PHOENIX
ENVIRONMENTAL SCIENCES

Short-range endemic invertebrate baseline survey of Anketell Point Rail Alignment and Port Projects

Prepared for Australian Premium Iron Management Pty Ltd

FINAL REPORT - Version 2

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Short-range Endemic Invertebrate Baseline Survey of Anketell Point Rail Alignment and Port Projects

Final Report – Version 2

Prepared for Australian Premium Iron Management Pty Ltd by Phoenix Environmental Sciences Pty Ltd

Authors: Jarrad Clark, Conor O'Neill

Reviewer: Melanie White

Date: 7th July 2010

Submitted to: Michelle Carey

Phoenix Environmental Sciences Pty Ltd

1/511 Wanneroo Road

BALCATTA WA 6021

P: 08 9345 1608

F: 08 6313 0680

E: admin@phoenixenv.com.au

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Table of Contents

List of Tables

List of Figures

EXECUTIVE SUMMARY

Phoenix Environmental Sciences Pty Ltd was commissioned by Australian Premium Iron Management Pty Ltd (API), to undertake a short-range endemic (SRE) invertebrate fauna survey of the Anketell Point Rail Alignment and Port Project (the study area). This report documents the results of the survey, which was undertaken in June 2009.

These results represent the most comprehensive, targeted, systematic survey of SRE taxa immediately east of Karratha on the mainland Pilbara Coast. The collection of new species was therefore expected. Thirty one invertebrate species from groups known to contain SRE taxa were recorded during the survey and up to eight of these represent new species. A total of 17 families and 24 genera were recorded.

The survey recorded six of the seven SRE groups commonly recorded in the Pilbara. Only millipedes (Diplopoda) were not recorded, which was surprising as a rainfall event occurred during the survey that mobilized land snails and would generally be expected to do the same for millipedes.

Four of the 31 species recorded have the potential to be SRE taxa. The potential SRE taxa were recorded from 12 of 24 survey sites. The likelihood of short-range endemism for each of these species ranges from moderate to high (Table 0-1). The estimations of endemism are based on the general representative biology and the known records of other members of the respective genera.

A new terrestrial snail *Quistrachia* sp. is considered to be of most interest, with the likelihood of short-range endemism being rated as "high". Members of this genus are typically confined to rocky habitats where they can seal straight to the rock surface. Individuals are unlikely to cross sandy plains and thus genetic flow between habitats is usually limited or absent.

The other three potential SRE species (*Synsphyronus* sp., *Lychas 'near harveyi'* and *Eucyrtops* sp.) are considered to have "moderate" potential for short-range endemism. The trap-door spider, *Eucyrtops* sp., was recorded only from a single clay-loam, mesic drainage basin, which suggests it may require habitats that have a greater ability to retain moisture conditions and thus maintain a favourable microclimate. The scorpion species, *Lychas* 'near *harveyi'* was also collected from a mesic drainage basin as well as a stony plain suggesting somewhat diverse habitat preferences but this genus does include some SRE taxa. The pseudoscorpion species, *Synsphyronus* indet. (juv.) was recorded only from Dixon Island and may be confined to the island.

A modern Araneomorph spider of the Gnaphosidae superfamily, *Meedo* sp. was previously included in the list of potential SRE taxa (with "low" likelihood of SRE status), but has since been removed from consideration due to key morphological characteristics and lack of physical dispersal barriers within the study area. Communication with the Western Australian Museum has indicated that due to these factors, the specimen collected during the survey is unlikely to be considered an SRE.

The physical environment of the study area is complex compared with inland Pilbara locations. Several diverse habitat types exist within a few kilometres, including coastal dunes, mangroves and tidal flats, rock piles, stony plains and low hills. The potential SRE taxa were recorded from a variety of habitat types. Based on the results of the survey, the most important habitats identified within the study area, for SREs are:

- Isolated coastal dunes;
- Drainage basins;
- Rock piles; and
- South facing rocky hill slopes

The two drainage basin sites standout as worthy of attention; Site 17 recorded the greatest number of groups known to include SRE taxa, and Site 16 recorded two potential SRE species. Only one of the 12 sites where potential SRE species were collected was located on Dixon Island.

Impacts to the potential SRE taxa have not been considered as part of this report, at the request of the client. However, additional systematic surveying is recommended to better define the habitat extent and preferences for these species.

Table 0-1 Potential SRE taxa recorded in the SRE survey

Taxon		Likelihood of SRE	Needing additional surveys	Rationale
Trap-door spider	*Eucyrtops* sp. (juv.)	Moderate	Yes	Few records of *Eucyrtops* from the Pilbara, largely a Midwest and Southwest genus. Recorded in a clay-loam drainage basin and may be confined to similar mesic habitats.
Scorpion	*Lychas* 'near *harveyi'*	Moderate	Yes	No previous records of this species exist. The majority of *Lychas* species in the Pilbara have been shown to be widely distributed but some SRE taxa do exist.
Pseudoscorpion	*Synsphyronus* indet. (juv.)	Moderate	Yes	Many of the members of the genus *Synsphyronus* may represent short-range endemic species (Framenau and Harvey 2009). This is especially true of rock dwelling species. This species was recorded from a coastal dune on Dixon Island, which represents an unusual habitat for the genus. May be confined to the island.
Land snail	*Quistrachia* sp.	High	Yes	Species of *Quistrachia* have been determined to be SREs at Cape Preston and other localities. The genus is comprised largely of rock-specialists with poor powers of dispersal.

1 INTRODUCTION

In June 2009, Phoenix Environmental Sciences Pty Ltd (Phoenix) was commissioned by Ms Michelle Carey of Australian Premium Iron Management Pty Ltd (API) to undertake a short range endemic (SRE) invertebrate fauna survey of the Anketell Point Rail Alignment and Port Projects (the study area). This report documents the results of the survey, which was undertaken in June 2009.

1.1 BACKGROUND

API is developing the West Pilbara Iron Ore Project (WPIOP) on behalf of equal joint venture partners Aquila Resources Ltd and America Metals and Coal Industries. The Project is located within the Shire of Roebourne, approximately 1,500km north of Perth and 30km northeast of Karratha in the Pilbara Region of Western Australia. The total study area is approximately 80km^2. The current proposed infrastructure associated with the WPIOP includes port facilities at Anketell Point and a rail alignment to the port facilities (Figure 1-1).

1.2 SCOPE OF WORK AND SURVEY OBJECTIVES

The aim of the survey was to provide sufficient baseline information on the presence and/or likelihood of presence of SRE species occurring in the study area to accurately assess the likely environmental impact that the proposed development will have on SRE species and habitats.

The scope of works was as follows:

- Undertake a desktop habitat assessment and database searches for SRE species;
- Conduct an SRE survey of the study area and regional reference sites;
- Map potential SRE habitats; and
- Provide a technical report that includes:
    - Full results of the survey;
    - Incorporation of available, relevant data and information from previous fauna surveys in the area.
    - Identification and discussion of any SRE species recorded in the current survey and other previous surveys;
    - Assessment of SRE habitats;
    - Assessment of potential impacts on SRE fauna and habitats from the proposed development; and
    - Recommendations for management of potential impacts on SRE fauna and SRE habitats.

Phoenix was subsequently requested to provide only a baseline survey report. This report therefore largely omits comment on impact assessment or management recommendations.

1.3 SURVEY SIGNIFICANCE

SRE fauna are defined as arthropods that display restricted geographic distributions that may be disjunct and highly localised (nominally defined as < 10km^2 in Harvey 2002). The most appropriate analogy is that of an island, where the movement of fauna is restricted by the surrounding marine waters, thus isolating the fauna from other terrestrial island populations. This analogy has relevance to some habitats / geographic features within the study area. In particular, the rock piles and the low hills that occur within the tidal mudflats are effectively isolated. The study area also encompasses Dixon Island which was considered to have high potential to harbour SRE taxa due to its isolation from the mainland.

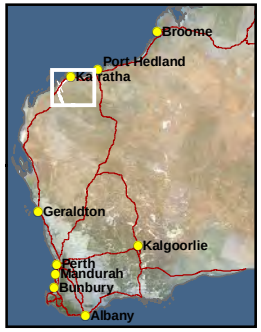
Location of the Anketell Point Rail Alignment and Port Projects

Figure 1.1

0 10 20 30

Kilometres

1:1,250,000



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1.4 EXISTING ENVIRONMENT

1.4.1 Interim Biogeographic Regionalisation of Australia (IBRA)

The study area falls within the Pilbara biogeographic region as defined by the IBRA (Thackway and Cresswell 1995). The Pilbara bioregion has four main geological components (subregions):

- the Hamersley Range, a mountainous area of Proterozoic sedimentary ranges and plateaux;
- the Fortescue Plains, consisting of alluvial plains and river frontages;
- the Chichester range comprising Archaean granite and basalt plains; and
- Roebourne, consisting of Quaternary alluvial plains

The study area falls on the northern border of the Roebourne and Chichester subregions, mainly occurring within the latter. The Chichester subregion is characterised by undulating Archaean granite and basalt plains including significant areas of basaltic ranges; the plains supporting a shrub steppe characterised by *Acacia pyrifolia* over *Triodia pungens* hummock grasslands; and *Eucalyptus leucophloeia* tree steppes occur on ranges. The Roebourne subregion is characterised by Quaternary alluvial and older colluvial coastal and sub-coastal plains with a grass savannah of mixed bunch and hummock grasses, and dwarf shrub steppe of *Acacia translucens* or *A. pyrifolia* and *A. inequilatera*. Uplands of the Roebourne subregion are dominated by *Triodia* (spinifex) hummock grasslands; ephemeral drainage lines support *Eucalyptus* woodlands; alluvial flats and river deltas contain samphire, *Sporobolus* and mangal; linear basalt ranges occur on the coastal plains; and islands comprise Quaternary sand accumulations, basalt and/or limestone (DEWHA 2009).

1.4.2 Land Systems

The Department of Agriculture and Food WA (Van Vreeswyk et al 2004) has mapped the Land Systems of the region from aerial photography, providing the largest-scale interpretation of vegetation units for the study area. Six Land Systems occur within the study area. SRE sites were installed within five of the six Land Systems, and also on Dixon Island (Table 1-1). The Rocklea Land System was not sampled.

- **Boolgeeda** - stony lower slopes and plains found below hill systems, supporting hard and soft spinifex grasslands and mulga shrublands. Predominantly deposition surfaces of very gently inclined stony slopes and plains becoming almost level further downslope.
- **Cheerawarra** - Sandy coastal plains and saline clay plains supporting soft and hard spinifex grasslands and minor tussock grasslands. Twelve sites (50%) were installed within this System.
- **Horseflats** - extensive, gilgaied clay plains supporting tussock grasslands and minor grassy snakewood shrublands. Depositional surfaces consisting of gilgaied and non – gilgaied clay plains, stony plains, narrow linear drainage depressions and dissected slopes marginal to the River Land Systems.
- **Littoral -** Bare coastal mudflats with mangroves on seaward fringes, samphire flats, sandy islands, coastal dunes and beaches.
- **Rocklea** - Basalt hills, plateaux, lower slopes and minor stony plains supporting hard spinifex (and occasionally soft spinifex) grasslands. A small section occurs to the north of the study area.
- **Ruth** - hills and ridges of volcanic and other rocks supporting hard spinifex and occasionally soft spinifex grasslands. They consist of erosional surfaces of rounded hills and ridges with

restricted lower slopes and stony interfluves with moderately to widely spaced drainage patterns.

Table 1-1 The representative Land System of each SRE site.

Site	Boolgeeda (RGEBGD)	Cheerawarra (RGECHE)	Horseflats (RGEHOF)	Littoral (RGELIT)	Ruth (RGERUT)	Dixon Is.
1			*			
2					*	
3						*
4						*
5					*	
6					*	
7						*
8						*
9						*
10					*	
11						*
12					*	
13				*		
14					*	
15					*	
16					*	
17					*	
18	*					
19				*		
20					*	
21					*	
22					*	
23		*				
24		*				
TOTAL	**1**	**2**	**1**	**2**	**12**	**6**

1.4.3 Climate

The Pilbara region has a semi-desert to tropical climate with highly variable, mostly summer rainfall. The average rainfall over the broader Pilbara area ranges from about 200mm to 350mm, although rainfall may vary widely from the average from year to year (DEWHA 2009). The Roebourne and coastal Chichester subregions experience significant cyclonic activity, with several systems affecting the coast and hinterland annually (CALM 2003).

Average annual rainfall at Cossack (the nearest Bureau of Meteorology weather station) is 25.9 mm. The bulk of rainfall in the region occurs from January to March and is significantly influenced by cyclonic activity. Average summer (December to March) maximum temperatures are 36.4°C and average winter maxima are 25.5°C.

1.4.4 Biological context

A number biological surveys have previously been conducted, both within and adjacent to the study area, which are relevant to SRE and their habitat.

Flora and vegetation

In 2009, AECOM (2010a and b) conducted flora and vegetation assessments on behalf of API for the proposed Anketell Point Rail Alignment and Port Projects.

A flora and vegetation survey was conducted (Mattiske Consulting 2007) on behalf of Cape Lambert Iron Ore Ltd for the Cape Lambert Iron Ore Project. This survey overlaps some of the current study area, particularly Dixon Island. This survey recorded 228 plant taxa (including subspecies and varieties) from 121 genera and 48 families. Six of the recorded species were introduced.

Invertebrates

In May 2007, Biota Environmental Sciences conducted an SRE survey, on behalf of Cape Lambert Iron Ore Ltd (Biota 2007). This survey had several sites located within the current study area. Twelve taxa belonging to groups known to support SREs were recorded. Of these, two undescribed species of mygalomorph spiders were collected that may potentially represent SRE taxa. An *Aganippe* sp. (Idiopidae) was collected from Dixon Island and *Aname* sp. MGY001. (Nemesiidae) was collected from Cape Lambert. *Aname* sp. MYG001 is the most common Pilbara *Aname* species within the WA Museum collection.

In April 2009 Biota Environmental Sciences undertook a targeted vertebrate fauna and SRE survey for API for an earlier rail line option to the east of that which is currently proposed. The results are in preparation.

In September – October 2008, Phoenix undertook an SRE survey of the Cape Preston Iron Ore Project, which is comparable in relative size and characteristics to the current study area, including the presence of an 'island', being Cape Preston itself which is cut off from the mainland by the tidal Mangrove Creek. The survey recorded several potential SRE taxa (Phoenix 2009a) and, a number of the species recorded in this survey.

1.4.5 Land use

The proposed port site is uninhabited and zoned Strategic Industrial in the Shire of Roebourne Town Planning Scheme. Excluding Dixon Island, much of the terrestrial component of the proposal falls on Mt Welcome Pastoral Station, with the balance (a section of the railway) traversing unallocated Crown Land.

Historical land use in the study area comprises pastoral grazing, limited tourism and recreation and mining activities just outside the study area. Further mining is likely to take place in the future within the centre of the study area, where exploration activities have recently ceased. Pastoral activities are likely to continue well into the future. With significant economic growth predicted for the region, recreational use is also likely to grow.

1.5 ENVIRONMENTAL PROTECTION AUTHORITY GUIDANCE

In May 2009, the Environmental Protection Authority (EPA) released Guidance Statement No. 20: *Sampling of Short Range Endemic Invertebrate Fauna for Environmental Impact Assessment in Western Australia* (EPA 2009). The Guidance Statement outlines preferred methods for undertaking SRE surveys in Western Australia, however it was not prescriptive in its scope and thus the survey design was based on Phoenix's experience with undertaking baseline surveys for EIA. That being said, where practicable the survey design, methodology and report-writing aspects adhere to Guidance Statement 20 and other relevant principles and guidelines, including:

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

2 METHODS

2.1 HABITAT ASSESSMENT AND SITE SELECTION

A desktop review of aerial photography and other available GIS data identified 24 suitable sampling sites (Figure 2-1) which were not included in Biota's (2008) survey of API's proposed rail line. At the broadest scale, site selection considered aspect, topography and land systems, while at the finer scale, consideration was given to vegetation and soil type, individual trap aspect (e.g. trap placement and foraging on the southern side of trees, shrubs and boulders) and proximity to water bodies and drainage lines or soaks. Final site selection was determined at the commencement of the initial field survey, following site verification. The review identified the following fauna habitats as having the potential to harbour short-range endemic taxa:

- Dixon Island and isolated coastal dunes;
- Rock piles and breakaways;
- Hill tops; and
- Rocky hill slopes (south facing).

