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HANCOCK PROSPECTING PTY LTD
ROY HILL IRON ORE PROJECT
SHORT RANGE ENDEMIC SURVEY

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HANCOCK PROSPECTING PTY LTD

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EXECUTIVE SUMMARY

The proposed Roy Hill Iron Ore Project (the Project) is situated approximately 100 km north of Newman in the east Pilbara region of Western Australia. The Project is located within existing Hancock Prospecting Pty Ltd (HPPL) exploration tenements E46/334, E46/335, E46/586 and E46/592 and E47/1326.

The primary objective of this document was to undertake an assessment that satisfies the Short-Range Endemic (SRE) assessment requirements documented in EPA's Guidance Statement 56 and Position Statement No. 3.

A short-range endemic species refers to an endemic species with restricted range, which is currently defined in Western Australia as less than 10,000 km^2 (100 km x 100 km). Such taxa are usually invertebrates, as they are more likely to display poor dispersal abilities and a more defined or restrictive biology that promotes their isolation and eventual speciation. The groups or organisms which display short-range endemism include (but are not limited to) molluscs (e.g. Camaenid land snails), onychophorans (velvet worms), millipedes, arachnids (e.g. scorpions, pseudoscorpions, mygalomorph spiders) and some crustaceans (isopods).

A review of literature was undertaken to establish whether SRE species could occur within the Project area and surrounds. It took into account both known and predicted distribution of SRE species and the availability of the potential SRE habitat. The review revealed that there was potential for SRE taxa to occur within the Project area and surrounds.

Consequently, an invertebrate survey targeting SRE taxa was conducted within the Project area and surrounds. Three major habitat assemblages were found to occur in the study area, namely Mulga woodland, major drainage lines and southern facing ridge slopes, all of which were not locally restricted and therefore unlikely to provide the processes which promote short-range endemism.

The Mulga woodland covers large areas of the region, presenting no obvious barriers to the dispersal of species and therefore not likely to the harbour relictual taxa. This is also somewhat true of the major drainage lines, which have the potential to promote dispersal of invertebrates between non-continuous microhabitats such as large shade bearing trees and dense litter accumulations. The southern facing ridge slopes were considered most likely to harbour SRE taxa. Nevertheless, the slopes form part of the Chichester Range, which is an extensive landscape unit and therefore offers a relatively continuous habitat. Invertebrate taxa that occupy the more protected microhabitats within the range during dry seasons are expected to be able to disperse from these locations during wet periods.

Ten invertebrate species from recognised SRE taxa were found during the survey, five of which were not formally described. These included two possibly new species of scorpion (i.e. *Urodacus* sp. and *Lychas* sp.), two new centipede species (i.e. a species from the order Geophilomorpha and *Asanda* ap.) and one undescribed, but known, isopod species (i.e. *Laevophiloscia* Wahrberg 1922 sp.).

The two undescribed species of scorpions were recorded from Mulga Woodland habitat. As stated previously, no obvious barriers to dispersal exist in this habitat, therefore the distribution of the species is expected to be much broader than the Project area. The impact from the Project is therefore unlikely to lead to the extinction or severe range contraction of the two scorpion species.

The two undescribed species of centipede and the isopod *Laevophiloscia* sp. were recorded from the southern facing ridge slope. As the slopes form part of the extensive Chichester Range, the centipedes and the isopod are expected to be able to disperse from the more protected microhabitats within the range during wet periods.

Further to the above, Western Australian experts, Dr Mark Harvey (scorpions) and Dr Simon Judd (isopods) indicated that the undescribed scorpion and isopod species are unlikely to be SRE or highly restricted species.

In conclusion, it appears that the habitat that is normally suitable to harbour SRE taxa is relatively widespread both within and outside the Project area. It is, therefore, unlikely that this habitat would facilitate allopatric speciation (speciation triggered by geographic isolation) that would give rise to SRE invertebrate species.

1.0 INTRODUCTION

1.1 PROJECT OVERVIEW

The proposed Roy Hill Iron Ore Project (the Project) is situated approximately 100 km north of Newman in the east Pilbara region of Western Australia (Figure 1.1). The Project is located within existing Hancock Prospecting Pty Ltd (HPPL) exploration tenements E46/334, E46/335, E46/586 and E46/592 and E47/1326.

HPPL is currently undertaking a Pre-feasibility Study for the Project. The Project will utilise conventional open-cut mining of iron ore. The current iron ore resource for the Project has been estimated at approximately 600 million tonnes (Mt) with expected extensions currently under further exploration. The study area covers approximately 4,160 hectares (ha) of open rangelands, and is situated in the hills and footslopes of the Chichester Range and the plains of the Fortescue Marsh.

The main Project components are likely to consist of:

- a number of open pits which will generally be located in three main areas;
- out-of-pit overburden emplacement areas;
- infrastructure including ore crushing and screening plant, site administration facilities, rail load-out facilities and stockpiles;
- if required, a beneficiation plant for ore washing and associated residue storages;
- an accommodation camp;
- haul and access roads;
- public road diversion;
- electricity transmission line; and
- a rail spur corridor to a junction near existing rail corridors and railways to ports.

1.2 LEGISLATIVE FRAMEWORK

The *Environmental Protection Act 1986* is "An Act to provide for an Environmental Protection Authority, for the prevention, control and abatement of environmental pollution, for the conservation, preservation, protection, enhancement and management of the environment and for matters incidental to or connected with the foregoing." Section 4a of this Act outlines five principles that are required to be addressed to ensure that the objectives of the Act are addressed. Three of these principles are relevant to native fauna, including invertebrate Short-range endemics:

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

Figure 1-1 The Location of the HPPL Proposed Roy Hill Iron Ore Mine

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

- *The Principle of the Conservation of Biological Diversity and Ecological Integrity*
  Conservation of biological diversity and ecological integrity should be a fundamental consideration.

Projects undertaken as part of the Environmental Impact Assessment (EIA) process are required to address guidelines produced by the EPA, in this case Guidance Statement 56: Terrestrial Fauna Surveys for Environmental Impact in Western Australia (EPA 2004), and principles outlined in the EPA's Position Statement No. 3 Terrestrial Biological Surveys as an element of Biodiversity Protection (EPA 2002).

Native fauna and flora in Western Australia are protected at a Federal level under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) and at a State level under the *Wildlife Conservation Act 1950* (WC Act).

The EPBC Act was developed to provide for the protection of the environment, especially those aspects of the environment that are matters of national environmental significance, to promote ecologically sustainable development through the conservation and ecologically sustainable use of natural resources; and to promote the conservation of biodiversity. The EPBC Act includes provisions to protect native species (and in particular prevent the extinction, and promote the recovery, of threatened species) and ensure the conservation of migratory species. In addition to the principles outlined in Section 4a of the EP Act, Section 3a of the EPBC Act includes a principle of ecologically sustainable development dictating that decision-making processes should effectively integrate both long-term and short-term economic, environmental, social and equitable considerations.

The WC Act was developed to provide for the conservation and protection of wildlife in Western Australia. Under Section 14 of this Act, all fauna and flora within Western Australia is protected; however, the Minister may, via a notice published in the *Government Gazette*, declare a list of fauna taxa identified as likely to become extinct, or is rare, or otherwise in need of special protection. The current listing was gazetted on 8th February 2005.

1.3 PURPOSE AND SCOPE OF THE DOCUMENT

A Short-range Endemic (SRE) species refers to an endemic species with restricted range, which is currently defined in Western Australia as less than 10,000 km^2 (100 km x 100 km). Such taxa are usually invertebrates, as they are more likely to display poor dispersal abilities and a more defined or restrictive biology that promotes their isolation and eventual speciation.

The purpose of this document is:

1) To present the available knowledge of SRE invertebrate fauna in the northwest of Western Australia, particularly as it relates to the Project area.
2) To present the results of the field survey.
3) To assess the environmental impact of the Project on the SRE invertebrate fauna.

1.4 SURVEY OBJECTIVES

Hancock Prospecting Pty Ltd commissioned *ecologia* Environment (ecologia) to undertake a baseline biological survey for invertebrate SRE fauna as part of the environmental impact assessment for the Project.
The primary objective of this document was to undertake an assessment that satisfies the requirements documented in EPA's Guidance Statement 56 and Position Statement No. 3, thus providing:

a) An inventory of:

- invertebrate fauna species from target groups likely to contain SRE taxa occurring in the study area;
- SRE habitats occurring or likely to occur in the study area.

b) A review of:

- the regional and local conservation value of SRE fauna present or likely to be present in the study area;
- SRE fauna species of particular conservation value such as Scheduled or DEC listed Priority species likely to occur in the study area; and

c) An assessment of the potential impacts to SRE taxa resulting from the Project.

d) Recommendations for management of potential impacts on SRE invertebrate fauna or their habitat.

