Venturex Resources

Sulphur Springs Copper - Zinc Project

Targeted Terrestrial SRE Invertebrate Fauna Assessment

November 2012

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Targeted Terrestrial SRE Invertebrate Fauna Assessment

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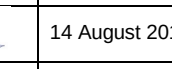
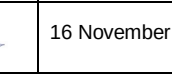
Draft Report V01	A. Scarfone P. Bolton	B. Parsons M. Goldstone		14 August 2012
Final Report	P. Bolton M. Goldstone	A. Robertson		16 November 2012

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Executive Summary

Venturex Resources Limited commissioned Outback Ecology to conduct a Targeted Terrestrial short-range endemic (SRE) invertebrate fauna assessment for the proposed Sulphur Springs Copper - Zinc Project. The Project is located approximately 57 kilometres (km) west of Marble Bar in the Pilbara region of Western Australia.

The Project will comprise the underground development of the Sulphur Springs Copper Zinc deposit, processing of ore at an onsite concentrate plant and haulage of concentrate from Sulphur Springs to Port Hedland via road train for export. Ore mined at the Venturex owned Whim Creek and Mons Cupri Projects will also be hauled to Sulphur Springs for processing. Development within the Project area will include a processing plant, tailings storage facility, evaporation pond ROM pad, access roads, workshops, borrow pit, offices, camp and air strip.

The Project footprint is expected to be approximately 178.3 ha in size. It is understood that this footprint includes all major infrastructure associated with the Project, however additionally clearing may be required outside the footprint during construction. Some areas within this footprint have been previously been cleared by CBH Resources during their exploration phase.

This report documents the results of a desktop study and a targeted terrestrial SRE invertebrate fauna assessment conducted over Venturex tenements and neighbouring tenements surrounding the Project (herein referred to as the Study area). The Study area covered an area of 27,425 hectares and was assessed via targeted searching and habitat mapping between 22 and 25 January 2012.

Previous biological work at Sulphur Springs by Biota in August 2006 resulted in the collection of a SRE pseudoscorpion *Feaella* 'PSE007' (previously *Feaella* sp. 'Sulphur Springs') from Drainage Line habitat. Additional work carried out by Outback Ecology in 2011 identified drainage features in the vicinity of the Project as forming potential SRE habitats as they have sheltered areas of vegetation that were uncommon in the surrounding area. Other potential SRE habitats identified by Outback Ecology in 2011 were Rubble Piles and Ficus Groves, however these habitats were considered unlikely to be impacted by the Project.

Consequently, the specific objectives of this targeted SRE assessment were to:

- assess the occurrence and likely distribution of terrestrial SRE invertebrate fauna within drainage habitats in the Study area;
- identify, describe and map drainage habitats in the Study area;
- assess survey findings in the context of regional comparisons with available data from the surrounding area and other localities within the Pilbara bioregion; and
- assess the potential impacts of the Project on any terrestrial SRE invertebrate fauna and their associated habitat identified within the Study area.

The field survey involved targeted searching for invertebrate fauna at 13 sites within the Study area. Habitat assessments were also conducted at these and an additional three survey sites. The targeted survey of SRE groups within the Study area yielded a total of 153 specimens from 13 species. Terrestrial snails were the most numerous group to be collected (64 specimens from five identifiable species), followed by aquatic snails (38 specimens from two species), millipedes (29 specimens from two identifiable species), slaters (20 specimens from three identifiable species), pseudoscorpions (one specimen) and mygalomorph spiders (one specimen). From this survey and previous survey work, four SRE species have been identified from the Study area, comprising:

- the millipede *Antichiropus* 'DIP005' (formally 'abydos');
- the millipede *Antichiropus* 'DIP034';
- the slater *Buddelundia* sp. 11; and
- the pseudoscorpion *Feaella* 'PSE007'.

Based on the desktop assessment, nine additional species were considered to have medium potential to occur in the Study area. This consideration is based on the proximity of records, the availability suitable habitat and the connectivity of habitat with the Study area.

Of the four SRE species collected within the Study area, only the millipede *Antichiropus* 'DIP005' has been collected within the Project footprint. This species has also been collected outside of the Project footprint within the Study area and at regional sites 12 km southwest of the Project. Although this species is likely to have a distribution that aligns with sheltered habitats in the vicinity of Sulphur Springs, the occurrence of this species at regional sites suggests that the Project is unlikely to pose a long term conservation risk to *Antichiropus* 'DIP005'. Provided that secondary impacts to habitats are minimised, the Project is also unlikely to pose a long term conservation risk to the other three species as they were not collected within the Project footprint.

The only known specimen of pseudoscorpion *Feaella* 'PSE007' was collected by Biota during a survey in 2006. No further specimens of *Feaella* 'PSE007' have been found despite two subsequent surveys which have aimed to better understand the distribution of this species.

Habitat assessments of the drainage features within the Study area identified five types of drainage habitat:

- Gorge;
- Creek Line;
- Riverine;
- Drainage Line; and
- Floodplain.

The Gorge and Creek Line habitats were considered to have high potential for supporting SRE species on the basis of the habitats forming sheltered microhabitats or by forming habitat isolates. Riverine habitat was considered to have medium potential to support SRE species.

The construction of the Project will result in the loss of approximately 2.73 ha of drainage habitat comprising 1.49 ha (1.3 km) of Gorge, 0.08 ha of Creek Line and 0.63 ha of Riverine habitats present in the Study area. These habitats will primarily be impacted through the construction of of the site access road. There also exists the potential for runoff from the site access road to cause sediment loading of the Gorge and Creek Line habitats in the vicinity and downstream of the access road. The natural hydrology of the Gorge and Creek Line may also make the access road susceptible to erosion during high rainfall events which may cause direct and downstream impacts to drainage habitats. Although these habitats are known to occur in other locations in the Study area, they are of limited extent and not well connected in the surrounding landscape. All other drainage habitats in the Study area were considered to have a low potential to support SRE species.

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1. INTRODUCTION

1.1. Project Location And Description

Venturex Resources Limited (Venturex) commissioned Outback Ecology to undertake a targeted terrestrial short-range-endemic (SRE) invertebrate fauna assessment of the proposed Sulphur Springs Copper - Zinc Project (the Project). The Project is located approximately 57 kilometres (km) west of Marble Bar in the Pilbara region of Western Australia (WA, **Figure 1**).

The Project footprint is expected to be approximately 178.3 ha in size (**Figure 2**). It is understood that this footprint includes all major infrastructure associated with the Project, however additionally clearing may be required outside the footprint during construction. Some areas within this footprint have been previously been cleared by CBH Resources during their exploration phase.

The Project will comprise the underground development of the Sulphur Springs Copper-Zinc deposit, processing of ore at an onsite concentrate plant and haulage of concentrate from Sulphur Springs to Port Hedland via road train for export. Ore mined at the Venturex owned Whim Creek and Mons Cupri Projects will also be hauled to Sulphur Springs for processing. Development within the Project area will include a processing plant, tailings storage facility (TSF), evaporation pond, ROM pad, access roads, workshops, borrow pit, offices, camp and air strip.

The Study area for this assessment encompasses a 27,425 hectare (ha) parcel of land which surrounds the Project (**Figure 2**). The Study area covers tenements held by Venturex and neighbouring tenements held by other resource companies.

Previous biological work at Sulphur Springs by Biota in August 2006 resulted in the collection of a SRE pseudoscorpion *Feaella* 'PSE007' (previously *Feaella* sp. 'Sulphur Springs') from a Drainage line. Additional work carried out by Outback Ecology (2011b) identified drainage features as forming potential SRE habitat as they had sheltered areas of vegetation that were uncommon in the surrounding area. These areas were identified as potentially being at risk from the Project. Consequently, this targeted SRE survey and habitat assessment of drainage features was undertaken within the vicinity of the Project and at regional sites to assess the potential impacts of the Project on SRE fauna and habitat.

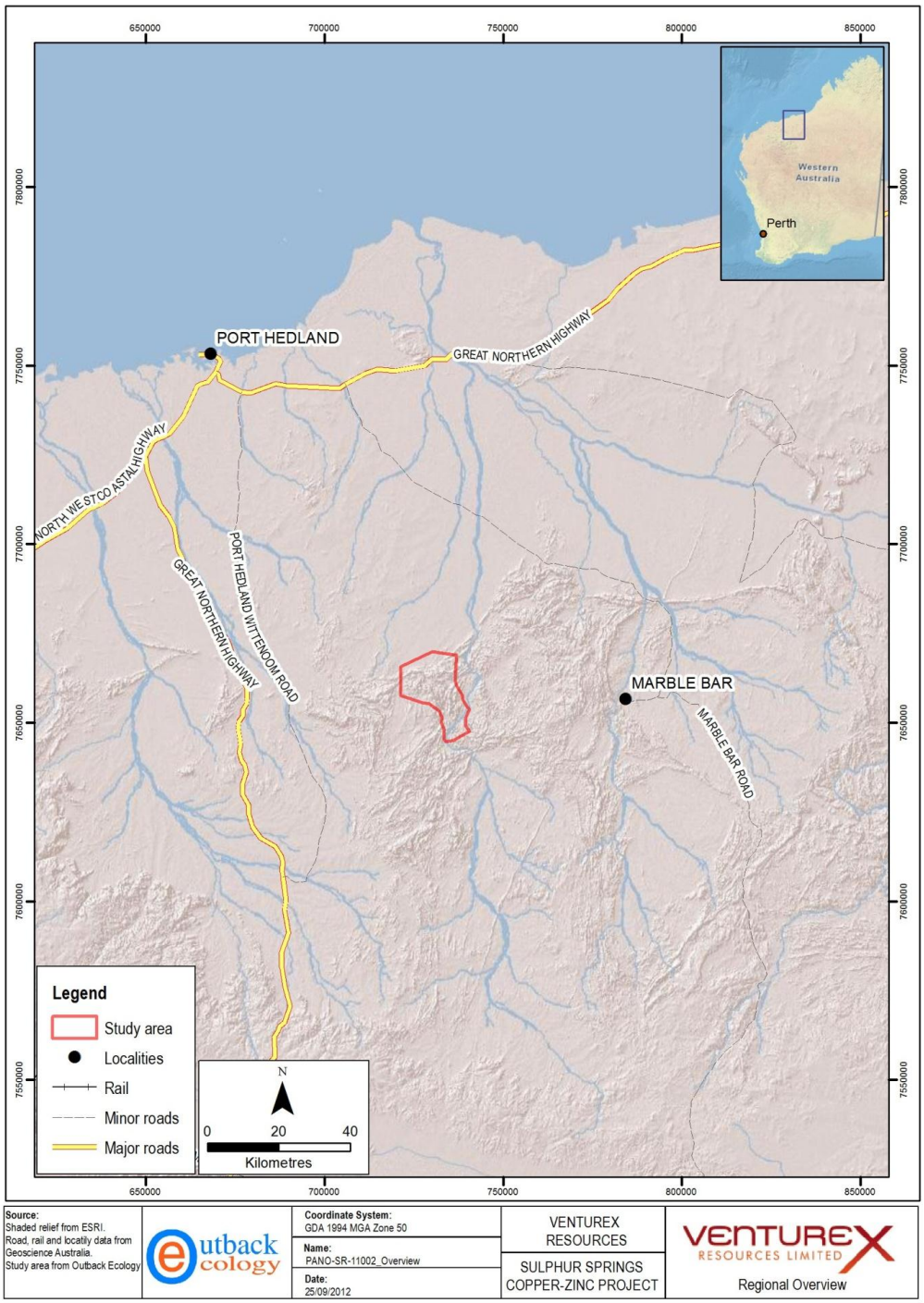

Figure 1: Regional location of the Study area

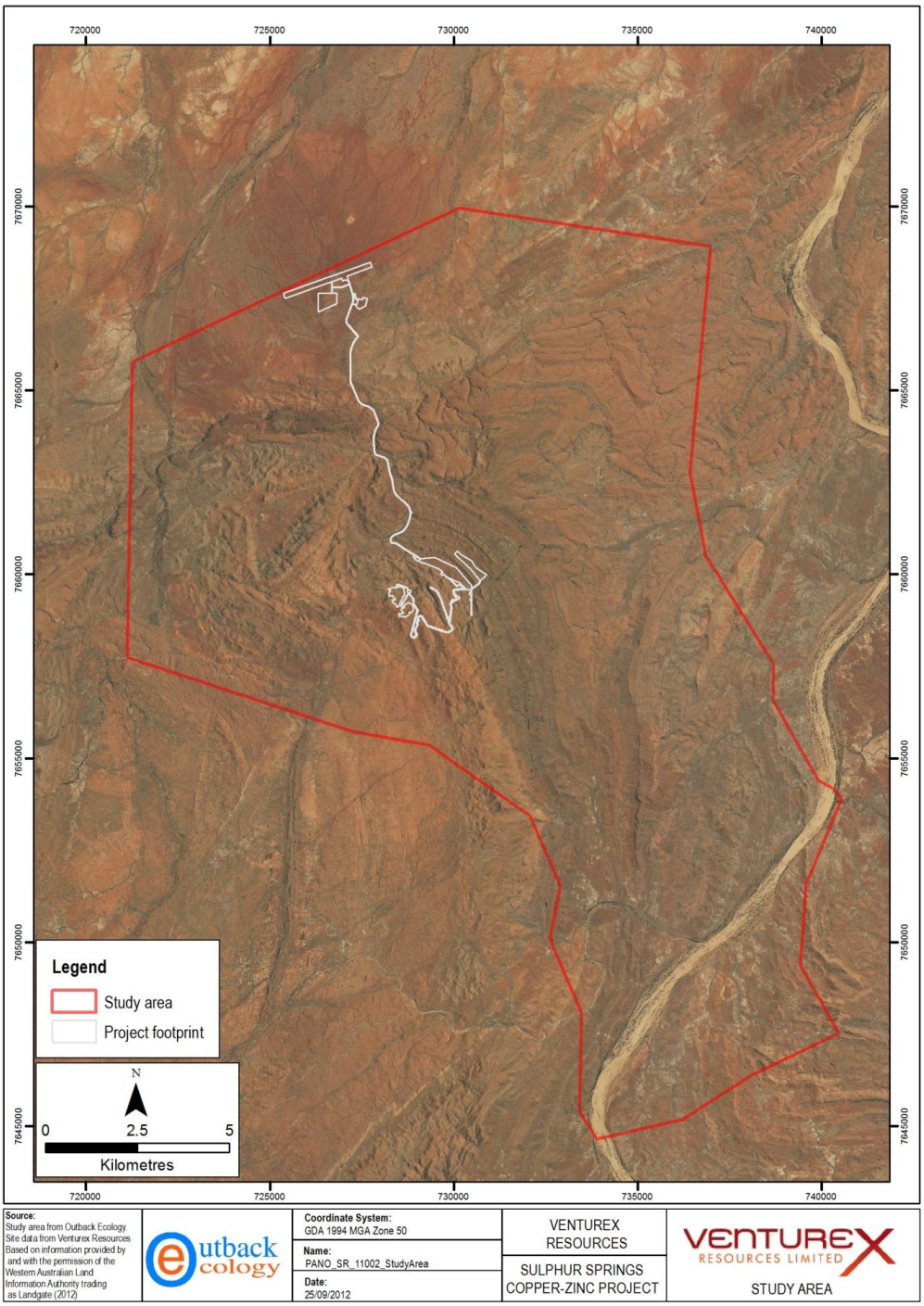

Figure 2: The Study area and Project footprint

1.2. Report Scope And Objectives

This report documents the results of a targeted terrestrial SRE invertebrate fauna assessment conducted over the Study area between 22 and 25 January 2012. For local and regional context, this report also presents a summary of terrestrial SRE invertebrate fauna surveys previously conducted in the Study area and surrounds.