2.2 TARGET TAXA

The survey targeted all taxonomic groups known to include SRE species in the Pilbara region:

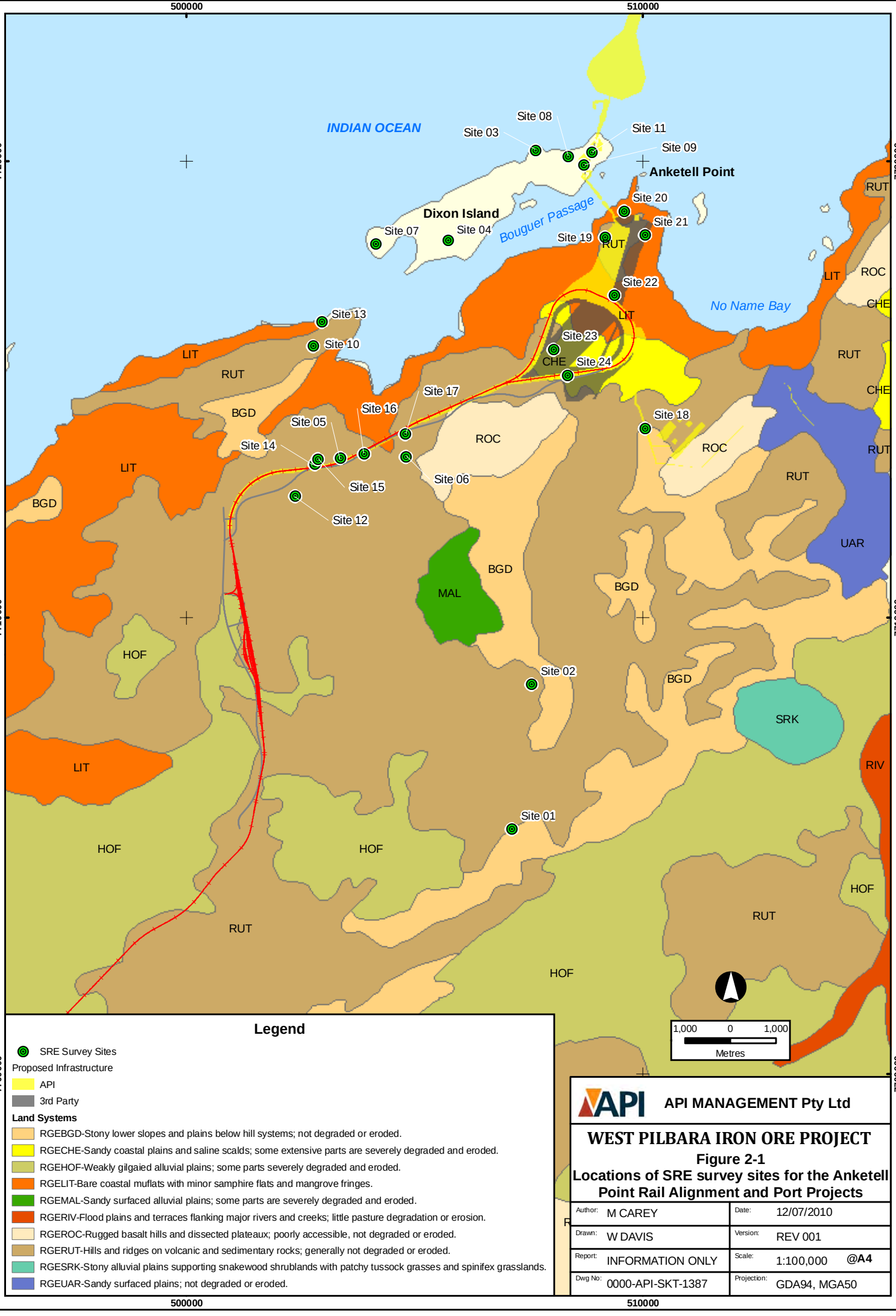
- Mollusca (land snails)
- Mygalomorphae (trap door spiders)
- Pseudoscorpiones (pseudoscorpions)
- Scorpiones (scorpions)
- Diplopoda (millipedes)
- Centipedes (chilopoda)
- Isopoda (slaters)

2.3 SAMPLING METHODOLOGY

The field survey consisted of three proven, industry-recognised, cost-effective and representative sampling techniques which target SRE invertebrate taxa;

- Wet pitfall trapping;
- Active searches (foraging); and
- The collection of leaf litter samples.

The wet pitfall trapping was conducted at 24 sites. Each 'site' comprised 10 wet pitfall traps placed within suitable microhabitats within a 50m x 50m area (approximately). The traps were made from one litre plastic containers with a 90 mm diameter that were partly-filled with a solution of ethylene glycol and formaldehyde (2.5% by volume). Polypropylene was not available in the weeks leading up to mobilisation and ethylene glycol was therefore used instead. All traps were fitted with a lid suspended ~2.5cm above the ground, to limit evaporation and discourage the entry of larger vertebrate species. All traps were left open for a period of 40 days. A trapping period of 30 days was originally planned but due to the fall of weekends and other commitments, the actual trapping period was extended.



API MANAGEMENT Pty Ltd

WEST PILBARA IRON ORE PROJECT

Figure 2-1
Locations of SRE survey sites for the Anketell Point Rail Alignment and Port Projects

Author:	M CAREY	Date:	12/07/2010
Drawn:	W DAVIS	Version:	REV 001
Report:	INFORMATION ONLY	Scale:	1:100,000 @A4
Dwg No:	0000-API-SKT-1387	Projection:	GDA94, MGA50

The foraging technique incorporated the systematic inspection of logs, larger plant debris, and the bark of larger trees and the underside of larger rocks (outcrops). Methodical searches were also conducted amongst the leaf litter of shade-bearing tall shrubs and trees. Rocks and rock crevices were also inspected, particularly for pseudoscorpions. A temporally and spatially standardised approach was undertaken, whereby each site was sampled for 60 - 90 minutes within a 50m x 50m area. Black-lighting for Scorpions was not undertaken due to logistical constraints.

Mygalomorphae trap door spider burrows identified during the searches were excavated if they were considered to be inhabited. Excavation involved removing soil from around the burrow to expose the burrow chamber and remove the spider.

Leaf litter and soil samples were taken from sites where there was considered to be potential for SRE occurrence. The collection of leaf litter samples was not standardised (either volumetrically or by weight) due to the high variability of the soil and leaf litter depth throughout the study area. Sample standardisation was not critical to the survey as the principle objective was to determine the presence of SRE species rather than assessing (for example) relative abundance or relative species diversity. Samples were thus taken from any prospective habitat available.

Habitat descriptions were recorded and photographs taken for each site (Appendix 1; Appendix 2). The coordinates of each site were recorded by a hand held GPS device (Appendix 3).

The need for a targeted snail survey was also slated by the DEC in pre-mobilisation discussions. However while significant rainfall was experienced during the trap installation phase, with many live snail specimens being collected, an additional targeted snail survey was undertaken in May 2010. These results are pending at the time of this report.

2.4 SAMPLE HANDLING

All specimens were transported to Perth for sorting and identification. Wet-trapped invertebrates were transferred into 100% ethanol prior to transport. Specimens collected by foraging techniques were placed in glass vials containing 100% ethanol and labelled accordingly.

Live snails were the only specimen not placed in ethanol, but were instead placed in a glass vial with some soil, vegetation and a few drops of water to maintain humidity for transport back to Perth.

All leaf litter samples were contained and transported in zip lock bags and were sieved (18mm, 8mm and 5mm stack) and sorted on return to Perth, using a stereo dissecting microscope. Tullgren funnel extraction was then used on the coarse-sieved leaf litter component.

2.5 TAXONOMY AND NOMENCLATURE

Taxonomy was conducted in-house as far as possible, in most instances to genus or morpho-species level. Where specific identifications could not be determined in-house, taxonomic services were sought by the following relevant experts:

- Dr Mark Harvey, WA Museum (pseudoscorpions);
- Dr Erich Volschenk (WA Museum (scorpions)
- Ms Shirley Slack-Smith, WA Museum (terrestrial molluscs);
- Dr Volker Framenau, WA Museum (mygalomorphs); and
- Dr Simon Judd (isopods).

2.6 SURVEY TIMING AND EFFORT

The wet pitfall trap installation was conducted from 16th to the 19th of June 2009. The traps were left open for a period of 40 days and then collected between the 29th of July and 1st of August. A total sample size of 9,600 trap nights was attained (Table 2-1). Foraging was undertaken at all sites for 60 - 90 minutes (30 - 45 mins. x 2 people). This equated to minimum 24 hours of hand searching, and a total search area of 12.5 hectares.

Live land snails were collected from 17th to the 19th of June 2009 following rainfall just prior to and during the SRE survey (29mm on the 12th of June and 6mm on the 18th of June) as these conditions were favourable for live collection.

Table 2-1 Sampling effort for the SRE Anketell Point Rail Alignment and Port Project Survey.

Techniques	No. sites	No. traps[a] / Area (m^2)[b]	No. nights[c] / Time (mins)[d]	Total sample size (n)
Wet pitfall trapping	24	10	40	9,600
Foraging	50	50m x 50m	2400 mins	3,750 mins 125,000m^2
Leaf litter samples	15	n/a	n/a	15

2.7 STATISTICAL ANALYSES

Invertebrate species richness accumulation curves (Figure 3-1) were generated to provide a quantitative, empirical measure of the completeness of the survey in terms of the recorded assemblage. In short species accumulation curves gauge whether the sampling effort of the survey has been sufficient. When each successive sample site adds little to no additional species to the total species richness of the survey, we can be confident that the majority of the assemblage has been sampled and thus, that the sample size is sufficient.

The accumulation curves are generated using a presence/absence data set. The data set is randomly permuted 999 times, with the data successively added to the analysis. Given that snails accounted for only seven additional species, their exclusion did not dramatically change the shape of the curves. Four indices were calculated, The SOBS, Jackknife 1, Jackknife2 and Bootstrap, in order to provide a level of confidence in the data. All recorded SRE group specimens, beetles, modern spiders, stick insects and praying mantis (to morpho-species) were included in the analysis. Other insect and arthropod groups were not included.

Hierarchical Cluster Analyses aim to determine the degree of taxonomic relatedness of each site, habitat, or other factor as defined. Thus hierarchical cluster analyses has particular relevance to SRE surveys where the aim is to identify species and habitats that are in need of species attention or protection, in the absence of complete knowledge. For example, where a single potential SRE specimen is collected (e.g. a new species of trap-door spider). In such cases a hierarchical cluster analyses can be used to help identify other sites / habitats in the project that may be expected to harbour that individual species based on the larger assemblage and thus, direct additional survey efforts.

In this case the Hierarchical Cluster Analyses was performed on a Resemblance Matrix (Bray-Curtis similarity) derived from the original presence / absence data set. No data transformation was necessary. The “group average” cluster mode was selected. All recorded SRE group specimens,

beetles, modern spiders, stick insects and praying mantis were included in the analysis. Other insect and arthropod groups were not included.

2.8 SURVEY PERSONNEL

Personnel involved in the SRE survey of the Anketell Point Rail Alignment and Port Project are listed in Table 2-2.

Table 2-2 Personnel involved in the SRE Anketell Point Rail Alignment and Port Project Survey.

Person	Title	Qualifications
Mr. Jarrad Clark	Senior Invertebrate Zoologist, Project Manager	BSc. Env. Mgt.
Mr Jarrad Donald	Level 2 Biologist	Bsc. Env. Mgt.
Ms Andrea Bending	Biologist	Pg. Dip Env. Mgt. and BSc. Mari. Sc.

All specimen photographs were taken in the laboratory by Mr. Simon Pynt (http://www.simonpynt.com/) using a Cannon 10d with an 100mm Macro lens and, using a light box for smaller specimens, such as the pseudoscorpions. Post photo production was done using Adobe Light Room software (Appendix 2).

3 RESULTS

These results represent the most comprehensive systematic survey for SRE taxa east of Karratha on the Pilbara Coast. The collection of new species was therefore expected.

Coastal dunes and rock piles and isolated hilltops were the most sampled habitat types (Table 3-1). A lesser number of south facing hill slopes, coastal ridges and minor creeklines were also sampled. A single stony plain site was also sampled. Seven sites were located on Dixon Island.

Table 3-1 Habitat-Site matrix.

Site	Habitat Type Rocky Slopes	Break-away	Hilltop	Rock Pile	Coastal Dunes, Basins and Sandy Ridges	Creek Line	Basin at foot of Slope	Stony Plain
1	√*							
2		√						
3					√*			
4			√*					
5				√				
6				√				
7					√*			
8					√*			
9					√*			
10	√							
11		√*						
12			√					
13					√			
14	√							
15						√		
16							√	
17							√	
18						√		
19				√				
20					√			
21			√					
22			√					
23			√					
24								√

* Denotes a site on Dixon Island

The survey recorded six of the seven SRE groups commonly recorded in the Pilbara. Only millipedes (Diplopoda) were not recorded, which was surprising given the rainfall that triggered large-scale mobilisation of land snails across the study area. Results of the taxonomic identifications indicate that a total of seventeen families and 24 genera are present.

A total of 31 species from groups known to include SRE taxa have been identified (Table 3-2). Of these species, there are four species which have been accorded 'potential SRE' status in the absence of further local and regional distributional data.

These comprise:

- *Eucyrtops sp.* (juv.)
- *Lychas* 'near *harveyi'*
- *Synsphyronus* indet. (juv.)
- *Quistrachia* sp.

Further the isopod species *Trichorhina?* sp. (Platyarthridae) was considered by the taxonomist (Dr S. Judd) to have the potential to be an SRE species, but as it was recorded from multiple habitat types, it appears to be a habitat generalist and has been treated as such below.

While SRE Site 17 recorded greatest number of groups known to include SRE taxa, SRE Site 16, a basin at the foot of a slope, contained the most potential SRE species (3) collected from a single site (Table 3-3).

A generated species accumulation curve suggests that the 24 pitfall trap sites installed captured the majority of the invertebrate assemblage (Figure 3-1) and thus indicates that the completeness of the survey was adequate. Further sampling would have recorded only a few additional species.

The difference in invertebrate community structure between each site (and habitat site) was analysed using a Hierarchical Cluster analysis (Figure 3-2) derived from a Bray-Curtis similarity matrix (Appendix 4). The analysis displayed no obvious trends with regard to the invertebrate assemblage of each site or with regard to habitat type. The result therefore indicates that the non-SRE invertebrate community is largely homogenous between the sites/habitat types – the analysis being largely driven by the contribution of the modern spiders and beetles.

The one exception was that of the coastal dune habitat. This habitat type showed 'minor' clustering and therefore a degree of similarity in the invertebrate assemblage. Five of the six coastal dune sites were split off within the first nine divisions of the dendogram. Further, three of the coastal dune sites most commonly recorded potential SRE species (Table 3-3).

Table 3-2 The invertebrate species from groups known to include SRE taxa recorded during the survey.

Family	Genus	Species	Site[a]																										Total # Sites	% Presence
			1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	AP 92	FG 01		
Arachnida - Araneomorphae																														
Gallieniellidae	*Meedo*	sp.																					1						**1**	**4**
Arachnida - Mygalomorphae																														
Idiopidae	*Aganippe*	MYG084							1*																				**1**	**4**
	Eucyrtops	sp. (juv.)(SRE)																1											**1**	**4**
Nemesiidae	*Aname*	?MYG001		1					1									1	1	1		1		1	1	1	1		**2**	**8**
Arachhida - Scorpiones																														
Buthidae	*Lychas*	*'adonis'*															1												**1**	**4**
		'near *harveyi*'(SRE)																1								1			**2**	**8**
		'hairy tail group'																		1									**1**	**4**
Arachnida - Pseudoscorpiones																														
Garypidae	*Synsphyronus*	indet. (juv.) (SRE)			1																								**1**	**4**
Chernetidae	*Cordylochernes*	*dingo*								1																			**1**	**4**
Chthoniidae	*Tyrannochthonius*	sp.						1																					**1**	**4**
Olpiidae	*Beierolpium*	sp. 8/2				1		1						1								1							**4**	**16**
		sp.																				1							**1**	**4**
	indet. (juv.)								1																				**1**	**4**
	Indolpium	sp.						1			1					1						1				1			**5**	**20**
Arthropods - Myriapoda: Chilopoda																														
Scutigeridae		sp.1	1	1	1	1	1	1					1				1						1						**9**	**36**
Cryptopidae		sp.1		1																1									**2**	**8**
Cryptopidae		sp.2					1																						**1**	**4**
	Cryptops	*haasei*																	1		1								**2**	**8**
Scolopendridae	*Ethmostigmus*	*curtipes*						1																					**1**	**4**
	Scolopendra	*morsitans*						1										1	1	1				1					**5**	**20**
Arthropods - Malacostraca: Isopoda																														
Armadillidae	*Buddelundia*	sp. nov.	1	1	1	1	1	1	1	1	1	1	1	1	1		1	1	1	1	1	1	1	1	1	1	1	1	**23**	**92**
		sp. 1			1	1	1	1	1	1		1	1	1		1					1	1							**12**	**48**
	Acanthodillo	sp.1													1														**1**	**4**
Platyarthridae	*Trichorhina?*	sp.									1	1						1	1	1			1						**6**	**24**
Mollusca - Stylommatophora																														

Family	Genus	Species	Site[a]																												Total # Sites	% Presence
			1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	AP 92	FG 01		
Camaenidae	*Rhagada*	*convicta*	1	1	1	1		1	1		1	1	1				1	1	1	1			1			1		1	**16**	**64**
	Quistrachia	sp. (SRE)						1				1																1	**3**	**12**
Pupillidae	*Gastrocopta*	*mussoni*							1											1									**2**	**8**
		sp.																		1									**1**	**4**
	Pupoides	*contrarius*		1		1		1	1			1											1						**6**	**24**
		lepidulus	1	1	1	1			1			1								1			1						**8**	**32**
Succineidae	*Succinea*	sp.						1																		1		1	**3**	**12**

*(SRE)*Denotes a potential short-range endemic species

[a] "1" denotes presence of species at the site; "AP92" is a vertebrate fauna trapping site; FG01 is a foraging site.

