OCTOBER 2012

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WOODSIDE ENERGY LTD

JAMES PRICE POINT: LIGHT INDUSTRIAL AREA, WORKERS' ACCOMMODATION CAMP AND SOUTHERN PIPELINE

SHORT RANGE ENDEMIC INVERTEBRATE FAUNA ASSESSMENT

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ACRONYMS

ACE	Abundance-based Coverage Estimator
ANOVA	Analysis of Variance
ANOSIM	Analysis of Similarities
BoM	Bureau of Meteorology
DEC	Department of Environment and Conservation
EIA	Environmental Impact Assessment
EPA	Environmental Protection Authority
EPBC Act	*Environment Protection and Biodiversity Conservation Act* 1999
JPP	James Price Point
LIA	Light Industrial Area
LNG	Liquefied Natural Gas
NEAT	North-East Access Track
SAC	Species Accumulation Curve
SP	Southern Pipeline
SRE	Short Range Endemic
WAM	Western Australian Museum
WC Act	*Wildlife Conservation Act 1950*

EXECUTIVE SUMMARY

Woodside Energy Ltd (Woodside), as operator of the proposed Browse LNG Development, plans to commercialise the Browse Joint Venture's three gas and condensate fields, Brecknock, Calliance and Torosa, located 425 km north of Broome off the Kimberley coast. Gas and Liquids from these fields will be extracted using offshore facilities then brought to an onshore Liquefied Natural gas (LNG) plant for processing at the Western Australian Government's planned Browse LNG Precinct, near James Price Point, about 60 km north of Broome. The Department of State Development, as the precinct proponent, is conducting a strategic assessment of the area. A draft Strategic Assessment Report (SAR) has been released for the BLNG Precinct, which includes the requirement for a Light Industrial Area (LIA), Workers' Accommodation Camp (WAC) and Southern Pipeline (SP) (Department of State Development 2010).

ecologia Environment (*ecologia*) was commissioned by Woodside via Sinclair Knight Merz (SKM)/Consolidated Environmental Services (CES) Partnership to undertake baseline studies for Short Range Endemic (SRE) invertebrate fauna within the BLNG development area (approximately 42 km^2), comprising the following survey areas:

- Light Industrial Area (LIA);
- Workers' Accommodation Camp (WAC); and
- Southern Pipeline (SP).

The SRE invertebrate fauna survey was completed during 12-19 April 2011 and 27 April – 5 May 2011. Survey site locations were selected in habitats likely to support SRE invertebrates, in particular micro habitats likely to maintain higher moisture levels such as underside of rocks and decaying logs, clumps of thick understorey vegetation, deep leaf litter beds around base of trees and low-lying drainage lines were targeted. A range of collecting techniques was used, including dry pitfall trapping, leaf litter sampling and opportunistic foraging.

Due to logistical contraints, no sampling could be conducted in the SP area: however, Biota have previously sampled within this area (Biota 2011). The LIA area was surveyed indirectly via trapping sites in the same habitat type along the North-East Access Track.

Traps were open for a combined total of 875 trap-nights. Thirteen person hours were spent foraging in the vicinity of all five trapping sites and further thirteen person hours were spent collecting and sieving leaf litter from each trapping site. Finally, three person hours were spent opportunistically foraging within the WAC area. The collected specimens were processed by ecologia staff and submitted to taxonomic experts for specific identification and classification of SRE status.

Species accumulation curves were used to assess survey adequacy and habitat assessment was used to assess potential associations between SRE species and habitat types.

The main conclusions of the survey were:

- Fifteen species from seven potential SRE groups were collected during the survey.
- Five species were classified as potential SREs (Aname MYG231, Aname MYG 232, *Dampetrus* sp., *Lychas* 'JPP' and *Buddelundia* sp. 1), four species were not SREs (*Rhagada bulgana, Quistrachia leptogramma, Lychas* 'multipunctatus' and *Scolopendra laeta*) and six species – all pseudoscorpions and the *Urodacus* scorpion - could not have their SRE status determined by experts due to poor taxonomic knowledge and/or juvenile status.

- A low overlap of species occurred between this survey and the previous survey conducted by Biota (2011) - only five species (*Aname* MYG 231, *Euryolpium* sp., *Rhagada bulgana*, *Quistrachia leptogramma* and possibly *Urodacus* sp.) were collected in both surveys. Only one of these species was a potential SRE (*Aname* MYG 231). This could be partly due to Biota surveying three habitat types (Pindan Shrubland, Open Forrest and Monsoon Vine Thicket) while *ecologia* surveyed only the two most common habitat types (Pindan Shrubland and Open Forrest) due to logistical constraints. Seasonality between the two years of 2010 (rainfall below average) and 2011 (rainfall above average), influencing activity of some groups, could also explain part of the variation.

- The species accumulation curve showed that whilst the majority of species had been collected, more SRE species were likely to occur within the Project areas (3-4 extra species).

- The habitat assessment revealed that each habitat type supported similar species diversity.

- None of the habitats in which the potential SRE species were located are unique to the proposed impact areas nor have any unique features that are restricted to the project area. The habitats - including the specific microhabitats such as underside of rocks and logs, clumps of thick understorey vegetation, deep leaf litter beds around base of trees and low-lying drainage lines - extend beyond the limits of the mapped area. Thus, the impact from the BLNG development on the potential SRE species in the area is expected to be low.

1 INTRODUCTION

1.1 PROJECT OVERVIEW

Woodside Energy Ltd (Woodside), as operator of the proposed Browse LNG Development, plans to commercialise the Browse Joint Venture's three gas and condensate fields, Brecknock, Calliance and Torosa, located 425 km north of Broome off the Kimberley coast. Gas and Liquids from these fields will be extracted using offshore facilities then brought to an onshore Liquefied Natural gas (LNG) plant for processing at the Western Australian Government's planned Browse LNG Precinct, near James Price Point, about 60 km north of Broome. The Department of State Development, as the precinct proponent, is conducting a strategic assessment of the area. A draft Strategic Assessment Report (SAR) has been released for the BLNG Precinct, which includes the requirement for a Light Industrial Area (LIA), Workers' Accommodation Camp (WAC) and Southern Pipeline (SP) (Department of State Development 2010).

ecologia Environment (*ecologia*) were commissioned by Woodside via Sinclair Knight Merz (SKM)/Consolidated Environmental Services (CES) Partnership to undertake baseline studies for Short Range Endemic (SRE) invertebrate fauna within the BLNG development area (approximately 42 km^2) (Figure 1.1), comprising the following survey areas:

- Light Industrial Area (LIA);
- Workers' Accommodation Camp (WAC); and
- Southern Pipeline (SP).

The WAC is rectangular in shape and covers an area 20.6 km^2 aligned on a NEE-SSW bearing. This area is located approximately 1 km from the coast. The LIA is located north of the WAC and is almost rectangular in shape with the SW corner truncated. The LIA is 9.7 km^2 in area and approximately 1.5 km from the coast. The SP is a longitudinal polygon that runs along 5 km of coastline between James Price Point and Quandong Point and encompasses an area of 11.5 km^2.

The survey area provided to *ecologia* and referred to as the Southern Pipeline (SP) in this study represents a larger area than the currently approved disturbance footprint for the Southern Pipeline option of the BLNG Development. This report assesses the invertebrate fauna of this larger area and further impact evaluation within the reduced disturbance footprint will occur as part of the relevant environmental referral documentation to be developed by Woodside.

1.2 SHORT RANGE ENDEMIC FAUNA: A REVIEW

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

Endemism refers to the restriction of species to a particular area, whether it is at the continental, national or local level (Allen *et al.* 2002). This review focuses on SREs, outlines the major paths to short range endemism, the current knowledge of short range endemism in Australia and the conservation significance of such species. It is important to note that the individual taxa and broader groups discussed are not an exhaustive list of all SREs. This is due to the fact that SRE are dominated

by invertebrate species, which are historically understudied and in many cases lack formal descriptions. An extensive, reliable taxonomic evaluation of these species has begun only relatively recently and thus the availability of literature relevant to SREs is relatively scarce.

1.2.1 Processes Promoting Short range Endemism

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

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

The historical connections between habitats are also important in determining species distributions and often explain patterns that are otherwise inexplicable by current conditions. Many SREs are considered to be relictual taxa (remnants of species that have become extinct elsewhere) and are confined to certain habitats, and in some cases, single geographic areas (Main 1996). Relictual taxa include extremely old species that can be traced back to the Gondwanan periods (180-65 million years ago) and have a very restrictive biology (Harvey 2002).

In Western Australia, relictual taxa generally occur in fragmented populations, from lineages reaching back to historically wetter periods. For example, during the Miocene period (from 25 million to 13 million years ago), the aridification of Australia resulted in the contraction of many areas of moist habitat and the fragmentation of populations of fauna occurring in these areas (Hill 1994). With the onset of progressively dryer and more seasonal climatic conditions since this time, suitable habitats have become increasingly fragmented. Relictual species now generally persist in habitats characterised by permanent moisture and shade, maintained by high rainfall and/or prevalence of fog. This may be induced by topography or coastal proximity, or areas associated with freshwater courses (e.g. swamps or swampy headwaters of river systems), caves or microhabitats associated with southern slopes of hills and ranges, rocky outcrops, deep litter beds or various combinations of these features (Main 1996; Main 1999). As a result, these habitats support only small, spatially isolated populations, which are further restricted by their low dispersal powers typical for all SRE species.

1.3 LEGISLATIVE FRAMEWORK

Federal and State legislation applicable to the conservation of native fauna include, but are not limited to, the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act), the *Wildlife Conservation Act 1950* (WC Act), and the *Environmental Protection Act 1986* (EP Act). Section 4a of

the *Environmental Protection Act 1986* requires that developments take into account the following principles applicable to native fauna:

- *The Precautionary Principle*

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

- *The Principles of Intergenerational Equity*

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

- *The Principle of the Conservation of Biological Diversity and Ecological Integrity*

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

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

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

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

Some better known SRE species have been listed as threatened or endangered under State or Commonwealth legislation in the WC Act and/or EPBC Act, but the majority have not. The lack of knowledge about these species often precludes their consideration for listing as threatened or endangered. Listing of species under legislation should therefore not be the sole consideration in environmental impact assessment for determining conservation or protection requirements.

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

This report also satisfies the requirements of the later released Guidance Statement No. 20: *Sampling of Short Range Endemic Invertebrate Fauna for Environmental Impact Assessment in Western Australia* (EPA 2009).

1.4 SURVEY OBJECTIVES

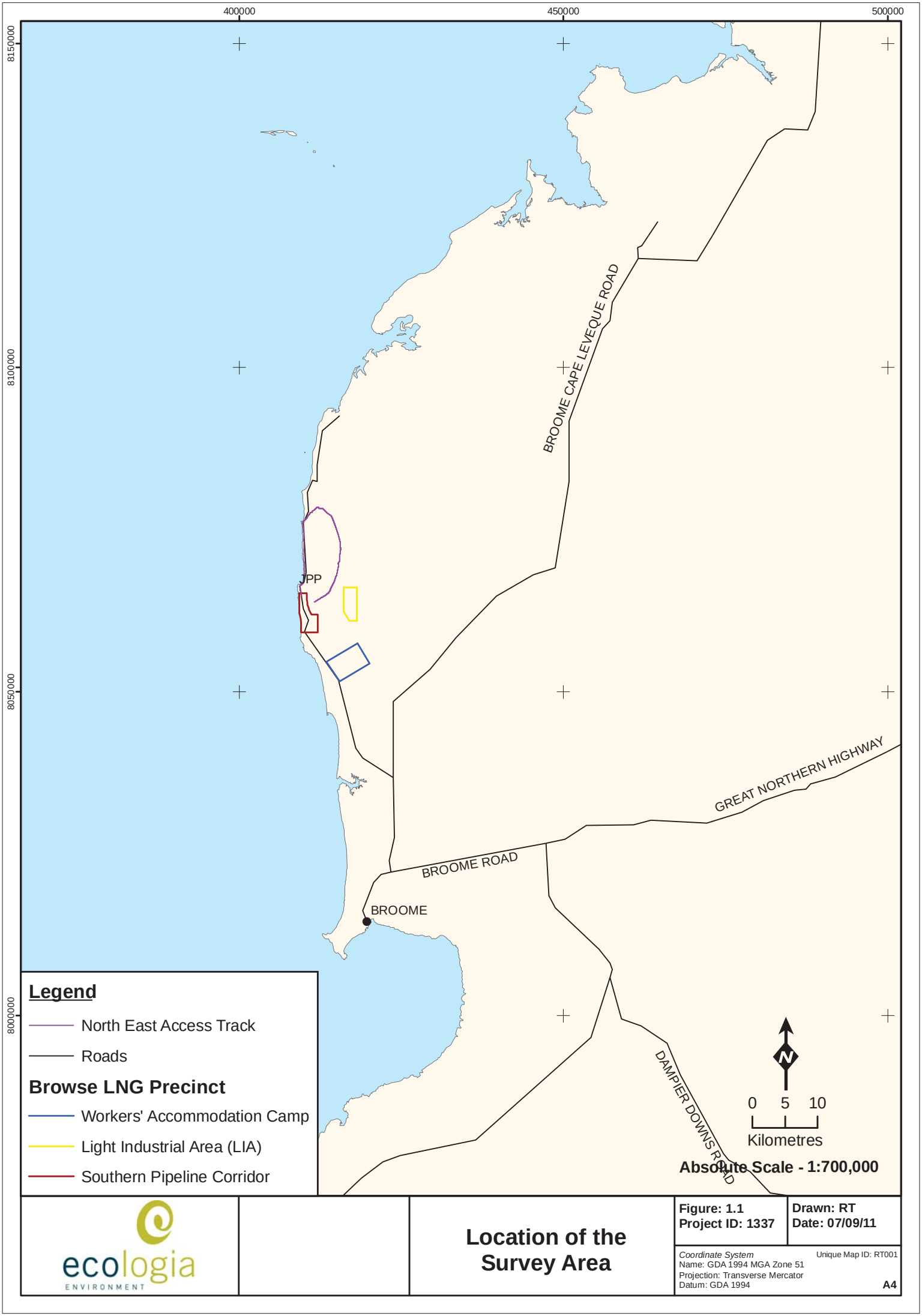
The EPA's objectives with regards to fauna management are to:

- maintain the abundance, species diversity and geographical distribution of terrestrial invertebrate fauna; and
- protect Specially Protected (Threatened) fauna, consistent with the provisions of the *Wildlife Conservation Act 1950* (WC Act).

Hence, the primary objective of this study was to provide sufficient information for the EPA to assess the impact of the Project on the invertebrate fauna of the area, thereby informing assessment against these objectives.

Specifically, the objectives were to undertake a survey that satisfies the requirements documented in EPA's Guidance Statement 20, thus providing:

- a review of background information (including literature and database searches);
- an inventory of potential SRE invertebrate species occurring in the project area, incorporating recent published and unpublished records;
- an inventory of species of biological and conservation significance recorded or likely to occur within the project area and surrounds;
- a description of the characteristics of the SRE invertebrate fauna habitats occurring in the project area;
- a description of the characteristics of SRE assemblages occurring in the project area;
- an appraisal of the current knowledge base for the area, including a review of previous surveys conducted in the area that are relevant to the current study; and
- a review of regional and biogeographical significance, including the conservation status of species recorded in the project area.



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Location of the Survey Area

Figure: 1.1
Project ID: 1337

Drawn: RT
Date: 07/09/11

Coordinate System
Name: GDA 1994 MGA Zone 51
Projection: Transverse Mercator
Datum: GDA 1994

Unique Map ID: RT001

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2 BIOPHYSICAL ENVIRONMENT

2.1 CLIMATE

The project area is situated in the Kimberley region of WA at the south-west edge of the Dampier Peninsula. The area has a dry, hot, tropical climate with two distinct seasons: the 'wet' from around December to March, and the 'dry' for the rest of the year. Rainfall is highly variable in the region due to the inconsistent nature of the movement and occurrence of thunderstorms and tropical systems. Tropical cyclones can occur as late as April, but are most common in January and February. Rainfall during the cooler months is usually associated with cloud bands originating from tropical waters to the north-west (BoM 2011). The average temperature over summer is over 33 °C, with warm overnight minima of around 26 °C (BoM 2011). Winter temperatures are quite mild, with average maximum and minimum temperatures in July being 26.9 °C and 12.0 °C respectively (BoM 2011).

The closest Bureau of Meteorology (BoM) weather station to the survey area is Broome Airport, located 51.8 km south of the project area. This station was selected as a reference to provide the best indication of the local climatic conditions of the project area (Figure 2.1).

The mean annual rainfall for Broome is 607 mm, although this can be quite variable with over 75% of the annual rainfall usually falling between January and March (BoM 2011). The mean number of rainfall days (≥1 mm) a year is only 35.1. Generally, the wettest month is February, with a mean of 179.1 mm falling over an average of 9.1 rainfall days. In terms of temperature, the hottest month is April and the coldest is July, with means of 34.3 °C and 28.8 °C respectively (Figure 2.1).

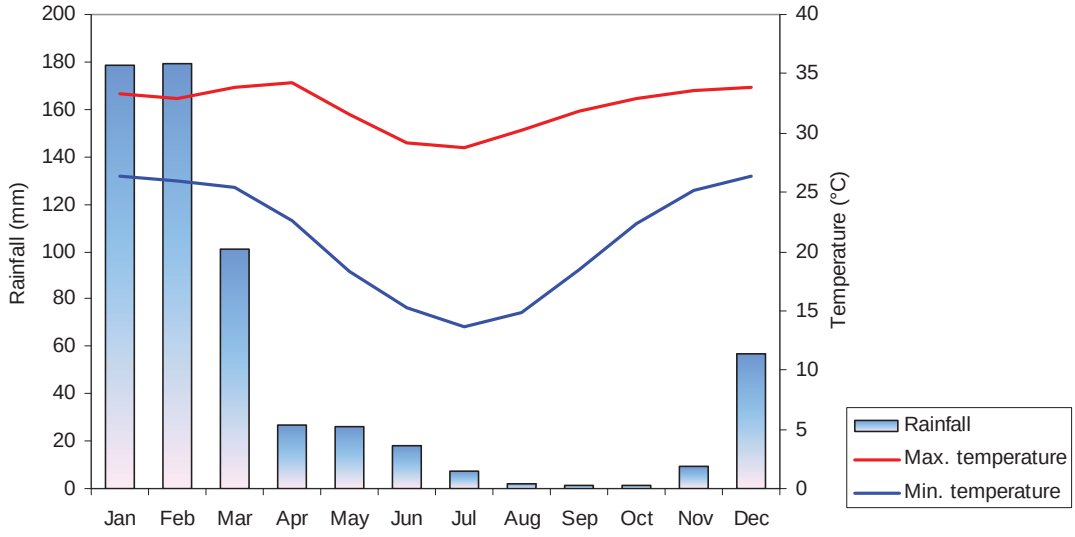


Figure 2.1 – Climatic Summary Data at Broome Airport from 1939-2011 (BoM 2011).

