Bennelongia Environmental Consultants

Yeelirrie Subterranean Fauna Assessment

Prepared for:

Cameco Australia

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Final Report

Short-Range Endemics | Subterranean Fauna

Waterbirds | Wetlands

Yeelirrie Subterranean Fauna Assessment

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EXECUTIVE SUMMARY

Cameco Australia Pty Ltd (Cameco) are proposing to mine uranium at the Yeelirrie Project using an open pit method of mining. In addition to removal of the calcrete body hosting the uranium, de-watering of the calcrete and groundwater abstraction from some surrounding areas will be required. This loss of subterranean habitat is relevant because the Yeelirrie Project area contains a very diverse subterranean fauna. Historical surveys commissioned by BHP Billiton Ltd, the previous operators of the Project identified 56 species of stygofauna and 45 species of troglofauna in the Project area and its vicinity. Cameco commissioned further stygofauna sampling in February and June/July 2015 to provide additional information on stygofauna species distributions. This report provides:

1. An assessment of the level of stygofauna and troglofauna sampling effort in the Project area;
2. Lists of stygofauna and troglofauna species present in the Project area, with updating of the species names used in Subterranean Ecology's (2011) report where appropriate; and
3. An assessment of the likely ranges of stygofauna and troglofauna species in relation to the proposed mine pit layout and the modelled groundwater drawdown resulting from mine de-watering and groundwater abstraction to supply processing water.

The Yeelirrie Project is based on an undeveloped uranium deposit in the Northern Goldfields of Western Australia, approximately 70 km south-west of Wiluna and 110 km north-west of Leinster. The Project is owned by Cameco Australia but prior to 2012 the lease for the area was held by BHP Billiton. The Project is located in the uppermost reaches of the Carey palaeochannel, which contains several bodies of calcrete, including the 40 km long Yeelirrie calcrete and a separate body of calcrete to the southeast associated with the Yeelirrie and the Albion Downs playas. The study area lies within the Lake Miranda catchment, which is part of the headwaters of the larger Carey catchment.

Information about the species of subterranean fauna at Yeelirrie was gathered by Subterranean Ecology undertaking field surveys in 2009 and 2010. This work showed that rich stygofauna and troglofauna communities occur at Yeelirrie, with some species recorded only from areas proposed to be disturbed by pit excavation of groundwater drawdown. In 2015, Bennelongia conducted additional sampling programs with the objective of showing wider distribution of stygofauna species known only from the predicted area of groundwater drawdown.

The subterranean community in the Yeelirrie calcrete is richer than known for any other calcrete in the Yilgarn, partly because sampling and identification efforts have been extensive compared to other calcretes and perhaps also because of the hydrological and geological characteristics of Yeelirrie. At least 70 species of stygofauna and 45 species of troglofauna (115 subterranean species in total) have been recorded in the Yeelirrie study area, which approximately matches the extent of Cameco's tenements at Yeelirrie. It is estimated that 148 species of subterranean fauna may actually occur.

Ten species of stygofauna and five species of troglofauna are currently known only from areas where the extent of habitat will be reduced by development of the Yeelirrie Project. Predicting the true range of these 15 species is difficult without a better understanding of the factors driving habitat selection of the individual species. However, existing evidence suggests that nine of the 15 species are unlikely to be restricted to the areas impacted by mining and groundwater abstraction. There is also some likelihood that the other six species may occur beyond the areas impacted by mining and groundwater abstraction.

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1. INTRODUCTION

Cameco Australia Pty Ltd (Cameco) are proposing to mine uranium at the Yeelirrie Project in the Northern Goldfields of Western Australia using an open pit method of mining. The uranium deposit is currently un-mined and, in addition to removal of the calcrete body hosting the uranium, de-watering of the calcrete and some surrounding areas will be required before mining can occur. Prior to 2012, the Project leases were held by BHP Billiton Ltd.

The Yeelirrie Project is located approximately 70 km south-west of Wiluna and 110 km north-west of Leinster (Figure 1). It lies in the Lake Miranda catchment within the uppermost reaches of the Carey palaeochannel, which contains several bodies of calcrete including the 40 km long Yeelirrie calcrete and a separate body of calcrete to the southeast associated with the Yeelirrie and the Albion Downs Playas.

Existing surveys and species inventories have shown that very diverse subterranean fauna communities occur in the vicinity of the Yeelirrie Project. Surveys conducted during 2009 and 2010 in a study area more or less coinciding with the Yeelirrie mineral leases identified the occurrence of 55 species of stygofauna and 45 species of troglofauna (Subterranean Ecology 2011). These surveys provide the framework for most of this report. The copepod *Mesocyclops brooksi* was recorded during earlier sampling by the Western Australian Museum, so that in fact 111 species were known from the area by the end of 2010.

Cameco commissioned a small amount of additional stygofauna sampling by Bennelongia in February and June/July 2015 to show wider distribution of stygofauna species potentially known only from the predicted area of groundwater drawdown associated with the Yeelirrie Project. The results of the 2015 stygofauna survey have been combined with the results of earlier stygofauna and troglofauna surveys at Yeelirrie to provide:

1. An assessment of the level of stygofauna and troglofauna sampling effort in the Project area;
2. Lists of stygofauna and troglofauna species present in the Project area, with updating of the species names used in Subterranean Ecology's (2011) report where appropriate; and
3. An assessment of the likely ranges of stygofauna and troglofauna species in relation to the proposed mine pit layout and the modelled groundwater drawdown resulting from mine de-watering and groundwater abstraction to supply processing water.

2. BACKGROUND

2.1. Stygofauna in the Yilgarn

Stygofauna are aquatic invertebrates that live in groundwater. They occur in an array of different groundwater habitats including porous, karstic and fractured rock aquifers, springs and the hyporheos of streams (Eberhard *et al*. 2005). Calcrete and alluvium are typically considered productive habitats for stygofauna because the fissures and voids in groundwater aquifers provide highly suitable habitat for stygofauna. Stygofauna have mostly been recorded from fresh to brackish groundwater but may occur in salinities up to 50,000 µS cm^{-1} or more (Reeves *et al*. 2007; Watts and Humphreys 2006). The calcrete bodies in the palaeovalleys of the Yilgarn have been identified as areas rich in stygofauna species, with many of these species being restricted to single calcrete bodies (Guzik *et al*. 2008; Karanovic and Cooper 2011a; Karanovic *et al*. 2014). The belief that most stygofauna species are restricted to individual calcrete bodies is often termed the 'calcrete island hypothesis' (Cooper et al. 2002, 2007). It is suggested that each calcrete body has a high proportion of restricted species because areas of unsuitable habitat (e.g. high clay content, unsuitable salinity) occur between calcretes that prevents migration from one to another. However, the alluvium and colluvium immediately around a calcrete body may be rich in the same stygofauna species present in the calcrete.

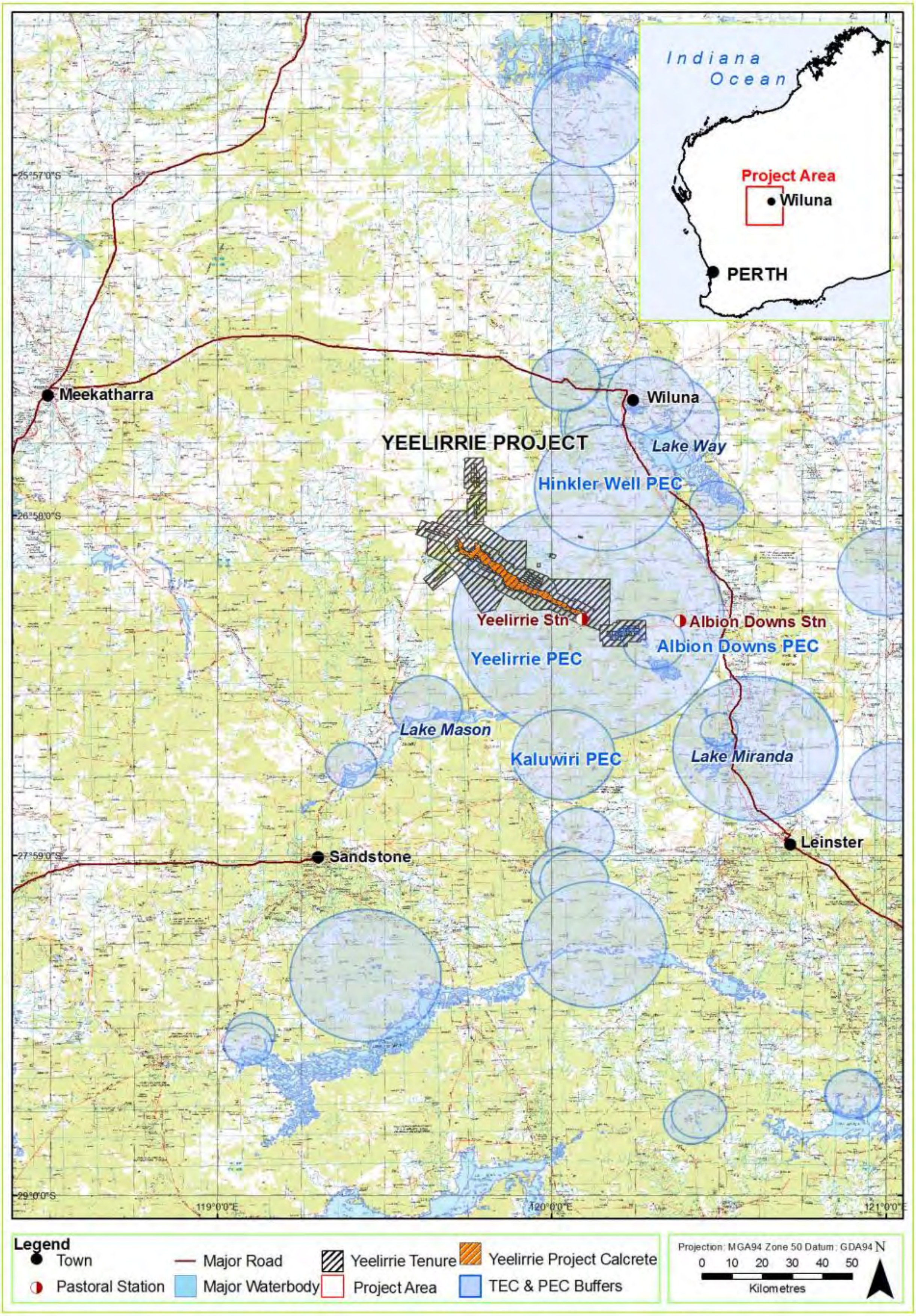

Figure 1. Location of the Yeelirrie Project in the Goldfields of Western Australia.
The boundaries of the Yeelirrie Priority Ecological Community (PEC) and three other overlapping PECs are shown, as well as other PECs in the vicinity.

2.2. Troglofauna in the Yilgarn

Troglofauna are subterranean animals that occur above the water table. They appear to be more common in karstic calcrete than in other habitats in the Yilgarn (Guzik *et al.* 2010; Humphreys 2008), although they also occur widely, at low abundance, in weathered and fractured rocks (Bennelongia 2009; GHD 2010) and may occur iin alluvium. The groups collected in calcrete include palpigrads (Barranco and Harvey 2008; Giribet *et al.* 2014), pseudoscorpions (Edward and Harvey 2008; Harrison *et al.* 2014), spiders (Baehr *et al.* 2012; Platnick 2008) and isopods (Taiti 2014).

Troglofauna associated with calcrete deposits occur in the zone of unsaturated calcrete. Troglofauna species often have smaller ranges than stygofauna species (Lamoureux 2004) and, given their small ranges and possible preference for calcrete habitats, would be expected to be restricted to single calcretes. Relatively few troglofauna species in the Yilgarn have been found to be widespread (Guzik *et al.* 2010).

2.3. Legislative framework

Faunal species in Western Australia, including subterranean fauna, are protected by State and federal legislation. At the State level, protection is afforded principally through the Wildlife Conservation Act 1950 (WC Act), which provides general protection for fauna as well as a special level of protection for listed species. The Environmental Protection Act 1986 also provides State-level protection for subterranean fauna in the environmental impact assessment process, with the Environmental Protection Authority's (EPA) Environmental Assessment Guideline 12 and Guidance Statement 54a (EPA 2007, 2013) providing frameworks for assessment. At the federal level, the Environmental Protection and Biodiversity Conservation Act 1999 (EPBC Act) provides protection for listed species.

Two fish, 17 invertebrate stygofauna and 17 invertebrate troglofauna species are listed for protection under the WC Act in Western Australia, while two fish and one stygofauna species are listed under the EPBC Act. In addition, the EPBC Act provides protection for listed ecological communities. While five subterranean fauna communities have been listed in the south-west of Western Australia as threatened ecological communities (TECs) under the EPBC Act, no TEC from the Yilgarn has been EPBC-listed. The WC Act does not provide for listing of communities but the Minister of the Environment has endorsed a list of Western Australian TECs to be protected by processes outside the WC Act. This list contains eight stygofauna communities, including the community at Depot Springs in the Yilgarn, and one troglofauna community in the Pilbara.

The Department of Parks and Wildlife (DPaW) also maintains lists of priority species and priority ecological communities (PECs). These are species and communities considered to be potentially threatened but for which there is little information. Two species of stygofauna and two species of troglofauna are listed as priority species. More significantly, 87 subterranean fauna communities in calcretes are listed as PECs, including the *Yeelirrie calcrete groundwater assemblage type on Carey palaeodrainage on Yeelirrie Station*, which is a Priority 1 PEC (there are three categories, with threat most likely for Priority 1).

The Project is subject to the provisions of the Uranium (Yeelirrie) Agreement Act 1978.

2.4. Ecological communities at Yeelirrie

Variable sized buffer zones are ascribed to the area around the known occurrence of each PEC and proponents of projects within a buffer zone need to determine whether or not the listed ecological community occurs within the area of their project.

As well as occupying the buffer zone of the *Yeelirrie calcrete groundwater assemblage type on Carey palaeodrainage on Yeelirrie Station* PEC, the Yeelirrie Project covers the centroid of the PEC (Figure 1) and the PEC must be regarding as occurring within the Project area. The threat to the PEC is identified as mining.