The objectives of this targeted SRE assessment are to:

- assess the occurrence and likely distribution of terrestrial SRE invertebrate fauna within drainage habitats in the Study area;
- identify, describe and map drainage habitats in the Study area;
- assess survey findings in the context of regional comparisons with available data from the surrounding area and other localities within the Pilbara bioregion; and
- assess the potential impacts of the Project on any terrestrial SRE invertebrate fauna and their associated habitat identified within the Study area.

The targeted terrestrial SRE invertebrate fauna survey was designed and conducted in accordance with the:

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

Field Code Changed

For a summary of the existing environment, including biogeographic region, climate, land systems and land use, please refer to the Sulphur Springs Copper Zinc Project Level 1 Fauna Survey (Outback Ecology 2011b).

2. MATERIALS AND METHODS

The methods used to assess the presence of terrestrial SRE invertebrate fauna and habitat during this assessment include database searches and a literature review (**Section 2.1**); and a targeted terrestrial SRE invertebrate fauna survey (**Section 2.2**).

2.1. DESKTOP STUDY

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

- determine the SRE taxa that have been previously collected in the region;
- facilitate the identification of SRE habitat within the Study area; and
- assist with the assessment of the conservation significance of the invertebrate species collected.

The results of the database search and literature review are presented in **Section 3.3**.

2.1.1. Database Searches

A database search was undertaken to provide a list of SRE invertebrate species that have previously been recorded or have the potential to occur within the Study area. The central point used for the database search was 50 K 741617 E 7674906 S.

- Western Australian Museum (WAM) Arachnid and Millipede Database (Western Australian Museum 2011) (square search area 200 x 200 km);
- NatureMap database (Department of Environment and Conservation 2012a) (40 km radius search area);
- Threatened and Priority Fauna Database (Department of Environment and Conservation 2012b) (square search area 200 x 200 km); and
- The Commonwealth Environment Protection and Biodiversity Conservation (EPBC) Act Protected Matters Database (Department of Environment Water Heritage and the Arts 2012) (square search area 100 x 100 km).

It should be noted that at present, WAM is only able to conduct database searches for SRE spiders, scorpions, pseudoscorpions and millipedes; and not snails or slaters.

2.1.2. Literature Review

To gain an understanding of terrestrial invertebrate SRE fauna recorded within the Study area and wider surrounds, a literature review was undertaken of previous SRE invertebrate fauna surveys conducted within a 100 km radius of the Study area. A radius of 100 km was used on the basis of a SRE species being loosely defined as having a distribution of less than 10 000 km^2 (Harvey 2002).

The surveys that fall within a 100 km radius of the Study area that were reviewed as part of this study include:

- Abydos DSO Project: Terrestrial Short Range Endemic Invertebrate Fauna Assessment (Outback Ecology 2012a)
- Sulphur Springs Copper-Zinc Project: Level 1 Terrestrial Fauna Survey (Outback Ecology 2011b)
- Mt Dove DSO Project: Terrestrial Short-range Endemic Invertebrate Fauna Assessment(Outback Ecology 2011a);
- Giralia Resources NL Mount Webber Iron Ore Project Short-Range Endemic Invertebrate Fauna Survey (ecologia 2011);
- Turner River Hub Project: Terrestrial Short-range Endemic Invertebrate Fauna Baseline Survey(Outback Ecology 2011c);
- Wodgina DSO Project Stage 2: Targeted Terrestrial Snail Survey (Outback Ecology 2010);
- Abydos Direct Shipping Iron Ore Project: Terrestrial Fauna Assessment (Bamford Consulting Ecologists 2009);
- Wodgina DSO Project Terrestrial Short-range Endemic Invertebrate Fauna Assessment (Outback Ecology 2009);
- RGP5 Rail Duplication Project: Chichester Deviation: Short-range Endemic Invertebrate Fauna Survey and Targeted Survey for the Trapdoor Spider, *Aurecocrypta* sp.(ecologia 2008);
- A Report on the Trapdoor Spider *Aurecocrypta* sp. from the Chichester Range(Raven 2008);
- Panorama Project: Mine Site and Haul Road Corridor Targeted Fauna Survey (Biota 2007a);
- Sulphur Springs Project: Mine Site and Haul Road Corridor Targeted Fauna Survey, Prepared for CBH Resources Ltd (Biota 2007b); and
- Fauna Habitats and Fauna Assemblage of the Proposed FMG Stage B Rail Corridor and Mine Areas (Biota 2005).

Of these surveys, the Study area overlies much of the area surveyed for the Sulphur Springs Project: Mine Site and Haul Road Corridor Targeted Fauna Survey (Biota 2007a) and the Sulphur Springs Copper Zinc Project: Level 1 Terrestrial Fauna Assessment (Outback Ecology 2011b). Additionally, the Study area lies adjacent to the area surveyed for the Abydos DSO Project: Terrestrial Short Range Endemic Invertebrate Fauna Assessment (Outback Ecology 2012a). These surveys are discussed in greater detail below.

Biota (2007a) Sulphur Springs Project: Mine Site and Haul Road Corridor Targeted Fauna Survey

This Level 2 survey was conducted to assess the Mine Site and Haul Road Corridor associated with the Sulphur Springs project in August-September 2006. Survey methods for invertebrate fauna included targeted searching and dry pitfall trapping.

The Study area encompassed three broad habitat types:

- a narrowly incised valley supporting mid-dense to dense riparian vegetation and small to medium sized pools and low stony hills vegetated with *Triodia* hummock grasslands.

- the “ridges, hills and upper slopes” slopes land unit with cobbled and stony substrates (with some bedrock exposures), vegetated primarily with *Triodia* hummock grasslands and scattered *Corymbia hamersleyana* as defined by Trudgen (2006), formed a broad valley floor at the northern and southern extremities of the valley.
- the “stony plains” land unit with cobbled and stony mantles over shallow red loamy substrates, vegetated primarily with *Triodia* hummock grasslands and scattered Acacia as defined by Trudgen (2006), formed a broad valley floor at the northern and southern extremities of the valley.

Invertebrate taxa prone to short-range endemism collected during the survey included terrestrial snails, mygalomorph spiders and pseudoscorpions. Species collected that potentially represented SRE species included the pseudoscorpion *Feaella* ‘PSE007’ (reported as *Feaella* sp. ‘Sulphur Springs’), the snail *Rhagada* sp. ‘Sulphur Springs’ and six specimens of a mygalomorph spider from the family Barychelidae that were not identified to species.

The six mygalomorph spider specimens have been since identified as *Aurecocrypta* `chichester` which is not considered to be a SRE species (Raven 2008). The snail *Rhagada* sp. ‘Sulphur Springs’ was informally separated from the species *Rhagada richardsonii* (described from Depuch Island which occurs 155 km west of the Study area) through genetic work completed by Biota (2007a). Morphological differences between the type specimens of *Rhagada richardsonii* and the specimens of Sulphur Springs appear to support this separation (**Appendix D**; Cory Whisson pers comm. May 2012). The specimens from Sulphur Springs most closely resemble a larger widespread form which has been collected from the Oakover River, Nullagine and Strelley River (**Appendix D**). The eastern branch of the Strelley River passes through the Study area. Based on this distribution, it appears unlikely that this species has a restricted distribution.

The only species collected during the survey still considered to represent a potential SRE is the pseudoscorpion *Feaella* ‘PSE007’. The specimen was collected beneath slate like rock on the south face of a low cliff adjacent to a narrowly incised ephemeral Drainage Line (Biota 2007b).

Biota (2007b) recommended that additional survey work be undertaken to delineate distribution and habitat of *Feaella* sp. 'PSE007' and that additional taxonomic work should be undertaken to resolve the identity of the specimen. As a result, additional survey work was undertaken with the assistance of Dr Mark Harvey from the WA museum in October 2007. The survey was unsuccessful in collecting additional specimens of *Feaella* sp. ’PSE007’.

Outback Ecology (2011b) Sulphur Springs Copper Zinc Project: Level 1 Fauna Assessment

In June 2011, Outback Ecology conducted a terrestrial fauna desktop study and reconnaissance survey of the Sulphur Springs Project. During this survey Rocky Ridges and Gorges and Drainage Lines were identified as potential SRE habitats, with Rubble Piles and Ficus Groves representing habitat isolates that may support SRE species.

Drainage Line habitat encompasses a considerable proportion of the Study area and was found to align with the only recorded location of the specimen *Feaella* sp. 'PSE007' collected by Biota (2007a). It was recommended that a targeted terrestrial invertebrate SRE survey for *Feaella* sp. 'PSE007' be conducted during the period of peak rainfall for the area to gain a better understanding of the species distribution and identify other potential habitats for *Feaella* sp. 'PSE007' outside of proposed impact areas.

Outback Ecology (2012a) Abydos DSO Project: Terrestrial Short Range Endemic Invertebrate Fauna Assessment

Atlas Iron Limited commissioned Outback Ecology to conduct a SRE invertebrate fauna assessment of the Abydos Direct Shipping Iron Ore Project which is located approximately 7 km west of the Study area. Two surveys were conducted from 28 March to 28 July 2010. Sampling methods included wet pitfall trapping, targeted searching and leaf litter and soil collection.

The surveys yielded a total of 1,453 invertebrate specimens from 43 species. Of these, six species were considered to be SRE comprising: the scorpion *Aops* 'pilbara'; the pseudoscorpion *Tyrannocthonius* 'near aridus'; the Slaters *Buddelundia* sp. 11 and *Buddelundia* sp. 18; the camaenid snail ?Gen. nov. sp. nov.; and the millipede *Antichiropus* 'DIP005' (reported as 'abydos').

During the survey, eight broad habitat types were identified from within the Study area. Gorge habitat was identified as having high potential to support SRE species, because it forms cool, sheltered habitats that were isolated from similar habitats in the surrounding landscape. Ridge habitat (i.e. southerly or easterly aspect), Gully and Riverine habitats were considered to have medium potential to support SRE species, as they also formed sheltered habitat isolates, however they were generally more exposed than the Gorge habitat.

2.2. Terrestrial SRE Invertebrate Fauna Field Survey

The field survey was conducted in accordance with the EPA Guidance Statement No 20 (Environmental Protection Authority 2009) and after consultation with specialists from DEC and the WAM. Recommendations and information given by the specialists was incorporated into the survey design.

2.2.1. Survey Timing

The Sulphur Springs targeted terrestrial SRE invertebrate fauna survey involved targeted searching and leaf litter collection from the 22 to 25 January 2012.

2.2.2. Weather Conditions

Eleven days prior to the field survey (12 January 2012), Tropical Cyclone Heidi crossed the Pilbara coast causing significant rainfall in the region. The rainfall caused flooding of major roadways and river crossings and subsequent road closures (Bureau of Meteorology 2012).

Field Code Changed

The records from Marble Bar, Port Hedland and Strelley weather stations were considered for this survey, and are located 58 km east, 92 km north west and 78 km north west of the Study area,

respectively. The Marble Bar and Port Hedland weather stations record both temperature and rainfall, whereas, only rainfall is recorded at Strelley. Despite this, information from Strelley is useful in providing a regional context, given the localised nature of rainfall in the Pilbara bioregion.

During the survey, the daily maximum temperature recorded at Marble Bar ranged from 35.7ºC to 39.5ºC, while the minimum temperature ranged from 23.5ºC to 27.3ºC (Bureau of Meteorology 2012). A mean maximum temperature of 37.3ºC and a mean minimum of 25.1ºC over the survey period were recorded at Marble Bar which is slightly lower than the long-term average. In the six weeks prior to the survey, 166.8 mm of rain was recorded at Marble Bar, 167.04 mm at Port Hedland and 180.5 mm at Strelley Station (**Figure 3**). During the survey period, 16 mm of rain was recorded at Marble Bar; 0 mm of rainfall was recorded at Port Hedland and 0.5mm at Strelley Station (**Figure 3**). The rainfall recorded prior to and during the first survey was higher than the long-term average as a result of cyclone activity (Bureau of Meteorology 2012).

Field Code Changed

Field Code Changed

The survey was conducted between November and April which is the optimum time for invertebrate surveys in the Pilbara bioregion (Environmental Protection Authority 2009). The peak activity of SRE taxa generally coincides with the wet season, in particular with rainfall events (Environmental Protection Authority 2009). The high level of rainfall prior to and during the survey resulted in ideal timing for the collection of specimens from SRE taxa.