Table 2.1 shows that rainfall at Broome Airport in the 2009 wet season (December 2008 – March 2009) was close to average. The 2010 wet season was extremely low, although the annual rainfall was somewhat made up by a large rainfall event in July. In contrast, the 2011 wet season had much higher rainfall than average due to the three tropical cyclones which occurred in the Kimberley region over this period. Figure 2.2 shows the effect these cyclones had on rainfall in Western Australia in

the six months prior to the surveys, with the Kimberley region receiving 150-300% of their typical rainfall.

Table 2.1- Rainfall Preceding the Survey (Broome Airport Records) (BoM 2011)

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Total Monthly Rainfall (mm)													
2009	180.6	203.4	76.8	0	5.6	6.2	1	0.6	0	0.6	46.2	179.4	700.4
2010	140	6.4	31	71.6	26.4	0	110.8	1.8	4.4	7.8	57.8	85.8	543.8
2011	449.2	275	87.2	18.6	0.4								
Mean Monthly Rainfall (mm)													
1939 - 2011	178.5	179.1	100.8	26.7	26.4	18	7.4	1.7	1.4	1.4	9.1	56.8	607

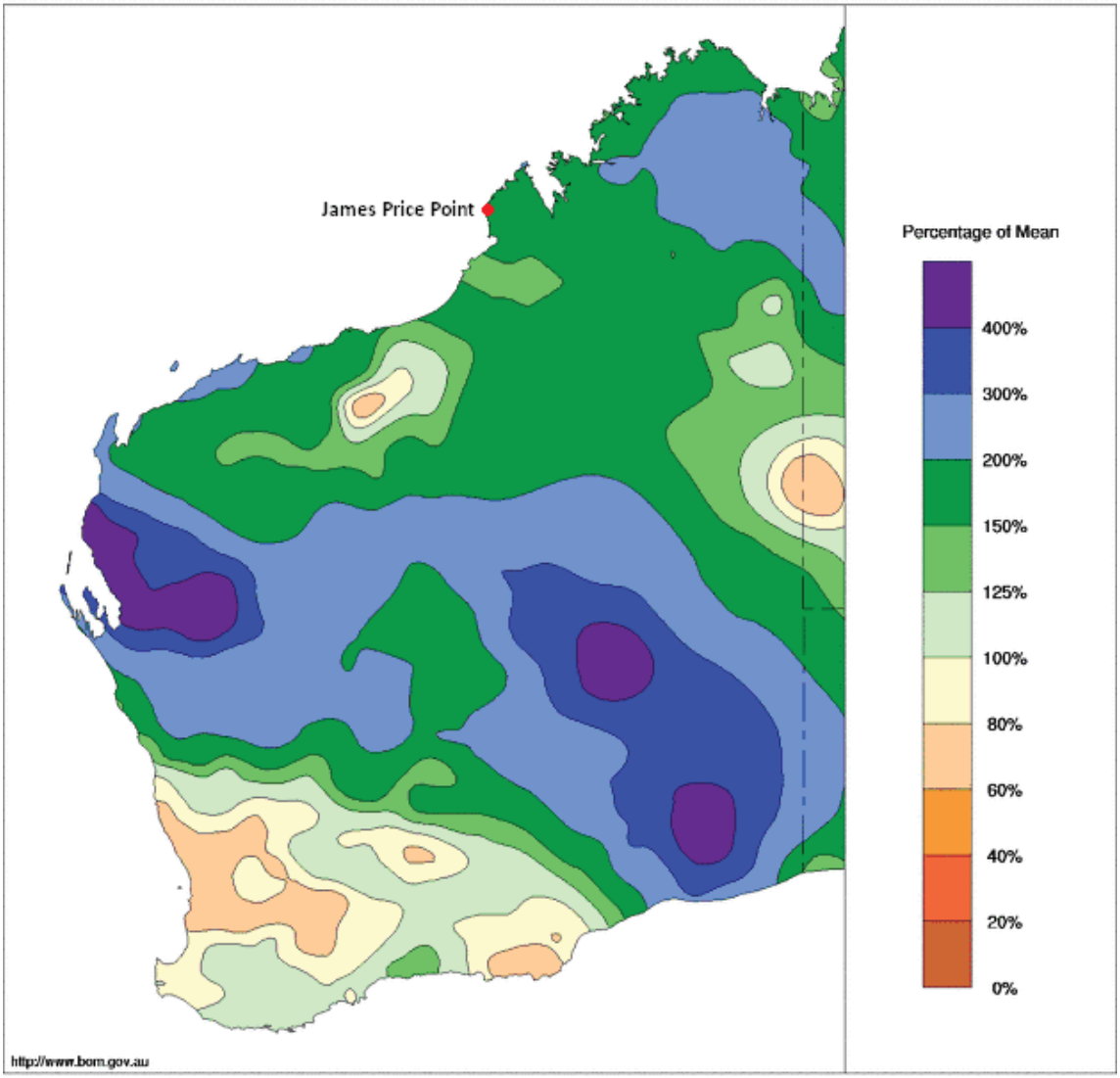


Figure 2.2 - Rainfall During the Six Months Prior to the 31st May 2011, (BoM 2011).

The invertebrate fauna assessment comprised two survey periods, April and May 2011, the weather for which is provided in Appendix B. The first survey in April 2011 consisted of hot days exceeding 30 °C, with overnight minima typically in the low 20s, but cooling (reaching as low as 15.4 °C) towards the end of the survey. The average maximum temperatures were slightly lower on the second survey than on the first, with high 20s and low 30s recorded. However, the minimum temperatures remained above 20 °C, even at night.

2.2 VEGETATION

The Dampier Peninsula in which the survey areas are located lies within the Northern Botanical Province. The vegetation of Western Australia was originally mapped at the 1:1,000,000 scale by Beard (1979), and was subsequently reinterpreted and updated to reflect the National Vegetation Information System (NVIS) standards (Shepherd *et al.* 2002). Two of the vegetation types identified by Shepherd *et al*. (2002) are found within the survey areas: Vegetation Associations 129 and 750. The majority of the three survey areas consist of vegetation type 750 (Figure 2.3), which is described as being mainly shrub-lands and pindan, comprised of *Acacia tumida* shrubs with medium height grey box and cabbage gum woodland, over ribbon grass and curly spinifex (Shepherd *et al.* 2002). The SP area also contains small areas of Vegetation Association 129, described as bare areas with drift sand. Both vegetation types are well represented outside the three survey areas, with less than 0.2% of their total post-European extent (Table 2.2).

Table 2.2 – Vegetation Associations in the Survey Areas

Survey Area	Vegetation Association	Total Area in WA (km^2)	Area in survey area (km^2)	Percent of the survey area	Percent of total Vegetation Association
Workers' Accommodation Camp	750	12415.59	20.60	100.00	0.17
Light Industrial Area	750	12415.59	9.70	100.00	0.078
Southern Pipeline	750	12415.59	11.54	99.90	0.093
	129	957.07	0.01	0.01	0.001

Vegetation of the James Price Point area, incorporating the current survey areas, was mapped at a finer scale by Biota (2010), with the general area of the current surveys mapped as containing eight vegetation communities (Table 2.3). *Ecologia* surveyed five on these vegetation communities in the current survey inlcluding Monsoon Vine Thicket Evergreen; Drainage Basin; Open Forest, Open Woodland and Pindan Shrubland. Descriptions of each vegetation type based on the results of the current survey are provided below.

1. Monsoon vine thicket evergreen

Isolated clumps of low trees of *Celtis philippensis*, *Diospyros humilis*, *Mimusops elengi* and *Sersalisia sericea* over tall shrubs of *Acacia monticola*, *Bridelia tomentosa*, *Exocarpos latifolius*, *Glycosmis macrophylla*, *G. trifoliata* and *Grewia breviflora* over vines including *Abrus precatorius*, *Caesalpinia major*, *Capparis lasiantha* and the invasive *Passiflora foetida* var. *hispida* with isloated tussock grasses of *Aristida holathera*, *Enneapogon caerulescens* and *Cymbopogon procerus*.

2. Drainage Basin

Low woodland of *Lophostemon grandiflorus* subsp. *grandiflorus* (P3), *Corymbia bella* over tall-mid shrubs of *Acacia colei*, *Ehretia saligna*, *Hakea macrocarpa*, *Santalum lanceolatum* and *Senna costata* over mid-low shrubs of *Solanum cunninghamii*, *Croton habrophyllus* and *Bridelia tomentosa* with dense grasses of *Aristida holathera* var. *holathera*, *Cymbopogon procerus* and *Setaria apiculata* and vines *Abrus precatorius*, *Passiflora foetida* var. *hispida* and *Tinospora smilacina*.

3. Open Forest

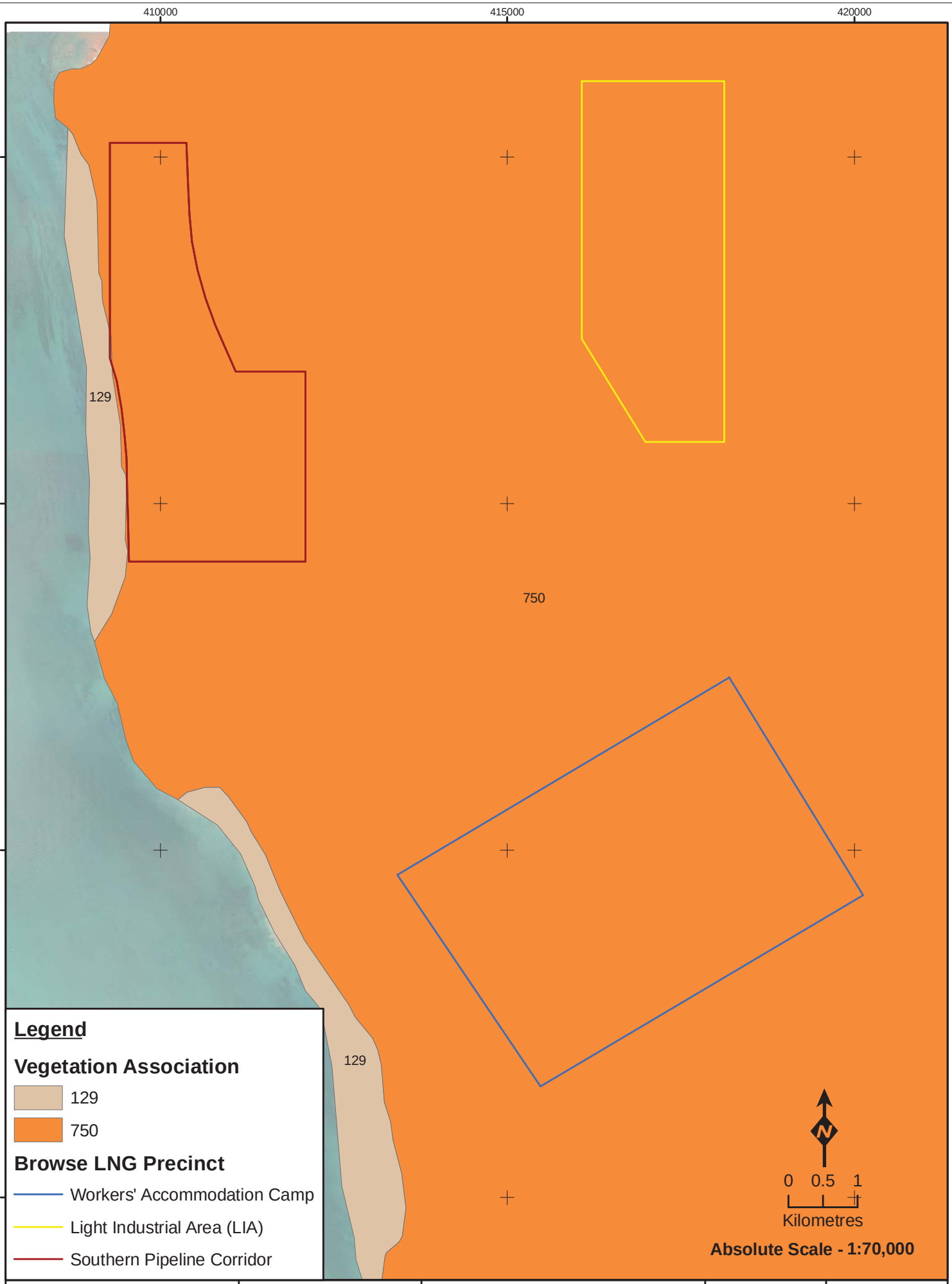
Open forest of *Eucalyptus miniata* and *Corymbia dampieri* over variably dense understorey of Acacias including *A. eriopoda*, *A. monticola*, *A. tumida*, and *A platycarpa* and *Grevillea pyramidalis*, over low shrubs of *A. hippuroides*, *Dodonaea hispidula* var. *arida* and *Gossypium rotundifolium* over grasses of *Aristida holathera* var. *holathera*, *Sorghum plumosum* and *Triodia schinzii.*

4. Open Woodland

Open woodland with mid-low trees of *Eucalyptus miniata*, *E. jensenii* or *Corymbia polycarpia* over tall shrubs of *Acacia monticola*, *A. tumida, A. eriopda*, *A. platycarpa* over *Bridelia tomentosa*, *Corchorus sidoides*, *Dodonaea hispidula* var. *arida*, *Microstachys chamelea* and *Waltheria indica* over grasses *Aristida contorta*, *Cymbopogon procerus*, and vines *Cassytha filiformis*, *Passiflora foetida* var. *hispida*.

5. Pindan shrubland

Scattered mid-low trees of *Corymbia dampieri* and *C. zygophylla* over tall mixed *Acacia* species (commonly *A. eriopoda* and *A. tumida*) over shrubs of *Carissa lanceolata*, *Dodonaea hispidula, Trichodesma zeylanicum, Acacia adoxa, Gossypium australe and Waltheria indica over* grasses *Triodia schinzii, Chrysopogon pallidus, Aristida holathera* var. *holathera* and *Eriachne obtusa.*



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Vegetation Associations of the Project Area (Shepherd et al. 2002)

Figure: 2.3
Project ID: 1337

Drawn: RT
Date: 07/09/2011

Coordinate System
Name: GDA 1994 MGA Zone 51
Projection: Transverse Mercator
Datum: GDA 1994

Unique Map ID: RT002

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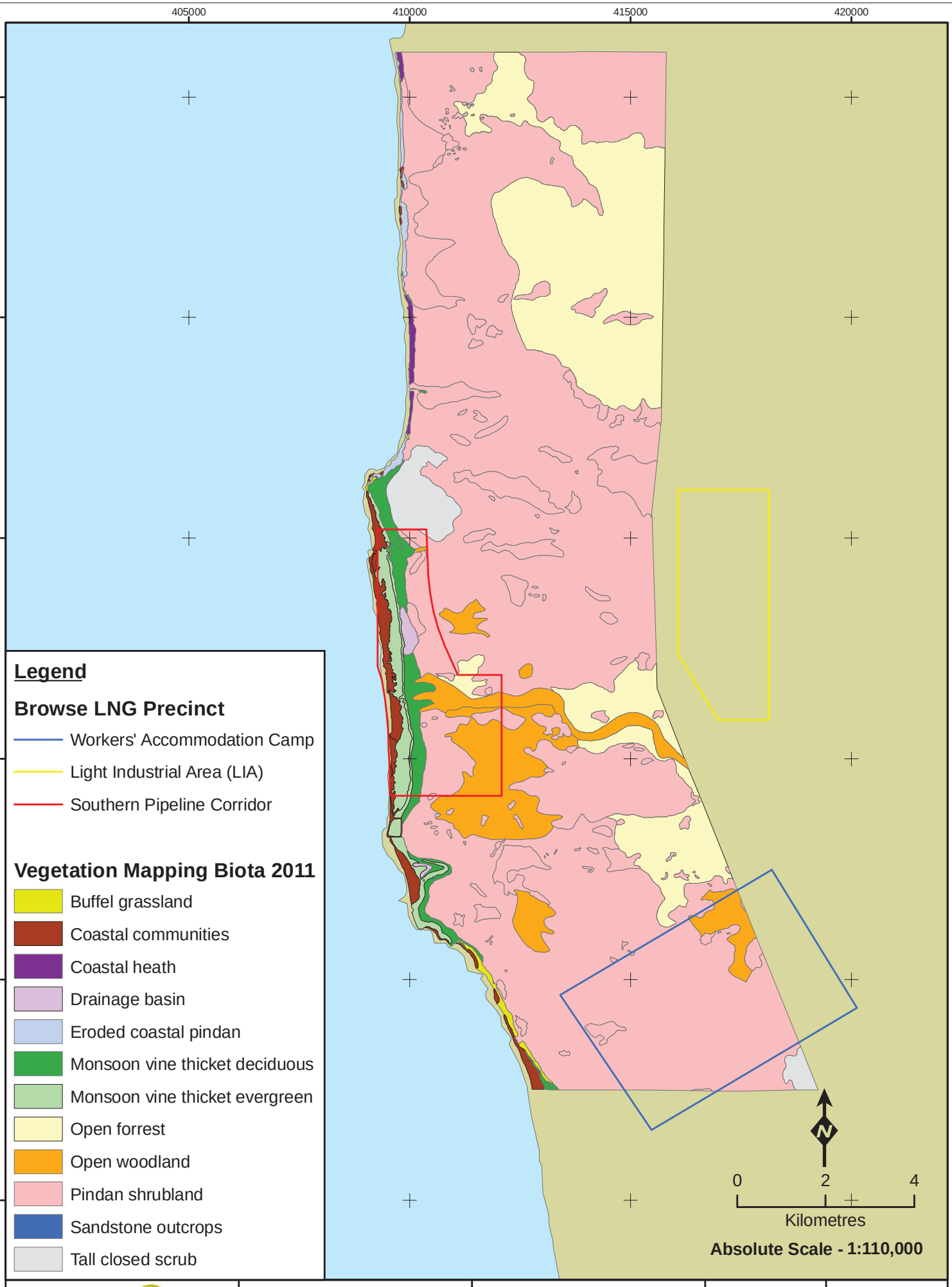

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Vegetation units mapped by Biota 2011

Figure: 2.4
Project ID: 1337

Drawn: RT
Date: 03/11/2011

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

Unique Map ID: RT028

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Table 2.3 – Vegetation Communities in the vicinity of the Project Area (Biota, 2010).

