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OAKAJEE PORT TERRESTRIAL DEVELOPMENT SHORT RANGE ENDEMIC INVERTEBRATE FAUNA ASSESSMENT

PART 1 – STUDY AREA

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OAKAJEE PORT AND RAIL

TERRESTRIAL PORT DEVELOPMENT

SHORT RANGE ENDEMIC INVERTEBRATE FAUNA ASSESSMENT PART 1

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ACRONYMS

BOM	Bureau of Meteorology
DEC	Department of Environmental Conservation
DEWHA	Department of the Environment, Water, Heritage and the Arts
EIA	Environmental Impact Assessment
EPA	Environmental Protection Authority
EPBC Act	*Environment Protection and Biodiversity Conservation Act 1950*
IBRA	Interim Biogeographic Regionalisation for Australia
OPR	Oakajee Port and Rail
SAC	Species Accumulation Curve
WCA, WC Act	*Wildlife Conservation Act 1950*

GLOSSARY

Approved Port The deepwater port facility at Oakajee for which the Department of State Development is the proponent. This Project was approved by the WA Government in 1998, with the release of Ministerial Statement 469 (Approved Port), and more recently updated with an approved Section

Conservation Significant This term is applied to species which are protected under the *Environment Protection and Biodiversity Conservation Act 1999*, the *Wildlife Conservation Act 1950*, or are listed by the Department of Environment and Conservation as priority fauna.

Oakajee Port and Rail Development The larger OPR project comprising the marine port, terrestrial port and rail components, each the subject of a separate approvals process.

The Project The Project refers to the footprint of this development as outlined in the PER.

Study Area An area larger than the Project, surveyed for the purpose of biological studies. The area may generally be described as extending approximately 12 km along the coast (between the Oakajee and Buller Rivers) and approximately 7 km inland at its widest point.

Short range endemics (SRE)	Species with ranges 10 000 km² or less.
Mygalomorphae	Trap-door spiders.
Megascolecidae	Native earth worms
Isopoda	Slaters
Pseudoscorpiones	False scorpions

EXECUTIVE SUMMARY

Oakajee Port and Rail Pty Ltd (OPR) proposes to construct a deepwater port and terrestrial iron-ore handling facilities at Oakajee. The site is located 24 kilometres north of Geraldton, within the proposed Oakajee Industrial Estate, between the Oakajee and Buller Rivers. The terrestrial facilities proposed that are of interest to this study include the port rail system, access and service corridors, a car dumper, stockpiles, ore in-loading and out-loading infrastructure, and supporting facilities.

Due to the history of pastoral land use in the area, suitable remnant vegetation associations on the sand plain plateau as well as on the coastal limestone ridge, the river margins, the southern valley slopes and the stable dunes on the western slope of the Oakajee site (Study Area henceforth) were expected to function as refugia for species with restricted distributions. Due to a paucity of invertebrate sampling in the Geraldton region, and the known presence of Short Range Endemic (SRE) taxa in the southwest region in general, it was considered likely that terrestrial SRE invertebrate taxa be present within and near the Study Area. As such, systematic techniques (pitfall trap grids) and opportunistic techniques (foraging) were employed to facilitate a comprehensive survey of groups known to include SRE taxa. The methods targeted Mygalomorph spiders, scorpions, pseudoscorpions, millipedes, centipedes, Megascolecidae annelids and land snails.

Approximately 500 specimens were collected and submitted to five external taxonomic experts for verification of identity and guidance concerning the conservation significance of each taxon. These individuals represented eleven orders, 21 families, 30 genera, and 36 species of invertebrates.

Mygalomorphae (trap-door spiders) spiders and centipedes were the most speciose groups, being represented by nine and seven species, respectively. The spiders included a number of undescribed and possibly restricted species. Isopods (Isopoda) were the third most speciose and abundant group, with six species being recorded. Five species of land snail (Mollusca), four species of pseudoscorpion (Pseudoscorpiones), three species of millipede (Diplopoda), and two species of scorpion (Scorpiones) were recorded.

Of the 13 taxa expected to be SRE species, 11 were new. Four of the 13 species were SREs (isopod *Hanoniscus tuberculatus* and millipedes *Podykipus* sp. 1, *Podykipus* sp. 2 and *Antichiropus* 'Geralton'), three were possible SREs (spiders *Aname* sp. 1 and *Aname* sp. 2 and snail *Bothriembryon* sp.) and six species could not have their SRE status determined (Table S1).

The overlying vegetation was of mixed condition, having suffered degradation from stock activity in the eastern, upper portions of the site, and from recreational motorbike activity in the western, lower portions of the site. Nevertheless, a number of new and suspected SRE species were recorded. This was considered most likely to be an article of a lack of historic sampling in the region and locally. The majority of these species were expected not to be constrained to the Study Area.

It is possible that the trap-door spider *Aname* sp. 2 (Nemesiidae) is restricted to the Oakajee River valley. The three new millipede species (Diplopoda), *Bothriembryon* land snail species, isopod species and the trapdoor spider *Aname* sp. 1, which were assessed as SREs or possible SRE's, were all located along the length of the fore dune vegetation and are all expected to be partially impacted by the Terrestrial Port Development. However, as stated above, it is expected that these species will be found in similar habitats to the north and south of the Study Area, and hence will suffer minimal distributional contraction from this proposal.

Table E 1: A list of all taxa (status confirmed, possible, unable to be determined or not SREs).

Class	Order	Family	Genus	Species	Sites
SREs					
Crustacea	Isopoda	Oniscidea	*Hanoniscus*	tuberculatus	OKS 2, FG 3, 58
Diplopoda	Polydesmida	Paradoxosomatidae	*Antichiropus*	Geraldton'	OKS 1-6, FG 9,11,18,19,21,25,43
Diplopoda	Spirostreptida	Iulomorphidae	*Podykipus*	sp. 1	FG 3,4,9,10,12-18,20-22,24-26,36,39,41,48,52,58
Diplopoda	Spirostreptida	Iulomorphidae	*Podykipus*	sp. 2	FG 36
New species, SRE status possible					
Arachnida	Mygalomorphae	Nemesidiae	*Aname*	sp. 1	OKS 1,2,4-6
Arachnida	Mygalomorphae	Nemesidiae	*Aname*	sp. 2	FG 45,47,62
Molusca	Pulmonata	Bulimulidae	*Bothriembryon*	sp.	OKS 2, FG 28,45
New species, SRE status could not be determined					
Arachnida	Mygalomorphae	Nemesidiae	*Chenistonia*	sp.	FG 46
Arachnida	Mygalomorphae	Nemesidiae	*Teyl*	sp.	OKS 4
Arachnida	Mygalomorphae	Nemesidiae	*Yilgarnia*	sp.	OKS 4
Crustacea	Isopoda	Armadillidae	*Buddelundia*	sp.	OKS 2
Crustacea	Isopoda	Philosciidae	*Leavophiloscia*	sp.	OKS 2
Crustacea	Isopoda	Platyarthridae	undescribed genus	sp.	OKS 2
Not SRE species					
Arachnida	Mygalomorphae	Nemesidiae	*Aname*	*mainae*	OKS 2
Arachnida	Mygalomorphae	Barychelidae	*Aurecocrypta*	*lugubris*	Vert. Site 2
Arachnida	Mygalomorphae	Barychelidae	*Idiomatta*	*blackwalli*	Vert. Site 2
Arachnida	Mygalomorphae	Actinopodidae	*Missulena*	sp.	OKS 1
Arachnida	Scorpionidae	Bothriuridae	*Cercophonius*	*granulatus*	OKS 1-6
Arachnida	Scorpionidae	Urodacidae	*Urodacus*	*novaehollandiae*	Vert. Site 5
Arachnida	Pseudoscorpionidae	Chernetidae	*Nesidiochernes*	sp.	OKS 4-6
Arachnida	Pseudoscorpionidae	Chthoniidae	*Austrochthonius*	sp.	OKS 2,4
Arachnida	Pseudoscorpionidae	Olpiidae	*Beierolpium*	sp.	OKS 2,4
Arachnida	Pseudoscorpionidae	Olpiidae	*Indolpium?*	sp.	OKS 2,4
Crustacea	Isopoda	Armadillidae	*Buddelundia*	*cinerascens*	OKS 1-6, FG 3-7, 10,15,20-22, 24-26, 34,36,38,39,41,46-48,52,56,58,60
Crustacea	Isopoda	Armadillidae	*Spherillo*	sp.	OKS 2
Molusca	Pulmonata	Helicidae	*Cochlicella*	*acuta*	OKS 1-6, FG 1-3,9,11,13,14,16-20,22,24 26,29,31-34,36,38-41,46,58
Molusca	Pulmonata	Helicidae	*Theba*	*pisana*	OKS 2,3,5, FG 3,16,17,19,21,22,24-26,32,34,36,39-41
Molusca	Pulmonata	Succineidae	*Succinea*	sp.	OKS 2,3, FG 1-3, 11,21,29,31-34,37,38,40,41,46,58,60
Molusca	Pulmonata	Pupillidae	*Pupoides*	*sp. c.f. beltianus*	FG 3
Chilopoda	Geophilomorpha	Mecistocephalidae	*Mecistocephalus*	*collinus*	FG 2, 9,13
Chilopoda	Scolopendramorpha	Scolopendridae	*Cormocephalus*	sp. near *westangelasensis*	Vert Site 4
Chilopoda	Scolopendramorpha	Scolopendridae	*Ethmostigmus*	*rubripes*	FG 7
Chilopoda	Scolopendramorpha	Scolopendridae	*Scolopendra*	*laeta*	OKS 1,3, FG 47,48
Chilopoda	Scolopendramorpha	Scolopendridae	*Scolopendra*	*morsitans*	OKS 3, 4, FG 3,6
Chilopoda	Scutigeromorpha	Scutigeridae	*Thereupoda*	sp.	OKS 2, FG 3

1 INTRODUCTION

1.1 PROJECT BACKGROUND

Oakajee Port and Rail Pty Ltd (OPR) proposes to construct a deepwater port and terrestrial iron-ore handling facilities at Oakajee. The site is located 24 kilometres north of Geraldton, within the proposed Oakajee Industrial Estate, between the Oakajee and Buller Rivers. The terrestrial facilities proposed that are of interest to this study include the port rail system, access and service corridors, a car dumper, stockpiles, ore in-loading and out-loading infrastructure, and supporting facilities. The Study Area, within which the development will be located, has been presented in Figure 2.1.

1.2 OBJECTIVES

The objectives of the survey were to provide:

(a) An inventory of the Short Range Endemic (SRE) invertebrate fauna species occurring in the Study Area, incorporating recent published and unpublished records.

(b) A review of regional and local conservation value of invertebrate fauna occurring within the Study Area.

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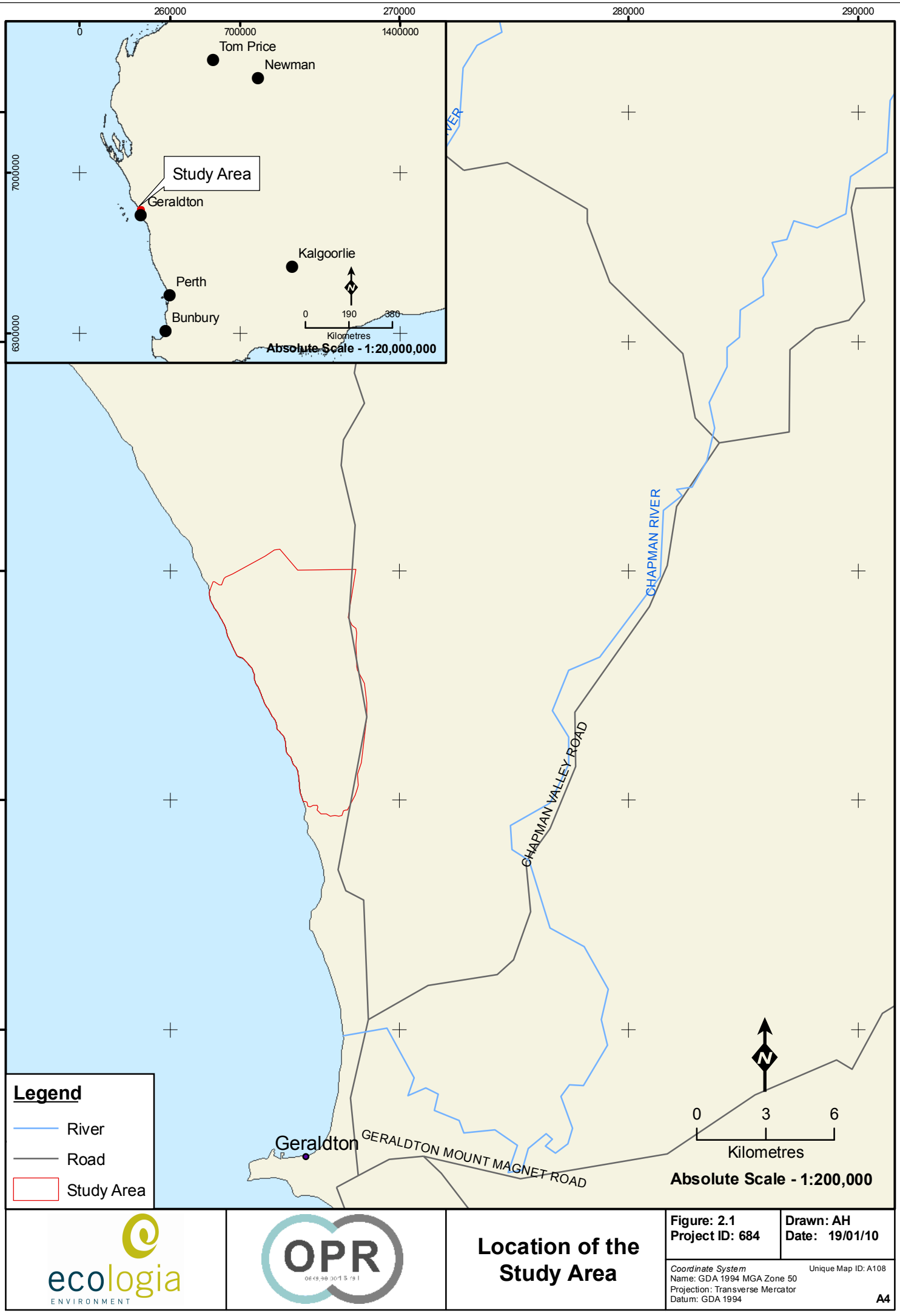
2 PROJECT AREA

