type material from Southern Flank, ca. 100 km north-east of Newman, but records also included a specimen 150 km north-west of Nullagine in the eastern Pilbara (Crews 2013). *Karaops nyangumarta* is therefore not an SRE.

***Karaops* sp. indet.**

A juvenile specimen of *Karaops* was in the material and could not be identified to species level; it may be *K. nyangumarta*. It is considered a potential SRE based on distribution patterns of known species within the genus.

3.2.2 Family Trochanteriidae (scorpion spiders)

The spider family Trochanteriidae, the long-jawed ground spiders, includes very small to very large spiders. They generally have a greatly flattened carapace with the eyes occupying most of the carapace width. The family name is derived from a greatly elongated trochanter of the fourth leg which might be more than twice as long as that of the third leg; however, this elongation is found in only a few trochanteriid genera (Platnick 2002). Some 115 species of Trochanteriidae in seventeen genera are known from Australia. A single non-indigenous species, *Platyoides walteri*, has apparently been introduce to Western Australia from Africa (Platnick 2002). Dorso-ventrally flattened trochanteriid morphology reflects their habitat preferences for narrow cracks and crevices such as under bark or slabs of exfoliating rock on rocky outcrops. Trochanteriidae are not known to include many, if any, SREs.

Trochanteriidae sp. indet.

The single juvenile of within the samples could not be identified to genus or species level. It is not considered an SRE.

3.3 ARANEAE – MYGALOMORPHAE (TRAPDOOR SPIDERS)

Trapdoor spiders represent one of the focal groups in surveys of SRE taxa (Harvey 2002). A number of mygalomorph spiders, e.g. *Idiosoma nigrum, Kwonkan eboracum* and *Moggridgea tingle* are listed on Schedule 1 of the *Wildlife Conservation (Specially Protected Fauna) Notice 2013* (Western Australian Government 2013). The Western Australian mygalomorph fauna is vast and many families and genera remain taxonomically poorly known (e.g. Barychelidae: *Idiommata*; Idiopidae: *Aganippe*; Nemesiidae: *Aname*, *Chenistonia*, *Kwonkan*).

3.3.1 Family Barychelidae (brush-footed trapdoor spiders)

Barychelid spiders, commonly called brush-footed trapdoor spiders, are small to fairly large in size with well-developed claw tufts and short terminal segment of the posterior lateral spinnerets (Raven 1994). In Western Australia, the genera *Aurecocrypta*, *Idiommata*, *Mandjelia* and *Synothele* are known to occur from the Southwest region into the Pilbara region and *Moruga* has been found in the Kimberleys (Raven 1994). Of all trapdoor spiders, few are as cryptic as the Barychelidae. Their burrows tend to be less than 60 cm deep and often lack the firm thick door of the Ctenizidae or the extensive

3.3.1.1 Genus *Aurecocrypta*

Species of *Aurecocrypta* are very similar to those in the genus *Synothele* but differ in the uniformly dark colour of the abdomen (mottled in *Synothele*) and some details of the male pedipalp. Two species are currently described, both only known from Western Australia, *A. katersi* and *A. lugubris* (Raven 1994); however, additional species are known from the collection of the WA Museum, in particular the Pilbara region of WA based, many of which confirmed based on COI sequence data. Some species in the genus appear to be widespread, whilst others are known from restricted ranges. Undetermined species of *Aurecocrypta* should therefore be considered potential SREs.

***Aurecocrypta* sp. indet.**

Aurecocrypta sp. indet. could not be specifically identified as the specimen is not an adult male. Representatives of this genus are known to have short-range distributions and this species is therefore considered to be a potential SRE.

3.3.2 Family Nemesiidae (wishbone trapdoor spider)

Members of the mygalomorph spider family Nemesiidae are represented in Western Australia by several genera, including *Aname*, *Chenistonia*, *Yilgarnia*, *Stanwellia*, *Teyl*, *Swolnpes* and *Kwonkan* (Main & Framenau 2009). They usually dig burrows in the soil, and do not cover their burrow entrances with lids.

3.3.2.1 Genus *Aname*

The genus *Aname* currently includes 37 named species in Australia and is well represented by four named and numerous unnamed species from many different regions in Western Australia. *Aname* currently represent a highly diverse array of species of very small to large spiders. Males generally have a spur and spine on the first tibia of males opposing an often incrassate metatarsus.

Members of the genus *Aname* are believed to be most common in sclerophyll forest, but are also known from rainforests and deserts (Raven 1981). *Aname* regularly belongs to the most diverse mygalomorph genera in biological spider surveys and with 12 species the Pilbara survey (Durrant *et al.* 2010) resulted in a similar number as found during the Carnarvon Basin survey (13 species) (Main *et al.* 2000). Many *Aname* species appear to have restricted distributions as shown by two studies from northern Australia, including the Pilbara (Harvey *et al.* 2012; Raven 1985). Therefore, unidentifiable specimens are considered potential SREs.

***Aname* sp. indet.**

The single juvenile could not be identified to species level, it is considered a potential SRE based on the distribution pattern of known species within the genus.

3.4 ORDER ISOPODA

Isopods are crustaceans which are recognised by their armour-like exoskeleton and possession of seven pairs of legs in the thoracic region. Isopods inhabit both terrestrial and aquatic environments. The Oniscidea, a suborder of the Isopoda, contain the supralittoral, terrestrial and secondarily aquatic slaters (or woodlice). Almost 200 species of slaters have been recorded from Australia (Green *et al.* 2010). Terrestrial (epigean and hypogean) isopods often have highly localised distribution and are very diverse; therefore they are recognised as a target group for SRE surveys (Harvey 2002). This is attributed to their photonegative tendencies (sensitivity to light) and susceptibility to desiccation in dry environments which are factors in limiting their dispersal abilities (Edney 1954). Slaters are an ideal biological model for faunistic and biogeographical studies, due to their reduced dispersal ability and narrow habitat preferences (Taiti & Argano 2009).

Overall the WA fauna is comparatively poorly known with many undescribed species (Judd & Horwitz 2003), although the isopod fauna of south-west WA is fairly well known based on a taxonomic study by Judd (2004).

3.5 FAMILY ARMADILLIDAE

Armadillidae typically have a convex dorsal surface and the animal can roll up into a ball. The family is diverse in Australia, currently 24 genera are described; many species live in litter or under wood and stones in forest or woodland or near the coast. The family is in need of a taxonomic review and many of the genera are unlikely to represent a distinct evolutionary unit. The terrestrial isopod fauna of the arid and semi-arid areas of Western Australian are dominated by isopods of the family Armadillidae.

3.5.1.1 Genus *Acanthodillo*

Australian species of *Acanthodillo* appear very similar with distinctive horizontal ridges on the epimera/junction and large dorsal humps. Seven species of *Acanthodillo* are currently described, of which one, *A. agasketos*, is known from the Kimberley region in WA (Lewis 1998). In the Pilbara region, the activity of this genus (October to May) appears to be associated with the wet season (S. Judd unpublished data). *Acanthodillo* is the most common and widespread genus of Armadillidae in WA after *Buddelundia* and is likely to contain a high percentage of SRE species.

***Acanthodillo* sp. indet.**

Two female specimens in good condition were collected from a single site of the Corunna Downs project. These were compared to material from Abydos, Mount Webber, McPhee Creek and the SHR project (all Outback Ecology). The specimens from Corunna Downs were morphologically different from all these and are considered to be a different species. This species is not given a parataxonomic designation since no male specimens were present. It is a likely SRE species.

3.5.1.2 Genus Buddelundiinae (unplaced)

This is a group of isopods found in the Pilbara and Kimberley. They belong to an undescribed genus closely related to *Buddelundia*. *Buddelundia albomarginata* from the Kimberley region belongs to this genus. This genus is only found in the northern half of WA and currently known species are considered potential SRE species in the Pilbara region based on reported distribution patterns.

Buddelundiinae 'abydos'

This species has a distribution similar to *Buddelundia* '18' (see below) and is considered a relatively widespread species in the Pilbara region.

Buddelundiinae 'mw'

This is a 'primitive' armadillid species and is only found at Mount Webber and Corunna Downs. It is considered a likely SRE species.

3.5.1.3 Genus: *Buddelundia*

Members of the genus *Buddelundia* belong to the most common terrestrial isopods in WA and the genus was well represented in the material. The genus is currently under taxonomic revision by S. Judd (Phoenix). Only a few species of *Buddelundia* have a very wide distribution, and many represent potential SREs.

Buddelundia '11'

This species has a distribution similar to *Buddelundia* '18' (see below). It was also found at Southern Haul Road and Southern Haul Road Realignment for the Turner River Hub, Abydos, Southwest Rail Alignment and possibly North Star. Populations from McPhee Creek differ morphologically to some extent and it currently remains unclear if they belong to the same species. Due to the taxonomic uncertainties associated with these morphological differences, the species is considered a potential SRE species although it is fairly common within its currently known range.

Buddelundia '13'

Buddelundia '13' is a widespread species complex known from numerous localities in the Pilbara region. These specimens appear conspecific with the voucher specimens for this species from the Roy Hill area and so the species is not considered an SRE.

Buddelundia '14MW'

Buddelundia '14MW' has previously been reported as *Buddelundia* '14'. This is a relatively widespread species complex and the most common form of *Buddelundia* found in the Pilbara. *Buddelundia* '14MW' is a morphological form found in the Mount Webber area. There are various other forms of *Buddelundia* '14' and species in the group are generally relatively widespread; hence, *Buddelundia* '14MW' is not considered an SRE. One *Buddelundia* specimen was in poor condition and could not be identified with certainty. It possibly represented *Buddelundia* '14MW' and is therefore listed here for this species with a question mark (Appendix 1).

Buddelundia '18'

This species is found from Abydos (Outback Ecology project) and North Star in the northwest, through Mount Webber (Outback Ecology project) and Corunna Downs to McPhee Creek (Outback Ecology project) in the east. The species was also found in the Southern Deviation Survey. This is a restricted distribution, but Buddelundia '18' does not constitute a potential SRE.

Buddelundia '86'

This species is known from three locations (Mount Webber, Corunna Downs) and the Southern Deviation Survey. Based on this distribution it is considered a potential SRE.

3.5.2 Family Philosciidae

In contrast to the Armadillidae, members of the family Philosciidae cannot conglobate (roll into a ball). Five of ten genera described from Australia are endemic to the country (*Abebaioscia*, *Ashtonia*, *Eurygastor*, *Huntonia* and *Metriogaster*) and *Laevophiloscia* and *Plymophiloscia* are mainly Australian (Department of the Environment 2011). The Philosciidae in Western Australia are very poorly known. Since they are very rarely collected and because the taxonomy is poorly known, all philosciids found in the Pilbara should be considered potential or likely SRE species. Specimens are fragile and easily damaged and they are best investigated by molecular methods.

Philosciidae 'corunna'

Two specimens (one male and one female) were collected from adjacent sites. They are assumed to be the same species but it is not possible to confirm this by morphological examination. The only suitable material available for comparison was from Sulphur Springs (Outback Ecology project) and 50 km SE of Wodgina Mine Site (Outback Ecology project TRH). The specimens here were not conspecific with either of these and Philosciidae 'corunna' is therefore considered a likely SRE.

3.6 ORDER: POLYDESMIDA

The Australian millipedes are poorly studied and biogeographic patterns remain largely unresolved (Black 1997; Shelley & Golovatch 2011). At least eight orders of millipedes are native to Australia; all species in the order Julida are introduced (Mesibov 2006). Millipedes belong to one of the main target groups of SRE surveys. Short-range endemism is particularly common within the orders Sphaerotheriida (rolling millipedes), Polydesmida, and Chordeumatida (not known from WA) (EPA 2009; Harvey 2002).

3.6.1 Family: Paradoxosomatidae

Members of the family Paradoxosomatidae are abundant and occur widely within Australia; some 170 species in forty genera are currently described from this country (Car & Harvey 2014; Car *et al.* 2013). They differ from the other two Australian families within the Polydesmida, Dalodesmidae and Haplodesmidae, by the separated bases of the male gonopods. Many paradoxomatids are relatively large with adults that range from 20 to 40 mm in length (Mesibov 2006). The described Western Australian fauna consists of eight genera, of which four (*Akamptogonus*, *Orthomorpha*, *Oxidus*, *Solaenodolichopus*) are represented by introduced species (Car *et al.* 2013). The remaining four indigenous genera are *Boreohesperus*, the only member of the *Australiosomatini* in WA (Car & Harvey 2013), and the antichiropodinine genera *Helicopodosma* (one described species from Kununurra), *Stygiochiropus*, a troglobitic genus from Cape Range (Humphreys & Shear 1993) and the diverse genus *Antichiropus* (Car & Harvey 2014; Car *et al.* 2013; Wojcieszek *et al.* 2011). There are many undescribed species in particular in the genus *Antichiropus*, from diverse habitats and most appear to have very small ranges. Most indigenous genera contain SRE taxa although they may be locally abundant.