A second Priority 1 PEC '*Albion Downs calcrete groundwater assemblage type on Carey palaeodrainage on Albion Downs Station*' and its buffer lie entirely within the Yeelirrie PEC. While the buffer of the Albion Downs PEC intersects part of the Yeelirrie study area, it lies outside the Project area (Figure 2). The buffer zones of two other Priority 1 PECs (*Hinkler Well calcrete groundwater assemblage type on Carey palaeodrainage on Lake Way Station* and *Kaluwiri calcrete groundwater assemblage type on Raeside palaeodrainage on Kaluwiri Station*) overlap the periphery of the Yeelirrie PEC but also do not extend into the Project area.

2.5. Subterranean habitats at Yeelirrie

The Yeelirrie palaeochannel comprises five major land forms: i) breakaways; ii) wash plains; iii) sand plains; iv) playas and v) calcretes (Subterranean Ecology 2011). Of these land forms, calcrete was identified as the most prospective habitat for subterranean fauna, although associated alluvium must be considered to have similar prospectivity. The Yeelirrie calcrete, which occupies a 40 km length of the middle of the palaeochannel (Figure 2), began to be laid down approximately 30 million years ago. The calcrete subsequently largely dissolved, before beginning to re-form in the last 10 million years in a constant process of re-mobilisation and formation (Mann and Horwitz 1979; Morgan 1993).

Stygofauna in the palaeochannel are considered to occur in areas of saturated calcrete and adjacent alluvium. The depth to watertable is about 5 m in the area of the proposed mine pit and about 10 m north-west of the mine pit. The thickness of saturated calcrete is mostly 3-5 m but reaches 13 m in north-western parts of the calcrete, while some other small parts of the Project area have very little saturated calcrete. There is a substantial gradient in groundwater salinity across the study area, with salinities mostly varying from about 1-2 g L^{-1} in the north-west to 10-25 g L^{-1} in the south-east (Figure 2). However, within this broad gradient there is substantial small-scale spatial variability. Salinity ranges from about 2 g L^{-1} to 33 g L^{-1} within the area of the proposed mine pit. Haloclines are present in some drill hole, where, for example, salinity may vary from 2 g L^{-1} at the groundwater surface to 7 g L^{-1} at 3 m below the surface.

Troglofauna habitat in calcrete extends upwards from the watertable to a point below the ground surface where relative humidity levels begin to decline and surface soil animals become abundant. This is considered likely to be 2-3 m below ground surface at Yeelirrie, although troglofauna habitat may extend closer to the surface. In rocky habitats in Europe, troglofauna habitat may be found as close as 0.1 m below the surface (Pipan *et al*. 2010). Assuming conditions become suitable for troglofauna 2-3 m below ground surface, troglofauna habitat is probably 2-3 m thick across most of the calcrete and thicker in the north-west, where it may be up to 10 m thick. During periods of flooding, when the watertable rises, the volume of troglofauna habitat probably contracts substantially.

3. PROJECT IMPACTS

The main factors likely to adversely impact on subterranean fauna at Yeelirrie are mine pit excavation and groundwater abstraction. Mine pit excavation causes loss of troglofauna habitat. While excavation also reduces stygofauna habitat, the mine pit will be contained within a larger area of lowered water tables as a result of mine pit de-watering and abstraction of processing water. Thus the focus of assessment of impacts on stygofauna is the extent of groundwater drawdown.

The extent of the proposed mine pit and the predicted areas of groundwater drawdown are shown in Figure 2, based on modelling by Cameco Corporation (2015). The mine pit and areas of groundwater

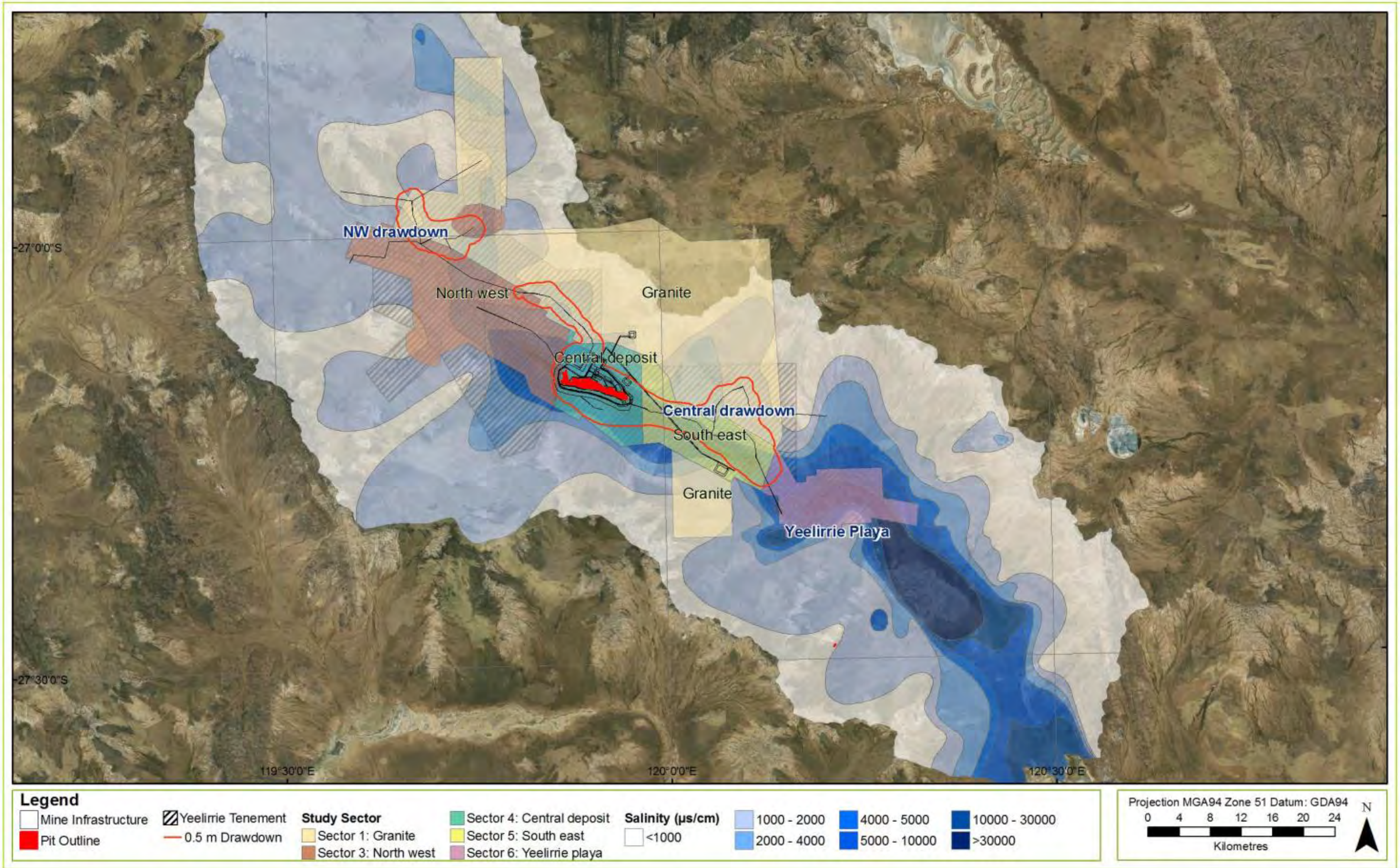

Figure 2. The Yeelirrie study area, showing the proposed mine pit and areas of groundwater drawdown, groundwater salinity and the sectors referred to when describing species distributions. .

drawdown are considered to be the only areas of significant impact on troglofauna and stygofauna, respectively. The mine pit is proposed to occupy an area of 726 ha. The predicted area of groundwater drawdown associated with mine pit de-watering will occupy an area of 25,840 ha at the 0.5 m drawdown contour and is referred to in this report as the central drawdown. Another predicted area of groundwater drawdown to the north-west, associated with abstraction of processing water, occupies 6125 ha.

For the purposes of documenting the distributions of stygofauna species known only from Yeelirrie, the following terms were applied. North-west means a species occurred west of the mine pit and outside the central drawdown, south-east means it occurred east of the mine pit and outside the central drawdown. Yeelirrie playa means a species occurred east of the Project area but within the study area. Most of Yeelirrie playa lies within the Albion Downs drawdown (which is not considered in this report). Species were considered to be widespread if they occurred in at least two sectors (Figure 2).

The same terminology was applied to troglofauna except that the proposed mine pit, rather than the area of central drawdown, comprised the impact area.

The impact of the drawdown of the Albion Downs wellfield, which is operated by BHP Billiton Nickel West, on areas within the Yeelirrie Project was taken into account when Cameco developed the groundwater model for Yeelirrie and predicted the extent of drawdown (refer to the Cameco PER document). The potential for the Albion Downs wellfield to impact elsewhere, such as at Yeelirrie playa, is not considered in this report because the wellfield is not related to the Yeelirrie Project.

4. SUBTERRANEAN FAUNA SURVEYS

4.1. Subterranean Ecology (2011)

4.1.1. Survey effort and species identification

The survey design and methods employed in the Level 2 field sampling program fit the framework outlined in the EPA's Environmental Assessment Guideline 12 (EPA 2013).

Between March 2009 and September 2010, Subterranean Ecology (2011) undertook six field surveys that resulted in collection of a total of 797 subterranean fauna samples from 259 existing bores and exploration drill holes (all referred to hereafter as bores) (Table 1; Figures 2 and 3). The same sample sometimes yielded both stygofauna and troglofauna, which increased the amount of information on both these groups.

Across the study area as a whole, stygofauna were collected either by net hauling (318 samples), pumping (26 samples), examination of root mats (3 samples) or when scrape sampling for troglofauna (111 samples). The deliberate stygofauna effort comprised 344 samples. Troglofauna were collected by scraping (299 samples), trapping (149 samples) or when net hauling for stygofauna (32 samples) (Table 1). Calculation of the deliberate troglofauna sampling effort is complex because it is best practice to collect both a scrape and a trap sample from a bore (Halse and Pearson 2014) and single trap or scrape samples are often treated as half-samples. If this is applied to Subterranean Ecology's (2011) sampling, the deliberate troglofauna sampling effort comprised 224 samples. Totals of 158 deliberate stygofauna samples and 51 deliberate troglofauna samples were collected from areas proposed for disturbance, while by-catch contributed a further 59 samples of stygofauna and four samples of troglofauna (Table 1). Deliberate troglofauna sampling effort in the impact area was much higher (101 samples), however, if scrapes and trap samples are treated as separate sample units.

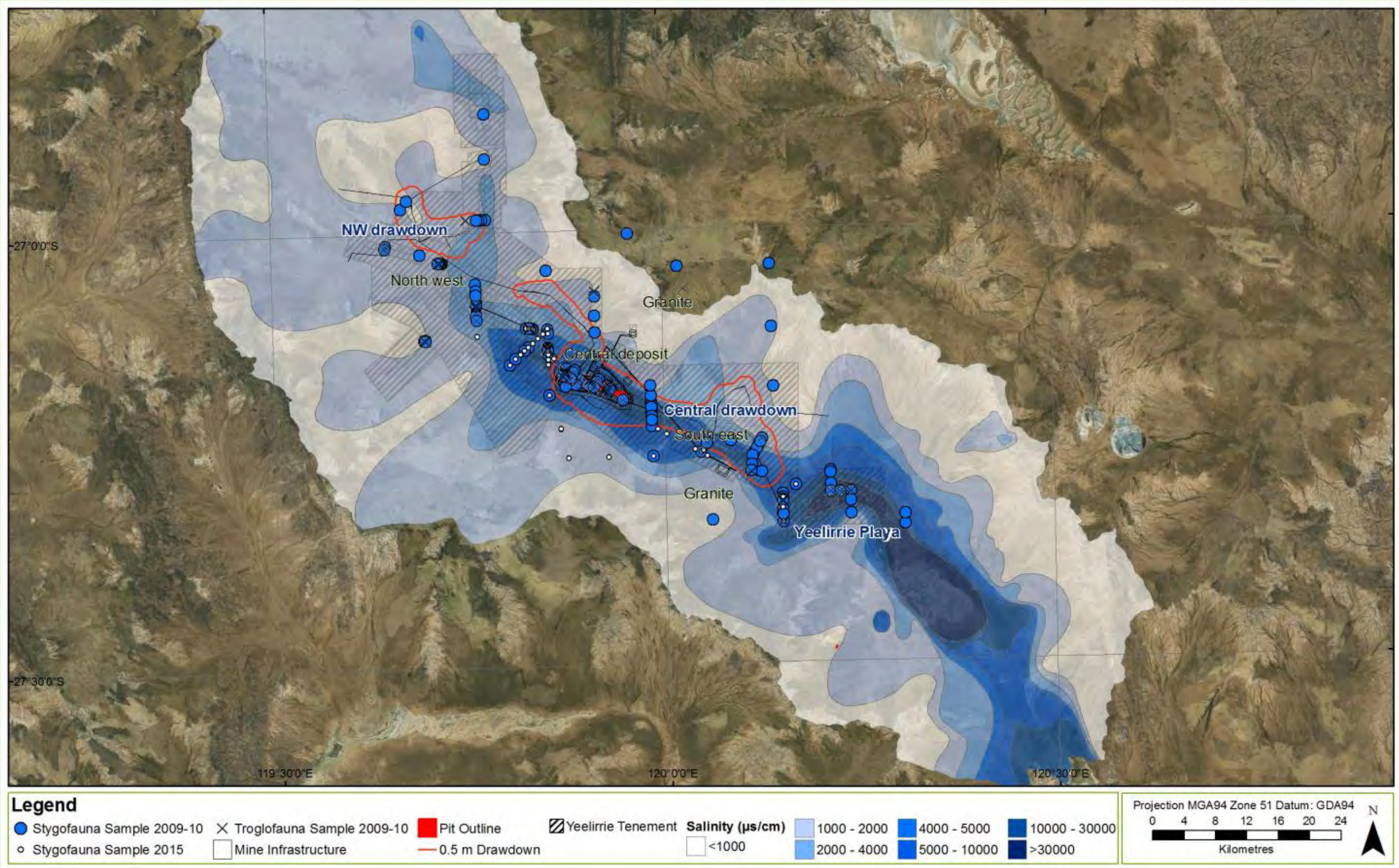

Figure 3. Bores sampled in the Yeelirrie study area for stygofauna and troglofauna by Subterranean Ecology (2009-2010) and Bennelongia (2015).