Table 3-3 Habitat-Site matrix outlining potential SRE species collected habitat sites[a].

	Habitat Type							
	Rocky slope	Break-away	Hilltop	Rock pile	Coastal dunes and sandy ridges	Creek line	Drainage basin at foot of Slope	Stony plain
1	0							
2	0	0						
3					1			
4			0					
5				0				
6				1				
7					1			
8					0			
9					1			
10	1							
11	0	0						
12			0					
13					0			
14	0							
15						0		
16							1	
17							1	
18						1		
19				0				
20					0			
21			1					
22			0					
23			0					
24								1
Total	**1**	**0**	**1**	**1**	**3**	**1**	**2**	**1**

[a] "1" denotes the presence of potential SRE species at the site; "0" denotes the absence of any SRE taxa at the site

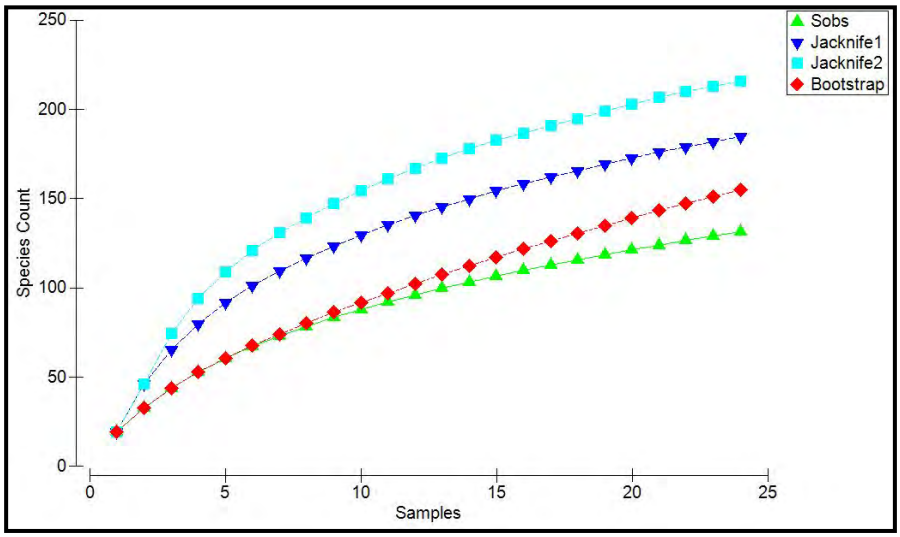


Figure 3-1 Species accumulation curves Anketell Point Rail Alignment and Port Projects SRE survey.

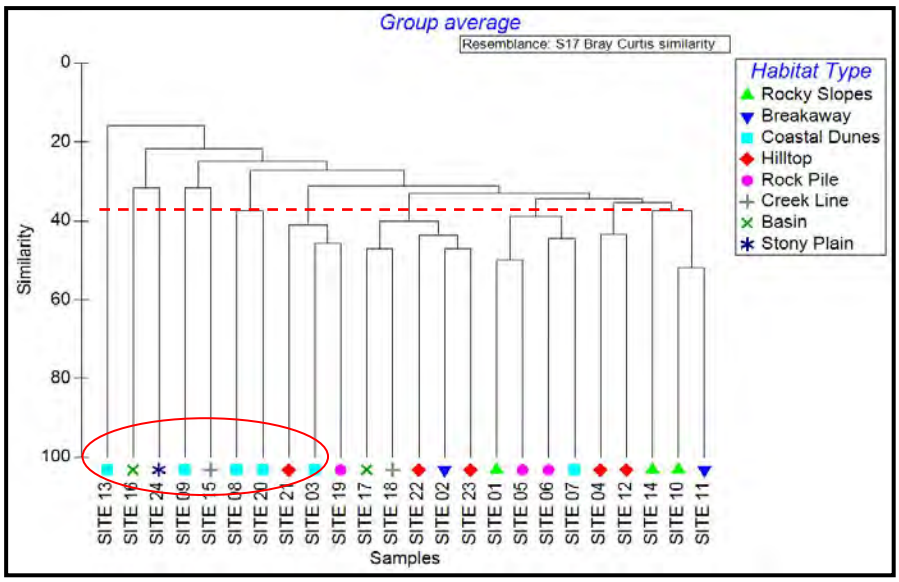


Figure 3-2 Invertebrate community Hierarchical Cluster analysis based on habitat type groupings.

3.1 ARANEOMORPHAE

The Gnaphosoidea super group of spiders are among the most abundant and important predators in both forest and drier habitats throughout Australia (plus New Caledonia and New Zealand). Five families are known to occur in Australasia (the Lamponidae, Gallieniellidae, Trochanteriidae, Prodidomidae, and Gnaphosidae). They are considered to be almost completely endemic to Australasia and some species are known to have very restricted ranges (AMNH 1997).

All modern spider data was included in the species accumulation curve and Hierarchical Cluster analyses (Figure 3-1; Figure 3-2), a total of 67 morpho-species of modern spider (Araneaomorphae) were identified (Appendix 5).

Species 01, 02 and 03 were the most widespread and commonly recorded species, being present at 20 (83.3%), 14 58.3%), 19 (79.2%) sites, respectively.

Sites 04, 07, 12 and 17 were the most diverse in terms of the modern spiders, recording 20, 14, 14 and 14 spider species, respectively.

Due to the time and budget constraints, no further analyses of this large data set data was possible, however within the group's data, an analysis of the morpho-species results from the modern spider group focused on the families which are recently known to potentially contain SRE species.

As such, the Gallieniellidae family of the Araneaomorphae modern spiders was examined in more depth as their taxonomic treatment was too late to be included in Harvey's (2002) list of groups known to include SREs.

3.1.1 Gallieniellidae

***Meedo* sp.**

Gallieniellidae are a small family of small ground spiders (related to the White-tailed spiders, Lamponidae) that were first recognised in Australia by Platnick (Platnick 2002); no further revisions have been conducted since then. The main body of evidence suggests that some species of this family may be SREs within the known distribution of some taxa for which a reasonable quantity of data exists (R. Raven pers. comm). In the family (Platnick 2002) some surveys have been conducted in Western Australia and a number of species displayed the requisite limited range (less than 100 km x 100 km area) for admission as an SRE. The family includes a number of Australian genera, one of which is the genus *Meedo* reported here.

There are two *Meedo* species recorded from coastal and inland Pilbara areas. The first, *Meedo* n. sp., was recorded in 2008 at Cape Preston (Phoenix 2009a). Unfortunately the specimen recorded at Anketell Point is a female and is missing the abdomen, making a definitive identification impossible, the condition of the specimen was such that a comparison with the Cape Preston specimen (which was also a female) would not be informative (V. Framenau pers. comm).

The second species is *Meedo houstoni* Main, 1987, which was recorded from coastal areas in northwest Western Australia as well as several inland localities a little further south (Platnick 2002). A female of *Meedo houstoni* was reported from Mundabullagana Station (20°31'S, 118°04'E), located north-east of Karratha, and a male was reported from Barrow Island.

In the current survey, *Meedo* sp. was recorded from a single location, Site 22 (hilltop 'island', surrounded by tidal flats). The site is located within the Ruth Land System. Some species of this genus are thought to show a limited range, however this may be an artefact of the limited number of collections or poor lodgement of specimens for formal taxonomic identification, rather than true short-range endemism being present within the genus. As this species belongs to a modern group of spiders with generally good dispersal capabilities (i.e. ballooning), at is most likely this species has a

more extended range pattern than those with either morphological or physical dispersal barriers. ***Meedo* sp. is therefore not considered to be an SRE species**.

3.2 MYGALOMORPHAE

3.2.1 Idiopidae

In Australia this family currently consists of eight genera and 66 species commonly known as 'Typical Trapdoor' spiders or twig-lining trap-doors. The name 'trapdoor' spider has caused some confusion as many species do not build lids or doors to their burrow entrance. Their burrows can be lidded, or non-lidded, inclined or vertical, some are curved and some branch out into multiple burrows. Burrows can be up to a metre deep and the majority end in a retreat chamber to avoid predation and maintain moisture within the burrow.

Most Idiopidae are generally considered medium to large spiders and their body is often compared to that of a tarantula (Brunet 2008). Like the Barychelids, females are sedentary and remain in a single burrow throughout life, foraging within the general locality of their burrow. Adult males abandon their burrows to 'wander' or search for a mate.

***Aganippe* MYG084**

The *Aganippe* are an endemic Australian tribe of the family Idiopidae, formerly Ctenizidae. Morphologically, *Aganippe* are distinguished from other Idiopidae by their eyes, which are arranged in three clearly defined rows of 2, 2 and 4 eyes; and by the shape of the labium which is relatively short and broad and is indented broadly in the anterior as opposed to more elongated and straight sided labium of other Idiopidae (Main 1957). Female and immature specimens of *Aganippe* are morphologically similar and classification to species is often reliant upon mature male specimens (Main 1985b), none of which were collected during the course of the survey.

Aganippe burrows can be observed with or without twig lining, their burrow doors are like flaps and many have vertical twigs, although some can be constructed of thick soil and appear plug-like. In the study area, burrows lids observed were constructed with thin lids, with vertical twigs 'hats' and a defined twig lining. Fifteen species in the Idiopid genus *Aganippe* are described from Australia and many new species await description (Main 1985). The genus is widespread south of the Tropic of Capricorn, to the western flanks of the Great Dividing Range.

A single male of *Aganippe* MYG084 was collected from Dixon Island, SRE Site 07. This species was the most commonly collected member of the genus during the recent DEC Pilbara survey. ***Aganippe* MYG084 is not considered to be an SRE species**.

***Eucyrtops* sp. (juv).**

In Western Australia the genus *Eucyrtops* currently includes three named species mainly described from collections in the southwest of Western Australia, however members of this genus are also known from South Australia and Queensland (Main 1985). Although similar to *Aganippe* in looks, members of the *Eucyrtops* family lacks sigillae on their abdomen, the cephalothorax has more rounded margins (sometimes with a highly domed cephalic area) and the male pedipalp lacks the upper digitiform process (Main 1957).

From the collections of WAM, many undescribed species are known and these include more than 30 species, almost all of which show the distribution pattern of short-range endemism. Nonetheless, seven or eight species have been recorded from the Carnarvon Basin in Western Australia, from very diverse habitats, and appear to be abundant.

A single immature specimen of *Eucyrtops* sp. was collected from Site 16, a coastal drainage basin (Table 3-4). Species identification was not possible and further survey work is required for the collection of a mature male specimen. ***Eucyrtops* sp. is considered to potentially be an SRE**

species. It may be locally restricted to the drainage basin habitats which receive and hold run-off leading to the formation of the clay loam soils present at the site.

3.2.2 Nemesiidae

Nemesiidae are burrowing trapdoor spiders, commonly called Wishbone spiders. The family reaches its highest diversity in Australia with different genera occurring in different habitats. Species of genera found in rainforests in eastern Australia tend to have highly localised distributions being restricted to one or two adjacent mountain tops. Species belonging to genera that dominate in drier forest to desert habitats (e.g. *Aname*) have generally wider distributions, but depending on the biogeographical history of the area, they may still have disjunct distributions.

Aname ?MYG001

According to the Descriptive Language for Taxonomy (DELTA) database, the genus *Aname* and its relatives (e.g. *Kwonkan*) have diversified strongly in Western Australia and show higher degrees of endemism than those genera in eastern Australia.

There are currently four named and numerous unnamed species from many different regions in Western Australia. Taxonomic revisions of Australian Nemesiidae have been predominantly of Queensland species where 47 new species have been described in the previous three decades (Raven 1981; 1982b; a; c; 1983; 1984a; b; 1985a; b; Raven 1994). In Western Australia, although the studies have been numerous (Main 1972; 1975; 1977; 1982b; a; 1983; 1985b; a; 1986; 1991; 1994; 2004; 2008), few have dealt with species outside the south–west land division. The result is that many species from large parts of Western Australia remain formally undescribed.

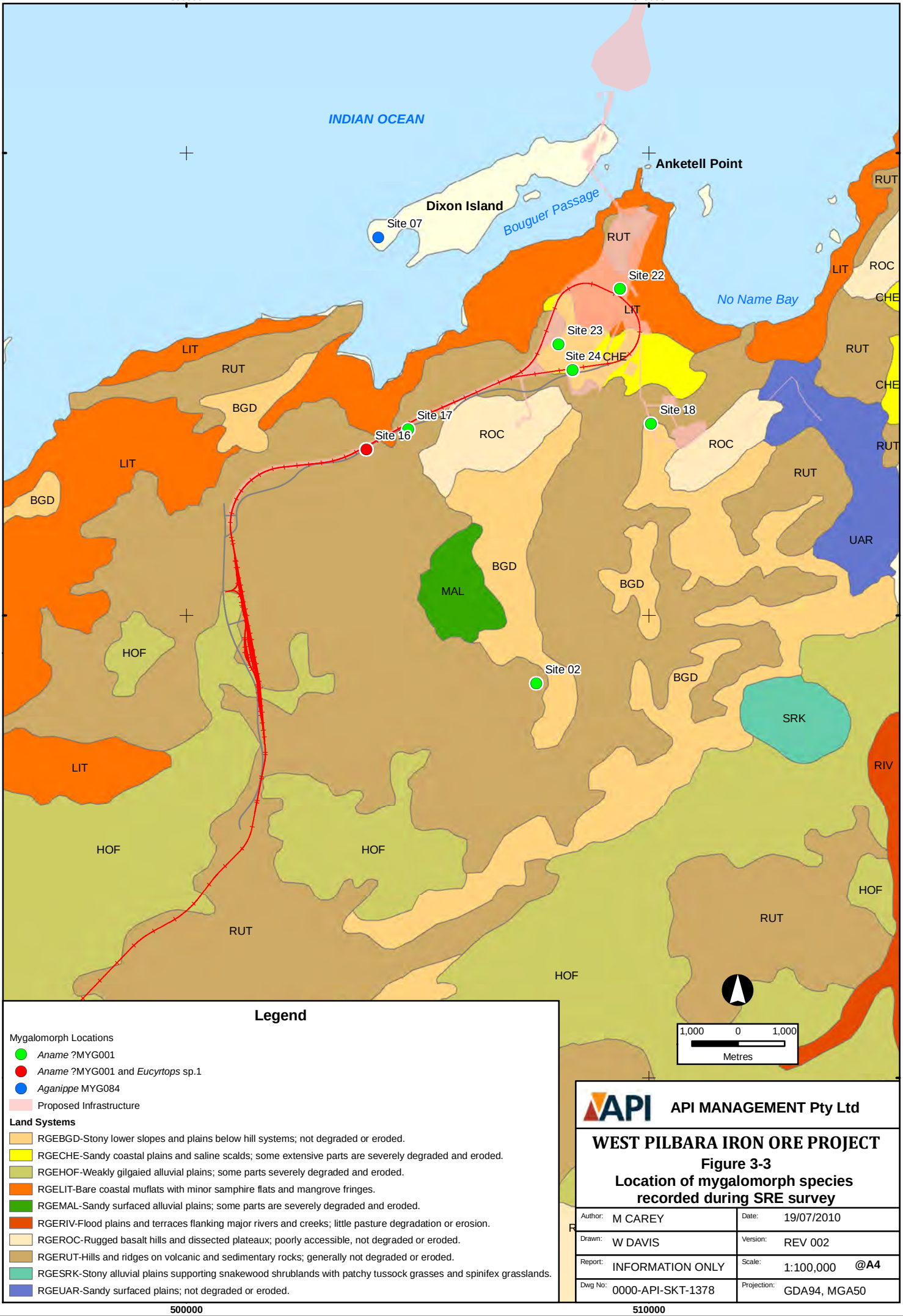
The same is true of the species found in this survey; however, *Aname* MYG001 is the most commonly recorded Pilbara *Aname* species. Specimens were recorded from ten sites and from all habitat types, except hill tops (Table 3-2, Table 3-4 and Figure 3-3). A recent taxonomic revision of this *Aname* group suggests that they may belong to at least four distinct species within the previously known single group, however, this data is unpublished and the potential geographic boundaries of these separate species is not known (Framenau, unpublished).