Paradoxosomatidae sp. indet.

Only fragments of this species were present, therefore the species could not be determined; however, representatives of this family are at large highly range restricted. For this reason this specimen is considered to represent a likely SRE.

3.7 ORDER: PSEUDOSCORPIONES

Pseudoscorpions resemble scorpions in that they possess a pair of long pedipalps with pincers which are directed anteriorly of the body; however, they do not possess the tail or a sting of scorpions. Most species are small to very small in size (most species are less than 1cm long). The Western Australian pseudoscorpion fauna is fairly diverse with representatives of 17 different families (Harvey 2011a). They are found in a variety of biotopes, but can be most commonly collected from the bark of trees, from the underside of rocks, or from leaf litter habitats (Harvey 1992a).

3.7.1 Family: Atemnidae

Atemnids are frequently found under bark of trees in Western Australia, but the systematics of the group, particularly of the genus *Oratemnus*, is uncertain and the taxonomy of individual species unclear (M. S. Harvey, pers. comm. to V. Framenau). However, based upon current evidence, it seems that most species will eventually be found to be widely distributed.

***Oratemnus* sp. indet.**

Four species of *Oratemnus* are currently known from Australia, of which three are known from Western Australia. However, the systematics of the genus is poorly resolved (M.S. Harvey personal communication). Based on their arboreal habitat preferences, species are generally collected from under bark of trees, members of *Oratemnus* are currently not considered SREs.

3.7.2 Family: Feaellidae

Pseudoscorpions in the family Feaellidae are among the most primitive and unusual of all pseudoscorpions. They can be recognised by the scalloped anterior margin of the carapace and largely raptorial pedipalps (Harvey 1992a). Feaellids have been reported from Africa, the Indian region and north-western Australia. They are usually found in leaf litter, soil, or under rocks (Harvey 2011a).

3.7.2.1 Genus: *Feaella*

Feaella is the only genus in the family Feaellidae. A single species is currently known from Australia, *F. anderseni* from the Kimberley region in WA (Harvey 1989). Two additional undescribed species are currently known from the Pilbara region of WA.

***Feaella* sp. nov.**

The specimen from this survey was directly compared with the known two Pilbara species and is thought to be a different species. This species is considered to be an SRE as are all other Pilbara species of *Feaella*.

3.7.3 Family: Garypidae

The family Garypidae occurs worldwide with 10 genera with highest generic diversity in Africa and Madagascar. Three genera are present in Australia: *Garypus*, *Anagarypus* and *Synsphyronus*. Garypids can be identified by two pairs of eyes on ocular tubercles, a subtriangular carapace and the lack of a helix within the spiracle (Harvey 1987). They are usually found under rocks and bark.

3.7.3.1 Genus *Synsphyronus*

Synsphyronus was revised by Harvey (1987) who recognized 26 Australian species; the genus is also known from New Zealand and New Caledonia (Harvey 1996). Many new species are known from collections, especially from the drier inland regions. Many species of *Synsphyronus* may represent short-range endemic species, but these species are generally found in ground habitats such as under rocks (Harvey 1987, 2011b, 2012). The tree-dwelling species tend to be much more widely distributed, and are not considered short-range endemics.

***Synsphyronus* '8/3 pilbara'**

Synsphyronus '8/3 pilbara' appears to represent a complex of species. Representatives of this complex are only classified as potential SREs if they are found on rocky outcrops or exposed rock ledges, unlike the representative from this sample.

3.7.4 Family: Olpiidae

Systematically, the Olpiidae are poorly defined and lack any uniting characters (Harvey 1992b; Murienne *et al.* 2008). In Australia, six genera in the family are listed with valid species, *Austrohorus*, *Beierolpium*, *Euryolpium*, *Linnaeolpium*, *Olpium* and *Xenolpium*. Olpiids are mostly found in xeric habitats, under stones, bark and in leaf litter and frequently belong to the most commonly collected pseudoscorpions in surveys for SRE in these habitats in Western Australia. Most species are generally widespread and not considered SREs, although some genera or species may be range-restricted, in particular in subterranean habitats (Harvey & Leng 2008).

3.7.4.1 Genus: *Austrohorus*

Austrohorus currently includes only a single described species, *A. exsul* (Harvey 2011a), named based on a specimen from Morawa in the WA Avon Wheatbelt. *Austrohorus* is commonly recorded in SRE surveys of arid Western Australia and unlikely to contain many SREs.

***Austrohorus* sp. indet.**

Based on known distribution patterns and habitat preferences, the unidentified *Austrohorus* from this survey are not considered SREs.

3.7.4.2 Genus: *Beierolpium*

A single species of *Beierolpium* is described from WA, *B. bornemisszai* (Harvey 1992a). The genus belongs to the most commonly collected pseudoscorpions in surveys in arid and semi-arid Western Australia and is unlikely to contain many SREs.

***Beierolpium* '8/3'**

Beierolpium '8/3' is a widespread species in the Pilbara.

***Beierolpium* sp. indet.**

One subadult specimen was present in the collection and could not be identified to species level; however, it is likely to represent a specimen of *Beierolpium* '8/3' since the samples are dominated by that species. It is therefore considered widespread.

3.7.4.3 Genus: *Indolpium*

The genus *Indolpium* is the most commonly collected genus of pseudoscorpions in SRE surveys in arid zones of WA. The genus is not considered to contain many, if any, SREs.

***Indolpium* sp. indet.**

Extremely similar specimens have been collected from other regions of the Pilbara, suggesting that only a single species is involved. Based on our current knowledge, this species is not an SRE.

3.7.4.4 Genus: *Xenolpium*

Xenolpium appear similar to *Indolpium* but can be readily distinguished from that genus by a very glossy appearance and specific arrangement of macrosetae on the carapace (Harvey 2013). None are known to be SRE’s.

***Xenolpium* sp. indet.**

This undescribed species of *Xenolpium* is known to be widespread in the Pilbara and is not an SRE.

3.8 ORDER: SCORPIONES

Scorpions are characterised by the presence of chelate pedipalps, pectines and an elongate metasoma furnished with a sting. Scorpions are important components of arid ecosystems because their levels of diversity and abundance contribute significantly to the biomass of animal assemblages and they are important predators and prey for other species (Volschenk *et al.* 2010).

3.8.1 Family: Buthidae

The family Buthidae is the most diverse and widespread of all scorpion families (Fet & Lowe 2000). In Australia, Buthidae is represented by the genera *Australobuthus*, *Isometrus*, *Isometroides*, *Lychas*, and *Hemilychas*. In Western Australia, only the genera *Isometrus*, *Isometroides* and *Lychas*, have been recorded. The taxonomy of the constituent species of *Isometrus*, *Isometroides* and *Lychas* is very problematic and each genus contains numerous undescribed species, most notably in the genus *Lychas* (E. S. Volschenk, unpublished data). Most Authors refer to Koch (1977) for keys and identification. This revision represents an important study of the Australian scorpions; however, several taxonomic decisions made by Koch (1977) have been rejected by subsequent authors and the taxonomy in the publication is not up-to-date. Most Australian buthid species appear to have wide distributions; however, a few taxa have confirmed SRE distributions (E. S. Volschenk unpublished data).

3.8.1.1 Genus: *Lychas*

The genus *Lychas* is widespread across the Australian mainland. The taxonomy of this genus is problematic, with numerous undescribed species known in Australia (Volschenk *et al.* 2010). The situation is further complicated with the genus being also represented in Africa, India and eastern Asia (Fet & Lowe 2000). All of the Australian species are endemic to the country and are currently under revision by E.S. Volschenk. Most species of *Lychas* appear to have wide distributions; however, a small number of undescribed species are known to be SREs.

***Lychas bituberculatus* Pocock, 1891**

Lychas bituberculatus is a widespread species and has been recorded widely throughout the Midwest, Pilbara and Kimberley regions of Western Australia.

***Lychas* 'gracilimanus'**

Lychas 'gracilimanus' is a well-defined and clearly recognised morphospecies. *Lychas* 'gracilimanus' has a very patchy distribution which is not well understood. Despite extensive surveys in the Pilbara, this species rarely appears in collections. *Lychas* 'gracilimanus' is a potential SRE.

***Lychas* 'hairy tail grp' species complex**

d. *Lychas* 'hairy tail grp' is highly variable and is likely to represent a species complex. *Lychas* 'hairy tail grp' represents several cryptic species in a species complex. Subtle and graded variation makes consolidation of species boundaries only possible after large series have been examined and represents a work in progress (Volschenk unpublished data). Members of this complex are known from the Midwest, Pilbara and Kimberley regions of Western Australia. Pilbara representatives of *Lychas* 'hairy tail grp' are widespread.

3.8.2 Family: Urodacidae

The family Urodacidae is endemic to Australia (Fet 2000; Prendini 2000; Prendini & Wheeler 2005; Volschenk *et al.* 2000) where it is represented by the genera *Urodacus* Peters, 1861 and Aops Volschenk and Prendini, 2008.

3.8.2.1 Genus: *Urodacus*

Urodacus was considered a member of the family Scorpionoidea for many years, but in a revision of the superfamily Scorpionoidea Latreille, Prendini (2000) placed *Urodacus* in its own family. Unlike the species designations for Buthidae, Koch's (1977) species of *Urodacus* have been mostly supported by subsequent authors (Harvey & Volschenk 2002; Volschenk & Prendini 2008; Volschenk *et al.* 2000). The biggest issue confronting *Urodacus* taxonomy is the number of undescribed species being uncovered through current revisionary work (E. S. Volschenk unpublished data). Currently 23 species of *Urodacus* are described; however, this may represent as little as 20% of the real diversity of this genus in Australia. *Urodacus* appears to be most diverse in Western Australia and few species are recorded east of the Great Dividing Range in eastern Australia. *Urodacus* contains both widespread and SRE species. During a large-scale survey of the Pilbara fauna, Volschenk et al. (Volschenk *et al.* 2010) recorded nine undescribed species and only one formerly describes species

***Urodacus* 'pilbara 16'**

Urodacus 'pilbara 16' is only known from the specimens present in this survey. Based on the distribution patterns of known species in the genus it is considered a potential SRE.

***Urodacus* 'pilbara 4'**

Urodacus 'pilbara 4' has been recorded widely throughout the Pilbara region of Western Australia. Despite its widespread distribution, it appears to have a very patchy distribution.

***Urodacus* 'pilbara 8'**

Urodacus 'pilbara 8' is a widespread and is one of the most common scorpion species in the Pilbara.

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Appendix 1 Invertebrates identified from the Corunna Downs Survey, Western Australia

Field number	Order	Family	Species	Males	Females	Juveniles	Total
Target 2-17	Araneae	Trochanteriidae	Trochanteriidae sp. indet.	0	0	1	1
Site 6-159	Araneae	Selenopidae	*Karaops nyangumarta*	0	1	0	1
Site 2-376	Araneae	Selenopidae	*Karaops* sp. indet.	0	0	2	2
Site 3-366	Araneae	Selenopidae	*Karaops* sp. indet.	0	0	1	1
Site I-447	Araneae	Selenopidae	*Karaops* sp. indet.	0	0	1	1
Site F-418	Araneae	Barychelidae	*Aurecocrypta* sp. indet.	0	1	0	1
Site 13-353	Araneae	Nemesiidae	*Aname* sp. indet.	0	0	1	1
Site 7-32	Pseudoscorpiones	Atemnidae	*Oratemnus* sp. indet.	1	0	1	2
Site 5-15	Pseudoscorpiones	Feaellidae	*Feaella* sp. indet.	0	1	0	1
Site 5-378	Pseudoscorpiones	Garypidae	*Synsphyronus* '8/3 pilbara'	1	1	1	3
Site 12-45	Pseudoscorpiones	Olpiidae	*Austrohorus* sp. indet.	0	1	0	1
Site 13-48A	Pseudoscorpiones	Olpiidae	*Austrohorus* sp. indet.	0	1	1	2
Site 8-181	Pseudoscorpiones	Olpiidae	*Austrohorus* sp. indet.	1	0	0	1
Site 8-241A	Pseudoscorpiones	Olpiidae	*Austrohorus* sp. indet.	0	1	1	2
Site 8-41A	Pseudoscorpiones	Olpiidae	*Austrohorus* sp. indet.	1	0	0	1
Site 1-364	Pseudoscorpiones	Olpiidae	*Beierolpium* '8/3'	1	0	0	1
Site 1-398	Pseudoscorpiones	Olpiidae	*Beierolpium* '8/3'	0	0	1	1
Site 8-173C	Pseudoscorpiones	Olpiidae	*Beierolpium* '8/3'	1	0	0	1
Site 8-184	Pseudoscorpiones	Olpiidae	*Beierolpium* '8/3'	2	0	0	2
Site 8-241B	Pseudoscorpiones	Olpiidae	*Beierolpium* '8/3'	0	0	1	1
Site 8-41C	Pseudoscorpiones	Olpiidae	*Beierolpium* '8/3'	0	0	1	1
Site 13-48c	Pseudoscorpiones	Olpiidae	*Beierolpium* sp. indet.	0	0	1	1