2.1 BIOGEOGRAPHY

The area is part of the Geraldton Sandplains bioregion (Thackway and Cresswell 1995) characterised by proteaceous scrub-heaths on an undulating lateritic sand plain, mantling Permian to Cretaceous strata. The climate is warm semi-arid to Mediterranean, with 400 – 500 mm of annual rainfall (CALM 2002). The site is considered to be part of the Greenough System within the Irwin District of the Southwestern Botanical Province (Beard 1976, 1980, 1990), associated with a coastal limestone belt of varying width and elevation. This belt includes abrupt rocky ridges, more gentle soil-covered areas, alluvial flats and, in some places, lagoons. The seaward side of the limestone belt is covered with recent, poorly consolidated or still mobile dune sands (Beard and Burns 1976). The vegetation is dominated by *Acacia rostellifera* and *Melaleuca cardiophylla* thickets on rocky ridges, *Acacia-Banksia* scrub on sand-covered limestone, *A. rostellifera* low forest on the alluvial flats and *Acacia ligulata* open scrub on the recent dunes (Dames and Moore 1993).

2.2 CLIMATE

The closest Bureau of Meteorology (BOM) weather station is situated at Geraldton, approximately 20 km south of the proposed Oakajee Terrestrial Port Development. The Geraldton Town weather station has been operational since 1877 and data collection is ongoing (BOM 2009).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1400000
7000000
6300000
Tom Price
Newman
Study Area
Geraldton
Kalgoorlie
Perth
Bunbury
0
190
380
Kilometres
Absolute Scale - 1:20,000,000
CHAPMAN RIVER
CHAPMAN VALLEY ROAD
GERALDTON MOUNT MAGNET ROAD
Geraldton
0
3
6
Kilometres
Absolute Scale - 1:200,000
Legend
River
Road
Study Area
ecologia
ENVIRONMENT
OPR
Location of the Study Area
Figure: 2.1
Project ID: 684
Drawn: AH
Date: 19/01/10
Coordinate System
Name: GDA 1994 MGA Zone 50
Projection: Transverse Mercator
Datum: GDA 1994
Unique Map ID: A108
A4

The project area experiences a warm semi-arid to Mediterranean climate, characterised by hot dry summers and mild wet winters. The area receives an average annual rainfall of 448 mm, the majority of which falls between May and August (Figure 2.2). January and February are the hottest months of the year, with a mean maximum temperature of 32°C experienced in February (Figure 2.3). The coldest month is August, with an average minimum temperature of 9°C. June is the wettest month, receiving on average 114 mm of rainfall (BOM 2009).

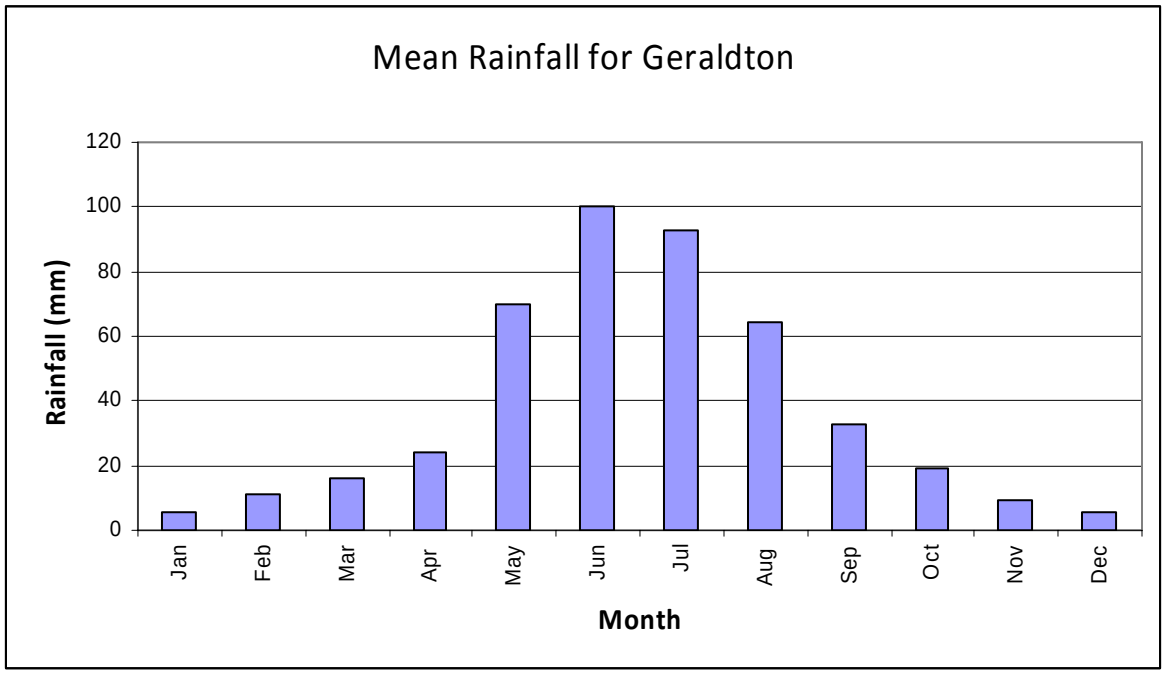

Figure 2.2 – Average Monthly GeraldtonRainfall.

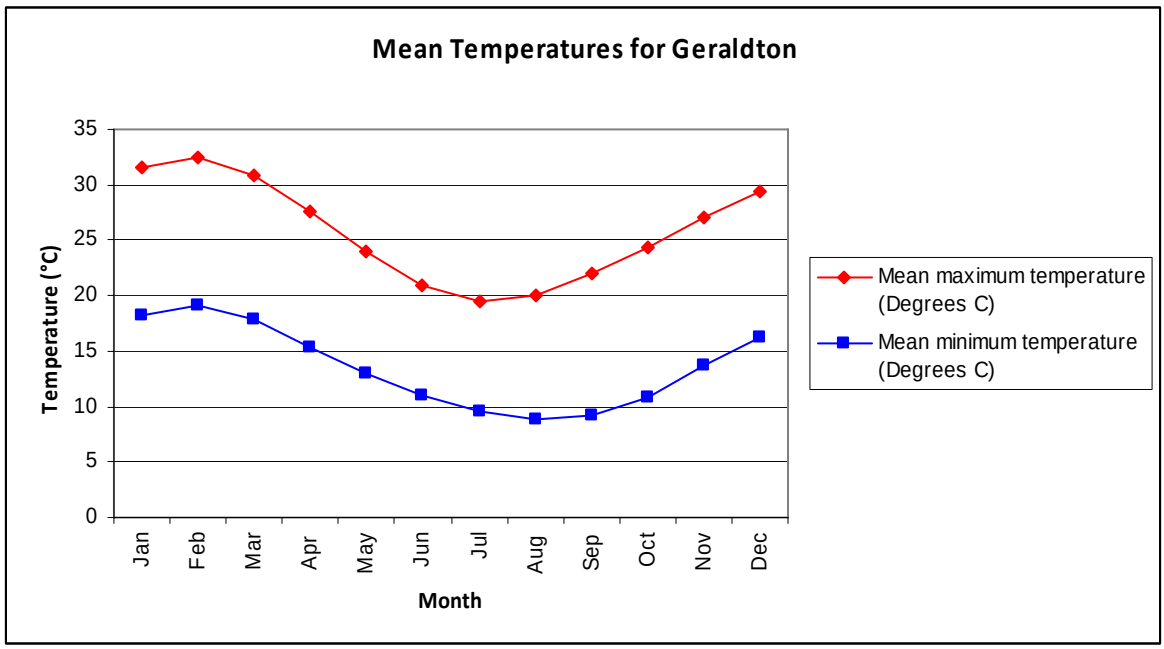

Figure 2.3 – Average Monthly Geraldton Temperatures.

2.3 LEGISLATIVE FRAMEWORK

Federal and State legislation applicable to the conservation of native fauna include, but are not limited to, the *Environment Protection and Biodiversity Conservation Act* 1999, the *Wildlife Conservation Act* 1950, and the *Environmental Protection Act* 1986. Section 4a of the *Environmental Protection Act* 1986 requires that developments take into account the following principles applicable to native fauna:

- The Precautionary Principle

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

- 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.

This document includes background information on the project, a literature review of the SRE fauna of Geraldton Sandplains; particularly in reference to the habitats and environments of the Terrestrial Port Development. The conservation significance of fauna in Western Australia is also outlined.

The document was constructed with a view to satisfy the requirements of EPA Guidance Statement No. 56: Terrestrial Fauna Surveys for Environmental Impact Assessment in Western Australia (EPA 2004). In relation to SRE fauna the guidance statement states that:

"Comprehensive systematic reviews of different faunal groups often reveal the presence of short range endemic species (Harvey 2002). Among the terrestrial fauna there are numerous regions that possess short range endemics. Mountainous terrains and freshwater habitats often harbour short range endemics, but the widespread aridification and forest contraction that has occurred since the Miocene has resulted in the fragmentation of populations and the evolution of many new species. Particular attention should be given to these types of species in environmental impact assessment because habitat loss and degradation will further decrease their prospects for long-term survival.

This document also satisfies the requirements of the later released Guidance statement 20: Sampling of Short Range Endemic Invertebrate Fauna for Environmental Impact Assessment in Western Australia (EPA 2009),

Harvey (2002) considered that although there were occasional short range endemics among the vertebrates and insects, there were much higher numbers among the molluscs, earthworms, some spider groups (especially the mygalomorphs), millipedes, and some groups of crustaceans. Short range endemics generally possessed similar ecological and life history characteristics, especially poor powers of dispersal, confinement to discontinuous habitats, slow growth, and low fecundity.

Some better known short range endemic species have been listed as threatened or endangered under State or Commonwealth legislation in the *Wildlife Conservation Act of WA* 1950 and/or *Environmental Protection and Biodiversity Conservation Act (EPBC)* 1999, but the majority have not. Often the lack of knowledge about these species precludes their consideration for listing as

threatened or endangered. Listing under legislation should therefore not be the only conservation consideration in environmental impact assessment.

The State is committed to the principles and objectives for the protection of biodiversity as outlined in The National Strategy for the Conservation of Australia's Biological Diversity (Commonwealth of Australia 1996). The EPA expects that environmental impact assessment will consider impacts on conservation of short range endemics in accordance with these principles and objectives" (EPA 2004).

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3 SHORT RANGE ENDEMIC FAUNA: A REVIEW

The decline in biodiversity of terrestrial communities has already been observed both nationally and state-wide (CALM 2004). There is also an increasing shift in environmental protection from species based conservation to biodiversity based conservation (Chessman 1995; Burbidge *et al.* 2000; McKenzie *et al.* 2000) and one of the important considerations involved in this is the presence of endemic species.

Endemism refers to the restriction of species to a particular area, whether it is at the continental, national or local level (Allen *et al.* 2002). This review focuses on short range endemics (SRE), those species that exhibit tight local range restrictions. It outlines the major paths to short range endemism, the current knowledge of short range endemism in Australia (with an emphasis on Geraldton Sandplains bioregion), and the conservation significance of such species. It is important to note that the individual taxa and broader groups discussed are not an exhaustive list of all SRE. This is due to the fact that SRE are dominated by invertebrate species, which are historically understudied and in many cases lack formal descriptions. An extensive, reliable taxonomic evaluation of these species has begun only relatively recently and thus the availability of literature relevant to SRE's is relatively scarce.

3.1 THREATS TO SHORT RANGE ENDEMICS

Short range endemism is influenced by numerous processes generally contributing to the isolation of a fauna species. A number of factors including life history, physiology, habitat requirements, habitat availability, the ability and opportunity to disperse, 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 of both plants and animals tend to differentiate both morphologically and genetically as they are influenced by different selective pressures over time. Additionally, a combination of novel mutation 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 2002).