2.0 BIOPHYSICAL ENVIRONMENT

2.1 CLIMATE

Roy Hill is situated in the Pilbara region of Western Australia and experiences an arid-tropical climate with two distinct seasons; a hot summer from October to April and a mild winter from May to September. Annual evaporation exceeds rainfall by as much as 500 mm per year. Seasonally low but unreliable rainfall, together with high temperatures and high diurnal temperature variations are also characteristic climatic features of the region. This region has in the past experienced no rainfall in any month of the year, which is typical of a desert climate (Beard 1975). Within the Pilbara, the temperature range is large and maxima are high. Summer temperatures may reach as high as 46°C at Newman, with a mean maximum of 31.3°C (Table 2.1). Light frosts occasionally occur during July and August. The climate experienced throughout the year is usually very dry since high temperature and humidity seldom occur simultaneously.

Table 2-1 Summary of Climatic Data for Newman

NEWMAN Elevation: 554 m Location: 23°22'S 199°44'E												
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Daily Mean Maximum Temperature (°C)	38.8	37.2	35.8	31.6	26.2	22.4	22.2	24.8	29.4	33.6	36.5	38.5
Daily Mean Minimum Temperature (°C)	25.3	24.4	22.5	18.5	13.3	9.6	8.0	10.2	13.7	18.0	21.5	24.1
Mean Rainfall (mm)	50.1	80.1	38.6	25.3	23.2	25.0	12.6	10.6	4.1	3.9	9.8	27.0
Mean Number of Rain Days	6.6	7.0	4.9	4.2	3.8	3.9	2.5	2.0	0.9	1.4	2.9	5.1

Rainfall in the Pilbara is highly unpredictable and recordings are highest at stations around the Hamersley Ranges, which lie at altitudes of up to 900 m (Beard 1975). From January to March, rain results from moist tropical storms penetrating from the north, producing sporadic and drenching thunderstorms. Tropical cyclones moving south from northern Australian waters also bring sporadic heavy rains. From May to June extensive cold fronts move easterly across the state and occasionally reach the Pilbara. These fronts produce only light winter rains that are ineffective for plant growth other than herbs and grasses. Larger perennial species require the intense and prolonged storms of summer. Surface water can be found in some pools and springs in the Pilbara all year round, although watercourses only flow briefly due to the short wet season. Within the study region, meteorological data has been recorded at the Bureau of Meteorology (BOM) weather station at Newman (23°22'S, 119°44'E). This BOM weather station is located approximately 100 km to the southwest of Roy Hill, providing an indication of climatic conditions experienced within the study area (Table 2.1).

The calculated average annual rainfall is 310.3 mm, occurring over 45 rain days (Table 2.1). It loosely follows the typical Pilbara bimodal distribution pattern, with a peak between December and March and a smaller peak in May and June (Figure 2.1). Most of the rainfall occurs in the summer period, with over 55% of total annual precipitation occurring between December and March.

Mean annual maximum and minimum temperatures for Newman are 31.4°C and 17.4°C respectively. Mean monthly maxima range from 38.8°C during January to 22.2°C in July, while mean monthly minima range from 25.3°C in January to 8.0°C in July (Figure 2.1).

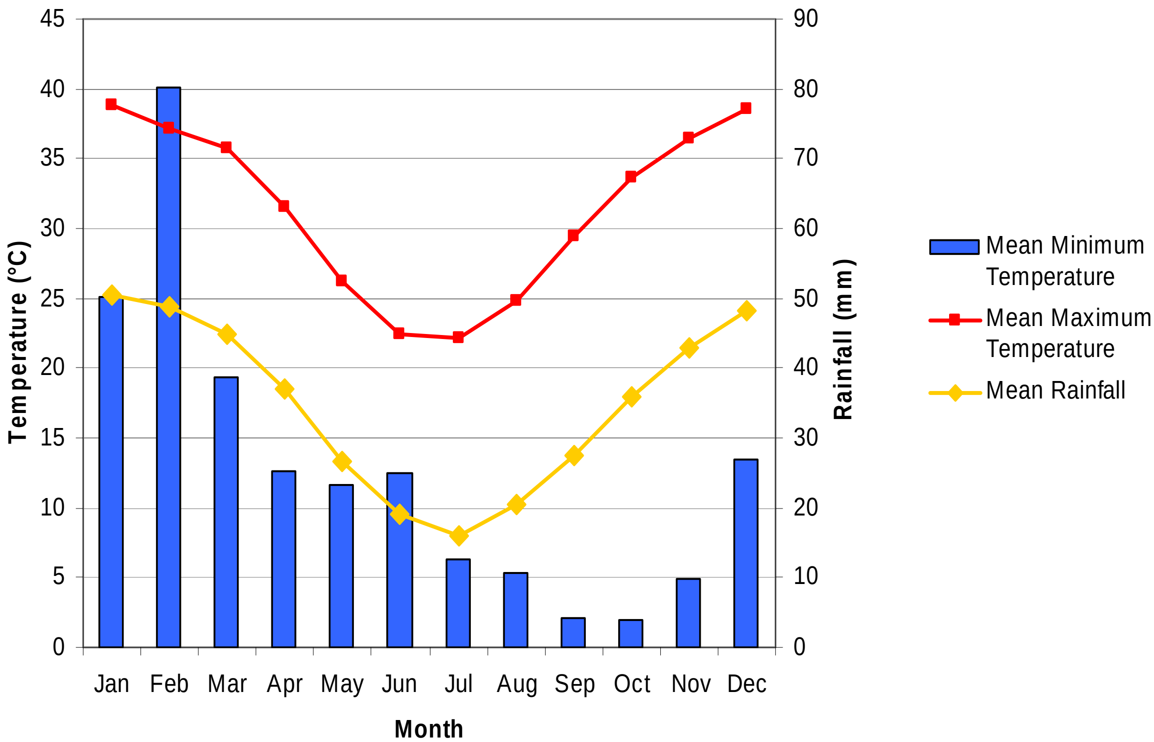

Figure 2-1 Summary of climatic data for Newman (Bureau of Meteorology 2006)

2.2 LAND FORMS

In their biological survey of the Hamersley Range National Park (Karijini National Park), Dawe and Muir (1983) developed a landform-vegetation classification system of nine main landforms which were further categorised into many sub-units. The study area covers four of these main landforms:

(a) Low Ridges or Hills: Low ridges and hills rising above the surrounding plains largely covered with skeletal soils, with areas of exposed rock. This landform supports *Eucalyptus leucophloia* open low woodland, *Acacia maitlandii* and *Acacia umbellata* low scrub and mid-dense *Triodia basedowii* hummock grassland.

(b) Outwash Plains: Plains of deep loams or clayey loams supporting *Acacia aneura* low woodland or *Eucalyptus victrix* low woodland over *Triodia pungens* hummock grassland and *Aristida*, *Enneapogon* and *Eragrostis* bunch grasses.

(c) Minor Drainage Lines: Minor drainage lines are generally shallow eroded channels with a sandy or gravelly washline and associated outwash areas. They support open fringing woodlands of *Eucalyptus*, *Grevillea* and *Acacia* species.

(d) Major Creeks: Heavy gravel channels with sandy levee banks and islands. The vegetation is characteristically open *Eucalyptus camaldulensis* woodland over *Acacia* or *Melaleuca glomerata* thicket.

2.3 BIOGEOGRAPHY

The study area is located on the boundary of the Fortescue Plains and Chichester biogeographic sub-regions. The Fortescue Plains sub-region is described as: “Alluvial plains and river frontages. Salt-marsh, mulga-bunch grass and short grass communities on alluvial plains. River Gum woodlands fringe the drainage lines” (Thackway and Cresswell 1995). The Chichester sub-region is described as: “Archaean granite and basalt plains supporting shrub steppe characterised by *Acacia pyrifolia* over *Triodia pungens* hummock grasses. Snappy gum tree steppes occur on ranges” (Thackway and Cresswell 1995) Dominant limiting factors and constraints for the Pilbara bioregion listed by Thackway and Cresswell (1995) include extinction of critical weight range (CWR) mammals, wildfire, feral animals (in particular the cat and fox), weeds, and grazing or pastoral activities. The reservation status of the bioregion is 1-5%, which is relatively low (some bioregions have a greater than 10% reservation status).

3.0 LITERATURE REVIEW

It is important to note that the potential SRE groups listed in this review are not exhaustive, and that invertebrates are historically understudied and in many cases lack formal descriptions. It is only relatively recently that extensive, reliable taxonomic evaluation of these species has begun and thus the availability of literature relevant to SREs is still scarce.