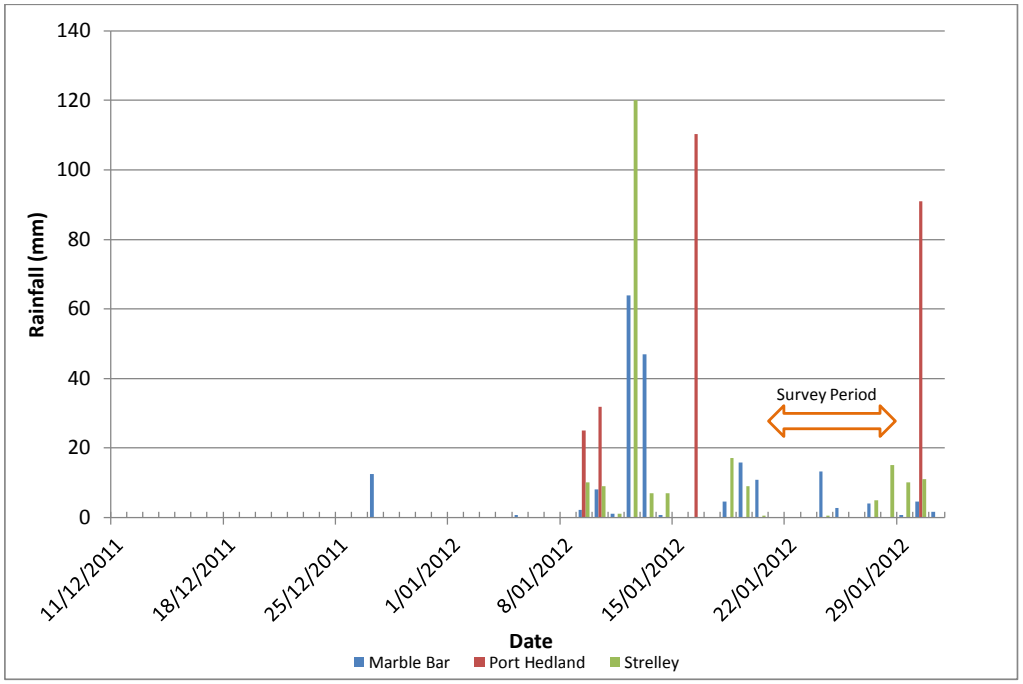

Figure 3: Rainfall recorded at Marble Bar, Port Hedland and Strelley weather station prior to and during the survey (Bureau of Meteorology 2012)

Field Code Changed

2.2.3. Survey Sites

Prospective survey sites were selected using satellite imagery prior to the survey. The actual survey sites selected were dependent on ground truthing and vehicle access at the time of the survey. Targeted searching, leaf litter collection and habitat assessments were conducted at a total of 13 survey sites. Habitat assessments were also conducted at an additional three survey sites to provide an adequate coverage of drainage habitats in the Study area (**Table 1** & **Figure 4**). Survey sites were located within Venturex, Atlas Iron, Zenith Minerals and Brockman Exploration tenements. Site descriptions for each of the survey sites assessed in the Study area are presented in **Appendix A**.

Table 1: Survey sites, habitat and survey methods within the Study area

Site	Habitat	Targeted searching	Leaf litter collection	Habitat assessment	Coordinates (GDA 94 MGA 50K)	
					Easting	Northing
1	Creek Line	X	X	X	728153	7660988
2	Riverine	X	X	X	727119	7665434
3	Creek Line	X	X	X	728695	7662229
4	Gorge	X	X	X	727956	7663270
5	Gorge	X	X	X	727931	7663990
6	Drainage Line	X	X	X	727205	7660204
7	Gorge	X	X	X	731862	7660742
8	Gorge	X	X	X	729692	7662604
9	Drainage Line	X	X	X	732605	7653429
10	Riverine	X	X	X	735640	7650327
11	Drainage Line	X	X	X	728244	7657541
12	Riverine	X	X	X	722249	7664139
13	Riverine	X	X	X	722113	7661781
HA01	Drainage Line			X	734403	7651623
HA02	Floodplain			X	727125	7666666
HA03	Gorge			X	722053	7662237

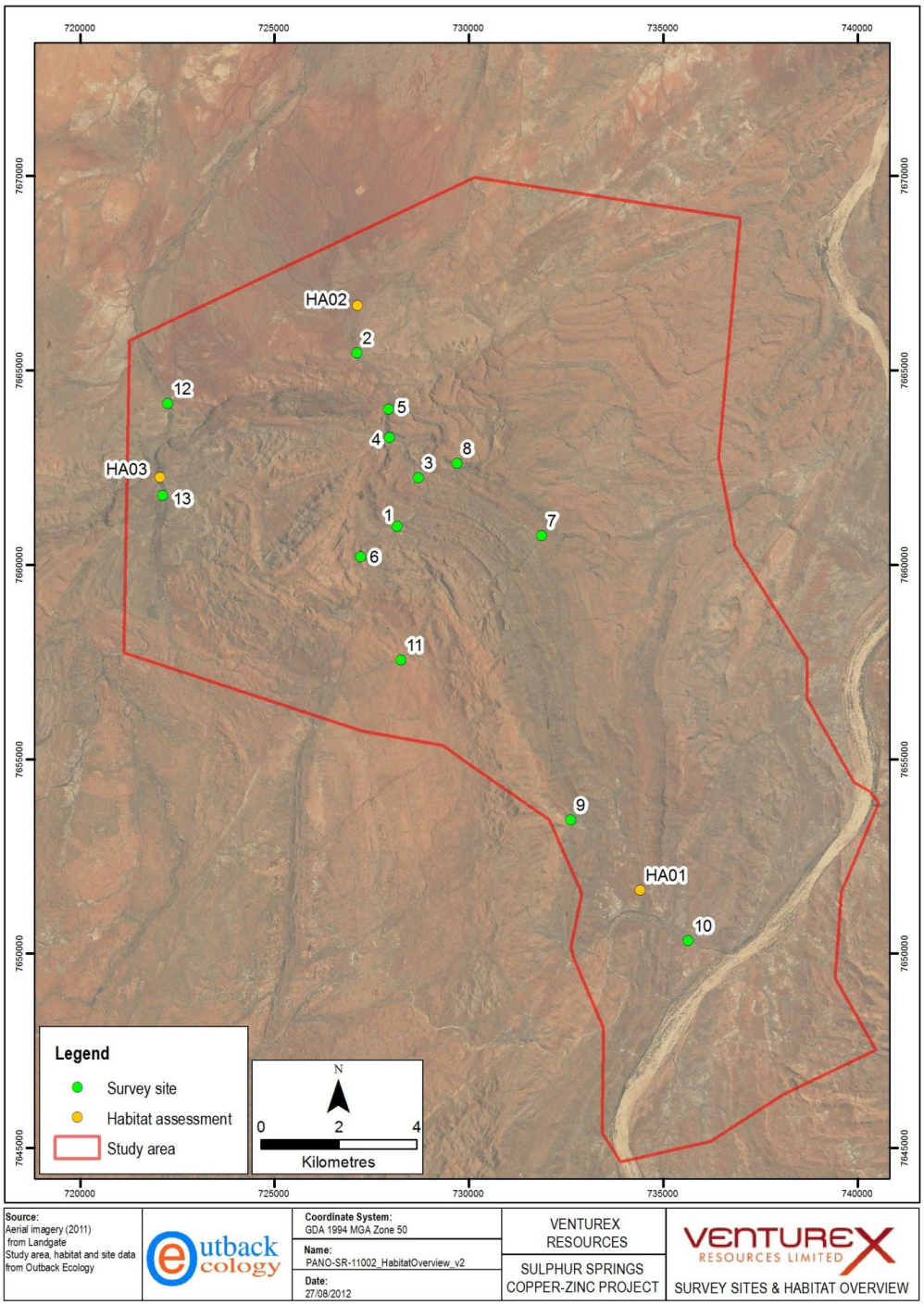

Figure 4: Survey site locations and habitats within the Study area

2.2.4. SRE Habitat Assessment

Potential terrestrial SRE habitats within the Study area were identified and assessed in terms of complexity, quality, connectivity and extensiveness within the landscape. A SRE habitat assessment was conducted for each potential SRE habitat unit identified within the Study area. This assessment entailed:

- establishment of habitat assessment reference sites of sufficient geographical spread and replication to characterise the extent of SRE habitat in the Study area; and
- compiling a standardised habitat assessment field sheet for each site. Assessments were made within a 50 m x 50 m area and the following information recorded: landscape position, outcropping, soil type, broad vegetation type, litter cover, existing disturbance, extensiveness and physical connectivity within the landscape.

Although there are no prescriptive guidelines for identifying SRE habitats, most prospective habitats tend to be those that are sheltered, isolated or both (Environmental Protection Authority 2009, Harvey 2002). Many SRE species are associated with sheltered environments that are pockets of relictual Gondwanan habitat. In the Pilbara, sheltered habitats include: deep gorges, ridges and slopes with south east facing aspects, drainage systems and fire refuge areas. Isolated habitats are more likely to support SRE species in comparison to extensive swathes of contiguous habitat. Habitat isolates in the Pilbara include individual *Ficus* trees and also mountains, outcrops and mesas surrounded by plains (Environmental Protection Authority 2009, Harvey 2002). Information collected from habitat assessments have been incorporated into the descriptions of each broad habitat in the Study area (**Section 3.1**).

2.2.5. Collection Techniques

Methods for the sampling and collection of targeted SRE taxa that were undertaken during this survey were aligned with those specified by the EPA (2009) and endorsed by invertebrate SRE specialists of the WAM and DEC (**Table** 2). These are described below.

Table 2: Summary of SRE sampling methods undertaken at each survey site

Sampling technique	Target group	Sampling effort	Total
Targeted searching	All groups	1.5 person hours at 13 sites	19.5 person hours
Leaf litter collection	All groups	3 samples at each of 13 sites	39 samples

Targeted Searching

Each site was searched for SRE invertebrates for one and a half person hours, resulting in a total of 19.5 hours of targeted searching within the Study area. Microhabitats searched included leaf litter, beneath logs, bark and rocks, crevices, at the bases of shrubs and trees and beneath Spinifex hummocks. Burrows suspected to be those of mygalomorph spiders or scorpions were excavated and the occupants if any, were collected.

Leaf Litter Collection and Tullgren Funnels

Three samples of leaf litter were collected from each site, with a total of 39 samples collected during the survey. The samples were collected by scraping back the top layer of litter to reveal the decomposition layer above the soil. Leaf litter samples were sealed in plastic bags and kept cool during fieldwork and subsequent transportation to the Outback Ecology laboratory. Tullgren funnels were used to extract invertebrates from the leaf litter samples. Tullgren funnels use light and heat generated above the sample to encourage the downward movement of invertebrates. Eventually the invertebrates exit the funnel and fall into a container of 100% ethanol. Leaf litter samples were left in the Tullgren funnels for at least 72 hours. After this time, the collection containers beneath the Tullgren funnels were examined for invertebrates using a dissecting microscope at six times magnification in the Outback Ecology laboratory. The leaf litter remaining in the funnels was searched for invertebrates using two times magnification.

2.2.6. Specimen Preservation

Mygalomorph spiders and scorpions had their third left leg removed and stored in 100% ethanol in a cryogenic tube and placed inside a larger vial with the remaining specimen stored in 75% ethanol. This allowed for the option of genetic testing if required. All other arthropod specimens were stored in 100% ethanol. Land snails were kept live in a state of aestivation by storing them in well ventilated, cool, dry containers.

2.2.7. Specimen Processing And Identification

Specimens belonging to taxa prone to short-range endemism were delivered to the WA Museum for registration and identification by specialist taxonomists (**Table 3**).

Table 3: Invertebrate taxonomists whom identified specimens collected from the Study area

Speciality	Taxonomist	Organisation
Spiders, pseudoscorpions and millipedes	Dr Mieke A. Burger Dr Catherine A. Car Mark A. Castalanelli Dr Mark S. Harvey	Western Australian Museum
Slaters	Dr Simon Judd	Independent consultant
Snails	Mr Corey Whisson	Western Australian Museum
Molecular Identification of millipedes	Mark A. Castalanelli Dr Mark S. Harvey	Western Australian Museum

2.2.8. SRE Survey Team And Licensing

The terrestrial SRE invertebrate fauna survey was conducted by:

Paul Bolton	B. Sc. (Marine Biology/Zoology) (Hons.)	Principal Environmental Scientist
Adele Scarfone	B.Sc. (Env. Sci. & Catchment Management)	Environmental Scientist

The survey was conducted under Licence to Take Fauna for Scientific Purposes (Regulation 17) – Licence No: SF008425

Date of issue: 24/01/2012

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Date of expiry: 23/01/2013

3. RESULTS

3.1. Terrestrial SRE Invertebrate Fauna Habitats

The Study area spans approximately 15 km from east to west, 22 km from north to south and covers approximately 27,425 ha in area. Drainage features were previously identified as having potential to support SRE species as they provide sheltered microhabitat that is uncommon in the surrounding landscape (Outback Ecology 2011b). The current survey assessed these drainage features and classified them into defined habitat types. These habitat types were then identified in the wider region both within and outside the Project footprint.

A total of five drainage habitat types were identified in the Study area: Gorge, Creek Line, Riverine, Drainage Line and Floodplain (**Table 4** & **Figure 5**). These habitats were categorised as having a high, medium or low potential for supporting SRE species on the basis of the habitats forming sheltered microhabitats or by forming habitat isolates (**Section 2.2.4**).