A number of habitats in Australia contain SRE's 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 genetic flow. Similarly, isolated habitats such as mountains, aquifers, lakes, and caves are essentially islands of differing environmental conditions amongst the surrounding landscape. Within Western Australia, caves and other subterranean habitats are examples of areas where short range endemics are common (Harvey 2002).

Historical connections of habitats are also important in determining species distributions and often explain patterns that are otherwise inexplicable by current conditions. Many SRE's are those from relict taxa (organisms surviving as a remnant of an otherwise extinct species) and are confined to

certain habitats and in some cases geographic areas (Main 1996). Relict taxa include species dating back to Gondwanan periods that have very restricted natures.

In Western Australia, relict taxa are generally fragmented populations from lineages reaching back to historically wetter periods. 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 progressively dryer and more seasonal climatic conditions since this time, the most favourable habitats have now become increasingly fragmented and such fauna are now restricted to specialised moist microhabitats which simulate, on a small scale, an earlier, more widespread habitat (Main 1996). Many of the current species have restricted distributions as a result of these processes.

Relict 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 (which benefit from rainwater runoff), mountain summits, swampy headwaters of river systems and caves (Main 1996). Topography, proximity to the coast and directional orientation are also influential in determining relict habitats. Due to the isolation of populations, many relict species of cave fauna have very disjunct populations, indicating that their dispersal is limited (Clarke and Spier-Ashcroft 2003).

3.2 CONSERVATION OF SHORT RANGE ENDEMICS

Specific characteristics of sites in south-west Australia in which relict SRE species might be found were proposed by Main (1996, 1997) , following Main and Main (1991), and include areas:

- unaffected by salinisation;
- of high rainfall with short summer drought;
- topographically high along the coast and subject to frequent mists, cloud and drizzle;
- adjacent to rocks from which water is shed;
- of impeded groundwater flow so producing winter wet swamps;
- of streams with extensive fresh headwater swamps and year round flow;
- where vegetation can harvest water from fog or cloud drip from leaves and stem flow e.g. tingle forest and south coast dunes and heath;
- with southern or south-west aspects which are thus sheltered from summer insolation e.g. valley slopes and wet valley floors; and
- of intact forest canopy under which the characteristics under storey shrubs and herbs occur.

To these, Horwitz and Rogan (2003) added:

- Springs and caves streams or other expressions of interstitial or groundwater.

3.3 SHORT RANGE ENDEMISM ON GERALDTON SANDPLAINS

Short range endemics are common among the invertebrates. Many species are confined to topographically or geographically restricted areas and specialised microhabitats because of their

small size and often specialised behaviour, typical for relict species. These microhabitats provide areas of short range endemism and are vulnerable to artificial disturbances imposed by agriculture and other rural and urban disruptions to the landscape, for instance roads and other human constructions (Main 1996).

Widespread and uniform short range endemism is found in both terrestrial and freshwater molluscs, onychophorans, millipedes, some arachnids and some crustaceans. Short range endemism also occurs in other groups but is not uniform throughout (Harvey 2002).

Many taxa that appear to be rare are often poorly documented and could prove to be more widespread than originally thought. Nevertheless, recent taxonomic and survey work has revealed that SRE species are common in Australia, and that (although rare) some taxonomic groups such as Megascolecidae are composed entirely of SRE species (Harvey 2002).

There is little published evidence of SRE fauna to date from the Geraldton Sandplains. This is most likely due to the historical lack of invertebrate research, as common in most areas of Australia. Geraldton Sandplains have a potential to provide refuges for SRE species where moist conditions have persisted during the continent's increasing aridity, as is the case for numerous relict invertebrate taxa in the south-west region of Western Australia (Abbott 1994; Horwitz and Rogan 2003). Due to the history of pastoral land use in the area, suitable remnant vegetation associations on the sand plain plateau as well as on the coastal limestone ridge, the river margins, the southern valley slopes and the stable dunes on the western slope of the Oakajee Study Area may function as refugia for invertebrates with restricted distributions and thus be important for their long-term survival.

Short range endemic members of groups such as millipedes (Diplopoda), centipedes (Chilopoda), land snails (Mollusca), native earthworms (Megascolecidae) and trapdoor spiders (Mygalomorphae) have been recorded (Abbott 1994; Harvey *et al.* 2000) or are considered likely to exist on the Geraldton Sandplains (Mark Harvey pers. comm., October 2006).

Within the larger context of coastal regions of south-western Australia, there is more evidence of the presence of SRE fauna. The southern Carnarvon Basin, for example, which neighbours Geraldton Sandplains immediately to the north, is known to harbour several invertebrate SRE species (Harvey *et al.* 2000; Volschenk *et al.* 2000). To the south, the Southern Jarrah Forests region contains numerous SRE aquatic and terrestrial invertebrates taxa (Trayler *et al.* 1996), including unique relict taxa (characteristic of a wetter, milder era) with groups and species of invertebrates normally associated with the rainforests, forests and wetlands of south-east Australia. The Fitzgerald subregion, too, contains significant and endemic fauna species including relict taxa occurring in the Stirling Ranges and Mount Manypeaks (Comer *et al.* 2002).

3.3.1 Local Endemism of Invertebrate Groups

Isopods (crustaceans), amphipods (crustaceans), annelids (worms), onychophorans (velvet worms) molluscs (snails), arachnids (spiders and scorpions) and myriapods (millipedes and centipedes) are all known to show local endemism in southern Australia (Abbott 1994; Harvey 2002; Horwitz and Rogan 2003). Many of these taxa are confined to freshwater systems but can occur in shallow subterranean systems in saturated soils, or saturated sediments of wetlands, where they can survive seasonal drought by remaining in damp soil (Horwitz and Rogan 2003).

3.3.1.1 Annelida (Worms) and Onychophora (Velvet worms)

The taxonomic status of the earthworm family Megascolecidae in Western Australia was revised by Jamieson in 1971. This study concluded that most of the earthworm genera are made up almost entirely of SRE. This is also the case with the velvet worms (Onychophorans). A number of taxonomic revisions have been conducted since in both groups, resulting in the number taxa expanding in recent years. Furthermore, a number of new species are still to be described (Harvey 2002). Both groups have potential to occur on the study area.

Of the earthworms, a single Acanthodriline species, *Microscolex dubius*, occurs in the coastal regions of south-western Western Australia (Dyne and Jamieson 2004). The known distribution data for earthworms throughout the state is shown by Abbott (1994) as a series of isolated dots on a map within the 400 mm rainfall zone. This highlights the current lack of information and distribution data for earthworms occurring in the Study Area and indeed throughout the state.

Velvet worms exhibit one of the most extreme forms of short range endemism inhabiting moist habitats (Harvey 2002). Very few of these species exceed ranges of 200 km² and some are restricted to single localities and have high genetic differentiation, indicating very little mobility and dependence on their permanently moist habitats (Harvey 2002).

The most widely distributed onychophoran appears to be O*cciperipatoides gilesii*, which occurs throughout the Darling Range, with occasional outlying populations on the Swan Coastal Plain (Harvey 2002). Onychophorans inhabit permanently moist habitats, usually in native forests, and are most commonly found in or under rotting logs (Harvey 2002). They exhibit one of the most extreme forms of SRE, with some species restricted to single localities and with high genetic differentiation, indicating poor mobility and a strong reliance upon permanently moist habitat for survival (Harvey 2002).

3.3.1.2 Arachnida (Spiders)

The majority of spider species in Australia are widely distributed, due to their ability to balloon (Harvey 2002). However, some of the Mygalomorph species (primitive terrestrial, burrowing spiders, including trapdoor and funnel-web spiders) exhibit short range endemism with some of the Mygalomorph genera completely composed of SRE. Many of these species are restricted to habitat isolates such as rainforest patches (Raven 1982) or mountain peaks. On the whole, however, short range endemism is not as common for spiders as it is for other invertebrates.

The Mygalomorphae are predominantly burrowing spiders, which occasionally make tubular silk nests in bark or moss on tree trunks. A number of Mygalomorph species occur in the south-west of Western Australia and have highly restricted ranges. Mygalomorphs are relictual in their distribution, long-lived and relatively sedentary with poor dispersal ability. They also have very specific microhabitat preferences (Main 1987). In Western Australia, most Mygalomorph genera are confined to humid and forested regions, with some persisting in favourable (moist) microhabitats within more arid areas (Main 1991).

In the Swan Coastal Plain, very few records exist to suggest the presence of short range endemic Mygalomorph spiders – those recorded and formally described are widespread in the southwest (Main *et al.* 1985; Main 1987). Nonetheless, the potential for encountering them in the Study Area exists, as it retains many of the features desirable to relict SRE fauna, such as seasonal wet/damp areas and 20 years of no fire (M. Harvey, pers. comm., October 2006).

3.3.1.3 Crustacea (Crustaceans)

Three families of the freshwater isopod suborder Phreatoicidea occur in Australia. Most are highly endemic, often allopatric, and all are constrained by their specific habitat requirements of permanent fresh water lakes and streams (see references within Harvey (2002)) and thus are not likely to be found in the project area. Similarly, the habitat requirements of other commonly targeted south-west SRE crustacean species, such as *Peludo paraliotus*, *Platypyga subpetrae*, *Hemiboeckella powellensis*, and the endangered crayfish genus *Engaewa*, are not present and thus the taxa are not likely to be found in the Study Area.

3.3.1.4 Mollusca (Snails)

Numerous species of freshwater molluscs from many genera have been identified in Australia, with most being short range endemics with highly restricted ranges (Harvey 2002). Freshwater snails of the family Hydrobiidae have recently been shown to be diverse in Australia (Ponder *et al.* 1999). Many hydrobiids show small morphological differences between populations, even in those from adjacent drainages (Ponder 1982; Ponder *et al.* 1993) and these differences are often indicative of marked genetic differentiation (Ponder *et al.* 1994; Ponder *et al.* 1995; Ponder *et al.* 1996; Ponder and Colgan 2002).

Small streams and, to a lesser extent, local groundwater seepages and springs are the major habitats of the majority of hydrobiid species in south-western Australia (Ponder 1997). Hyrdobiids have very poor powers of dispersal and are good indicators of long term permanent water due to their restricted distributions and local genetic differentiation (Ponder 1997).

The terrestrial molluscan fauna also have highly restricted ranges with many families consisting entirely of SRE's (Harvey 2002). Land snails inhabit microhabitats across much of the state, from the Kimberley to the moist uplands of the Stirling and Porongurup Ranges. In the south-west of Western Australia, land snails are patchily distributed "in a mosaic" with distributions seemingly influenced by topography and soil type (S. Slack-Smith, pers. comm., August 2007). On a finer scale, leaf litter and calcrete concentrations in soil can influence occurrence of land snails. Rocky habitats associated with higher altitudes are more likely to contain species of restricted land snails than the lowlands areas of the south-west of Western Australia, where species can disperse more readily. Salinity levels in soil can also affect the distribution of land snails as many are intolerant of increasing salinity levels.

Short range endemic molluscs potentially occurring at or near the project area include members of the genus *Bothriembryon*, such as *B. kendricki* that occurs on the Swan Coastal Plain, escarpment, and plateau (Hill *et al.* 1983).

3.3.1.5 Myriapods (Millipedes and Centipedes)

Despite millipedes being highly abundant in soil and leaf litter, and highly diverse at the level of order (Harvey 2002), they are inadequately studied and relatively little is known of their biogeography.

Recent research into the paradoxosmatid genus, *Antichiropus* (endemic to south-western Australia and South Australia) has revealed an extensive array of taxa, most of which possess extremely short ranges (Harvey 2002). These large, black millipedes are mostly undescribed, and all are restricted to relatively small geographical areas (M. Harvey and P. West, pers. comm. October 2006). Approximately 90 species have been recorded so far, with most species known from single localities (Harvey 2002). The lack of mobility of both juvenile and adult millipedes, coupled with extremely seasonal life cycles, suggest that such species are extremely limited in their dispersal. *Antichiropus*

variabilis is known from the Darling Range east of Perth, with isolated occurrences as far south as Manjimup and Forest Grove (Harvey 2002). However, the only relevant Swan Coastal Plain record is of a number of unidentified female juvenile *Antichiropus*, which were recently recorded in Malaga as part of the survey for the Stage 2 extension of Hepburn Avenue (Speers and Wasaha 2004).

The genus *Antichiropus* includes species that appear restricted to seasonally moist biotypes with individuals seemingly active for only a short period during times of high winter rainfall (M. Harvey and P. West, pers. comm., October 2006). It is likely that many millipedes show allopatric speciation and extremely short ranges, especially in areas where soil and vegetation vary considerably across the landscape (Harvey 2002).

Currently centipedes are not officially recognised as a group which contains SRE species. Recent personal communication with Matt Colloff (CSIRO) however, indicated that taxon with in the Geophilomorpha sub-order of centipedes is likely to contain restricted species. As more research into invertebrates is conducted as part of the EIA process, the distribution of taxon within this poorly known group will improve.

Based on the literature records SRE millipedes and centipedes are likely to occur on the Study Area

4 METHODS

Due to a paucity of invertebrate sampling in the region, and the known presence of SRE taxa in the southwest region in general, it was considered likely that terrestrial SRE invertebrate taxa may be present within remnant bushland situated in and near the Study Area. As such, both systematic techniques (pitfall trap grids) and opportunistic techniques (foraging) were employed to facilitate a comprehensive survey of groups known to include SRE taxa. The methods targeted Mygalomorph (trap-door) spiders, scorpions, pseudoscorpions, millipedes, centipedes, annelids (Megascolecidae) and land snails (e.g. Camaenidae).