3.1 PROCESSES PROMOTING SHORT-RANGE ENDEMISM

Short-range endemism is influenced by numerous processes which generally contribute to the geographical isolation of the species. A number of factors, including the ability and opportunity to disperse, life history, physiology, habitat requirements, habitat availability, biotic and abiotic interactions and historical conditions influence not only the distribution of a taxon, but also the tendency for differentiation and speciation (Ponder and Colgan 2002).

Isolated populations tend to differentiate both morphologically and genetically as they are influenced by different selective pressures over time. Additionally, a combination of novel mutations and genetic drift promote the accumulation of genetic differences between isolated populations. Conversely, the maintenance of genetic similarity is promoted by a lack of isolation through migration between the populations, repeated mutation and balancing selection (Wright 1943). The amount of differentiation and speciation between populations will be determined by the relative magnitude of these factors, with the amount of migration generally being the strongest determinant. Migration is hindered by poor dispersal ability of the taxon as well as geographical barriers to dispersal. Thus, those taxa that exhibit short-range endemism are generally characterised by poor dispersal, reliance on habitat types that are discontinuous, low growth rates and low fecundity (Harvey 2002b).

A number of habitats in Australia contain short-range endemics because they are surrounded by geographic barriers. Islands are a classic example, where terrestrial fauna are surrounded by a marine environment which impedes migration and thus gene flow. Similarly, habitats such as mountains, aquifers, lakes and caves are essentially islands exhibiting unique environmental conditions in comparison to the surrounding landscape. There are areas of the Pilbara and more so in the Northern Yilgarn which exemplify this, where ridgelines are separated by tens of kilometres of dissimilar Spinifex plain, preventing the flow of genes from one ridge to the next. Similarly, fresh-water habitats in Australia have a high proportion of short-range endemic species, including many relictual lineages from Gondwanan periods restricted to individual river systems or drainage basins (Harvey 2002b).

The historical connections of habitats are also important in determining species distributions and they often explain patterns that are otherwise inexplicable by current conditions. Many SREs are considered to be relictual taxa (organisms surviving as a remnant of an otherwise extinct species) and are confined to certain habitats. In a few extreme cases, the species are known to exist only on a single hilltop or a granite outcrop (Main 1996).

In Western Australia, relictual taxa generally occur in fragmented populations, from lineages reaching back to historically wetter periods. For example, during the Miocene period (from 25 million to 13 million years ago), the aridification of Australia resulted in the contraction of many areas of moist habitat and the fragmentation of populations of fauna occurring in these areas (Hill 1994). With the onset of progressively dryer and more seasonal climatic conditions since this time, suitable habitats have become increasingly fragmented. Relictual species now generally persist in habitats characterised by permanent moisture and shade, with conditions provided by high rainfall (Main 1996). Such conditions can be seen at sites adjacent to granite outcrops that drain water, mountain summits, swampy headwaters of river systems and caves. Topography, proximity to the coast and directional orientation are also influential in determining relictual habitats (Main 1996).

3.2 CURRENT KNOWLEDGE OF SHORT-RANGE ENDEMIC SPECIES IN NORTHERN WESTERN AUSTRALIA, WITH EMPHASIS ON THE STUDY AREA

The groups or organisms which display short-range endemism include (but are not limited to) molluscs, onychophorans, millipedes, arachnids, and some crustaceans (Harvey 2002b). Nevertheless, the current state of knowledge on short-range endemism of particular species in Northern Western Australia is relatively poor. The paucity of targeted collections makes assessing the likely occurrence and the distribution of SRE fauna very difficult. There is only a single recent survey of SRE taxa in the region which can be drawn upon for comparison with the study area. The survey was conducted for the impact assessment process of the Fortescue Metals Group (FMG) Stage B Project and recorded two undescribed species of arachnids using opportunistic and systematic sampling techniques (Biota 2005).

TAXONOMIC GROUPS LIKELY TO SUPPORT SRE TAXA

3.2.1 Arachnids (Phylum: Arthropoda, Class: Arachnida)

Arachnids include four orders which can exhibit short-range endemism: Pseudoscorpiones (false scorpions), Scorpiones (true scorpions), Schizomida (schizomids) and Araneae (incl. Mygalomorph trap-door spiders). The vast majority of spider species in Australia are widely distributed due to their ability to ‘balloon’ (use silk to lift them off the ground and disperse via wind). However, the majority of mygalomorph trapdoor spiders are incapable of ballooning. This dispersal limitation, joint with their extreme longevity and the long-term persistence of females in a single burrow makes mygalomorph spiders good candidates for short-range endemism and extremely vulnerable to disturbance (Raven 1982). Mygalomorph spiders are largely considered ‘old world’ spiders and, as such, are generally adapted to past climatic regimes making them vulnerable to desiccation in semi/arid environments. They display a variety of behavioural adaptations to avoid desiccation, of which the most obvious one is their burrow - in semi/arid areas the burrow may reach up to 70 cm in depth (Main 1982). Mygalomorph spiders are thus capable of surviving on the periphery of the great central desert region and minor habitats within the general arid regions of the continent. They are, therefore, likely to be found in many areas of the Pilbara, including the study area.

(Biota 2005) recorded two previously undescribed mygalomorph species as part of the FMG Stage B Project.

Another member of the arachnid class, the Schizomida, is comprised entirely of SREs, with most recorded from single localities (Harvey 2002a). Forty-six schizomid species have been described in northern Australia. Most are known to occur in the entrances and inside caves, while the remainder occur in nearby habitats (Harvey 2002a). Only one example, a troglobitic species *Draculoides vinei*, is currently described from the Pilbara, and has now been recorded in a network of 33 caves in limestone formations on the Cape Range Peninsula (Harvey 1992; Harvey 2002a). Although the range of this species extends to 100 km^2, allozyme analyses indicate that speciation may have occurred within this range and a number of species with even narrower ranges exist (Adams and Humphreys 1993).

Scorpions (Scorpiones: Urodacus) and pseudoscorpions (Pseudoscorpiones) also exhibit high degrees of endemism (Harvey 1996; Koch 1981) and some species display restricted ranges (Harvey 1996), Although they are found in most climatic zones, scorpions are popularly thought of as desert animals. This may be a consequence of their larger size (a morphological adaptation to such environments) which makes them more conspicuous. There is currently little recently published data on distribution of either of these orders in Western Australia (Harvey 2002b; Koch 1977).

3.2.2 Crustaceans (Phylum Athropoda, Subclass Crustacea)

Three families of the freshwater isopod suborder Phreatoicidea occur in Australia. Most are endemic and often allopatric, and all are constrained by their specific habitat requirements of permanent freshwater lakes, streams, mound springs and groundwater (see references within Harvey, 2002). Their dispersal ability is also thought to be poor as nearly all are restricted to areas that have been above sea level since the middle Cretaceous (Harvey 2002b). Phreatoicid isopods are renowned for their localised distributions (Harvey 1996; Horwitz and Rogan 2003) and numerous taxa occur in the north-west of Western Australia.

Eight described genera of Phreatoicidea isopod have been described from Western Australia. However, undescribed species-level diversity may be present in a number of genera (Wilson and Keable 2002). As relictual aquifers and permanent waters become better known in Western Australia, additional taxa of Phreatoicideans are likely to be found (Wilson and Keable 2002).

3.2.3 Millipedes and Centipedes (Phylum Athropoda, Class Myriapoda)

Despite the fact that millipedes can be highly abundant in soil and leaf litter and very diverse at the level of order (Harvey 2002b), they are inadequately studied and relatively little is known of their biogeography. One of the genera that have been studied is the Stygiochiropus (Humphreys and Shear 1993). This genus consists solely of four species that are found in the caves and subterranean cavities in the Cape Range Peninsula, three of which are restricted to single caves; *S. isolatus* Humphreys and Shear (1993) *S. sympatricus* Humphreys & Shear (1993) and *S. peculiaris* Shear & Humphreys (1996). The fourth species, *S. communis*, occurs throughout the Peninsula, occurring sympatrically with *S. sympatricus*.

Although centipedes (Chilopoda) are not listed by Harvey (2002b) as SRE taxon, they have been shown to be endemic to small areas on the east coast (Edgecombe *et al.*, 2002) and south-western coast around Albany (Jones 1996). Examination of the distributions of species featured in the CSIRO centipede webpage also reveals disjunct and isolated occurrences of many species (Colloff *et al.* 2005). A number of genera have Pangaean and Gondwanan affinities (Edgecombe *et al.* 2002), they have relatively poor dispersal abilities and display relatively cryptic biology, preferring moist habitats in deep litter accumulations, under rocks and in rotting logs (Lewis 1981) This suggests that they could potentially harbour SRE species.