Table 4: Drainage habitats present in the Study area

Habitat	Potential for Supporting SRE taxa	Rationale for classification	Survey Site	Area (ha) in the Study area	Extent (%) of the Study area
Gorge	High	Gorges form cool, sheltered habitats that are isolated from similar habitats in the landscape. The dense vegetation results in an accumulation of leaf litter along the banks and around the bases of trees and rocks which provides habitat suitable for relictual invertebrate species.	Site 4	80	0.3
			Site 5		
			Site 7		
			Site 8		
			HA03		
Creek Line	High	Creek lines form sheltered habitats compared to the surrounding environment. The dense vegetation provides sheltered areas suitable to relictual invertebrate species.	Site 1	8	< 0.1
			Site 3		
Riverine	Medium	Rivers support large Eucalypts that provide both shade and accumulated leaf litter and contain higher levels of moisture when compared with the surrounding landscape (e.g semi-permanent pools).	Site 2	967	3.5
			Site 10		
			Site 12		
			Site 13		
Drainage Line	Low	Drainage lines in the Study area are typically exposed with limited sheltered areas. Moisture retention is relatively limited compared to Riverine habitat.	Site 6	95	0.4
			Site 9		
			Site 11		
			HA01		
Floodplain	Low	Floodplain forms an open and largely exposed habitat with the exception of scattered *Eucalyptus victrix* and *Melaleuca* sp. The similarity of this habitat with the surrounding environment suggests that the Floodplain is unlikely to support species with restricted ranges.	HA02	38	0.1
			TOTAL	**1,188**	**4.3**

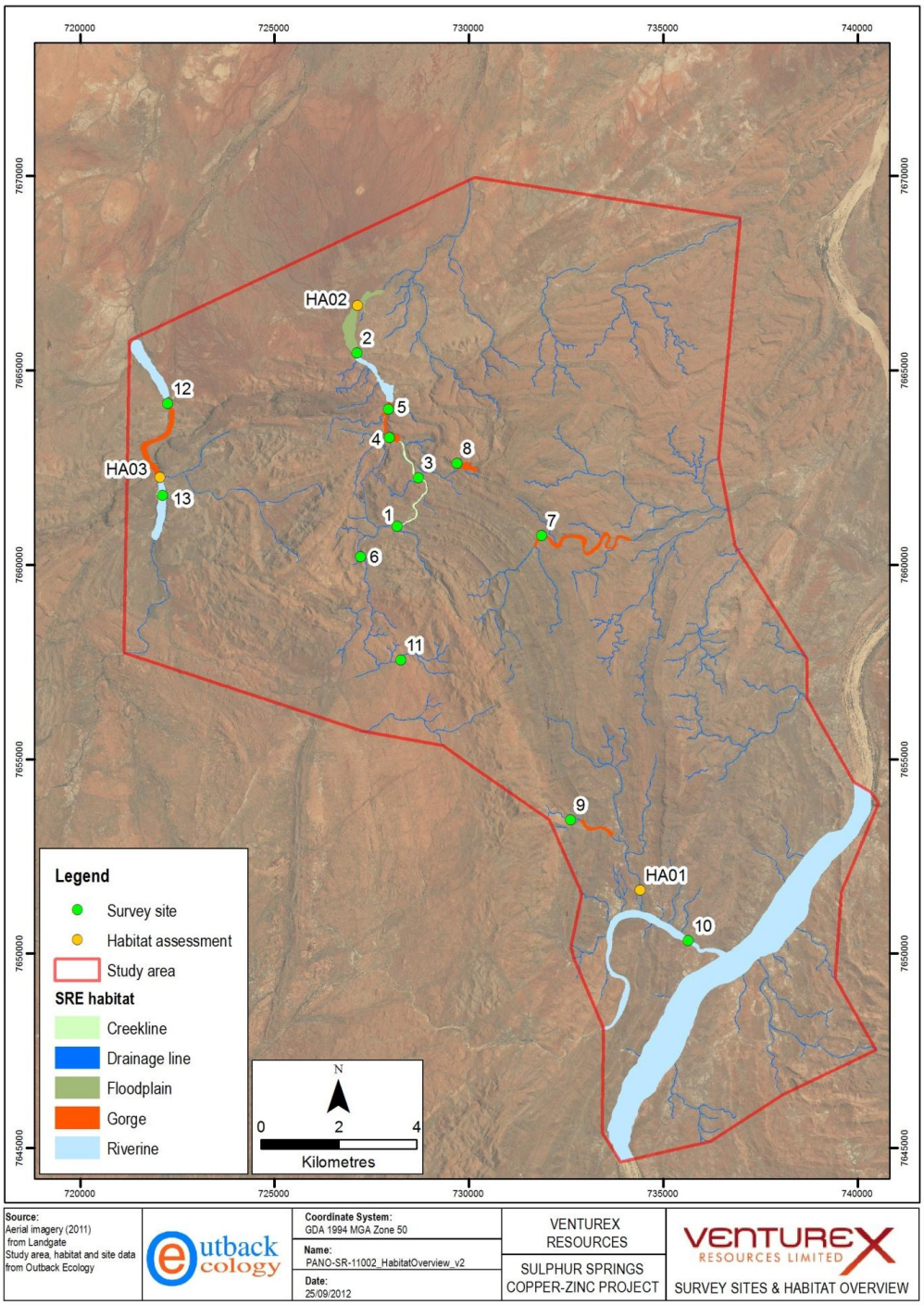

Figure 5: Potential SRE habitat in the Study area

3.1.1. Gorge

Gorges have a high potential to support SRE species because they form cool, sheltered habitats that are isolated from similar habitats in the surrounding landscape. The main Gorge in the Study area has been formed over time by erosion from flowing water, which has cut through the rock to form a narrow channel. This channel is subject to seasonal flooding with sections containing semi-permanent pools and springs of permanent flowing water. A total of five Gorges were located within the Study area. Each of these features represent habitat isolates in the landscape.

Vegetation in Gorge habitat is typified by an overstorey of *Eucalyptus victrix*, over a midstorey of *Acacia inaequilatera* and *Acacia tumida*; over an understory of *Melaleuca* sp., *Triodia* sp. and sedges. The presence of dense vegetation results in an accumulation leaf litter along the banks and around the bases of trees and rocks which provides habitat suitable for relictual invertebrate species. Substrate within Gorge habitat comprised rocks and alluvial sands.

Gorge habitat occurs in the west, central and south east portions of the Study area (**Figure 4**) and was assessed at survey sites 4, 5, 7, 8 and HA03 (**Appendix A**). The Gorge habitat covers an area of 80 ha which represents approximately 0.2 % of the Study area (**Table 4**).

3.1.2. Creek Line

Creek lines have a high potential to support SRE species because they form sheltered habitats compared to the surrounding landscape. The dense vegetation within this habitat also provides sheltered areas with potential to support SRE species. This habitat is subject to seasonal flooding and there is evidence of high water flow. Unlike Drainage Line habitat, the Creek Line habitat carries flowing water for longer periods after rainfall.

Vegetation in the Creek Line habitat was typified by a scattered overstorey of *Eucalyptus victrix*, *Acacia inaequilatera* and *Melaleuca* sp. over understorey of *Triodia* sp. Leaf litter had accumulated along the banks and around the bases of trees and rocks. Substrate within Creek Line habitat consisted of alluvial rocks and sands.

Creek Line habitat occurs in the central portion of the Study area (**Figure 4**) and was assessed at survey sites 1 and 3 (**Appendix A**). The Creek Line habitat covers an area of 8 ha which represents approximately 0.03 % of the Study area (**Table 4**).

3.1.3. Riverine

Rivers have a medium potential to support SRE species because they support large Eucalypt trees which provide both shade and leaf litter. Additionally, Riverine habitat retains moisture after rain events for longer periods than other habitats within the landscape. Furthermore, Riverine habitat commonly contains permanent and semi-permanent water pools, which are uncommon more widely.

Vegetation in Riverine habitat was typified by large *Eucalyptus camaldulensis* along the banks with scattered *Eucalyptus victrix* and *Melaleuca* sp., with understorey of *Triodia sp. and Cenchrus ciliaris*

(Buffel Grass). The substrate consisted of rocky river beds with alluvial sands and clays. These areas are generally degraded due to prolonged grazing by cattle.

Riverine habitat occurs in the west and south east portions of the Study area (**Figure 4**) and was assessed at survey sites 2, 10, 12 and 13 (**Appendix A**). Riverine habitat covers an area of 966 ha which represents approximately 3.52 % of the Study area (**Table 4**).

3.1.4. Drainage Line

Drainage lines in the Study area had a low potential to support SRE species as they formed a habitat that was exposed with limited sheltered areas. Unlike Creek Line habitat, the Drainage Line habitat carries water only briefly after rainfall. The Drainage Line habitats form the upper tributaries of the Study area.

Common vegetation in the Drainage Line habitat comprised a scattered over-storey of *Eucalyptus victrix* and *Melaleuca* sp., with understorey *of Triodia* sp. The substrate comprised of alluvial gravels and sands. Areas within this habitat were subjected to grazing by cattle.

The Drainage Line habitat occurs throughout the Study area (**Figure 4**) and was assessed at survey sites 6, 9, 11 and HA01 (**Appendix A**). The Drainage Line habitat covers an area of 95 ha which represents approximately 0.35 % of the Study area (**Table 4**).

3.1.5. Floodplain

Floodplain habitat has a low potential to support SRE species as it is exposed with limited shelter offered by landforms or vegetation. Floodplain habitat in the Study area is open with a number of minor channels. The water flows through this habitat rapidly after rainfall without forming pools or a permanent water source.

Common vegetation in the Floodplain habitat comprised isolated *Eucalyptus victrix* along some of the minor channels with and understorey of *Triodia* sp. Due to high water flow, leaf litter is largely removed from the area. The substrate is made up of alluvial sands and clays.

The Floodplain habitat occurs in the northern portion of the Study area (**Figure 4**) and was assessed at survey site HA02 (**Appendix A**). The Floodplain habitat covers an area of 38 ha which represents approximately 0.14 % of the Study area (**Table 4**).

3.2. Terrestrial SRE Invertebrate Fauna Species Recorded From The Study area

The targeted survey of the Study area yielded a total of 153 invertebrate specimens from 15 species (

Table 5). For brevity, the term “species” refers to both species and morphospecies. A number of specimens from each target group were not able to be identified to species level, as they were of an inappropriate sex or life stage.

Terrestrial snails were the most numerous of the groups collected, with 64 individuals collected from five identifiable species (

Table 5). This was followed by aquatic snails, millipedes, slaters, pseudoscorpions and mygalomorph spiders (

Table 5). A total of 113 specimens were collected through targeted searching and 40 through leaf litter or Tullgren sampling.

Table 5: Summary of invertebrates from SRE taxa collected during the targeted SRE survey

Target group	Number of specimens	Number of species
Mygalomorph spiders	1	1
Pseudoscorpions	1	1
Millipedes	29	2
Slaters	20	3
Terrestrial snails	64	5
Aquatic snails	38	2
TOTAL	**153**	**13**

Based on scientific knowledge at the time of this report, three of the species collected were considered potential SRE species:

- *Antichiropus* 'DIP005'
- *Antichiropus* 'DIP034'
- *Buddelundia* sp. 11

Table 6: SRE species collected from the Study area showing site, number of specimens and associated habitat

Habitat	Site	Number of SRE specimens collected		
		Antichiropus 'DIP005'	*Antichiropus* 'DIP034'	*Buddelundia* sp. 11
Gorge	Site 4	8	-	-
	Site 8	-	-	3
Creek Line	Site 1	10	-	-
	Site 3	9	-	4
Riverine	Site 2	2	1	-
Total		**29**	**1**	**7**

3.2.1. Mygalomorph Spiders

The single specimen of *Aname* sp. collected during the survey was not a male and therefore, it could not be identified to species level. The distribution and conservation status of many species of this

genus are not well understood with some species having limited distributions (**Appendix B**). Since this specimen was not a male, it is not possible to establish whether it is a potential SRE species.

3.2.2. Pseudoscorpions

The single female specimen of *Indolpium* sp. collected during the survey could not be identified to species level. Since extremely similar specimens have been collected from other regions in Western Australia, it is considered unlikely that *Indolpium* sp. represents a SRE species (**Appendix B**).

3.2.3. Millipedes

Two millipede species collected during the survey - *Antichiropus* 'DIP005' *and Antichiropus* 'DIP034' - were considered SRE species (**Table 6**; **Appendix B**). Most species of the genus *Antichiropus* are considered SRE species and many have a species range of only a few hundred square kilometres (Harvey 2002, 2000).

The millipede *Antichiropus* 'DIP005' was represented by three male specimens collected from Creek Line habitat. Twenty six juvenile and female *Antichiropus* millipede specimens were also collected during the survey; however, these specimens could not be identified to species level using morphology because this can only be done using mature male specimens. To confirm the status of these individuals, Mitochondrial DNA (mtDNA) sequencing was used to compare the specimens with other millipedes collected nearby and in the surrounding region. Results of this analysis revealed that the juvenile and female *Antichiropus* specimens comprised two distinct species. One of these species was *Antichiropus* 'DIP005' which had been previously collected at the Abydos DSO Project (9 km south west of the Study area); the other species was *Antichiropus* 'DIP034' which had been collected at Marble Bar (65 km east of the Study area).

Antichiropus 'DIP005' was collected from Creek Line and Gorge habitats during this survey (**Table 6**) and from ridge (southerly or easterly aspect), Gorge and gully habitats during the Abydos DSO Project: Terrestrial Short Range Endemic Invertebrate Fauna Assessment (Outback Ecology 2012a). Since this species has been collected from a limited range in the Abydos and Sulphur Springs area, it is still considered a SRE species (**Appendix B** and **Appendix E**).

Antichiropus 'DIP034' was only collected from the Riverine habitat during the survey (**Table 6**), however it has also been previously collected from a disturbed areas in the vicinity of the Marble Bar Hotel (65 km east of the study area). Since this species has been collected from a limited range in the Sulphur Springs and Marble Bar area, it is also considered a SRE species (**Appendix E**).

3.2.4. Slaters

Seven specimens of the SRE slater *Buddelundia* sp. 11 were collected during the survey (**Plate 1**). These specimens were collected from Creek Line and Gorge habitats (**Table 6**). Other specimens of this species have been collected from regional locations including the Abydos DSO Project (9 km south west of the Study area), the Mt Webber DSO Project (30 km south of the Study area) and the McPhee Creek DSO project (85 km south east of the Study area). Although this species has been collected at a number of sites in the region, its range is still limited to within 10,000 km^2 and therefore is still considered an SRE species (**Appendix C**). Other non SRE species collected during the survey were *Buddelundia* sp.14 and *Laevophiloscia* sp.

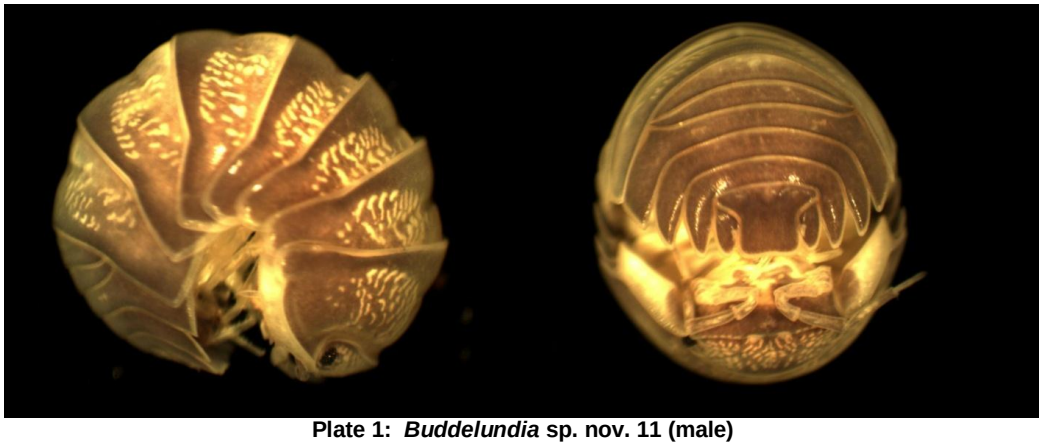

Plate 1: *Buddelundia* sp. nov. 11 (male)

3.2.5. Snails

None of the snails collected during the survey were considered to be SRE species as all are likely to represent species that have been collected more widely in the Pilbara and many are known from other locations in the state of Western Australia (**Appendix D**). The specimens identified as *Rhagada* cf. *richardsonii* (**Appendix D**) are likely to be the same species collected by Biota and identified as *Rhagada* 'Sulphur Springs' (Biota 2007a) (**Plate 2**).