Field number	Order	Family	Species	Males	Females	Juveniles	Total
Site 10-344	Pseudoscorpiones	Olpiidae	*Indolpium* sp. indet.	0	0	1	1
Site 1-1	Pseudoscorpiones	Olpiidae	*Indolpium* sp. indet.	1	0	1	2
Site 2-369	Pseudoscorpiones	Olpiidae	*Indolpium* sp. indet.	0	0	1	1
Site 8-241C	Pseudoscorpiones	Olpiidae	*Indolpium* sp. indet.	0	1	0	1
Site 8-396	Pseudoscorpiones	Olpiidae	*Indolpium* sp. indet.	0	0	1	1
Site 8-41B	Pseudoscorpiones	Olpiidae	*Indolpium* sp. indet.	0	0	2	2
Site 9-34	Pseudoscorpiones	Olpiidae	*Indolpium* sp. indet.	1	1	3	5
Target 5-52	Pseudoscorpiones	Olpiidae	*Indolpium* sp. indet.	1	0	0	1
Target 6-53A	Pseudoscorpiones	Olpiidae	*Indolpium* sp. indet.	0	1	0	1
Site 10-36	Pseudoscorpiones	Olpiidae	*Xenolpium* sp. indet.	2	1	5	8
Site 11-39	Pseudoscorpiones	Olpiidae	*Xenolpium* sp. indet.	2	2	4	8
Site 13-48B	Pseudoscorpiones	Olpiidae	*Xenolpium* sp. indet.	2	1	0	3
Site 2-387	Pseudoscorpiones	Olpiidae	*Xenolpium* sp. indet.	0	0	1	1
Site 2-4	Pseudoscorpiones	Olpiidae	*Xenolpium* sp. indet.	1	0	0	1
Site 3-7	Pseudoscorpiones	Olpiidae	*Xenolpium* sp. indet.	3	0	6	9
Site 4-11	Pseudoscorpiones	Olpiidae	*Xenolpium* sp. indet.	0	0	2	2
Site 6-28	Pseudoscorpiones	Olpiidae	*Xenolpium* sp. indet.	0	1	2	3
Site 6-30	Pseudoscorpiones	Olpiidae	*Xenolpium* sp. indet.	1	0	1	2
Target 5-51	Pseudoscorpiones	Olpiidae	*Xenolpium* sp. indet.	2	1	1	4
Target 6-53B	Pseudoscorpiones	Olpiidae	*Xenolpium* sp. indet.	3	0	0	3
Site 10-342	Scorpiones	Buthidae	*Lychas bituberculatus*	1	1	1	3
Site 10-352	Scorpiones	Buthidae	*Lychas bituberculatus*	1	0	0	1
Site 10-37	Scorpiones	Buthidae	*Lychas bituberculatus*	0	0	1	1

Field number	Order	Family	Species	Males	Females	Juveniles	Total
Site 11-375	Scorpiones	Buthidae	*Lychas bituberculatus*	1	0	0	1
Site 12-178	Scorpiones	Buthidae	*Lychas bituberculatus*	2	0	0	2
Site 12-187	Scorpiones	Buthidae	*Lychas bituberculatus*	1	0	0	1
Site 12-341	Scorpiones	Buthidae	*Lychas bituberculatus*	1	1	0	2
Site 13-349	Scorpiones	Buthidae	*Lychas bituberculatus*	3	0	1	4
Site 13-350	Scorpiones	Buthidae	*Lychas bituberculatus*	3	0	2	5
Site 13-358	Scorpiones	Buthidae	*Lychas bituberculatus*	1	0	1	2
Site 1-361	Scorpiones	Buthidae	*Lychas bituberculatus*	1	1	0	2
Site 2-368	Scorpiones	Buthidae	*Lychas bituberculatus*	1	0	0	1
Site 2-377	Scorpiones	Buthidae	*Lychas bituberculatus*	0	0	1	1
Site 2-388	Scorpiones	Buthidae	*Lychas bituberculatus*	2	1	0	3
Site 2-391B	Scorpiones	Buthidae	*Lychas bituberculatus*	0	0	1	1
Site 3-359	Scorpiones	Buthidae	*Lychas bituberculatus*	1	1	1	3
Site 3-367	Scorpiones	Buthidae	*Lychas bituberculatus*	3	0	1	4
Site 3-390	Scorpiones	Buthidae	*Lychas bituberculatus*	1	0	2	3
Site 3-392	Scorpiones	Buthidae	*Lychas bituberculatus*	1	0	0	1
Site 3-8	Scorpiones	Buthidae	*Lychas bituberculatus*	0	1	0	1
Site 4-12	Scorpiones	Buthidae	*Lychas bituberculatus*	0	1	0	1
Site 4-163	Scorpiones	Buthidae	*Lychas bituberculatus*	1	0	6	7
Site 6-158A	Scorpiones	Buthidae	*Lychas bituberculatus*	2	3	1	6
Site 6-26	Scorpiones	Buthidae	*Lychas bituberculatus*	0	1	0	1
Site 6-27	Scorpiones	Buthidae	*Lychas bituberculatus*	0	1	0	1
Site 8-176	Scorpiones	Buthidae	*Lychas bituberculatus*	0	0	1	1

Field number	Order	Family	Species	Males	Females	Juveniles	Total
Site 8-43	Scorpiones	Buthidae	*Lychas bituberculatus*	0	0	1	1
Site 9-35	Scorpiones	Buthidae	*Lychas bituberculatus*	0	0	2	2
Site 9-382	Scorpiones	Buthidae	*Lychas bituberculatus*	1	1	1	3
Site 9-395	Scorpiones	Buthidae	*Lychas bituberculatus*	0	0	1	1
Site B-437	Scorpiones	Buthidae	*Lychas bituberculatus*	1	0	0	1
Site F-420	Scorpiones	Buthidae	*Lychas bituberculatus*	1	0	0	1
Target 6-54	Scorpiones	Buthidae	*Lychas bituberculatus*	0	0	1	1
Site F-414	Scorpiones	Buthidae	*Lychas* 'gracilimanus'	0	1	0	1
Site 10-342B	Scorpiones	Buthidae	*Lychas* 'hairy tail grp'	1	0	0	1
Site 10-352B	Scorpiones	Buthidae	*Lychas* 'hairy tail grp'	0	0	1	1
Site 10-355	Scorpiones	Buthidae	*Lychas* 'hairy tail grp'	1	0	0	1
Site 11-389	Scorpiones	Buthidae	*Lychas* 'hairy tail grp'	2	1	4	7
Site 12-341B	Scorpiones	Buthidae	*Lychas* 'hairy tail grp'	1	0	0	1
Site 13-358B	Scorpiones	Buthidae	*Lychas* 'hairy tail grp'	0	1	0	1
Site 2-2	Scorpiones	Buthidae	*Lychas* 'hairy tail grp'	1	0	0	1
Site 2-368B	Scorpiones	Buthidae	*Lychas* 'hairy tail grp'	1	0	0	1
Site 2-377B	Scorpiones	Buthidae	*Lychas* 'hairy tail grp'	1	0	0	1
Site 2-388B	Scorpiones	Buthidae	*Lychas* 'hairy tail grp'	1	1	0	2
Site 2-391	Scorpiones	Buthidae	*Lychas* 'hairy tail grp'	1	0	0	1
Site 3-359B	Scorpiones	Buthidae	*Lychas* 'hairy tail grp'	2	0	0	2
Site 3-367B	Scorpiones	Buthidae	*Lychas* 'hairy tail grp'	3	0	0	3
Site 3-390B	Scorpiones	Buthidae	*Lychas* 'hairy tail grp'	1	0	0	1
Site 3-392B	Scorpiones	Buthidae	*Lychas* 'hairy tail grp'	3	0	0	3

Field number	Order	Family	Species	Males	Females	Juveniles	Total
Site 4-156	Scorpiones	Buthidae	*Lychas* 'hairy tail grp'	1	0	0	1
Site 4-162	Scorpiones	Buthidae	*Lychas* 'hairy tail grp'	1	0	0	1
Site 4-163B	Scorpiones	Buthidae	*Lychas* 'hairy tail grp'	1	0	1	2
Site 4-166	Scorpiones	Buthidae	*Lychas* 'hairy tail grp'	3	0	0	3
Site 6-158B	Scorpiones	Buthidae	*Lychas* 'hairy tail grp'	2	0	1	3
Site G-448	Scorpiones	Buthidae	*Lychas* 'hairy tail grp'	0	0	1	1
Site H-440	Scorpiones	Buthidae	*Lychas* 'hairy tail grp'	0	0	1	1
Site G-443	Scorpiones	Urodacidae	*Urodacus* 'pilbara 16'	1	0	0	1
Site B-438	Scorpiones	Urodacidae	*Urodacus* 'pilbara 4'	1	0	0	1
Site E-423	Scorpiones	Urodacidae	*Urodacus* 'pilbara 4'	1	0	0	1
Site E-424	Scorpiones	Urodacidae	*Urodacus* 'pilbara 4'	1	0	0	1
Site E-425	Scorpiones	Urodacidae	*Urodacus* 'pilbara 4'	1	0	0	1
Site E-426	Scorpiones	Urodacidae	*Urodacus* 'pilbara 4'	1	0	0	1
Site E-429	Scorpiones	Urodacidae	*Urodacus* 'pilbara 4'	1	0	0	1
Site E-430	Scorpiones	Urodacidae	*Urodacus* 'pilbara 4'	1	0	0	1
Site E-431	Scorpiones	Urodacidae	*Urodacus* 'pilbara 4'	1	0	0	1
Site E-432	Scorpiones	Urodacidae	*Urodacus* 'pilbara 4'	1	0	0	1
Site F-415	Scorpiones	Urodacidae	*Urodacus* 'pilbara 4'	1	0	0	1
Site F-417	Scorpiones	Urodacidae	*Urodacus* 'pilbara 4'	1	0	0	1
Site F-419	Scorpiones	Urodacidae	*Urodacus* 'pilbara 4'	1	0	0	1
Site F-421	Scorpiones	Urodacidae	*Urodacus* 'pilbara 4'	1	0	0	1
Site F-446	Scorpiones	Urodacidae	*Urodacus* 'pilbara 4'	1	0	0	1
Site G-401	Scorpiones	Urodacidae	*Urodacus* 'pilbara 4'	1	0	0	1

Field number	Order	Family	Species	Males	Females	Juveniles	Total
Site G-402	Scorpiones	Urodacidae	*Urodacus* 'pilbara 4'	1	0	0	1
Site G-404	Scorpiones	Urodacidae	*Urodacus* 'pilbara 4'	1	0	0	1
Site G-405	Scorpiones	Urodacidae	*Urodacus* 'pilbara 4'	1	0	0	1
Site G-406	Scorpiones	Urodacidae	*Urodacus* 'pilbara 4'	1	0	0	1
Site G-407	Scorpiones	Urodacidae	*Urodacus* 'pilbara 4'	1	0	0	1
Site G-408	Scorpiones	Urodacidae	*Urodacus* 'pilbara 4'	1	0	0	1
Site G-409	Scorpiones	Urodacidae	*Urodacus* 'pilbara 4'	1	0	0	1
Site G-441	Scorpiones	Urodacidae	*Urodacus* 'pilbara 4'	1	0	0	1
Site G-442	Scorpiones	Urodacidae	*Urodacus* 'pilbara 4'	1	0	0	1
Site J-444	Scorpiones	Urodacidae	*Urodacus* 'pilbara 4'	1	0	0	1
Site 12-44	Scorpiones	Urodacidae	*Urodacus* 'pilbara 8'	0	1	0	1
Site J-445	Scorpiones	Urodacidae	*Urodacus* 'pilbara 8'	1	0	0	1
Site 5-14	Polydesmida	Paradoxosomatidae	Paradoxosomatidae sp. indet.	0	0	1	1
Site 5-400	Isopoda	Armadillidae	*Acanthodillo* sp. indet.	0	2	0	2
Site 4-164B	Isopoda	Armadillidae	*Buddelundia* '11'	2	1	4	7
Site 4-167	Isopoda	Armadillidae	*Buddelundia* '11'	1	0	0	0
Site 4-9	Isopoda	Armadillidae	*Buddelundia* '11'	2	1	2	5
Site 5-13	Isopoda	Armadillidae	*Buddelundia* '11'	1	0	1	2
Site 5-397B	Isopoda	Armadillidae	*Buddelundia* '11'	0	1	0	1
Site 6-151B	Isopoda	Armadillidae	*Buddelundia* '11'	0	2	2	4
Site 6-152A	Isopoda	Armadillidae	*Buddelundia* '11'	1	2	0	3
Site 6-161A	Isopoda	Armadillidae	*Buddelundia* '11'	0	2	1	3
Site 8-172	Isopoda	Armadillidae	*Buddelundia* '11'	1	10	0	11