The methodology for the fauna survey was developed based on the principles outlined in EPA Guidance Statement 56: Terrestrial Fauna Surveys for Environmental Impact Assessment in Western Australia (EPA 2004). In May 2009, Guidance statement 20: Sampling of Short Range Endemic Invertebrate Fauna for Environmental Impact Assessment in Western Australia (EPA 2009) was released detailing the requirements of sampling SRE species. The methodology developed for the survey is compliant with these requirements.

4.1 SITE SELECTION

Following a preliminary reconnaissance, survey sites were chosen based on the following hierarchy:

1. habitats considered most likely to support SRE invertebrate fauna;
2. areas of potential environmental impact; and
3. representative vegetation associations.

4.2 SYSTEMATIC SURVEY – INVERTEBRATE PITFALL TRAPPING

The pitfall trapping comprised five invertebrate pitfall traps over six sites. Each site was open for 30 nights (6/08/2006 to 5/09/2006), resulting in 150 trap nights per site and a total of 900 trap nights for the entire survey (see Table 4.1 for summary).

The location of the pitfall trap sites can be seen in Figure 4.1.

The traps consisted of two-litre containers (16 cm of diameter) placed in each corner of a 50 m by 50 m grid with the fifth container placed in the centre of the grid, equating to a total survey area of 15000 m^2 given the six sites covered.

Each container contained a 500 ml solution of Ethylene Glycol (engine coolant with bittering agent to prevent ingestion by larger vertebrates) / Formalin (3 % of total volume). The high viscosity of the Ethylene Glycol prevents small invertebrate animals from escaping and the Formalin euthanases collected specimens and fixes animal tissues. Lastly, a lid made of Medium Density Fibreboard (MDF) was placed over each trap approximately 3 cm above the ground level to reduce vertebrate fauna by-catch and evaporation of trap fluids.

Table 4.1 – Summary of the particulars of techniques employed in the SRE survey.

Technique	A: Number of pits per site / foraging time (hrs)	B: Number of sites	C: Number of trap nights per site	D: Sample size (n)	E. Trap area (m)	F. Sample area (m^2) (B x E)
Foraging	0.5	54	n/a	27 person hrs	10 x 10	5400
Invertebrate Pitfall Traps	5	6	150	900 trap nights	50 x 50	15000
Vertebrate Pitfall Traps	30 (10 pits with 20 funnels)	10	300	3000 trap nights	50 x 10*	5000*

* estimation made for trap-door spider males, scorpions and large millipedes and centipedes

4.3 HAND FORAGING

Hand foraging was conducted across the range of vegetation associations and within suitable microhabitats within each. A site was standardised temporally by completing the foraging within 30 minutes (0.5 person hour) and spatial standardised by conducting the work within a 10 m x 10 m quadrat. Fifty-four quadrats were surveyed in total, equating to a total survey area of 5400 m².

The locations of the opportunistic foraging sites are presented in Figure 4.1.

The foraging was completed on the 6th of August 2006 when the pitfall-trap survey commenced.

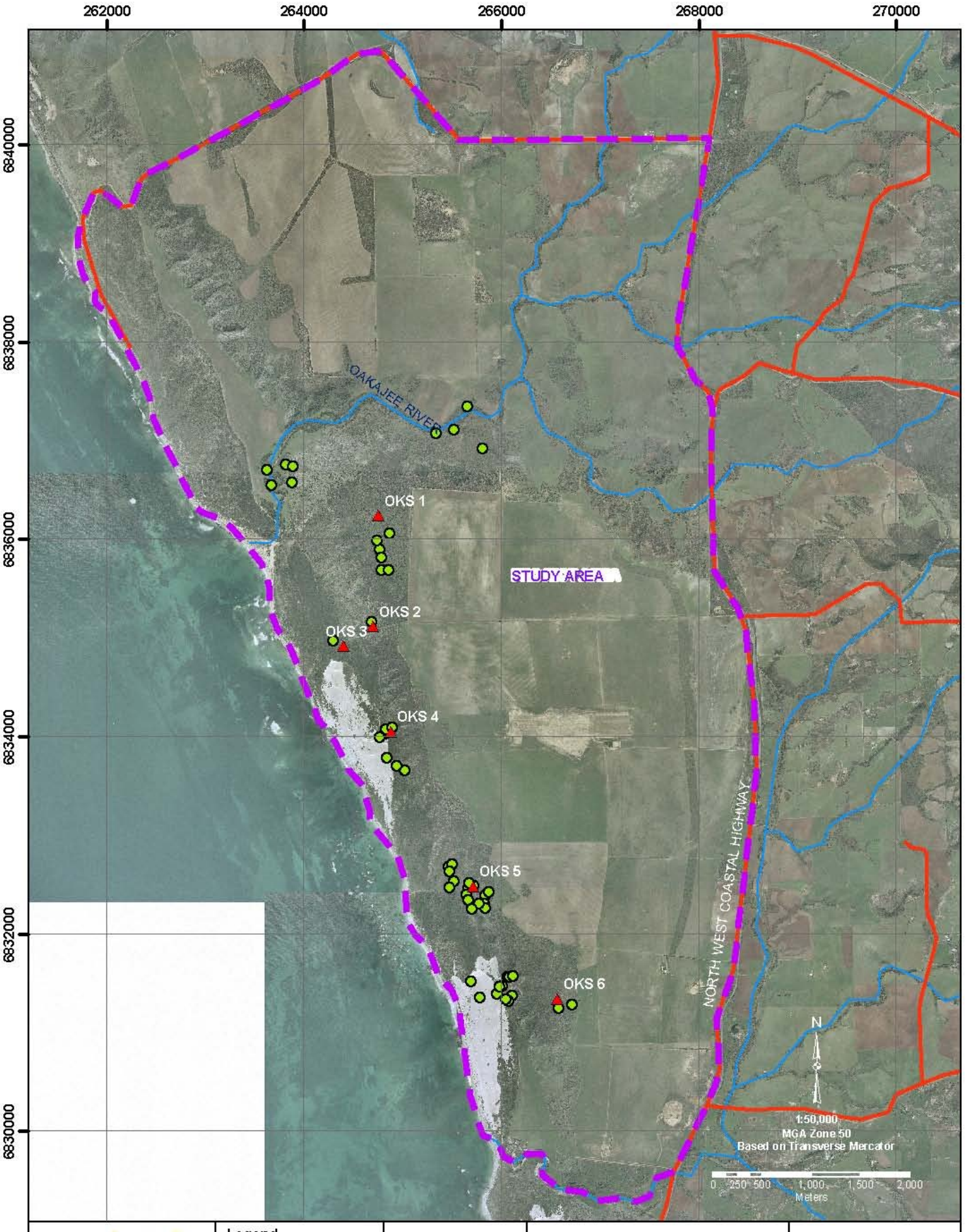
Specifically, hand foraging involved raking leaf litter (targeting millipedes, centipedes and mygalomorph spiders), inspecting under the bark of more flaky live trees (targeting pseudo scorpions, small scorpions, centipedes and millipedes), turning over rocks and logs and inspecting both the log itself and the soil below (targeting Mygalomorph spiders, scorpions, annelids, isopods, millipedes and centipedes). The base of large trees and shrubs were also investigated. Animals collected using these techniques were immediately placed in 100% ethanol and labelled with the respective site number.

4.4 SUPPLEMENTAL DATA – VERTEBRATE FAUNA PITFALL AND FUNNEL TRAPS

Significant additional data on invertebrate distribution, diversity, and abundances in the Study Area was obtained by using the standard vertebrate fauna pitfall trap method. Experience from previous ecologia vertebrate fauna surveys in the Neerabup, Jack Hills, Weld Range and more broadly those such as in the Pilbara (Marillana, Hashimoto and Jirridi undertaken for BHP Billiton) and on the South Coast (Wellstead) has shown that these pit traps and funnel traps are capable of collecting wandering invertebrates from groups such as Mygalomorphae spiders, centipedes, millipedes and scorpions.

Supplemental data for this survey was collected from a vertebrate fauna survey which comprised of 10 sites. Ten pit traps consisting of five PVC pipes (16 cm diameter, minimum 50 cm deep) and five buckets (30 cm diameter, 40 cm deep) were established at each site, each trap had a drift fence 5 m either side. Twenty funnel traps Ecosystematica Type III were also established at each site, one was positioned at either end of the drift fence. The locations of these sites can be seen in Figure 4.2. Each

trap was estimated to be effective for large invertebrates on area 50 x 10 m, therefore the total area surveyed was estimated as 5000 m^2 (Table 4.1).



ecologia
ENVIRONMENT

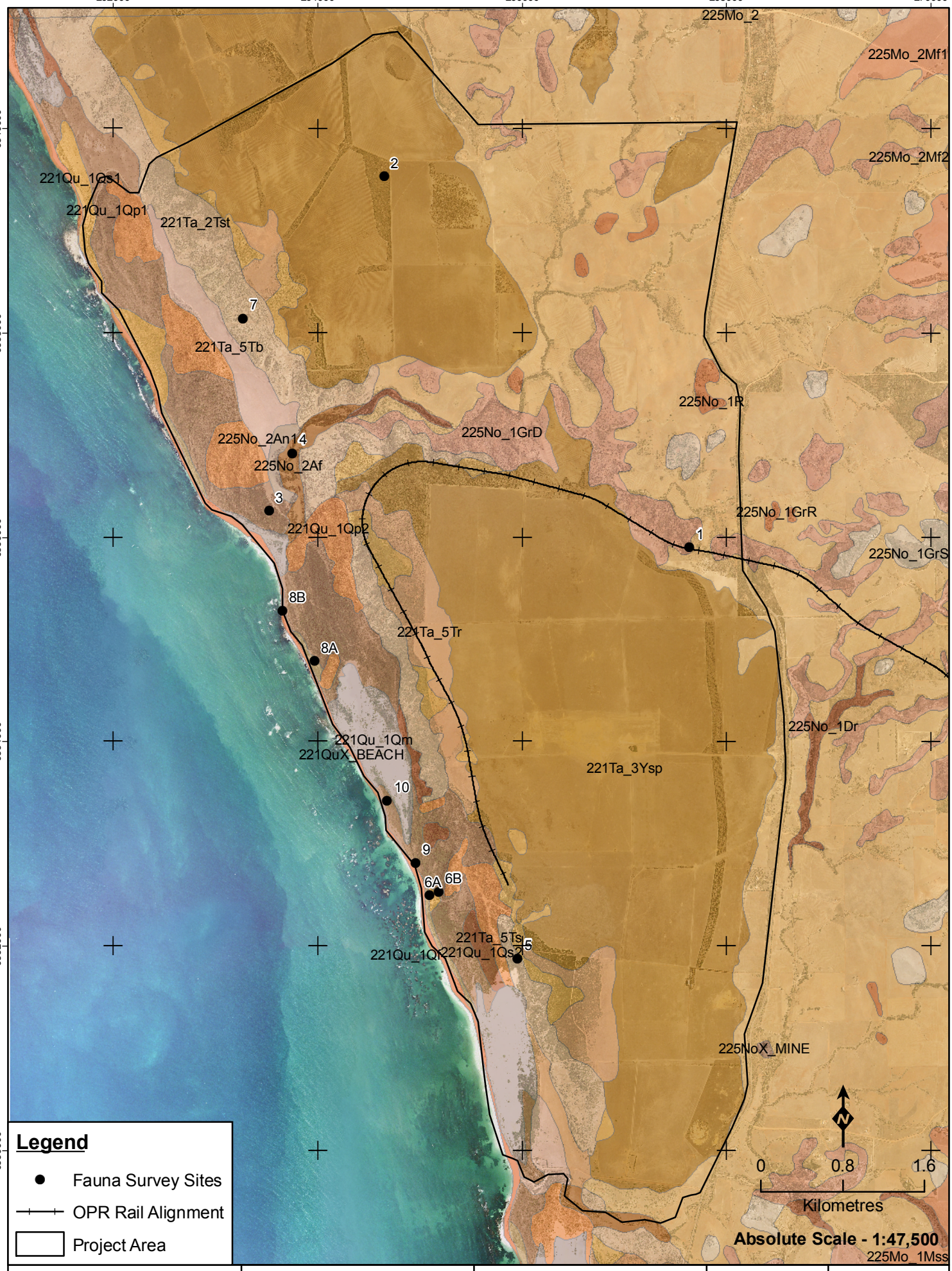
Author: BSM

Legend
- Foraging Site
- Pit Site
- Study Area
- Roads
- Rivers

Oakajee Port

Oakajee
Short Range Endemic
Pit and Foraging Sites

Date: 22/5/2007
Scale: 1:50,000
Figure: 4.1
Project ID: 684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221Qu_1Qp1
221Ta_2Tst
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221Ta_5Tb
225No_1R
225No_1GrD
225No_2An1
4
225No_2Af
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221Qu_1Qp2
225No_1GrR
1
225No_1GrS
8B
221Ta_5Tr
8A
225No_1Dr
221Qu_1Qm
221QuX_BEACH
221Ta_3Ysp
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6A
6B
221Ta_5Ts
221Qu_1Qs2
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225NoX_MINE
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Legend
Fauna Survey Sites
OPR Rail Alignment
Project Area
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OPR
Supplementary Vertebrate Survey Sites within the Study Area
Figure: 4.2
Project ID: 709
Drawn: SG
Date: 28/04/09
Coordinate System
Name: GDA 1994 MGA Zone 50
Projection: Transverse Mercator
Datum: GDA 1994
Unique Map ID: M087
A4

4.5 CURATION AND SPECIES IDENTIFICATION

All specimens obtained during hand foraging were immediately placed in 100% absolute ethanol in the field. All biological material from the invertebrate pitfall traps was transferred into 75% ethanol at the end of the 30-day pitfall-trap survey.