Other species collected during the survey that were not considered SRE species included the terrestrial species: *Pupoides pacificus, Gastrocopta larapinta*, *Gastrocopta mussoni* and *Stenopylis coarctata*; and the aquatic species: *Gyraulus* sp. *Isidorella* cf. *egregia, Austropeplea* cf. *lessoni.*

Plate 2: *Rhagada* sp. 'Sulphur Springs' (photo: Roy Teale) (Biota 2007a).

3.3. SRE Species Previously Recorded From The Study Area And The Wider Region

The database searches and a literature review yielded a total of 26 SRE invertebrate species that have been collected within a 100 km radius of the Study area (**Table 7**, **Figure 6**, **Figure 7**). Of these 26 species, nine were considered to have medium potential to occur in the Study area while fourteen species were considered to have a low potential to occur in the Study area due to a lack of suitable habitat or lack of connecting habitat with the Study area. Two of the three remaining species were confirmed to occur in the Study area (*Antichiropus* 'DIP005' and *Buddelundia* sp. 11) during this survey (**Section 3.2**). Additionally, the pseudoscorpion *Feaella* 'PSE007' was collected in the Study area during a previous survey (Biota 2007b) but was not collected during the current survey.

Table 7: SRE invertebrate collection records yielded by database searches and literature review

SRE species	Group	Source	Habitat(s)	Potential for occurrence in the Study area	Reason for potential occurrence
Antichiropus `DIP005`	Millipede	• Abydos DSO Project (Outback Ecology 2012a)	• Ridge (southerly or easterly aspect) • Gorge • Gully	Confirmed	Species was collected from the Drainage Line habitat in the Study area at Site 1, 3 and 4.
Feaella `PSE007`	Pseudoscorpion	• Sulphur Springs Project (Biota 2007b)	• South facing cliff close to Drainage Line	Confirmed	Species was collected within the Study area by Biota in 2007.
Buddelundia sp. 11	Slater	• Turner River Hub Project (Outback Ecology 2011c) • Abydos DSO Project (Outback Ecology 2012a) • McPhee Creek DSO Project (Outback Ecology 2012b) • Mt Webber DSO Project (Outback Ecology 2012c)	• Gorge • Ridge (southerly or easterly aspect) • Gully • Ridge (northerly or westerly aspect)	Confirmed	Species was collected from two sites within the Study area.
Buddelundia sp. 18	Slater	• Abydos DSO Project (Outback Ecology 2012a) • McPhee Creek DSO Project (Outback Ecology 2012b)	• Gorge • Ridge (southerly or easterly aspect) • Gully • Ridge (northerly or westerly aspect)	Medium	Species has been collected from a number of locations across Pilbara. Closest records are from Abydos (199 specimens) approximately 6.7 km SW of the Study area. Similar habitat occurs in the Study area.
Aops 'pilbara 2'	Scorpion	• Abydos DSO Project (Outback Ecology 2012a)	• Ridge (southerly or easterly aspect)	Medium	Species has been collected at Abydos (four specimens) located approximately 7 km W of the Study area. Habitat occurs within the Study area.
Tyrannocthonius 'nr aridus'	Pseudoscorpion	• Abydos DSO Project (Outback Ecology 2012a) • Mt Dove DSO Project (Phase 1) (Outback Ecology 2011a)	• Ridge (southerly or easterly aspect) • Gully • Ridge (northerly or westerly aspect)	Medium	Species has been collected at Abydos 10 km SW (33 specimens) and at Mt Dove (two specimens) located 79 and 80 km N and NW of the Study area respectively. Similar

SRE species	Group	Source	Habitat(s)	Potential for occurrence in the Study area	Reason for potential occurrence
					habitat may occur in the Study area.
Barrowdillo sp. nov. 2	Slater	• Turner River Hub Project (Outback Ecology 2011c)	• Ridge (northerly or westerly aspect)	Medium	Similar habitat occurs in the Study area. Closest record is 44.1km SW of the Study area
Kwonkan `MYG200`	Mygalomorph Spider	• Giralia Mt Webber (ecologia 2011)	• South facing slope	Medium	Similar habitat occurs in the Study area. Closest record is 45 km SSE of the Study area.
Karaops sp. `Mt Webber`	Selenopid Spider	• Turner River Hub Project (Outback Ecology 2011c)	• Ridge (southerly or easterly aspect)	Medium	Similar habitat occurs in the Study area. Closest record is 45 km SSE of the Study area.
Karaops sp. 'Wodgina'	Selenopid Spider	• Turner River Hub Project (Outback Ecology 2011c)	• Calcrete Breakaway • Ridge (southerly or easterly aspect) • Gully • Ridge (southerly or easterly aspect)	Medium	Closest record is located 37 km SW of the Study area.
Gen. nov. sp. nov	Snail	• Abydos DSO Project (Outback Ecology 2012)	• Gorge • Ridge (southerly or easterly aspect)	Medium	Similar habitat occurs in the Study area. Closest record is 7 km.
Feaella 'PSE017'	Pseudoscorpion	• Turner River Hub Project (Outback Ecology 2011c)	• Riverine	Medium	Similar habitat occurs in the Study area. Closest record is 40 km SSW of the Study area
Karaops sp. 'Mt Dove`	Selenopid Spider	• Mt Dove DSO Project (Phase 1) (Outback Ecology 2011a)	• Ridge (southerly or easterly aspect)	Low	Species represented by a single record from a habitat isolate 78 km NW from the Study area.
Urodacus 'pilbara 13'	Scorpion	• Turner River Hub Project (Outback Ecology 2011c)	• Maritime grassland • Low Acacia heath with Spinifex	Low	Habitat does not occur in the Study area
Troglochernes 'sp. nov. 001'	Pseudoscorpion	• Mt Dove DSO Project (Phase 1) (Outback Ecology 2011a)	• Ridge (southerly or easterly aspect)	Low	Species represented by five records from a habitat isolate from 85 km NW of Study area
Antichiropus	Millipede	• WAM Database (Western	• South facing Gully	Low	Species is likely to have a very

SRE species	Group	Source	Habitat(s)	Potential for occurrence in the Study area	Reason for potential occurrence
`Chichester`		Australian Museum 2011)	Floor • Creek line		restricted distribution. Closest record 102km S of the Study area.
Aname 'MYG100'	Spider	• WAM Database (Western Australian Museum 2011)	• Spinifex plain	Low	Habitat does not occur in the Study area
Aname 'MYG103'	Spider	• WAM Database (Western Australian Museum 2011)	• Spinifex plain	Low	Habitat does not occur in the Study area
Aname 'MYG208'	Mygalomorph Spider	• Turner River Hub Project (Outback Ecology 2011c)	• Acacia, Spinifex sandplain	Low	Habitat does not occur in the Study area
Aname 'MYG209'	Mygalomorph Spider	• Turner River Hub Project (Outback Ecology 2011c)	• Acacia, Spinifex sandplain	Low	Habitat does not occur in the Study area
Synsphyronus 'PSE008'	Pseudoscorpion	• WAM Database (Western Australian Museum 2011)	• Granite Outcrop	Low	Habitat does not occur in the Study Area
Sundochernes 'PSE021'	Pseudoscorpion	• WAM Database (Western Australian Museum 2011)	• Granite Outcrop	Low	Habitat does not occur in the Study Area
Oratemnus 'PSE018'	Pseudoscorpion	• WAM Database (Western Australian Museum 2011)	• Granite Outcrop	Low	Habitat does not occur in the Study Area
Quistrachia turneri	Slater	• Turner River Hub Project (Outback Ecology 2011c)	• Granite Outcrop • Ridge (southerly or easterly aspect • Calcrete Breakaway	Low	Habitats are limited in the Study area. Closest collection record 70 km S of the Study Area.
Spherillo? sp.	Slater	• Turner River Hub Project ((Outback Ecology 2011c)	• Granite Outcrop	Low	Habitat does not occur in the Study Area
Buddelundia sp. 21	Slater	• Mt Dove DSO Project (Phase 1) (Outback Ecology 2011a)	• Ridge (southerly or easterly aspect)	Low	Habitat is limited in the Study Area. Closest collection record approximately 80 km NW of the Study area.

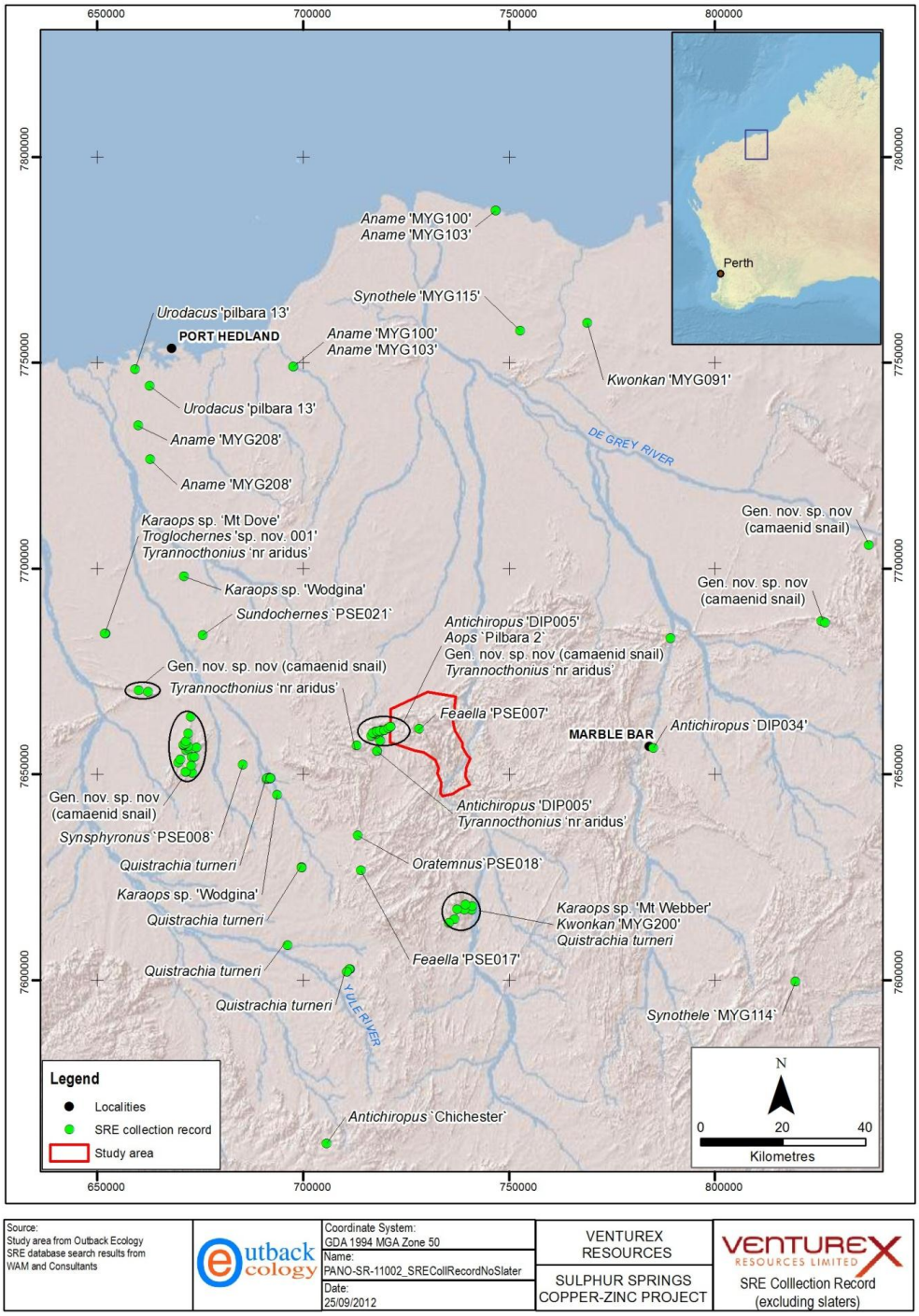

Figure 6: SRE Collection records yielded by database searches and literature review with reference to habitat distribution within the Study area and surrounds

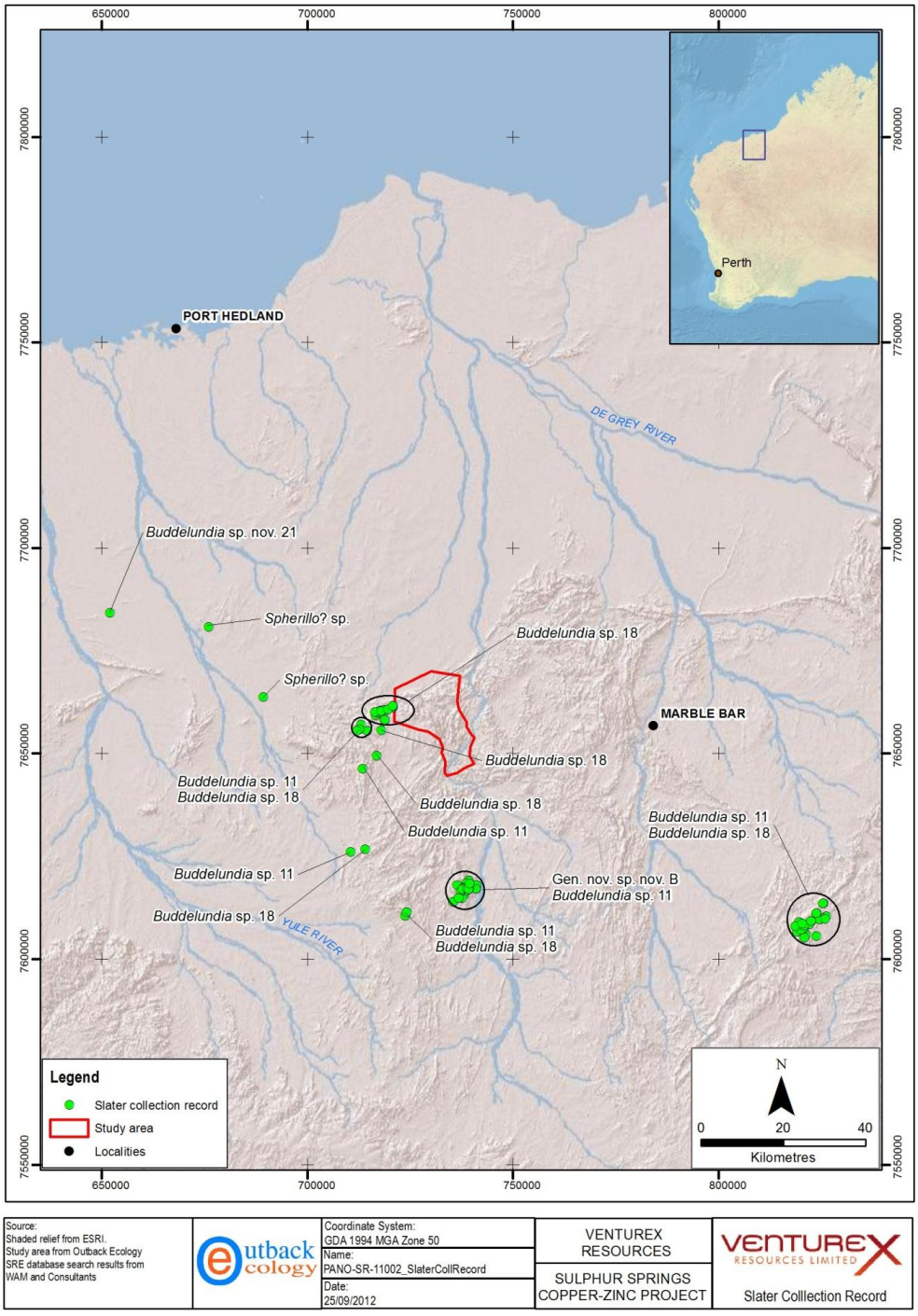

Figure 7: Collection records of slaters yielded by database searches and literature review with reference to habitat distribution within the Study area and surrounds

4. SURVEY LIMITATIONS AND CONSTRAINTS

A number of factors can influence the design and intensity of a SRE invertebrate fauna survey. The EPA (2004) lists possible limitations and constraints that can impinge on the adequacy of a survey (**Table 8**). All SRE invertebrate fauna surveys are limited to some degree by time and seasonal factors and in an ideal situation several surveys would be undertaken over a number of years during different seasons. Nevertheless, all potential limitations and constraints identified by the EPA (2004) were considered and satisfied.