3.2.4 Molluscs (Phylum: Mollusca)

Numerous species of freshwater and terrestrial molluscs have been identified in Australia, with most being SRE taxa (Harvey 2002b). Restricted ranges of the terrestrial molluscs of the drier northern and western Australia were noted for a vast number of species (Solem 1997). Among these were seven endemic species of *Rhagada* from the Dampier Archipelago, five of which were found to occur sympatrically on one island. However, in a recent genetic study conducted on the same species (Johnson *et al.* 2004), allozyme analysis revealed little variation between taxa. Such a finding could indicate that there is merely high morphological diversity within one or a few species. It is also possible however, that there is a number of highly endemic species and morphological diversity has taken place rapidly with little genetic change (Johnson *et al.* 2004).

3.2.5 Worms (Phylum: Annelida)

The taxonomic status of the earthworm family, Megascolecidae, in Western Australia was revised by Jamieson in 1971. The study contributed to a conclusion that most of the earthworm genera are composed almost entirely of short-range endemic species (Harvey 2002b). This also applies to the Velvet worms (onychophorans) - due to several taxonomic revisions that have been conducted (see references within (Harvey 2002b), the number of onychophoran species has expanded from six to over 70 species, and a number of species still remain undescribed (Harvey 2002b). Very few of these species exceed ranges of 200 km^2, some are restricted to single localities and display high genetic differentiation, indicating very little mobility and dependence on their permanently moist habitats (Harvey 2002b).

3.3 THREATS TO SHORT-RANGE ENDEMICS

Due to their restricted nature, many SREs are extremely vulnerable to loss of habitat. The primary threatening processes faced by SRE invertebrates in the Pilbara are listed below (Yen and Butcher 1997):

1. clearing of native vegetation;
2. habitat fragmentation;
3. inappropriate fire regimes;
4. mineral extraction; and
5. long-term environmental changes.

The conservation significance of highly restricted, non-agile species is considered to be analogous to species that are restricted to caves or islands and therefore the threatening processes are the same. Many may be susceptible to land degradation and clearing, but definitive taxonomic and ecological studies are currently lacking to determine their full ranges or any threatening processes (Harvey and West).

Short-range endemics are especially vulnerable to the effects of anthropogenic activity due to their limited dispersal abilities and specific habitat requirements. Therefore, identifying SREs is essential in the conservation of biodiversity, not only because the possibility of their entire range being destroyed is greater, but also because their limited dispersal capabilities makes them even more vulnerable to the effects of habitat fragmentation and the problems of decreasing population size, inbreeding and the loss of genetic fitness that accompanies it. Thus, even if loss of habitat only occurs in parts of their range, local species extinction may still occur due to their inability to exchange genes between fragments and recolonise those that go extinct due to stochastic events.

Unfortunately, there has been a lack of sampling and taxonomic studies of invertebrate species and many SREs may be unrecognised as a result of insufficient data (Harvey 2002b), placing them at an even greater risk (EPA 2004). Further investigation of existing taxa, xtensive field studies and reliable taxonomic resolution are required to contribute to better recognition of SRE taxa (Ponder and Colgan 2002).

3.4 POTENTIAL OCCURRENCES OF SHORT-RANGE ENDEMICS IN THE STUDY AREA

The study area covers approximately 4,160 hectares (ha) of open rangelands, and is situated in the hills and footslopes of the Chichester Range and the plains of the Fortescue Marsh. Despite a relatively homogenous landscape (Mulga plain) across much of the study area, it is likely that many microhabitats capable of supporting SRE taxa (as the knowledge of each group currently stands), are present. Such areas include (but are not limited to) the larger drainage gullies, such as the Kulkinbah Creek and Kulbee Creek, and the foothills of the Chichester Range. The Chichester Range habitats are considered to have the greatest likelihood of harbouring invertebrates known to include SRE taxa. In fact, all of the listed groups in Table 3.1 are likely to be found in these areas.

It is possible that individual gorges and minor gullies harbour taxa such as Camaenid snails that may or may not be allopatric. Movement between drainage lines in the Roy Hill area is considerate unlikely for an animal as small and vulnerable as a land snail.

In contrast, the project area contains no permanent water bodies and thus taxa such as Phreatoicid isopods (sub-order Phreatoicidea), which are typically SREs, are almost certainly not going to be present.

Table 3-1 Potential SRE taxa, suitable habitat and likelihood of occurrence in study area

Presence of Short-range Endemic Taxa			HPPL Roy Hill		
		Current Information	Likelihood Rating		
Taxa	**Suitable Habitat in Study Area**	**Data Sources**	**Propensity to form SREs**	**SRE-forming habitat conditions**	**SRE Likelihood Rating**
Millipedes	Deep leaf litter accumulations in Chichester Range Gullies and ridges and under rocks and large debris	Desktop literature review, CALM/WAM Faunabase search, expert opinion, anecdotal	5	4	20
Mollusca: Camaenidae: *Rhagada* sp., and others	Deep leaf litter accumulations in Chichester Range gullies and ridges and under rocks and large debris	Desktop literature review, CALM/WAM Faunabase search, expert opinion, anecdotal	5	4	20
Pseudoscorpions	Under bark and under logs / debris in Chichester Range Gullies / ridges	Desktop literature review, CALM/WAM Faunabase search, expert opinion, anecdotal	5	4	20
Mygalomorphae spiders: Ctenizidae; Dipluridae: *Cethegus* sp.; Hexathelidae; Theraphosidae, especially *Selenocosmia stirlingi* ; Actinopodidae: *Missulena* sp.	Deep leaf litter accumulations in the larger Chichester Range gullies and ridges and under rocks and large debris. May also be present in the Mulga Plains at base of Acacia and other trees and under leaf litter accumulations	Desktop literature review, CALM/WAM Faunabase search, expert opinion, anecdotal	4	4	16
Scorpions (*Urodacus* sp.)	Under bark and under logs / debris in Chichester Range Gullies / ridges. Also may be found in open areas and burrows under litter on Mulga Plains	Desktop literature review, CALM/WAM Faunabase search, expert opinion, anecdotal	3	2	6
Schizomids	Caves in Chichester Ranges	Desktop literature review, CALM/WAM Faunabase search, expert opinion, anecdotal	5	1	5
Centipedes	Deep leaf litter accumulations in Chichester Range Gullies and ridges and under rocks and large debris	Desktop literature review, CALM/WAM Faunabase search, expert opinion, anecdotal	3	2	6
Isopods: Phreatoicidae	Permanent fresh water bodies	Desktop literature review, CALM/WAM Faunabase search, expert opinion, anecdotal	5	1	5

Likelihood Matrix:

Likelihood Assessment Rating		Likelihood of SRE-forming habitat conditions: 5 ALMOST CERTAIN Habitats highly likely to lead to SRE's is expected to occur in most circumstances	4 LIKELY SRE will probably occur in most circumstances	3 POSSIBLE SRE could occur	2 UNLIKELY SRE could occur but not expected	1 RARE SRE occur only in exceptional circumstances
Taxa Group Propensity to form SREs	5 – VERY HIGH	25	20	15	10	5
	4 – HIGH	20	16	12	8	4
	3 – MODERATE	15	12	9	6	3
	2 – MINOR	10	8	6	4	2
	1 – LOW	5	4	3	2	1

21 – 25	High likelihood of unrecorded SRE taxa, site specific survey required
6 – 20	Medium likelihood, site specific survey recommended
1 - 5	Low likelihood, site specific survey not required

3.5 CONSERVATION STATUS OF SHORT-RANGE ENDEMICS IN THE STUDY AREA

A number of invertebrate species are listed under Federal (*Environment Protection and Biodiversity Conservation Act* (EPBC Act) 1999) and State (*Wildlife Conservation Act* (WC Act) *1950*) legislature and the Department of Environment and Conservation (DEC) Priority fauna listing.

Under the federally administered EPBC act, there are a number of invertebrate groups listed as Critically Endangered, Endangered and Vulnerable. The only Western Australian species listed, Remipede *Lasionectes exleyi* Yager and Humphreys, is found at the Bundera Sinkhole within the Cape Range peninsula. This species is therefore unlikely to be found in the study area.

Taxa from the Pilbara, which are listed under the WC Act as Schedule 1, comprise four millipedes, six arachnids, 16 crustaceans and one polychaete with listings ranging from critically endangered to vulnerable. The majority of these species were recorded from Barrow Island and Cape Range and are not known to exist within the vicinity of Roy Hill. The majority of Priority listed invertebrate species have a Priority 1 ranking (taxa with few, poorly known populations on threatened lands). These taxa comprise three insects (two dragonflies and a blind cockroach), one arachnid from Cape Range, two crustaceans (stygofauna) and one gastropod from Depuch Island. None of these Priority invertebrate species are known to exist in habitats near to, or similar to, that of the Project area.