Vegetation Type	Description
Coastal Communities (cc)	Sparsely vegetated mobile foredunes usually including Beach Spinifex (*Spinifex longifolius*), along with the sedges *Fimbristylis cymosa* and *F. sericea,* which were usually dominant in blow-out areas. Stabilised dunes were dominated by *Spinifex longifolius*.
Monsoon Evergreen Vine Thickets (evt)	Discrete, closed-canopy patches, more commonly on the coastal dunes and sometimes extending into the swales. The evergreen trees included *Celtis philippensis, Diospyros humilis, Mimusops elengi*, *Sersalisia sericea* and the P4 species *Pittosporum moluccanum*. Shrubs included *Exocarpos latifolius, Glycosmis macrophylla* and *G. trifoliata*. Typical vines included *Abrus precatorius, Caesalpinia major*, *Capparis lasiantha, Gymnanthera oblonga*, *Jacquemontia paniculata, Opilia amentacea, Sarcostemma viminale* subsp. *brunonianum*, *Tinospora smilacina* and *Tylophora cinerascens.*
Monsoon Deciduous Vine Thickets (dvt)	Typical deciduous tree species included *Bauhinia cunninghamii, Croton habrophyllus*, *Grewia breviflora*, *Gyrocarpus americanus* and *Terminalia petiolaris*. Deciduous shrub species included *Bridelia tomentosa, Flueggea virosa* subsp. *melanthesoides, Grewia retusifolia, Pavetta kimberleyana* and *Premna acuminata*. Vine species were similar to those recorded in the evergreen vine thickets. The P3 grass *Eriachne semiciliata* (now known as *Eriachne* sp. Dampier Peninsula) was only recorded from deciduous vine thickets.
Drainage Basins (db)	Areas subject to ephemeral freshwater flooding, ponding, or seepage and were found behind coastal sand dunes subject to seasonal inundation. Such areas were often associated with monsoon vine thicket but were characterised by the occurrence of Lardik (*Lophostemon grandiflorus*) and the paperbark Karnbor (*Melaleuca dealbata*), neither of which were recorded from vine thicket.
Tall Closed Scrub (tcs)	Complex mosaic, devoid of eucalypts and dominated by dense wattles. The major dominants were *Acacia monticola* and *A. colei,* with some *A. eriopoda, Hakea arborescens* and *H. macrocarpa,* with *Acacia hippuroides, Calytrix exstipulata, Dodonaea hispidula* and *Lithomyrtus retusa* in the understorey.
Pindan Shrubland (ps)	Ubiquitous grassland dominated by a sparse upper layer composed mainly of eucalypts with a variably dense thicket-forming middle layer of wattles. Dominated by mixed *Acacia* species (particularly *A. eriopoda* and *A. tumida*), with widely scattered Ghost Gums (*Corymbia flavescens*) near the coast and scattered Bloodwoods (*Corymbia dampieri* and *C. zygophylla*) and occasional Darwin Box (*Eucalyptus tectifica*) elsewhere. Understorey shrubs included Conkerberry (*Carissa lanceolata*), *Dodonaea hispidula*, Camel Bush (*Trichodesma zeylanicum*), *Acacia adoxa, Gyrostemon tepperi,* Native Cotton (*Gossypium australe*), *Gonocarpus leptothecus, Waltheria indica* and *Solanum cunninghamii*. The principal grasses are Soft Spinifex (*Triodia schinzii*), Ribbon Grass (*Chrysopogon pallidus*), Sorghum (*Sorghum stipoideum*) and Bunch Speargrass (*Heteropogon contortus*).
Open Woodland (ow)	Manowan or Woollybutt (*Eucalyptus miniata*) on sandy soils, with Long-fruited Bloodwood (*Corymbia polycarpa*) confined to seasonally inundated areas such as along Kundandu Creek. Localised patches of Wandi Ironbark (*Eucalyptus jensenii*) occurred throughout the open woodland, and were often associated with *Acacia monticola*.
Open Forest (of)	Relatively dense tree cover, with an upper layer of *Eucalyptus miniata* and an understorey of wattles that included *Acacia eriopoda, A. tumida* and *A. platycarpa.* Grass species were similar to those in the pindan shrubland but also included Annual Sorghum (*Sorghum stipoideum*) and Bunch Speargrass (*Heteropogon contortus*).

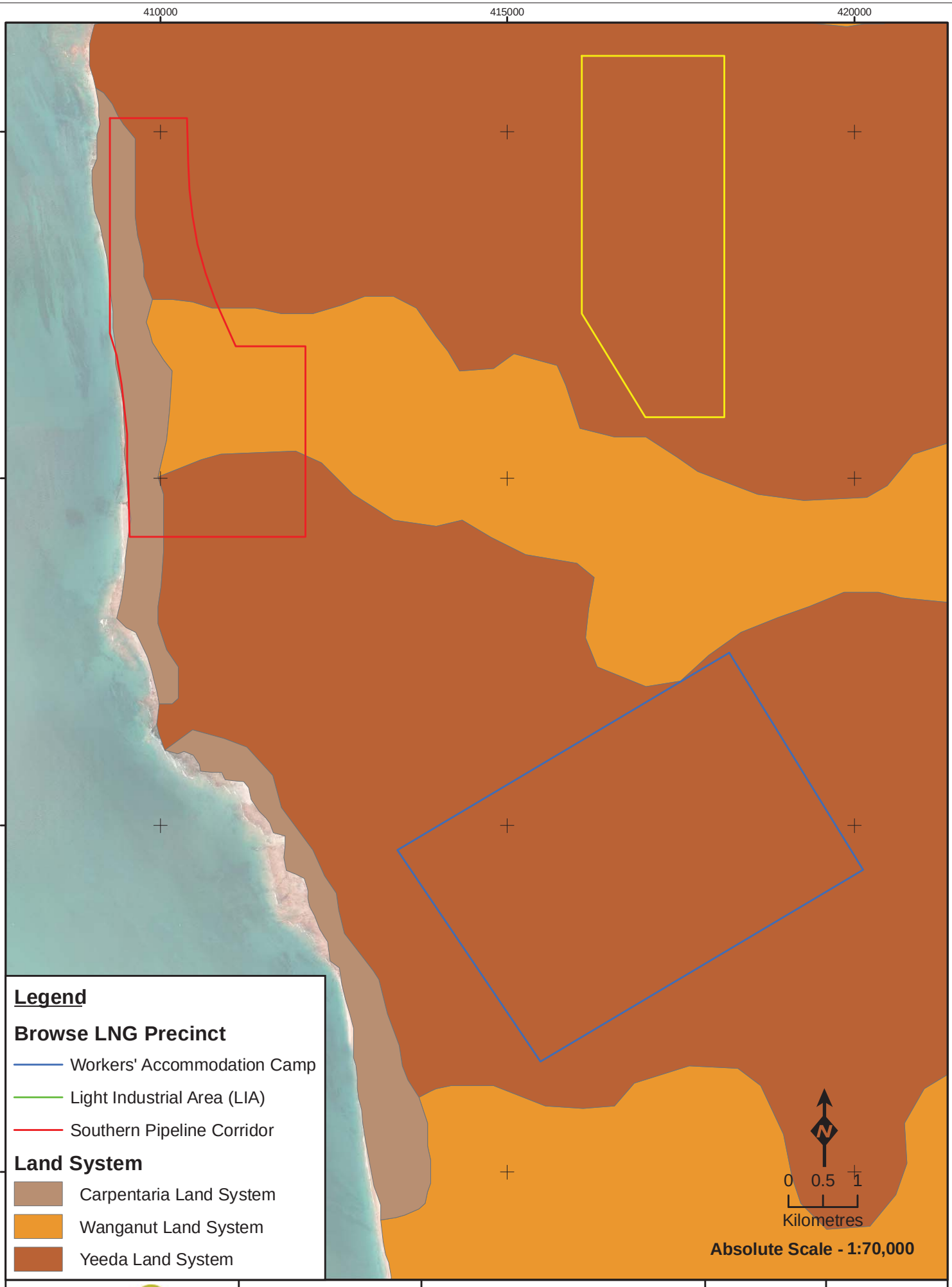
2.3 LAND SYSTEMS

Land systems are described using the biophysical characteristics of geology, landforms, vegetation and soils. The survey areas contain three land systems: Wanganut, Yeeda and Carpentaria (Table 2.4 and Figure 2.5). The Wanganut land system is characterised as low-lying sandplains and dune fields with drainage formations, supporting pindan acacia shrublands with emergent eucalypt trees. The Yeeda land system is similarly described as being sandplains with red and yellow sands, supporting pindan acacia shrublands with emergent eucalypt trees. The Carpentaria land system consists of coastal flats and associated sandy margins and dunes, and saline sands and muds. Such terrain can support paperbark thickets, samphire meadows or extensive bare mud flats with fringing mangrove forests (McKenzie and Kenneally 1983).

The Yeeda land system is found throughout the WAC and LIA survey areas, and makes up the greatest portion of the SP area (39.8%). The SP area also contains the Wanganut and Carpentaria land systems. All three of the land systems found within the survey areas are well-represented outside of the proposed footprint for these, as each area makes up less than 0.5% of the total land system area in WA.

Table 2.4 – Land Systems in the Survey Areas.

Project Area	Land System	Total Area in WA (km^2)	Area in Survey Area (km^2)	Percent of the Survey Area	Percent of Total Land System
WAC	Yeeda	21244.4	20.6	100	0.097
LIA	Yeeda	21244.4	9.7	100	0.046
SP	Wanganut	7188.0	3.9	34.1	0.055
	Yeeda	21244.4	4.6	39.8	0.022
	Carpentaria	6131.8	3.0	26.1	0.490



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Land Systems of the Project Area (Cotching 2005)

Figure: 2.5
Project ID: 1337

Drawn: EF
Date: 20/06/11

Coordinate System
Name: GDA 1994 MGA Zone 51
Projection: Transverse Mercator
Datum: GDA 1994

Unique Map ID: EF044

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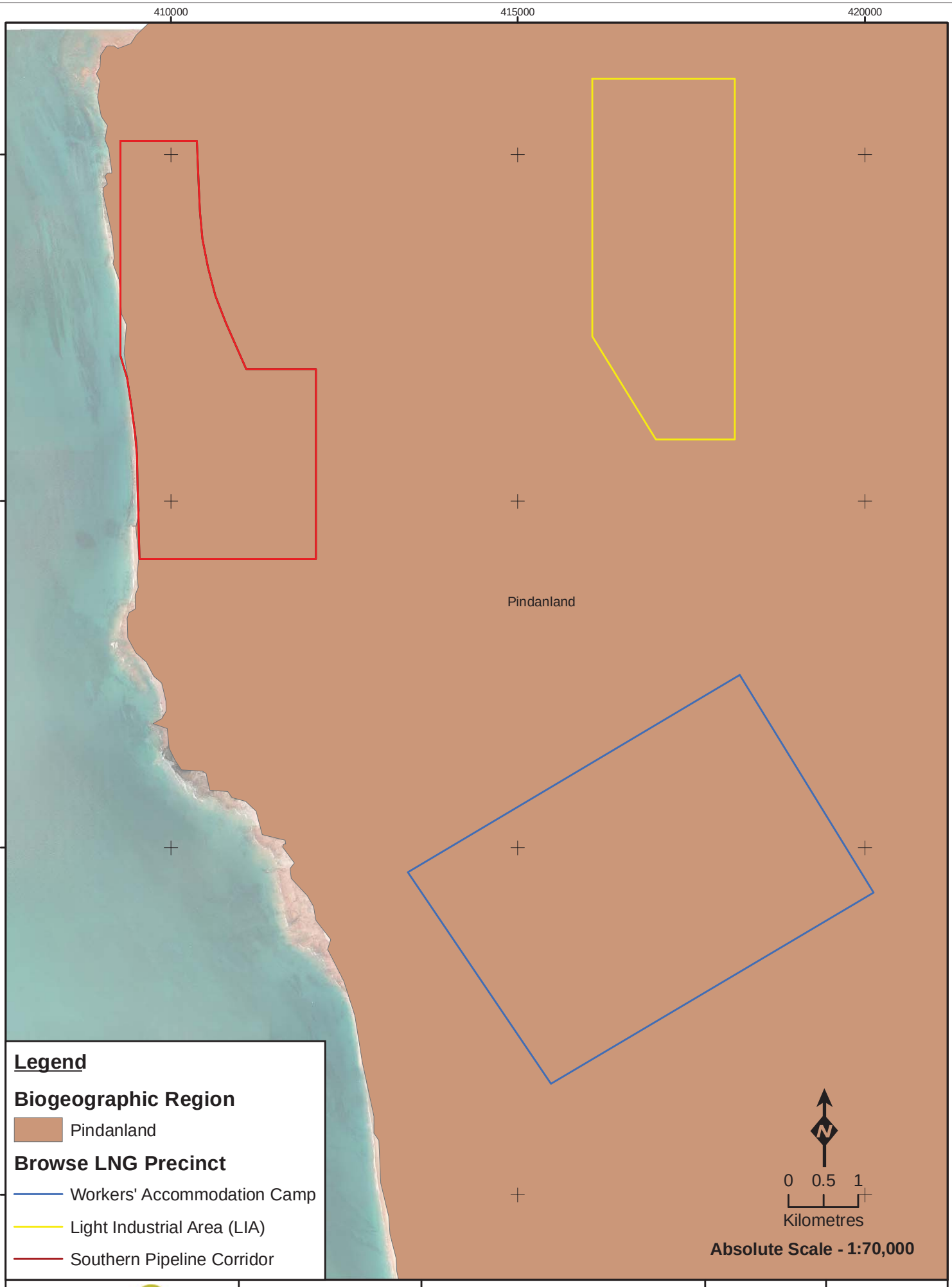
2.4 BIOGEOGRAPHY

The Interim Biogeographic Regionalisation for Australia (IBRA) classifies the Australian continent into bioregions of similar geology, landform, vegetation, fauna and climate characteristics (DSEWPC 2010). According to IBRA (Version 6.1), the survey area is located in the Dampierland bioregion. With an area of 88,130 km2, the Dampierland bioregion is smaller than most. This is typical of bioregions situated along the coast where vegetation is less uniform than the arid interior.

The Dampierland bioregion is further divided into the subregions Fitzroy Trough (DL1) and Pindanland (DL2), the latter of which includes the project area (Figure 2.6). The Pindanland subregion is made up of the western part of Dampierland (including the hinterland of Eighty Mile Beach), and the sandplains of the Dampier Peninsula, covering 51,989 km^2 (Graham 2001). The terrain of the Pindanland subregion is a fine-textured sand-sheet with subdued dunes, supporting vegetation that is described primarily as pindan.

The dominant land use categories within the Pindanland subregion are unallocated crown land, crown reserves and native pastures for grazing (Graham 2001). The principal limiting factors and threatening processes are considered to be feral animals (donkeys, cats, foxes), wildfire, weeds, land clearing (for agriculture or construction), erosion, human disturbance, and grazing or pastoral activities (Graham 2001). The IBRA protection level of the subregion is 0.01 – 5%, meaning that not only are ecosystems under-represented, the management of existing parks and reserves is also ranked as poor to fair. More pertinently, monsoon vine thicket ecosystems are considered to be inadequately represented and under threat (Graham 2001). The full extent is not known of the main threatening processes (wildfire, weeds, feral animals) in the Dampierland bioregion, compounding the paucity of knowledge on the status of critical weight range mammals there (Graham 2001).



ecologia ENVIRONMENT

Biogeographic Regions of the Project Area (SEWPaC 2010)

Figure: 2.6
Project ID: 1337

Drawn: RT
Date: 07/09/11

Coordinate System
Name: GDA 1994 MGA Zone 51
Projection: Transverse Mercator
Datum: GDA 1994

Unique Map ID: RT003

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3 METHODS

3.1 DETERMINATION OF SURVEY DESIGN AND INTENSITY

Prior to the development of field survey methods, a review was undertaken of factors likely to influence survey design and intensity (Table 3.1). Based on this review, the level of disturbance, data from previous surveys and the results of a desktop study (*ecologia* 2010), a SRE field survey was recommended, incorporating a variety of SRE collecting techniques.

Table 3.1 – Factors Influencing Survey Design.

Factor	Relevance
Bioregion-level of existing survey knowledge of the region and associated ability to predict accurately.	Two previous biological surveys have been conducted within 100 km of the survey area.
Landform special characteristics/specific fauna/specific context of the landform characteristics and their distribution and rarity in the region.	Landforms of the survey area are typical of the Pindanland subregion.
Lifeforms, life cycles, types of assemblages and seasonality (e.g. migration) of species likely to be present.	The best time to survey for all invertebrate fauna groups in the Kimberley is the wet season (typically December – March), or soon after. A dry season (April to August) survey can also be conducted.
Level of existing knowledge and results of previous regional sampling (e.g. species accumulation curves, species/area curves).	One baseline SRE invertebrate survey has been conducted within 100 km. One targeted SRE invertebrate survey has previously been conducted within the project area.
Number of different habitats or degree of similarity between habitats within a survey area.	The majority of the three survey areas have very similar habitat, particularly the WAC and LIA areas. There are a few distinct areas of more unique habitat types (e.g. monsoon vine thicket, coastal dunes) within the SP.
Climatic constraints (e.g. temperature or rainfall that preclude certain sampling methods).	The Kimberley region experiences hot summers with occasional cyclonic rain events, followed by warm winters with little rain. Rainfall is highly unpredictable.
Sensitivity of the environment to the proposed activities.	Coastal habitats (found within the SP) are potentially more sensitive to impact than the extensive areas of continuous habitat found further inland (WAC and LIA).
Size, shape and location of the proposed activities.	There are three survey areas, all near James Price Point, North of Broome. The WAC is a rectangle (roughly 4x5 km) adjacent to Manari road. This road runs through the Southern Pipeline area (2.5x6 km). The rectangular LIA lies to the east of the SP area, and is approximately 2x5.5 km.
Scale and impact of the proposal.	The survey area covers three infrastructure areas, each under 20 km^2, with a total area of approximately 42 km^2.

3.2 LITERATURE REVIEW AND DATABASE SEARCHES

Several databases were consulted in the preparation of potential SRE invertebrate fauna lists, with searches conducted within 50 km of the survey area (Table 3.2). In addition, publications reporting on invertebrate fauna surveys conducted predominantly within 150 km of the survey area were consulted (Table 3.3). The results of all database searches and previous surveys are presented in Appendix D.

Table 3.2 - Fauna Databases Searched to Determine the Potential Invertebrate Fauna Assemblages of the Project Area

Database	Search Details
DEC Invertebrate Fauna Database	Records within 50 km of the survey area
DEC NatureMap	Records within 40 km of the survey area

Table 3.3 - Previous Biological Survey Reports within 150 km of the Project Area.