Table 8: Summary of potential survey limitations and constraints

Aspect	Constraint?	Current survey
Competency/experience of consultants	no	Members of the survey team have had a combined experience in excess of six years undertaking SRE invertebrate fauna surveys of this kind in WA. Invertebrate specimens were identified by recognised taxonomic specialists.
Scope	no	Terrestrial SRE invertebrate fauna and habitat were assessed using established and standardised sampling techniques and habitat assessments.
Proportion of fauna identified, recorded and/or collected	no	The survey of the Study area yielded a total of 153 invertebrate specimens from 13 species belonging to taxa prone to short-range endemism. All specimens collected from groups prone to short range endemism in WA were submitted to the WAM or relevant specialists for identification. Whilst, all specimens were identified down to the lowest taxonomic level possible, it was not always possible to identify to species level if the taxonomy of the group was not well resolved or if the life stage or sex required for identification was not collected. The survey was designed to maximise the collection of specimens belonging to target groups; however, it is recognised that surveys across years and seasons may be necessary to collect the majority of species in an area.
Sources of information (e.g. previously available data as distinct from new data)	no	Data relevant to this survey was obtained via database searches (Section 2.1.1) and by undertaking a literature review (Section 2.1.2). The results from these database and literature reviews are presented in Section 3.3.
Proportion of task achieved, and further work which might be needed	no	Representative sites from all potential SRE habitats in the Study area were sampled using targeted searching and leaf litter collection. Specimens belonging to target SRE groups were collected from all 13 sampled sites. All specimens from target groups were identified by relevant taxonomic experts.
Timing, weather, season, cycle	no	Targeted searching was conducted during the optimum time for invertebrate surveys in the Pilbara (Environmental Protection Authority 2009). This was considered satisfactory given that the climatic conditions during the survey period were conducive to invertebrate activity. The temperature and during the survey was typical of the time of year however rainfall prior to the survey was higher than average due to cyclone activity (Section 2.2.2).

Aspect	Constraint?	Current survey
Disturbances	no	Evidence of grazing pressure from cattle was observed in the Drainage Line, Open Drainage Line, Riverine and Open Woodland habitats within the Study area. Vehicle access tracks impacted on the Gorge, Drainage Line and Floodplain (Habitat Assessment 1 Habitat Assessment 2). However, most of the area within these habitat considered to be important to SRE invertebrates was largely undisturbed.
Intensity	no	Targeted searching, soil and litter collection were employed at 13 sites. Additionally, habitat assessments were conducted at a further 3 survey sites. In total, the survey comprised 19.5 hours of targeted searching and the collection of 31 leaf litter samples.
Completeness	no	All potential SRE habitats within the Study area were adequately surveyed.
Resources	no	Resources were adequate to complete the survey. Survey participants were competent in the collection of invertebrates and identification of the habitats encountered during the survey.
Remoteness and access problems	partial	Due to flooding of access tracks in the Study area at the time of the survey, access by 4WD was slower than during previous visits to the area. As a result, the number of targeted search sites had to be reduced from 14 down to 13 sites. Coverage of the Study area by targeted searching was still adequate given the scale of proposed impacts.
Availability of contextual information	no	Contextual information on the occurrence of SRE species in the region was available and sourced through the WAM Database and through a literature review of regional SRE invertebrate fauna surveys. Additional information was also considered which included DEC's Threatened and Priority Fauna Database and DECs NatureMap database.

5. IMPACT ASSESSMENT

This section presents an assessment of the potential impacts of the Project on terrestrial SRE invertebrate fauna habitat and SRE species identified during field survey and also via the desktop study in accordance with requirements outlined by the EPA (2004, 2009). The primary objectives of this section are to describe the relevant threatening processes associated with the Project (**Section 5.1**), and to examine the likely impact of these threatening processes on SRE invertebrate fauna habitat (**Section 5.2**) and SRE species present in the Study area or immediate surrounds (**Section 5.3**).

5.1. Threatening Processes

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

5.1.1. Land Clearing

Land clearing is likely to be the threatening process that will have the largest impact on SRE invertebrate fauna and habitat. To develop the Project, land clearing will be required for a processing plant, TSF, evaporation pond, ROM pad, access roads, workshops, borrow pit, offices, camp and air strip.

The Project footprint is expected to be approximately 178.3 ha in size. It is understood that this footprint includes all major infrastructure associated with the Project, however additionally clearing may be required outside the footprint during construction. Some areas within this footprint have been previously been cleared by CBH Resources during their exploration phase.Land clearing will directly remove potential SRE invertebrate fauna habitat resulting in a reduction in available habitat and potentially habitat fragmentation. Short-range endemic invertebrate fauna species typically have poor powers of dispersal and are therefore unable to emigrate from land as it is being cleared. Land clearing will result in the loss of SRE individuals that occur within the Project footprint. The clearing of habitats with a high or medium potential to support SRE species (**Section 3.1**) should be limited where practicable.

5.1.2. Fire

The development and operation of the Project may alter the fire regime of the Study area. SRE invertebrate habitat such as cliffs, ridges and Gorges are often fire refuges (Environmental Protection Authority 2009) as they do not experience fire with the frequency of the surrounding landscape. Fire refuges in the Pilbara often support *Ficus* sp. trees and other fire intolerant vegetation, which are an important component of SRE habitats. Increasing fire frequency in fire refuges is likely to be detrimental to SRE species which have evolved in the absence of fire. The impact of inappropriate fire regimes may be reduced through the implementation of an appropriate fire management plan.

5.1.3. Introduced Flora

The Project may result in the introduction or spread of existing weeds in the Study area. Weeds may have a negative impact on SRE species as they can fundamentally alter the composition and structure of vegetation communities (Cowie and Werner 1993, Gordon 1998). Invasion by non-native species typically results in a decline in native plant species richness (Grice 2006). It is therefore important to implement management strategies to reduce the occurrence and spread of weeds during mining operations.

5.1.4. Changes To Surface Hydrology

The Project will impact upon drainage habitats in the vicinity of the Project, primarily through the construction of the access road (**Figure 5**). There exists the potential for runoff from the access road to cause sediment loading of the Gorge and Creek Line habitats in the vicinity and downstream of the access road. The natural hydrology of the Gorge and Creek Line may also make the access road susceptible to erosion during high rainfall events which may cause direct and downstream impacts to drainage habitats.

Drainage control structures may also affect the natural flow of water through drainage habitats. This may divert or interrupt the natural flow of water away from areas that were previously moist environments reducing the quality of SRE habitat and the health of vegetation occurring in these areas.

5.1.5. Noise And Vibration

Noise and vibration from the Project is likely to be associated with blasting, crushing and screening, haul trucks, road trains, diesel power generation and general machinery necessary for mine operation. Information on the potential effects of noise and vibration on SRE species is limited. A trial that tested the effect of exploration drilling on the SRE Shield-backed trapdoor spider has been conducted at Jack Hills in the Murchison by Crosslands Resources (Department of Mines and Petroleum 2010). In the trial, spiders were observed in their burrows while vibration simulating drilling was produced. Preliminary results suggest that the effects of vibration on spiders may be limited; however; the intrusion of the burrows by endoscopic camera may also have influenced spider behaviour. Raven (2008) suggests that vibrations created by blasting and heavy earthmoving equipment may actually attract spiders and other arachnids, which subsequently places these individuals at risk of direct contact with mining activities. Without further research, it is not possible to predict and quantify the noise and vibration impacts on SRE species.

5.1.6. Light

The operation of the Project and potential use of the access road during night-time hours could result in an increase in the exposure of SRE fauna to artificial light. Most SRE invertebrate fauna in the Pilbara are active during the hours of darkness and it is possible that artificial light will influence feeding and breeding behaviour. To reduce possible impacts of artificial light on SRE fauna, lighting should be designed to illuminate designated operations areas rather than the surrounding landscape.

5.1.7. Dust

The Project will potentially result in an increase in dust pollution resulting from the movement of light and heavy vehicles and the general use of equipment on site. Dust pollution may lead to the degradation of surrounding vegetation and high levels may reduce plant growth resulting in the degradation of the overall ecosystem and the increased risk of disease in plants. Adequate dust suppression measures should be implemented to reduce the effects of dust on potential SRE habitats and SRE species, particularly in the vicinity of the Gorge and Creek Line habitats

5.2. Impact on SRE Habitat

The construction of the Project will result in the loss of habitat. Habitat loss is listed as a key threatening process under the EPBC Act; however, it is recognised that this is a necessary and typical part of the development of the Project. The removal of SRE habitat within the Project footprint will result in the loss of the SRE populations that reside in those habitats.

Five drainage habitats were identified within the Study area. Of these habitats, the Gorge and Creek Line habitat were considered to have a high potential to support SRE species, whereas the Riverine habitat was considered to have a medium potential to support SRE species. The development of the access road component of the Project will impact all three of these habitat types and impacts to the many Drainage Lines that feed Gorge and Creek Lines are also likely to have an effect on these habitats.

The Gorge habitat has a high potential to support SRE species (**Section 3.1**). There were a total of five Gorges located within the Study area and each of these features formed a habitat isolate in the landscape. The development of the Project will directly impact one of these Gorges by removing 1.5 ha for 1.3 km along the Gorge for the construction of the access road (**Table 9**; **Figure 8**). Secondary impacts from the access road such as erosion and sedimentation may occur in the vicinity and downstream of the access road as a result of high volume water flow through the Gorge after periods of high rainfall. The other four Gorges in the Study area occur to the west, east and south east of the Project and comprise approximately 75.5 ha. These Gorges are unlikely to be impacted by the Project. Similar habitat also occurs beyond the Study area to the south west at the Abydos DSO Project (Outback Ecology 2012a). Because Gorges form habitat isolates and are of limited extent in the landscape, impacts to this habitat should be minimised as much as possible.

The Creek Line habitat has a high potential to support SRE species (Section 3.1). The development of the Project will result in the direct loss of approximately 0.08 ha of the Creek Line habitat for the construction of the access road where it crosses the Creek Line in one location (**Table 9**; **Figure 8**). This habitat was not identified elsewhere in the Study area. As this habitat is not well connected in the landscape and has a limited extent within the Study area, impacts to this habitat should be minimised where possible.

The Riverine habitat has medium potential to support SRE species (Section 3.1). The development of the Project will result in the loss of approximately 0.63 ha of the Riverine habitat for the construction of

the access road (**Table 9**; **Figure 8**). Approximately 950 ha of this habitat is also known to occur to the west and south east of the Project within the Study area and is unlikely to be impacted by the Project. This habitat is extensive both within and outside the Study area in association with the Shaw River, however impacts to this habitat should be minimised where possible because of its medium potential to support SRE species and the potential to have downstream secondary impacts.