An *Aname* species was recorded in a previous targeted SRE survey from Dixon Island (Biota 2008). While the records from this survey were juveniles and females (making identification difficult), it is considered likely the records from the two surveys are for the same species as *Aname* MYG001 is the most commonly recorded Pilbara *Aname* species. Due to the diverse range of habitat types and the number of specimens collected, **the species is not considered to be an SRE species**.

Table 3-4 The number of Mygalomorphae records per habitat type.

FAMILY	GENUS	SPECIES	RS	BA	HT	RP	CDBSR	CL	BS	SP
Nemesiidae	*Aname* ?MYG001	?MYG001		1	2	1	1	1	4	1
Idiopidae	*Aganippe*	MYG084								1
	Eucyrtops	sp.1					1			

RS – rocky slopes, BA - breakaways, HT – hilltop, RP – rock pile, CDBSR – coastal dunes, basins and sandy ridges, CL – creek line, BS – basin at foot of slope, SP – stony plain.



Legend

Mygalomorph Locations

- *Aname* ?MYG001
- *Aname* ?MYG001 and *Eucyrtops* sp.1
- *Aganippe* MYG084
- Proposed Infrastructure

Land Systems

- RGEBGD-Stony lower slopes and plains below hill systems; not degraded or eroded.
- RGECHE-Sandy coastal plains and saline scalds; some extensive parts are severely degraded and eroded.
- RGEHOF-Weakly gilgaied alluvial plains; some parts severely degraded and eroded.
- RGELIT-Bare coastal muflats with minor samphire flats and mangrove fringes.
- RGEMAL-Sandy surfaced alluvial plains; some parts are severely degraded and eroded.
- RGERIV-Flood plains and terraces flanking major rivers and creeks; little pasture degradation or erosion.
- RGEROC-Rugged basalt hills and dissected plateaux; poorly accessible, not degraded or eroded.
- RGERUT-Hills and ridges on volcanic and sedimentary rocks; generally not degraded or eroded.
- RGESRK-Stony alluvial plains supporting snakewood shrublands with patchy tussock grasses and spinifex grasslands.
- RGEUAR-Sandy surfaced plains; not degraded or eroded.

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Figure 3-3
Location of mygalomorph species recorded during SRE survey

Author:	M CAREY	Date:	19/07/2010
Drawn:	W DAVIS	Version:	REV 002
Report:	INFORMATION ONLY	Scale:	1:100,000 @A4
Dwg No:	0000-API-SKT-1378	Projection:	GDA94, MGA50

3.3 SCORPIONES: BUTHIDAE

Only one family and representative genus were recorded (Buthidae: *Lychas*) from the Anketell Point Railway and Port Projects study area. No members of the endemic Australian family Urodacidae were recorded. Species of *Lychas* are abundant and increasingly diverse (due to recent taxonomic work) across all of mainland Australia (Koch 1977), as well as adjacent parts of south-eastern Asia. All species are generally quite small with slender pedipalps and mottled colouration.

3.3.1 Buthidae

Lychas 'adonis'

An immature male specimen was recorded 3.5km south of Cleaverville, SRE Site 15, a minor creek line site within Ruth Land System (Table 3-5, Figure 3-4). This species is common throughout Western Australia with numerous specimens lodged at the Western Australian Museum. ***Lychas 'adonis'* is not an SRE species**.

***Lychas* 'hairy-tail group'**

Two males were found 2.6km south of Cleaverville, at SRE Site 18 within creek line vegetation. This group is currently known to be restricted to the Pilbara Region of Western Australia, **but it is thought unlikely to contain any SRE species** .

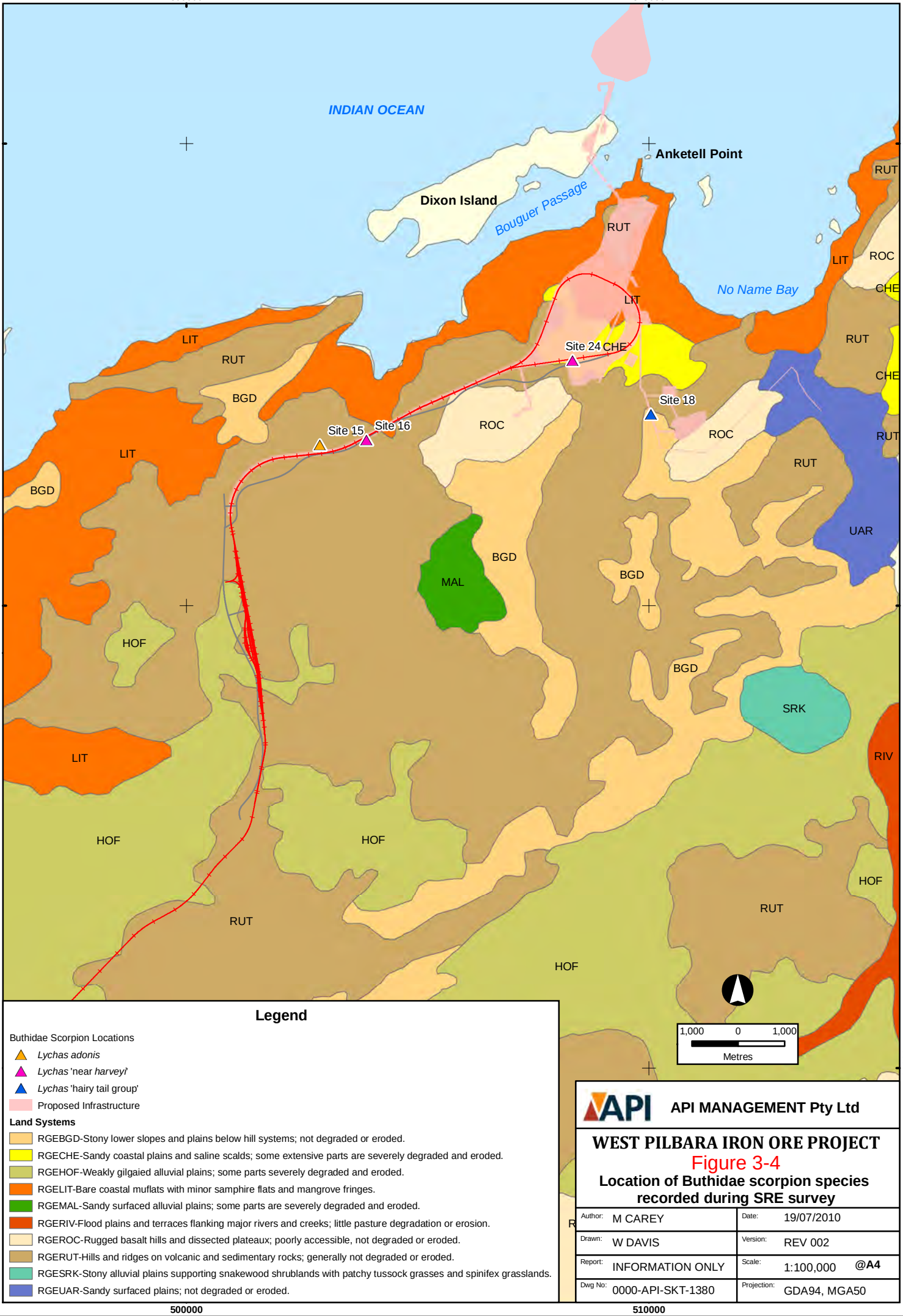
***Lychas* 'near *harveyi*'**

Four males and a juvenile specimen of *Lychas* 'near *harveyi*' were recorded from two sites within the study area, SRE Site 16, a basin at the foot of a slope 20km east-north-east of Karratha and from a stony plain near Cleaverville at SRE Site 24. Site 24 recorded the highest collections of scorpions (5) of all sites. ***Lychas* 'near *harveyi*' is not currently known from any previous collections and may represent an SRE species.** Further survey work is required to further define its extent.

Table 3-5 The number of Buthidae scorpion records per habitat type.

FAMILY	GENUS	SPECIES	RS	BA	HT	RP	CDBSR	CL	BS	SP
Buthidae	*Lychas*	*' adonis'*						1		
		'hairy tail group'						2		
		'near *harveyi*'							1	4

RS – rocky slopes, BA - breakaways, HT – hilltop, RP – rock pile, CDBSR – coastal dunes, basins and sandy ridges, CL – creek line, BS – basin at foot of slope, SP – stony plain.



Legend

Buthidae Scorpion Locations

- *Lychas adonis*
- *Lychas* 'near *harveyi*'
- *Lychas* 'hairy tail group'
- Proposed Infrastructure

Land Systems

- RGEBGD-Stony lower slopes and plains below hill systems; not degraded or eroded.
- RGECHE-Sandy coastal plains and saline scalds; some extensive parts are severely degraded and eroded.
- RGEHOF-Weakly gilgaied alluvial plains; some parts severely degraded and eroded.
- RGELIT-Bare coastal muflats with minor samphire flats and mangrove fringes.
- RGEMAL-Sandy surfaced alluvial plains; some parts are severely degraded and eroded.
- RGERIV-Flood plains and terraces flanking major rivers and creeks; little pasture degradation or erosion.
- RGEROC-Rugged basalt hills and dissected plateaux; poorly accessible, not degraded or eroded.
- RGERUT-Hills and ridges on volcanic and sedimentary rocks; generally not degraded or eroded.
- RGESRK-Stony alluvial plains supporting snakewood shrublands with patchy tussock grasses and spinifex grasslands.
- RGEUAR-Sandy surfaced plains; not degraded or eroded.

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Figure 3-4

Location of Buthidae scorpion species recorded during SRE survey

Author:	M CAREY	Date:	19/07/2010
Drawn:	W DAVIS	Version:	REV 002
Report:	INFORMATION ONLY	Scale:	1:100,000 @A4
Dwg No:	0000-API-SKT-1380	Projection:	GDA94, MGA50

3.4 PSEUDOSCORPIONES

The Western Australian pseudoscorpion fauna is fairly diverse with representatives of 17 different families. They are found in a variety of biotopes, but can be most commonly collected from the bark of trees, from the underside of rocks, or from leaf litter habitats. The pseudoscorpion fauna from Anketell Point was found to consist of species in the families Chernetidae, Chthoniidae, Garypidae and Olpiidae.

3.4.1 Chernetidae

The most diverse of the pseudoscorpion families, the Chernetidae comprise more than 110 named genera and over 650 named species worldwide. The Australian genera contain 37 described species (Harvey 2009). These pseudoscorpions are generally found under bark of trees, but are also found in leaf litter, under stones or in caves.

Cordylochernes dingo
This species was collected from a single site, SRE Site 08 which contained coastal dunes and sandy ridges. It has been described from north-western Australia and **is not an SRE species.**

3.4.2 Chthoniidae

This family is divided into two subfamilies, the Chthoniidae and the Pseudotyrannochthoniidae which contain 27 and five genera respectively. Members of this family are found in most regions of the world and occur mainly in soil, leaf litter and under rocks. This family also contains many troglobitic chthoniids found in caves in regions around the world (Framenau and Harvey 2009).

***Tyrannochthonius* sp.**
In tropical regions, *Tyrannochthonius* can be found in leaf litter and the upper layer of soil. In Western Australia, five species have been described. The male specimen was found at Site 06 in a rock pile near Cleaverville. ***Tyrannochthonius* sp. is unlikely to represent an SRE species.**

3.4.3 Garypidae

This family contains 20 genera and over 70 species. The majority of these possess strongly divided arolia on the tarsus of all legs, with only members of five of these genera lacking this feature. The Garypidae are found from areas all over the world, and usually inhabit the underneath of tree bark.

***Synsphyronus* sp. indet (juv.)**
A single juvenile specimen was collected from coastal dune habitat (SRE Site 03) at Dixon Island. According to Harvey (1987) many of the *Synsphyronus* may represent short-range endemic species, especially when they are found on ground habitats such as under rocks. The juvenile specimen cannot be identified to species level, so the collection of further specimens is required to determine this species. **It is possible that *Synsphyronus* sp. is an SRE species**, as members of this genus are not usually known from coastal dune habitats.

3.4.4 Olpiidae

Throughout the world, this family contains 33 genera and more than 250 species divided into two tribes, the Olpiini and the Hesperolpiini based on the length of the venom ducts. Olpiids are found under stones, in leaf litter and under the bark of trees (Framenau and Harvey 2009).

***Beierolpium* sp. 8/2 and *Beierolpium* sp.**
In Australasia, members of the genus *Beierolpium* are considered to be widespread (Framenau and Harvey 2009); however the systematic status of members of this genus in the Pilbara has not been fully assessed. It is not possible to firmly establish the identity of these specimens, or determine whether any are short-range endemics, until a complete systematic revision of the Western Australian members of *Beierolpium* is undertaken in the Pilbara and other bioregions. It is likely that

Beierolpium sp. is *Beierolpium* sp. 8/2. The species was the second most abundant species collected during this survey (Table 3-6; Figure 3-5), present on hilltops, in rock-piles and within coastal dune and ridge systems and is therefore a habitat generalist. It was also recorded recently near Cape Preston 80km west of Karratha (Phoenix 2009a) and Davidson Creek, 80 km east of Newman (Phoenix 2009b). ***Beierolpium* sp. 8/2 is unlikely to be an SRE species.**

***Indolpium* sp.**

A number of specimens of *Indolpium* sp. were collected, and were recorded from rock piles, rocky slopes, dunes, basins and sandy ridges on the coast, and at a drainage basin at the foot of low hills. The specimens represent a single species, known from other regions of Western Australia. **Based on the current levels of knowledge of this species, *Indolpium* sp. is considered unlikely to be an SRE species.**

***Olpiidae* sp. indet. (juv.)**

It was not possible to identify these as they were immature specimens; however it is thought they may be juveniles of the genus *Beierolpium*.

Table 3-6 The number of pseudoscorpion records per habitat type.

FAMILY	GENUS	SPECIES	RS	BA	HT	RP	CDB SR	CL	BS	SP
Garypidae	*Synsphyronus*	indet. juv.					1			
Olpiidae	*Beierolpium*	sp.8/2			5	1	1			
		sp.					1			
	Indolpium	sp. indet.	1				2			3
	Olpiidae	sp. indet. juv.					1			
Chthoniidae	*Tyrannochthonius*	sp. 1				1				
Chernetidae	*Cordylochernes*	*dingo*					2			

RS – rocky slopes, BA - breakaways, HT – hilltop, RP – rock pile, CDBSR – coastal dunes, basins and sandy ridges, CL – creek line, BS – basin at foot of slope, SP – stony plain.