Table 1. Subterranean fauna sampling effort in the study area (2011).

	Number of bores or samples collected		
	Impact area	**Reference area**	**Total**
Designated stygofauna samples			
Bores	76	86	162
Samples	158	189	347
Stygofauna by-catch samples			
Dill holes	25	36	61
Samples	59	52	111
Designated troglofauna samples			
Drill holes	21	79	100
Paired samples[1]	36	105	141
Single samples	29[2]	137[3]	166
Troglofauna by-catch samples			
Bores	1	16	17
Samples	4	28	32

[1] Pairs of samples, each consisting of a scrape and trap sample from the same bore on the same trap-set date, [2] 27 scrape samples, 2 trap samples
[3] 131 scrape samples, 6 trap samples.

Most species identifications were initially based on morphology, although in some groups DNA provided the main method of identification. DNA analyses were conducted to aid the identification process and 27% of the identified stygofauna and 26% of the troglofauna species identifications were made as a result of DNA analyses.

4.1.2. Stygofauna results

Subterranean Ecology (2011) collected 8188 specimens belonging to 46 species of invertebrate stygofauna and nine species of 'amphibious' subterranean fauna. These amphibious species (seven worms and two isopods) were considered likely to live at the interface between groundwater and unsaturated subterranean habitat but are treated as stygofauna. In addition, the Western Australian Museum database shows that earlier surveys of Yeelirrie collected an amphipod species, an isopod and the copepod *Mesocyclops brooksi*, which is widespread in southern Australia. Thus, at least 56 stygofauna species were known from Yeelirrie in 2011. A species accumulation curve suggested that between 76% and 88% of the stygofauna species present at Yeelirrie were collected by the Subterranean Ecology (2011) sampling program. This implied that up to 71 species of stygofauna may occur in the study area. The most diverse groups present were copepods and worms.

Eleven species collected by Subterranean Ecology (2011) were found only in the area predicted to be impacted by de-watering and groundwater abstraction, with six of these species apparently restricted to the proposed mine pit itself. The five species known only from the wider groundwater production area were the worms Enchytraeidae sp. Y4, Enchytraeidae sp. Y5, syncarid *Atopobathynella* sp. 'line K' and copepods *Kinnecaris lined* and *Novanitocrella* 'araia' sp. n. The species known only from the mine pit were the worm Enchytraeidae sp. Y6, copepods *Halicyclops* cf. *eberhardi* sp. B, *Schizopera akolos*, *S. emphysema* and *S.* sp. 7439 and isopod Philosciidae sp. n. Y2 (Table 2, Figure 4).

4.1.3. Troglofauna results

Subterranean Ecology (2011) collected 498 specimens belonging to 45 species of invertebrate troglofauna. Troglofauna isopods accounted for 22% of the fauna, pseudoscorpions 18%, symphylans 16% and pauropods 11%. A species accumulation curve suggested that between 67% and 83% of the troglofauna species present at Yeelirrie were collected, implying that up to 55 species of troglofauna may occur in the study area.

Seventeen troglofauna species were collected from the proposed mine pit. Of these, 12 species had ranges extending beyond the mine pit and five species were known only from the proposed mine pit. The five apparently restricted species were the isopods *Trichorhina* sp. n. F., the pseudoscorpions *Austrohorus* sp. n. Y1 and *Tyrannochthonius* sp. n. Y1, the pauropod Pauropoda sp. S6B, and the symphylan Symphyla sp. Y7 (Table 3, Figure 5).

Table 2. Stygofauna species known only from bores within the predicted areas of groundwater drawdown >0.5 m based on Subterranean Ecology (2011) sampling.
Species shown to be more widespread as a result of sampling in 2015 highlighted in blue.

Taxonomic Groups	Species	Samples	Bores	No. of animals	Salinity ($g\ L^{-1}$ TDS)
Oligochaeta					
Enchytraeidae	Enchytraeidae sp. Y4	1	1	38	3
	Enchytraeidae sp. Y5	2	2	3	9.5
	Enchytraeidae sp. Y6	1	1	1 (4)[1]	11
Crustacea					
Syncarida	*Atopobathynella* sp. 'line K'	2	1	2	9.5
Cyclopoida	*Halicyclops* cf. *eberhardi* sp. B *	4	1	372	14
Harpacticoida	*Kinnecaris lined*	1	1	100	NA
	Novanitocrella 'araia; sp. n. *	1	1	1	12
	Schizopera akolos	3	1	4	12
	Schizopera emphysema *	4	1	8	24
	Schizopera sp. 7439 *	1	1	1 (5)	NA
Isopoda	Philosciidae sp. n. Y2 *	4	2	6	NA

* Species known only from the proposed mine pit; [1]first value is number of animals rigorously identified, value in parentheses is inferred number belonging to species.

Table 3. Troglofauna species collected only from bores in the mine pit proposed in 2011.

Taxonomic Groups	Species	Samples	Drill holes	No. of animals
Crustacea				
Isopoda	*Trichorhina* sp. n. F	1	1	1
Arachnida				
Pseudoscorpiones	*Austrohorus* sp. n. Y1	1	1	1
	Tyrannochthonius sp. n. Y1	2	2	2
Myriapods				
Pauropoda	Pauropoda sp. S6B	1	1	1 (2)[1]
Symphyla	Symphyla sp. Y7	1	1	1

[1] First value is number of animals identified. Value in parenthesis refers to the number of animal belonging to that species.

4.1.4. Species name changes

Seventeen subterranean fauna species have been formally described since completion of the Subterranean Ecology (2011) report. The 16 stygofauna species are all copepods: *Dussartstenocaris idioxenos* (Karanovic and Cooper 2011b), *Kinnecaris esbe, K. linesae, K. lined, K. lined, K. uranusi, Nitokra esbe, N. yeelirrie, Schizopera akation, S. akolos, S. analspinulosa, S. analspinulosa linel, S. emphysema, S. kronosi, S. leptafurca*, and *S. uranusi* (Karanovic and Cooper 2011a; Karanovic and Cooper 2012; Karanovic, Eberhard *et al.* 2014; Karanovic and McRae 2013). The single troglofauna species is the goblin spider *Prethopalpus callani* (Baehr *et al.* 2012).

Appendix 1 provides the updated taxonomy for these species, including previously used names.

4.2. Bennelongia (2015)

4.2.1. Survey effort and species identification

A further 66 stygofauna samples were collected in February (20 samples) and June/July 2015 (46 samples) by Bennelongia from outside the areas of predicted groundwater drawdown (Appendix 2). This targeted Level 2 sampling program aimed to show the wider distributions of species known only from areas of predicted groundwater drawdown (Figure 3). The bores sampled were considered to be prospective for these targeted species because they were in close proximity, and had similar salinities, to the bores from which the apparently restricted species were collected. Eight of the bores sampled in February and 11 of the bores sampled in June/July were previously sampled by Subterranean Ecology (2011). Sampling in 2015 followed the methods described in Guidance Statement No. 54A (EPA 2007), using an approach that complies with the recommendations of Environmental Assessment Guideline 12 (EPA 2013).

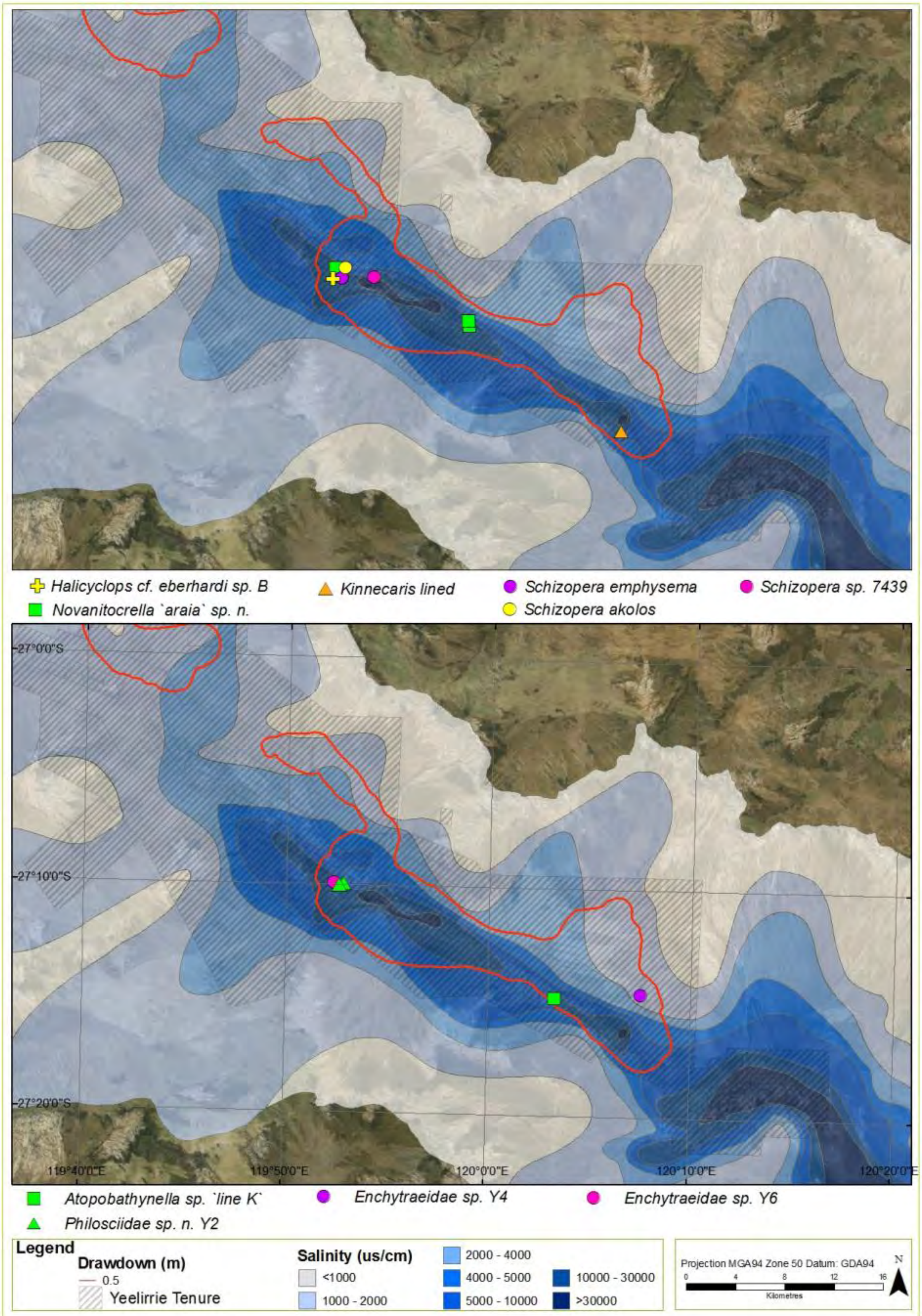

Figure 4. Locations of stygofauna species known only from the currently predicted areas of groundwater drawdown.

Enchytraeidae sp. Y5 is not shown because it was collected outside the predicted drawdown in 2015 (see Appendix 6).

Figure 5. Locations of troglofauna species known only from the proposed mine pit.

Taxonomic identifications were mostly based on morphology using information given in previous reports and the available scientific literature (Karanovic 2007; Karanovic and Cooper 2011; Karanovic and Cooper 2012; Karanovic *et al.* 2014). Stygofauna animals were dissected and slide-mounted as needed to aid the identification process. DNA analyses were carried out on 41 animals to refine identifications using the CO1 barcoding gene (Appendix 3). When pairwise sequence divergences were <9.5%, animals were considered to belong to the same species (see Appendix 4 for results; also Castalanelli *et al.* 2014; Hebert *et al.* 2003).

4.2.2. Personnel

Fieldwork in 2015 was undertaken by Michael Curran, Dean Main and Jim Cocking and all samples were sorted in the laboratory by Jane McRae. Morphological identifications were made by Jane McRae (beetles, crustaceans, worms) and Stuart Halse (ostracods). DNA laboratory work and analyses were undertaken by Danilo Harms.

4.2.3. Results

Ten of the 20 bores sampled in February yielded stygofauna. These were six bores in a small area of <8 km^2 west of the central groundwater drawdown and four holes to the southeast of the central groundwater drawdown (see Figure 3). The ten bores that did not yield any specimens were mostly on the periphery of the cluster of western bores that yielded. Thirty four bores of the 46 bores sampled in June/July yielded stygofauna. The bores that did not yield were mostly from the southern periphery of the central drawdown area.

Altogether 1352 (534 in February and 818 in June/July) specimens were collected and they represented at least 36 species of stygofauna (Appendix 5). Fifteen of these species were recorded at Yeelirrie for the first time. Fourteen of the species are undescribed and have unknown distributions, while the described copepod *Halicyclops kieferi* is common in the Yilgarn (Karanovic 2004).

Only one targeted species was collected in the 2015 sampling. The worm Enchytraeidae sp. Y5, previously identified using DNA analysis as three animals from two bores (Subterranean Ecology 2011), was collected from another two bores outside the predicted drawdown area and now has a known linear range of at least 23 km (Appendix 6). Enchytraeidae sp. Y5 was collected at salinities of 2.4 and 7.6 g L^{-1} in 2015 compared with 11.6 g L^{-1} in 2009-2010.

As a result of collecting Enchytraeidae sp. Y5, the number of stygofauna species known only from the groundwater drawdown areas was reduced from 11 to 10. There are several likely reasons for failure to collect more targeted species in 2015. One is the small sample effort in 2015 compared with the earlier surveys of Subterranean Ecology (2011). The 66 samples collected by Bennelongia in 2015 represent only 14% of the sampling effort of 2009 and 2010 surveys (Table 1), so that only a small subset of the species found during the earlier surveys would be expected to be collected again.