Table 9: The extent of drainage habitats within the proposed Project footprint

Drainage habitat	Area in Study area (ha)	Area in Project footprint (ha)
Gorge	80	1.49
Creek Line	8	0.08
Riverine	967	0.63
Drainage Line	95	0.13
Floodplain	38	0.41
Total	**1,188**	**2.73**

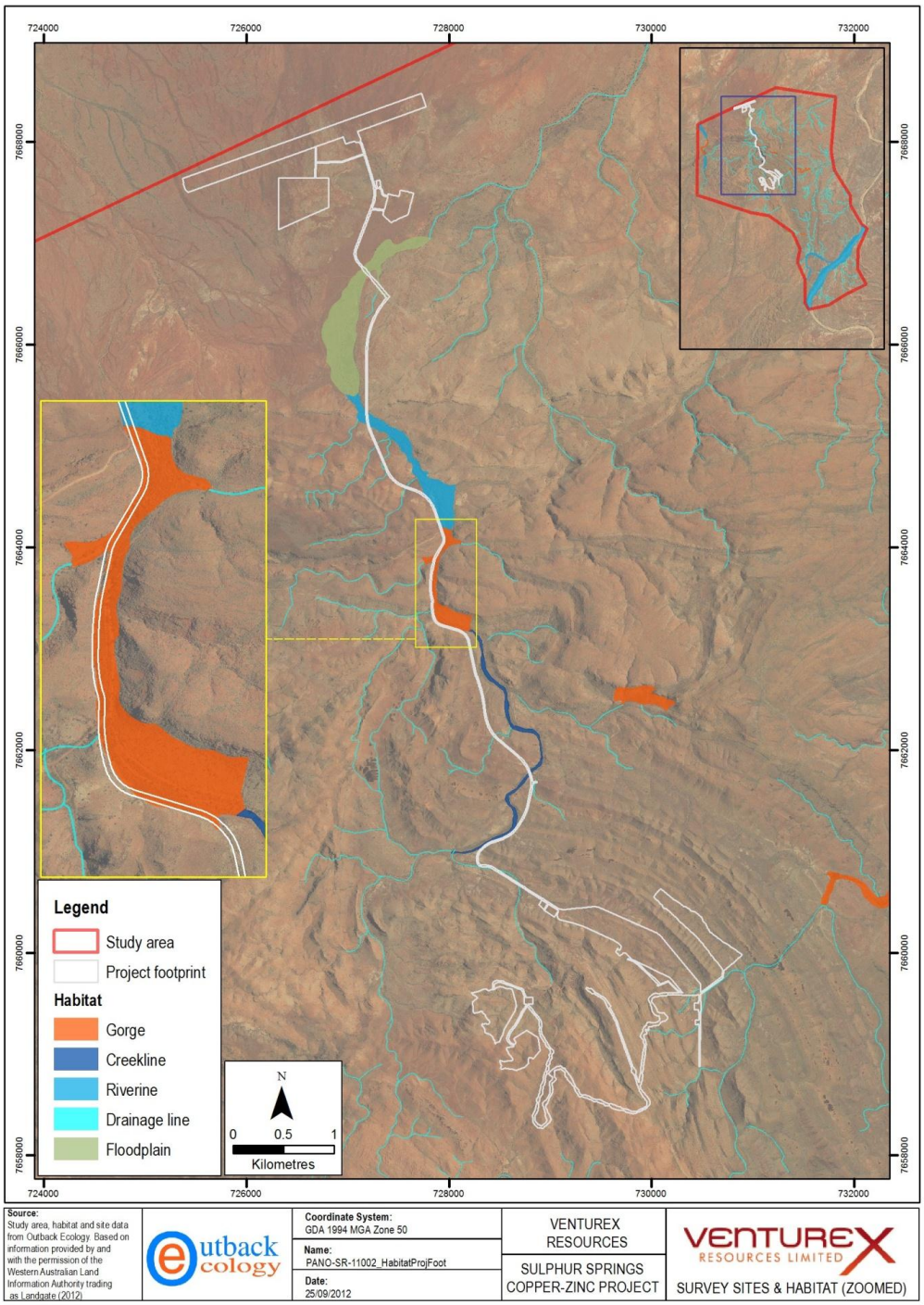

Figure 8: Drainage habitats in relation to the proposed Project footprint

5.3. Impact on SRE Species

Three SRE species were collected during the targeted SRE survey of the Study area (**Section 3.2**). Additionally, one species has been collected within the Study area during a survey by Biota (2007a) (**Section 3.3**).

Table 10: The distribution of SRE species and their habitat in relation to the Project footprint

SRE species	Records			Habitat(s) from which species were collected
	Project footprint	Study area (outside of Project footprint)	Regional (outside of Study area)	
Antichiropus DIP005	X	X	X	Gorge
				Creek Line
Antichiropus DIP34		X	X	Riverine
				Disturbed
Buddelundia sp. 11		X	X	Drainage Line
				Gorge
Feaella PSE007		X		Creek Line

5.3.1. *Antichiropus* 'DIP005'

The millipede *Antichiropus* 'DIP005' is a SRE species that was collected at one site within the Project footprint and three sites outside the Project footprint (**Table 10**; **Figure 9**). Within the Study area, *Antichiropus* 'DIP005' was collected from Gorge and Creek Line habitats which are considered to have a high potential to support SRE species. The development of the Project will remove 1.49 ha (1.3 km) of Gorge habitat and 0.08 ha of Creek Line habitat (**Table 9**). Although the Project will impact upon the Gorge and Creek Line where this species was collected; this species is also known to occur at another Gorge away from the Project footprint within the Study area. Additionally, this species is known to occur at six sites 9 km south west of the Study area at the Abydos DSO Project (**Figure 10**).

Although *Antichiropus* 'DIP005' is a SRE species that is likely to have a distribution that aligns with sheltered habitats in the vicinity of Sulphur Springs, the known distribution of this species extends outside of the footprint for the Project both locally and regionally. Consequently, the Project is unlikely to pose a long term conservation risk to *Antichiropus* 'DIP005'.

5.3.2. *Antichiropus* 'DIP034'

The millipede *Antichiropus* 'DIP034' is a SRE species collected at one site in Riverine habitat less than 100 m downstream of the access road component of the Project footprint (**Table 10**; **Figure 9**). The Riverine habitat has medium potential to support SRE species and 0.63 ha of this habitat occurs within the Project footprint (**Table 9**). Although the Project will impact upon the Riverine habitat where this species was collected; this species is also known to occur outside of the Study area at Marble Bar (65 km east of the Study area) (**Figure 10**).

Although *Antichiropus* 'DIP034' is a SRE species that is likely to have a distribution that aligns with sheltered habitats in the vicinity of Sulphur Springs, the distribution of this species extends outside of

the footprint for the Project regionally. Consequently, the Project is unlikely to pose a long term conservation risk to *Antichiropus* 'DIP034'.

5.3.3. Buddelundia sp. 11

The slater *Buddelundia* sp. 11 is a SRE species collected at two sites during the survey outside of the Project footprint (**Table 10**; **Figure 12**). Within the Study area, *Buddelundia* sp. 11 was collected from Gorge and Creek Line habitats which are considered to have a high potential to support SRE species. The development of the Project will remove 1.49 ha (1.3 km) of Gorge habitat and 0.08 ha of Creek Line habitat (**Table 9**). *Buddelundia* sp. 11 has also been collected at a number of regional locations including the Abydos DSO Project, Mt Webber DSO Project and the McPhee Creek DSO Project as well as other locations.

Although *Buddelundia* sp. 11 has been collected from habitats that occur within the Project footprint, none of the specimens were collected from within the Project footprint. Additionally, *Buddelundia* sp. 11 is known to have a wide regional distribution from collection records from a number of other locations. Consequently, the Project is unlikely to pose a long term conservation risk to *Buddelundia* sp. 11.

5.3.4. *Feaella* PSE007

The pseudoscorpion *Feaella* PSE007 is a SRE species known from a single specimen collected outside the Project footprint habitat by Biota (2007a) (**Table 10**; **Figure 13**). This species was collected from Creek Line habitat which is considered to have a high potential to support SRE species. The Project will remove 0.08 ha of Creek Line approximately 1 km downstream of where the specimen of *Feaella* PSE007 was collected.

Only one specimen has been collected despite several surveys being conducted with the aim of collecting additional specimens, suggesting that the species is very cryptic and may only be active during certain climatic conditions. Given the Project will not impact the collection location of this species and given that impacts to the Creek Line habitat are limited, it appears unlikely that the Project will pose a long term conservation risk to *Feaella* PSE007.

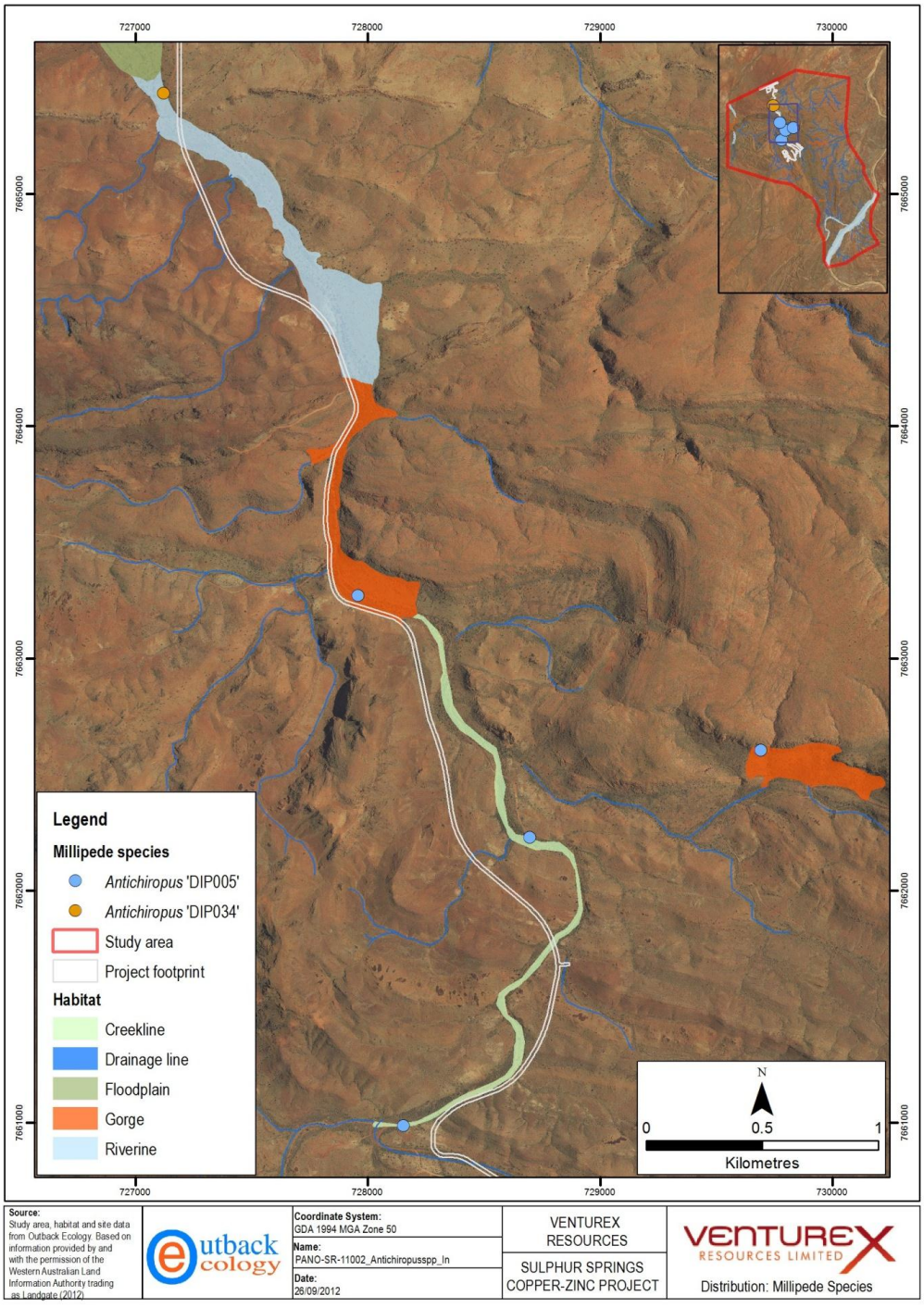

Figure 9: Collection locations of the millipede *Antichiropus* 'DIP005' and Antichiropus '034' with respect to habitat types within the Study area

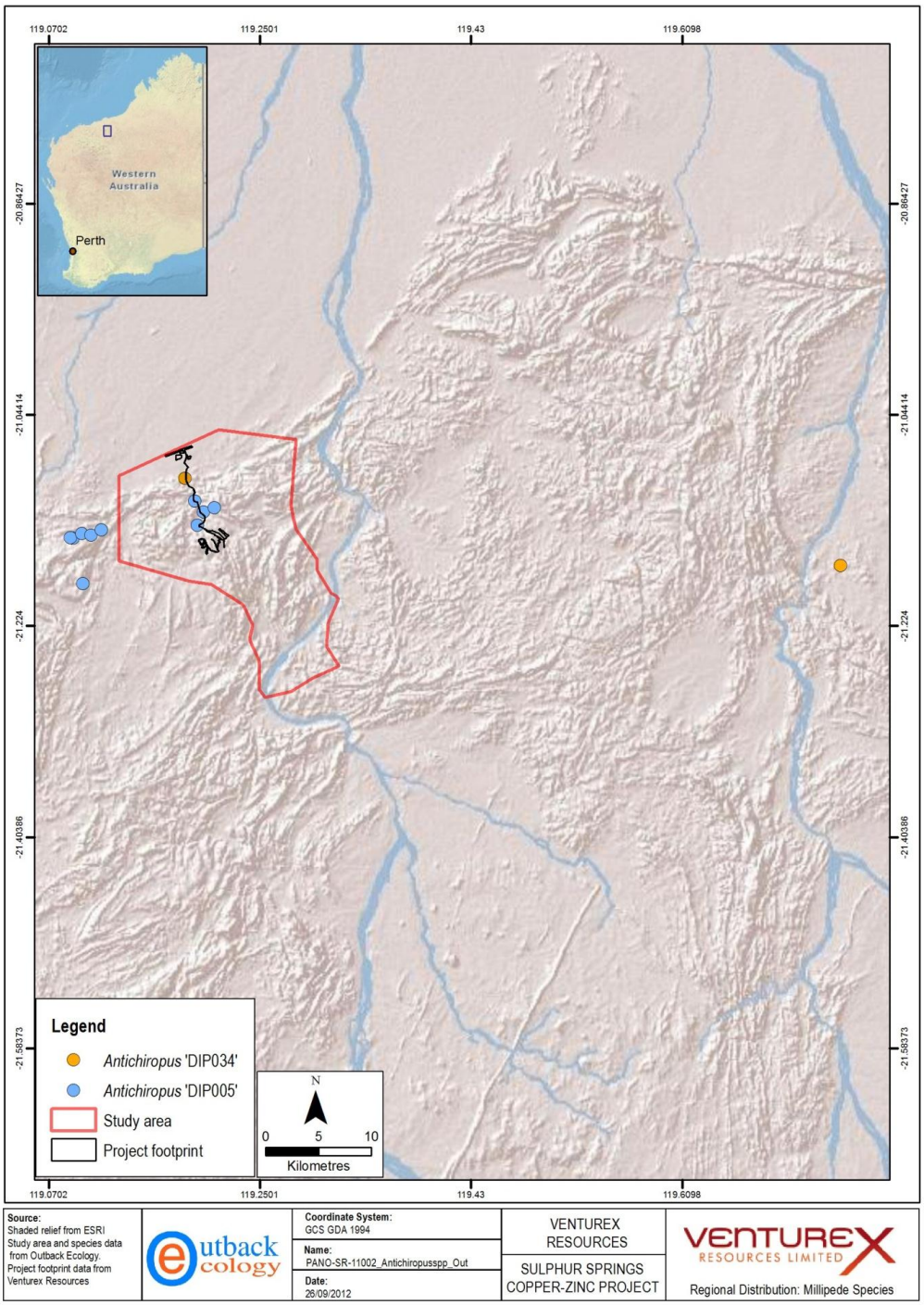

Figure 10: Distribution map of the millipede *Antichiropus* 'DIP005' and *Antichiropus* 'DIP034'