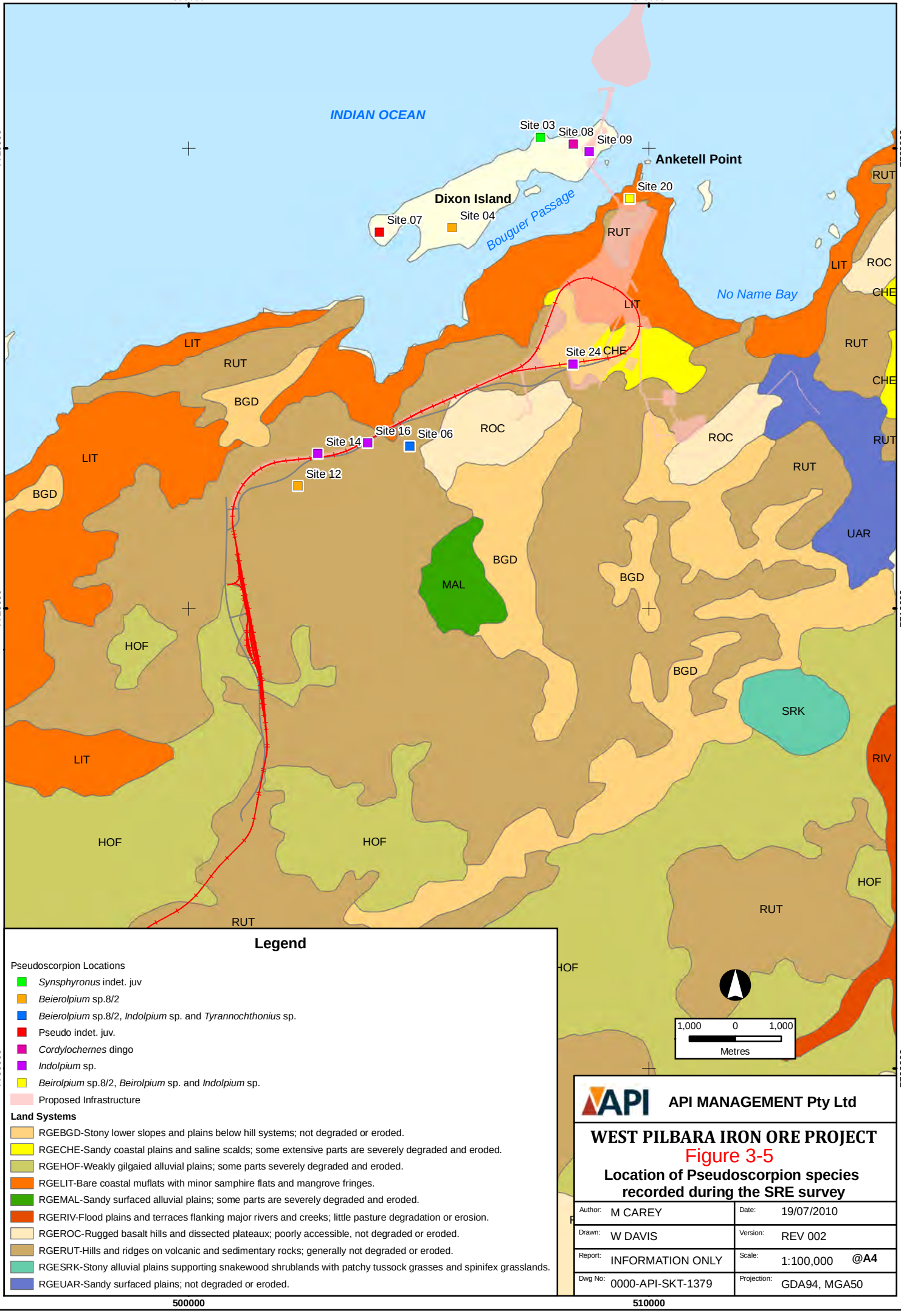

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Figure 3-5

Location of Pseudoscorpion species recorded during the SRE survey

Author:	M CAREY	Date:	19/07/2010
Drawn:	W DAVIS	Version:	REV 002
Report:	INFORMATION ONLY	Scale:	1:100,000 @A4
Dwg No:	0000-API-SKT-1379	Projection:	GDA94, MGA50

3.5 MYRIAPODA: CHILOPODA

3.5.1 Scutigeridae

A single species of Scutigeridae was recorded. The taxonomy of this family is still poorly resolved and thus many species remain undescribed. Nonetheless, it is apparent that the species is a habitat generalist, being recorded from all eight habitat types sampled (Table 3-7; Figure 3-6**). The species is therefore not considered to be an SRE species.**

3.5.2 Cryptopidae

Much like the family Scutigeridae, the Cryptopidae are poorly resolved taxonomically and many undescribed species remain.

Cryptopidae morpho-species 1 was recorded from a breakaway (SRE Site 02) and a creek line (SRE Site 18), which are two very different habitat types. **This species is therefore considered unlikely to be an SRE species**.

Cryptopidae morpho-species 2 was recorded from a single rock pile (SRE Site 05). This site is located within the Railway Corridor however the site is located greater than 50m from the centre line of the proposed rail line. It's status as an SRE is unknown because of the single record, however this record occurs outside the study area.

Cryptops haasei (Attems, 1903)
This species was recorded from SRE Site 17 and SRE Site 19 which represent drainage basin and rock pile habitats, respectively. This species is known from several locations in the Pilbara and **is not an SRE species**.

3.5.3 Scolopendridae

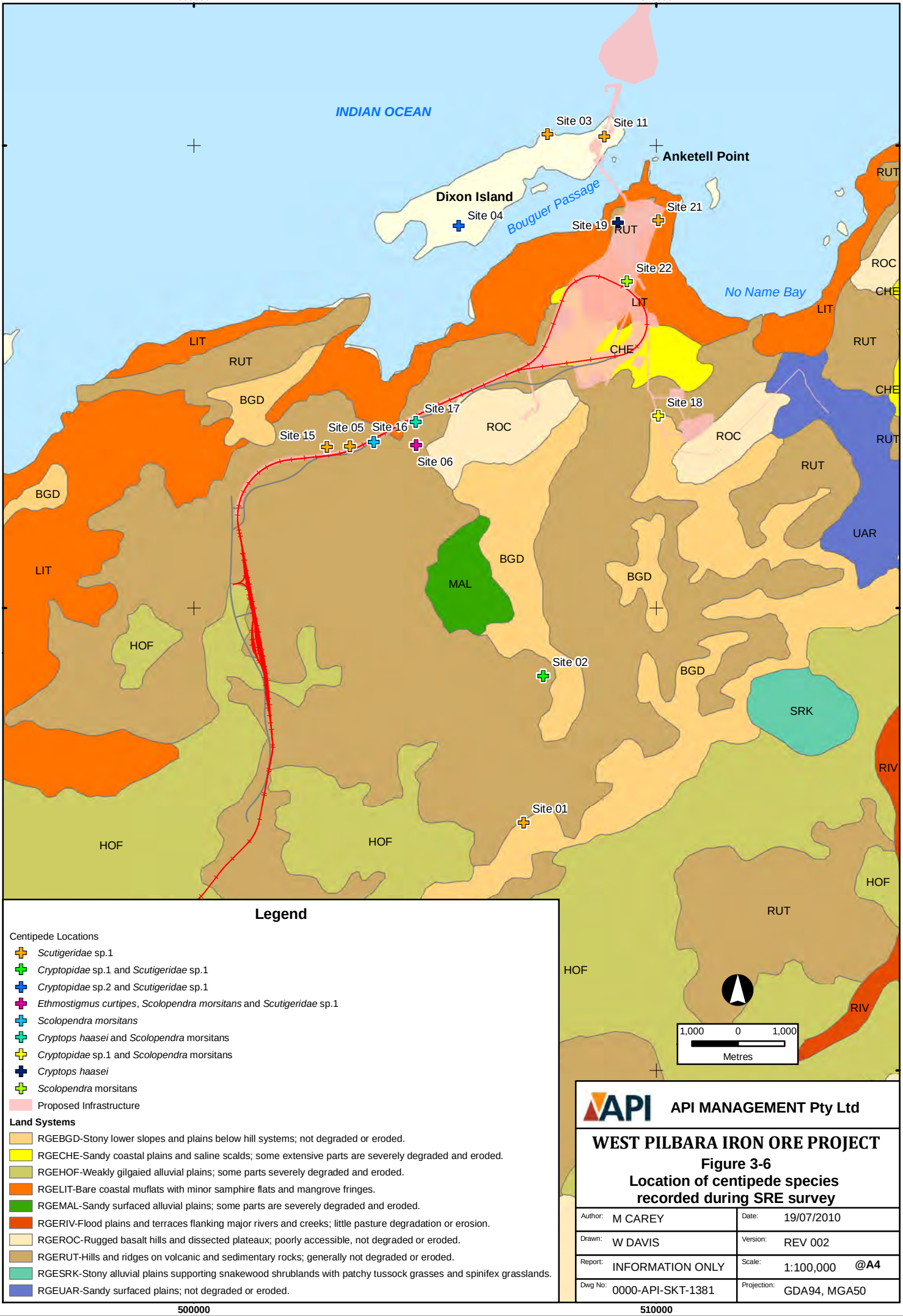
Ethmostigmus curtipes (*Koch, 1983)*
This species is found across most of Western Australia and **is therefore not an SRE species.**

Scolopendra morsitans *(Linnaeus, 1758)*
This species is widespread and common across much of northern Australia and **is therefore not an SRE species.**

Table 3-7 The number of centipede records per habitat type.

FAMILY	GENUS	SPECIES	RS	BA	HT	RP	CDBSR	CL	BS	SP
Scutigeridae		sp.1	3	2	5	3	6	2	2	1
Cryptopidae		sp.1		1				1		
Cryptopidae		sp.2				1				
	Cryptops	*haasei*								
Scolopendridae	*Ethmostigmus*	*curtipes*								
	Scolopendra	*morsitans*								

RS – rocky slopes, BA - breakaways, HT – hilltop, RP – rock pile, CDBSR – coastal dunes, basins and sandy ridges, CL – creek line, BS – basin at foot of slope, SP – stony plain.



Legend

Centipede Locations

- *Scutigeridae* sp.1
- *Cryptopidae* sp.1 and *Scutigeridae* sp.1
- *Cryptopidae* sp.2 and *Scutigeridae* sp.1
- *Ethmostigmus curtipes*, *Scolopendra morsitans* and *Scutigeridae* sp.1
- *Scolopendra morsitans*
- *Cryptops haasei* and *Scolopendra* morsitans
- *Cryptopidae* sp.1 and *Scolopendra* morsitans
- *Cryptops haasei*
- *Scolopendra* morsitans
- Proposed Infrastructure

Land Systems

- RGEBGD-Stony lower slopes and plains below hill systems; not degraded or eroded.
- RGECHE-Sandy coastal plains and saline scalds; some extensive parts are severely degraded and eroded.
- RGEHOF-Weakly gilgaied alluvial plains; some parts severely degraded and eroded.
- RGELIT-Bare coastal muflats with minor samphire flats and mangrove fringes.
- RGEMAL-Sandy surfaced alluvial plains; some parts are severely degraded and eroded.
- RGERIV-Flood plains and terraces flanking major rivers and creeks; little pasture degradation or erosion.
- RGEROC-Rugged basalt hills and dissected plateaux; poorly accessible, not degraded or eroded.
- RGERUT-Hills and ridges on volcanic and sedimentary rocks; generally not degraded or eroded.
- RGESRK-Stony alluvial plains supporting snakewood shrublands with patchy tussock grasses and spinifex grasslands.
- RGEUAR-Sandy surfaced plains; not degraded or eroded.

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Figure 3-6
Location of centipede species recorded during SRE survey

Author:	M CAREY	Date:	19/07/2010
Drawn:	W DAVIS	Version:	REV 002
Report:	INFORMATION ONLY	Scale:	1:100,000 @A4
Dwg No:	0000-API-SKT-1381	Projection:	GDA94, MGA50

3.6 MALACOSTRACA: ISOPODA: ARMADILLIDAE

3.6.1 Armadillidae

Three species of Isopod were recorded, with two species belonging to the family Armadillidae (*Buddelundia* and *Acanthodillo*) and one species belonging to the family Platyarthridae, genus *Trichorhina*.

It is clear that *Buddelundia* sp. nov and *Buddelundia* sp. 1 are habitat generalists, with multiple records from eight and five of the habitat types respectively, including hilltops, coastal dunes, creek lines basins and stony plains (Table 3-8; Figure 3-7).

***Acanthodillo* sp. 1**

While collections of this species were only made from a single habitat type within the study area, collections have been recorded from other sites in the Pilbara and further afield. It is known as a cryptic species and can often be found under logs and stones. The genus is common around all of WA and the species **is therefore not considered to be an SRE species**.

***Buddelundia* sp. nov**

Buddelundia sp. nov is a new species of the common and predominantly Western Australian genus, *Buddelundia*. This species is quite common from records in the Pilbara and it **is not considered to be an SRE species.**

***Buddelundia* sp.1**

This species appears to be widespread and is considered regionally common. ***Buddelundia* sp.1 is not an SRE species**.

3.6.2 Platyarthridae

While the family Platyarthridae is a widespread family, only one species is described from Western Australia.

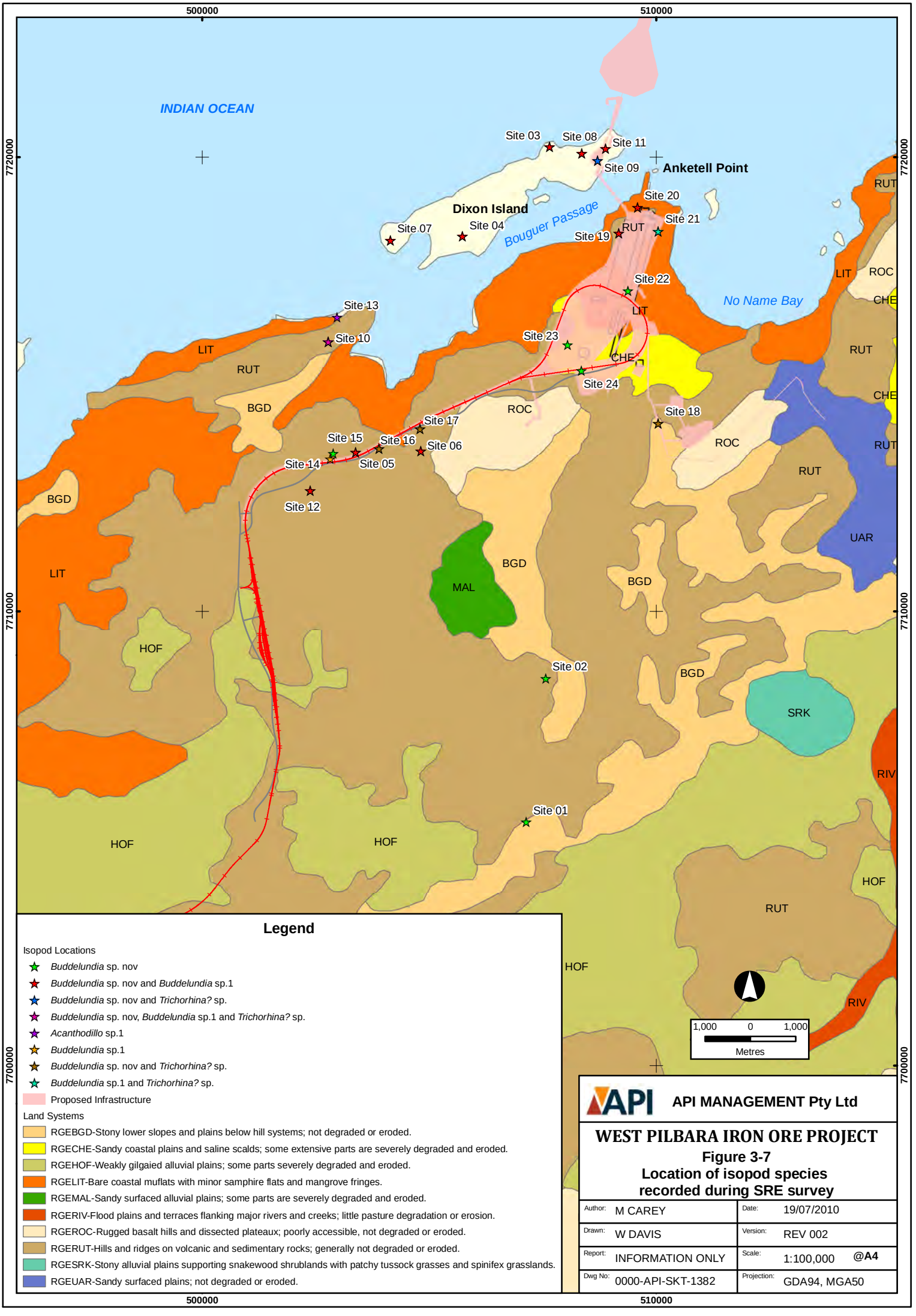
***Trichorhina?* sp.**

The male specimen lodged by Phoenix does not match the described *Trichorhina australiensis* and more taxonomic work is required for further species determination. As the species are small, cryptic, and largely subterranean, it is thought they have great potential for short-range endemism. In contrast, *Trichorhina?* sp. is a habitat generalist, recorded from a rocky slope, a hilltop, a coastal dune, a creek line and from a drainage basin at the foot of a moderate hill. ***Trichorhina?* sp. is therefore not considered to be an SRE species.**

Table 3-8 The number of isopod records per habitat type.