Another possible reason for failing to collect the target species is the difficulty of identifying prospective microhabitats prior to sampling. For example; there was relatively poor agreement between the salinities of the bores sampled in 2015 and the salinities at which the targeted species were collected. Sixty-seven per cent of samples in 2015 were collected from groundwater salinities <5 g L^{-1} TDS although it was intended to sample more saline groundwater because seven of the eight targeted species for which salinity data was recorded in 2009-2010 came from saline water (Table 2). Only 16% of samples collected in 2015 were from salinities 7-14 g L^{-1}, which is the salinity range in which six of the eight species were collected in 2009-2010. Only one sample in 2015 had a salinity of 24 g L^{-1} to match the known occurrence of *Schizopera emphysema*, although another three samples were collected from water 16 19 g L^{-1}, which may possibly represent suitable *Schizopera emphysema* habitat.

5. SURVEY OVERVIEW

5.1. Survey coverage and adequacy

Species accumulation curves implied that 76-88% of stygofauna and 67-83% of troglofauna species present were documented by Subterranean Ecology (2011). While there is no explicitly recognized threshold of survey adequacy, these percentages compare quite favourably with the results of most subterranean surveys undertaken for environmental assessment purposes (e.g. Biota 2006, Subterranean Ecology 2011; see also Halse *et al*. 2006) and suggest the level of survey meets the requirements of Environmental Assessment Guideline 12 (EPA 2013).

Additional stygofauna sampling in 2015 added 15 species to the list of stygofauna known from Yeelirrie, which is now 70 species compared with Subterranean Ecology's (2011) accumulation curve prediction of 71 stygofauna species. Species accumulation curves for both stygofauna and troglofauna were re-calculated using EstimatesS software (http://viceroy.eeb.uconn.edu/estimates/), the ICE richness estimator (see Colwell *et al*. 2012) and the combined datasets of Subterranean Ecology (2011) and Bennelongia (2015). The curves were first calculated for the study area as a whole and then separately for the mine pit and groundwater drawdown areas. Only the results of dedicated stygofauna and troglofauna sampling were included in the accumulation curves and estimates of species richness. In reality, 10 stygofauna and one troglofauna species recorded in 2009-2010 were collected as by-catch when sampling for the opposite group (i.e. 10 stygofauna species were collected when scraping for troglofauna).

Species accumulation curves did not appear to have flattened off for both stygofauna and troglofauna at Yeelirrie as a whole (Figure 6) and, based on the ICE species richness estimator, 83 species of stygofauna and 65 species of troglofauna occur at Yeelirrie. This suggests that 84% of estimated stygofauna and 69% of estimated troglofauna species have been collected. Despite an extra 15 stygofauna species having been recorded in 2015, the estimates provided here are in broad agreement with those of Subterranean Ecology (2011), who using ICE estimated 81% of stygofauna and 69% of troglofauna had been collected. The other three estimators used by Subterranean Ecology (2011) suggested a range of sampling efficiencies for stygofauna but ICE, Chao1 and Jacknife made consistent estimates of sampling efficiency for troglofauna (67-69%), with the estimate of 83% by Bootstrap being an outlier.

The most probable reason for the large subterranean sampling effort at Yeelirrie failing to collect all (or nearly all) of the species present is high spatial turnover of species across the calcrete. This turnover led to 15 additional species being collected from a small area in 2015, despite previous sampling in 2009-2010 of bores nearby. Other parts of Yeelirrie that have not previously been sampled intensively are also likely to yield more species. For this reason, even the current estimate of 82 stygofauna species occurring at Yeelirrie is likely to be low.

In contrast to the study area as a whole, sampling efficiency for stygofauna in the drawdown areas appears to have been close to complete, with an ICE estimate of 23 species and 25 species actually collected. More species were collected than estimated because four species were collected while scraping for troglofauna and 21 were collected by dedicated stygofauna sampling. There are likely to be very few undocumented species of stygofauna in the drawdown areas.

Idiosyncrasies in the data prevented ICE providing a realistic estimate of troglofauna richness in the mine pit. The Chao 2, Jacknife and MM Means algorithms suggest between 15 and 29 troglofauna species occupy in the mine pit, which translates to a sampling efficiency of 24-47%. At this level of efficiency, algorithms usually underestimate the number of species present and the troglofauna community in the mine pit appears to be poorly documented, in contrast to the greater efficiency of collection across the study area as a whole. However, it should be recognised that the characteristics

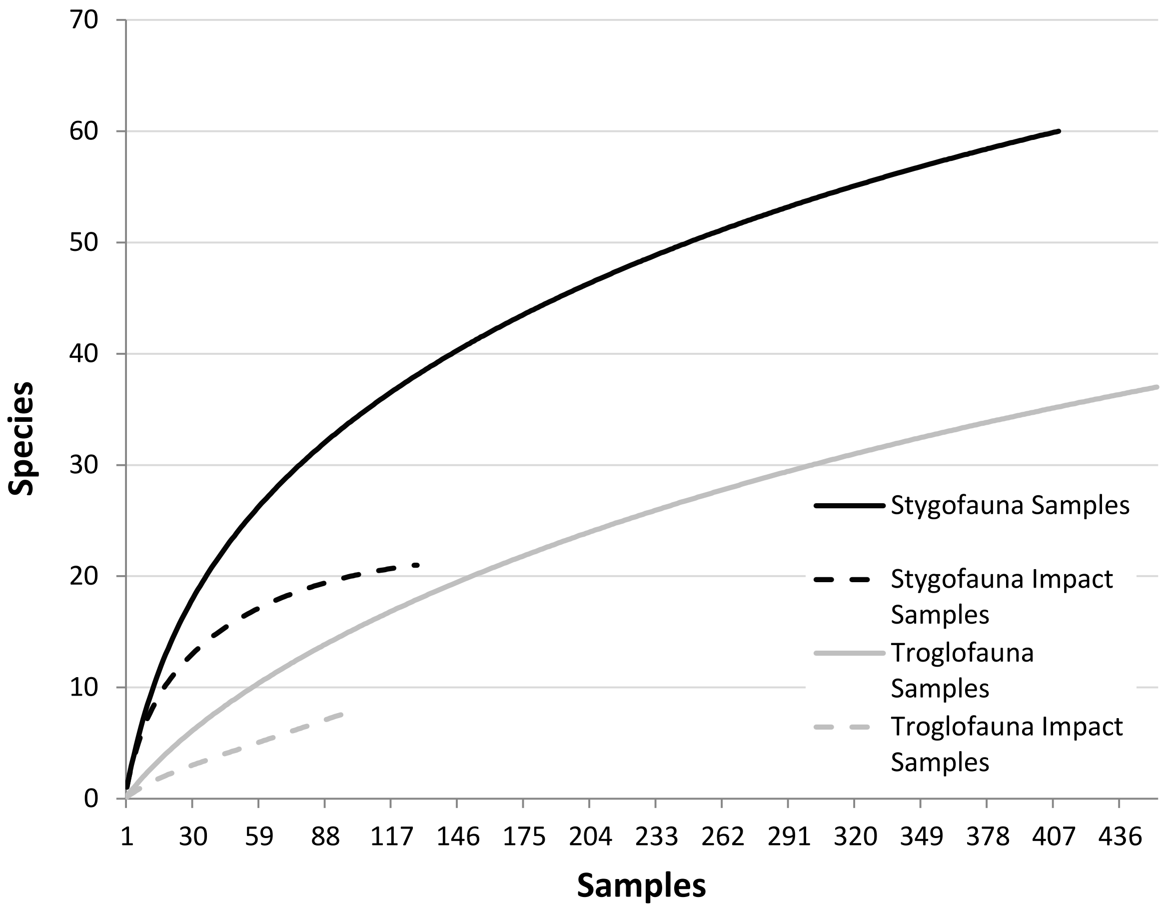

Figure 6. Species accumulation curves for stygofauna and troglofauna at Yeelirrie.

of the mine pit data that led to problems with ICE may also have caused overestimates in the other algorithms and the mine pit sampling may have been more efficient than the estimators suggest.

5.2. Stygofauna richness

The 70 stygofauna species documented within the Yeelirrie mining tenement (see examples in Figure 7) represent greater richness than is known from any other area of the Yilgarn. It should be noted, however, that 10 species occurred only at Yeelirrie playa (Table 6). In addition to lying within the Yeelirrie PEC, some of the Yeelirrie playa also lies within the boundary of the Albion Downs PEC and the species there are probably more closely linked to the Albion Downs than Yeelirrie PEC. Nevertheless, these species all occur within the Yeelirrie tenement.

The number of stygofauna species collected from individual bores ranged up to 27 species at bore YU1 in the northwest sector (Figure 8). Thirteen bores had 10 or more species, with six bores in the northwest sector, five in the central drawdown and two at Yeelirrie playa. This pattern of very high species richness in a small number of bores seems to be typical of stygofauna and has been recorded in the Pilbara, too (Eberhard *et al*. 2009). Despite the picture based on richness per bore being somewhat confounded by the distribution of bores sampled and the greater sampling effort in many of the central drawdown and northwest sector bores, there appears to be a richer 'community' in the northwest and central calcrete sectors than in adjacent parts of the study area and this richer area may perhaps represent the Yeelirrie PEC, with the bores at Yeelirrie playa perhaps sampling the Albion Downs PEC.

Figure 7. Examples of stygofauna species collected at the Yeelirrie Project.
A= *Atopobathynella* sp. S5; B = nr *Phreatochiltonia* sp. n. S1; C = *Schizopera* sp. B16; D = *Halicyclops kieferi*; E = *Candonopsis* sp. Y1; and F = *Pseudectinosoma* sp. indet.

While considerable numbers of stygofauna species have been collected from a relatively small number of bores at Yeelirrie, it should also be recognized that there are probably many calcretes in the Yilgarn that are rich in stygofauna (Humphreys 2001, 2008). High numbers of stygofauna recorded in calcretes include 58 species at three calcretes in the Lake Way area north of Yeelirrie (Outback Ecology 2012), 33 species from a small part of the Yeo palaeochannel (Bennelongia 2013) and 18 species from a small calcrete at Sturt Meadows (Allford *et al*. 2008). Nevertheless, the richness of the copepod fauna at Yeelirrie (36 species; 63% of all stygofauna species) is especially striking. The study area harbours between 35-40% of the known regional copepod diversity (Karanovic *et al.* 2014).

Much of the apparently higher species richness at Yeelirrie than other areas is the result of intensive sampling and better species level resolution in the identification process than achieved at most other calcretes because of the detailed morphological and genetic work undertaken by Subterranean Ecology (2011). However, it also seems likely that the occurrence of a range of salinities within the Yeelirrie tenement, and the diverse physical structure within the calcrete and the surrounding alluvium (combined with a complex mosaic of salinities), have contributed to the high recorded species richness.

5.2.1. Restricted species

A total of 10 stygofauna species are currently known only from the central drawdown (Table 4). Nine species are currently known from single bores and one species is known from only two bores. Seven

Table 4. Stygofauna species recorded at Yeelirrie.

Species known only from the predicted area of groundwater drawdown are shaded in blue and species recorded for the first time in 2015 are shaded orange. Both the number of animals of each species and the number of samples in which they were collected are shown. North-west indicates the species occurs west of the central groundwater drawdown, south-east means the species occurs to the south-east of the central groundwater drawdown, widespread means the species occurs in at least two areas at Yeelirrie. No species was restricted to the north-west groundwater drawdown.

Taxonomic group	Species	Abund./ (Samples)	Known distribution	Remarks
Rotifera	Bdelloidea sp. 2:2	50 (1)	Northwest	Probably collected in 2011 but not recorded
Nematoda	Nematoda sp.	114 (9)	Granite, Northwest, Southwest	Probably collected in 2011 but not recorded
Platyhelminthes				
	Turbellaria sp.	1 (1)	Yeelirrie playa	New in 2015, unknown range
Oligochaeta				
Aeolosomatidae	*Aeolosoma* sp. S1	101 (2)	Yeelirrie playa	
Enchytraeidae	Enchytraeidae sp. Y1	19 (2)	Yeelirrie playa	
	Enchytraeidae sp. Y2	31 (2)	Northwest	
	Enchytraeidae sp. Y3	14 (1)	Northwest	
	Enchytraeidae sp. Y4	38 (1)	Central drawdown	Apparently restricted to impact area
	Enchytraeidae sp. Y5	42 (4)	Northwest, Central drawdown	
	Enchytraeidae sp. Y6	4 (1)	Central drawdown	Apparently restricted to impact area
	Enchytraeidae sp. Y7	10 (2)	Northwest, Yeelirrie playa	
	Enchytraeidae sp. B03	4 (2)	Northwest	New in 2015
	Enchytraeidae sp. B04	5 (1)	Yeelirrie playa	New in 2015
	Enchytraeidae sp. B05	5 (1)	Northwest	New in 2015
Naididae	Naididae sp. S4	4 (4)	Northwest, Central drawdown	
	Naididae sp. S5	3 (1)	Northwest	
Phreodrilidae	Phreodrilidae sp. S8	12 (7)	Northwest, Central drawdown, Yeelirrie playa	
	Phreodrilidae sp. B06	2 (1)	Northwest	New in 2015
	Phreodrilidae sp. B07	2 (1)	Yeelirrie playa	New in 2015
Crustacea				
Amphipoda	nr *Phreatochiltonia* sp. n. S1	610 (107)	Northwest, Central drawdown, Yeelirrie playa	
Isopoda	Philosciidae sp. n. S1	3 (2)	Yeelirrie playa	
	Philosciidae sp. n. Y2	5 (3)	Central drawdown	Apparently restricted to impact area
Syncarida	*Atopobathynella* sp. 'line K'	2 (1)	Central drawdown	Apparently restricted to impact area
	Atopobathynella sp. S4	16 (2)	Northwest, Yeelirrie playa	
	Atopobathynella sp. S5	585 (45)	Northwest, Central drawdown	
	Atopobathynella sp. Y1	6 (3)	Northwest	
	Atopobathynella sp. Y2	1 (1)	Northwest	
	Atopobathynella sp. Y3	7 (4)	Northwest	
	Bathynellidae sp. S2	29 (11)	Northwest, Central drawdown	
	Bathynellidae sp. S4	10 (3)	Yeelirrie playa	
Cyclopoida	*Dussartcyclops* 'dostoyevskyi' sp. n.	443 (32)	Northwest, Central drawdown, Yeelirrie playa	
	Halicyclops cf. *eberhardi* sp. A	659 (22)	Northwest, Central drawdown	Possibly widespread in Yilgarn
	Halicyclops cf. *eberhardi* sp. B	372 (4)	Central drawdown	Apparently restricted to impact area
	Halicyclops cf. *eberhardi* sp. C	171 (2)	Yeelirrie playa	
	Halicyclops cf. *eberhardi* sp. D (B01)	106 (7)	Yeelirrie playa	New in 2015
	Halicyclops kieferi	3 (1)	Yeelirrie playa	New in 2015, widespread in Yilgarn
	Mesocyclops brooksi	1 (1)	Yeelirrie playa	Occurs across southern Australia
Harpacticoida	*Australocamptus hamondi*	344 (3)	Northwest	Widespread in Yilgarn
	Dussartstenocaris idioxenos	488 (16)	Northwest	
	Kinnecaris esbe	19 (1)	Yeelirrie playa	
	Kinnecaris linesae	32 (5)	Northwest	
	Kinnecaris lined	100 (1)	Central drawdown	Apparently restricted to impact area
	Kinnecaris linel	158 (5)	Yeelirrie playa	
	Kinnecaris 'linep' sp. n.	1 (1)	Northwest	
	Kinnecaris uranusi	125 (16)	Northwest, Central drawdown	
	Nitokra esbe	15 (1)	Yeelirrie playa	
	Nitokra yeelirrie	4 (1)	Yeelirrie playa	
	Nitokra sp. B03	53 (8)	Northwest, Central drawdown	New in 2015
	Novanitocrella 'araia' sp. n.	124 (4)	Central drawdown	Apparently restricted to impact area
	Pseudectinosoma 'pentedicos' sp. A	18 (1)	Yeelirrie playa	
	Pseudectinosoma 'pentedicos' sp. B	25 (3)	Yeelirrie playa	
	Pseudectinosoma 'pentedicos' sp. C	4 (2)	Northwest	
	Schizopera akation	73 (16)	Northwest, Central drawdown, Yeelirrie playa	
	Schizopera akolos	4 (2)	Central drawdown	Apparently restricted to impact area
	Schizopera analspinulosa	34 (1)	Yeelirrie playa	
	Schizopera analspinulosa linel	38 (5)	Yeelirrie playa	