4.0 SURVEY METHODS

4.1 SURVEY TIMING

Surveying was undertaken between the 1st and 7th of June 2006. The current knowledge concerning SRE invertebrate groups is that they are most active and hence best surveyed during the cooler winter months. Thus, the survey was conducted at the most appropriate time for the animals being investigated.

Table 4-1 Summary of Survey Timing and Duration

SURVEY	DURATION	PERSON DAYS
Pitfall Traps	2nd – 7th of June 2006	5 (nights)
Foraging	1st – 7th of June 2006	7 (2 people)

4.2 SITE SELECTION

It was considered upon visitation of the Project area that southern facing portions of the slopes and the drainage lines, where areas of deep litter accumulation and larger logs can be found, were the most appropriate areas in which to target the SRE invertebrate groups.

Three pitfall trap sites were located in southern facing ridge slopes and three sites were placed in three separate large drainage lines. The mulga plain was not surveyed specifically for invertebrates due to its large, uniform nature, however additional survey data from sites located within the mulga plain were collected during the vertebrate pitfall trapping

The GPS locations of all survey sites are provided in Appendices A and B and survey sites can be seen in Figure 4.1.

4.3 SAMPLING METHODS

Surveys were developed in consideration of Guidance Statement 56, and although no specific methodologies are currently dictated, a range of survey methods were developed in consultation with experts at the WA Museum.

4.3.1 Invertebrate Pitfall Traps

Pitfall trapping was undertaken at six sites (Sites 1 to 6) in June 2006, encompassing five invertebrate pitfall traps per site (Figure 3.1). Three of the sites were located on southern facing ridge slopes within deep shaded areas and other three sites were placed in major drainage lines. Each site was open for 5 nights (2nd – 7th June 2006), resulting in 75 trap nights per habitat type and a total of 150 pit trap nights for the survey (Table 4.2).

Pitfall traps consisted of two litre (2L) ice-cream containers placed in strategic positions which maximised the chances of collecting potential SRE specimens. Such locations included areas under small overhangs or at the bases of large rocks which provided a lot of shade during the majority of the day. In the drainage lines, pits were typically located on the banks in thick grass and in the channel under the root masses of the larger trees.

Each trap contained a 200 ml solution of Ethylene Glycol (99.8%) and Formalin (3% of total volume). This solution acts to euthanise collected animals and fix tissues. To minimise the chance of by-catch, each trap was roofed with a sheet of Medium Density Fibreboard (MDF) positioned 3 cm above the surface.

In addition, invertebrate specimens were also collected in dry pitfall traps used during the terrestrial fauna assessment in May 2006 (*ecologia* Environment 2006).

4.3.2 Leaf Litter / Soil Samples

Approximately 500 g of soil / leaf litter were taken from each site. Ten replicate samples were taken from each habitat type considered likely to harbour SRE taxa. Sixty samples were collected (Table 4.2), with 30 samples taken from the southern facing ridge slopes and 30 from the larger drainage lines. These sites corresponded with that of the pitfall trapping sites and as such, no separate maps or GPS coordinates are provided.

Collection bags were labelled and the GPS coordinates of the location recorded. Upon return to Perth, samples were sieved and processed under a Leica S6 stereo microscope for invertebrates.

4.3.3 Hand Foraging

Hand foraging was conducted in each habitat type, including in the mulga plains, which were considered unlikely to harbour SRE taxa. Foraging techniques included lifting of rocks, raking of leaf litter and foraging at the base of large shade bearing trees and old decaying logs. Each site was surveyed for 30 minutes within a 10 m2 area. A total of 46 sites were surveyed, yielding a total of 23 hours spent opportunistically searching for SRE taxa.

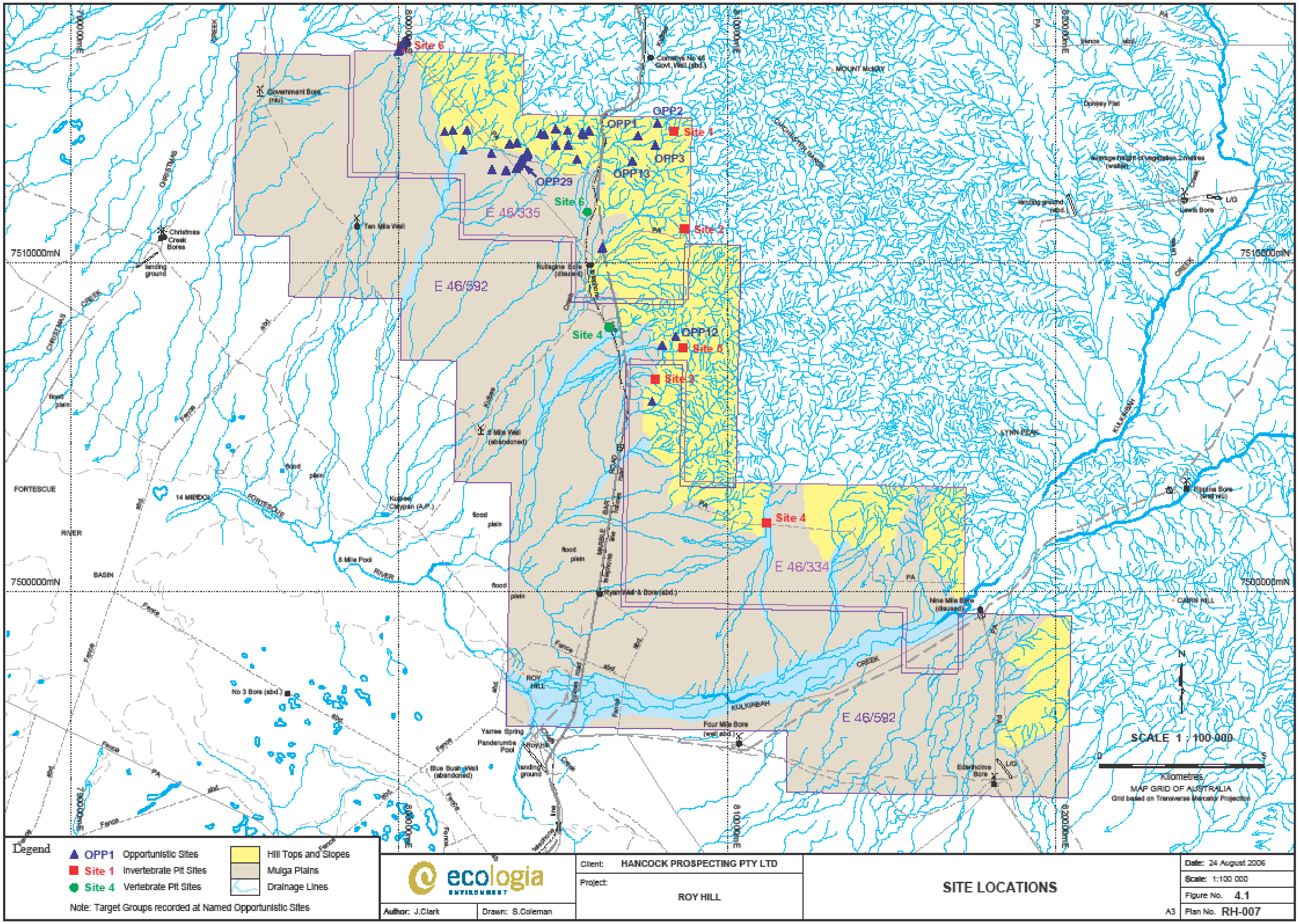

Figure 4-1 The Location of the SRE Pitfall Trap Sites and Foraging Sites.

Table 4-2 Summary of the components of the SRE survey

Task	Number of Replicates	Number of Sites	Number of Trap Nights	Total Sample Size
Systematic Techniques				
Leaf Litter Sampling	10	6	N/A	60
Invertebrate Pitfall traps	5	6	5	150
Vertebrate Pitfall Traps	10	12	7	840
Total	**25**	**24**	**12**	**1050**
Opportunistic Techniques				
Hand Foraging	**23 hrs**	**46**	**N/A**	**46 hrs**

4.4 CURATION AND SPECIES IDENTIFICATION

All invertebrate material collected were immediately placed in 100% absolute ethanol. All species identification was carried out by suitably qualified experts. Scorpion identifications were made by Dr Mark Harvey and Dr Erich S. Volschenk. Identifications of Isopod species were made by Dr Simon Judd. Ecologia scientists identified all centipede specimens using the CSIRO centipede keys available on their internet website.