Invertebrate specimens collected from vertebrate pitfall traps were transferred into 100% ethanol at the end of each day. All chemicals were taken to the project area and removed at the end of the survey. Any fauna specimens that could not be identified in the field / ecologia laboratory, or that were considered to be SRE, were lodged with the WA Museum (WAM).

The level of specimen identification achievable is dependent on the level of taxonomic knowledge and expertise currently available. Taxa belonging to groups known to include SRE, or for which expertise is readily available at the WAM (e.g. Mygalomorph spiders, pseudoscorpions, scorpions, millipedes and land snails) were identified to genus or species level by the relevant experts (Table 4.2). Other invertebrate groups collected in the pitfall traps, such as ants and flying insects were not identified and therefore not reported.

Table 4.2 – The List of experts used to identify potential SRE taxa found in the Sudy Area.

Organism	Person	Institution
Mygalomorph Trap door spider	B. Main	UWA
Barychelidae (Mygalomorphae)	R. Raven	QLD Museum
Centipedes	J. Clark	Ecologia
Scorpions	M. Harvey	WAM
Diplopoda (Millipedes)	M. Harvey	WAM
Mollusca	S. Slack-Smith	WAM
Isopoda	S. Judd	Private Consultant
Annelida	I. Abbot	DEC

4.6 SURVEY LIMITATIONS AND CONSTRAINTS

According to the EPA Guidance Statement No. 20: Sampling of Short Range Endemic Invertebrate Fauna for Environmental Impact Assessment in Western Australia (EPA 2009), 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 in relation to the Study Area survey are detailed below in Table 4.3.

Table 4.3 – SRE Invertebrate fauna 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.
Scope	No	The survey design satisfied the requirements of EPA Guidance Statement No. 20.
Proportion of fauna identified, recorded and/or collected	No	All fauna recorded were identified to the lowest possible determination.
Sources of information e.g. previously available information vs. new data	Yes – moderate (20-60 % of potential fauna not sampled; M. Harvey, pers. comm., 2006)	Museum records are not comprehensive and a limited number of other surveys of similar scope have been conducted in the region. This survey will provide valuable information to the existing records.
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 (May – September) in the southern half of the state. The survey was carried out in this period and hence was appropriate.

ASPECT	CONSTRAINT (yes/no)	COMMENT
Disturbances which affected results	No	N/A
Intensity (in retrospect was the intensity adequate)	No	Surveys met the requirements of Guidance Statement 20.
Completeness	No	Surveying is complete.
Resources	No	Systematic invertebrate specific and vertebrate pitfall trapping equated a total sample size of 1400 trap-days; foraging techniques were equal to 27 person hours (covering 5400 m^2).
Remoteness and/or access problems	No	Areas selected for survey were, in the main, able to be accessed by 4WD tracks. In those instances where tracks were unavailable, Zoologists walked to these sites.
Availability of contextual (e.g. biogeographic) information on the region	No	The Geraldton Sandplains have been subjected to previous biological surveying. (However, few studies which are contextually relevant are available due to the recent requirement for inventories of SRE invertebrates in the EIA process.)

5 RESULTS AND DISCUSSION

Approximately 500 specimens were submitted to five external taxonomic experts for verification of identity and guidance concerning the conservation significance of each taxon. These individuals represented eleven orders, 21 families, 30 genera, and 36 species of invertebrates. A summary of the survey results is presented in Table 5.1. Figure 5.1 illustrates the locations the Mygalomorphae, the *Bothriembryon* land snail and *Hanoniscus* isopods, Figure 5.2 illustrates the location of the SRE millipedes located within the Study Area.

Mygalomorphae (trap-door spiders) spiders and centipedes were the most speciose groups, being represented by nine and seven species, respectively. The spiders included a number of undescribed and possibly restricted species. Isopods (Isopoda) were the third most speciose and abundant group, with six species being recorded. Five species of land snail (Mollusca), four species of pseudoscorpion (Pseudoscorpiones), three species of millipede (Diplopoda), and two species of scorpion (Scorpiones) were recorded.

5.1 ARACHNIDA (MYGALOMORPHAE)

A total of 32 specimens of Mygalomorphae, comprising eight juveniles, nine females, and 15 males, were recorded. These individuals represented three families, seven genera, and nine species. Two species are suspected of having restricted ranges and three species are suspected of being new species, therefore their conservation status uncertain. The locations of these species are given in Table 5.1 and illustrated in Figure 5.1.

5.1.1 Actinopodidae: *Missulena* sp 1.

A single juvenile from the genus *Missulena* was collected at invertebrate site 1. *Missulena* includes the widespread *M. insignis* (Cambridge, 1877) and other species, all of which are generally common and widespread. Despite this specimens being juvenile, preventing a more definitive identification, it is not expected to be an SRE species.

5.1.2 Nemesiidae: *Aname mainae* Raven, 2000

Two females of *Aname mainae* were collected at invertebrate site 2 and at the Oakajee River. The species is widespread in southern WA and extends east in to the Eyre Peninsular in South Australia. It is therefore not considered to be an SRE species and is thus not of conservation concern.

5.1.3 Nemesiidae: *Aname* sp.1

Eleven males of *Aname sp. 1* were collected at invertebrate sites 1,2,4 and 5 and three juveniles were collected at site 6. *Aname* is the most widely distributed mygalomorph genus in Australia, however, the group is in need of review as it almost certainly includes several currently unrecognised genera within a complex of numerous species. It was the opinion of Prof. Barbara Main (W.A. Mygalomorph spider expert) that the species 1 (for the purpose of this report) may be SRE species, however it is unlikely to be restricted to the Study Area.

5.1.4 Nemesiidae: *Aname* sp. 2

Three individuals of the species here designated as species 2 (for the purpose of this report) were recorded from foraging sites at the Oakajee River. The species may be SRE and may have restricted ranges to the Oakajee River (B.Y. Main, pers. comm., 2006).

5.1.5 Nemesiidae: *Chenistonia* Hogg, 1901

A single juvenile from the genus *Chenistonia* was collected during foraging. The genus is endemic to Australia and is found widely across southern Australia. Six species are currently formally described, of these, only *C. palludigena* is known from Western Australia. Because of the specimen's juvenile state, identification beyond genus was not achievable. The likelihood of the specimen belonging to *C. palludigena* is low, however, as the species has been previously recorded only from the south coast of Australia. The Oakajee speciemen is likely to represent a new species.

5.1.6 Nemesiidae: *Teyl* Main 1975

A female from the genus *Teyl* was collected at invertebrate site 4. *Teyl* harbours over 50 species, with only one species described from Western Australia. Although females are difficult to identify to species, the specimen collected in this survey is likely to be a new species. The conservation status of this species is difficult to assess due to the lack of knowledge about its abundance and distribution.

5.1.7 Nemesiidae: *Yilgarnia* Main, 1986

Seven specimens of *Yilgarnia* were recorded at invertebrate site 4, however the specimen could not be identified to species level. Only one species has been named but the genus is known to have many species in WA and South Australia. The Oakajee specimen is likely to represent a new species. Once again, it is difficult to determine the conservation status of this species due to the lack of knowledge about its abundance and distribution.

5.1.8 Barychelidae: *Idiommata blackwalli* (Cambridge, 1870)

Two heavily damaged specimens of *Idiommata blackwalli* were recorded from vertebrate pitfall trap Site 2. Only the cephalothorax and legs remained after presumably being predated upon by a beetle. However, the remains were matched to that of *I. blackwalli* held within the ecologia Environment SRE invertebrate voucher collection.

Idiommata blackwalli is typically found in low open shrubland, open forest, woodland, coastal dunes, open forest woodland, grassy and shrubby open scrub (Main *et al.* 1985). The species is widespread and common in southwestern and north western coastal areas of Australia, including off-shore islands such as Rottnest Island, Garden Island and the Abrolhos Islands, and it may possibly extend as far east as the Mount Lofty and Flinders Ranges in South Australia (Main *et al.* 1985). The species is not considered an SRE species and is of little conservation significance in the context of this study.

5.1.9 Barychelidae: *Aurecocrypta lugubris* Raven, 1994

A single specimen of a male *Aurecocrypta lugubris* (Barychelidae) was recorded from vertebrate pitfall trap Site 2. The type locality for this species is between Chittering and Pearce Air Force base. The species was until recently considered a SRE. However, Prof Barbara Main has indicated that she

has collected this species from Bullsbrook and Muchea (pers. comm.) and the record of this species from the current survey at Oakajee extends the range of *A. lugubris* beyond the definition of short range sensus Harvey (2002). The species is, therefore, not a SRE.

5.2 ARACHNIDA (SCORPIONES)

Two species of scorpions were collected during the survey. The specimens belongs to the genera *Cercophonius* and *Urodacus*. They are unlikely to be short range endemic species as their distribution is too widespread.

5.2.1 Bothriuridae: *Cercophonius granulatus* Kraepelin, 1908

Six individuals of *C. granulatus* were collected in Oakajee, one adult from each of the six invertebrate pitfall traps.

This species was described as being endemic to Western Australia and is known to be widespread throughout the mid-west region of the state. It ranges as far north as the Cape Range region and can be very common locally in certain habitats, such as low woodlands, and in certain seasons (Harvey 2006). This is not a SRE species and thus is of little conservation significance in the context of this study.

5.2.2 Urodacidae: *Urodacus novaehollandiae* Peters, 1861

These specimens were recorded during the vertebrate pitfall trapping programme. *U. novaehollandiae* is probably the most common and widespread *Urodacus* scorpion in the south half of Western Australia. It is therefore not a SRE species.

5.3 ARACHNIDA (PSEUDOSCORPIONIDA)

Several different Pseudoscorpion species were collected during the survey, these included *Austrohorus* sp., *Beierolpium* sp. *Nesidiochernes* sp. and *Indolpium* sp. None of these species are considered likely to be of conservation significance.

5.3.1 Chthoniidae: *Austrochthonius* sp. 1

Three individuals of *Austrochthonius* sp. 1 were collected from the invertebrate pitfall traps. These included one male from the Site 2 and two females from the Site 4.

Members of the genus *Austrochthonius* occur in a variety of habitat types in Western Australia including caves and other underground spaces, as well as epigean environments (Harvey 2006). They live in leaf litter and soil habitats. Whilst the two known subterranean species from Western Australia are described and named, the taxonomy of the epigean populations is less well-known. There appear to be at least two species in south-western Australia, and they sometimes occur in sympatry, especially in the Darling Range (Harvey 2006). Due to the confusion surrounding the resolution of the taxonomy of the Western Australian species of *Austrochthonius*, the exact identity of the Oakajee specimens will remain slightly uncertain. According to Harvey (2006), however, examination of the specimens revealed that they appear very similar – if not identical – to other populations of *Austrochthonius* found throughout the mid-west region of Western Australia. Therefore, this species of *Austrochthonius* is not expected to be a SRE species (Harvey 2006).

5.3.2 Olpiidae: *Beierolpium* sp. 1

Three individuals of a single species of *Beierolpium* were recorded from the invertebrate pitfall traps at Sites 1, 2 and 4.

Species of the genus *Beierolpium* are found throughout much of the drier regions of Australia, and can also be found throughout Asia, Africa and South America (Harvey 2006). The exact identity of this species has not been determined as yet, but it may possibly be *Beierolpium bornemisszai* originally described from Gnangara north of Perth (Harvey 2006). According to Harvey (2006), this species of *Beierolpium* is not expected to be a SRE species.

5.3.3 Olpiidae: *Indolpium* sp. 1

Four juvenile specimens of a single species from the genus *Indolpium* were recorded from the invertebrate pitfall trap Sites 2 and 4.

Species of the genus *Indolpium* are found throughout some of the drier regions of Australia and can also be found in parts of Asia. The exact identity of this species has not been determined as yet due to the lack of adult specimens amongst the collection. Harvey (2006) does not expect this species of *Indolpium* to be a SRE species.

5.3.4 Chernetidae: *Nesidiochernes* sp. 1

Several specimens of a single species of *Nesidiochernes* were recorded from the invertebrate pitfall traps. These included one male, one female and three nymphs at Site 5, one male at Site 4 and one female at Site 6.

Species of the genus *Nesidiochernes* are found throughout much of the Pacific region (Harvey 2006). The exact identity of this species has not been determined as yet, but it may possibly be *Nesidiochernes australiensis* originally described from western New South Wales but also recorded from Victoria, South Australia and Western Australia (Harvey 2006). This species of *Nesidiochernes* is not a SRE species.