Survey Location and Author(s)	Distance to Survey Area (km)	Comments
James Price Point Browse LNG Precinct Targeted Terrestrial Fauna Survey (Biota 2011)	0	1-phase survey
James Price Point Terrestrial Fauna Survey (Biota 2009)	0	1-phase survey

3.3 SURVEY TIMING

Sufficient rainfall is required for optimal SRE sampling, therefore the optimal sampling period in the Kimberly is during cyclone season, between November and April (EPA 2009). The first survey was completed between 12th and 19th April 2011 and the second survey between 27th April and 5th May 2011 (Table 3.4). Road closures prevented access to the sites until this time. The surveys followed a much wetter than average wet season owing to the three tropical cyclones experienced by the Kimberley region (Table 3.1).

Table 3.4 – Duration and Person Days for each Survey

Survey	Duration (days)	Person Days
Survey 1	8	16
Survey 2	9	18
Total	**17**	**34**

3.4 SITE SELECTION

Aerial photographs (Google Earth™) and vegetation and land system maps of the project area were studied to determine the vegetation communities and land systems in which the SREs were likely to occur. Survey site locations were selected primarily based on those habitats likely to support SRE invertebrates. In particular, micro habitats likely to maintain higher moisture levels such as underside of rocks and decaying logs, clumps of thick understorey vegetation, deep leaf litter beds around base of trees and low-lying drainage lines were targeted.

Once in the field, sites had to be selected within close proximity to vertebrate fauna trapping lines (used by *ecologia* for the same Woodside studies) due to logistical requirements. However, it was still possible to select appropriate sites which housed appropriate SRE microhabitats from within these areas. In total, five trapping sites were selected, two within the proposed WAC, and three along the North-East Access Track (NEAT), 3 km to the west and north of the LIA (Figure 3.1). The LIA was a prohibitively long distance from the nearest vehicle access to support adequate SRE assessment, therefore agreement between the Department of Environment and Conservation (DEC) and

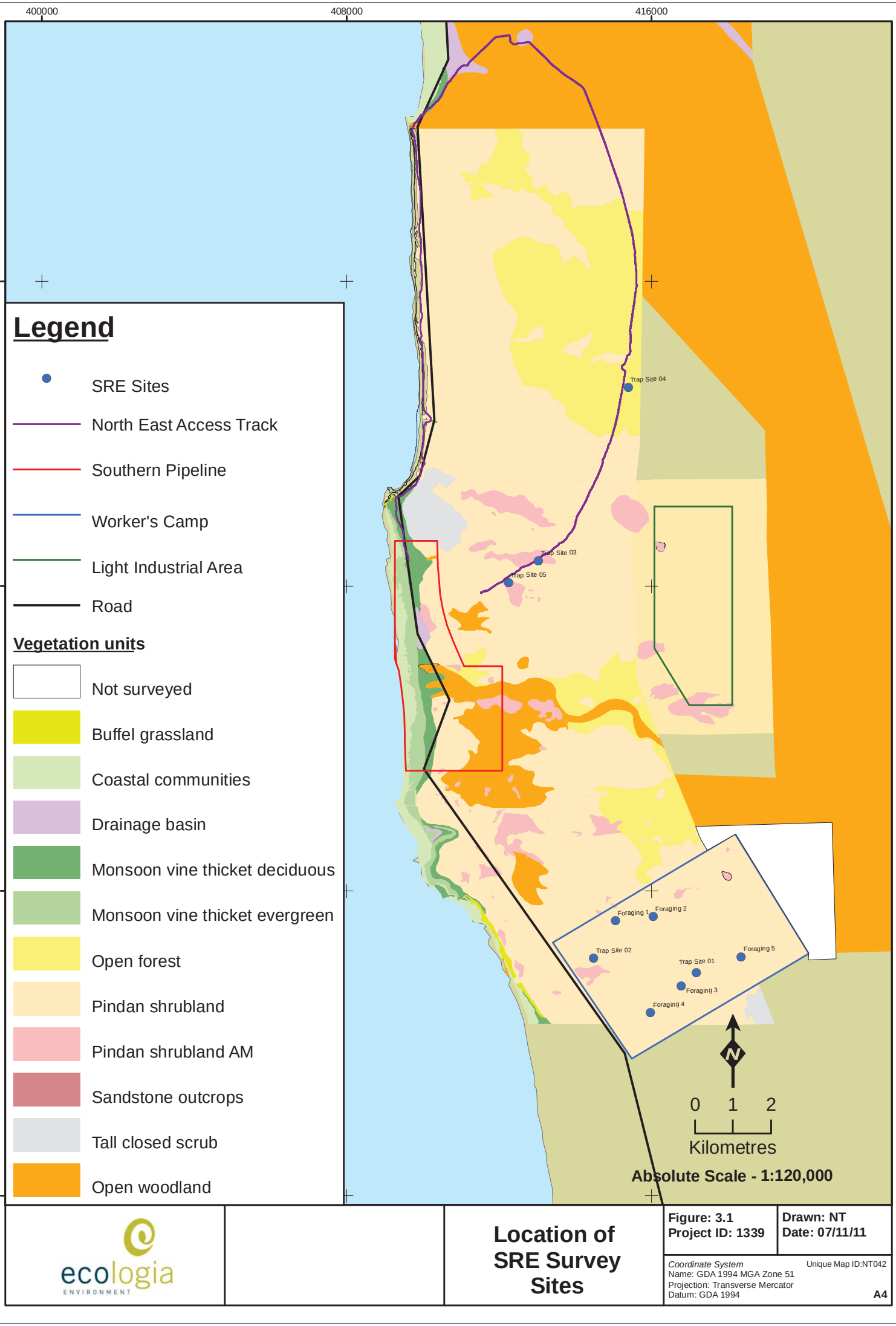
Woodside was reached prior to the survey to undertake systematic trapping in similar representative habitat as present in the LIA (i.e. NEAT area). In addition, five sites within the proposed WAC were surveyed by opportunistic foraging. No sites were surveyed within the SP due to logistical constraints. The locations of sites are provided in Table 3.5 and site habitat descriptions are provided in Appendix B.

Previous SRE sampling sites surveyed by Biota (2011) are shown in Figure 3.2. These sites were predominantly found in the coastal communities and Monsoon Vine Thicket (both evergreen and deciduous) in the Southern Pipeline Survey area, with several sites located to the north of JPP, and one site located south of Quandong point in Pindan Shrubland.

Table 3.5 – Location of Ecologia SRE Survey Sites.

Site Name	Survey Type	Coordinates		Fauna Habitat	Vegetation Association	Land System
		Easting	Northing			
Invertebrate Trap Site 01	WAC	417173	8053876	Pindan Shrubland	750	Yeeda
Invertebrate Trap Site 02	WAC	414487	8054235	Pindan Shrubland	750	Yeeda
Invertebrate Trap Site 03	LIA	413039	8064674	Pindan Shrubland	750	Yeeda
Invertebrate Trap Site 04	LIA	415397	8069240	Open Forest	750	Wanganut
Invertebrate Trap Site 05	LIA	412254	8064097	Pindan Shrubland	750	Wanganut
Invertebrate Forage 01	WAC	415056	8055230	Pindan Shrubland	750	Yeeda
Invertebrate Forage 02	WAC	416043	8055330	Pindan Shrubland	750	Yeeda
Invertebrate Forage 03	WAC	416786	8053511	Pindan Shrubland	750	Yeeda
Invertebrate Forage 04	WAC	415975	8052814	Pindan Shrubland	750	Yeeda
Invertebrate Forage 05	WAC	418359	8054286	Pindan Shrubland	750	Yeeda

Datum: WGS84
Zone: 51K



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Location of SRE Survey Sites

Figure: 3.1
Project ID: 1339

Drawn: NT
Date: 07/11/11

Coordinate System
Name: GDA 1994 MGA Zone 51
Projection: Transverse Mercator
Datum: GDA 1994

Unique Map ID:NT042

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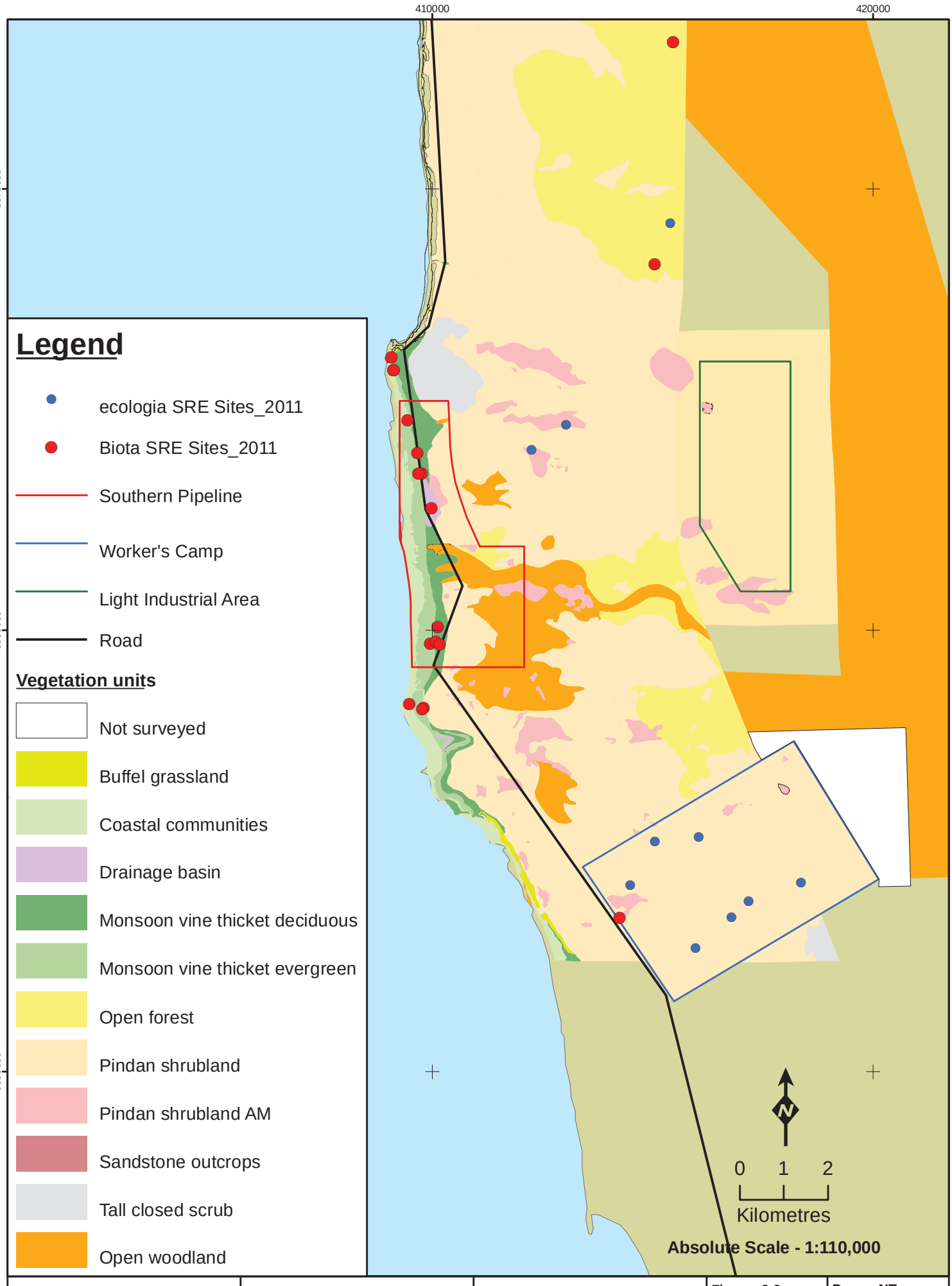

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Previous SRE Survey Sites (Biota 2011)

Figure: 3.2
Project ID: 1339

Drawn:NT
Date: 07/11/11

Coordinate System
Name: GDA 1994 MGA Zone 51
Projection: Transverse Mercator
Datum: GDA 1994

Unique Map ID:NT043

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3.5 SAMPLING METHODS

The survey methods adopted by *ecologia* are aligned with the EPA Guidance Statement No. 20 (EPA 2009) and Position Statement No. 3 (EPA 2002).

The survey was undertaken using a variety of sampling techniques, both systematic and opportunistic. Systematic sampling refers to data methodically collected over a fixed time period in a discrete habitat type, using an equal or standardised sampling effort. The resulting information can be analysed statistically, facilitating comparisons between habitats. Opportunistic sampling includes data collected non-systematically from both fixed sampling sites and as opportunistic records gathered during foraging sessions.

3.5.1 Systematic Sampling

3.5.1.1 Dry Pitfall Trapping

A battery of dry-pitfall traps were deployed at each sampling site. Within the WAC area, each battery consisted of fifty traps arranged in rows of five across the selected site. Within the LIA area, each battery consisted of twenty five traps arranged in rows of five. The traps were plastic jars, 85 mm high x 63 mm in diameter, and were dug into the ground so that the top edge of the container was level with the soil surface (Figure 3.3).

The traps were left out for five nights for the duration of the survey, at the end of which they were removed. The traps were cleared each morning and any potential SRE specimens were collected and placed in individual vials containing absolute ethanol.

Figure 3.3 – Dry Pitfall Trap at Invertebrate Site 03

3.5.1.2 Leaf Litter Collection

At each site, 5 m^2 of leaf-litter was collected and placed in Winkler sacks for 48 hours (1 m^2 per Winkler sack) with collection vials at the base (Figure 3.4). Vials were removed after 48 hours and

sent to Perth for sorting and identification. Furthermore, 3 m^2 of leaf litter was sifted in the field using a graduated geo-sieve. Any invertebrate fauna specimens collected were placed in vials containing absolute ethanol and returned to *ecologia*'s Perth laboratory for sorting and identification.

Figure 3.4 – Example of Winkler Sacs in Use (courtesy of J. Majer)

3.5.2 Opportunistic Data

Opportunistic foraging was undertaken at additional five sites within the WAC. This involved physically searching through microhabitats for SRE invertebrates, paying particular attention to the underside of rocks and logs. Snail shells and trapdoor spiders were collected and their location documented.

3.5.3 Laboratory Sorting and Specimen Identification

All specimens, whether from foraging or pitfall traps, were examined under a Stereo microscope and sorted into related groups. These specimens were labelled with the project name, site number, GPS coordinates, the collection trap number or leaf-litter sift number and the collector names. The invertebrate fauna specimens were sent to the relevant taxonomic expert for further identification. Table 3.6 shows the list of taxonomic specialists used for identification and experience of staff involved in the survey.

Table 3.6 – Experience and Qualifications of Taxonomic Experts and Field Staff Involved During the Survey

	Institution	Relevant Experience
Corey Whisson	Western Australian Museum	Taxonomic expert in molluscs
Dr Erich Volschenk	Private consultant	Taxonomic expert in scorpions
Dr Mark Harvey	Western Australian Museum	Taxonomic expert in pseudoscorpions and myriapods
Shirley Slack-Smith	Western Australian Museum	Taxonomic expert in molluscs
Dr Simon Judd	Private consultant	Taxonomic expert in isopods
Dr Volker Framenau	Western Australian Museum	Taxonomic expert in mygalomorph spiders
Laura Quinn (MSc)	*ecologia* field staff	>3 years experience with SRE invertebrates
Sean White (BSc)	*ecologia* field staff	>7 years experience with terrestrial invertebrates

3.6 SRE STATUS

The likelihood of the invertebrate species to be considered a SRE or not a SRE was determined by expert taxonomists (Mark Harvey, Department of Terrestrial Invertebrates, WAM; Shirley Slack-Smith and Corey Whisson, Department of Malacology; Volker Framenau, private consultant, Erich Volschenk, private consultant and Simon Judd, private consultant) based on the current knowledge of the distribution and biology of each species, as follows:

- No – Not considered a SRE
- Confirmed – Current knowledge confirms that this species is a SRE
- Likely – Current knowledge suggests this species is probably a SRE. However, further research is required to confirm status.
- Potential – Current knowledge of this species or group is very limited, however, there is the potential for this species to represent a SRE. Further research is required to confirm status.

In cases where the SRE status of species could not be determined due to juvenile stage of the specimens or a lack of taxonomic knowledge, the term 'undetermined' has been used.

3.7 CONSERVATION SIGNIFICANT FAUNA

Fauna species that have been formally recognised as rare, threatened with extinction, or as having high conservation value are protected by law under Commonwealth and State legislation. At the national level, fauna are protected under the EPBC Act. Within WA, rare fauna are listed under the Western Australian WC Act 1950: Wildlife Conservation (Specially Protected Fauna) Notice 2010.

Schedule 1 of the Commonwealth EPBC Act 1999 contains a list of species that are considered Critically Endangered, Endangered, Vulnerable, Extinct, Extinct in the wild and Conservation Dependent (Appendix A).

Classification of rare and endangered fauna under the WA Wildlife Conservation (Specially Protected Fauna) Notice 2010 of the WC Act recognises four distinct schedules. In addition, DEC maintains a Priority Fauna list which includes those removed from the WC Act and other species known from only a few populations or in need of monitoring. Five Priority Codes are recognised.

There are over 50 listed invertebrate species recorded in the Kimberley area, all of which belong to order Mollusca (snails). The species names are given in Appendix D.

3.8 SURVEY EFFORT

Survey effort expended within the survey area included the following:

- traps were open for a combined total of 875 trap-nights;
- thirteen person hours spent foraging in the vicinity of all five trapping sites;
- thirteen person hours spent collecting and sieving leaf litter from each trapping site; and
- three person hours spent opportunistically foraging within the WAC area.

Total survey effort is presented in Table 3.7.

Table 3.7 - Survey Effort

Site	Dry Trap Nights	Collecting Leaf Litter Samples (person hours)	Foraging (person hours)	Opportunistic Foraging (person hours)
Invertebrate Trap Site 01	250	6	3.5	n/a
Invertebrate Trap Site 02	250	6	3.5	n/a
Invertebrate Trap Site 03	125	7	6	n/a
Invertebrate Trap Site 04	125	7	6	n/a
Invertebrate Trap Site 05	125	7	6	n/a
Invertebrate Forage 01	n/a	n/a	n/a	0.5
Invertebrate Forage 02	n/a	n/a	n/a	0.5
Invertebrate Forage 03	n/a	n/a	n/a	0.5
Invertebrate Forage 04	n/a	n/a	n/a	0.5
Invertebrate Forage 05	n/a	n/a	n/a	1

3.9 DATA ANALYSIS

3.9.1 Survey Adequacy

There are three general methods of estimating species richness from sample data: extrapolating species-accumulation curves (SAC), fitting parametric models of relative abundance, and using non-parametric estimators (Bunge and Fitzpatrick 1993; Colwell and Coddington 1994; Gaston 1996). In this report, the level of survey adequacy was estimated using the rarefaction of SACs as computed by Mao Tao estimator. In addition, the following species richness estimators: ACE, ICE, Chao-1, Jacknife-1, Jacknife-2, Bootstrap and their 95% confidence limits were calculated. Finally, a Michaelis-Menten enzyme kinetic curve was calculated and used as a stopping rule technique. To eliminate features caused by random or periodic temporal variation, the sample order was randomised 50 times. The estimators applied to the data set were performed using EstimateS (version 8, Colwell 2009).