4.5 SURVEY LIMITATIONS AND CONSTRAINTS

According to the EPA Guidance Statement No. 56: Terrestrial Fauna Surveys for Environmental Impact Assessment in Western Australia (EPA 2004), fauna surveys may be limited by the following:

- Competency/experience of the consultant carrying out the survey;
- Scope (what fauna groups were sampled and were some sampling methods not able to be employed because of constraints such as weather conditions, e.g. pitfall trapping in waterlogged soils);
- Proportion of fauna identified, recorded and/or collected;
- Sources of information e.g. previously available information (whether historic or recent) vs. new data;
- The proportion of the task achieved and further work which might be needed;
- Timing/weather/season/cycle;

- Disturbances (e.g. fire, flood, accidental human intervention etc) which affected results of survey;
- Intensity (in retrospect was the intensity adequate);
- Completeness (e.g. was the relevant area fully surveyed);
- Resources (e.g. degree of expertise available in animal identification to taxon level);
- Remoteness and/or access problems; and
- Availability of contextual (e.g. biogeographic) information on the region.

An assessment of these aspects is detailed in Table 4.3.

Table 4-3 The Survey Constraints

ASPECT	CONSTRAINT (yes/no)	COMMENT
Competency/experience of the consultant carrying out the survey	No	All members of the survey team have appropriate training, experience and mentoring in fauna identification and fauna surveys (See Section 8.0).
Scope	No	The survey was designed to satisfy the requirements of EPA Guidance Statement No. 56
Proportion of invertebrates identified, recorded and/or collected	No	All fauna recorded in the field were identified to species or recognised as new or undescribed.
Sources of information e.g. previously available information vs. new data	Yes - moderate	Museum records are not comprehensive and a limited number of other surveys of similar scope have been conducted in the region. The FMG Stage B invertebrate fauna inventory survey is the only survey of similar scope and location for which data is currently available.
The proportion of the task achieved and further work which might be needed	No	Surveying is complete.
Timing/weather/season/cycle	No	SRE invertebrate fauna are currently thought to be most active during the cooler winter months in the Pilbara region and in other regions south and east of the Pilbara. The survey was carried out in the coolest month of the year and hence was ideal.
Disturbances which affected results of survey	No	N/A

ASPECT	CONSTRAINT (yes/no)	COMMENT
Intensity (in retrospect was the intensity adequate)	No	Despite a very limited number of potential SRE species being recorded it is believed that the survey intensity was adequate. Surveys were developed in consideration of Guidance Statement 56, and although no specific methodologies are currently dictated, a range of survey methods were developed in consultation with experts at the WAM
Completeness	No	Surveying is complete
Resources	No	Systematic invertebrate specific and vertebrate pitfall trapping and leaf litter samples equated to a total of 1050 samples (see Table 4.2 for details), supplemented by 23 hours of opportunistic sampling.
Remoteness and/or access problems	No	Areas to be disturbed by the development are largely accessible by roads or tracks. Areas within the southern section of the lease were not accessible, however these areas were not considered to include prospective SRE habitat
Availability of contextual (e.g. biogeographic) information on the region	Yes	Numerous invertebrate surveys have been undertaken in the Pilbara region, arising primarily from expansion of the resources section. This has lead to rapidly growing knowledge of invertebrate biodiversity in the region. The large number of new species being discovered and awaiting description indicates that this knowledge base of is still in its infancy. Short-range endemic 'groups' are often taxonomically poorly known. Poor or very patchy knowledge on the distribution of many 'SRE groups' also mean that the regional context is very poorly defined.

4.6 TAXONOMY

Laboratory identification of potential SRE invertebrate species were based on keys, or completed at the WA Museum using their available collection of specimens as follows:

Scorpions . . . . Dr Mark Harvey & Dr Erich S. Volschenk (WAM collection)

Isopods . . . . Dr Simon Judd (WAM collection)

Centipedes . . . . M. Colloff *et al.*, 1995 and

http://www.ento.csiro.au/biology/centipedes/centipedeKey.html

5.0 RESULTS

Three major habitat assemblages were found to occur in the study area, namely Mulga woodland, major drainage lines and southern facing ridge slopes, all of which were not locally restricted and therefore unlikely to provide the processes which promote short-range endemism.

The Mulga woodland covers large areas of the region, presenting no obvious barriers to the dispersal of species and therefore not likely to the harbour relictual taxa. This is also somewhat true of the major drainage lines, which have the potential to promote dispersal of invertebrates between non-continuous microhabitats such as large shade bearing trees and dense litter accumulations. The southern facing ridge slopes were considered most likely to harbour SRE taxa. Nevertheless, the slopes form part of the Chichester Range, which is an extensive landscape unit and therefore offers a relatively continuous habitat. Invertebrate taxa that occupy the more protected microhabitats within the range during dry seasons are expected to be able to disperse from these locations during wet periods.

The results of the survey are further detailed in the following sections.

5.1 ARACHNIDS (PHYLUM: ARTHROPODA, SUB CLASS: ARACHNIDA)

5.1.1 Trap-Door Spiders (Mygalomorphae)

No Mygalomorphae trap-door spiders were recorded.

5.1.2 Schizomida

No Schizomida specimens were recorded.

5.1.3 Scorpions (Scorpiones)

Urodacidae: *Urodacus* Peters 1861

Two specimens of an undescribed and possibly new species of *Urodacus* scorpion were recorded from a vertebrate trapping Site 4 located in Mulga woodland Mulga woodland is very common and widespread in the Roy Hill area and throughout the Pilbara and thus there are no obvious barriers to the dispersal or to gene flow. It would be expected that the distribution of this species is much broader and the Project is unlikely to lead to the extinction or severe contraction of its range.

Buthidae: *Lychas* L Koch 1844

One specimen of *Lychas* was recorded from a vertebrate trapping Site 6 located in Mulga woodland. There are currently many unnamed species of *Lychas* in Western Australia and the experts at the WA Museum were unable to place a species name on the specimen. As previously stated, Mulga woodland is very common and widespread in the Roy Hill area and throughout the Pilbara and thus there are no obvious barriers to the dispersal or to gene flow. It would be expected that the distribution of this species is much broader and the Project is unlikely to lead to the extinction or severe contraction of its range.

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5.2 CRUSTACEANS (PHYLUM ARTHROPODA, SUBCLASS CRUSTACEA)

5.2.1 Isopods

A single undescribed isopod from the sub-order Philosciidae, genera *Laevophiloscia* Wahrberg was recorded from foraging Site 12. The site was a deeply shaded southern facing slope. The individual was found within the cracks of a large rock in deep shade.

As previously stated, the slopes form part of the Chichester Range, which is an extensive landscape unit and therefore offers a relatively continuous habitat. Isopods that occupy the more protected microhabitats within the range during dry seasons are expected to be able to disperse from these locations during wet periods.

5.3 MILLIPEDES AND CENTIPEDES (PHYLUM ARTHROPODA, SUBCLASS MYRIAPODA)

5.3.1 Centipedes

Scolopendromorpha: Cryptopidae: *Cryptops spinipes* (Fabricius 1793)

Two individuals of the species *Cryptops spinipes* were recorded from foraging site 13 and 29. However, the species is currently known only from NE coastal Queensland and due to a lack of available expertise this possible range extension can not be verified.

More importantly, however, the species was recorded from under small to medium size rocks on southern facing ridge slopes. As previously stated, the slopes form part of the Chichester Range, which is an extensive landscape unit and therefore offers a relatively continuous habitat. The centipedes that occupy the protected microhabitats within the range during dry seasons are expected to be able to disperse from these locations during wet periods and therefore are not expected to present SRE species.

Scolopendridae: *Arthrorhabdus mjobergi* Kraepelin 1916

One individual of *Arthrorhabdus mjobergi* was recorded from foraging Site 13. The species was found amongst medium sized rocks on southern facing ridge slopes and as it is widespread across Australia, it is thus not considered an SRE species.

Scolopendridae: *Arthrorhabdus paucispinus* Koch 1984

Arthrorhabdus paucispinus was found only at foraging Site 1. The species is restricted to Western Australia, but it is widespread, being recorded from the south coast, inland and in the Kimberley. Therefore, the species can not be considered to be an SRE species.

Scolopendridae: *Asanda* Meinert 1885

Only a single described representative of the genus *Asanda*, *A. brevicornis,* exists in Australia. The morphological characters of the specimen recorded from foraging Site 12 on southern facing ridge slopes do not match those of *A. brevicornis*.

However, existence of a second, undescribed species is recognised. The undescribed *Asanda* species is known only from the Pilbara region of Western Australia and thus the Roy Hill specimen is assumed to belong to that species. It is difficult to determine accurately the conservation significance of this species due to the lack of a formal description and limited data, however as the southern facing ridge slopes form part of the large Chichester Range with a relatively continuous habitat, the centipede is not expected to be an SRE species

Scolopendridae: *Scolopendra morsitan*s Linnaeus 1758

Scolopendra morsitans is a large species of centipede up to 127 mm in length. It is common in the Pilbara region and it is found across mainland Australia. The species is, therefore, not considered to be an SRE species.