Taxonomic group	Species	Abund./ (Samples)	Known distribution	Remarks
	Schizopera emphysema	8 (4)	Central drawdown	Apparently restricted to impact area
	Schizopera kronosi	31 (14)	Northwest, Central drawdown,	
	Schizopera leptafurca	810 (47)	Northwest, Central drawdown	
	Schizopera 'linen' sp. n.	1 (1)	Yeelirrie playa	
	Schizopera uranusi	532 (58)	Northwest, Central drawdown	
	Schizopera sp. 7439	5 (1)	Central drawdown	Apparently restricted to impact area
	Schizopera sp. B16	33 (1)	Yeelirrie playa	New in 2015
	Schizopera sp. B17	17 (1)	Yeelirrie playa	New in 2015
Ostracoda	*Candonopsis* sp. n. Y1	156 (28)	Northwest, Central drawdown	
	Cyprididae sp.	1 (1)	Northwest	New in 2015
	?Strandesia sp.	1 (1)	Northwest	New in 2015
Insecta				
Coleoptera	*Limbodessus* sp. n. 'yeelirriensis'	44 (26)	Northwest, Central drawdown	
	Limbodessus sp. S1	40 (26)	Northwest, Central drawdown	
	Paroster sp. n. 'angustus'	29 (18)	Northwest, Central drawdown	

of the restricted species occur in the more western part of the area of central drawdown. The other three species are found in the middle and southeastern part of this drawdown area.

No restricted species has been recorded only from the area of northwest groundwater drawdown (Figure 2). The north-west drawdown is associated with groundwater abstraction for additional processing water.

5.2.2. Widespread species

Three of the species collected at Yeelirrie are also known from other calcretes in the Yilgarn region (*Halicyclops kieferi*, *Mesocyclops brooksi*, *Australocamptus hamondi*). One of the species of *H.* cf. *eberhardi* (most likely sp. A) may also be widespread because, prior to the DNA analysis that caused splitting of the species, *H eberhardi* was regarded as having a Yilgarn-wide distribution (Karanovic 2004). All of these widespread species are cyclopoid copepods with surface, as well as subterranean, populations and their wide distributions probably reflect multiple colonisation events of different calcretes by surface populations of the species.

Twenty-one other species are widespread (to varying degrees) within the study area, including the amphipod nr *Phreatochiltonia* sp. n. S1, syncarid *Atopobathynella* sp. S5, copepod *Schizopera uranusi* and beetle *Limbodessus* sp. S1, which are found across the entire area in a wide range of salinities (Figure 9). The distributions of species within the study area are probably determined by a mixture of physiological and life history characteristics. Species with broad salinity tolerances are likely to be widespread within the calcrete because the large size of widespread species such as nr *Phreatochiltonia* sp. n. S1 and *Limbodessus* sp. S1 suggest the physical structure of subterranean spaces is unlikely to be a constraint to species ranges within Yeelirrie.

5.3. Troglofauna richness

Although some other calcretes in the Yilgarn contain substantial numbers of troglofauna species, the 45 troglofauna species documented within the Yeelirrie mining tenement represents greater richness than is known elsewhere. The richness of the main Yeelirrie calcrete is less than that of the tenement as a whole because 12 species were collected only from the vicinity of Yeelirrie playa. These species are probably more closely linked to the Albion Downs than Yeelirrie calcrete (Table 5).

The number of troglofauna species collected from individual bores ranged up to 10 species at bore YYHC0048 at Yeelirrie playa (Figure 10). Eleven bores had five or more species, with five bores at Yeelirrie playa, four in the central calcrete (but only one of these was within the proposed mine pit) and two in the northwest sector. Only 29% of bores sampled yielded troglofauna and it can be seen from Figure 10 that no troglofauna were collected from many bores in close proximity to those that

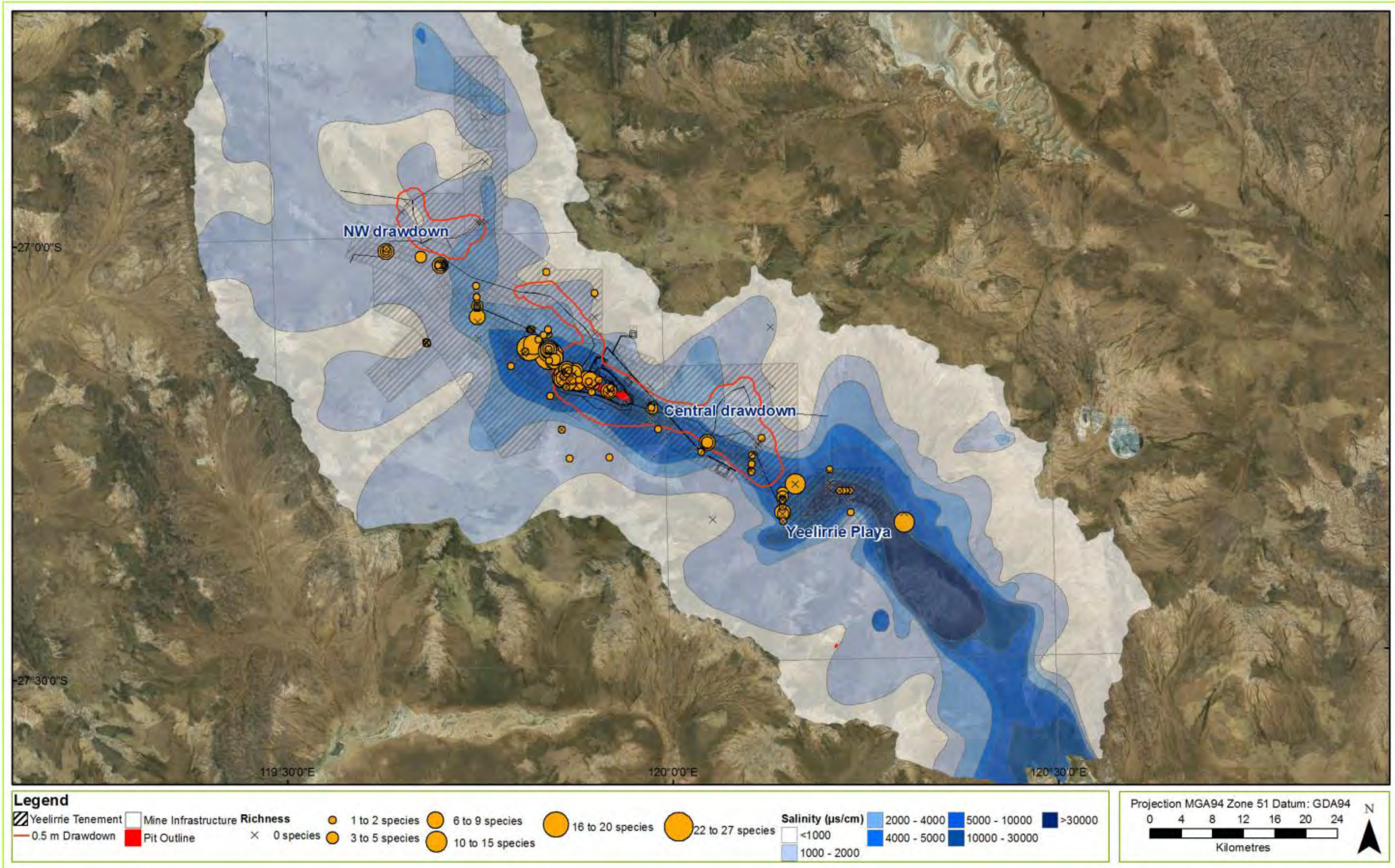

Figure 8. Number of stygofauna species recorded from each bore sampled for stygofauna.

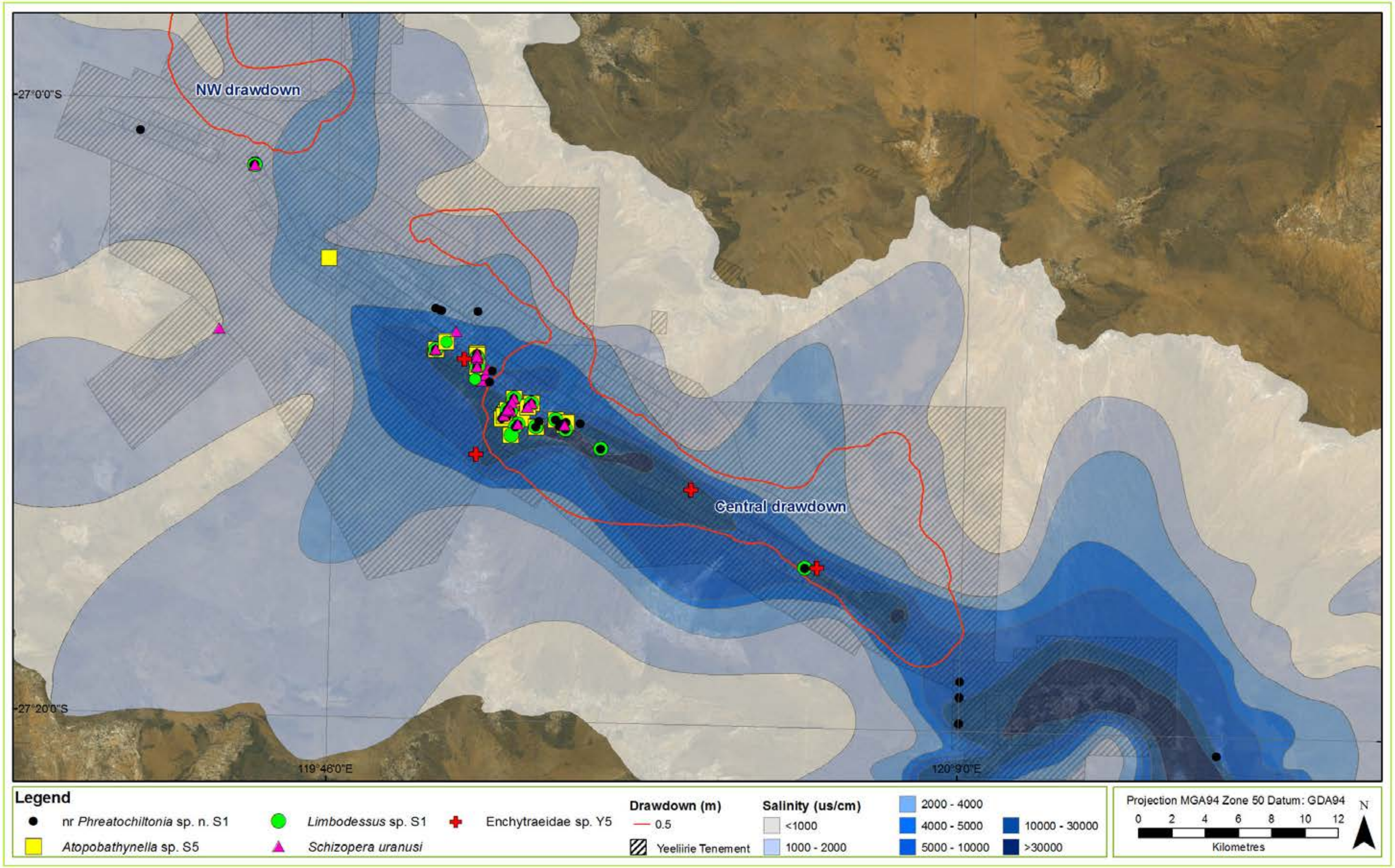

Figure 9. Distributions of stygofauna species that are widespread within the Yeelirrie study area.