Field number	Order	Family	Species	Males	Females	Juveniles	Total
Site 8-173A	Isopoda	Armadillidae	*Buddelundia* '11'	5	12	0	17
Site 8-174	Isopoda	Armadillidae	*Buddelundia* '11'	3	7	0	10
Site 8-179A	Isopoda	Armadillidae	*Buddelundia* '11'	9	8	0	17
Site 8-182	Isopoda	Armadillidae	*Buddelundia* '11'	7	7	0	14
Site 8-183A	Isopoda	Armadillidae	*Buddelundia* '11'	4	0	0	4
Site 8-242B	Isopoda	Armadillidae	*Buddelundia* '11'	4	4	0	8
Site 8-42	Isopoda	Armadillidae	*Buddelundia* '11'	3	1	0	4
Site F-422	Isopoda	Armadillidae	*Buddelundia* '11'	2	0	0	2
Site H-439	Isopoda	Armadillidae	*Buddelundia* '11'	1	0	0	1
Site 6-161C	Isopoda	Armadillidae	*Buddelundia* '13'	1	0	0	1
Site 10-351A	Isopoda	Armadillidae	*Buddelundia* '14MW'	0	0	1	1
Site 12-177	Isopoda	Armadillidae	*Buddelundia* '14MW'	7	15	22	44
Site 12-186	Isopoda	Armadillidae	*Buddelundia* '14MW'	12	15	3	30
Site 12-243	Isopoda	Armadillidae	*Buddelundia* '14MW'	5	12	4	21
Site 12-346A	Isopoda	Armadillidae	*Buddelundia* '14MW'	1	2	5	8
Site 12-365	Isopoda	Armadillidae	*Buddelundia* '14MW'	2	6	0	8
Site 12-384	Isopoda	Armadillidae	*Buddelundia* '14MW'	8	5	6	19
Site 12-393	Isopoda	Armadillidae	*Buddelundia* '14MW'	1	0	0	1
Site 12-399	Isopoda	Armadillidae	*Buddelundia* '14MW'	9	9	24	42
Site 12-46	Isopoda	Armadillidae	*Buddelundia* '14MW'	0	0	1	1
Site 1-362	Isopoda	Armadillidae	*Buddelundia* '14MW'	0	1	0	1
Site 1-363A	Isopoda	Armadillidae	*Buddelundia* '14MW'	0	1	0	1
Site 1-380	Isopoda	Armadillidae	*Buddelundia* '14MW'	2	1	0	3

Field number	Order	Family	Species	Males	Females	Juveniles	Total
Site 1-385A	Isopoda	Armadillidae	*Buddelundia* '14MW'	4	3	1	8
Site 2-381C	Isopoda	Armadillidae	*Buddelundia* '14MW'	0	1	0	1
Site 4-157	Isopoda	Armadillidae	*Buddelundia* '14MW'	3	0	4	7
Site 5-394	Isopoda	Armadillidae	*Buddelundia* '14MW'	0	1	0	1
Site 5-397A	Isopoda	Armadillidae	*Buddelundia* '14MW'	3	2	17	22
Site 7-168	Isopoda	Armadillidae	*Buddelundia* '14MW'	0	1	0	1
Site 7-171	Isopoda	Armadillidae	*Buddelundia* '14MW'	0	1	0	1
Site 8-242A	Isopoda	Armadillidae	*Buddelundia* '14MW'	1	2	6	9
Site 9-379A	Isopoda	Armadillidae	*Buddelundia* '14MW'	1	0	0	1
Site B-435	Isopoda	Armadillidae	*Buddelundia* '14MW'	0	2	0	2
Site B-436	Isopoda	Armadillidae	*Buddelundia* '14MW'	1	2	0	3
Site D-411A	Isopoda	Armadillidae	*Buddelundia* '14MW'	0	1	0	1
Site E-427	Isopoda	Armadillidae	*Buddelundia* '14MW'	0	3	0	3
Site E-428	Isopoda	Armadillidae	*Buddelundia* '14MW'	3	8	0	11
Site F-416	Isopoda	Armadillidae	*Buddelundia* '14MW'	1	0	0	1
Site G-403	Isopoda	Armadillidae	*Buddelundia* '14MW'	0	1	0	1
Target 2-16A	Isopoda	Armadillidae	*Buddelundia* '14MW'	0	1	11	12
Site 1-386B	Isopoda	Armadillidae	*Buddelundia* sp'14MW'?	1	0	0	1
Site 10-345	Isopoda	Armadillidae	*Buddelundia* '18'	1	1	4	6
Site 10-351B	Isopoda	Armadillidae	*Buddelundia* '18'	6	10	0	16
Site 10-356	Isopoda	Armadillidae	*Buddelundia* '18'	1	0	0	1
Site 10-38	Isopoda	Armadillidae	*Buddelundia* '18'	0	1	0	1
Site 11-360B	Isopoda	Armadillidae	*Buddelundia* '18'	1	0	0	1

Field number	Order	Family	Species	Males	Females	Juveniles	Total
Site 12-346B	Isopoda	Armadillidae	*Buddelundia* '18'	0	2	0	2
Site 13-347	Isopoda	Armadillidae	*Buddelundia* '18'	1	1	0	2
Site 13-348	Isopoda	Armadillidae	*Buddelundia* '18'	1	2	0	3
Site 13-354	Isopoda	Armadillidae	*Buddelundia* '18'	3	2	0	5
Site 13-357B	Isopoda	Armadillidae	*Buddelundia* '18'	1	0	2	3
Site 13-47	Isopoda	Armadillidae	*Buddelundia* '18'	0	1	0	1
Site 1-385C	Isopoda	Armadillidae	*Buddelundia* '18'	0	1	0	1
Site 1-386A	Isopoda	Armadillidae	*Buddelundia* '18'	1	1	0	2
Site 2-381B	Isopoda	Armadillidae	*Buddelundia* '18'	1	0	0	1
Site 8-183B	Isopoda	Armadillidae	*Buddelundia* '18'	0	3	2	5
Site 8-242D	Isopoda	Armadillidae	*Buddelundia* '18'	1	0	0	1
Site A-433B	Isopoda	Armadillidae	*Buddelundia* '86'	0	6	0	6
Site A-434	Isopoda	Armadillidae	*Buddelundia* '86'	1	0	0	1
Site D-410	Isopoda	Armadillidae	*Buddelundia* '86'	3	0	0	3
Site D-411B	Isopoda	Armadillidae	*Buddelundia* '86'	5	0	3	8
Site D-412	Isopoda	Armadillidae	*Buddelundia* '86'	1	4	0	5
Site F-413	Isopoda	Armadillidae	*Buddelundia* '86'	0	1	0	1
Site 7-169	Isopoda	Armadillidae	Buddelundiinae 'abydos'	1	0	0	1
Site 8-173B	Isopoda	Armadillidae	Buddelundiinae 'abydos'	1	0	0	1
Site 8-179B	Isopoda	Armadillidae	Buddelundiinae 'abydos'	1	0	0	1
Site 8-242C	Isopoda	Armadillidae	Buddelundiinae 'abydos'	0	5	0	5
Site A-433A	Isopoda	Armadillidae	Buddelundiinae 'abydos'	0	1	0	1
Target 2-16B	Isopoda	Armadillidae	Buddelundiinae 'abydos'	1	0	0	1

Field number	Order	Family	Species	Males	Females	Juveniles	Total
Site 11-360A	Isopoda	Armadillidae	Buddelundiinae 'mw'	0	2	0	2
Site 11-370	Isopoda	Armadillidae	Buddelundiinae 'mw'	0	2	1	3
Site 13-357A	Isopoda	Armadillidae	Buddelundiinae 'mw'	1	15	0	16
Site 1-363B	Isopoda	Armadillidae	Buddelundiinae 'mw'	0	2	0	2
Site 1-385B	Isopoda	Armadillidae	Buddelundiinae 'mw'	0	1	0	1
Site 2-372	Isopoda	Armadillidae	Buddelundiinae 'mw'	0	1	0	1
Site 2-381A	Isopoda	Armadillidae	Buddelundiinae 'mw'	0	1	0	1
Site 4-164A	Isopoda	Armadillidae	Buddelundiinae 'mw'	0	1	0	1
Site 6-151A	Isopoda	Armadillidae	Buddelundiinae 'mw'	0	2	1	3
Site 6-152B	Isopoda	Armadillidae	Buddelundiinae 'mw'	0	1	0	1
Site 6-161B	Isopoda	Armadillidae	Buddelundiinae 'mw'	0	0	1	1
Site 9-371	Isopoda	Armadillidae	Buddelundiinae 'mw'	0	4	0	4
Site 9-373	Isopoda	Armadillidae	Buddelundiinae 'mw'	0	1	0	1
Site 9-374	Isopoda	Armadillidae	Buddelundiinae 'mw'	1	0	0	1
Site 9-379B	Isopoda	Armadillidae	Buddelundiinae 'mw'	0	6	0	6
Site 11-40	Isopoda	Philosciidae	Philosciidae 'corunna'	1	0	0	1
Target 1-25	Isopoda	Philosciidae	Philosciidae 'corunna'	0	1	0	1
			TOTAL	**258**	**271**	**210**	**738**

Appendix E Molecular Identification of Molluscs (Camaenidae) from Corunna Station ca 160km SE Port Hedland, Western Australia

Molecular Identification of Molluscs (Camaenidae) from Corunna Station *ca*. 160km SE Port Hedland, Western Australia

Brief report to *MWHGlobal*

28 July 2014

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Summary

Nine specimens of land snail collected from Corunna Station ca. 160km SE Port Hedland, Western Australia were lodged into the Western Australian Museum collection by *MWHGlobal* (see Appendix 1 for specimen details). One of the nine specimens was not suitable for molecular analysis as it was noted as being dried tissue (it may have been dead prior to collection or perhaps dried out during submission as a vial was noted dry on first inspection at WAM). The main objectives of the WA Museum's Molecular Systematics Unit (MSU) were to use COI DNA barcoding to compare DNA barcoding sequences to the WAM and published DNA databases to: 1) determine the taxonomic identity of the remaining eight Camaenidae specimens; and 2) determine the distribution and thus SRE status of the queried specimens.

DNA was extracted and DNA barcoding sequences (CO1) were amplified by PCR in the MSU and sequenced at the Australian Genomic Research Facility (AGRF) Perth node. DNA sequences were BLASTED against the Western Australian Museum DNA database and publically accessible GenBank. Published journal articles were accessed to confirm identity of sequences present on GenBank.

A summary of specimen identifications together with their SRE status may be found in Table 1. A full explanation of the SRE categories used by the Western Australian Museum may be found in Appendix 2.

Table 1. Summary of WAMTS194 specimen identifications and SRE status.

FAMILY	GENUS	SPECIES	# OF SPECIMENS	SRE SUB-CATEGORY
Camaenidae	*Rhagada*	*convicta*	7	Potential SRE status with subcategory A, D, E
Camaenidae	*Rhagada*	*Sp. 'nov'*	1	Potential SRE status with subcategory A, D, E

Results

COI DNA barcodes were amplified and successfully sequenced from all eight specimens. The eight queried Camaenidae COI sequences were compared to the Western Australian Museums' DNA barcode database and GenBank. A summary of the comparison (BLAST results) is provided in Table 2. Details of specimens identified in BLAST searches that contextualise the taxonomic and distributional status of the queried species are provided in Table 3. Simple Neighbour-Joining (distance based) trees are provided in Appendix 3 for visualisation of genetic relationships. DNA sequences of queried specimens are provided in Appendix 4.