Geophilomorha

A Geophilomorpha specimen was recorded from foraging Site 12 on the southern facing ridge slopes. The morphological characters of this specimen do not fit any of the character states defined in the CSIRO Centipede Page identification keys. Thus, it was impossible to assign it to a group below Order. Although the current collections of this species are relatively poor, it is unlikely that the species is an SRE, given that the habitat in which it was recorded forms part of the large Chichester Range and thus it is not particularly isolated.

Scutigeridae: *Thereupoda longicornis* Fabricius 1793

A single specimen of *Thereupoda longicornis* was recorded from foraging Sites 1, 2 and 29. Each specimen was found under large rocks or stones on southern facing slopes. The specimen was keyed out to species level using the CSIRO Centipede keys. The species is currently known only from NE coastal Queensland and it is not a recognised SRE species.

5.3.2 Millipedes

No Millipedes (Diplopoda) were recorded in the survey.

5.4 MOLLUSCS (PHYLUM: MOLLUSCA)

No land snail (Mollusca) species were recorded during this survey.

5.5 WORMS (PHYLUM: ANNELIDA)

No earthworms or aquatic worms (Annelida: Oligochaete) were recorded during this survey.

5.6 ACTIVITIES THAT COULD RESULT IN IMPACTS TO SRE TAXA

A risk assessment completed as part of this assessment identified three main risk issues associated with the Project. These included are: Vegetation Clearing/Ground disturbance, Dust Emissions and an Increased Risk of Fire in the Project area (see Appendix C).

With regard to vegetation clearing it was determined that the risk of land clearing on SRE taxa was low due to the lack of SRE taxa recorded. However, many of the species targeted display cryptic habitats and therefore it is possible that SRE taxa were not recorded as part of the survey. As such, further controls are required to minimise the risk to any SRE taxa that were not recorded. Specifically the following controls were considered the most prudent and practically achievable:

- Clearing should be restricted to that which is necessary;
- Clearing boundaries should be defined in the field; and
- Cleared areas should be rehabilitated.

Similarly, it was determined that the risk of increased dust in the area damaging vegetation comprising SRE habitat was also low. Available controls routinely used in other Pilbara mine sites should be implemented. These include:

- Dust suppression measures should be implemented, including management of road speed on unsealed roads.

Finally, it was determined that the risk of fire degrading or removing SRE habitat was also low. Available control measures routinely implemented in other Pilbara mine sites should be adopted. These include:

- A fire prevention strategy should be implemented. Vehicles should be fitted with fire extinguishers and personnel trained in their use.

Table 5-1 The Results of the Roy Hill SRE Invertebrate Survey

Taxa					**Opportunistic Survey Sites**						**Vertebrate Trapping Site**	
Class	**Order**	**Family**	**Genus**	**Species**	**1**	**2**	**3**	**12**	**13**	**29**	**4**	**6**
Arachnida	Scorpiones	Urodacidae	*Urodacus*	sp.							2	
		Buthidae	*Lychas*	sp.								1
Chilopoda	Scolopendromorpha	Cryptopidae	*Cryptops*	*spinipes*					1	1		
		Scolopendridae	*Arthrorhabdus*	*mjobergi*					1			
				paucispinus	1							
			Asanada	sp.				1				
			Scolopendra	*morsitans*			1			1		
	Geomorphila			sp.				1				
	Scutigeromorpha	Scutigeridae	*Thereeuopoda*	*longicornis*	1	1				1		
Malacostraca	Isopda	Philosciidae	*Laevophiloscia*	sp.				1				
Total Abundance					2	1	1	3	2	3	2	1

6.0 CONCLUSIONS

Three major habitat assemblages were found to occur in the study area, namely Mulga woodland, major drainage lines and southern facing ridge slopes, all of which were not locally restricted and therefore unlikely to provide the processes which promote short-range endemism.

The Mulga woodland covers large areas of the region, presenting no obvious barriers to the dispersal of species and therefore not likely to the harbour relictual taxa. This is also somewhat true of the major drainage lines, which have the potential to promote dispersal of invertebrates between non-continuous microhabitats such as large shade bearing trees and dense litter accumulations. The southern facing ridge slopes were considered most likely to harbour SRE taxa. Nevertheless, the slopes form part of the Chichester Range, which is an extensive landscape unit and therefore offers a relatively continuous habitat. Invertebrate taxa that occupy the more protected microhabitats within the range during dry seasons are expected to be able to disperse from these locations during wet periods.

Ten invertebrate species from recognised SRE taxa were found during the survey, five of which were not formally described. These included two possibly new species of scorpion (i.e. *Urodacus* sp. and *Lychas* sp.), two new centipede species (i.e. a species from the order Geophilomorpha and *Asanda* ap.) and one undescribed, but known, isopod species (i.e. *Laevophiloscia* Wahrberg 1922 sp.).

The two undescribed species of scorpions were recorded from Mulga Woodland habitat. As stated previously, no obvious barriers to dispersal exist in this habitat, therefore the distribution of the species is expected to be much broader than the Project area. The impact from the Project is therefore unlikely to lead to the extinction or severe range contraction of the two scorpion species.

Western Australian experts, Dr Mark Harvey and Dr Erich S. Volschenk (scorpions) and Dr Simon Judd (isopods) indicated that the undescribed scorpion and isopod species are unlikely to be SRE or highly restricted species.

The two undescribed species of centipede and the isopod *Laevophiloscia* sp. were recorded from the southern facing ridge slope. As the slopes form part of the extensive Chichester Range, the centipedes and the isopod are expected to be able to disperse from the more protected microhabitats within the range during wet periods.

7.0 REFERENCES

Adams, M., and W. F. Humphreys. 1993. Patterns of genetic diversity within selected subterranean fauna of the Cape Range peninsula, Western Australia: systematic and biogeographic implications. Records of the West Australian Museum Supplement. 45:145 - 164.

Beard, J. S. 1975. Pilbara. Explanatory notes to Sheet 4, 1:1,000,000 Series Vegetation Survey of Western Australia. Univ. of W.A. Press.,

Biota. 2005. Fauna Habitats and Fauna Assemblage of the Proposed FMG Stage B Rail Corridor and Mindy Mindy, Christmas Creek, Mt Lewin and Mt Nicholas Mine Areas. Prepared for Fortescue Metals (FMG) Group Pty Ltd, 156. January 2005

Bureau of Meteorology. 2006. Bureau of Meteorology. Australian Government.

Colloff, M. J., A. M. Hastings, F. Spier, and J. Devonshire. 2005. Centipedes of Australia. CSIRO Entomology and Australian Biological Resources Study., Canberra.

Dawe, C., and B. G. Muir. 1983. A Fauna survey of the Hamersley Range National Park, Western Australia, 1980. National Parks Authority of Western Australia, Nedlands.

ecologia Environment. 2006. Roy Hill Terrestrial Vertebrate Fauna Assessment. Unpublished Report for Hancock Prospecting Pty Ltd, June, 2006.

Edgecombe, G., G. Giribet, and W. C. Wheeler. 2002. Phylogeny of Henicopidae (Chilopoda: Lithobiomorpha): a combined analysis of morphology and five molecular loci. Systematic Entomology. 27:31-64.

EPA. 2002. Position Statement No. 3 Terrestrial Biological Surveys as an element of Biodiversity Protection. Environmental Protection Authority,

EPA. 2004. Guidance for the Assessment of Environmental Factors No. 56: Terrestrial Fauna Surveys for Environmental Impact Assessment in Western Australia. Environmental Protection Authority, 28 June 2004

Harvey, M. S. 1992. The Schizomida (Chelicerata) of Australia. Invertebrate Taxonomy. 6:77 - 129.

Harvey, M. S. 1996. The Biogeography of Gondwanan pseudoscorpions (Arachnida). Revue Suisse de Zoologie. 1:255 - 264.

Harvey, M. S. 2002a. The neglected cousins: what do we know about the smaller Arachnid orders? The Journal of Arachnology. 30:357–372.

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

Harvey, M. S., and West. unpublished report on Millipedes.

Hill, R. S. E. 1994. History of Australian Vegetation: Cretaceous to Recent. Cambridge University Press, Cambridge, UK.

Horwitz, P., and R. Rogan. 2003. Aquatic macroinvertebrates and non-flowing wetland values of the Yarragadee (outcropping and subcropping) groundwater dependent systems of south-western Australia. Centre for Ecosystem Management, Edith Cowan University., Humphreys, W. F., and W. A. Shear. 1993. Troglobitic millipedes (Diplopoda : Paradoxosomatidae) from semi-arid Cape Range, Western Australia: Systematics and biology. Invertebrate Taxonomy. 7:173 - 195.