3.9.2 Habitat Assessment

Habitat types reflect vegetation, underlying geology, soil, surface hydrology and position in the landscape, and provide a reasonable surrogate of habitat parameters in respect to SREs. Importantly, variability of habitats has been linked strongly with invertebrate species richness and thus the classification and distribution of habitat types in the landscape, and the species utilising them, provides critical information on species distribution.

Previous surveys conducted in the project area (Biota 2011) recorded potential SRE groups from the following habitats:

- Pindan Shrubland;
- Open Forest; and
- Monsoon Vine Thicket.

Statistical analyses were carried out on a combined data set from the Biota and *ecologia* surveys. Raw data were log + 1 transformed in order to reduce the influence of the high and low magnitude variables (e.g. highly abundant species). Differences between habitat types and species richness were tested with a one-way ANOVAs. Prior to undetaking the ANOVA, tests of normality (Anderson – Darling) and homogeneity (Barlett's and Levene) were performed in order to determine if the data set conforms with the *a-priori* assumptions required for this type on analysis.

To analyse differences in species diversity between habitats, a Euclidean similarity measure was calculated for each pairwise site comparison followed by a non-metric multidimensional scaling (MDS) of similarity matrix. Stress values below 0.20 were considered to indicate a good fit of the scaling to the matrix. The dimensions that reduced the majority of the "raw stress" were chosen for the final scaling. In addition, to test whether the differences in species diversity between habitat types were significant, analyses of similarity (ANOSIM) (Clarke 1993) comparisons were made using the one-way ANOSIM function in the PAST software package (Hammer *et al.* 2001). ANOSIM was calculated using the Bray-Curtis Similarity Index with 999 permutations. Bray Curtis is a widely used and well-tested index for incidence data.

3.10 SURVEY TEAM

Field survey team members are listed in Table 3.8. The survey was conducted under DEC Regulation 17 Scientific Licence SF008017.

Table 3.8 - Survey Personnel

Survey Member	Qualification	Experience
Dr Lazaro Roque-Albelo	BSc, MSc, PhD, Principal Zoologist	>25 years
Dr Magdalena Davis	BSc, MSc, PhD, Manager Invertebrate Sciences	>10 years
Laura Quinn	BSc, MSc , Invertebrate Zoologist	>3 years
Sean White	BSc, Invertebrate Zoologist	>7 years

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4 RESULTS

4.1 LITERATURE REVIEW

4.1.1 Summary From Previous Surveys

Twelve potential SRE species were collected in vicinity of the project area by Biota (2009, 2011). The taxa were collected from three habitat types (Pindan Shrubland, Open Forrest and Monsoon Vine Thicket) and are listed below:

1. *Aname* 'MYG 231' (Pindan shrubland, Monsoon Vine Thicket)
2. *?Aganippe* sp. (Pindan shrubland)
3. *Synothele* 'MYG179' (Pindan shrubland)
4. *Conothele* sp. (Pindan shrubland, Monsoon Vine Thicket)
5. *Missulena* sp. (Pindan shrubland, Monsoon Vine Thicket)
6. *Euryolpium* sp. (unknown habitat)
7. *Urodacus* 'rugosus' (Pindan shrubland, Monsoon Vine Thicket)
8. *Urodacus* 'JP' (Pindan shrubland)
9. Pachybolidae millipede (Monsoon Vine Thicket)
10. *Rhagada bulgana* (Pindan Shrubland, Open Forrest and Monsoon Vine Thicket)
11. *Quistrachia leptogramma* (Pindan Shrubland, Open Forrest and Monsoon Vine Thicket)
12. *Pilbarascutigera incola* (Pindan shrubland)

None of the species was reported as restricted to the project area (Biota 2009, 2011).

No species listed under the EPBC Act, WC Act and/or DEC list have been recorded within, or close to, the project area during previous surveys (Biota 2009, 2011).

4.1.2 Taxonomic Groups Likely to Support Short Range Endemism in the Kimberley region

4.1.2.1 Arachnids (Phylum: Arthropoda, Sub Class: Arachnida)

Four orders of arachnids can exhibit short range endemism: Pseudoscorpiones (false scorpions), Scorpiones (true scorpions), Schizomida (short-tailed whip spiders) and Araneae (i.e. Infraorder: Mygalomorphae or trap-door spiders). Many mygalomorph trap-door spider species are vulnerable to disturbance and exhibit short range endemism due to their limited ability to disperse. These spiders also have extreme longevity and the long-term persistence of females in a single burrow (Raven 1982). Mygalomorph spiders are largely considered 'old world' spiders and, as such, are generally adapted to past climatic regimes making them vulnerable to desiccation in arid environments. They use a variety of behavioural techniques to avoid desiccation, the most obvious of which is their burrow, which may reach up to 70 cm in depth (Main 1982). Mygalomorph groups are thus capable

of surviving on the periphery of the great central desert region and minor habitats within the general arid regions of the continent. Previous surveys in the James Price Point area have identified mygalomorph spider taxa from the genera *Missulena*, *Synothele*, *Conothele*, *Aganippe* and *Aname*. None of the species/taxa has been formally described, however, and their SRE status is currently unknown (Biota 2011).

Another member of the arachnid class, the Schizomida, is currently known to be composed entirely of SREs, with most recorded from single localities (Harvey 2002). Forty-six schizomid species have been described in northern Australia. Most are known to occur in the entrances to and inside caves, while the remainder occur in nearby habitats (Harvey 2002). Epigean schizomid taxa are known to occur in the Kimberley region (Harvey 1991).

Scorpions and pseudoscorpions also exhibit high degrees of endemism (Koch 1981; Harvey 1996) and both groups occur in the Kimberley region (Harvey 1991). Previous surveys in the area collected a pseudoscorpion species from the genus *Euryolpium*, with an unknown but unlikely SRE status, and two species of scorpions, *Urodacus* 'rugosus' (confirmed SRE) and *Urodacus* sp. (potential SRE) (Biota 2011).

4.1.2.2 Millipedes and Centipedes (Phylum Arthropoda, Class Myriapoda)

Despite millipedes being highly abundant in soil and leaf litter and highly diverse at the order level, they are inadequately studied and relatively little is known of their biogeography (Harvey 2002). Spirobolid millipedes are known to occur in the Kimberley region – previous surveys collected specimens from the family Pachybolidae (SRE status unknown) (Biota 2011).

Centipedes are not listed by Harvey (2002) as SRE species; however they have been shown to be endemic to small areas on the eastern coast of Australia (Edgecombe *et al.* 2002). Examination of the distributions of species featured in the CSIRO centipede webpage also reveals disjunct and isolated occurrences of many species. A number of genera have Pangaean and Gondwanan affinities (Edgecombe *et al.* 2002). In general, these animals have a relatively cryptic biology, preferring moist habitats in deep litter accumulations, under rocks and in rotting logs, and they have relatively poor dispersal abilities (Lewis 1981). This suggests that they are potential candidates for designation as SREs. Members of the order geophilomorpha have been especially considered as possible SRE species due to their small size and cryptic biology. Previous surveys in the area collected a centipede species *Pilbarascutigera incola*, which is not an SRE species (Biota 2011).

4.1.2.3 Isopods (Phyllum: Arthropoda, Class Crustacea)

There are currently around 10,215 described species of isopod worldwide classified into 11 suborders. However, little understanding of the taxonomy of Australian isopod genera currently exists (Brusca and Brusca 2003; Judd *et al.* 2008). Numerous species of terrestrial and subterranean isopods belonging to several different genera have been identified in Western Australia with several genera containing known and potential SREs including *Pseudolaureola*, *Buddenlundia, Cubaris* and Platyarthridae (Judd 2009, 2010; Judd 2011). SRE isopods have been collected from the Pilbara and Kimberely regions of Western Australia (Judd *et al.* 2008). Many species have Gondwanan affinities suggesting that relictual habitats originating from much wetter climate periods persist across the State (Main 1987). Due to a lack of taxonomic knowledge and paucity of data, the precise distributions of each species is unknown and more taxonomic work at species level is required before the status of individual populations can be ascertained.

4.1.2.4 Molluscs (Phylum: Mollusca)

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

Some species of the terrestrial snail genera *Rhagada* and *Quistrachia* are known to be SREs. Species of these genera have been recorded within the Kimberley region with some occurring in areas close to the project area (Johnson 2010). Previous surveys collected two species of land snails - *Quistrachia leptogramma* and *Rhagada bulgana* (Biota 2011). Phylogenetic studies of these land snails concluded that they are not SREs unique to the James Price Point coastal area (Johnston 2010).

4.1.2.5 Worms (Phylum: Annelida & Onychophora)

The taxonomic status of the earthworm family, Megascolecidae, in Western Australia was revised by Jamieson in 1971. As a result of this study, it was concluded that most of the earthworm genera are made up almost entirely of SREs (Harvey 2002). This is also the case with the velvet worms (Onychophorans). Due to several taxonomic revisions that have been conducted (see references within Harvey, 2002), the number of onychophoran species has expanded from six to over 70 species, and a number of species still remain undescribed (Harvey 2002). Very few of these species have a known range that exceeds 200 km^2 and some are restricted to single localities and have high genetic differentiation, indicating very little mobility and dependence on their permanently moist habitats (Harvey 2002). Both groups are known from the tropical areas of the Kimberley region (McKenzie 1991)

4.2 SURVEY RESULTS

4.2.1 Specimens collected

A total of 78 invertebrate specimens were collected during the survey. These individuals represented seven orders, eight families, 12 genera and at least 15 species of invertebrates (Table 4.1). The taxonomy, distribution and SRE status of these genera are discussed in the following sections.

As typical in SRE surveys, six species were recorded in low abundance, being represented only by singletons (one record each, two taxa) and / or doubletons (two records each, four taxa) (Figure 4.1). Rarity of fauna species presents difficulties in determining their distribution across the area.

When compared with specimens collected during the 2011 Biota survey (Figure 4.2), similarities exist between number of species collected (i.e low numbers of spiders and scorpions, higher numbers of snails). Both surveys recorded scorpions from the genus *Urodacus*, spiders from the genus *Aname*, pseudoscorpions from the genus *Euryolpium*, and snails *Rhagada* and *Quistrachia, w*hereas the ecologia 2011 survey recorded scorpions from the genus *Lychas* and pseudoscorpions *Beierolpium*, *Indolpium* and *Austrohorus*, the isopod *Buddelundia*, and harvestman *Dampertrus*, that were not previously recorded from the Biota survey. The previous Biota survey also yielded several species of

mygalomorph spider that were not collected during the 2011 survey (e.g. *Missulena, Conothele, Synothele*).

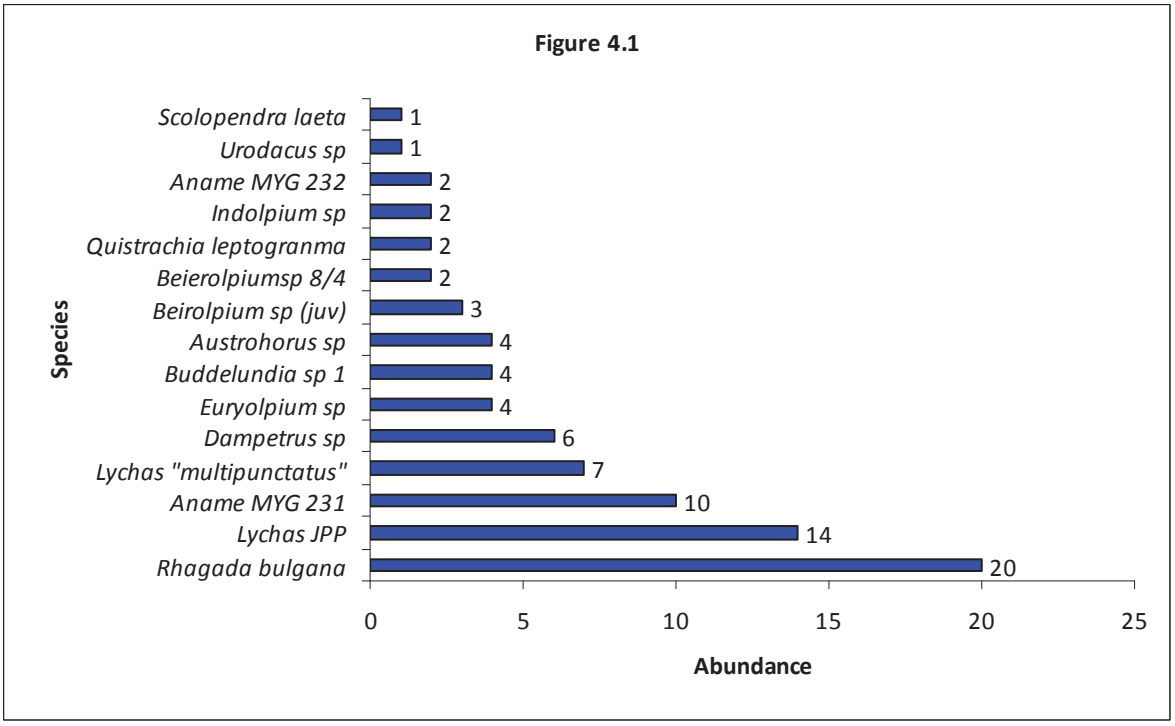


Figure 4.1 – Abundance Histogram of potential SRE Groups (Ecologia 2011 data).

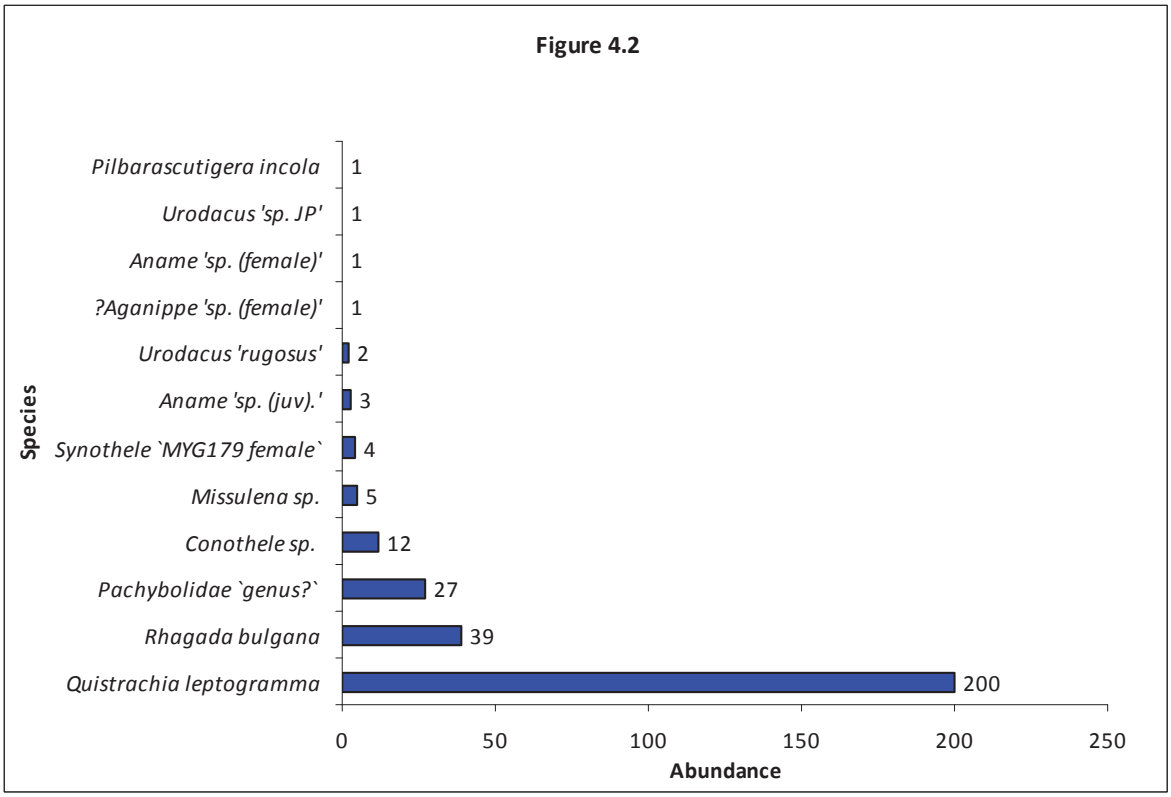


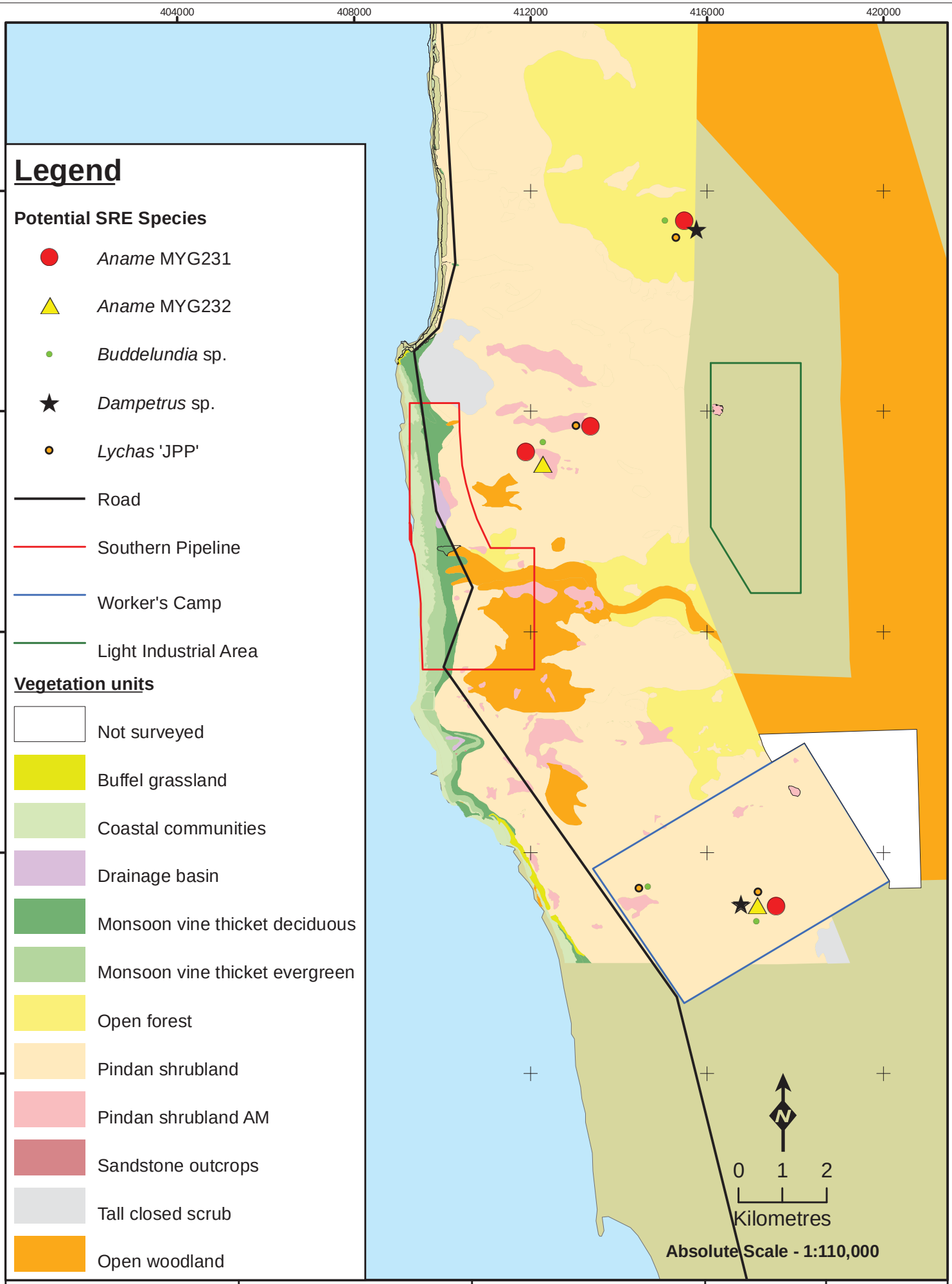
Figure 4.2 – Abundance Histogram of Potential SRE Groups Collected During Biota Survey (2011).