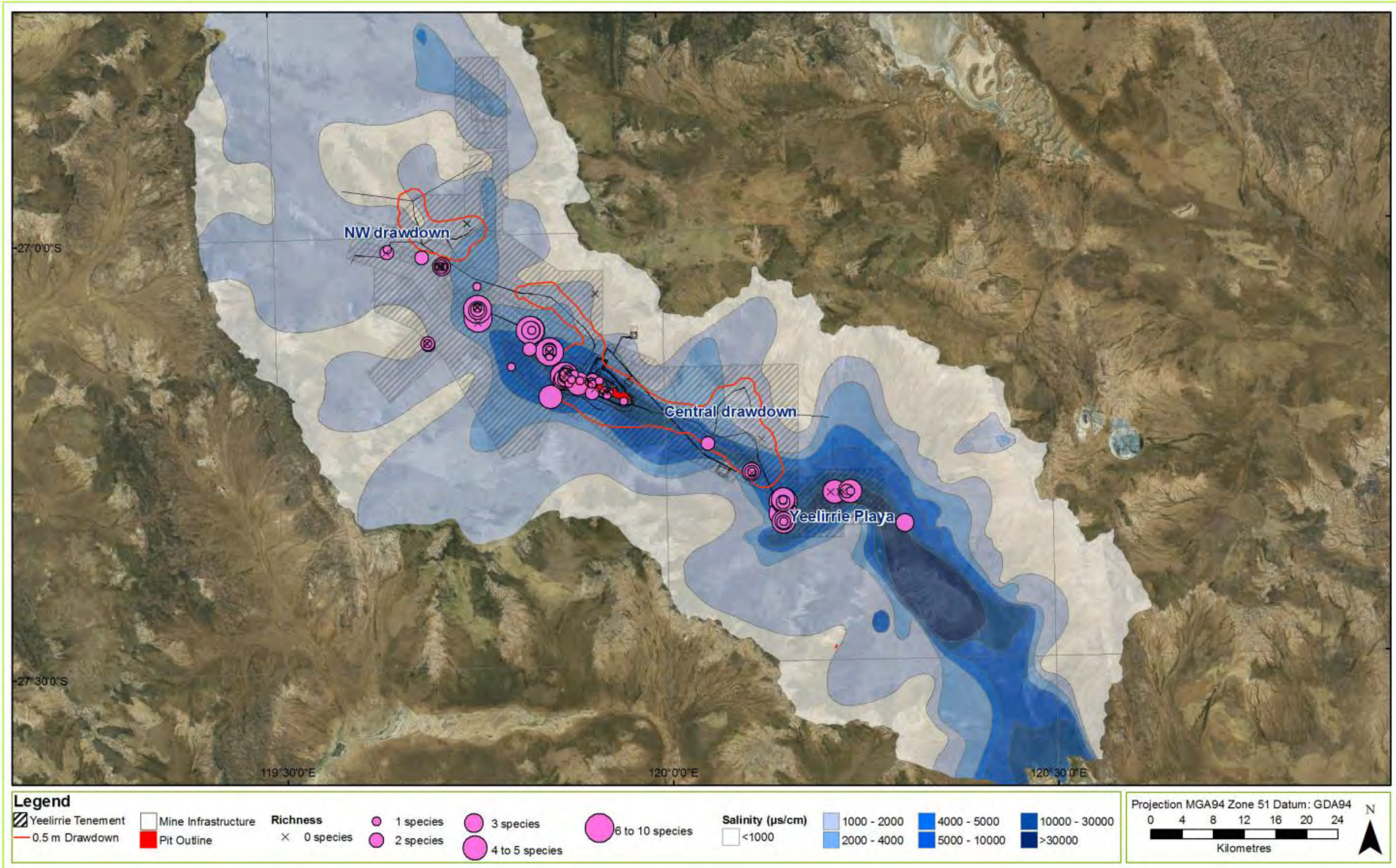

Figure 10. Number of troglofauna species recorded from each bore sampled for troglofauna.

Table 5. Troglofauna species recorded at Yeelirrie.

Species known only from the proposed mine pit are shaded in blue. Both the number of animals of each species and the number of samples in which they were collected are shown. North-west indicates the species occurs west of the mine pit, south-east means the species occurs to the south-east of the mine pit, widespread means the species occurs in at least two areas at Yeelirrie.

Taxonomic group	Species	Abund./ (Samples)	Known distribution	Remarks
Crustacea				
Isopoda	*Troglarmadillo* sp. n. S7A	9 (2)	Northwest	
	Troglarmadillo sp. n. S7C	3 (1)	Northwest	
	Troglarmadillo sp. n. S9	7 (2)	Southwest	60 m west of mine pit
	Troglarmadillo sp. n. S12	1 (1)	Yeelirrie playa	
	Troglarmadillo sp. n. S13	8 (5)	Southwest, Yeelirrie playa	
	Trichorhina sp. n. F	1 (1)	Mine pit	Apparently restricted to impact area
	Trichorhina sp. n. G	8 (6)	Northwest	
	Trichorhina sp. n. H	5 (3)	Northwest	
	Trichorhina sp. n. I	1 (1)	Southwest	
	Stenoniscidae sp. n. Y1	3 (1)	Yeelirrie playa	
Arachnida				
Araneae	*Opopaea* sp. n. Y2	1 (1)	Yeelirrie playa	
	Prethopalpus callani	5 (5)	Northwest, Southwest	
	Prethopalpus sp. n. B	1 (1)	Yeelirrie playa	
	Desognanops sp.n. Y1	9 (7)	Northwest, Southwest, Yeelirrie playa	
Palpigradi	*Eukoenenia* sp. n. S2	21 (6)	Northwest, Yeelirrie playa	
Pseudoscorpiones	*Tyrannochthonius* sp. n. Y1	1 (1)	Mine pit	Apparently restricted to impact area
	Tyrannochthonius sp. n. Y2A	6 (4)	Northwest, Mine pit, Southwest	
	Tyrannochthonius sp. n. Y2C	1 (1)	Yeelirrie playa	
	Tyrannochthonius sp. n. Y3	1 (1)	Yeelirrie playa	
	Tyrannochthonius sp. n. Y4	1 (1)	Yeelirrie playa	
	Tyrannochthonius sp. n. Y5	2 (2)	Yeelirrie playa	
	Austrohorus sp. n. Y1	1 (1)	Mine pit	Apparently restricted to impact area
	Austrohorus sp. n. Y2	2 (2)	Yeelirrie playa	
Myriapoda				
Chilopoda	Geophilidae sp. Y1	11 (10)	Northwest, Southwest, Yeelirrie playa	
	Cryptops sp.Y1	4 (4)	Northwest	
Diplopoda	Polyxenida sp. S1 (Yeelirrie)	58 (32)	Northwest, Mine pit, Southwest, Yeelirrie playa	
Pauropoda	Pauropoda sp. S6A	1 (1)	Northwest	
	Pauropoda sp. S6B	3 (1)	Mine pit	Apparently restricted to impact area
	Pauropoda sp. Y1	4 (1)	Northwest	
	Pauropoda sp. Y2	1 (1)	Northwest	
	Pauropoda sp. Y3	46 (1)	Yeelirrie playa	
Symphyla	Symphyla sp. Y1	8 (4)	Northwest	
	Symphyla sp. Y2	2 (1)	Northwest	
	Symphyla sp. Y3	1 (1)	Northwest	
	Symphyla sp. Y4	3 (2)	Northwest	
	Symphyla sp. Y5	2 (2)	Yeelirrie playa	
	Symphyla sp. Y6	1 (1)	Yeelirrie playa	
	Symphyla sp. Y7	1 (1)	Mine pit	Apparently restricted to impact area
Hexapoda				
Diplura	Japygidae sp. Y3	7 (5)	Northwest, Yeelirrie playa	
	Parajapygidae sp. Y1	3 (3)	Northwest, Yeelirrie playa	
	Projapygidae sp Y2	10 (10)	Northwest, Mine pit, Southwest, Yeelirrie playa	
Hemiptera	Enicocephalidae sp. Y1	1 (1)	Yeelirrie playa	
	Meenoplidae sp. Y1	83 (17)	Northwest, Southwest, Yeelirrie playa	
Thysanura	Atopatelurini sp. n. Y2	1 (1)	Southwest	
	Hemitrinemura sp. n. Y1	4 (4)	Northwest, Southwest	

yielded well. This is also true of stygofauna but less easy to see in Figure 8. The highly variable yields of adjacent bores highlights the complexities of identifying bores that may show wider distribution of particular troglofauna species currently known only in the proposed mine pit. It was pointed out in EPA (2007), mainly in relation to stygofauna that even in prospective areas only a small proportion of bores yield and bore construction was postulated to be one factor affecting yield. Another is likely to be whether, by chance, the bore intersects vugs and spaces containing troglofauna or passes unsuitable troglofauna habitat.

There have been relatively few even moderately comprehensive surveys of troglofauna in other Yilgarn calcretes and caution must be applied when comparing the richness of Yeelirrie with other areas. In one of the more comprehensive surveys, Outback Ecology (2011) collected 20 troglofauna species in the calcretes of the Lake Way area and cited unpublished Western Australian Museum reports referring to "numerous [other] troglomorphic species" in these calcretes. The Western Australian Museum collected at least 17 troglofauna species at Sturt Meadows with sampling effort and taxonomic rigour that were considerable less than applied at Yeelirrie. Thus, much of the high species richness at Yeelirrie compared with other areas may be attributable to sampling effort and detailed taxonomic resolution, based on both detailed morphological and genetic work, applied by Subterranean Ecology (2011).

5.3.1. Restricted species

A total of five troglofauna species are presently known only from the proposed mine pit at Yeelirrie. Four of the species were collected from single bores, while the fifth species was collected from two bores (Table 3). Four of the restricted species were found in the most north-western part of the proposed mine pit (Figure 5). The other species (*Trichorhina* sp. n. F) was also collected in the western part of the mine pit.

5.3.2. Widespread species

Subterranean Ecology (2011) concluded that the millipede Polyxenida sp. S1 (Yeelirrie) and bug Meenoplidae sp. Y1 are regionally widespread, while other species of troglofauna are likely to be restricted to the study area. This fits with experience in the Pilbara where some polyxenid millipede and meenoplid bug species are widespread.

Fourteen of these species are widespread within the study area, including all three diplurans and two centipedes (Chilopoda) collected and at least one species of each faunal group other than symphylans and pauropods (Table 5). In approximately two-thirds of samples, species were represented by single animals which suggests that the distributions of species within the study area are probably poorly documented because insufficient numbers of animals have been collected (see Wisz *et al.* 2008). Collection of additional specimens would enable species ranges to be better defined. In most cases, ranges are likely to be larger than present estimates suggest.

6. RISK ASSESSMENT

6.1. Yeelirrie PEC

The Yeelirrie subterranean fauna community is a Priority 1 PEC. It is currently the most species-rich stygofauna community known from the Yilgarn, although this may be a result of sampling effort being much higher in the Yeelirrie calcrete than any other part of the Yilgarn. Approximately 52% of the saturated calcrete habitat within the PEC will experience >0.5 m drawdown as a result of development of the Yeelirrie Project. It is difficult to assess the significance of this loss in terms of the conservation values of the PEC as a community because the extent of the PEC has not been defined. This cannot be done without a clear statement from the listing agency (DPaW) about the character of the PEC or general guidelines about how the extent of PECs should be determined. Consequently, the assessment of threat was undertaken principally at the species level (see below).

6.2. Stygofauna

Ten species of stygofauna are currently known from the area of central groundwater drawdown. They are the worms Enchytraeidae sp. Y4, Enchytraeidae sp. Y6, syncarid *Atopobathynella* sp. 'line K', copepods *Halicyclops* cf. *eberhardi* sp. B, *Kinnecaris lined, Novanitocrella* 'araia' sp. n., *Schizopera akolos, Schizopera emphysema, Schizopera* sp. 7439 and isopod Philosciidae sp. n. Y2. The likelihood of these species being restricted to the drawdown area is discussed below and summarised in Table 6.

Enchytraeidae sp. Y4

In total, 1133 enchytraeid worms were collected throughout the Yeelirrie calcrete and the Yeelirrie Playa and a handful yielded DNA to show that nine species are present. Subterranean oligochaetes, including enchytraeids, are usually moderately widespread (Pinder 2008) and the pattern of localised occurrence at Yeelirrie inferred from DNA results is unusual. It is most likely that Enchytraeidae sp. Y4, which was detected genetically from a single animal (the other 37 enchytraeids in the sample were assumed to be the same species), occurs more widely in the Yeelirrie calcrete. Enchytraeidae sp. Y4 was probably identified in only one sample because a very small proportion of worm specimens were analysed genetically.

Enchytraeidae sp. Y6

This amphibious species was collected in one sample from one bore within the proposed mine pit. As with Enchytraeidae sp. Y4, identifications were based on DNA sequence data (here for a single animal) and the remaining three animals from the same locality were attributed to this species. Based on existing information, it is considered most likely that Enchytraeidae sp. Y6 is occurs more widely at Yeelirrie.

***Atopobathynella* sp. 'line K'**

This syncarid species was collected from a single drill hole in the southeastern part of the central groundwater drawdown. *Atopobathynella* sp. 'line K' is one of six species of *Atopobathynella* collected in the study area and the two species collected from multiple drill holes were both widespread (Table 6). This suggests that it is likely further sampling would show *Atopobathynella* sp. 'line K' occurs outside the central groundwater drawdown.

***Halicyclops* cf. *eberhardi* sp. B**

The copepod *Halicyclops* cf. *eberhardi* sp. B was collected in four samples from a single bore on the periphery of the proposed mine pit within the central groundwater drawdown. The closely related *H.* cf. *eberhardi* sp. A is more widely distributed in the Yeelirrie calcrete and, perhaps, regionally. Another closely related species, *H.* cf. *eberhardi* sp. C, was collected at Yeelirrie playa. Little can currently be said about the likely range of *H.* cf. *eberhardi* sp. A other than that the species may possibly be restricted to the central groundwater drawdown.

Kinnecaris lined

This copepod species was referred to as *Kinnecaris* 'lined' sp. n. by Subterranean Ecology (2011) but has been formally described as *Kinnecaris lined* (Karanovic and Cooper 2011). A total of 100 specimens were collected from a single bore in the southeastern part of the central groundwater drawdown. The identification was based on DNA sequence data and morphology (Karanovic and Cooper 2011). Given that six species of *Kinnecaris* occur in the study area, with all species other than *K. uranusi* having restricted known ranges, it is likely most of the species occupy specific microhabitats within the study area. Thus, it is possible that *K. lined* may be restricted to the central groundwater drawdown.