5.4 CRUSTACEA (MALACOSTRACA: ISOPODA)

A large number of isopods were collected during the survey and these included species belonging to five genera within four families - Armadillidae (*Buddelundia, Spherillo*), Phillociidae (*Laevophiloscia*), Oniscidea (*Hanoniscus*) and Platyarthridae.

Only one species, *Hanoniscus tuberculatus*, is currently considered a SRE, however there was not enough scientific information on three species (*Buddelundia, Leavophiloscia* and *Platyarthridae*) in order to determine if any of them could be short range endemic species.

5.4.1 Armadillidae: *Buddelundia cinerascens* (Budde-Lund 1912)

This species is described as a large rolling isopod. Found in all invertebrates pitfall samples and many foraging sites. It is a widespread species found in sandy soils close to the West Coast. It has previously been recorded from the Perth area north to Cape Range. Due to its extensive range, it is not considered a SRE species.

5.4.2 Armadillidae: *Buddelundia* sp.

This tiny rolling isopod was found in two invertebrate pitfall samples. The specimens are undescribed but similar species are found along the west coast of Western Australia. It is considered unlikely to be a SRE species.

5.4.3 Armadillidae: *Spherillo undescribed* sp.

This specimen was a tiny rolling isopod which was found in one invertebrate pitfall sample. It is thought to be the same species as a widely distributed species found throughout the Swan Coastal Plain. It is considered unlikely to be an SRE species.

5.4.4 Philosciidae: *Leavophiloscia* sp.

This genus is part of a large species complex and appears quite mobile. It is usually found wherever there is considerable leaf litter. This form is found across the Swan Coastal Plain and none of the specimens are morphologically different enough to consider that it is a restricted species variant. However, more taxonomic work is needed on this genus for it to be understood well enough.

5.4.5 Oniscidea: *Hanoniscus tuberculatus* Budde-Lund 1912

This species occurs in seasonally damp areas on the Swan Coastal Plain. Its range is restricted and likely to have disappeared from many habitats as much of the Swan Coastal Plain wetlands have been cleared for residential and agricultural purposes. This is the farthest north it has been collected. Given the local and regional reduction in suitably moist habitats, this species can be considered a SRE species. The location of this species is illustrated in Figure 5.1.

5.4.6 Platyarthridae: undescribed genus

This species from an undescribed genus of Platyarthridae is a small, flat isopod, which is most likely to be largely subterranean. The group is relatively widespread but cryptic and therefore not much is known about this family within Australia. It is difficult to comment upon its SRE status or its conservation status due to the lack of information regarding abundance and general biology.

5.5 MOLLUSCA (SNAILS)

Five snail species belonging to the families Helicidae, Succineidae, Pupillidae and Bulimulidae were collected. As very little information is available regarding the taxonomy of these groups, it is difficult to determine with certainty which species they belong to. Identifications have been given as the most similar known species. Due to the lack of knowledge it is difficult to determine if any of the specimens collected are SRE species (Slack-Smith 2006).

5.5.1 Helicidae: *Theba pisana* (Müller, 1774)

The family Helicidae is not represented in the native snail fauna of Australia, although various species have been widely introduced, particularly to the faunas of southern Australia. The two helicid species collected are typical of those species flourishing in the coastal areas of south-western and southern Western Australia. As there is little knowledge of this group it cannot be determined whether these specimens are SRE species.

5.5.2 Helicidae: *Cochlicella acuta* (Müller, 1774)

This helicid species collected is typical of those species flourishing in the coastal areas of south-western and southern Western Australia. As there is little knowledge of this group it cannot be determined whether these specimens are SRE species.

5.5.3 Succineidae: *Succinea* sp.

The family Succineidae can be found worldwide. Living succineids are rarely encountered in the south of WA outside the periods of winter rainfall, although fragile dead-taken shells are encountered throughout the year and are, apparently, widespread (Slack-Smith 2006).

No revision of the succineid species native or introduced to Australia has been carried out. Due to the lack of information available regarding this family specific names that have been applied are of suspect validity.

The specimens of *Succinea* submitted to the WAM for identification could be identified as any (or all) of the nominate species from WA: -

- *Succinea contenta* (Iredale 1939) – type locality Perth, WA.
- *Succinea menkeana* Pfeiffer, 1850 – type locality Hay District, WA.
- *Succinea scalarina* Pfeiffer, 1861 – type locality King George Sound area, WA.
- *Succinea strigillata* Adams & Angas, 1864 – Type locality Fitzroy River, WA.

From the list above, the specimens collected from Oakajee were thought to belong to *S. contenta*. However, in the absence of any detailed research on these taxa and on the populations throughout WA, any specific name applied to the specimens from the Oakajee survey would be suspect and therefore the SRE status of these specimens cannot be confirmed.

5.5.4 Pupillidae: *Pupoides* sp. c. f. beltianus (Tate, 1894)

The family Pupillidae also has a worldwide distribution and the native Australian land snail fauna includes a number of diverse pupillid taxa. The single specimen from the sample FG 03 appears to belong to the species *Pupoides beltianus*. However, in the most recent taxonomic revisions of the Western Australian species of *Pupoide*s, Solem (1988)) expressed some doubt on the co-specificity of the extensive W.A. central coastal populations with the widespread central Australian taxon. This doubt is likely to remain until research (distributional, morphological, and genetic) provides further information. Therefore determining the conservation significance of this species is difficult.

5.5.5 Bulimulidae: *Bothriembryon* sp.

The family Bulimulidae is distributed through south and Central America, some Pacific Islands, New Zealand and Australia. The distributions of Australian native species are mainly confined to the southern (particularly the south-western) part of the continent, with one species in Tasmania, a few in South Australia, and relict species living in favourable habitats in the Pilbara and central Australia.

Worn, shell specimens from the genus *Bothriembryon* were present in three separate samples.

One sample (Foraging Site 28), contained only long-dead, eroded shells, which have fairly heavy sculpture, similar to that of an undetermined, un-named specimen lot (also long dead and eroded) from Meanarra Hill, near Kalbarri – although these snails are smaller (possibly younger) and more fragile.

Shells of what appear to belong to a second species (Foraging Site 45 and Pitfall Trap Site 2) are much more delicately sculptured and more fragile than those in sample FG 28. They closely resemble an un-named taxon that appears to be fairly common northwards from about Northampton to just north of the Murchison River.

Neither group can be identified with named *Bothriembryon* species' *B. perobesus* and *B whitley* (Iredale 1939), both of which are rarely recorded from the central coastal regions of WA. It can therefore be considered a SRE species until such time as it is located outside of the project area.

5.6 MYRIAPODA (CHILOPODA)

Several species were collected at the Study area, most of which are not SREs.

5.6.1 Scolopendridae: *Cormocephalus* nr. *westangelasensis* L. E. Koch, 1923

A single *Cormocephalus* specimen which resembled *C. westangelensis* was recorded from vertebrate pitfall trap 4. Currently *C. westangelensis* is known only from the Pilbara and thus, should the specimen be positively identified as *C. westangelensis* the record would represent a significant range extension. Unfortunately there is no national or international expert available to determine the specimens' identification. Therefore it is not possible to comment on the conservation significance of this species at present.

5.6.2 Scolopendridae: *Ethmostigmus rubripes* (Brandt 1840)

A single *E. rubripes* specimen was recorded during foraging site five. This is a typical solitary litter and soil dwelling predatory species, which is common and widespread across the Australian continent. It is not considered a SRE species.

5.6.3 Scolopendridae: *Scolopendra laeta* Haase, 1887 and *S. morsitans* Linnaeus, 1758

Two specimens of *S. laeta* were collected in pit traps at Sites 1 and 3 and four specimens of *S. morsitans* were collected in pit traps at Sites 3 and 4 and foraging Sites 3 and 6. Both species are solitary litter and soil dwelling predators, occasionally occurring under bark of trees. Both species have wide distributions in all Australian states and territories and thus are not considered SRE species.

5.6.4 Scurigeridae: *Thereuopoda* sp.

Two specimens of un-identified species of *Thereuopoda* were collected in pit trap Site 2 and foraging Site 3. The species is solitary litter and soil dwelling predator, occasionally occurring under bark of trees. The only described species, *T. longicornis*, is known from Queensland, where it displays a wide distribution. The species is, therefore, not considered a SRE.

5.6.5 Mecistocephalidae: *Mecistocephalus collinus* Verhoeff 1937

Three *Mecistocephalus collinus* specimens were recorded during foraging activities from Sites 2, 9 and 13. It is a solitary litter and soil dwelling predatory species. This species is known from south western coastal areas. The species distribution is greater 10,000 km² and therefore is not considered a SRE species.

5.6.6 Henicopidae: *Henicops* sp.

A single *Henicops* Newport 1848 specimen was recorded from foraging Site 11. This was the only specimen recorded from the Order Lithobiomorpha. Unfortunately the specimen was slightly damaged and thus identification below genus was not achieved.

There are currently three described species of *Henicops*, one is known from coastal south-eastern Australian and Tasmania, the other two are known only from south western Australia. However due to the poor condition the specimen was collected in it was not possible to identify this species and thus comment on the conservation significance of this species.

5.7 MYRIAPODA (DIPLOPODA)

Three new species were collected at the Study Area, all of which are likely SREs.

5.7.1 Polydesmida Paradoxosomatidae: *Antichiropus* sp. nov. "Geraldton"

Three hundred and three individuals of a single species of *Antichiropus*, known as *Antichiropus* sp. nov. "Geraldton", were recorded from invertebrate pitfall traps (Sites 1, 2, 3, 4, 5 and 6) and eight foraging areas (Sites FG 9, 11, 18, 19, 21, 25, 43 and 58).

Members of the millipede genus *Antichiropus* are abundant throughout the southern half of Western Australia, usually occurring south of the mulga-eucalypt line, but with isolated species found throughout suitable habitats in the Pilbara region. The vast majority of *Antichiropus* species are SRE species (Harvey 2006).

The Western Australian Museum has previously encountered *Antichiropus* sp. nov. "Geraldton" throughout the Geraldton region from several different locations. It is a SRE species, but was observed in large numbers in the Study Area and is not restricted to the Oakajee site (Harvey 2006).

5.7.2 Spirostreptida: Iulomorphidae: *Podykipus* sp. 1

One hundred and three individuals of *Podykipus* sp. 1 were collected by foraging at sites FG 3, 4, 9, 10, 12-18, 20-22, 24-26, 36,39, 41, 48, 52 and 58.

Members of the millipede genus *Podykipus* are found throughout the mid-west region of Western Australia ranging as far south as the Swan Coastal Plain. The taxonomy of the genus is poorly understood and the Western Australian Museum has records of several new species. All species of *Podykipus* appear to be SRE species (Harvey 2006).

Podykipus sp. 1 has not been encountered previously by the Western Australian Museum. It is considered to be a SRE species, but it was observed in large numbers in the Study Area and is unlikely to be restricted to it (Harvey 2006).

5.7.3 Spirostreptida: Iulomorphidae: *Podykipus* sp. 2

A single male specimen of *Podykipus* sp. 2 was collected by foraging at the foraging site FG 36. It is substantially smaller than *Podykipus* sp. 1 and, similarly to *Podykipus* sp. 1, it has not been previously encountered by the Western Australian Museum. It is considered to be a SRE species, but it is probably not restricted to the Oakajee site (Harvey 2006).

Table 5.1 – Short Range Endemic Invertebrate Pitfall Trapping and Foraging Results.

Class (Order)	Family	Genus	Species	SRE	Pitfall Trap Sites						Foraging Site															
					OKS01	OKS02	OKS03	OKS04	OKS05	OKS06	FG01	FG02	FG03	FG04	FG05	FG06	FG07	FG09	FG010	FG011	FG012	FG013	FG014	FG015	FG016	FG017
Arachnida (Araneae)																										
	Nemessidae	*Aname*	sp.1	√	1	1		1	1	1																
			sp. 2	√																						
			mainae			1																				
		Chenistonia	sp.																							
		Teyl	sp.					1																		
		Yilgarnia	sp.					1																		
	Barychelidae	*Aurecocrypta*	*lugubris*																							
		Idiomatta	*blackwalli*																							
	Actinopodidae	*Missulena*	sp.		1																					
Arachnida (Scorpiones)																										
	Bothriuridae	*Cercophonius*	*granulatus*		1	1	1	1	1	1																
Arachnida (Pseudoscorpionida)																										
	Chernetidae	*Nesidiochernes*	sp.					1	1	1																
	Chthoniidae	*Austrochthonius*	sp.			1		1																		
	Olpiidae	*Beierolpium*	sp.		1	1		1																		
		Indolpium?	sp.			1		1																		
Malacostraca (Isopoda)																										
	Armadillidae	*Buddelundia*	*cinerascens*		1	1	1	1	1	1			1	1	1	1	1		1					1		
			sp.			1		1																		
		Spherillo	sp.			1																				
	Philosciidae	*Leavophiloscia*	sp.			1				1																
	Oniscidea	*Hanoniscus*	*tuberculatus*	√		1							1													
	Platyarthridae	undescribed genus	undescribed sp.			1			1	1																

Table 5-1 cont.