FAMILY	GENUS	SPECIES	RS	BA	HT	RP	CDBSR	CL	BS	SP
Armadillidae	*Buddelundia*	sp. nov	2	2	5	3	5	2	2	1
		sp.1	2	1	2	3				
	Acanthodillo	sp. 1					1			
Platyarthridae	*Trichorhina?*	sp.1	1		1		1	1	2	

RS – rocky slopes, BA - breakaways, HT – hilltop, RP – rock pile, CDBSR – coastal dunes, basins and sandy ridges, CL – creek line, BS – basin at foot of slope, SP – stony plain.



Legend

Isopod Locations

- *Buddelundia* sp. nov
- *Buddelundia* sp. nov and *Buddelundia* sp.1
- *Buddelundia* sp. nov and *Trichorhina?* sp.
- *Buddelundia* sp. nov, *Buddelundia* sp.1 and *Trichorhina?* sp.
- *Acanthodillo* sp.1
- *Buddelundia* sp.1
- *Buddelundia* sp. nov and *Trichorhina?* sp.
- *Buddelundia* sp.1 and *Trichorhina?* sp.
- Proposed Infrastructure

Land Systems

- RGEBGD-Stony lower slopes and plains below hill systems; not degraded or eroded.
- RGECHE-Sandy coastal plains and saline scalds; some extensive parts are severely degraded and eroded.
- RGEHOF-Weakly gilgaied alluvial plains; some parts severely degraded and eroded.
- RGELIT-Bare coastal muflats with minor samphire flats and mangrove fringes.
- RGEMAL-Sandy surfaced alluvial plains; some parts are severely degraded and eroded.
- RGERIV-Flood plains and terraces flanking major rivers and creeks; little pasture degradation or erosion.
- RGEROC-Rugged basalt hills and dissected plateaux; poorly accessible, not degraded or eroded.
- RGERUT-Hills and ridges on volcanic and sedimentary rocks; generally not degraded or eroded.
- RGESRK-Stony alluvial plains supporting snakewood shrublands with patchy tussock grasses and spinifex grasslands.
- RGEUAR-Sandy surfaced plains; not degraded or eroded.

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Figure 3-7
Location of isopod species recorded during SRE survey

Author:	M CAREY	Date:	19/07/2010
Drawn:	W DAVIS	Version:	REV 002
Report:	INFORMATION ONLY	Scale:	1:100,000 @A4
Dwg No:	0000-API-SKT-1382	Projection:	GDA94, MGA50

3.7 MOLLUSCA

Land snail species were collected from various habitats within the survey area (Table 3-9; Figure 3-8).

3.7.1 Camaenidae

The family Camaenidae is diverse and abundant in the north of Australia. The taxa of the coastal areas of the Pilbara have been fairly well studied in contrast to other areas such as the inland Pilbara (for example, Solem 1985; 1997). Two species representing two genera from this family were recorded in the survey. Two indeterminate Camaenid specimens were also collected. The Camaenid family includes many SRE species.

***Rhagada convicta* (Cox, 1870)**

Rhagada convicta was collected live and dead from a number of sites both on Dixon Island and from mainland site at each of the habitat types (Table 3-9; Figure 3-8). It has previously been recorded along the northern WA coastline from the Minilya River to Dampier (Solem 1997) and **is not an SRE species.** The extent of isolation between the recorded populations is currently being investigated.

***Quistrachia* sp.**

Species of *Quistrachia* have been identified from the inland Western Kimberley to the coastal region between Exmouth Gulf and Shark Bay. *Quistrachia* 'n. sp.1' and 'n.sp.2' were recently recorded from Cape Preston (~140km to the west of the study area) and specimens of the same genus have been recorded from a few other nearby localities to the west and south of the study area.

Species of the genus *Quistrachia* are generally associated with rock habitats (O'Neill 2008). *Quistrachia* sp. was recorded from three sites comprising a rocky slope, a rock pile and a grassy plain near a major drainage line. The latter specimen was most likely washed down from a more typical rocky habitat. **Based on current knowledge, the species is considered likely to be an SRE species.** Further taxonomic (and genetic) work is required on this genus (and this species) to further determine species distributional and genetic boundaries, and thus each member's status as an SRE in coastal Pilbara region near Karratha.

3.7.2 Pupillidae

Members of the Pupillid family are known to be widespread throughout the Pilbara. They are almost all minute, air breathing terrestrial gastropods.

***Pupoides contrarius* (E.A. Smith, 1894)**

This species is regarded as having a widespread distribution from the Pilbara Region to the locality of the Houtman Abrolhos. It was collected from five of the eight habitat types. **It is not an SRE species.**

***Pupoides lepidulus* (Adams & Angus, 1864)**

This taxon, originally described from collections in the Shark Bay area of Western Australia, was collected from six of the eight habitat sites from breakaways and rocky slopes, through coastal dunes, basins and sandy ridges and within creek lines. **The species is therefore not considered to be an SRE species.**

***Gastrocopta mussoni* and sp. indet (Pilsbry, 1917)**

Although this species was only collected from coastal drainage basins and creek lines within the study area, this species is known to have a wide distributional range from the coastal areas of northern Australia to Central Australia. **This species is not an SRE species.**

The *Gastrocopta* sp. was collected as a small juvenile and is thought to be *Gastrocopta mussoni*.

3.7.3 Succineidae

***Succinea* sp.**

This species was collected from both stony/rocky habitats and creek lines from within the study area. Whilst not collected from a greater number of habitat sites during the survey, members of the genera collected from the Southwestern Australia and from the Fitzroy area of the Kimberley have not displayed SRE characteristics. It is therefore considered unlikely *Succinea* sp. is an SRE species.

Table 3-9 The mollusc species records per habitat type.

FAMILY	GENUS	SPECIES	RS	BA	HT	RP	CDB SR	CL	BS	SP
Camaenidae	*Rhagada*	*convicta*	1	1	1	1	1	1	1	1
	Quistrachia	sp.	1			1		1		
Pupillidae	*Pupoides*	*lepidulus*	1	1	1	1	1	1		
		contrarius	1	1	1	1	1			
	Gastrocopta	*mussoni*					1	1		
		sp.						1		
Succineidae	*Succinea*	sp.				1		1		1

RS – rocky slopes, BA - breakaways, HT – hilltop, RP – rock pile, CDBSR – coastal dunes, basins and sandy ridges, CL – creek line, BS – basin at foot of slope, SP – stony plain.

1 – Denotes presence of species within the habitat type

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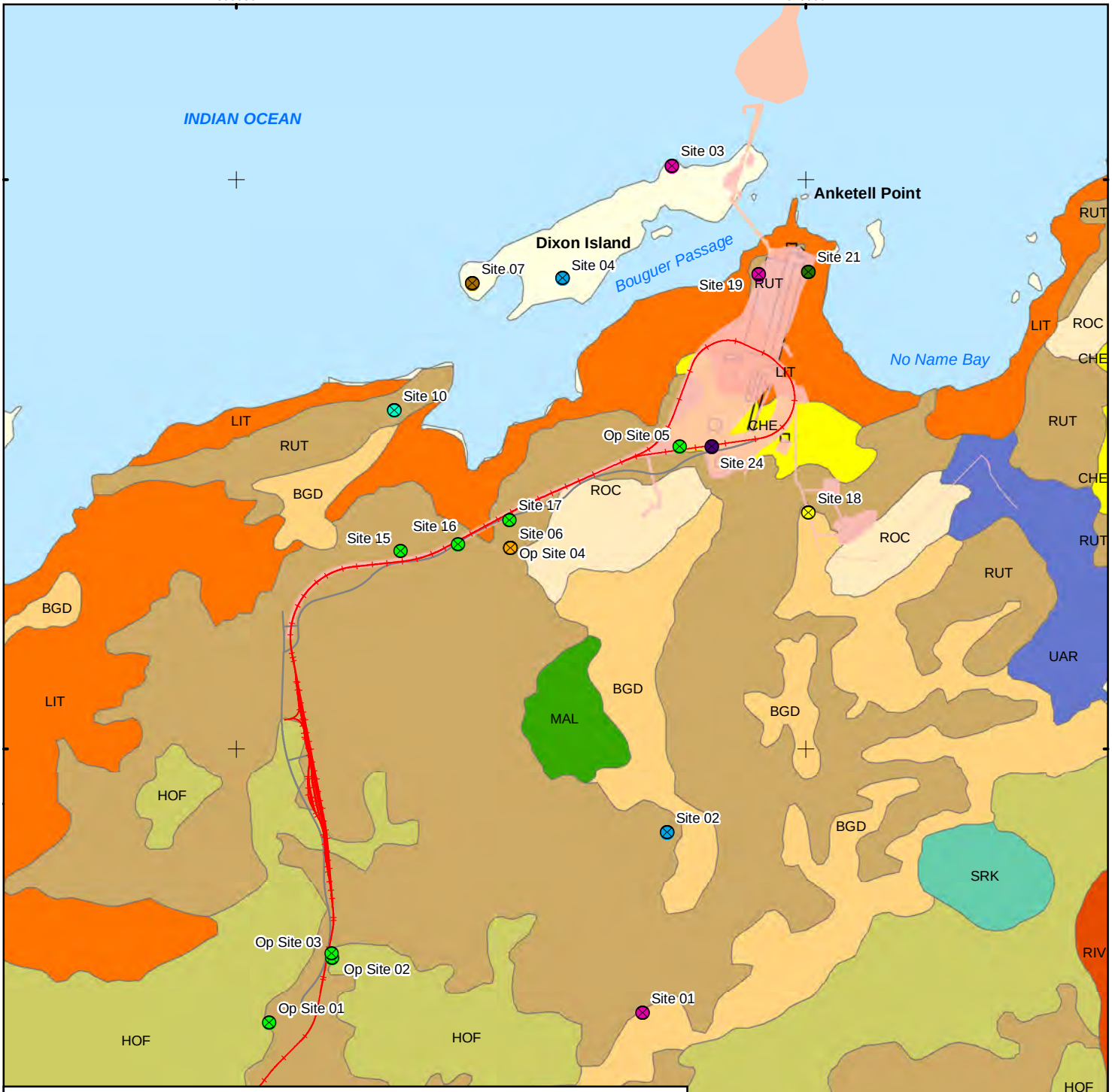

Legend

Mollusc Locations

- *Rhagada convicta*
- *Quistrachia* sp., *Rhagada convicta* and *Succinea* sp.
- *Pupoides lepidulus* and *Rhagada convicta*
- *Pupoides contrarius, Pupoides lepidulus* and *Rhagada convicta*
- *Pupoides contrarius, Quistrachia* sp., *Rhagada convicta* and *Succinea* sp.
- *Gastrocopta mussoni, Pupoides contrarius, Pupoides lepidulus* and *Rhagada convicta*
- *Pupoides contrarius, Pupoides lepidulus, Quistrachia* sp. and *Rhagada convicta*
- *Gastrocopta mussoni, Gastrocopta* sp., *Pupoides lepidulus* and *Rhagada convicta*
- *Pupoides contrarius, Pupoides lepidulus* and *Rhagada convicta*
- *Rhagada convicta* and *Succinea* sp.
- Proposed Infrastructure

Land Systems

- RGEBGD-Stony lower slopes and plains below hill systems; not degraded or eroded.
- RGECHE-Sandy coastal plains and saline scalds; some extensive parts are severely degraded and eroded.
- RGEHOF-Weakly gilgaied alluvial plains; some parts severely degraded and eroded.
- RGELIT-Bare coastal muflats with minor samphire flats and mangrove fringes.
- RGEMAL-Sandy surfaced alluvial plains; some parts are severely degraded and eroded.
- RGERIV-Flood plains and terraces flanking major rivers and creeks; little pasture degradation or erosion.
- RGEROC-Rugged basalt hills and dissected plateaux; poorly accessible, not degraded or eroded.
- RGERUT-Hills and ridges on volcanic and sedimentary rocks; generally not degraded or eroded.
- RGESRK-Stony alluvial plains supporting snakewood shrublands with patchy tussock grasses and spinifex grasslands.
- RGEUAR-Sandy surfaced plains; not degraded or eroded.

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WEST PILBARA IRON ORE PROJECT

Figure 3-3
Location of mollusc species recorded during SRE survey

Author:	M CAREY	Date:	19/07/2010
Drawn:	W DAVIS	Version:	REV 002
Report:	INFORMATION ONLY	Scale:	1:100,000 @A4
Dwg No:	0000-API-SKT-1383	Projection:	GDA94, MGA50

3.8 COLEOPTERA

A total of 40 morpho-species of terrestrial beetle were recognised (Appendix 6). While this group are not yet recognised to contain SRE taxa, all beetle data was included in the species accumulation curve and Hierarchical Cluster analyses presented (Figure 3-1and Figure 3-2) to determine species abundance and richness of the habitats chosen.

The data in Appendix 6 shows that Sites 01 (Rocky Hill Slope), 15 and 18 (Creek lines) recorded the most diverse beetle assemblages (7, 8 and 10 species, respectively). Additionally, species 04, 08 and 20 were the most widespread being recorded from 11 (45.8%), 8 (33.3%) and 10 (41.6%) sites, respectively. No sites stand out as distinct in the analyses.

3.9 LIMITATIONS

Limitations of the survey were reviewed and discussed (Table 3-10).

Table 3-10 Survey limitations.

Limitations	Relevant to this survey? Yes / no	Comments
Competency / experience of the consultant carrying out the survey.	No	The project manager has extensive experience in conducting SRE surveys throughout the Pilbara, Midwest, Southwest, Kimberley and Goldfields regions of W.A.
Scope (what faunal 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 or inability to use pitfall traps.)	No	The survey targeted all groups known to include SREs. Extensive foraging effort supplemented the trapping program, to ensure that groups such as Pseudoscorpions were represented in the survey.
Proportion of fauna identified, recorded and/or collected.	Yes	Due to the paucity of knowledge concerning SREs and invertebrates in general, it is almost impossible to know for sure that all species have been recorded. Despite this, throughout the survey and in analysis of the results species area curves may be used to determine the likelihood that species are adequately represented, but only if multiple survey data is generated. The graphs demonstrated that the collection of samples was sufficient to cover all faunal assemblages.
Sources of information e.g. previously available information (whether historic or recent) as distinct from new data.	Yes	As above, there is limited data concerning invertebrates in the region. However, recent data from Cape Preston and surrounds provides some contextual data and suggests that the majority of potential SRE taxa were recorded (Phoenix 2009a). The Pilbara Biological Survey conducted by the DEC had sites very close to the study area also. That being said, the DEC program was designed to target broad-scale habitats and not the isolated habitats typically habited by SRE taxa as in our survey. AN SRE specific survey was also

Limitations	Relevant to this survey? Yes / no	Comments
		undertaken in 2008 very close to and within the study area (Biota 2008).
Timing/weather/season/cycle.	No	In the past SRE surveys have been recommended for the May – September period in the Pilbara; however, the recent publication of EPA Guidance Statement 20 has amended that recommendation to the wet season (December – March). The survey commenced in June and concluded in July. However, good rainfall was experienced before and during the trap installation and foraging activities leading to the collection of live snail specimens. The use of the wet pitfall trapping approach and the collection of a relatively large sample size was designed to off-set the timing issue.
The proportion of the task achieved and further work which might be needed.	No	The program was implemented as planned. A total of 24 pitfall sites were established and foraging was undertaken at all these sites. That being said, additional surveys are required for a number of species identified as potential SRE species.
Disturbances (e.g. fire, flood, accidental human intervention etc.) which affected results of survey.	No	Exploration activities have taken place in the southern section of the study area. Fire scars were present throughout much of the study area. And the area has a history of human use, including pastoral use.
Intensity (in retrospect, was the intensity adequate?)	No	The sample size was large. In addition there were SRE specific surveys undertaken recently in the area (Biota 2008) and the DEC Pilbara Biological Survey also included sites very close to the study areas.
Completeness (was relevant area fully surveyed?)	No	The majority of habitats with the greatest potential for facilitating short-range endemism, which were not surveyed by Biota (2008), were sampled across the study area.
Remoteness and/or access problems.	No	All habitats selected were surveyed adequately. Helicopters were used to access Dixon Island and some of the higher and more inaccessible hill tops.
Availability of contextual (e.g. biogeographic) information on the region.	No	The Pilbara coast is fairly well known from a floristic and vertebrate faunal context. However, as stated above, Pilbara terrestrial invertebrate biology, taxonomy and biogeography are still in their infancy, but a number of reports were available on the region.

4 DISCUSSION

These results represent the most comprehensive systematic trapping survey of SRE taxa east of Karratha on the Pilbara Coast. The collection of new species was therefore expected. Thirty one invertebrate species from groups known to contain SRE taxa were recorded during the survey and up to eight of these represent new species. A total of 17 families and 24 genera were recorded

Four of the 31 species from groups containing SRE taxa are potential SRE species. The potential SRE species were recorded from 12 of the 24 survey sites.