Table 4.1– Summary of Invertebrate Fauna Specimens Collected During Ecologia Survey 2011

Taxa					Trap Site						Foraging Site					
Class (Order)	**Family**	**Genus**	**Species**	**SRE**	**1**	**2**	**3**	**4**	**5**		**1**	**2**	**3**	**4**	**5**	**Total no of specimens**
Arachnida (Aranae)																
Mygalomorphae	Nemesiidae	***Aname***	**MYG231**	**potential**	1	0	1	4	4		0	0	0	0	0	10
		Aname	**MYG232**	**potential**	1	0	0	0	1		0	0	0	0	0	2
Arachnida (Opiliones)																
Opiliones	Assamiidae	***Dampetrus***	**sp.**	**potential**	1	0	0	5	0		0	0	0	0	0	6
Arachnida (Scorpiones)																
Scorpiones	Buthidae	*Lychas*	multipunctatus	no	3	1	2	0	1		0	0	0	0	0	7
		Lychas	**JPP'**	**potential**	7	2	2	3	0		0	0	0	0	0	14
	Urodacidae	*Urodacus*	sp. Indet	undetermined	0	0	0	1	0		0	0	0	0	0	1
Arachnida (Pseudoscorpiones)																
Pseudoscorpiones	Opiidae	*Austrohorus*	sp.	undetermined	3	1	0	0	0		0	0	0	0	0	4
		Beierolpium	sp. 8/4'	undetermined	0	0	0	1	1		0	0	0	0	0	2
		Beierolpium	sp. (juv)'	undetermined	0	1	1	0	1		0	0	0	0	0	3
		Euryolpium	sp	undetermined	0	0	4	0	0		0	0	0	0	0	4
		Indolpium	sp	undetermined	0	0	1	0	1		0	0	0	0	0	2
Mollusca																
Gastropoda	Camaenidae	*Rhagada*	*bulgana*	no	4	1	0	0	0		0	0	2	7	6	20
		Quistrachia	*leptogramma*	no	0	1	0	0	0		0	0	0	0	1	2
Crustacea																
Isopoda	Armadillidae	***Buddelundia***	**sp.1**	**potential**	1	1	0	1	1		0	0	0	0	0	4
Myriapoda (Chilopoda)																
Geophilomorpha	Scolopendridae	*Scolopendra*	*laeta*	no	0	1	0	0	0		0	0	0	0	0	1

Table 4.2 – Summary of Specimens Collected During Previous Survey Biota 2011

Class (Order)				SRE Survey Sites																	
Family	Genus	Species	SRE	JPPSRE02	JPPSRE03	JPPSRE04	JPPSRE05	JPPSRE06	JPPSRE07	JPPSRE08	JPPSRE10	JPPSRE11	JPPSRE13	JPP01A	JPP10A	JPP15A	JPP18A	JPP105	JPP113	JPP114	QU Sites	OPP
Arachnida (Aranae)																					
Actinopodidae	*Missulena*	sp. (female) and (Juv)	Potential		2						1									2		
Barychelidae	*Synothele*	MYG179'	Potential							3			1	1								
Ctenizidae	*Conothele*	sp. 1 (female)	Potential		3		1				2	1		1						2		
Ctenizidae	*Conothele*	sp. (juv. sp. 1)	Potential					1														
Ctenizidae	*Conothele*	sp. (juv. sp. 2)	Potential		1			1														
Ctenizidae	*Conothele*	sp. 2 (female)	Potential				1															
Idiopidae	*?Aganippe*	sp. (female)	Potential										1									
Nemesiidae	*Aname*	MYG231'	Potential				1					1	1	2								
Arachnida (Scorpiones)																						
Urodacidae	*Urodacus*	rugosa'	Potential												1	1						
Urodacidae	*Urodacus*	sp. JP'	Potential													1						
Arachnida (Pseudoscorpiones)																						
Olpiidae	*Euryolpium*		No																			1
Diplopoda (Millipedes)																						
Pachybolidae	*genus?'*	sp. (female)'	Potential		2		3	5							2					2		
Pachybolidae	*genus?'*	sp. (Juv)'	Potential		1			2		5					2					3		
Chilopoda (Centipedes)																						
Scutigeridae	*Pilbarascutigera*	*incola*	Potential											1								
Gastropoda (Snails)																						
Camaenidae	*Quistrachia*	*leptogramma*	Potential	15	40	2			14	1	2				10		49	7	4		56	
Camaenidae	*Rhagada*	bulgana	Potential											1			33				5	



ecologia ENVIRONMENT

Location of SRE Species

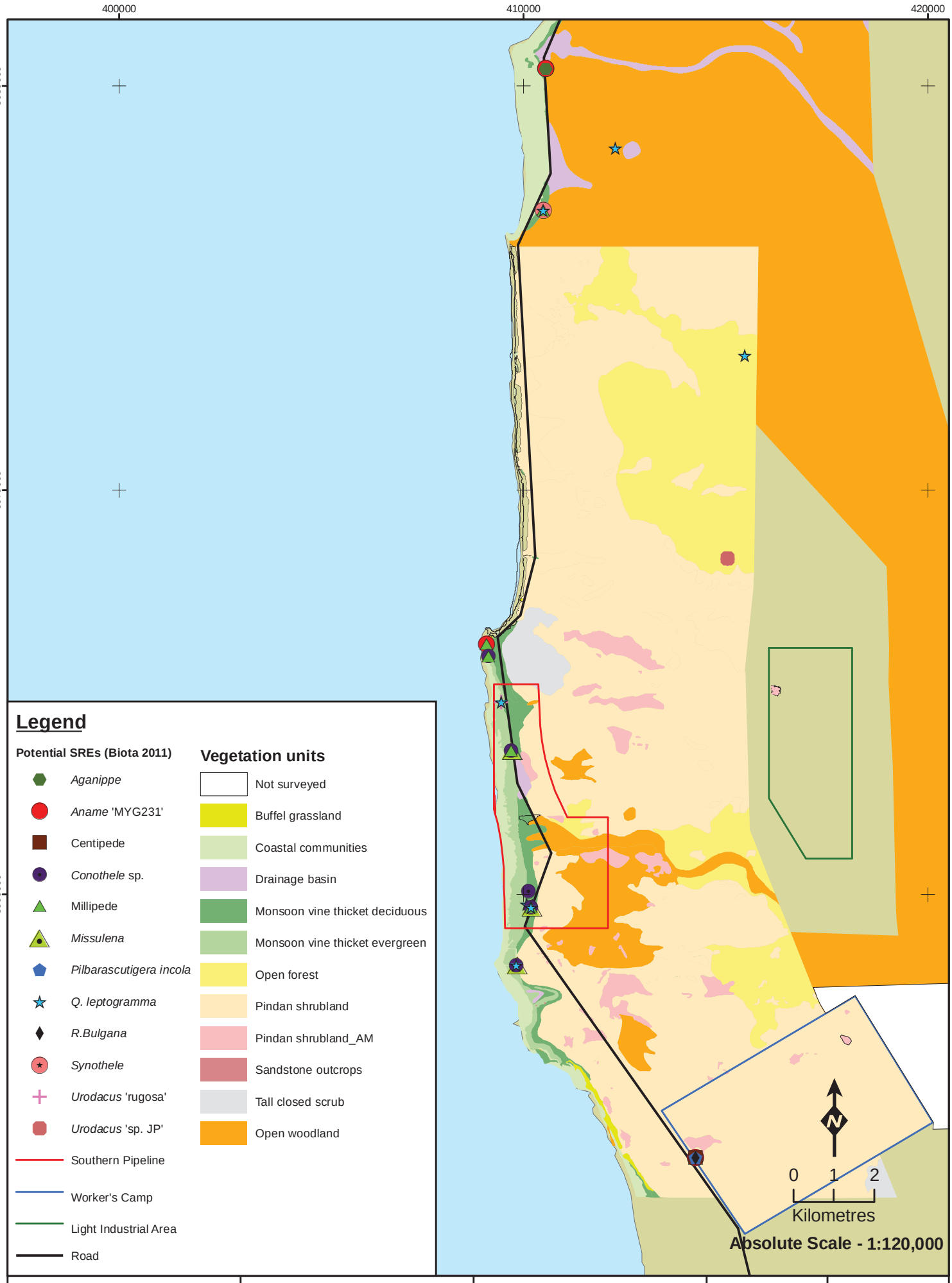
Figure: 4.3
Project ID: 1339

Drawn:NT
Date: 07/11/11

Coordinate System
Name: GDA 1994 MGA Zone 51
Projection: Transverse Mercator
Datum: GDA 1994

Unique Map ID:NT044

A4



ecologia ENVIRONMENT

Biota 2011 SRE Species Locations

Figure: 4.4
Project ID: 1339

Drawn:NT
Date: 07/11/11

Coordinate System
Name: GDA 1994 MGA Zone 51
Projection: Transverse Mercator
Datum: GDA 1994

Unique Map ID:NT045

A4

4.2.2 Trapdoor Spiders: Mygalomorphae

Twelve specimens of trapdoor spider were collected, representing two species from the family Nemesiidae. Both species have been collected from within the proposed WAC and adjacent to the LIA area (Figure 4.3).

Family Nemesiidae

Genus *Aname*

The genus *Aname* currently includes 33 named species in Australia, and is well represented by four named, and numerous unnamed species from many different regions in Western Australia. Members of this genus are believed to be most common in sclerophyll forest, but are also known from rainforests and deserts (Raven 1981). *Aname* regularly belongs to the most diverse mygalomorph genera found during biological spider surveys. Many *Aname* species appear to have limited distributions (Raven 1985).

***Aname* 'MYG231'**

Ten specimens were collected from Trap Site 01 within the proposed WAC, and Trap Sites 03, 04 and 05 within the proposed LIA. This morphospecies is likely to be conspecific with the species *Aname* sp. previously collected within the project area by Biota (2011), however DNA study is required to confirm this as no mature male specimens for identification were available from the Biota survey. This is a medium sized spider with a curved embolus (Figure 4.5). Based on the incidence of short range endemism in *Aname* from northern Australia, this species is considered a **potential SRE**.

Figure 4.5 – Male Specimen of *Aname* 'MYG 231' - Potential SRE Species

***Aname* 'MYG232'**

Two specimens were collected from Trap Site 01 within the proposed WAC and Trap Site 05 within the proposed LIA. This is a comparatively small species of *Aname,* light in colour (Figure 4.6), and it has not been known previously from the WA Museum morphospecies collection. Based on the incidence of short range endemism in *Aname* from northern Australia, this species is considered a **potential SRE**.

Figure 4.6 – Male Specimen of *Aname* 'MYG 232' - Potential SRE Species

4.2.3 Scorpions: Scorpiones

A total of 22 scorpion specimens were collected from all trapping sites within the proposed WAC and LIA areas, representing two genera and two families.

Family Buthidae

***Lychas* 'JPP'**

A total of 14 specimens were collected from Trap Sites 01, 02 and 04. *Lychas* is a widespread genus across mainland Australia, however, a small number of species have restricted distributions. *Lychas* 'JPP' is a distinct morphospecies from any previously collected species (Figure 4.7) and is only known from these 13 specimens. As such, it is a **potential SRE species**.

Figure 4.7 - Male Specimen of *Lychas* 'JPP'- Potential SRE Species

Lychas 'multipunctatus'

Seven specimens were collected from Trap Sites 01, 02, 03 and 05. *Lychas* is a widespread genus across mainland Australia. Although a small number of species have restricted distributions, *Lychas* 'multipunctatus' is widely recorded throughout the Pilbara region (Figure 4.8) and thus **it is not a SRE species**.

Figure 4.8 - Female Specimen of *Lychas* 'multipunctatus'

Family Urodacidae

***Urodacus* sp.**

A single juvenile specimen was collected from the Trap Site 04. The genus *Urodacus* is the most diverse in Western Australia and contains both widespread and SRE species. As the specimen was a juvenile, identification could not be completed and thus the **SRE status of this species is undetermined**.

4.2.4 Pseudoscorpions: Pseudoscorpiones

A total of 15 pseudoscorpion specimens were collected within the proposed WAC and LIA areas from leaf litter at Trap Sites 01 – 05, representing four genera from a single family.

Family Olpiidae

***Austrohorus* sp.**

Four specimens were collected from Trap Sites 01 and 02. This species appears similar to other *Austrohorus* from Western Australia (Figure 4.9). However, due to current lack of taxonomic knowledge, identification could not be completed and thus the **SRE status of this species is undetermined**.

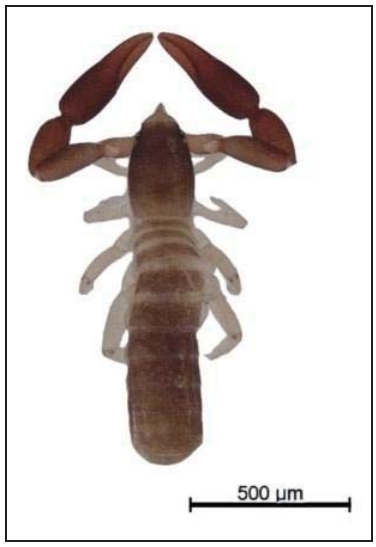


Figure 4.9 - Male Specimen of *Austrohorus* sp.

***Beierolpium* sp.**

Three specimens were collected from Trap Sites 02, 03 and 05. As these specimens were juveniles (Figure 4.9), identification could not be completed and thus the **SRE status of this species is undetermined**.

Figure 4.10 – Juvenile Specimen of *Beierolpium* sp.

***Beierolpium* 'sp. 8/4'**

Two specimens were collected from Trap Sites 04 and 05. The '8/4' representation refers to the number of sensory hairs on the fixed and movable fingers of adults, which may be a feature distinct to the species (Figure 4.11). However, due to current lack of taxonomic knowledge, identification could not be completed and thus the **SRE status of this species is undetermined**.

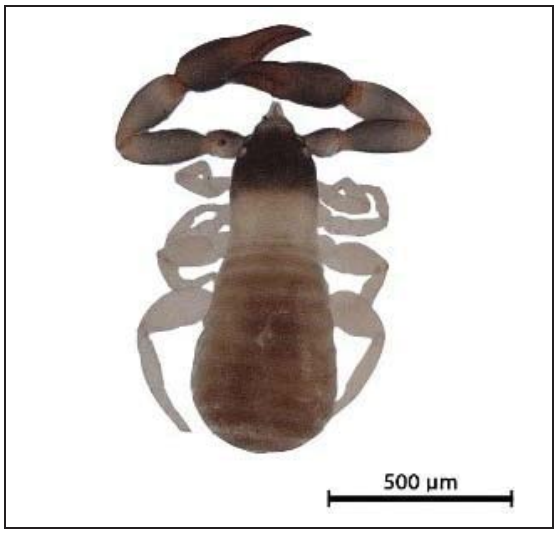


Figure 4.11 - Male Specimen of *Beierolpium* 'sp. 8/4'

***Euryolpium* sp.**

Four specimens were collected from Trap Site 03 (no image available). As these specimens were juveniles, identification could not be completed and thus the **SRE status of this species is undetermined**.

***Indolpium* sp.**

Two specimens were collected from Trap Sites 03 and 05 (no image available). Similar specimens have been collected in Western Australia, and thus these specimens are considered **not a SRE species.**

4.2.5 Snails: Gastropoda

A total of 22 snail specimens were collected within the proposed WAC area, representing two species from the family Camaenidae.

Family Camaenidae

Rhagada bulgana

A total of 20 specimens were collected from Trap Sites 01, 02 and Foraging sites 3, 4 and 5. While the known distribution of *R. bulgana* (Figure 4.12) is to the area between Quondong Point and the northern tip of the Dampierland Peninsula, the WAM experts expect the species to be found beyond this area (Slack-Smith and Whisson 2011). In addition, molecular taxonomy suggests that the species is synonymous with *R. cygna* in the north and *R. reigna* in the south of Dampierland (Johnson 2010). This indicates that, firstly, taxonomic revision is required, and, secondly, the species ranges extend beyond SRE definition. Thus, this is **not a SRE species**.

Figure 4.12 – Dead-taken Specimen of *Rhagada bulgana*

Quistrachia leptogramma

Two specimens were collected from Trap Site 02 and Foraging Site 5. *Quistrachia leptogramma* (Figure 4.13) has been found from Broome northwards to Cape Leveque, and other scattered records are known. The WAM experts thus consider it **not a SRE species** (Slack-Smith and Whisson 2011).