Class (Order)	Family	Genus	Species	SRE	Pitfall Trap Sites						Foraging Site														
					OKS01	OKS02	OKS03	OKS04	OKS05	OKS06	FG01	FG02	FG03	FG04	FG05	FG06	FG07	FG09	FG010	FG011	FG012	FG013	FG014	FG015	FG016	FG017
Gastropoda (clade Heterobranchia)																									
	Helicidae	*Cochlicella*	*acuta*		1	1	1	1	1	1	1	1	1					1		1		1	1		1	1
		Theba	*pisana*			1	1		1				1												1	1
	Succineidae	*Succinea*	sp.			1	1				1	1	1							1						
	Pupillidae	*Pupoides*	sp. c. f. *balteolus*																							
	Bulimulidae	*Bothriembryon*	sp.	√		1																				
Chilopoda (Geophilomorpha)																									
	Mecistocephalidae	*Mecistocephalus*	*collinus*									1						1				1				
Chilopoda (Scolopendramorpha)																									
	Scolopendridae	*Cormocephalus*	sp. near *westangelasensis*																							
		Ethmostigmus	*rubripes*														1									
		Scolopendra	*laeta*		1		1																			
			morsitans				1	1					1			1										
Chilopoda (Scutigeromorpha)																									
	Scutigeridae	*Thereupoda*	sp.			1							1													
Chilopoda (Lithobiomorpha)																									
	Henicopidae	*Henicops*	sp.																	1						
Diplopoda (Spirostreptida)																									
	Iulomorphidae	*Podykipus*	sp. 1	√									1	1				1	1		1	1	1	1	1	1
			sp. 2	√																						
Diplopoda (Polydesmida)																									
	Paradoxosomatidae	*Antichiropus*	sp. "Geraldton"	√	1	1	1	1	1	1								1		1						

Table 5-1 cont.

Class (Order)	Family	Genus	Species	SRE	Foraging Site																		
					FG018	FG019	FG020	FG021	FG022	FG023	FG024	FG025	FG026	FG027	FG028	FG029	FG030	FG031	FG032	FG033	FG034	FG035	FG036
Arachnida (Araneae)																							
	Nemessidae	*Aname*	sp.1	√																			
			sp. 2	√																			
			mainae																				
		Chenistonia	sp.																				
		Teyl	sp.																				
		Yilgarnia	sp.																				
	Barychelidae	*Aurecocrypta*	*lugubris*																				
		Idiomatta	*blackwalli*																				
	Actinopodidae	*Missulena*	sp.																				
Arachnida (Scorpiones)																							
	Bothriuridae	*Cercophonius*	*granulatus*																				
Arachnida (Pseudoscorpionida)																							
	Chernetidae	*Nesidiochernes*	sp.																				
	Chthoniidae	*Austrochthonius*	sp.																				
	Olpiidae	*Beierolpium*	sp.																				
		Indolpium?	sp.																				
Malacostraca (Isopoda)																							
	Armadillidae	*Buddelundia*	*cinerascens*				1	1	1		1	1	1								1		1
			sp.																				
		Spherillo	sp.																				
	Philosciidae	*Leavophiloscia*	sp.																				
	Oniscidea	*Hanoniscus*	*tuberculatus*	√																			
	Platyarthridae	undescribed genus	undescribed sp.																				

Table 5-1 cont.

Class (Order)	Family	Genus	Species	SRE	Foraging Site																		
					FG018	FG019	FG020	FG021	FG022	FG023	FG024	FG025	FG026	FG027	FG028	FG029	FG030	FG031	FG032	FG033	FG034	FG035	FG036
Gastropoda (clade Heterobranchia)																							
	Helicidae	*Cochlicella*	*acuta*		1	1	1		1		1	1	1			1		1	1	1	1		1
		Theba	*pisana*			1		1	1		1	1	1						1		1		1
	Succineidae	*Succinea*	sp.					1								1		1	1	1	1		1
	Pupillidae	*Pupoides*	sp. c. f. *balteolus*																				
	Bulimulidae	*Bothriembryon*	sp.	√											1								
Chilopoda (Geophilomorpha)																							
	Mecistocephalidae	*Mecistocephalus*	*collinus*		1																		
Chilopoda (Scolopendramorpha)																							
	Scolopendridae	*Cormocephalus*	sp. near *westangelasensis*																				
		Ethmostigmus	*rubripes*																				
		Scolopendra	*laeta*																				
			morsitans																				
Chilopoda (Scutigeromorpha)																							
	Scutigeridae	*Thereupoda*	sp.																				
Chilopoda (Lithobiomorpha)																							
	Henicopidae	*Henicops*	sp.																				
Diplopoda (Spirostreptida)																							
	Iulomorphidae	*Podykipus*	sp. 1	√	1		1	1	1		1	1	1										1
			sp. 2	√																			1
Diplopoda (Polydesmida)																							
	Paradoxosomatidae	*Antichiropus*	sp. "Geraldton"	√	1	1		1				1											

Table 5-1 cont.

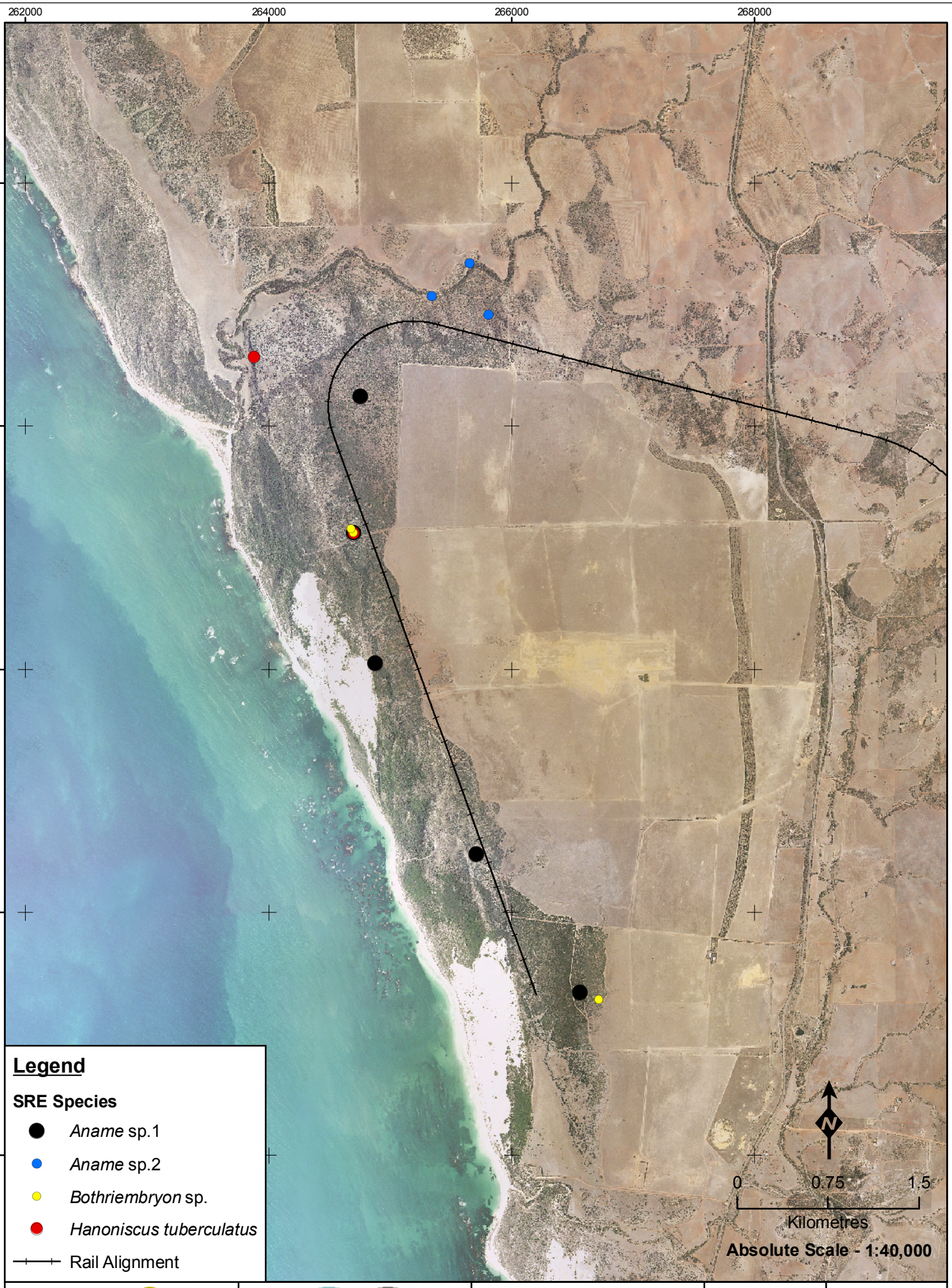
Class (Order)	Family	Genus	Species	SRE	Foraging Site																		
					FG037	FG038	FG039	FG040	FG041	FG042	FG043	FG044	FG045	FG046	FG047	FG048	FG050	FG052	FG054	FG056	FG058	FG060	FG062
Arachnida (Araneae)																							
	Nemessidae	*Aname*	sp.1	√																			
			sp. 2	√									1		1								1
			mainae																				
		Chenistonia	sp.											1									
		Teyl	sp.																				
		Yilgarnia	sp.																				
	Barychelidae	*Aurecocrypta*	*lugubris*																				
		Idiomatta	*blackwalli*																				
	Actinopodidae	*Missulena*	sp.																				
Arachnida (Scorpiones)																							
	Bothriuridae	*Cercophonius*	*granulatus*																				
Arachnida (Pseudoscorpionida)																							
	Chernetidae	*Nesidiochernes*	sp.																				
	Chthoniidae	*Austrochthonius*	sp.																				
	Olpiidae	*Beierolpium*	sp.																				
		Indolpium?	sp.																				
Malacostraca (Isopoda)																							
	Armadillidae	*Buddelundia*	*cinerascens*			1	1		1					1	1	1		1		1	1	1	
			sp.																				
		Spherillo	sp.																				
	Philosciidae	*Leavophiloscia*	sp.																				
	Oniscidea	*Hanoniscus*	*tuberculatus*	√																	1		
	Platyarthridae	undescribed genus	undescribed sp.																				

Table 5-1 cont.

Class (Order)	Family	Genus	Species	SRE	Foraging Site																		
					FG037	FG038	FG039	FG040	FG041	FG042	FG043	FG044	FG045	FG046	FG047	FG048	FG050	FG052	FG054	FG056	FG058	FG060	FG062
Gastropoda (clade Heterobranchia)																							
	Helicidae	*Cochlicella*	*acuta*			1	1	1	1					1							1		
		Theba	*pisana*				1	1	1														
	Succineidae	*Succinea*	sp.		1	1		1	1					1							1	1	
	Pupillidae	*Pupoides*	sp. c. f. *balteolus*																				
	Bulimulidae	*Bothriembryon*	sp.	√									1										
Chilopoda (Geophilomorpha)																							
	Mecistocephalidae	*Mecistocephalus*	*collinus*																				
Chilopoda (Scolopendramorpha)																							
	Scolopendridae	*Cormocephalus*	sp. near *westangelasensis*																1				
		Ethmostigmus	*rubripes*																				
		Scolopendra	*laeta*												1	1							
			morsitans																				
Chilopoda (Scutigeromorpha)																							
	Scutigeridae	*Thereupoda*	sp.																				
Chilopoda (Lithobiomorpha)																							
	Henicopidae	*Henicops*	sp.																				
Diplopoda (Spirostreptida)																							
	Iulomorphidae	*Podykipus*	sp. 1	√			1		1							1		1			1		
			sp. 2	√																			
Diplopoda (Polydesmida)																							
	Paradoxosomatidae	*Antichiropus*	sp. "Geraldton"	√							1										1		

Table 5.2 – SRE Vertebrate Pitfall Trapping Results

Class (Order)	Family	Genus	Species	SRE	Vertebrate site									
					Site 1	Site 2	Site 3	Site 4	Site 5	Site 6	Site 7	Site 8	Site 9	Site 10
Arachnida (Araneae)														
	Barychelidae	*Aurecocrypta*	*lugubris*			1								
		Idiomatta	*blackwalli*			1								
Arachnida (Scorpiones)														
	Urodacidae	*Urodacus*	*novaehollandiae*						1					
Chilopoda (Scolopendramorpha)														
	Scolopendridae	*Cormocephalus*	sp. near *westangelasensis*					1						