***Novanitocrella* 'araia' sp. n.**

The copepod *Novanitocrella* 'araia' sp. n. is known only from a single animal in a sample from within the proposed mine pit. The species is defined morphologically and a further 123 animals belonging to a subspecies *Novanitocrella* 'araia linec' ssp. n. are known from the east of the mine pit in the central groundwater drawdown. The species and subspecies are treated here as a single taxonomic unit. Given the differentiation that has occurred between the nominate species and the subspecies within the central groundwater drawdown, it is possible that the species, or a valid taxonomic unit, is restricted to the 40 km drawdown area. The only other species of the genus, *Novanitocrella aboriginesi*, has a known linear range of about 20 km (Karanovic 2004).

Schizopera akolos

This copepod species was previously referred to as *Schizopera* 'akolos' sp. n. but was recently formally described as *Schizopera akolos* (Karanovic and Cooper 2012). In total, nine species and one subspecies of *Schizopera* have been collected from the study area, with the four species from multiple bores shown to be widespread at Yeelirrie (Table 6) In the case of *S. akolos*, four animals were collected in two samples from a single bore within the proposed mine pit. Given that the intensity of sampling was very high around bore YYD22 at the western end of the proposed mine pit where *S. akolos* was recorded, its collection from a single bore is probably a consequence of *S. akolos* occupying a relatively rare microhabitat in a heterogeneous subterranean environment (see Bradford 2010).

Schizopera emphysema

This species was previously referred to as *Schizopera* 'emphysema' sp. n. but was recently formally described as *Schizopera emphysema* (Karanovic and Cooper 2012). Eight animals of this species were collected in four samples from bore YYAC1004C within the proposed mine pit. As with *S. akolos*, this species probably occupies a microhabitat that is relatively rare within the study area because it was not collected from bores YYAC1004A, B and D that are only a few metres away from YYAC1004C (Karanovic and Cooper 2012). It is considered likely that *S. emphysema* is a species with a patchy, but at least moderately widespread, occurrence at Yeelirrie.

Table 6. Likely distributions of potentially restricted stygofauna species.

Species	Samples	Drill holes	No. of animals	Likely status
Enchytraeidae sp. Y4	1	1	1 (38)*	Not restricted
Enchytraeidae sp. Y6	1	1	1 (4)*	Not restricted
Atopobathynella sp. 'line K'	1	1	2	Not restricted
Halicyclops cf. *eberhardi* sp. B	4	1	1 (372) *	Possibly restricted
Kinnecaris lined	1	1	100	Possibly restricted
Novanitocrella 'araia' sp. n.	1	1	1	Possibly restricted
Schizopera akolos	3	3	4	Not restricted
Schizopera emphysema	4	1	8	Not restricted
Schizopera sp. 7439	1	1	1 (5)*	Uncertain
Philosciidae sp. n. Y2	4	2	6	Possibly restricted

* First value is number of animals identified; value in parenthesis is inferred number of animals belonging to the species.

Schizopera sp. 7439

Schizopera sp. 7439, which was identified from genetic analyses of a single animal, was collected in one sample of five animals from one bore within the proposed mine pit. It is possible that this species was collected more widely and not identified morphologically. As this species was recorded from a single sample, with identification based on a single individual, the probability that collection of additional specimens would increase its range is high but little can be said currently about its distribution.

Philosciidae sp. n. Y2

This amphibious isopod species was collected in three samples from two drill holes within the proposed mine pit. Terrestrial isopods often have restricted ranges (Judd *et al.* 2003) and other subterranean philosciids have sometimes been shown to be restricted to single calcretes or to have mine-scale distributions (Cooper *et al.* 2008; Taiti and Humphreys 2001). Philosciidae sp. Y2 is considered, in the absence of more information, to be possibly restricted to the central drawdown area.

6.3. Troglofauna

Five species of troglofauna are currently known from the area of the proposed mine pit. They are the isopod *Trichorhina* sp. n. F., the pseudoscorpions *Austrohorus* sp. n. Y1 and *Tyrannochthonius* sp. n. Y1, the pauropod Pauropoda sp. S6B, and the symphylan Symphyla sp. Y7. The likelihood of these species being restricted to the proposed mine pit is discussed below and summarised in Table 7.

Trichorhina sp. n. F

Three of the four species of *Trichorhina* collected in the study area are known from single bores, with *Trichorhina* sp. n. F being represented by a single animal within the proposed mine pit. The fourth species, *Trichorhina* sp. n. G, occurs in multiple bores but is restricted to the north-western part of the Yeelirrie calcrete (Table 7). It is likely *Trichorhina* sp. n. F will have a restricted range and may possibly be restricted to the proposed mine pit.

Table 7. Likely distributions of potentially restricted troglofauna species.

Species	Samples	Drill holes	No. of animals	Likely status
Trichorhina sp. n. F	1	1	1	Possibly restricted
Pauropoda sp. S6B	1	1	1 (2)*	Not restricted
Symphyla sp. Y7	1	1	1	Not restricted
Austrohorus sp. n. Y1	1	1	1	Not restricted T
Tyrannochthonius sp. n. Y1	2	2	2	Not restricted T

* First value is number of animals identified; value in parenthesis is inferred number of animals belonging to the species.

***Tyrannochthonius* sp. n. Y1**

Three of the six species of *Tyrannochthonius* were collected from two or three bores. As a result, both *Tyrannochthonius* sp. n. Y2A and *Tyrannochthonius* sp. n. Y4 showed relatively wide distributions. *Tyrannochthonius* sp. n. Y1 was recorded only within the proposed mine pit. It appears likely that further sampling would show that *Tyrannochthonius* sp. n. Y1 is also more widely distributed. Available data for other subterranean pseudoscorpions indicate that species are usually relatively widespread in a subterranean habitat consisting of a common karst system (Harvey and Edward 2007; Harvey and Leng 2008).

***Austrohorus* sp. n. Y1**

This species was a true singleton record, being known only from one specimen in the proposed mine pit. Both species of *Austrohorus* collected in the study area came from single drill holes. It is likely that *Austrohorus* sp. n Y1 is more widely distributed in the Yeelirrie calcrete than the proposed mine pit although the limited sampling results to date cannot show this. Data from elsewhere for subterranean pseudoscorpions indicate that species are usually relatively widespread in a subterranean habitat consisting of a common karst system (Harvey and Edward 2007; Harvey and Leng 2008). A further consideration is the proximity of the existing record to land outside the proposed mine pit.

Pauropoda sp. S6B

All five pauropod species collected in the study area have apparently restricted distributions, although in some cases it was because single animals were collected. Pauropoda sp. S6B was collected in one sample containing three animals, only one of which was analysed genetically. Recent taxonomic work on pauropods in Australia suggests that many species have restricted distributions (Scheller 2010; Scheller 2013). This, combined with the apparently restricted distributions of the other species collected from the study area, suggests Pauropoda sp. S6B may be restricted to the proposed mine pit. However, the proximity of the one record to the edge of the mine pit suggests the species' range is more likely to extend outside the pit.

Symphyla sp. Y7

All seven symphylan species collected from the study area have apparently restricted distributions, although as with pauropods this is often the result of single animals being collected, as was the case with Symphyla sp. Y7. Little can be said about the likely range of Symphyla sp. Y7 because of the poor taxonomic framework for this group in Australia and the resultant lack of species level identifications. Thus, it must be considered possible that Symphyla sp. Y7 is restricted to the proposed mine pit, although the proximity of the one record to the edge of the mine pit suggests that, on balance, the species' range is likely to extend outside the pit.

7. CONCLUSIONS

The proposed Yeelirrie Project lies in a palaeovalley that contains the 40 km long Yeelirrie calcrete. This calcrete appears to provide the main habitat for subterranean fauna within the area.

The subterranean community in the Yeelirrie calcrete is richer than known for any other calcrete in the Yilgarn, partly because sampling and identification efforts have been extensive compared to other calcretes and perhaps also because of the hydrological and geological characteristics of Yeelirrie. Subterranean fauna sampling has confirmed the presence of at least 70 species of stygofauna and 45 species of troglofauna (115 subterranean species in total). It is estimated that 83 species of stygofauna and 65 species of troglofauna occur at Yeelirrie (148 subterranean species in total), although this may include a broader community than the Yeelirrie PEC.

Ten species of stygofauna and five species of troglofauna are currently known only from areas where the extent of habitat will be reduced by development of the Yeelirrie Project. Predicting the true range of these 15 species is difficult without a better understanding of the factors driving habitat selection of the individual species. However, existing evidence suggests that nine of the 15 species are unlikely to be restricted to the areas impacted by mining and groundwater abstraction. There is also some likelihood that the other six species may occur beyond the areas impacted by mining and groundwater abstraction.

8. REFERENCES

Allford, A., Cooper, S.J.B., Humphreys, W.F., and Austin, A.D. (2008) Diversity and distribution of groundwater fauna in a calcrete aquifer: does sampling method influence the story? *Invertebrate Systematics* **22**, 127–138.

Baehr, B.C., Harvey, M.S., Burger, M., and Thoma, M. (2012) The new Australasian goblin spider genus *Prethopalpus* (Araneae, Oonopidae). *Bulletin of the American Museum of Natural History* **369**, 1-113.

Barranco, P., and Harvey, M.S. (2008) The first indigenous palpigrade from Australia: a new species of *Eukoenenia* (Palpigradi: Eukoeneniidae). *Invertebrate Systematics* **22**, 227-233.

Bennelongia (2008a) Troglofauna survey at Koolyanobbing. Report 2008/49, Bennelongia Pty Ltd, Jolimont, 24 pp.

Bennelongia (2008b) Troglofauna survey at Koolyanobbing – update and recommendations. Report 2008/37, Bennelongia Pty Ltd, Jolimont, 13 pp.

Bennelongia (2008c) Troglofauna survey of Mount Jackson Range, Western Australia. Report 2008/50, Bennelongia Pty Ltd, Jolimont, 15 pp.

Bennelongia (2008d) Troglofauna survey of the Orebody 18 mine modification. Report 2008/27, Bennelongia Pty Ltd, Jolimont, 21 pp.

Bennelongia (2009) Area C mining operation environmental management plan (Revision 4) A, D, P1 and P3 deposits: troglofauna assessment. Report 2008/48, Bennelongia Pty Ltd, Jolimont, 44 pp.

Bennelongia (2013) Yamarna Project subterranean fauna assessment. Report 2013/199. Bennelongia Pty Ltd, Jolimont, 35 pp.

Biota (2006) Species accumulation and troglobitic fauna sampling adequacy at Mesa A. Project No. 291. Biota Environmental Sciences, Leederville, 17 pp

Biota (2007) Hematite and Magnetite Projects desktop subterranean fauna assessment. Project No. 389, Biota Environmental Sciences, Leederville, 29 pp.

Bradford, T., Adams, M., Humphreys, W.F., Austin, A.D., and Cooper, S.J.B. (2010) DNA barcoding of stygofauna uncovers cryptic amphipod diversity in a calcrete aquifer in Western Australia's arid zone. *Molecular Ecology Resources* **10**, 41-50.

Castalanelli, M.A., Teale, R., Rix, M.G., Kennington, W.J., and Harvey, M.S. (2014) Barcoding of mygalomorph spiders (Araneae : Mygalomorphae) in the Pilbara bioregion of Western Australia reveals a highly diverse biota. *Invertebrate Systematics* **28**, 375-385.

Colwell, R.K., Chao, A., Gotelli, N.J., Lin, S.-Y., Mao, C.X., Chazdon, R.L., and Longino, J.T. (2012) Models and estimators linking individual-based and sample-based rarefaction, extrapolation and comparison of assemblages. *Journal of Plant Ecology* **5**, 3-21.

Cooper, S.J.B., Hinze, S., Leys, R., Watts, C.H.S., and Humphreys, W.F. (2002) Islands under the desert: molecular systematics and evolutionary origins of stygobitic water beetles (Coleoptera: Dytiscidae) from central Western Australia. *Invertebrate Systematics* **16**, 589-598.

Cooper, S.J.B., Bradbury, J.H., Saint, K.M., Leys, R., Austin, A.D., and Humphreys, W.F. (2007) Subterranean archipelago in the Australian arid zone: mitochondrial DNA phylogeography of amphipods from central Western Australia *Molecular Ecology* **16**, 1533-1544.

Eberhard, S.M., Halse, S.A., and Humphreys, W.F. (2005) Stygofauna in the Pilbara region, north-west Western Australia: a review. *Journal of the Royal Society of Western Australia* **88**, 167-176.

Eberhard, S.M., Halse, S.A., Williams, M.R., Scanlon, M.D., Cocking, J., and Barron, H.J. (2009) Exploring the relationship between sampling efficiency and short-range endemism for groundwater fauna in the Pilbara region, Western Australia. *Freshwater Biology* **54**, 885-901.

Ecology, S. (2011) Yeelirrie Subterranean Fauna Survey. Proposed Yeelirrie Development. Report prepared for BHP Billiton Yeelirrie Development Company Pty Ltd. Subterranean Ecology Pty Ltd, Stirling, Western Australia, 87 pp.

Edward, K.L., and Harvey, M.S. (2008) Short-range endemism in hypogean environments: the pseudoscorpion genera *Tyrannochthonius* and *Lagynochthonius* (Pseudoscorpiones: Chthoniidae) in the semiarid zone of Western Australia. *Invertebrate Systematics* **22**, 259-293.

Environmental Protection Authority (2007) Sampling methods and survey considerations for subterranean fauna in Western Australia (Technical Appendix to Guidance Statement No. 54). Environmental Protection Authority, Perth, 32 pp.

Environmental Protection Authority (2013) Environmental Assessment Guildline No. 12 - Consideration of Subterranean Fauna in Environmental Impact Assessment in WA. Environmental Protection Authority Western Australia, Perth, 24 pp.

Cameco Corporation (2015) Numerical Groundwater Flow and Solute Transport Model of the Yeelirrie Uranium Deposit. Draft Report for Cameco Australia. Perth, Western Australia, 61 pp.