Figure 4.13 - Specimen of *Quistrachia leptogramma*

4.2.6 Harvestmen: Opiliones

***Dampetrus* sp.**

Six specimens of *Dampertrus* sp. (Figure 4.14) were collected within the proposed WAC and LIA areas from Trap Sites 01 and 03. It is possible that these specimens represent a SRE species, however, identification could not be completed due to a lack of taxonomic knowledge and thus the **SRE status of this species is undetermined**.

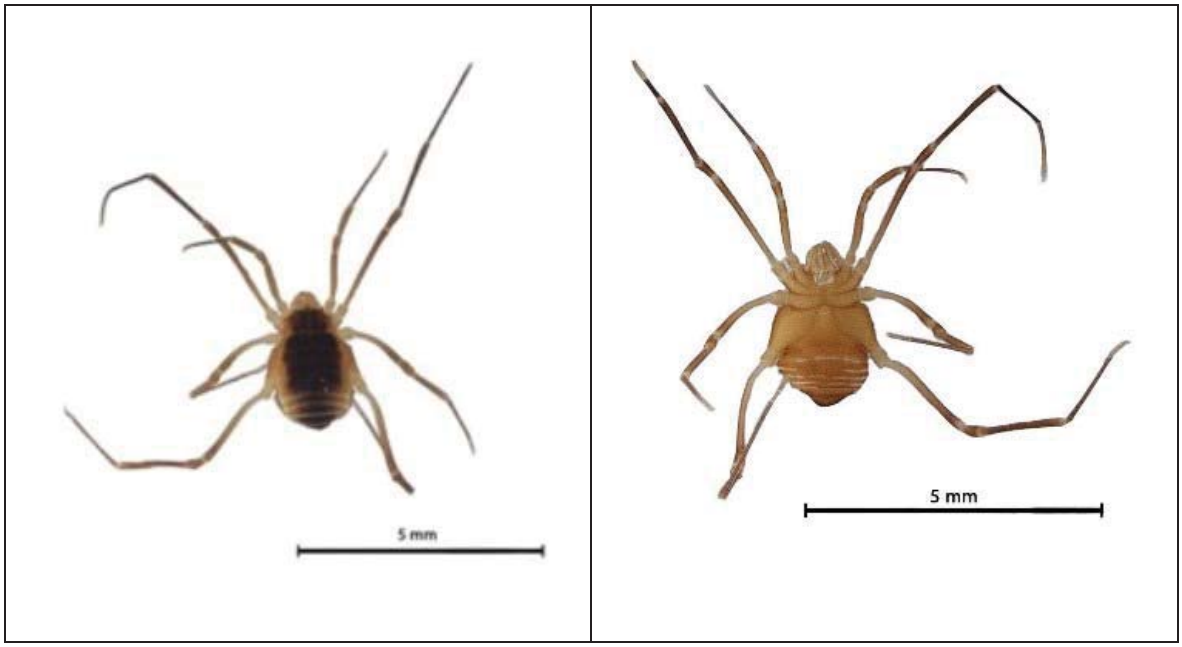


Figure 4.14 - Dorsal and Ventral Views of Specimen of *Dampetrus* sp.

4.2.7 Slaters: Isopoda

Family Armadillidae

Genus *Buddelundia*

As a generalisation based on known distributions of described species, *Buddelundia* species are not SREs as they tend to be habitat generalists with wide ranges quite common in WA's arid zones (A. Hosie, WAM, pers. comm. 17/6/2011). Exceptions will exist, however, such as species belonging to troglomorphic forms or *Buddelundia* sp.15 currently known only from the Hamersley Range (S. Judd, pers. comm.).

***Buddelundia* sp. 1**

A total of four isopod specimens were collected within the proposed WAC and LIA areas from Trap Sites 01, 02, 04 and 05, all belonging to the same species identified here as *Buddelundia* sp. 1 (no image available). The specimens present the first record of *Buddelundia* from Dampierland and there are currently no known records of this species elsewhere (A. Hosie, WAM, pers. comm. 17/6/2011). Although A. Hosie from WAM expects the species to have a significant range in arid areas of the Kimberley region and possibly the Pilbara, this species is currently considered a **potential SRE** due to lack of reference data.

4.2.8 Centipedes: Chilopoda, Geophilomorpha

Family Scolopendridae

Scolopendra laeta Haase, 1887

A single specimen was collected within the proposed WAC from Trap Site 02 (no image available). This species is very widespread and common in Western Australia and, therefore, it is **not a SRE**.

The list of all potential SRE species collected in the survey is given in Table 4.3, including habitat type in which they were collected.

Table 4.3 – Summary of Potential SRE Species Collected during the Survey

Species	SRE Status	Habitat	Collected in Previous Survey (Biota 2011)
Aname MYG 231	potential	Pindan Shrubland, Open Forest	Yes (Monsoon Vine thicket)
Aname MYG 232	potential	Pindan Shrubland	No
Dampetrus sp.	potential	Pindan Shrubland, Open Forest	No
Lychas 'JPP'	potential	Pindan Shrubland, Open Forest	No
Buddelundia sp.1	potential	Pindan Shrubland, Open Forest	No

4.3 HABITAT ASSESSMENT ANALYSIS

Six different habitats occur within the study area and three of these were sampled for SRE species (combined data of Biota 2011 and this survey). The results indicate that the Pindan Shrubland (21 species and 131 specimens) is the most abundant and diverse habitat, followed by the Open Forest (12 species and 85 specimens) and the Monsoon Vine Thicket habitat with six species and 106 specimens. All of these habitat types extend outside the proposed impact area. The five potential SRE species collected were present within the Pindan Shrubland habitat. *Aname* MYG 231 also occurred within Monsoon Vine Thicket (Biota 2011) and Open Forest. *Dampetrus* sp, *Buddelundia* sp. 1 and *Lychas* 'JPP' were also present in Open Forest (Table 4.3). However, according to the ANOVA test on the utilisation-availability data, there was no statistically significant difference between habitats types and species richness (F= 1.14, P=0.41, DF 14) and abundance (F= 0.85, P> 0.61, DF 14).

A multivariate one-way ANOSIM test showed no statistical difference in species assemblages among the three habitat types, Pindan Shrubland, Open Forest and Monsoon Vine Thicket (R= 0.14; P= 0.32; 999 permutations). Visual inspection of the ordination diagram did not reveal any clear pattern of sample grouping (Figure 4.15). It can be reasonably inferred that the invertebrate assemblage containing potential SRE groups identified in this study is not associated with specific habitat.

The outliers of the ordination diagram (i.e. ps2, ps4) show that some sampling points are significantly richer in species than others (Figure 4.15).

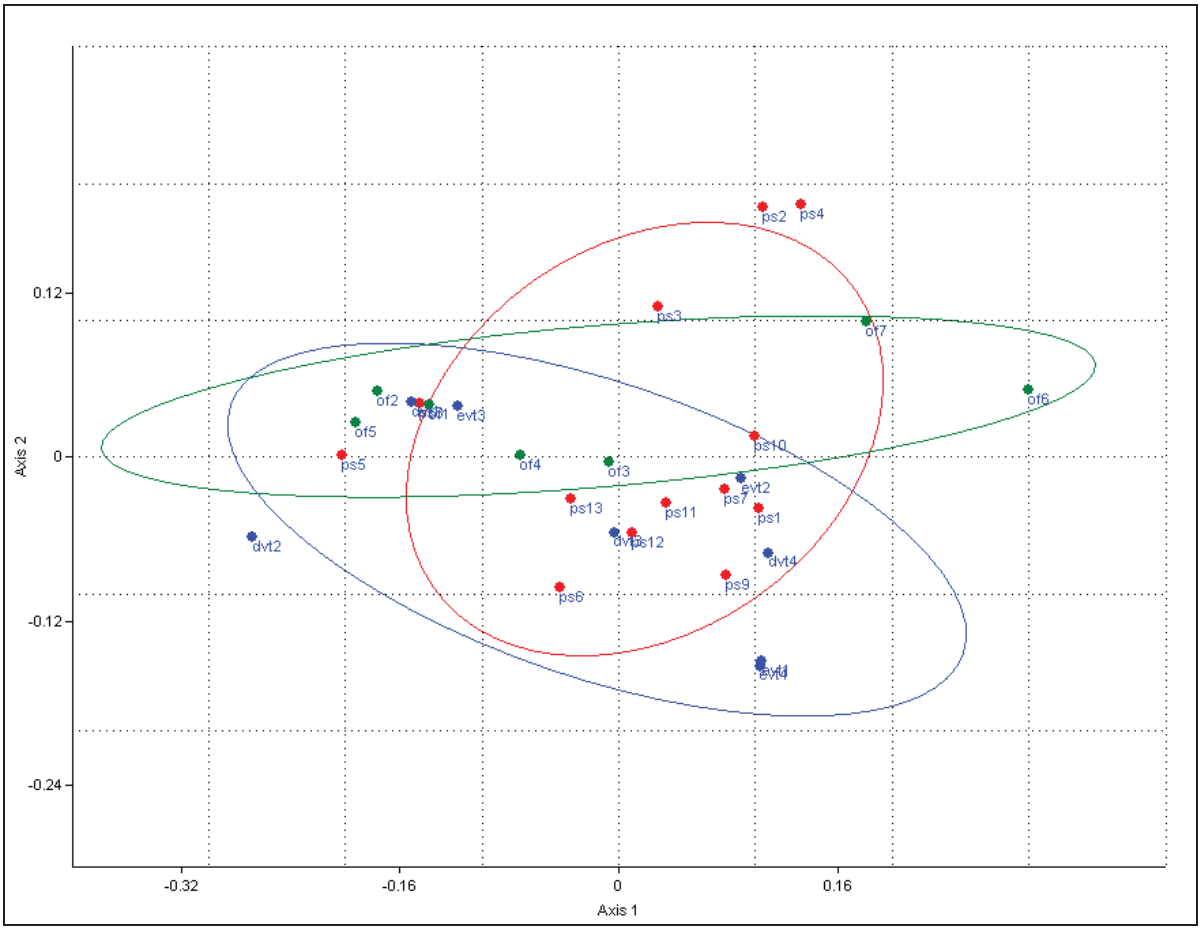


Figure 4.15 - Ordination Diagram of a Multivariate One-Way ANOSIM test, stress level = 0.09 (ps – Pindan Shrubland, of – Open Forest, evt & dvt – evergreen and deciduous Monsoon Vine Thicket)

4.4 SRE FAUNA HABITATS

Six different SRE fauna habitats were recorded within the survey area:

- Pindan Shrubland
- Coastal Communities
- Open woodland to open forest
- Monsoon Vine Thicket
- Drainage Basin
- Tall Closed Scrub

These habitats are detailed in Table 4.4 and described in greater detail below. One additional habitat was recorded previously in the vicinity, but did not occur inside the survey areas (Biota 2009):

- Coastal Heath

Table 4.4 – Amount Of Fauna Habitat In Survey Areas.

	Total Area in Vicinity of Survey Area* (km^2)	Area in Southern Pipeline (km^2)	Area in Workers Camp (km^2)	Area in LIA (km^2)	Combined Infrastructure (km^2)	% of Total Area
Pindan Shrubland	116.25	3.91	20.60	9.70	34.21	29.4
Coastal Communities	1.91	1.16	0	0	1.16	60.7
Open Forest	36.40	2.77	0	0	2.77	7.6
Monsoon Vine Forest	5.15	3.26	0	0	3.26	63.3
Drainage Basin	0.32	0.26	0	0	0.26	81.2
Tall Closed Scrub	2.65	0.02	0	0	0.02	0.8
Coastal Heath	0.35	0	0	0	0	0

* Based on vegetation mapping from Biota (2009).

4.4.1 Pindan Shrubland

Pindan shrubland within the survey area reflects the vegetation mapping completed by Biota (2009) and roughly corresponds to the Yeeda land system (Figure 2.5). When present, the overstorey consists of very open to scattered eucalypt (*Corymbia*) species. *Acacia* shrubs (primarily *A. eriopoda* and *A. monticola*) range from very dense (Invertebrate Trap Site 01, Invertebrate Trap Site 03) to open (Invertebrate Trap Site 02). The substrate is pindan with a cover of dense to open tussock grasses, which have the potential to maintain higher moisture levels and thus comprise potential SRE habitat.

4.4.2 Coastal Communities

Coastal communities occupy the fore dunes along the coast within the SP survey area. *Spinifex longifolius* grass with scattered patches of *Crotalaria* and *Terminalia* shrubs cover loose coastal sands.

4.4.3 Open Forest

A patch of open forest follows along Kundandu Creek in the SP project area, and trapping sites were placed in this habitat on the NEAT (Invertebrate Trap Sites 04 and 05). This habitat roughly corresponds to the Wanganut land system (Figure 2.5). The vegetation is open *Eucalyptus miniata* and other eucalypt species over an open to moderately dense understorey of mixed *Acacia* species. The substrate is yellow sand with a moderate to dense cover of tussock grasses. The moist SRE microhabitats included underside of rocks and decaying logs, tussocks of grasses and deep leaf litter beds around base of trees.

4.4.4 Monsoon Vine Thicket

Monsoon vine thickets occur along a narrow band within 1 km of the coast line in the SP area. *Terminalia ferdinandiana* and *Diospyros humilis* low trees and shrubs on coastal sand are the dominant vegetation of this habitat.

4.4.5 Drainage Basin

A single drainage basin lies in the SP, located between Monsoon Vine Thicket and Pindan Shrubland. This area is subject to ephemeral freshwater flooding during and after the wet season. During the current survey the area was dry and the habitat appeared similar to surrounding areas, however when the area contains water it is likely to attract a distinctly different fauna assemblage to the surrounding area.

4.4.6 Tall Closed Scrub

A small patch of tall closed scrub lies in the north-eastern corner of the SP Project area. This unit was characterised by being a complex mosaic, devoid of eucalypts and dominated by dense wattles. The major dominants were *Acacia monticola* and *A. colei*, with some *A. eriopoda*, *Hakea arborescens* and *H. macrocarpa*, with *Acacia hippuroides*, *Calytrix exstipulate*, *Distichostemon hispidulus* and *Lithomyrtus retusa* in the understorey.

4.5 SURVEY ADEQUACY

4.5.1 Species Accumulation Curves/ Number of Samples

Both the empirically observed SAC and the estimated Mau and Tau rarefaction curve suggest that a fraction of the diversity of SRE groups was sampled (Figure 4.16). The observed SAC is nearly a straight line with a slight plateau near the centre and an indication of asymptotic behaviour at the end. The Chao-1 estimator of total species richness predicts that the SRE assemblage in the area consists of approximately 14 species, with 95% confidence interval between 13 and 21 species. Most of the other richness estimators resulted in estimate values within the same interval (Table 4.5). The Michaelis-Menten estimator used as stopping rule indicated that at the sample 175 (full dataset), a total of 17.84 species can potentially occur in the survey area. This number indicates that approximately 72 % of the predicted SRE species were collected. At this level of collection success, the possibility of some SRE species not have been recorded cannot be discounted (potentially 3-4 more species).

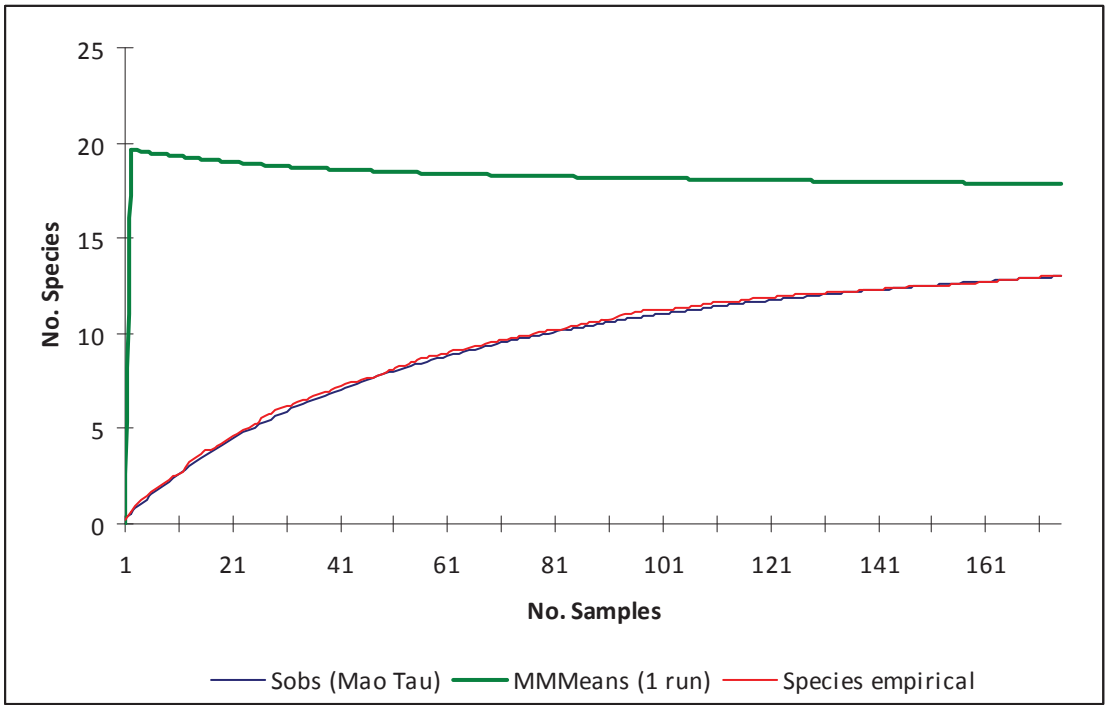


Figure 4.16 – SAC of the SRE Fauna Data

Table 4.5 – Mean estimates of total species richness of the SRE assemblage at James Price Point based on 50 randomisations

Richness Estimators	Richness Estimate
ACE	15.2
ICE	15.2
Chao-1	13.7
Jack-1	15.9
Jack-2	16.0
Bootstrap	14.6
Michaelis-Menten	17.8

4.6 SURVEY LIMITATIONS

The limitations of the survey are provided below in Table 4.6.

Restricted access to some survey areas presented the main limitation of the survey. Specifically, the LIA was surveyed indirectly by surveying similar type of habitat along the NEAT, and the SP area was not surveyed at all due to logistical constraints. The LIA was located several kilometres from the nearest vehicle access track and this access track was a relatively long distance from Broome where the survey team was based. Whilst the SP area was located close to the Manari Road, logistical (time) constraints prevented it from being surveyed. However, this area was previously surveyed by Biota (2011), in which four potential SREs occurred (Figure 4.4). Woodside safety and security needs required travel to and from the survey area to be restricted to specific periods which also presented a limitation to the assessment.

Another significant limitation was poor taxonomic resolution of some specimens due to the lack of taxonomic experts' knowledge of the species collected. This poor taxonomic resolution can make it difficult to determine the distribution of the species collected and therefore the level of management they require.