The likelihood of short-range endemism for each of these species ranges from moderate to high (Table 4-1). The estimations of endemism are based on the general representative biology and the known records of other members of the respective genera.

The new *Quistrachia* species is considered to be of most interest, with the likelihood of short-range endemism being rated as "high". Members of this genus are typically confined to rocky habitats where they can seal straight to the rock surface. Individuals are unlikely to cross sandy plains and thus genetic flow between habitats is usually limited or absent.

The other three potential SRE species (*Synsphyronus* sp., *Lychas 'near harveyi'* and *Eucyrtops* sp.) are considered to have "moderate" potential for short-range endemism. The trap-door spider, *Eucyrtops* sp., was recorded only from a single clay-loam, mesic drainage basin, which suggests it may require habitats that have a greater ability to retain moisture conditions and thus maintain a favourable microclimate. The scorpion species, *Lychas* 'near *harveyi'* was also collected from a mesic drainage basin as well as a stony plain, suggesting a somewhat more diverse habitat preference, however this species is not known from any previous collections and members of this genus do include some SRE taxa (although most are widespread in the Pilbara). The pseudoscorpion species, *Synsphyronus* indet. (juv.) was recorded only from Dixon Island and may be confined to the island.

The physical environment of the study area is complex compared with inland Pilbara locations. Several diverse habitat types exist within a few kilometres, including coastal dunes, mangroves and tidal flats, rock piles, stony plains and low hills. In relation to SRE habitats, four habitat types were identified through the desktop habitat assessment as having the greatest chance of recording SRE taxa in the study area, namely, rock piles, isolated low rocky hill slopes / hill tops and isolated sections of coastal dune. These habitats were largely confined to the northern, coastal sections of the study area. The coastal dunes tended to be well connected or only partially isolated, yet most commonly recorded potential SRE taxa. Many isolated rock piles exist in the study area, some of which yielded potential SRE taxa during the survey. Hilltops and ridges, mostly occurring in the southern section of the study area are largely connected and more abundant than in the north and recorded no potential SRE taxa.

Drainage basins at the feet of low coastal rocky hills were identified as further potential SRE habitat during the field survey and therefore sampled. The drainage basin sites yielded considerable results in terms of SREs. Drainage basin Site 17 recorded the greatest number of groups known to include SRE taxa, while Site 16 (also a drainage basin), recorded two potential SRE species; *Lychas* 'near *harveyi'* and *Eucyrtops* sp. These habitats were also particularly diverse in modern spiders (araneaomorphae) and beetles (Coleoptera).

Single potential SRE species were also recorded in stony plain and creek line habitats (*Lychas* 'near *harveyi'* and *Quistrachia* sp., respectively). As these habitats are more widespread regionally, it is considered more likely that these species also occur more widely, although they cannot be ruled out as SRE species.

It was anticipated that Dixon Island would harbour SRE taxa, despite the relative close proximity of this island to the mainland (for example, meaning that speciation and genetic divergence between the island and mainland taxa should only be minor in comparison to species on Delambre Island or Barrow Island). In fact, only one of the six sites located on Dixon Island recorded a potential SRE species, a coastal dune habitat at SRE Site 03.

In summary, based on the results of the survey, the most important habitats identified within the study area, for SREs are:

- Isolated coastal dunes;
- Drainage basins;
- Rock piles; and
- South facing rocky hill slopes

Impacts to the potential SRE taxa have not been considered as part of this report, at the request of the client. However, additional systematic surveying is recommended to better define the habitat extent and preferences for these species.

Table 4-1 Potential SRE taxa recorded in the SRE survey.

Taxon		Likelihood of SRE	Needing additional surveys	Rationale
Trap-door spider	*Eucyrtops* sp. (juv.)	Moderate	Yes	Few records of *Eucyrtops* from the Pilbara, largely a Midwest and Southwest genus. Recorded in a clay-loam drainage basin and may be confined to similar mesic habitats.
Scorpion	*Lychas* 'near *harveyi'*	Moderate	Yes	No previous records of this species exist. The majority of *Lychas* species in the Pilbara have been shown to be widely distributed but some SRE taxa do exist.
Pseudoscorpion	*Synsphyronus* indet. (juv.)	Moderate	Yes	Many of the members of the genus *Synsphyronus* may represent short-range endemic species (Framenau and Harvey 2009). This is especially true of rock dwelling species. This species was recorded from a coastal dune on Dixon Island, which represents an unusual habitat for the genus. May be confined to the island.
Land snail	*Quistrachia* sp.	High	Yes	Species of *Quistrachia* have been determined to be SREs at Cape Preston and other localities. The genus is comprised largely of rock-specialists with poor powers of dispersal.

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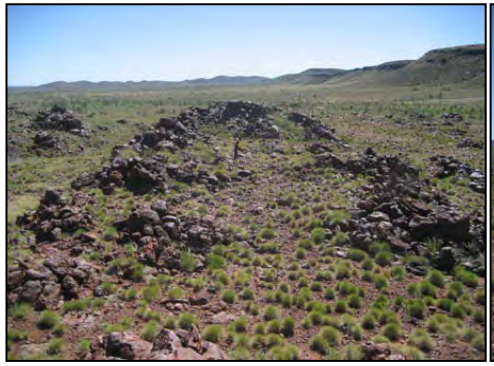
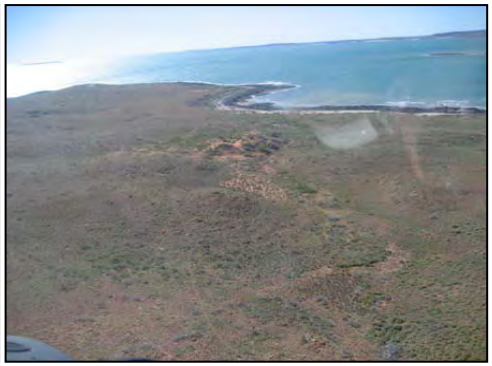
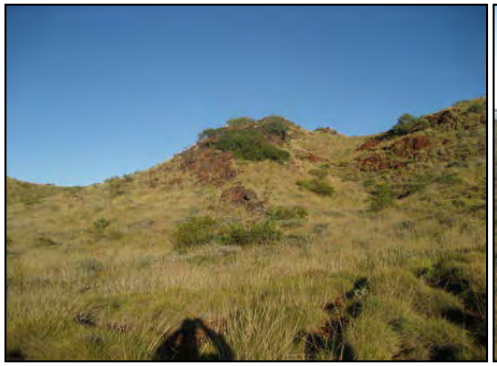
APPENDIX 1: ANKETELL POINT RAIL ALIGNMENT AND PORT PROJECTS SRE SITE DESCRIPTIONS

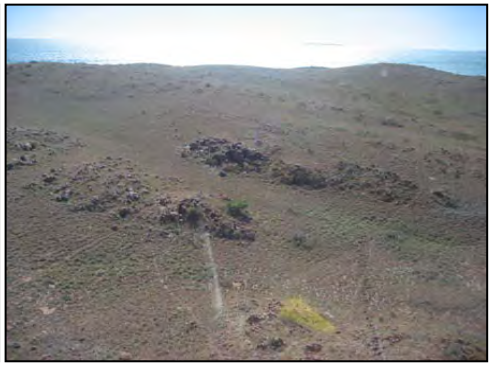
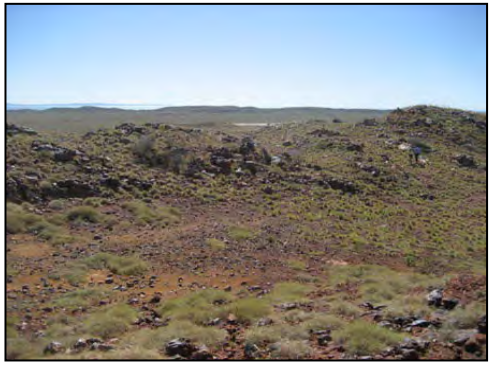
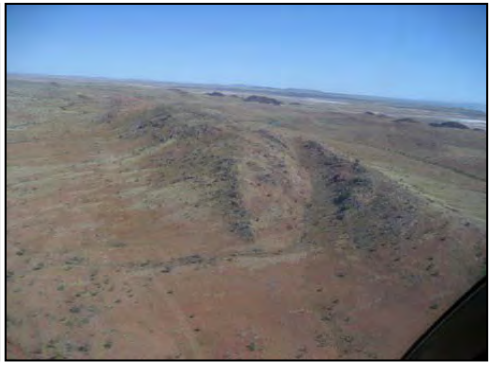
Site Description	Site Photos
Site 1 16/06/09 Rocky Hill Slope (Lower slope) – Dixon Island Vegetation in excellent condition, no fire, grazing or other disturbances present. Mixed A*cacia* shrubs over *Triodia* and mixed grasses. Total vegetation cover 60% with a leaf litter cover of 20%. Good drainage with 60% exposed rock. Dark brown loamy sand of a fine/medium consistency.	
Site 2 16/06/09 Breakaway (Mid-slope) Vegetation in excellent condition, no fire, grazing or other disturbances present. Sparse Low mixed shrubs over *Triodia.* Total vegetation cover 25% with a leaf litter cover of 5 %. Poor drainage with 75% exposed rock in a loamy sand of fine consistency.	 

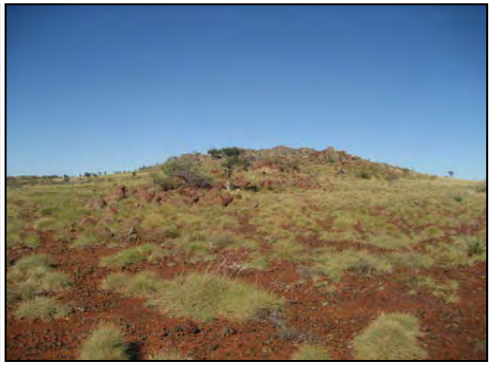
Site Description	Site Photos
Site 3 16/06/09 Coastal Ridge - Dixon Island (Mid to upper gentle southern slope) Vegetation in excellent condition, with evidence of kangaroo grazing no evidence of fire disturbance. Sparse low mixed shrub over annual grasses. Total vegetation cover 75%, with leaf litter cover of 20%. Moderate drainage with 35% exposed rock in a loamy sand of fine consistency.	 
Site 4 16/06/09 Hilltop (Upper slope) – Dixon Island Vegetation in excellent condition, no fire, grazing or other disturbances present. Scattered *Ficus* over *Triodia.* Total vegetation cover 80% with a leaf litter cover of 80%. Moderate drainage with 20% exposed rock. Sandy loam of a fine/medium consistency.	 

Site Description	Site Photos
Site 5 17/06/09 Rock pile/minor drainage (Mid-slope, southern facing) Vegetation in excellent condition, no fire, grazing or other disturbances present. Scattered *Hakea* over *Triodia* and small clumps of hummock grasses. Total vegetation cover 70%, with leaf litter cover less than 5%. Moderate drainage with 25% exposed rock. Brownish red, sandy loam of fine/medium consistency.	 
Site 6 17/06/09 Rock pile, (just above mudflats) Vegetation in very good condition, fire disturbance present but no grazing. Sparse *Eucalyptus* sp over scattered mixed A*cacia* over mixed grasses. Total plant cover 65% and leaf litter cover 60%. Moderate drainage with exposed granitic boulders. Brown/red sandy loam soil of a fine/medium consistency.	

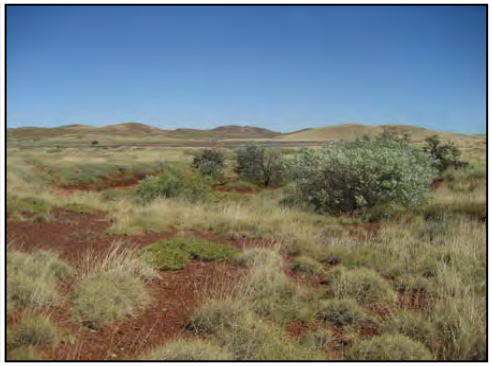
Site Description	Site Photos
Site 7 17/06/09 Coastal dune basin – Dixon Island Vegetation in good condition, no fire disturbance but evidence of kangaroo grazing and exotic species *Cenchrus ciliaris* (Buffel grass). Mixed *Acacia* and *Myoporum montanum* over *Rhagodia eremaea* and *Santalum lanceolatum* over *Cenchrus ciliaris.* Total vegetation cover 80% with leaf litter cover 30%. Deep course grey/brown sand.	 
Site 8 17/06/09 Coastal dune – Dixon Island Vegetation in good condition, fire disturbance present as well as evidence of kangaroo grazing. Kangaroo hides under most of the larger shrubs. Mixed *Acacia* and *Myoporum montanum* over mixed shrubs over *Cenchrus ciliaris.* Total vegetation cover 60%, leaf litter cover 30%. Deep course grey/brown sand.	 

Site Description	Site Photos
Site 9 17/06/09 Coastal dunes (Red sand) - – Dixon Island Vegetation in good condition, no fire disturbance but evidence of kangaroo hides and grazing. Scattered *Eucalyptus* over *Eremophila* and mixed shrub over *Cenchrus ciliaris* Total cover a leaf litter cover of around 25%. Red sandy clay loam.	 
Site 10 17/06/09 Rocky Hill slope (Upper slope). Located on the shoulder of the ridge, and a reference site for *ficus* sp site on Dixon island. Vegetation in very good condition, no fire, grazing or other disturbances present. Scattered large *Ficus* over *Spinifex* and mixed grasses. A leaf litter cover of about 100% under the *Ficus* sp where traps were located Good drainage with 25% exposed rock. Sand of a fine consistency.	 

Site Description	Site Photos
Site 11 18/06/09 Breakaway – Dixon Island Vegetation in good condition, although no fire disturbance present there is evidence of kangaroo grazing and exotic specie *Cenchrus ciliaris* (Buffel grass). Scattered low mixed shrubs over *Cenchrus ciliaris*. Vegetation cover 45% and leaf litter 10 %. Poor drainage with granitic/basalt exposed rock. Loamy sand of a fine/medium consistency.	 
Site 12 18/06/09 Hill top Vegetation in very good condition, no fire, grazing or other disturbances present. Scattered *Acacia* and *Eremophila* shrubs over *Triodia* and mixed grasses. Vegetation cover 50% and leaf litter 10%. Poor drainage with granitic/basalt exposed rock and brown/red sandy soil.	 

Site Description	Site Photos
Site 13 17/06/09 Coastal dunes/ dune valley (swale) Vegetation in very good condition, fire disturbance present but no grazing or exotic flora. Mixed *Acacia* over *Eremophila* and mixed shrubs over mixed grasses. Vegetation cover 85% and leaf litter 100% where traps were placed. Good drainage with exposed sands of a medium consistency.	 
Site 14 18/06/09 Ridge (Lower slope) Vegetation in very good condition, no fire or gazing but some exotic species *Cenchrus ciliaris* (Buffel grass) present. Sparse *Acacia* over *Triodia* and *Cenchrus ciliaris.* Vegetation cover 40%, leaf litter cover 10% and bare ground 50%. Good drainage with basalt exposed rock and loamy sands of a fine/medium consistency.	 

Site Description	Site Photos
Site 15 18/06/09 Creek line Vegetation in very good condition, no fire, or gazing but exotic species *Cenchrus ciliaris* (Buffel grass). Mixed *Acacia* over low mixed shrubs over *Triodia, Cenchrus ciliaris* and mixed grasses. Vegetation Cover 80% with leaf litter cover of 100% where traps were placed. Good drainage system with a sandy clay soil type of a fine/medium consistency.	 
Site 16 18/06/09 Basin at Base of South Hill Slope Vegetation in excellent condition, no fire, gazing or other disturbances present. Mixed *Acacia* over low mixed shrubs over *Triodia* and mixed grasses. Vegetation Cover 80% with leaf litter cover of 80% where traps were placed. Poor drainage system with some exposed basalt in a brown/red sandy clay loam of a fine/medium consistency.	 