Table 2. Summary of BLAST analysis

REGNO	SPECIES	SUMMARY OF BLAST RESULTS
S88273 S88276 S88277 S88278 S88279 S88280 S88281	*Rhagada convicta*	These specimens all share exactly the same genetic haplotype, i.e. are 100% identical in 655 base pairs of COI. This lineage forms a sister (3.82% average divergence) to two specimens of *Rhagada convicta* from GenBank (Kohler and Criscione, 2013). Together the queried specimens and those of *Rhagada convicta* (Kohler and Criscione, 2013) are sister (3.80% average divergence) to WAM specimens S83206, S83208, S83209, S83210, S83211, S83216. Altogether these are sister to more specimens of *Rhagada convicta* from WAM (S42988 and S83884), and GenBank (Johnson *et al*., 2012).
S88274	*Rhagada* 'sp. nov.'	This specimen is aligned with two WAM specimens (S58022 and S83866). Average diversity among these three specimens is low 0.63%. Together these three specimens **form a distinct and yet unnamed lineage** (14.16% average divergence) at the base of a group of three species: i) *Rhagada torulus* (WAM S65082 and Johnson *et al*., 2012); ii) *Rhagada capensis* (Johnson *et al*., 2012); iii) *Rhagada globosa* (Johnson *et al*., 2012).

Table 3. Details of registered WAM specimens and GenBank sequences related to the queried Camaenidae specimens.

Reg No/ GenBank No	Family	Genus	Species	Locality	Latitude	Longitude	Reference
AM C.463524/ KC703157	Camaenidae	*Rhagada*	*convicta*	Pilbara, Cape Keraudren, N of Great Western Hwy, WA	19°57'37″ S	119°46'06″ E	Kohler & Criscione, 2013
AM C.463525/ KC703158	Camaenidae	*Rhagada*	*convicta*	Pilbara, Cape Keraudren, nr ranger station, WA	19°59'14″ S	119°47'22″ E	Kohler & Criscione, 2014
S83206	Camaenidae	*Rhagada*	*'convicta group'*	WA: c. 150km W of Marble Bar	21°8`23.55"S	119°23`26"E	WAM database
S83208	Camaenidae	*Rhagada*	*'convicta group'*	WA: c. 150km W of Marble Bar	21°12`20.19"S	119°14`26.81"E	WAM database
S83209	Camaenidae	*Rhagada*	*'convicta group'*	WA: c. 150km W of Marble Bar	21°7`3.15"S	119°11`40.95"E	WAM database
S83210	Camaenidae	*Rhagada*	*'convicta group'*	WA: c. 150km W of Marble Bar	21°6`39.76"S	119°11`39.74"E	WAM database
S83211	Camaenidae	*Rhagada*	*'convicta group'*	WA: c. 150km W of Marble Bar	21°7`24.03"S	119°12`41.41"E	WAM database
S83216	Camaenidae	*Rhagada*	*'convicta group'*	WA: c. 150km W of Marble Bar	21°7`54.15"S	119°8`19.22"E	WAM database
S42988	Camaenidae	*Rhagada*	*convicta*	Cane River CP; SE area; along Mt Stuart Road	22°18`54.9"S	115°40`37.8"E	WAM database
S83884	Camaenidae	*Rhagada*	*convicta*	Cape Lambert, 155.2 km SW of Port Hedland	20°39`3.7"S	117°8`41.6"E	WAM database
JQ362689	Camaenidae	*Rhagada*	*convicta*	2 locations for four sequences: Mundabullangana Station 20.4424 S 118.0558 E Southern Burrup 20.6949 S 116.6547 E			Johnson *et al*., 2012
JQ362691	Camaenidae	*Rhagada*	*convicta*				Johnson *et al*., 2012
JQ362695	Camaenidae	*Rhagada*	*convicta*				Johnson *et al*., 2012

Reg No/ GenBank No	Family	Genus	Species	Locality	Latitude	Longitude	Reference
JQ362696	Camaenidae	*Rhagada*	*convicta*				Johnson *et al*., 2012
S58022	Camaenidae	*Rhagada*	'sp. nov. '	Near Carrawine Gorge; N face of mesa near summit	21°28`15.891"S	121°02`45.23"E	WAM database
S83866	Camaenidae	*Rhagada*	'sp. nov. '	31km S Pannawonica	21°55`9.93"S	116°18`2.82"E	

Conclusions

The main objectives were to compare barcoding sequences of the eight queried Camaenidae specimens to the WAM and published genetic databases to: 1) determine the taxonomic identity of the remaining eight Camaenidae specimens; and 2) determine the distribution and thus SRE status of the queried specimens. According to currently available DNA barcoding (COI) data, seven of the eight queried Camaenidae belong to a species complex currently known as *Rhagada convicta*. At times in the taxonomic history of this species, it has consisted of a number of sub-species but it is currently recognized as a single species. However we find it lacks rigorous sampling and genetic data. In the molecular study of Johnson *et al*. (2012), *R. convicta* was polyphyletic with two phylogenetic and geographical groups separated by approximately 7% average sequence divergence. Herein, some distances among tested *R. convicta* individuals/populations mirror levels of genetic divergence observed among different species of *Rhagada* (compare Fig. A with Fig. B). This suggests that closer examination of tested populations may reveal cryptic species. For this reason we suggest potential SRE status with subcategories A, D, E for these seven specimens. The remaining specimen (S88274) represents an as yet unnamed lineage of *Rhagada*, related to *R. torulus*, *R. capensis*, and *R. globosa,* to the best of our knowledge, recognised via DNA for the first time here. The COI DNA sequence of this specimen is closely aligned to two specimens in the WAM collection. The linear geographic separation of these three specimens is approximately 493 km. However, there is a tendency for these species to be restricted to drainage lines/ riparian zones/ gorges, and therefore the width of the distribution could be relatively narrow. Thus we do not have enough knowledge about their biology or distribution, so suggest potential SRE status with subcategory A, D, E.

References

Johnson, M. S., et al. (2004). Evolutionary genetics of island and mainland species of *Rhagada* (Gastropoda : Pulmonata) in the Pilbara Region, Western Australia. Australian Journal of Zoology **52**(4): 341-355.

Johnson, M. S., et al. (2012). Endemic evolutionary radiation of *Rhagada* land snails (Pulmonata: Camaenidae) in a continental archipelago in northern Western Australia. Biological Journal of the Linnean Society **106**(2): 316-327.

Koehler, F. and F. Criscione (2013). Plio-Pleistocene out-of-Australia dispersal in a Camaenid land snail. Journal of Biogeography **40**(10): 1971-1982.

Appendix 1. Specimen data for nine queried Camaenidae specimens

Reg. No.	Field No.	SubClass	Family	Genus	Species	Latitude	Longitude	Collection method	Substrate	Vegetation	Habitat
S88273	Site 5-18	Pulmonata	Camaenidae	*Rhagada*	*convicta*	21°23`19.40"S	119°37`06.50"E	Targeted Searching	Under rocks	Riperian	Drainage Line
S88274	Site 2-5	Pulmonata	Camaenidae	Rhagada	Sp. 'nov'	21°28`03.00"S	119°40`15.00"E	Targeted Searching	Ironstone	Ficus	Gorge
S88275*	Target 4-50	Pulmonata	Camaenidae	Rhagada	Undeter -mined	21°26`06.20"S	119°40`11.00"E	Targeted Searching	Ironstone	Ficus	Gorge
S88276	Site 5-19	Pulmonata	Camaenidae	*Rhagada*	*convicta*	21°23`19.40"S	119°37`06.50"E	Targeted Searching	Under rocks	Riperian	Drainage Line
S88277	Site 5-20	Pulmonata	Camaenidae	*Rhagada*	*convicta*	21°23`19.40"S	119°37`06.50"E	Targeted Searching	Under rocks	Riperian	Drainage Line
S88278	Site 5-21	Pulmonata	Camaenidae	*Rhagada*	*convicta*	21°23`19.40"S	119°37`06.50"E	Targeted Searching	Under rocks	Riperian	Drainage Line
S88279	Site 5-22	Pulmonata	Camaenidae	*Rhagada*	*convicta*	21°23`19.40"S	119°37`06.50"E	Targeted Searching	Under rocks	Riperian	Drainage Line
S88280	Site 5-23	Pulmonata	Camaenidae	*Rhagada*	*convicta*	21°23`19.40"S	119°37`06.50"E	Targeted Searching	Under rocks	Riperian	Drainage Line
S88281	Site 5-24	Pulmonata	Camaenidae	*Rhagada*	*convicta*	21°23`19.40"S	119°37`06.50"E	Targeted Searching	Under rocks	Riperian	Drainage Line

* specimen not suitable for molecular analysis as it was dried tissue and it may have been dead prior to collection or perhaps dried out during submission as a vial was noted dry on first inspection at WAM.

Appendix 2. WAM Short-Range Endemic Categories

<table>
<tr><th></th><th>Taxonomic Certainty</th><th>Taxonomic Uncertainty</th></tr>
<tr><td>Distribution < 10 000km^2</td><td>Confirmed SRE
A known distribution of < 10 000km².
The taxonomy is well known.
The group is well represented in collections and/ or via comprehensive sampling.</td><td rowspan="2">Potential SRE
Patchy sampling has resulted in incomplete knowledge of the geographic distribution of the group.
We have incomplete taxonomic knowledge.
The group is not well represented in collections.
This category is most applicable to situations where there are gaps in our knowledge of the taxon.
Sub-categories for this SRE designation are outlined below</td></tr>
<tr><td>Distribution > 10 000km^2</td><td>Widespread (not an SRE)
A known distribution of > 10 000km².
The taxonomy is well known.
The group is well represented in collections and/ or via comprehensive sampling.</td></tr>
</table>

SRE SUB-CATEGORIES

If a taxon is determined to be a "Potential SRE", the following sub-categories will further elucidate this status.

A. Data Deficient:

- There is insufficient data available to determine SRE status.
- Factors that fall under this category include:
  - Lack of geographic information.
  - Lack of taxonomic information.
  - The group may be poorly represented in collections.
  - The individuals sampled (e.g. juveniles) may prevent identification to species level.

B. Habitat Indicators:

- It is becoming increasingly clear that habitat data can elucidate SRE status.
  - Below are some examples of habitats that are currently known to be associated with SRE taxa and vice versa.

C. Morphology Indicators:

- A suite of morphological characters are characteristic of SRE taxa.
- Below are some examples of morphological characters associated with SRE taxa and vice-versa.

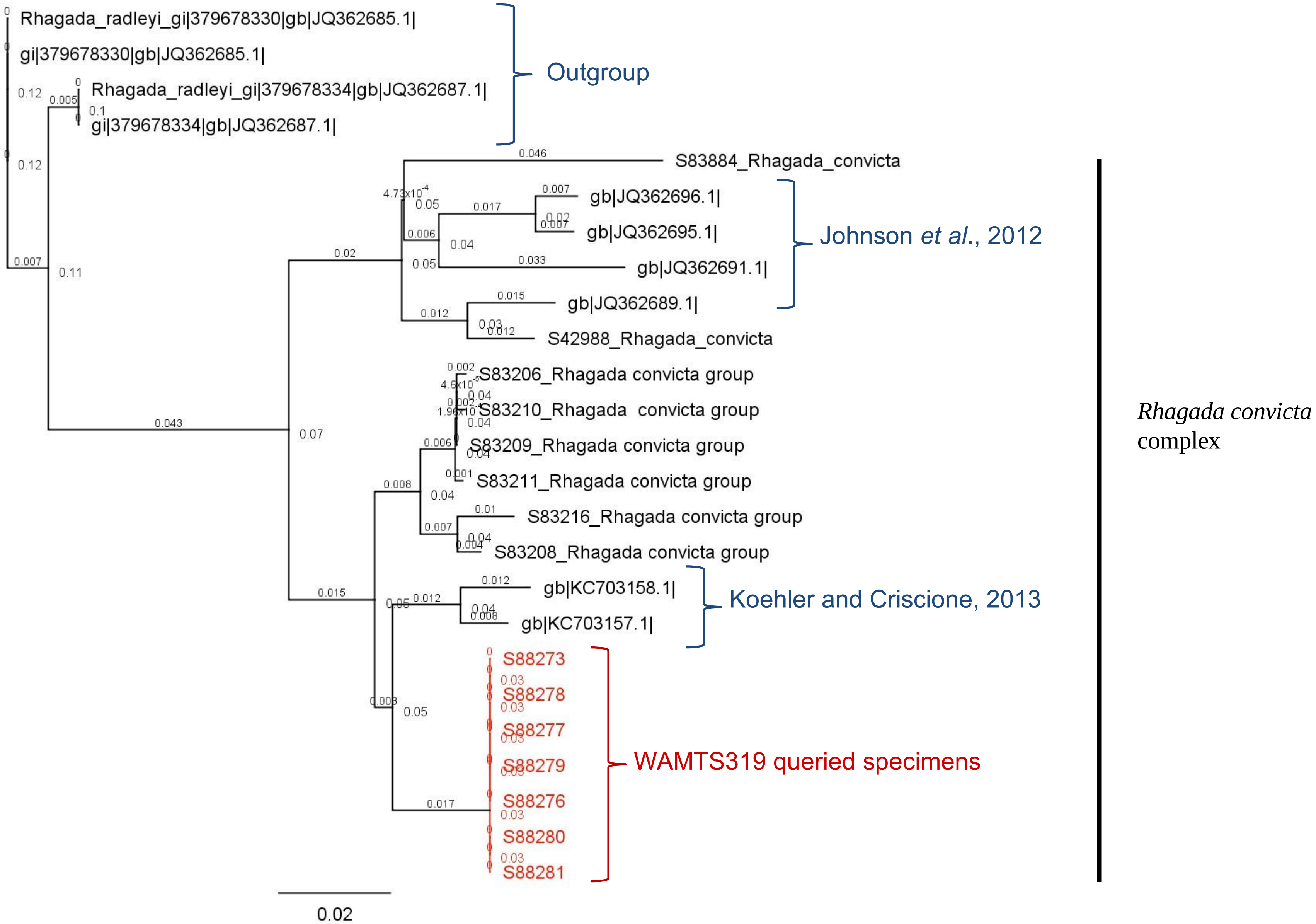
D. Molecular Evidence:

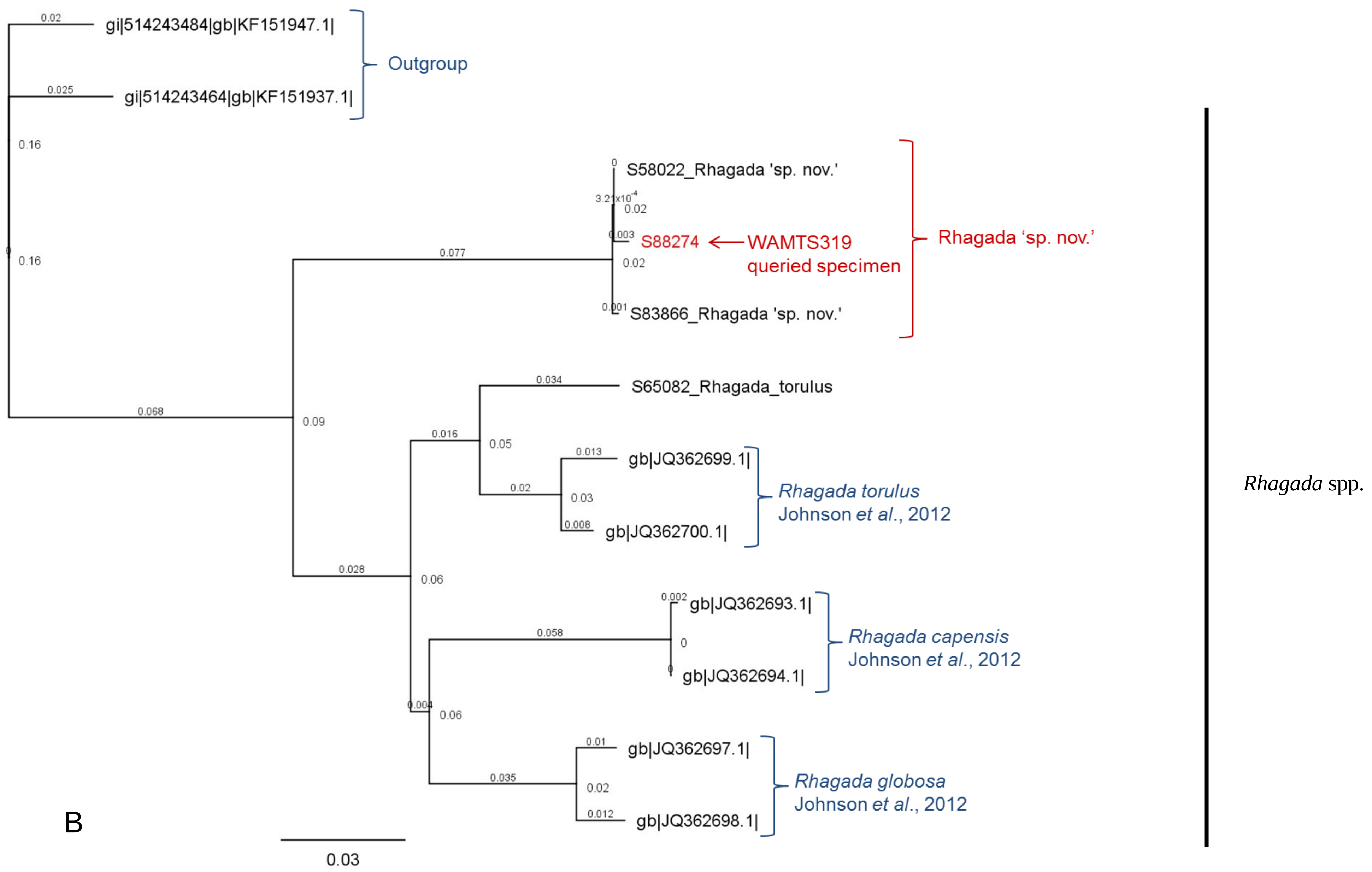
- If molecular work has been done on this taxon (or a close relative), it may reveal patterns congruent or incongruent with SRE status.
- Below are some examples of phylogenetic patterns associated with SRE taxa and vice-versa.

E. Research & Expertise:

- Previous research and/ or WAM expertise elucidates taxon SRE status.
- This category takes into account the expert knowledge held within the WAM.

Appendix 3. Simple Neighbour-Joining (distance based) tree to be used *ONLY* for visualisation of genetic distance relationships (not a comprehensive analysis using appropriate molecular models and search algorithms). Neighbour Joining tree of **A)** *R. convicta* complex and **B**) *R. torulus, R. capensis, R. globosa and R. sp. "nov.'* –DNA relationships.




0.02
gi|514243484|gb|KF151947.1|
Outgroup
0.025
gi|514243464|gb|KF151937.1|
0.16
0.16
0
S58022_Rhagada 'sp. nov.'
3.21x10-4
0.02
0.003
S88274
WAMTS319
queried specimen
0.077
0.02
0.001
S83866_Rhagada 'sp. nov.'
Rhagada 'sp. nov.'
0.034
S65082_Rhagada_torulus
0.068
0.09
0.016
0.05
0.013
gb|JQ362699.1|
0.02
0.03
Rhagada torulus
Johnson et al., 2012
0.008
gb|JQ362700.1|
0.028
0.06
0.002
gb|JQ362693.1|
0.058
0
Rhagada capensis
Johnson et al., 2012
gb|JQ362694.1|
0.004
0.06
0.01
gb|JQ362697.1|
0.035
0.02
Rhagada globosa
Johnson et al., 2012
0.012
gb|JQ362698.1|
B
0.03
Rhagada spp.

Appendix 4. COI DNA sequence data for queried Camaenidae specimens

>S88273
CACATTATATTTACTATTTGGTGTGTGGTGTGGGATGGTTGGCACGGGCTTATCTTTACTAATTCGGT
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>S88274
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>S88276
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>S88277
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>S88278
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>S88279
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>S88280
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>S88281
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CTTCCGGTGTTAGCTGGAGCGATCACAATATTATTAACTGATCGAAATTTTAACACTGCTTTTTTTGA
TCCTGTGGGGGGCGGCGACCCAATTTTGTATCAGCATCTTTTT

Appendix F Terrestrial Isopod Identification for Corunna Downs Project

Dr Simon Judd
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Carine
Western Australia. 6020.
simon_judd@iprimus.com.au
Tel: 0429 020 042

MWH Global
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Jolimont
Western Australia. 6014.

Attn: Paul Bolton

19th October 2016

Re: Terrestrial Isopod Identification for Corunna Downs Project.

I have examined the material recently collected from the Corunna Downs Project. All the taxa present have been reported before (Phoenix Environmental Sciences, August 2014). There have been no changes to the taxonomy of these morphospecies, or to their known distributions and SRE assessments, since this time.

This report is accompanied by a datasheet. This has been prepared ready for specimen lodgement through the Western Australian Museum Taxonomic Services system (WAMTS). WAM registration numbers will be allocated to the column headed "REGNO". Some specimens were not considered suitable for lodgement. These have been discarded and they are indicted on the datasheet.

All specimens belong to the family Armadillidae. The taxonomy of the Australian Armadillidae is confused and the taxa mentioned here reflect the current state of taxonomy. They are useful only in the sense that they allow for comparison to the terrestrial isopods found elsewhere in Australia or in previous reports. A brief summary table of the taxa identified in this batch of specimens and an assessment of their SRE status are given below. The taxa summaries are a revised version of those given in the Phoenix report.

Taxon	Sites Collected	SRE Status
Buddelundiinae 'abydos'	Site D	Not an SRE
Buddelundiinae 'mw'	CMMS-SR-01	Likely SRE
Buddelundia '11'	TARG-06, PBSHELL-01-1004	Potential SRE
Buddelundia '14MW'	Sites D, K I, L, M, N	Not an SRE
Buddelundia '86'	Sites D, F, M, N	Potential SRE

Family ARMADILLIDAE

Armadillidae typically have a convex dorsal surface and the animal can roll up into a ball. The family is diverse in Australia, currently 24 genera are described. The family is in need of a taxonomic review and many of the genera are unlikely to represent a distinct evolutionary unit.

3.5.1.2 Genus Buddelundiinae (unplaced)

This is a group of isopods found in the Pilbara and Kimberley. They belong to an undescribed genus closely related to *Buddelundia*. This genus is only found in the northern half of WA and currently known species in the Pilbara region are usually considered potential SRE species based on reported distribution patterns.

Buddelundiinae 'abydos'

This species is found from Abydos (Outback Ecology project) through Mount Webber (Outback Ecology project) and Corunna Downs to McPhee Creek (Outback Ecology project) in the east. The species has a restricted distribution, but does not currently constitute a potential SRE.

Buddelundiinae 'mw'

This is a ‘primitive’ armadillid species and is only found at Mount Webber and Corunna Downs. It is considered a likely SRE species.

3.5.1.3 Genus: *Buddelundia*

Members of the genus *Buddelundia* are the most common terrestrial isopods in WA. Only a few species of *Buddelundia* have a very wide distribution, and many represent potential SREs. *Buddelundia* normally account for more than 80% of samples from the arid regions of Western Australia (Judd & Taiti, 2011)

Buddelundia '11'

This species has a distribution similar to *Buddelundiinae 'abydos'* (see above). It was also found at Southern Haul Road and Southern Haul Road Realignment for the Turner River Hub, Southwest Rail Alignment and possibly North Star. Populations from McPhee Creek differ morphologically to some extent and it currently remains unclear if they belong to the same species. Due to the taxonomic uncertainties associated with these morphological differences, the species is considered a potential SRE species but it is fairly common within its currently known range.

Buddelundia '14MW'

Buddelundia ‘14MW’ has previously been reported as *Buddelundia* ‘14’. This is a relatively widespread species complex and the most common form of *Buddelundia* found in the Pilbara. *Buddelundia* ‘14MW’ is a morphological form found in the Mount Webber area. There are various other forms of *Buddelundia* ‘14’ and species in the group are generally relatively widespread; hence, *Buddelundia* ‘14MW’ is not considered an SRE.

Buddelundia '86'

This species is known from three locations (Mount Webber, Corunna Downs) and the Southern Deviation Survey. Based on this distribution it is considered a potential SRE.

REFERENCE

Judd, S. & Taiti S. (2011). *Preliminary taxonomy and biogeography of the subfamily Buddelundiinae Vandel (Armadillidae) in Western Australia*. In: Zidar, P. & Štrus, J. (Eds.) Proceedings of the 8th International Symposium of Terrestrial Isopod Biology ISTIB 2011. Ljubljana: pp. 33–34.

Appendix G Molecular Identification of arachnids from Corunna Downs, ca 30 km SSW of Marble Bar, Western Australia

Molecular Identification of arachnids from Corunna Downs, ca 30 km SSW of Marble Bar, Western Australia

Report to *MWHGlobal* 31 October 2016

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Summary

A total of five specimens of arachnids, collected from Corunna Downs, ca 30 km SSW of Marble Bar were lodged into the Western Australian Museum collection by *MWHGlobal* (see Appendix 1 for specimen details). Four specimens belong to the family Selenopidae, Molecular analyses were only performed on three of these four specimens as T141888 was only an exoskeleton and would not contain amplifiable DNA. The fifth specimen is from the infraorder Mygalomorphae. *MWHGlobal* requested molecular analyses from four additional specimens from the WA Museum. Three of these four specimens could be included in the analyses. The main objectives of the WA Museum's Molecular Systematics Unit (MSU) were to use COI DNA barcoding to compare DNA sequences to the WA Museum and published DNA databases to: 1) determine the taxonomic identity of the arachnid specimens where possible; and 2) determine the distribution and thus SRE status of the queried specimens.