Johnson, M. S., Z. R. Hamilton, C. E. Murphy, C. A. MacLeay, B. Roberts, and P. Kendrick. 2004. Evolutionary genetics of island and mainland species of Rhagada (Gastropoda: Pulmonata) in the Pilbara Region, Western Australia. Australian Journal of Zoology. 52:341 - 355.

Jones, R. E. 1996. A new genus of centipede, Australoschendyla (Chilopoda: Geophilomorpha: Scendylidae), from Western Australia. Records of the Western Australian Museum. 17:411-415.

Koch, L. E. 1977. The taxonomy, geographic distribution and evolutionary radiation of Australo-Papuan scorpions. Records of the Australian Museum. 5:83-367.

Koch, L. E. 1981. The scorpions of Australia: aspects of their ecology and zoogeography. Pp. 875-884 *in* K. A., ed. Ecological Biogeography of Australia. Monogr. Biol. 41 (2).

Lewis, J. G. E. 1981. The Biology of Centipedes. Cambridge University Press, Cambridge.

Main, B. Y. 1982. Adaptions to arid habitats by mygalomorph spiders *in* W. R. Barker, and P. J. M. Greenslade, eds. Evolution of the Flora and Fauna of Arid Australia. Peacock Publications.

Main, B. Y. 1996. Terrestrial invertebrates in south-west Australian forests: the role of relict species and habitats in reserve design. Journal of the Royal Society of Western Australia. 79:277 - 280.

Ponder, W. F., and D. J. Colgan. 2002. What makes a narrow-range taxon? Insights from Australian freshwater snails. Invertebrate Systematics. 16.

Raven, R. J. 1982. Systematics of the Australian mygalomorph spider genus *Ixamatus* Simon (Diplurinae: Dipluridae: Chelicerata). Australian Journal of Zoology. 30.

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

Thackway, R., and I. D. Cresswell. 1995. An Interim Biogeographic Regionalisation for Australia. Australian Nature Conservation Agency,

Wilson, G. D. F., and S. J. Keable. 2002. New genera of Phreatoicidea (Crustacea: Isopoda) from Western Australia. Records of the Australian Museum. 54:41-70.

Wright, S. 1943. Isolation by distance. Genetics. 28:114 - 138.

Yen, A. L., and R. J. Butcher. 1997. An Overview of the Conservation of Non-Marine Invertebrates in Australia. Environment Australia,

8.0 STUDY TEAM

The HPPL Roy Hill Fauna Assessment described in this document was planned, coordinated and executed by:

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We wish to thank Dr Mark Harvey (WAM) for identifying the few scorpion specimens recorded and Dr Simon Judd for identifying the single isopod specimen recorded in this survey.

LICENSES

No license is required to take invertebrate fauna under current state and federal legislation.

APPENDICES

APPENDIX A PITFALL TRAP SITES GPS COORDINATES

Grid UTM
Datum GDA

Site	Zone Num.	Easting (m)	Northing (m)	Elevation (m)
1	50	808386	7513997	520
2	50	808689	7511048	483
3	50	807796	7506465	468
4	51	194118	7502192	435
5	51	191365	7507415	450
6	50	800090	7516580	448

APPENDIX B OPPORTUNISTIC FORAGING GPS COORDINATES

Grid UTM
Datum GDA

Name	Zone Num.	easting	northing	Elevation
1	50	807277	7513836	469
2	50	807874	7514212	505
3	50	807809	7513533	480
4	50	800111	7516619	453
5	50	800157	7516682	447
6	50	800211	7516695	449
7	50	800196	7516727	450
8	50	800226	7516738	452
9	50	800243	7516769	447
10	50	806205	7510446	440
11	50	806187	7510417	442
12	50	808433	7507719	475
13	50	807112	7513062	503
14	50	799981	7516420	452
15	50	800014	7516434	453
16	50	807711	7505736	446
17	50	808020	7507429	444
18	50	804772	7513558	468
19	50	804439	7513860	464
20	50	804312	7513901	463
21	50	804782	7514042	482
22	50	805133	7513989	472
23	50	805594	7513929	461
24	50	805617	7513880	466
25	50	805796	7513988	476
26	50	805160	7513556	463
27	50	805430	7513115	461
28	50	803760	7513119	454
29	50	803710	7513083	447
30	50	803678	7512991	449
31	50	803633	7512921	449
32	50	803573	7512830	447
33	50	803872	7513195	447
34	50	803908	7513200	445
35	50	803924	7513269	449
36	50	803936	7513319	448
37	50	803921	7513338	445
38	50	803370	7513594	441
39	50	803593	7513611	449
40	50	802072	7514006	436
41	50	801647	7513993	432
42	50	801395	7513956	429
43	50	801969	7513391	424
44	50	803274	7512785	433
45	50	802820	7513311	432
46	50	802832	7512804	437

APPENDIX C HPPL ROY HILL SRE INVERTEBRATE RISK ASSESSMENT

Biological Environmental Impact Risk Assessment											
Project: HPPL Roy Hill		*Location: Roy Hill*					*Date: 06 December* 2006				
			Inherent Risk					Residual Risk			
Risk Issue	Aspect (Event)	Impact	Likelihood	Consequence	Risk Level	Significance	Controls	Likelihood	Consequence	Risk Level	Significance
Mine Site											
Vegetation clearing	Removal of SRE invertebrate fauna habitat	Loss of local SRE invertebrate fauna communities	3	2	6	Med	Clearing should be restricted to that which is necessary. Clearing boundaries should be defined in the field. Cleared areas should be rehabilitated as soon as is practical.	1	2	2	Low
Vegetation clearing	Removal of SRE invertebrate fauna habitat	Adverse impact to ecological function	3	2	6	Med	Clearing should be restricted to that which is necessary. Clearing boundaries should be defined in the field. Cleared areas should be rehabilitated as soon as is practical.	1	2	2	Low
Vegetation clearing	Removal of SRE invertebrate fauna habitat	Habitat fragmentation	4	1	4	Low	Clearing should be restricted to that which is necessary. Clearing boundaries should be defined in the field. Cleared areas should be rehabilitated as soon as is practical.	2	1	2	Low
Vegetation clearing	Removal of SRE invertebrate fauna habitat	Reduction in SRE invertebrate fauna populations	2	1	2	Low	Clearing of southern facing ridge slopes should be avoided where possible	2	1	2	Low
Dust	Dust emissions arising from mining operations	Damage to vegetation resulting in loss of SRE invertebrate fauna habitat	5	2	10	Med	Dust suppression measures should be implemented, including management of road speed on unsealed roads.	2	1	2	Low
Fire	Wildfire arising as a result of mining operations	Degradation of fauna habitat and populations	2	2	4	Low	A fire prevention strategy should be implemented. All cars should be fitted with fire extinguishers & all personnel trained in their use.	1	1	1	Low

Likelihood:		
Value	**Description**	**Criteria**
5	Almost Certain	Environmental issue will occur, is currently a problem or is expected to occur in most circumstances.
4	Likely	Environmental issue has been a common problem in the past and there is a high probability that it will occur in most circumstances.
3	Possible	Environmental issue may have arisen in the past and there is a high probability that it could occur at some time.
2	Unlikely	Environmental issue may have occurred in the past and there is a moderate probability that it could occur at some time but not expected.
1	Rare	Environmental issue has not occurred in the past and there is a very low probability that it may occur in exceptional circumstances.

Consequence:		
Value	**Description**	**Criteria**
5	Catastrophic	Significant impact to fauna species of conservation significance or regional
4	Major	Impact to fauna species of conservation significance in project area.
3	Moderate	Loss of fauna biodiversity in project area.
2	Minor	Short term or localised impact to fauna biodiversity.
1	Insignificant	No impact to fauna of conservation significance or biodiversity.

Risk Matrix:

	Risk Assessment Rating	LIKELIHOOD 5 ALMOST CERTAIN Is expected to occur in most circumstance	4 LIKELY Will probably occur in most circumstance	3 POSSIBLE Could occur	2 UNLIKELY Could occur but not expected	1 RARE Occurs in exceptional circumstances
CONSEQUENCES	5 - CATASTROPHIC Significant impact to fauna species of conservation significance or regional biodiversity	25	20	15	10	5
	4 - MAJOR Impact to fauna species of conservation significance in project area.	20	16	12	8	4
	3 - MODERATE Loss of fauna biodiversity in project area.	15	12	9	6	3
	2 - MINOR Short term or localised impact to fauna biodiversity.	10	8	6	4	2
	1 - INSIGNIFICANT No impact to fauna of conservation significance or biodiversity.	5	4	3	2	1

11-25	High risk, site/issue specific mangement programmes required, advice/approval from regulators required.
6 – 10	Medium risk, specific management and procedures must be specified.
1 – 5	Low risk, managed by routine procedures.