Seasonality may be a potential limiting factor to the current survey as no rainfall occurred immediately before or during the surveys. This limitation exists even given that the surveys were conducted during the late wet season with an above average rainfall event occurring two months prior to the surveys. In general, 2011 was a good year for invertebrate sampling in the project area, however members of some SRE groups (i.e. snails, some spiders) are active only during, or a few days before and after, a rainfall event and therefore are less likely to have been collected during the survey.

Table 4.6 – Limitations for the SRE Survey at James Price Point

Constraint	Relevant (Yes/No)			Comment
	WAC	SP	LIA	
Survey Adequacy	No	Yes	Yes	The Species Accumulation Curve analysis suggested that about 72% of the potential SRE species were collected in the survey, predicting that approximately four potential SRE species are still being undetected. While the sampling size in the WAC area has been relatively sufficient, the extrapolation of data from the NEAT survey area may generate incomplete species data for the LIA area. Previous data exists for the SP area (Biota 2011) showing 3-4 SRE species occurring there. No SP data exists for current survey due to logistical constraints.
Method Efficiency	No	Yes	No	The methods were consistent with the EPA Guidance Statement 20 and covered all main potential SRE groups. The limitation in the SP area is related to the fact that no sampling could be conducted there due to time constraints.
Seasonality	No	No	No	Survey occurred during the late wet season which is consistent with the EPA Guidance Statement 20. However, no rainfall event occurred immediately before or after the surveys, which could present limitation to activity of some SRE groups.
Field Personal Experience	No	No	No	All field personnel had a minimum of three years experience working with terrestrial invertebrates.
Species Identification Resolution	Yes	N/A	Yes	The taxonomy of many SRE groups is unresolved, especially in historically understudied Kimberley areas such as the James Price Point. The lack of knowledge of the species collected can make it difficult to determine the distribution of the species collected and therefore the level of management they require.

5 DISCUSSION

The literature review and database searches showed that there was a high potential for species from SRE groups to occur in the project area, including trap-door spiders, scorpions, pseudoscorpions, isopods, snails and myriapods. These results were confirmed during the field surveys as specimens from all of these groups were collected. However, no conservation significant species listed under EPBC Act, WC Act and/or DEC list have been recorded in the project area.

Of the 15 species collected from potential SRE groups (Table 4.1), five species were classified as potential SREs (*Aname* MYG231, *Aname* MYG 232, *Dampetrus* sp., *Lychas* 'JPP' and *Buddelundia* sp. 1). At least one of these species (*Buddelundia* sp. 1) is expected to have wide ranges but reference data from regional areas are required to confirm this expectation. Four of the remaining species are not SREs (*Rhagada bulgana*, *Quistrachia leptogramma*, *Lychas* 'multipunctatus' and *Scolopendra laeta*) and six species – all pseudoscorpions and the *Urodacus* scorpion - could not have their SRE status determined by experts due to poor taxonomic knowledge and/or juvenile status.

There was a low overlap of species between this survey and the previous survey conducted by Biota (2011) (Figure 4.1 and Figure 4.2). Of the 15 species collected by ecologia and 12 species collected by Biota, only five species (*Aname* MYG 231, *Euryolpium* sp., *Rhagada bulgana*, *Quistrachia leptogramma* and possibly *Urodacus* sp.) were collected in both surveys. Regarding the species classified as potential SREs, only one (*Aname* MYG 231) was collected during both surveys. This could be partly explained by the fact that Biota surveyed three habitat types (Pindan Shrubland, Open Forest, and Monsoon Vine Thicket) while ecologia surveyed only the two most common habitat types (Pindan Shrubland and Open Forest) due to logistical constraints. Seasonality between the two years of 2010 and 2011, influencing activity of some groups, could also explain part of the variation. Specifically, the 2010 was a dry year with below-average rainfall while 2011 was a wet year with above average rainfall in January and February (BoM 2011).

The test of survey adequacy revealed that approximately 72 % of the predicted SRE species were collected. Such collection success is relatively low, given that 90% and over is normally considered adequate. It is, therefore, likely that some SRE species (3-4, as predicted by some of the estimators) have not been collected. Further sampling may reveal more SRE species in the project area, especially within the Monsoon Vine Thicket habitat, which has not been sampled in this survey. However, the survey undertaken previously by Biota (2011) predominantly surveyed within the SP area and Monsoon Vine Thicket vegetation. Approximately four potential SRE species were previously recorded in the Monsoon Vine Thicket including the spiders *Aname* 'MYG231' and *Conothele* sp., the snail *Quistrachia* and the unknown genus of millipede. The current survey also recorded the spider *Aname* and the snail *Quistrachia*, but did not record the millipede or the spider *Conothele*, thus accounting for at least two of the four potential species not collected during this survey.

Habitat types reflect vegetation, underlying geology, soil, surface hydrology and position in the landscape, and provide a reasonable surrogate of habitat parameters in respect to SREs. Nevertheless, the results demonstrated that the invertebrate assemblage of the project area, as determined from the combined Biota and ecologia data set, was not associated with any particular habitat type. This means that each of the three habitat types sampled (Pindan Shrubland, Open Forest and Monsoon Vine Thicket) supports a similar species diversity. The data also showed that the species occur in clusters rather than being distributed homogeneously across the habitat types. Such distribution is typical of potential SRE groups, reflecting the 'island' nature of microhabitats they occupy within the broader habitat types (Main 1996; Main 1999).

None of the habitats surveyed within the James Price Point BLNG project area are considered unique to the proposed impact areas, nor have any unique features that are restricted to the project area. It should be noted that the three habitat types in which the SRE species were located, including the specific microhabitats such as underside of rocks and logs, clumps of thick understorey vegetation, deep leaf litter beds around base of trees and low-lying drainage lines, extend beyond the limits of the mapped area. Thus, the impact from the BLNG development on the potential SRE species in the area is expected to be low.

6 CONCLUSIONS

The main conclusions of the survey were:

- No conservation significant species listed under EPBC Act, WC Act and/or DEC list have been recorded in the project area.
- Fifteen species from seven potential SRE groups were collected during the survey.
- Five species were classified as potential SREs (*Aname* MYG231, *Aname* MYG 232, *Dampetrus* sp., *Lychas* 'JPP' and *Buddelundia* sp. 1), four species were not SREs (*Rhagada bulgana, Quistrachia leptogramma, Lychas* 'multipunctatus' and *Scolopendra laeta*) and six species – all pseudoscorpions and the *Urodacus* scorpion - could not have their SRE status determined by experts due to poor taxonomic knowledge and/or juvenile status.
- A low overlap of species occurred between this survey and the previous survey conducted by Biota (2011) - only five species (*Aname* MYG 231, *Euryolpium* sp., *Rhagada bulgana*, *Quistrachia leptogramma* and possibly *Urodacus* sp.) were collected in both surveys. Only one of these species was a potential SRE (*Aname* MYG 231). This could be partly due to Biota surveying three habitat types while ecologia surveyed only the two most common habitat types due to logistical constraints. Seasonality between the two years of 2010 and 2011, influencing activity of some groups, could also explain part of the variation.
- The species accumulation curve showed that whilst the majority of species had been collected, more SRE species were likely to occur within the Project areas (3-4 extra species).
- The habitat assessment revealed that each habitat type (Pindan Shrubland, Open Forest and Monsoon Vine Thicket) supported similar species diversity.
- None of the habitats in which the potential SRE species were located are unique to the proposed impact areas nor have any unique features that are restricted to the project area. The habitats, including the specific microhabitats such as underside of rocks and logs, clumps of thick understorey vegetation, deep leaf litter beds around base of trees and low-lying drainage lines, extend beyond the limits of the mapped area. Thus, the impact from the BLNG development on the potential SRE species in the area is expected to be low.

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APPENDIX A EXPLANATION OF CONSERVATION CODES

Appendix A1 Definitions of relevant categories under the *Environment Protection and Biodiversity Conservation Act.1999*

Category	Definition
Endangered (EN)	The species is likely to become extinct unless the circumstances and factors threatening its abundance, survival or evolutionary development cease to operate; or its numbers have been reduced to such a critical level, or its habitats have been so drastically reduced, that it is in immediate danger of extinction.
Vulnerable (VU)	Within the next 25 years, the species is likely to become endangered unless the circumstances and factors threatening its abundance, survival or evolutionary development cease to operate.

Appendix A2 Definition of Schedules under the *Wildlife Conservation Act 1950*.

Schedule	Definition
Schedule 1 (S1)	Fauna which are rare of likely to become extinct, are declared to be fauna that is in need of special protection.
Schedule 2 (S2)	Fauna which are presumed to be extinct, are declared to be fauna that is in need of species protection.
Schedule 3 (S3)	Birds which are subject to an agreement between the governments of Australia and Japan relating to the protection of migratory birds and birds in danger of extinction, are declared to be fauna that is in need of species protection.
Schedule 4 (S4)	Declared to be fauna that is in need of species protection, otherwise than for the reasons mentioned above.

Appendix A3 Definition of Department of Environment and Conservation Priority Codes.

Priority	Definition
Priority 1 (P1)	*Taxa with few, poorly known populations on threatened lands.* Taxa which are known from few specimens or sight records from one or a few localities, on lands not managed for conservation, e.g. agricultural or pastoral lands, urban areas, active mineral leases. The taxon needs urgent survey and evaluation of conservation status before consideration can be given to declaration as threatened fauna.
Priority 2 (P2)	*Taxa with few, poorly known populations on conservation lands.* Taxa which are known from few specimens or sight records from one or a few localities, on lands not under immediate threat of habitat destruction or degradation, e.g. national parks, conservation parks, nature reserves, State forest, vacant crown land, water reserves, etc. The taxon needs urgent survey and evaluation of conservation status before consideration can be given to declaration as threatened fauna.
Priority 3 (P3)	*Taxa with several, poorly known populations, some on conservation lands.* Taxa which are known from few specimens or sight records from several localities, some of which are on lands not under immediate threat of habitat destruction or degradation. The taxon needs urgent survey and evaluation of conservation status before consideration can be given to declaration as threatened fauna.
Priority 4 (P4)	*Taxa in need of monitoring.* Taxa which are considered to have been adequately surveyed, or for which sufficient knowledge is available, and which are considered not currently threatened or in need of special protection, but could if present circumstances change. These taxa are usually represented on conservation lands.
Priority 5 (P5)	*Taxa in need of monitoring.* Taxa which are not considered threatened but are subject to a specific conservation program, the cessation of which would result in the species becoming threatened within five years.

APPENDIX B DAILY WEATHER DATA DURING SURVEYS

Appendix B Daily weather data during surveys

Date	Mean Minimum Temperature (°C)	Mean Maximum Temperature (°C)	Rainfall (mm)
Survey 1 (Workers' Accommodation)			
10/4/2011	25.8	35.2	0
11/4/2011	22.6	35.2	0
12/4/2011	21.3	34.5	0
13/4/2011	22.4	34.9	0
14/4/2011	22.4	34.8	0
15/4/2011	23.3	35.6	0
16/4/2011	23.2	34.7	0
17/4/2011	22.7	33.9	0
18/4/2011	17.8	30.4	0
19/4/2011	15.4	31.5	0
20/4/2011	15.5	32.5	0
21/4/2011	15.8	33.4	0
Survey 2 (Southern Pipeline and LIA)			
27/4/2011	19.4	32.6	0
28/4/2011	22.1	33.8	0
29/4/2011	20.9	32.8	0
30/4/2011	22.2	31.4	0
1/5/2011	22.2	33.8	0
2/5/2011	21.7	32.3	0
3/5/2011	21.1	33.4	0
4/5/2011	20.8	33.5	0
5/5/2011	22.9	29.1	0
6/5/2011	21.5	28.4	0
7/5/2011	20.3	26.7	0.4
8/5/2011	20.3	28.4	0

APPENDIX C SITE DESCRIPTIONS

Appendix C Site descriptions and Coordinates (Datum WGS84)

Vegetation and Habitat Description	Site Photo
Invertebrate Trap Site 01 Habitat type: Pindan Shrubland *Corymbia greeniana* open woodland, over *Acacia eriopoda* shrubland, areas of *Triodia schinzii* dense hummock grasslandan and *Chrysopogon pallidus* open tussock grassland on pindan sand. Leaf litter concentrated under trees/shrubs, with a depth of 1-5cm. Site has a fire history of 1-5 years, with no evidence of disturbance. Coordinates: 51K, 417212mE, 8053851mN	
Invertebrate Trap Site 02 Habitat type: Pindan Shrubland *Corymbia zygophylla* open woodland, over dense mixed acacia shrubland– *Acacia eriopoda* dominant with *Acacia platycarpa*, *Premna acuminata*, *Clerodendrum floribundum* over *Aristida hygrometrica* and *Chrysopogon pallidus* tussock grassland on pindan sand. Leaf litter concentrated under trees/shrubs, with a depth of 1-5cm. Site has a fire history of 1-5 years, with no evidence of disturbance. Coordinates: 51K, 414399mE, 8054569mN	
Invertebrate Trap Site 03 Habitat type: Pindan Shrubland *Eucalyptus miniata* open low trees over dense *Acacia eriopoda* and *Dodonaea hispidula* shrubland over *Chrysopogon pallidus* open tussock grassland on pindan sand. Leaf litter concentrated under trees/shrubs, with a depth of 1-5cm. Site has a fire history of 1-5 years, with no evidence of disturbance Coordinates: 51K, 413039mE, 8064674mN	

Vegetation and Habitat Description	Site Photo
Invertebrate Trap Site 04 Habitat type: Open Forest *Eucalyptus miniata* open woodland over open *Acacia tumida* shrubland over open *Eriachne obtusa, Chrysopogon pallidus* open tussock grassland on yellow inland sandplains. Leaf litter concentrated under trees/shrubs, with a depth of 1-5cm. Site has a fire history of 1-5 years, with no evidence of disturbance. Coordinates: 51K, 415397mE, 8069240mN	
Invertebrate Trap Site 05 Habitat type: Open Woodland *Eucalyptus miniata* open woodland over open *Acacia tumida* shrubland over open *Eriachne obtusa, Chrysopogon pallidus* open tussock grassland on yellow inland sandplains. Leaf litter concentrated under trees/shrubs, with a depth of 1-5cm. Site has a fire history of 1-5 years, with no evidence of disturbance. Coordinates: 51K, 412254mE, 8064097mN	

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APPENDIX D RECORD OF SPECIES FROM WAM DATABASE SEARCH AND PREVIOUS SURVEYS

Appendix D Record of Species from WAM Database Search and Previous Surveys

Order / Suborder and Species	Conservation Status			James Price Point (Biota 2009)	James Price Point (Biota 2011)	WAM Database Search	This Survey
	EPBC Act	WC Act*	DEC				
Araneomorphae							
Scytodes sp.					X		
Mygalomorphae							
Aname 'MYG231'							X
Aname 'MYG232'							X
?*Aganippe* `sp. (female)`					X		
Aname `sp. (female)`					X		
Aname `sp. (juv).`					X		
Synothele `MYG179`						X	
Synothele `MYG179 (female)'						X	
Conothele `sp. (female sp. 2)`					X		
Conothele `sp. (juv. sp. 1).`					X		
Conothele `sp. (juv. sp. 2).`					X		
Missulena `sp. (female)`					X		
Synothele `MYG179`					X		X
Opiliones							
Dampetrus sp.							X
Scorpiones							
Lychas 'JPP'							X
Lychas multipunctatus'							X
Urodacus `JP`					X	X	X
Urodacus `rugosus`					X	X	X
Urodacus sp. Indet							X
Pseudoscorpiones							
Austrohorus sp							X
Beierolpium sp. 8/4'							X
Beierolpium sp. (juv)'							X
Euryolpium sp.					X		X
Indolpium sp.							X
Gastropoda							
Quistrachia leptogramma				X	X	X	X
Rhagada bulgana				X	X	X	X
Amplirhagada astuta	VU						
Amplirhagada herbertena			P1				
Amplirhagada montalivetensis			P1				
Amplirhagada novelta			P1				
Amplirhagada questroana			P1				
Baudinella baudinensis			P3				
Carinotrachia carsoniana	VU						

Order / Suborder and Species	Conservation Status			James Price Point (Biota 2009)	James Price Point (Biota 2011)	WAM Database Search	This Survey
	EPBC Act	WC Act*	DEC				
Cristilabrum bubulum	EN						
Cristilabrum buryillum	CR						
Cristilabrum grossum	CR						
Cristilabrum isolatum	EN						
Cristilabrum monodon	CR						
Cristilabrum primum	CR						
Cristilabrum rectum	CR						
Cristilabrum simplex	CR						
Cristilabrum solitudum	CR						
Cristilabrum spectaculum	EN						
Damochlora millepunctata			P1				
Damochlora spina			P3				
Dupucharopa millestriata			P2				
Gastrocopta cf. *bannertonenis*						X	
Glacidorbis occidentalis			P2				
Hadra wilsoni			P2				
Kimboraga exanimus			P3				
Kimboraga micromphala			P2				
Kimboraga yammerana			P1				
Magilaoma sp.						X	
Mouldingia occidentalis	CR						
Mouldingia orientalis	VU						
Ningbingia australis australis	CR						
Ningbingia australis elongata	CR						
Ningbingia bulla	CR						
Ningbingia dentiens	CR						
Ningbingia laurina	CR						
Ningbingia octava	CR						
Ningbingia res	CR						
Ordtrachia elegans	CR						
Physa ?acuta						X	
Pilsbrycharopa tumida			P1				
Prymnbriareus nimberlinus			P3				
Pupoides pacificus						X	
Rhagada gibbensis			P1				
Rhagada harti			P2				
Rhagada reinga						X	
Rhagada spp.						X	
Torresitrachia thedana			P1				
Turgenitubulus christenseni	EN						
Turgenitubulus costus	CR						

Order / Suborder and Species	Conservation Status			James Price Point (Biota 2009)	James Price Point (Biota 2011)	WAM Database Search	This Survey
	EPBC Act	WC Act*	DEC				
Turgenitubulus depressus	CR						
Turgenitubulus foramenus	CR						
Turgenitubulus opiranus	CR						
Turgenitubulus pagodula	VU						
Turgenitubulus tanmurrana	CR						
Westraltrachia alterna	VU						
Westraltrachia inopinata	VU						
Westraltrachia lievreana			P1				
Westraltrachia recta			P1				
Westraltrachia subtila			P1				
Westraltrachia turbinata	VU						
Isopoda							
Buddelunida sp. 1							X
Chilopoda							
Pilbarascutigera incola					X		
Scolopendra laeta							X
Diplopoda							
Pachybolidae					X		

* None of the species are listed under the WC Act