A summary of specimen identifications together with their SRE status may be found in Table 1. A full explanation of the SRE categories used by the Western Australian Museum may be found in Appendix 2.

Table 1. Summary of WAMTS453 specimen identifications and SRE status

FAMILY	GENUS	SPECIES	# SPECIMENS	SRE SUB-CATEGORY
Selenopidae	*Karaops*	'sp. indet. 1'	1	Potential SRE- (D) Molecular Evidence
Selenopidae	*Karaops*	'sp. indet. 2'	2	Potential SRE- (D) Molecular Evidence
Idiopidae	*Aganippe(?)*	(pseudogene present)	1	Not assessed

Methods and Results

DNA was extracted from a half leg of each of the four queried and three reference arachnid specimens using a Qiagen DNA extraction kit. The Folmer's primers, LCO1490 and HCO2198 were used to amplify COI DNA barcodes. COI DNA barcodes were successfully amplified and sequenced from six of the seven specimens. Unfortunately the remaining sequence (Mygalomorphae: query specimen T141889) contained two copies of the COI gene and the copies that could be clearly identified from chromatograms contained numerous stop codons signifying dysfunctional copies of the gene (pseudogene). This was despite attempting a limiting dilution approach to dilute out nuclear copies. (This involved an additional 7 PCRs representing a dilution series of DNA from T141889 and an additional DNA sequencing reaction). Such pseudogenes are common in the family Idiopidae and cannot be used to accurately identify species. A summary of the comparison (BLAST) for the three successful queried specimens (including context of WA Museum specimens) is provided in Table 2. Details of other museum specimens that were identified in BLAST searches and contextualise the status of the queried species are provided in Table 3. Simple Neighbour-Joining (distance based) trees are provided in Appendix 3 for visualisation of genetic relationships. DNA sequences (where target gene was acquired) of queried specimens are provided in Appendix 4.

Options for Future Resolution of Pseudogene Problem for this study

The barcoding gene, Cytochrome Oxidase I, is a protein-coding mitochondrial gene. Mitochondrial genes can sometimes be copied to the nucleus and become dysfunctional. These dysfunctional genes are called pseudogenes. The protein coding DNA sequence in pseudogenes often contain stop-codons, making them readily detectable in DNA analyses, but this is not always the case. Considering the pseudogene problem in this study (clearly two sequences present in the DNA sequence chromatograms) it is possible to perform a technique that will improve chances of obtaining the correct target COI gene. The method is based on the fact that there is only one nucleus in each cell but many more mitochondria. The idea is to dilute the sample to the extent where the nuclear copies are removed and there are only mitochondrial copies left. Success is not guaranteed, but the likelihood of getting only the mitochondrial copy of the gene is improved. For efficiency of time this method was used on the Mygalomorph sample from the outset. It proved ineffective in this case, but as it has been successful in the past. The technique could be repeated on this specimen if necessary.

Table 2. Summary of BLAST analysis

REGNO	SPECIES	SUMMARY OF BLAST RESULTS
T141885	*Karaops* 'sp. indet. 1'	**Nearest:** Specimen T141885 is 4.56% divergent from WA Museum specimens T122640 and T122644, *Karaops* 'sp. indet.' Given current evidence, these 3 specimens are considered to be the same species. **Broader context:** This species (including T141885, T122640, T122644) is 7.02% divergent from previously recognised lineages ARA-003-DNA and ARA-005-DNA.
T141886 T141887	*Karaops* 'sp. indet. 2'	**Nearest:** T141886 and T141887 are in a lineage with T136189, T136190 and T136192. These 5 specimens have on average 99.6% sequence similarity. Given current evidence, these 5 specimens are considered to be same species. **Broader context:** This species (including T141886, T141887, T136189, T136190, T136192) is 8.40% divergent from other lineages including recognised *Karaops martamarta*. Species such as *K. nyangumarta* and *K. feedtime* are more distantly related (see simple phylogenetic tree in Appendix 3).
T141889	*Aganippe ?*	Pseudogene present- common in Idiopidae. Partial sequence with redundancies is within the genus *Aganippe*. This is a rough estimate only- sequencing data cannot be relied upon in this case.

Table 3. Details of registered WAM specimens in related lineages to the queried *Karaops* specimens according to DNA barcoding.

Reg. No.	Field No.	Order	Family	Genus	Species	Locality	Latitude	Longitude	Collection method	Habitat
T122640	Target 3-12	Araneae	Selenopidae	Karaops	`sp. indet. (juvenile)`	ca. 60 km SW. of Marble Bar	-21.587	119.291	Target Searching	Drainage line with granite
T122644	Site 2-104	Araneae	Selenopidae	Karaops	`sp. indet. (juvenile)`	ca. 60 km SW. of Marble Bar	-21.521	119.304	Wet Pitfall	Ridge (south facing)
*T136189	Site 3-366	Araneae	Selenopidae	*Karaops*	`sp. indet. (juvenile)`	Corunna Downs Station, ca. 75 km NW. of Nullagine	-21.487	119.669	Wet Pitfall Trap	Gorge
*T136190	Site 1-447	Araneae	Selenopidae	*Karaops*	`sp. indet. (juvenile)`	Corunna Downs Station, ca. 75 km NW. of Nullagine	-21.473	119.669	Funnel Trap	Gorge
*T136192	Site 2-376	Araneae	Selenopidae	*Karaops*	`sp. indet. (juvenile)`	Corunna Downs Station, ca. 75 km NW. of Nullagine	-21.468	119.671	Wet Pitfall Trap	Gorge

*Sequenced for this study. DNA sequences are provided in Appendix 4.

Conclusions

The main objectives were to use DNA barcoding to: 1) determine the taxonomic identity of the arachnid specimens where possible; and 2) determine the distribution and thus SRE status of the queried specimens. According to currently available DNA barcoding (COI) there are three species represented in the four queried specimens. T141885 aligns with T122640 and T122644 and together they represent an as yet undescribed species of *Karaops* that is only represented by juveniles though DNA barcoding. All three specimens from this undescribed species were collected within 10,000 km^2 and therefore this species (*Karaops* 'sp. indet. 1') represents a potential SRE (D- Molecular Evidence).

Specimens T141886 and T141887 align with the three sequences from the WA Museum Wet Store that *MWHGlobal* requested be included in the molecular analyses. There is 99.6% sequence similarity between these 5 specimens. There nearest relatives are 8.4% divergent and include *Karaops martamarta* and another undescribed lineage. These five specimens were all collected well within 10,000km^2 and therefore they are considered a potential short range endemic (D- Molecular Evidence).

The third species cannot be confirmed due to the presence of pseudogenes but is very likely to be from the family Idiopidae and could potentially be from the genus *Aganippe*. SRE status for this specimen was not assessed.

Appendix 1. Specimen data for queried specimens

Reg. No.	Field No.	Infraorder	Family	Genus	Species	Locality	Collection method	Habitat
T141885	Site F - 152	Araneomorphae	Selenopidae	*Karaops*	'sp. indet. 1'	Corunna Downs, ca 30 km SSW of Marble Bar	pitfall trap	Calcrete
T141886	CKMS-SR-01 - 112	Araneomorphae	Selenopidae	*Karaops*	'sp. indet. 2'	Corunna Downs, ca 30 km SSW of Marble Bar	Searching	Rocky Ridge and Gorge
T141887	PBSEL-01-1001 - 274	Araneomorphae	Selenopidae	*Karaops*	'sp. indet. 2'	Corunna Downs, ca 30 km SSW of Marble Bar	Searching	Rocky Ridge and Gorge
T141888	Site M - 267	Araneomorphae	Selenopidae	*Karaops*	Exoskeleton only- not assessed	Corunna Downs, ca 30 km SSW of Marble Bar	Searching	Rocky Foothills
T141889	Targ 7 - 157	Mygalomorphae	Likely Idiopidae	*Aganippe ?*	Pseudogene present- not assessed	Corunna Downs, ca 30 km SSW of Marble Bar	Searching	Rocky Ridge and Gorge

Appendix 2. WAM Short-Range Endemic Categories

<table>
<tr><th></th><th>Taxonomic Certainty</th><th>Taxonomic Uncertainty</th></tr>
<tr><td>Distribution < 10 000km^2</td><td>Confirmed SRE
A known distribution of < 10 000km^2.
The taxonomy is well known.
The group is well represented in collections and/ or via comprehensive sampling.</td><td rowspan="2">Potential SRE
Patchy sampling has resulted in incomplete knowledge of the geographic distribution of the group.
We have incomplete taxonomic knowledge.
The group is not well represented in collections.
This category is most applicable to situations where there are gaps in our knowledge of the taxon.
Sub-categories for this SRE designation are outlined below</td></tr>
<tr><td>Distribution > 10 000km^2</td><td>Widespread (not an SRE)
A known distribution of > 10 000km^2.
The taxonomy is well known.
The group is well represented in collections and/ or via comprehensive sampling.</td></tr>
</table>

SRE Sub-Categories

If a taxon is determined to be a "Potential SRE", the following sub-categories will further elucidate this status.

A. *Data Deficient:*
- There is insufficient data available to determine SRE status.
- Factors that fall under this category include:
  - – Lack of geographic information.
  - – Lack of taxonomic information.
  - – The group may be poorly represented in collections.
  - – The individuals sampled (e.g. juveniles) may prevent identification to species level.

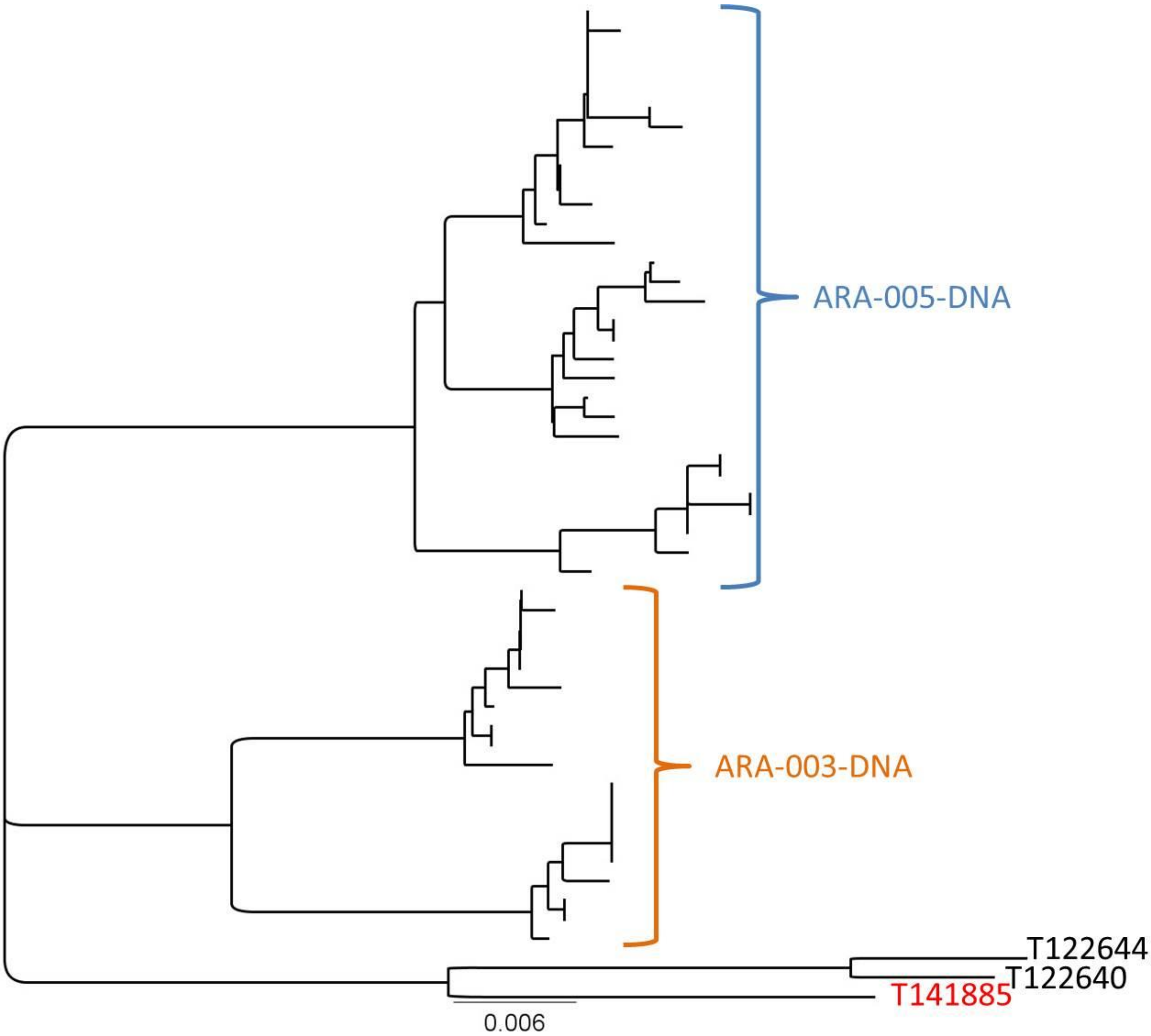
B. *Habitat Indicators:*
- It is becoming increasingly clear that habitat data can elucidate SRE status.
  - Below are some examples of habitats that are currently known to be associated with SRE taxa and vice versa.