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OPR

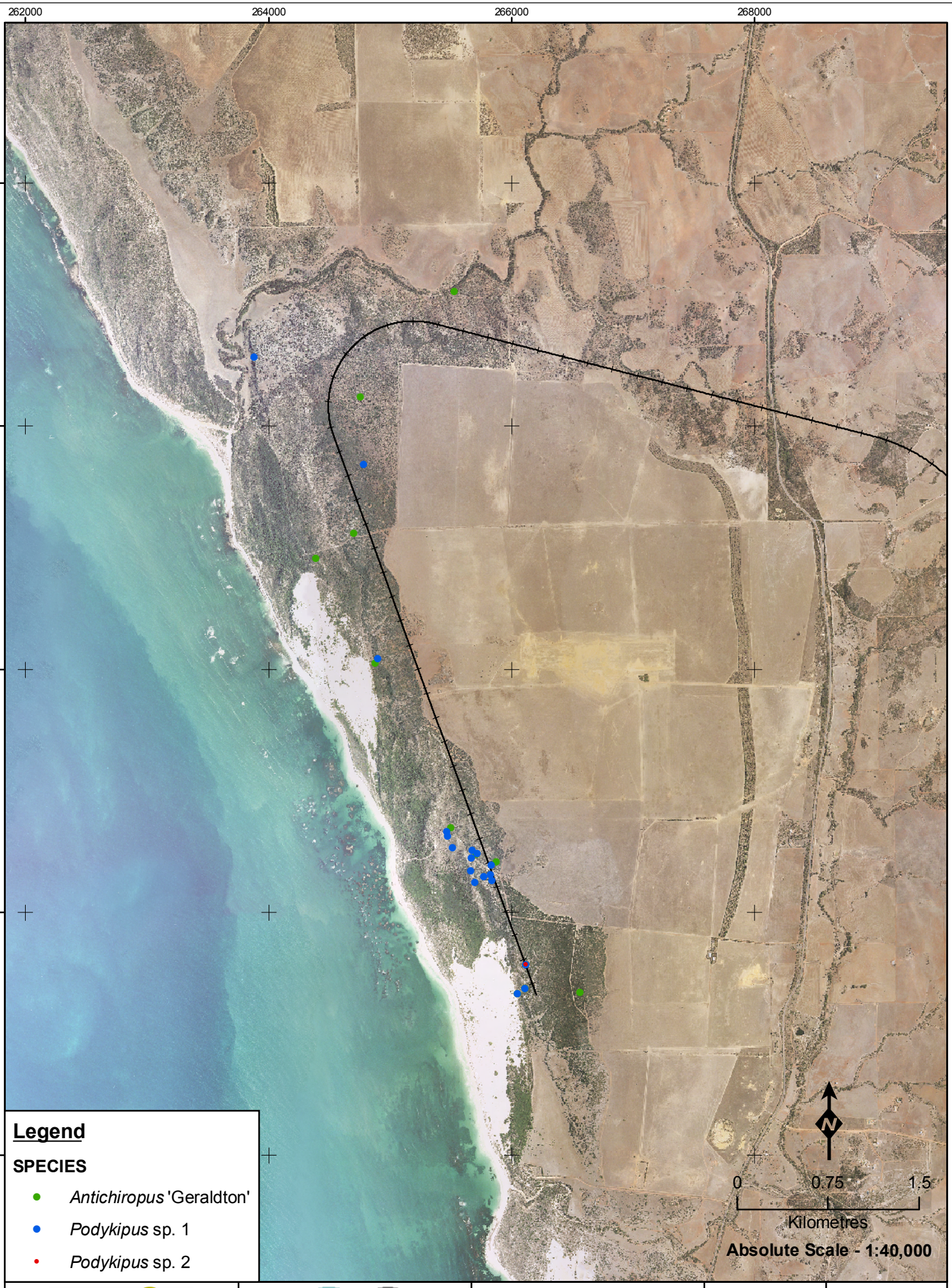
SRE Species

Figure: 5.1
Project ID: 684
Drawn: SG
Date: 17/05/10

Coordinate System
Name: GDA 1994 MGA Zone 50
Projection: Transverse Mercator
Datum: GDA 1994

Unique Map ID: S139

A4



ecologia ENVIRONMENT

OPR

SRE Species

Figure: 5.2	**Drawn: SG**
Project ID: 684	**Date: 17/05/10**

Coordinate System Unique Map ID: S140
Name: GDA 1994 MGA Zone 50
Projection: Transverse Mercator
Datum: GDA 1994

A4

6 CONCLUSIONS

Of the 13 taxa expected to be SRE species, 11 were new. Four of the 13 species were SREs (isopod *Hanoniscus tuberculatus* and millipedes *Podykipus* sp. 1, *Podykipus* sp. 2 and *Antichiropus* 'Geralton'), three were possible SREs (spiders *Aname* sp. 1 and *Aname* sp. 2 and snail *Bothriembryon* sp.) and six species could not have their SRE status determined see . The species were located within habitats found on the coastal foredunes and the Oakajee River channel (see Figures 4.1 and Figure 4.2).

The overlying vegetation was of mixed condition, having suffered degradation from stock activity in the eastern, upper portions of the site, and from recreational motorbike activity in the western, lower portions of the site. Nevertheless, number of new and suspected SRE species were recorded. This was considered most likely to be an article of a lack of historic sampling in the region and locally as it is well established that species richness is often a function of the intensity of sampling (Ingram and Raven 1991). As such, the distribution of the majority of these species is expected extend beyond the Study Area and its impact footprint (Harvey 2006).

It is possible that the trap-door spider *Aname* sp. 2 (Nemesiidae) is restricted to the Oakajee River valley. The three new millipede species (Diplopoda), the one *Bothriembryon* land snail species, the one isopod species and the trapdoor spider *Aname* sp. 1, which were assessed as SREs or possible SRE's, were all located along the length of the fore dune vegetation. It is expected that these species will be found in similar habitats to the north and south of the Study Area.

Table 6.1 – A list of all taxa ranked by status (confirmed, possible, unable to be determined or not SREs).

Class	Order	Family	Genus	Species	Sites
SREs					
Crustacea	Isopoda	Oniscidea	*Hanoniscus*	tuberculatus	OKS 2, FG 3, 58
Diplopoda	Polydesmida	Paradoxosomatidae	*Antichiropus*	Geraldton'	OKS 1-6, FG 9,11,18,19,21,25,43
Diplopoda	Spirostreptida	Iulomorphidae	*Podykipus*	sp. 1	FG 3,4,9,10,12-18,20-22,24-26,36,39,41,48,52,58
Diplopoda	Spirostreptida	Iulomorphidae	*Podykipus*	sp. 2	FG 36
New species, SRE status possible					
Arachnida	Mygalomorphae	Nemesidiae	*Aname*	sp. 1	OKS 1,2,4-6
Arachnida	Mygalomorphae	Nemesidiae	*Aname*	sp. 2	FG 45,47,62
Molusca	Pulmonata	Bulimulidae	*Bothriembryon*	sp.	OKS 2, FG 28,45
New species, SRE status could not be determined					
Arachnida	Mygalomorphae	Nemesidiae	*Chenistonia*	sp.	FG 46
Arachnida	Mygalomorphae	Nemesidiae	*Teyl*	sp.	OKS 4
Arachnida	Mygalomorphae	Nemesidiae	*Yilgarnia*	sp.	OKS 4
Crustacea	Isopoda	Armadillidae	*Buddelundia*	sp.	OKS 2
Crustacea	Isopoda	Philosciidae	*Leavophiloscia*	sp.	OKS 2
Crustacea	Isopoda	Platyarthridae	undescribed genus	sp.	OKS 2
Not SRE species					
Arachnida	Mygalomorphae	Nemesidiae	*Aname*	*mainae*	OKS 2
Arachnida	Mygalomorphae	Barychelidae	*Aurecocrypta*	*lugubris*	Vert. Site 2
Arachnida	Mygalomorphae	Barychelidae	*Idiomatta*	*blackwalli*	Vert. Site 2
Arachnida	Mygalomorphae	Actinopodidae	*Missulena*	sp.	OKS 1
Arachnida	Scorpionidae	Bothriuridae	*Cercophonius*	*granulatus*	OKS 1-6
Arachnida	Scorpionidae	Urodacidae	*Urodacus*	*novaehollandiae*	Vert. Site 5
Arachnida	Pseudoscorpionidae	Chernetidae	*Nesidiochernes*	sp.	OKS 4-6
Arachnida	Pseudoscorpionidae	Chthoniidae	*Austrochthonius*	sp.	OKS 2,4
Arachnida	Pseudoscorpionidae	Olpiidae	*Beierolpium*	sp.	OKS 2,4
Arachnida	Pseudoscorpionidae	Olpiidae	*Indolpium?*	sp.	OKS 2,4
Crustacea	Isopoda	Armadillidae	*Buddelundia*	*cinerascens*	OKS 1-6, FG 3-7, 10,15,20-22, 24-26, 34,36,38,39,41,46-48,52,56,58,60
Crustacea	Isopoda	Armadillidae	*Spherillo*	sp.	OKS 2
Molusca	Pulmonata	Helicidae	*Cochlicella*	*acuta*	OKS 1-6, FG 1-3,9,11,13,14,16-20,22,24 26,29,31-34,36,38-41,46,58
Molusca	Pulmonata	Helicidae	*Theba*	*pisana*	OKS 2,3,5, FG 3,16,17,19,21,22,24-26,32,34,36,39-41
Molusca	Pulmonata	Succineidae	*Succinea*	sp.	OKS 2,3, FG 1-3, 11,21,29,31-34,37,38,40,41,46,58,60
Molusca	Pulmonata	Pupillidae	*Pupoides*	*sp. c.f. beltianus*	FG 3
Chilopoda	Geophilomorpha	Mecistocephalidae	*Mecistocephalus*	*collinus*	FG 2, 9,13
Chilopoda	Scolopendramorpha	Scolopendridae	*Cormocephalus*	sp. near *westangelasensis*	Vert Site 4
Chilopoda	Scolopendramorpha	Scolopendridae	*Ethmostigmus*	*rubripes*	FG 7
Chilopoda	Scolopendramorpha	Scolopendridae	*Scolopendra*	*laeta*	OKS 1,3, FG 47,48
Chilopoda	Scolopendramorpha	Scolopendridae	*Scolopendra*	*morsitans*	OKS 3, 4, FG 3,6
Chilopoda	Scutigeromorpha	Scutigeridae	*Thereupoda*	sp.	OKS 2, FG 3

7 STUDY TEAM

The Oakajee Terrestrial Port Development Short Range Endemic Invertebrate Survey described in this document was planned, coordinated, and executed by:

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APPENDIX 1: GPS LOCATION DATA FOR TRAPPING AND FORAGING SITES

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INVERTEBRATE PITFALL TRAPS GPS LOCATION DATA

Name	Zone Number	Zone Character	Easting(mE)	Northing (mN)
OKS01	50	J	264750.6	6836251
OKS02	50	J	264696.6	6835122
OKS03	50	J	264390.7	6834922
OKS04	50	J	264878	6834052
OKS05	50	J	265708.6	6832483
OKS06	50	J	266563	6831343

* WGS 84

VERTEBRATE TRAPS GPS LOCATION DATA

Name	Zone Number	Zone Character	Easting(mE)	Northing (mN)
1	50	J	267638.8	6835906
2	50	J	264646.9	6839538
3	50	J	263520.2	6836263
4	50	J	263752.2	6836830
5	50	J	265953	6831881
6	50	J	265091.2	6832497
7	50	J	263269.6	6838150
8A	50	J	263968.1	6834789
8B	50	J	263649	6835283
9	50	J	264958.5	6832814
10	50	J	264677.1	6833424

* WGS 84

FORAGING SITES GPS LOCATION DATA

Name	Zone Number	Zone Character	Easting (mE)	Northing (MN)
FG001	50	J	264823.1	6834025
FG002	50	J	264293.6	6834966
FG003	50	J	264681.2	6835159
FG004	50	J	265718.3	6832485
FG005	50	J	266719.2	6831282
FG006	50	J	266675.1	6831282
FG007	50	J	266581.4	6831240
FG009	50	J	265834.4	6832390
FG010	50	J	265825.1	6832309
FG011	50	J	265872.9	6832420
FG012	50	J	265836.1	6832261
FG013	50	J	265666.7	6832457
FG014	50	J	265770.2	6832300
FG015	50	J	265677	6832514
FG016	50	J	265648	6832399
FG017	50	J	265461.8	6832674
FG018	50	J	265660.7	6832343
FG019	50	J	265498.7	6832701
FG020	50	J	265696.2	6832248
FG021	50	J	266107.5	6831373
FG022	50	J	265474.4	6832629
FG023	50	J	266076.1	6831313
FG024	50	J	265515.1	6832533
FG025	50	J	266044.7	6831335
FG026	50	J	265471.9	6832464
FG027	50	J	265690.5	6831513
FG028	50	J	265778.2	6831349

Name	Zone Number	Zone Character	Easting (mE)	Northing (MN)
FG029	50	J	265022.9	6833658
FG030	50	J	265954.3	6831388
FG031	50	J	264940.4	6833704
FG032	50	J	266061	6831563
FG033	50	J	264766	6835891
FG034	50	J	266080.5	6831560
FG035	50	J	264736.3	6835986
FG036	50	J	266117	6831572
FG037	50	J	264868.7	6836055
FG038	50	J	266005.6	6831472
FG039	50	J	263818.8	6836753
FG040	50	J	265977	6831460
FG041	50	J	263886	6836734
FG042	50	J	264840.2	6833781
FG043	50	J	265522.8	6837114
FG044	50	J	264765.2	6833990
FG045	50	J	265810.6	6836919
FG046	50	J	264834.4	6834074
FG047	50	J	265651.9	6837350
FG048	50	J	264895.4	6834093
FG050	50	J	264785.2	6835815
FG052	50	J	264784	6835691
FG054	50	J	264859.2	6835686
FG056	50	J	263626.3	6836705
FG058	50	J	263878.3	6836576
FG060	50	J	263665.2	6836547
FG062	50	J	265341.2	6837073