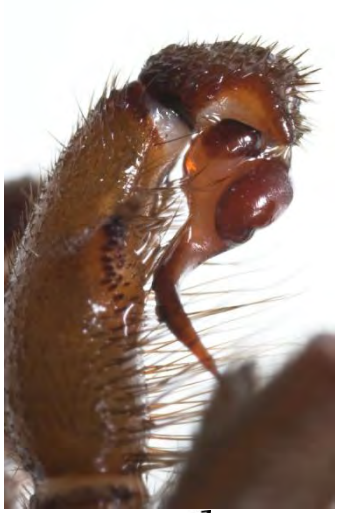
Site Description	Site Photos
Site 17 18/06/09 Basin at Base of South Hill Slope Vegetation in excellent condition, no fire, gazing or other disturbances present. Scattered *Acacia inequilatera* over mixed *Acacia* over low mixed shrubs over mature *Triodia* and mixed grasses. Vegetation Cover 80% with leaf litter cover of 80% where traps were placed. Poor drainage system with some exposed basalt in a brown/red sandy clay loam of a fine/medium consistency.	 
Site 18 18/06/09 Drainage line /creek line Vegetation in very good condition, no fire, gazing or other disturbances present. Mixed *Acacia* over low mixed shrubs over *Triodia* and mixed grasses. On the creek banks vegetation cover was 90% with leaf litter cover 100% where traps were placed. Good drainage system with, Some depositional basalt in a sandy clay loam soil of a fine consistency.	 

Site Description	Site Photos
Site 19 19/06/09 Rock Pile (Lower slope) Vegetation in good condition, no fire or grazing disturbance, however exotic species *Cenchrus ciliaris* (Buffel grass) abundant. Scattered mixed low shrub over *Cenchrus ciliaris* and mixed grasses. Vegetation cover 20% and leaf litter cover 20%. Moderate drainage with 60% exposed basalt rock in a brown sandy clam loam of a fine consistency.	 
Site 20 19/06/09 Coastal dunes. Vegetation in very good condition, no fire or grazing disturbance but exotic species *Cenchrus ciliaris* (Buffel grass) present. Mixed *Acacia* over mixed low coastal shrubs over *Cenchrus ciliaris* and mixed grasses. Vegetation cover 60% and leaf litter cover 55%. Whitish/yellow sand of a fine consistency.	 

Site Description	Site Photos
Site 21 19/06/09 Hill top/South slope. Vegetation in very good condition, no fire but presence of kangaroo grazing and exotic species *Cenchrus ciliaris* (Buffel grass) present. Scattered *Acacia* (live and dead) and flowering *Eremophila* over *Cenchrus ciliaris* and mixed grasses. Vegetation cover 60% and leaf litter cover 20%. Moderate drainage with exposed basalt rock in a brown/red sandy clay loam of a fine consistency.	 
Site 22 19/06/09 Hill top 'island' surrounded by marsh (Mid-upper slope) Vegetation in good condition, no fire but presence of kangaroo grazing and *Cenchrus ciliaris* present. Scattered small shrubs over dense *Triodia* and scattered *Cenchrus ciliaris*. Vegetation cover 55% and leaf litter <5% Moderate drainage with exposed iron stone/rock in a brown/red sandy clay loam soil of a fine consistency.	 

Site Description	Site Photos
Site 23 19/09/09 Hill top (Upper slope) Vegetation in very good condition, no fire or grazing disturbance but *Cenchrus ciliaris* present. Scattered small shrubs over dense *Triodia* and scattered *Cenchrus ciliaris*. Vegetation cover 60% and leaf litter <5% Moderate drainage with 40% exposed basalt in a sandy clay loam soil of a fine consistency.	
Site 24 19/06/09 Flat Stony Plain Vegetation in good condition, no fire or grazing disturbance but *Cenchrus ciliaris* present. Scattered *Acacia* thickets over *Cenchrus ciliaris,* mixed herbs and annual grasses. Vegetation cover 50% and leaf litter cover 70% where traps were placed. Poor drainage.	 

APPENDIX 2: ANKETELL POINT RAIL ALIGNMENT AND PORT PROJECTS SRE SPECIMENS PHOTOGRAPHS

Mygalomorphae Trap Door Spiders	
 Kwonkan m.sp.1 ♀(924-035)	
 *Kwonkan* m.sp.1♀ (924-033)	
 *Aganippe* Sp1. ♂ (924-037)	

Mygalomorphae Trap Door Spiders (Cont.)	
 Nemesiidae m.sp.2, Juv. (924-027)	
 *Aname* 'Pilbara sp. 001' ♀	
Scorpions	
 924-018	

Scorpions (Cont.)	
 924-021	
 924-022	
 *Lychas 'bituberculatus'* group (924-019)	

Scorpions (Cont.)	
 924-020	
Isopods	
 *Buddelundia*, M.sp. 1 (924-001)	 *Buddelundia*, M.sp.2 (924-003)
 *Barrowdilo*, M.sp.3 (924-005)	 *Buddelundia* M.sp.4, (924-004)

Pseudoscorpions	
 924-006	
 *Beierolpium* sp. (924-007)	
 *Beierolpium* sp.(924-008)	

Pseudoscorpions (Cont.)	
 *Indolpium* sp.(924-009)	
 924-010	
 *Beierolpium* sp. (924-011)	

Pseudoscorpions (Cont.)	
 *Euryolpium* sp. (924-12)	
 *Indolpium* sp. (924-013)	
 *Beierolpium* sp. (924-014)	

Pseudoscorpions (Cont.)	
 *Indolpium* sp. (924-015)	
 *Indolpium* sp. ? (924-016)	
 *Beierolpium* sp. (924-031)	

Pseudoscorpions (Cont.)	
 *Beierolpium* sp. (924-036)	
 *Beierolpium* sp. (924-017)	
 924-032	

Molluscan Land Snails	
 *Rhgada convicta*	
 *Rhgada convicta*	
 *Quistrachia herberti* (?)	
 *Quistrachia herberti* (?)	

APPENDIX 3: ANKETELL POINT RAIL ALINGMENT AND PORT PROJECTS SRE SITE GPS COORDINATES

	Datum:	WGS-84 (50 K)			
	Name	Easting (UTM)	Northing (UTM)	Latitude	Longitude
1	Site 1	507132	7705359	-20º 45' 5.173"	117º 4' 6.654"
2	Site 2	507561	7708533	-20º 43' 21.929"	117º 4' 21.45"
3	Site 3	507651	7720244	-20º 37' 0.959"	117º 4' 24.355"
4	Site 4	505728	7718275	-20º 38' 5.046"	117º 3' 17.964"
5	Site 5	503377	7713502	-20º 40' 40.339"	117º 1' 56.741"
6	Site 6	504809	7713530	-20º 40' 39.407"	117º 2' 46.259"
7	Site 7	504142	7718180	-20º 38' 8.142"	117º 2' 23.161"
8	Site 8	508356	7720101	-20º 37' 5.592"	117º 4' 48.731"
9	Site 9	508706	7719927	-20º 37' 11.255"	117º 5' 0.827"
10	Site 10	502775	7715945	-20º 39' 20.873"	117º 1' 35.911"
11	Site 11	508881	7720196	-20º 37' 2.521"	117º 5' 6.871"
12	Site 12	502378	7712664	-20º 41' 7.584"	117º 1' 22.231"
13	Site 13	502964	7716481	-20º 39' 3.431"	117º 1' 42.445"
14	Site 14	502811	7713365	-20º 40' 44.778"	117º 1' 37.182"
15	Site 15	502880	7713481	-20º 40' 41.005"	117º 1' 39.551"
16	Site 16	503889	7713594	-20º 40' 37.344"	117º 2' 14.431"
17	Site 17	504794	7714025	-20º 40' 23.304"	117º 2' 45.726"
18	Site 18	510047	7714152	-20º 40' 19.11"	117º 5' 47.281"
19	Site 19	509172	7718335	-20º 38' 3.055"	117º 5' 16.973"
20	Site 20	509588	7718909	-20º 37' 44.375"	117º 5' 31.315"
21	Site 21	510044	7718384	-20º 38' 1.446"	117º 5' 47.087"
22	Site 22	509371	7717062	-20º 38' 44.459"	117º 5' 23.863"
23	Site 23	508045	7715873	-20º 39' 23.137"	117º 4' 38.053"
24	Site 24	508350	7715308	-20º 39' 41.515"	117º 4' 48.623"

APPENDIX 4: BRAY-CURTIS SIMILARITY MATRIX

	Site 01	Site 02	Site 03	Site 04	Site 05	Site 06	Site 07	Site 08	Site 09	Site 10	Site 11	Site 12	Site 13	Site 14	Site 15	Site 16	Site 17	Site 18	Site 19	Site 20	Site 21	Site 22	Site 23	Site 24
Site 01																								
Site 02	45.0																							
Site 03	27.3	36.8																						
Site 04	30.8	26.1	32.0																					
Site 05	50.0	41.2	36.8	39.1																				
Site 06	43.5	40.0	36.4	34.6	40.0																			
Site 07	31.1	30.8	32.6	35.3	41.0	44.4																		
Site 08	29.3	40.0	35.9	17.0	28.6	29.3	30.0																	
Site 09	15.4	18.2	21.6	17.8	6.1	20.5	31.6	29.4																
Site 10	34.1	34.3	41.0	38.3	34.3	34.1	40.0	33.3	41.2															
Site 11	37.5	46.2	33.3	21.1	38.5	31.3	25.8	37.0	16.0	51.9														
Site 12	35.0	35.3	31.6	43.5	35.3	30.0	25.6	28.6	18.2	34.3	46.2													
Site 13	16.2	12.9	5.7	23.3	12.9	0.0	11.1	12.5	20.0	31.3	8.7	19.4												
Site 14	27.9	32.4	29.3	40.8	48.6	27.9	42.9	36.8	33.3	47.4	27.6	32.4	29.4											
Site 15	31.1	30.8	32.6	23.5	30.8	17.8	13.6	25.0	31.6	35.0	32.3	35.9	16.7	33.3										
Site 16	14.0	21.6	9.8	20.4	27.0	23.3	14.3	15.8	22.2	26.3	6.9	16.2	23.5	30.0	28.6									
Site 17	38.3	43.9	17.8	34.0	39.0	34.0	26.1	19.0	20.0	33.3	36.4	39.0	15.8	31.8	39.1	36.4								
Site 18	28.0	36.4	20.8	25.0	22.7	36.0	20.4	31.1	27.9	40.0	27.8	36.4	19.5	29.8	32.7	42.6	47.1							
Site 19	32.4	32.3	45.7	32.6	32.3	21.6	22.2	31.3	20.0	31.3	43.5	32.3	28.6	23.5	33.3	11.8	36.8	24.4						
Site 20	10.8	25.8	22.9	27.9	19.4	16.2	27.8	37.5	26.7	31.3	26.1	32.3	21.4	29.4	11.1	23.5	26.3	34.1	21.4					
Site 21	20.0	41.2	36.8	34.8	35.3	20.0	20.5	22.9	12.1	28.6	30.8	35.3	12.9	32.4	25.6	21.6	39.0	36.4	45.2	19.4				
Site 22	31.6	43.8	27.8	27.3	37.5	26.3	21.6	24.2	12.9	30.3	41.7	31.3	6.9	22.9	27.0	28.6	46.2	38.1	34.5	20.7	31.3			
Site 23	35.0	47.1	31.6	26.1	35.3	35.0	25.6	28.6	18.2	34.3	46.2	47.1	12.9	21.6	30.8	21.6	39.0	36.4	32.3	25.8	35.3	43.8		
Site 24	14.6	28.6	20.5	25.5	17.1	24.4	15.0	11.1	5.9	11.1	14.8	22.9	6.3	5.3	15.0	31.6	38.1	31.1	25.0	31.3	28.6	36.4	28.6	

APPENDIX 5: ARAENOMORPHAE SPIDER RECORDS

	Site																								
Morph-Species	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	No. of Species per Site
sp. 1	*	*	*	*	*	*	*	*		*	*	*		*	*		*	*	*		*	*	*	*	**20**
sp. 2	*	*				*		*	*	*	*	*		*	*		*	*				*	*		**14**
sp. 3	*	*	*	*	*			*		*	*	*	*	*	*		*	*	*	*	*	*	*		**19**
sp. 4	*		*																*			*			**4**
sp. 5	*		*	*	*	*	*					*											*	*	**9**
sp. 6	*	*						*							*										**4**
sp. 7	*			*	*							*		*	*		*								**7**
sp. 8	*												*						*						**3**
sp. 9	*			*																					**2**
sp. 10	*	*		*	*	*	*							*		*	*								**9**
sp. 11	*									*			*												**3**
sp. 12	*																	*							**2**
sp. 13	*											*					*	*							**4**
sp. 14	*	*				*	*	*	*																**6**
sp. 15		*										*	*			*	*	*		*				*	**8**
sp. 16		*				*																			**2**
sp. 17		*	*		*		*	*						*							*				**7**
sp. 18		*	*								*	*			*		*		*		*		*		**9**
sp. 19			*							*					*										**3**
sp. 20			*					*								*									**3**
sp. 21			*			*		*	*									*	*						**6**
sp. 22			*			*	*			*								*							**5**
sp. 23			*						*						*										**3**
sp. 24				*		*											*	*		*	*			*	**7**
sp. 25				*												*						*			**3**
sp. 26				*			*		*	*			*	*	*		*		*						**9**
sp. 27				*													*								**2**
sp. 28				*		*	*																		**3**
sp. 29				*													*					*		*	**4**
sp. 30				*					*	*		*	*	*	*	*		*							**9**

	Site																							
Morph-Species	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	No. of Species per Site
sp. 31				*	*								*	*		*									**5**
sp. 32				*								*									*				**3**
sp. 33				*																					**1**
sp. 34				*																					**1**
sp. 35				*																					**1**
sp. 36				*																					**1**
sp. 37				*		*						*						*					*		**5**
sp. 38					*		*							*			*				*	*			**6**
sp. 39							*																		**1**
sp. 40							*																		**1**
sp. 41							*																		**1**
sp. 42							*																		**1**
sp. 43							*																		**1**
sp. 44								*																	**1**
sp. 45								*																	**1**
sp. 46									*																**1**
sp. 47									*											*					**2**
sp. 48									*						*										**2**
sp. 49									*																**1**
sp. 50										*						*									**2**
sp. 51										*	*														**2**
sp. 52												*										*			**2**
sp. 53												*									*		*		**3**
sp. 54												*													**1**
sp. 55													*												**1**
sp. 56														*	*										**2**
sp. 57																*									**1**
sp. 58																	*								**1**
sp. 59																				*					**1**
sp. 60																								*	**1**
sp. 61																						*			**1**

	Site																								
Morph-Species	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	No. of Species per Site
sp. 62																					*				**1**
sp. 63																							*		**1**
sp. 64																							*		**1**
sp. 65																								*	**1**
sp. 66																								*	**1**
sp. 67																								*	**1**
Sp. Richness	**14**	**10**	**11**	**20**	**8**	**11**	**14**	**10**	**10**	**10**	**5**	**14**	**8**	**11**	**12**	**8**	**14**	**11**	**7**	**5**	**9**	**9**	**9**	**9**	

APPENDIX 6: COLEOPTERA (BEETLE) RECORDS

Morph-Species	Site 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	Species per Site
sp. 1	*																								**7**
sp. 2	*				*	*									*	*	*						*		**3**
sp. 3	*					*	*																		**2**
sp. 4	*										*														**11**
sp. 5	*	*			*	*	*			*	*						*	*				*	*		**1**
sp. 6	*																								**3**
sp. 7	*				*														*						**1**
sp. 8		*																							**8**
sp. 9		*	*	*															*		*	*	*	*	**1**
sp. 10			*																						**7**
sp. 11			*	*			*		*	*				*						*					**1**
sp. 12			*																						**1**
sp. 13			*																						**2**
sp. 14			*												*										**2**
sp. 15				*						*															**2**
sp. 16				*														*							**4**
sp. 17				*									*						*		*				**5**
sp.18					*										*	*		*				*			**1**
sp. 19						*																			**3**
sp. 20							*		*					*											**10**
sp. 21							*	*	*	*			*	*		*		*		*			*		**1**
sp. 22								*																	**4**
sp. 23								*						*				*		*					**1**
sp. 24								*																	**2**
sp. 25								*												*					**1**
sp. 26													*												**1**
sp. 27													*												**1**
sp. 28													*												**4**
sp. 29														*		*		*			*				**2**
sp. 30															*			*							**1**
sp. 31															*										**7**
sp. 32															*	*	*	*	*		*			*	**2**
sp. 33															*	*									**1**
sp. 34															*										**2**
sp. 35																		*			*				**1**

	Site																								
Morph-Species	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	Species per Site
sp. 36																	*								**1**
sp. 37																	*								**1**
sp. 38																		*							**1**
sp. 39																							*		**1**
sp. 40																							*		**7**
Sp. Richness	**7**	**3**	**6**	**5**	**4**	**4**	**5**	**5**	**3**	**4**	**2**	**0**	**5**	**5**	**8**	**6**	**5**	**10**	**4**	**4**	**5**	**3**	**6**	**2**