C. *Morphology Indicators:*
- A suite of morphological characters are characteristic of SRE taxa.
- Below are some examples of morphological characters associated with SRE taxa and vice-versa.

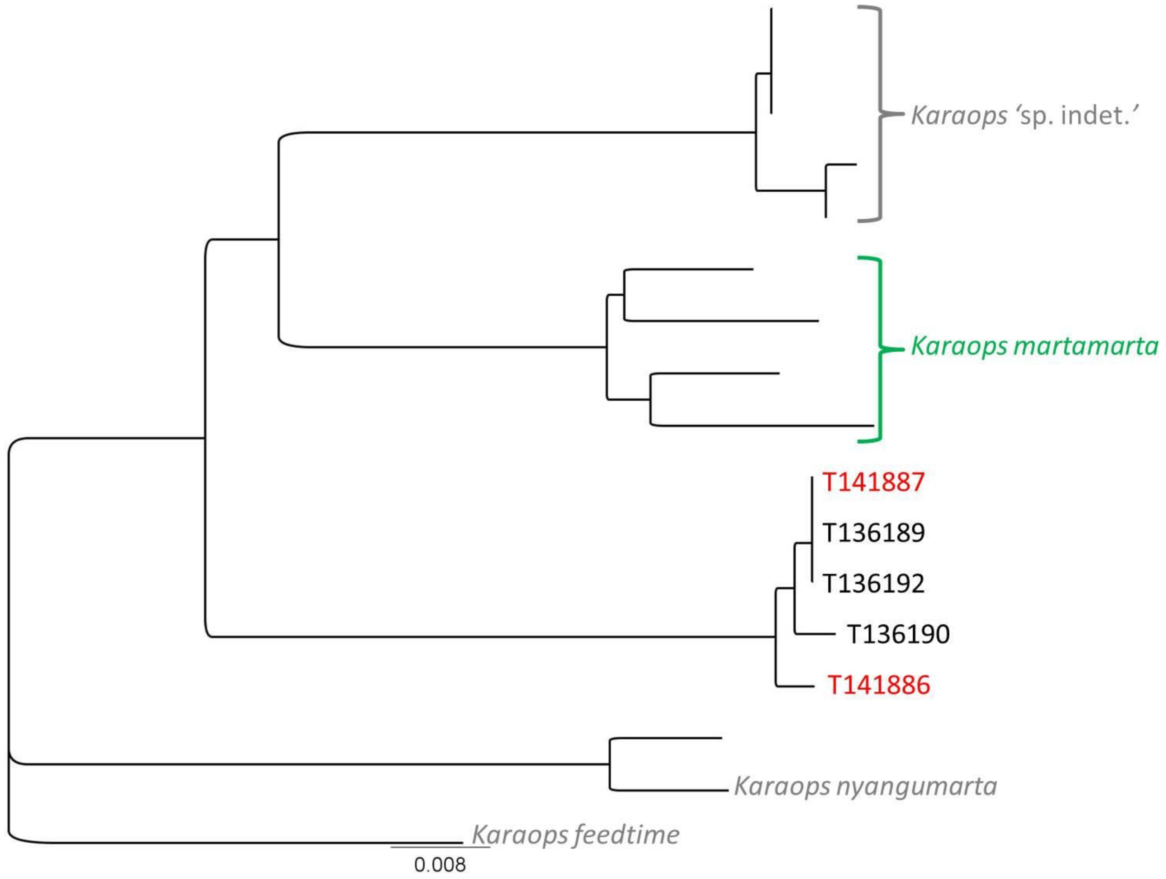
D. *Molecular Evidence:*
- If molecular work has been done on this taxon (or a close relative), it may reveal patterns congruent or incongruent with SRE status.
- Below are some examples of phylogenetic patterns associated with SRE taxa and vice-versa.

E. *Research & Expertise:*
- Previous research and/ or WAM expertise elucidates taxon SRE status.
- This category takes into account the expert knowledge held within the WAM.

Appendix 3. Simple Neighbour-Joining (distance based) trees to be used *ONLY* for visualisation of genetic distance relationships (not a comprehensive analysis using appropriate molecular models and search algorithms).



a) 141885



b) T141886, T141887. *Karaops feedtime* and *K.myangumarta* were used to root the tree.

Appendix 4. DNA sequence data for targeted COI sequences from queried specimens

>T141885
GACTTTATATTTAATTTTTGGAGCTTGATCTGCTATGGTAGGAACGGCTATAAGAGTTTTAATTCGAA
TGGAGTTAGGTCAGACTGGTAGATTTTTGGGAGATGATCATATGTACAATGTTATTGTTACTGCTCAT
GCTTTTGTTATAATTTTTTTTATAGTTATACCTATTTTGATTGGAGGTTTTGGAAATTGGTTAATTCC
CTTGATGTTAGGAGCCCCAGATATAGCTTTTCCTCGTATGAATAATTTGAGTTTTTGGTTATTACCTC
CTTCTTTAATATTATTGTTTATTTCATCAATGGTGGAAATAGGGGTTGGAGCTGGATGGACAGTATAC
CCTCCTTTAGCGAGAGTTATGGGGCATGCTGGAAGTGCTGTTGATTTTGCAATTTTTTCTTTGCATTT
AGCTGGTGCATCTTCTATTATGGGAGCTGTTAATTTTATTTCTACTGTAATTAATATACGTTCTGTAG
GAATATCAATAGAAAAGGTTCCTTTATTTGTATGGTCTGTTTTTATTACAGCTATTTTATTATTATTA
TCATTGCCGGTTTTAGCTGGGGCTATTACTATATTATTAACTGATCGAAATTTTAATACTTCTTTTTT
TGATCCTGCTGGAGGAGGAGATCCGATTTTATTTCAACATTTATTT

>T141886
GACTTTATATTTGATTTTTGGAGCTTGATCTGCTATGGTAGGGACGGCTATAAGAGTATTGATTCGAA
TGGAATTAGGTCAGACTGGTAGATTTTTAGGGGATGATCATATGTATAATGTTATTGTTACTGCACAT
GCTTTTGTTATAATTTTTTTTATAGTAATACCTATTTTGATTGGGGGTTTTGGAAATTGATTAATTCC
TTTAATGTTAGGAGCTCCGGATATGGCTTTTCCTCGTATGAATAATTTGAGTTTTTGATTATTGCCTC
CTTCTTTAATATTATTATTTATTTCATCAATAGTAGAAATAGGAGTTGGGGCTGGATGGACGGTGTAT
CCGCCTTTGGCGAGAGTTATAGGACATGCTGGAAGTGCTGTTGATTTTGCGATCTTTTCTTTACATTT
AGCTGGTGCTTCTTCTATTATAGGGGCTGTTAATTTTATTTCTACTGTAATTAATATGCGTTCTGTGG
GAATGTCAATGGAAAAGGTTCCTTTATTTGTATGATCTGTTTTTATTACAGCTATTTTGTTATTATTA
TCACTACCGGTTTTAGCTGGGGCTATTACTATATTATTAACTGATCGGAATTTTAATACTTCTTTTTT
TGATCCTGCTGGGGGAGGAGATCCAATTTTATTTCAACATTTATTT

>T141887
GACTTTATATTTGATTTTTGGAGCTTGATCTGCTATGGTAGGGACGGCTATAAGAGTATTGATTCGAA
TGGAATTAGGTCAGACTGGTAGATTTTTAGGGGATGATCATATGTATAATGTTATTGTTACTGCACAT
GCTTTTGTTATAATTTTTTTTATAGTAATACCTATTTTGATTGGGGGTTTTGGAAATTGATTAATTCC
TTTAATGTTAGGAGCTCCGGATATGGCTTTTCCTCGTATGAATAATTTGAGTTTTTGATTATTGCCTC
CTTCTTTAATATTATTATTTATTTCATCAATAGTAGAAGTAGGAGTTGGGGCTGGATGGACGGTGTAT
CCGCCTTTGGCGAGAGTTATAGGACATGCTGGAAGTGCTGTTGATTTTGCGATCTTTTCTTTACATTT
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GAATGTCAATGGAAAAGGTTCCTTTATTTGTATGATCTGTTTTTATTACAGCTATTTTGTTATTATTA
TCATTACCGGTTTTAGCTGGGGCTATTACTATATTATTAACTGATCGGAATTTTAATACTTCTTTTTT
TGATCCTGCTGGGGGAGGAGATCCAATTTTATTTCAACATTTATTT

>T136189
GACTTTATATTTGATTTTTGGAGCTTGATCTGCTATGGTAGGGACGGCTATAAGAGTATTGATTCGAA
TGGAATTAGGTCAGACTGGTAGATTTTTAGGGGATGATCATATGTATAATGTTATTGTTACTGCACAT
GCTTTTGTTATAATTTTTTTTATAGTAATACCTATTTTGATTGGGGGTTTTGGAAATTGATTAATTCC
TTTAATGTTAGGAGCTCCGGATATGGCTTTTCCTCGTATGAATAATTTGAGTTTTTGATTATTGCCTC
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CCGCCTTTGGCGAGAGTTATAGGACATGCTGGAAGTGCTGTTGATTTTGCGATCTTTTCTTTACATTT
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GAATGTCAATGGAAAAGGTTCCTTTATTTGTATGATCTGTTTTTATTACAGCTATTTTGTTATTATTA
TCACTACCGGTTTTAGCTGGGGCTATTACTATATTATTAACTGATCGGAATTTTAATACTTCTTTTTT
TGATCCTGCTGGGGGAGGAGATCCAATTTTATTTCAACATTTATTT

>T136190
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TGGAATTAGGTCAGACTGGTAGATTTTTAGGGGATGATCATATGTATAATGTTATTGTTACTGCACAT
GCTTTTGTTATAATTTTTTTTATAGTAATACCTATTTTGATTGGGGGTTTTGGAAATTGATTAATTCC
TTTAATGTTAGGAGCTCCGGATATGGCTTTTCCTCGTATGAATAATTTGAGTTTTTGATTATTGCCTC
CTTCTTTAATATTATTATTTATTTCATCAATAGTAGAAATAGGAGTTGGGGCTGGATGGACGGTGTAT
CCGCCTTTGGCGAGAGTTATAGGACATGCTGGAAGTGCTGTTGATTTTGCGATCTTTTCTTTACATTT
AGCTGGTGCTTCTTCTATTATAGGGGCTGTAAATTTTATTTCTACTGTAATTAATATGCGTTCTGTGG
GAATGTCAATGGAAAAGGTTCCTTTATTTGTATGATCTGTTTTTATTACAGCTATTTTGTTATTATTA
TCACTACCGGTTTTAGCTGGGGCTATTACTATATTATTAACTGATCGGAATTTTAACACTTCTTTTTT
TGATCCTGCTGGGGGAGGAGATCCAATTTTATTTCAACATTTATTT

>T136192
GACTTTATATTTGATTTTTGGAGCTTGATCTGCTATGGTAGGGACGGCTATAAGAGTATTGATTCGAA
TGGAATTAGGTCAGACTGGTAGATTTTTAGGGGATGATCATATGTATAATGTTATTGTTACTGCACAT
GCTTTTGTTATAATTTTTTTTATAGTAATACCTATTTTGATTGGGGGTTTTGGAAATTGATTAATTCC
TTTAATGTTAGGAGCTCCGGATATGGCTTTTCCTCGTATGAATAATTTGAGTTTTTGATTATTGCCTC
CTTCTTTAATATTATTATTTATTTCATCAATAGTAGAAATAGGAGTTGGGGCTGGATGGACGGTGTAT
CCGCCTTTGGCGAGAGTTATAGGACATGCTGGAAGTGCTGTTGATTTTGCGATCTTTTCTTTACATTT
AGCTGGTGCTTCTTCTATTATAGGGGCTGTTAATTTTATTTCTACTGTAATTAATATGCGTTCTGTGG
GAATGTCAATGGAAAAGGTTCCTTTATTTGTATGATCTGTTTTTATTACAGCTATTTTGTTATTATTA
TCACTACCGGTTTTAGCTGGGGCTATTACTATATTATTAACTGATCGGAATTTTAATACTTCTTTTTT
TGATCCTGCTGGGGGAGGAGATCCAATTTTATTTCAACATTTATTT

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