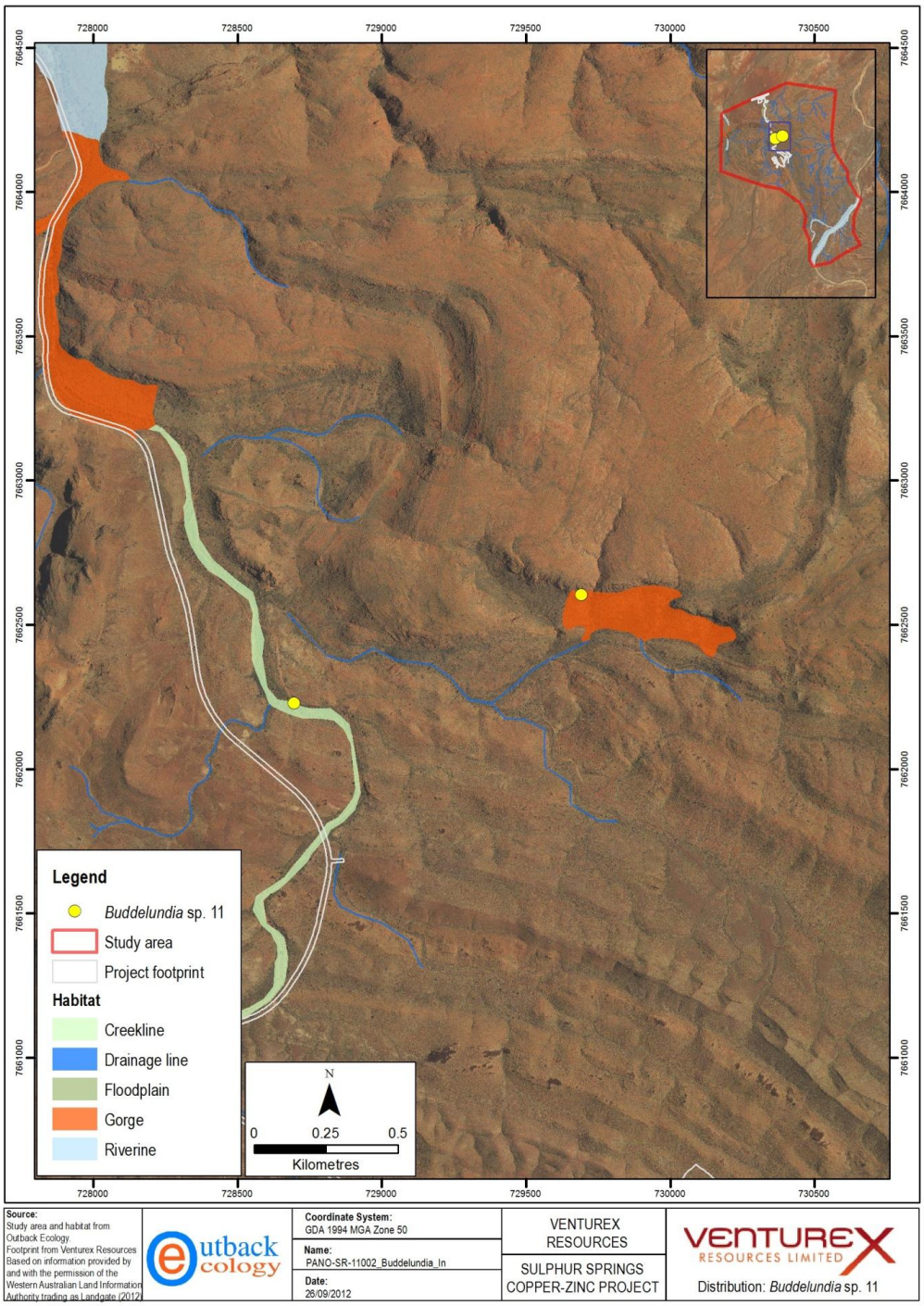

Figure 11: Collection records of the slater *Buddelundia* sp. 11 with respect to habitats within the Study area

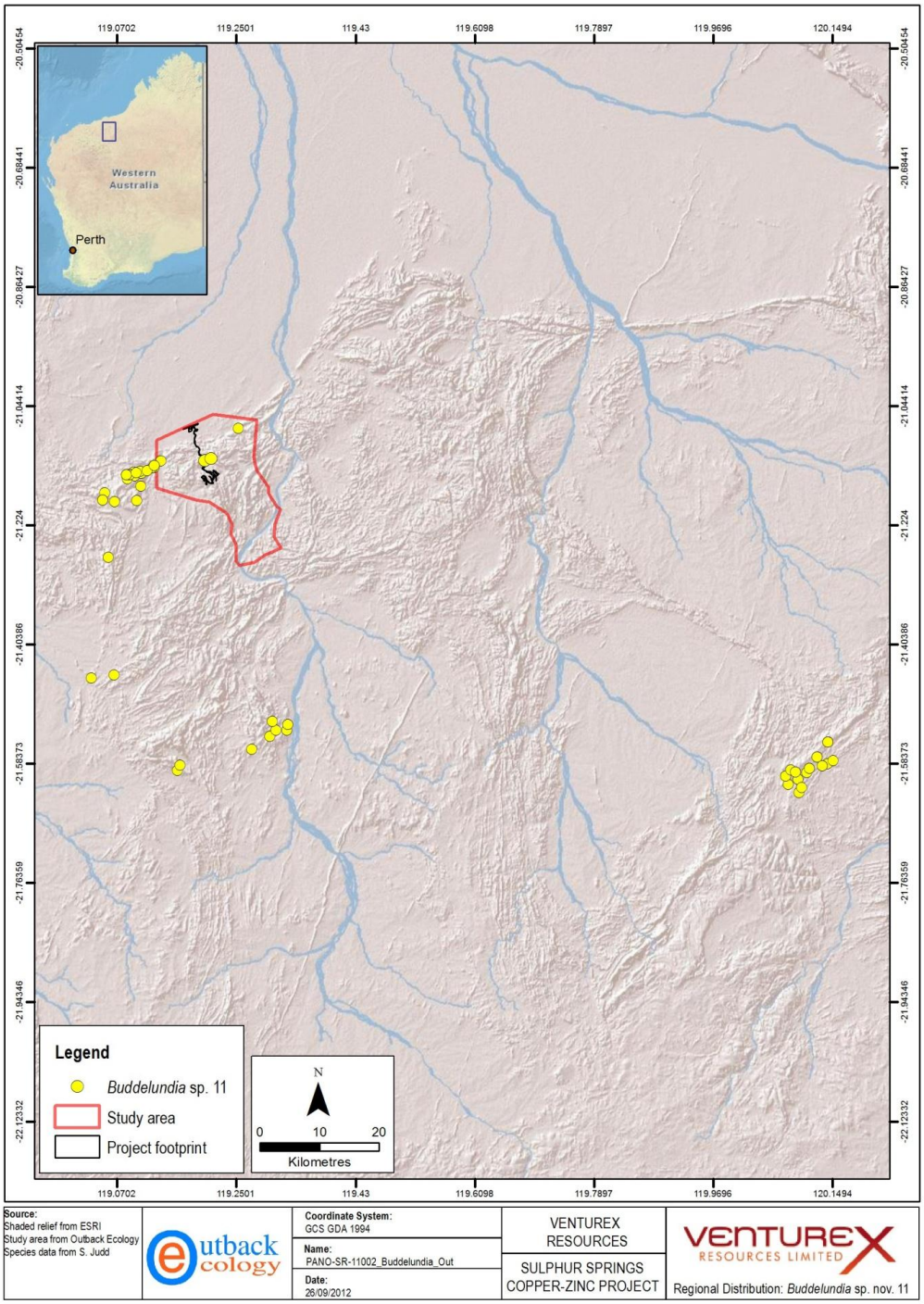

Figure 12: Regional distribution of the slater *Buddelundia* sp. 11

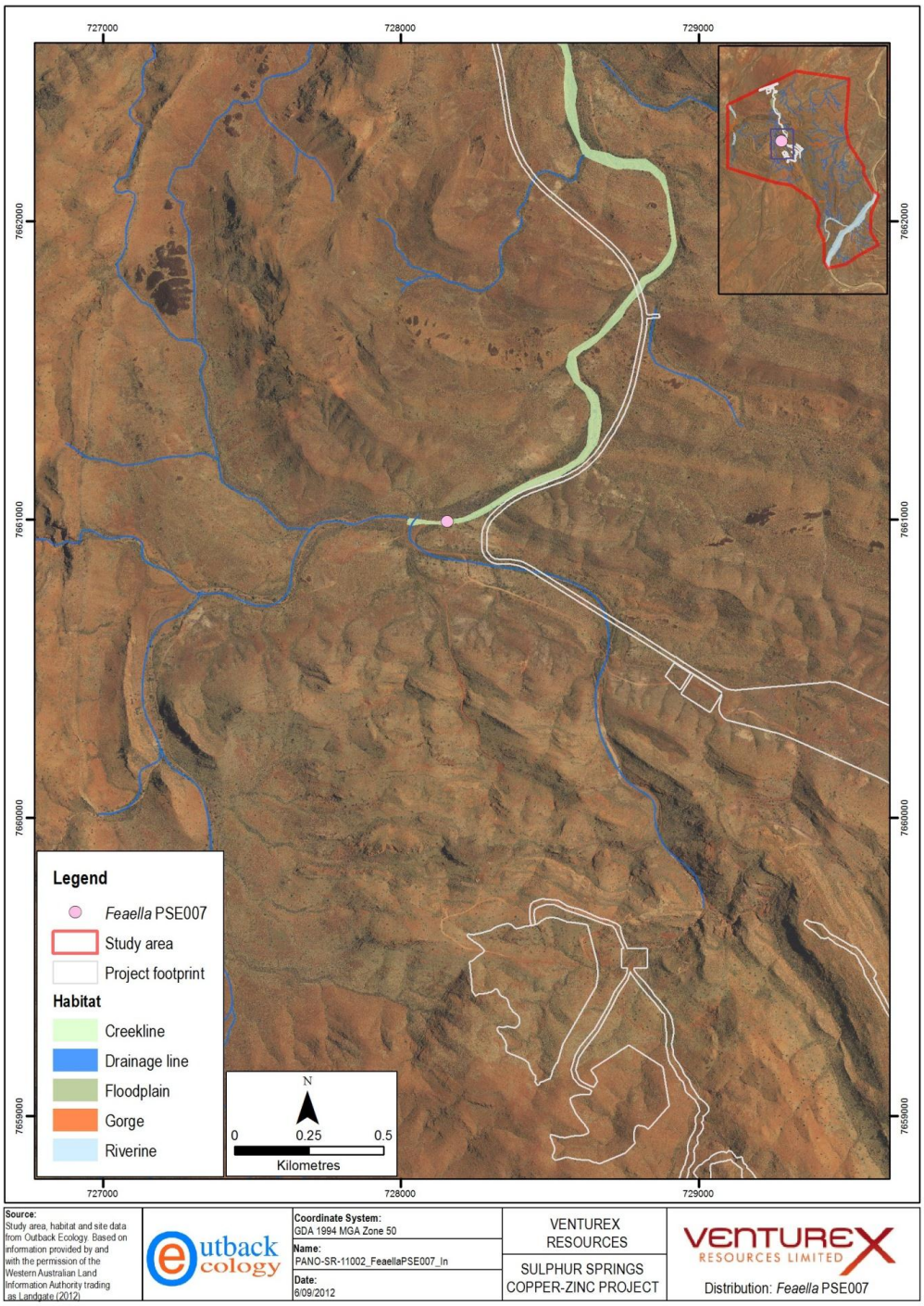

Figure 13: Collection records of the pseudoscorpion *Feaella* PSE007 with respect to habitats within the Study area

6. CONCLUSIONS

The Project will impact upon SRE species through the loss of individuals and habitat on a local scale through direct loss of individuals during clearing, loss of habitat and indirect impacts, particularly in the vicinity of the proposed mine access road.

The targeted survey of SRE groups within the Study area resulted in the collection of four SRE species:

- the millipede *Antichiropus* 'DIP005';
- the millipede *Antichiropus* 'DIP034',
- the slater *Buddelundia* sp. 11; and
- the pseudoscorpion *Feaella* 'PSE007'.

Based on the desktop assessment, nine additional species were considered to have medium potential to occur in the Study area based on the proximity of records, the availability suitable habitat and the connectivity of habitat with the Study area.

Of the four species collected within the Study area, only the millipede *Antichiropus* 'DIP005' has been collected within the Project footprint. However this species has also been collected outside of the Project footprint within the Study area and at regional sites 12 km southwest of the Project. Although this species is likely to have a distribution that aligns with sheltered habitats in the vicinity of Sulphur Springs, the occurrence of this species at regional sites suggests that the Project is unlikely to pose a long term conservation risk to *Antichiropus* 'DIP005'. Provided that secondary impacts to habitats are minimised, the Project is also unlikely to pose a long term conservation risk to the other three species as they were not collected within the Project footprint.

The Project footprint is expected to be approximately 178.3 ha in size. It is understood that this footprint includes all major infrastructure associated with the Project, however additionally clearing may be required outside the footprint during construction. Some areas within this footprint have been previously been cleared by CBH Resources during their exploration phase.

Habitat assessments of the drainage features within the Study area identified five types of drainage habitat:

- Gorge;
- Creek Line;
- Riverine;
- Drainage Line; and
- Floodplain.

The Gorge and Creek Line habitats were considered to have high potential for supporting SRE species and Riverine habitat was considered to have medium potential to support SRE species.

The construction of the Project will result in the loss of approximately 2.73 ha of drainage habitat. This will comprise 1.49 ha (1.3 km) of Gorge habitat, 0.08 ha of Creek line habitat and 0.63 ha of Riverine habitat present in the Study area. These habitats will primarily be impacted thought the construction of the mine access road. There also exists the potential for runoff from the access road to cause sediment loading of the Gorge and Creek Line habitats in the vicinity and downstream of the access road. The natural hydrology of the Gorge and Creek Line may also make the access road susceptible to erosion during high rainfall events which may cause direct and downstream impacts to drainage habitats. Although these habitats are known to occur in other locations in the Study area, they are of limited extent and not well connected in the surrounding landscape. All other drainage habitats in the Study area were considered to have a low potential to support SRE species.

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APPENDIX A
Site Descriptions

APPENDIX B

Arachnids and Diplopods from Sulphur Springs, Western Australia

APPENDIX C

Slaters of the Venturex Copper Zinc Project: Sulphur Springs

APPENDIX D

Non - Marine Molluscs from Sulphur Springs, Western Australia

Appendix E
Outback Ecology DNA Bar-coding Project (Antichiropus)