GHD (2010) Report for Jack HIlls expansion project troglofauna phase 5 and 6 results and habitat assessment. GHD, Perth, 22 pp.

Giribet, G., McIntyre, E., Christian, E., Espinasa, L., Ferreira, R.L., Francke, O.F., Harvey, M.S., Isaia, M., Kovác, L., McCutchen, L., Souza, M.F.V.R., and Zagmajster, M. (2014) The first phylogenetic analysis of Palpigradi (Arachnida) - the most enigmatic arthropod order. *Invertebrate Systematics* **28**, 350-360.

Guzik, M.T., Abrams, K.M., Cooper, S.J.B., Humphreys, W.F., Cho, J.-L., and Austin, A.D. (2008) Phylogeography of the ancient *Parabathynellidae* (Crustacea: Bathynellacea) from the Yilgarn region of Western Australia. *Invertebrate Systematics* **22**, 205-216.

Guzik, M.T., Austin, A.D., Cooper, S.J.B., Harvey, M.S., Humphreys, W.F., Bradford, T., Eberhard, S.M., King, R.A., Leys, R., Muirhead, K.A., and Tomlinson, M. (2010) Is the Australian subterranean fauna uniquely diverse? *Invertebrate Systematics* **24**, 407-418.

Guzik, M.T., Cooper, S.J.B., Humphreys, W.F., Ong, S., Kawakami, T., and Austin, A.D. (2011) Evidence for population fragmentation within a subterranean aquatic habitat in the Western Australian desert. *Heredity* **107**, 215-230.

Harrison, S.E., Guzik, M.T., Harvey, M.S., and Austin, A.D. (2014) Molecular phylogenetic analysis of Western Australian troglobitic chthoniid pseudoscorpions (Pseudoscorpiones: Chthoniidae) points to multiple independent subterranean clades. *Invertebrate Systematics* **28**, 386-400.

Hebert, P.D.N., Ratnasingham, S., and deWaard, J.R. (2003) Barcoding animal life: cytochrome c oxidase subunit 1 divergences among closely related species. *Proceedings of the Royal Society of London Series B-Biological Sciences* **270**, S96-S99.

Humphreys, W.F. (2001) Groundwater calcrete aquifers in the Australian arid zone: the context to an unfolding plethora of stygal biodiversity. *Records of the Western Australian Museum Supplement* **64**, 63-83.

Humphreys, W.F. (2008) Rising from Down Under: developments in subterranean biodiversity in Australia from a groundwater fauna perspective. *Invertebrate Systematics* **22**, 85-101.

Judd, S., and Perina, G. (2003) Diversity and biogeography of terrestrial isopods (Isopoda, Oniscidea) from southwestern Australia: organic matter and microhabitat utilization in seasonally dry landscapes. *Crustacean Monographs* **2**, 191-215.

Judd, S., and Perina, G. (2013) An illustrated key to the morphospecies of terrestrial isopods (Crustacea: Oniscidea) of Barrow Island, Western Australia. *Records of the Western Australian Museum Supplement* **83**, 185-207.

Karanovic, I. (2007) Candoninae (Ostracoda) from the Pilbara region in Western Australia. *Crustaceana Monographs* **7**, 1-432.

Karanovic, T., and Cooper, S.J.B. (2011a) Molecular and morphological evidence for short range endemism in the *Kinnecaris solitaria* complex (Copepoda: Parastenocarididae), with descriptions of seven new species. *Zootaxa* **3026**, 1-64.

Karanovic, T., and Cooper, S.J.B. (2011b) Third genus of parastenocaridid copepods from Australia supported by molecular evidence (Copepoda, Harpacticoida). In: Defaye, D., E. Suárez-Morales J.C. Vaupel Klein (eds.). Crustacean Monographs, Studies on Freshwater Copepoda: a volume in honour of Bernard Dussart. Brill, 574 pp.

Karanovic, T., and Cooper, S.J.B. (2012) Explosive radiation of the genus *Schizopera* on a small subterranean island in Western Australia (Copepoda : Harpacticoida): unravelling the cases of cryptic speciation, size differentiation and multiple invasions. *Invertebrate Systematics* **26**, 115-192.

Karanovic, T., Eberhard, S., Cooper, S.J.B., and Guzik, M.T. (2014) Morphological and molecular study of the genus *Nitokra* (Crustacea, Copepoda, Harpacticoida) in a small palaeochannel in Western Australia. *Organisms, Diversity & Evolution* **15**, 1-35.

Karanovic, T., and McRae, J. (2013) The genus Schizopera (Copepoda, Harpacticoida) in the Pilbara region of Western Australia, with description of a new species and its molecular and morphological affinities. *Records of the Western Australian Museum* **119**, 28.

Lamoureux, J. (2004) Stygobites are more wide-ranging than troglobites. *Journal of Cave and Karst Studies* **66**, 18-19.

Leys, R., and Watts, C.H.S. (2008) Systematics and evolution of the Australian subterranean hydroporine diving beetles (Dytiscidae), with notes on *Carabhydrus*. *Invertebrate Systematics* **22**, 217-225.

Leys, R., Watts, C.H.S., Cooper, S.J.B., and Humphreys, W.F. (2003) Evolution of subterranean diving beetles (Coleoptera: Dytiscidae Hydroporini, Bidessini) in the arid zone of Australia. *Evolution* **57**, 2819-2834.

Mann, A.W., and Horwitz, R.C. (1979) Groundwater calcrete deposits in Australia: some observations from Western Australia. *Journal of the Geological Society of Australia* **26**, 293-303.

Morgan, K.H. (1993) Development, sedimentation and economic potential of palaeoriver systems of the Yilgarn Craton of Western Australia. *Sedimentary Geology* **85**, 637-656.

Pipan, T., López, H., Oromí, P., Polak, S., and Culver, D.C. (2010) Temperature variation and the presence of troglobionts in terrestrial shallow subterranean habitats. *Journal of Natural History* **45**, 253-273.

Platnick, N I. (2008) A new subterranean ground spider genus from Western Australia (Araneae : Trochanteriidae). *Invertebrate Systematics* **22**, 295-299.

Reeves, J.M., de Deckker, P., and Halse, S.A. (2007) Groundwater ostracods from the arid Pilbara region of northwestern Australia: distribution and water chemistry. *Hydrobiologia* **585**, 99-118.

Subterranean Ecology (2011) Fortescue Metals Group Solomon Project: Kings deposits subterranean fauna survey and assessment. Report 2010/20. Subterranean Ecology, Stirling, 96 pp.

Taiti, S. (2014) New subterranean Armadillidae (Crustacea, Isopoda, Oniscidea) from Western Australia. *Tropical Zoology*, **27**, 1-13.

Watts, C.H.S., and Humphreys, W.F. (2006) Twenty-six new Dytiscidae (Coleoptera) of the genera *Limbodessus* Guignot and *Nirripirti* Watts & Humphreys, from underground waters in Australia. *Transactions of the Royal Society of Australia* **130**, 123-185.

Wisz, M.S., Hijmans, R.J., Li, J., Petersen, A.T., Graham, C.H., and Guisan, A. (2008) Effects of sample size on the performance of species distribution models. *Diversity and Distributions* **14**, 763-773.

9. APPENDICES

Appendix 1 – Species with an updated taxonomy

Taxonomic Groups	Species list 2011	Revised species list 2014
Crustacea		
	Dussartstenocaris 'idioxenos'	*Dussartstenocaris idioxenos* Karanovic and Cooper (2011b
	Kinnecaris 'esbe' sp. n.	*Kinnecaris esbe* Karanovic and Cooper (2011a)
	Kinnecaris 'linea' sp.	*Kinnecaris linesae* Karanovic and Cooper (2011a)
	Kinnecaris 'lined' sp. n.	*Kinnecaris lined* Karanovic and Cooper (2011a)
	Kinnecaris 'linel' sp. n.	*Kinnecaris linel* Karanovic and Cooper (2011a)
	Kinnecaris 'uranusi' sp. n.	*Kinnecaris uranusi* Karanovic and Cooper (2011a)
	Nitokra 'esbe' sp. n.	*Nitokra esbe* Karanovic *et al.* (2014).
	Nitokra 'yeelirrie' sp. n.	*Nitokra yeelirrie* Karanovic *et al.* (2014).
	Schizopera 'akation' sp. n.	*Schizopera akation* Karanovic and Cooper (2012)
	Schizopera 'akolos' sp. n.	*Schizopera akolos* Karanovic and Cooper (2012)
	Schizopera 'analspinulosa' sp. n.	*Schizopera analspinulosa* Karanovic and Cooper (2012)
	Schizopera 'analspinulosa linel' spp. n.	*Schizopera analspinulosa linel* Karanovic and Cooper (2012)
	Schizopera 'emphysema' sp. n.	*Schizopera emphysema* Karanovic and Cooper (2012)
	Schizopera 'kronosi' sp. n.	*Schizopera kronosi* Karanovic and Cooper (2012)
	Schizopera 'leptafurca' sp. n.	*Schizopera leptafurca* Karanovic and Cooper (2012)
	Schizopera 'uranusi' sp. n.	*Schizopera uranusi* Karanovic and Cooper (2012)
Arachnida		
	'Prethopalpus' 'callani' Gen. n. sp. n.	*Prethopalpus callani* Baehr *et al.* (2012)

Appendix 2 - Bores sampled in February and June/July 2015.

Bore Code	Site Code	Latitude	Longitude	Sample Date	SWL (m)	EOH (m)	Historically sampled (yes/no)	Stygofauna (yes/no)	Number of stygofauna species
February 2015									
Bottle Well Bore	CAM140	-27.1536457	119.803698	18-Feb	10.28	11.8	No	No	0
Mica Well	CAM153	-27.2619112	119.984998	19-Feb	22.66	26	No	No	0
TPB33-1	CAM151	-27.1337679	119.827828	19-Feb	8.7	24	Yes	Yes	7
YU1	CAM144	-27.1427352	119.853174	19-Feb	6.65	12	Yes	Yes	12
YU2	CAM146	-27.1373062	119.853163	19-Feb	9.46	50	Yes	Yes	2
YUN1	CAM152	-27.1896221	119.853363	19-Feb	10.43	16.5	No	No	0
YYHC0047B	CAM154	-27.3121787	120.150659	19-Feb	3.78	11	Yes	Yes	2
YYHC0048A	CAM156	-27.3238288	120.150661	19-Feb	4.23	20	No	Yes	1
YYHC0049B	CAM155	-27.3405247	120.150629	19-Feb	6.54	10	Yes	Yes	1
YYHC0052A	CAM142	-27.1183972	119.853128	18-Feb	6.09	29.6	No	No	0
YYHC0052B	CAM150	-27.1183987	119.853132	19-Feb	5.75	7	No	Yes	1
YYHC0053A	CAM147	-27.1362823	119.853158	19-Feb	9.4	24	No	No	0
YYHC0054C	CAM145	-27.1374405	119.853137	19-Feb	9.9	12	Yes	Yes	3
YYHC0056B	CAM157	-27.2979335	120.167512	19-Feb	5.64	8	No	Yes	9
YYHC0071A	CAM143	-27.1120133	119.826015	18-Feb	9.42	18	No	No	0
YYHC0084A	CAM141	-27.1201003	119.762375	18-Feb	16.1	36.6	No	No	0
YYHC0086A	CAM148	-27.1356778	119.853162	19-Feb	10.45	33	No	No	0
YYHC0086D	CAM149	-27.1356862	119.853124	19-Feb	10.1	12	Yes	Yes	2
YYHC0097B	CAM139	-27.1470872	119.811234	18-Feb	7.04	41.5	No	No	0
YYHC0098A	CAM138	-27.1376682	119.823171	18-Feb	8.47	39	Yes	No	0
June/July 2015									
3 Mile Bore	CAM159	-27.25841	120.0467	29-June	4.97	9	Yes	Yes	1
Bore 2	CAM174	-27.228616007	119.867255939	01-July	21.44	26	Yes	Yes	2
Bore 3	CAM175	-27.227792719	119.867503022	01-July	20.82	39	Yes	No	0
Bottle Well Bore	CAM140	-27.1536457	119.803698	3-June	9.9	12	No	Yes	1
Mallee Hen Bore	CAM172	-27.262029259	119.927868866	01-July	23.16	40	Yes	Yes	1
Mica Well	CAM153	-27.261911215	119.984997699	01-July	23	27	No	No	0
Midnight Bore	CAM178	-27.114095427	119.852930534	01-July	5.47	7	Yes	Yes	2
Paddy Bore	CAM173	-27.262011304	119.876544799	01-July	27.97	38	Yes	Yes	2
TPB33-1	CAM151	-27.133767863	119.827828273	01-July	7.8	23	No	Yes	7
YRAC0001	CAM177	-27.11269909	119.8530402	01-July	5.6	14	Yes	Yes	1
YRAC0002	CAM169	-27.12955105	119.8334929	30-June	9.76	15	Yes	Yes	11
YRAC0004	CAM176	-27.13946864	119.8208351	01-July	6.47	9	Yes	No	0
YRAC0005	CAM168	-27.14197161	119.8174995	30-June	7.44	15	Yes	No	0
YRAC0006	CAM170	-27.12400028	119.8403	30-June	10.38	14	Yes	Yes	2
YRAC0007	CAM171	-27.11883265	119.8468843	30-June	6.08	15	Yes	Yes	1
YRAC0008	CAM165	-27.14826944	119.8531773	30-June	5.33	11	Yes	Yes	1
YRAC0009	CAM164	-27.15398919	119.8531816	30-June	5.1	15	Yes	No	0
YRAC0013	CAM182	-27.14515105	119.8609944	02-July	9.13	14	Yes	Yes	7
YRAC0014	CAM166	-27.14921461	119.8590406	30-June	5.47	10	Yes	Yes	9
YRAC0019	CAM181	-27.14710388	119.8607921	02-July	7.96	14	Yes	Yes	3
YRAC0026	CAM163	-27.23111501	119.9919254	29-June	10.39	16	Yes	Yes	1
YRAC0027	CAM162	-27.23666936	120.0033138	29-June	10.27	15	Yes	No	0
YRAC0028	CAM161	-27.25480725	120.0391557	29-June	5.2	16	Yes	No	0
YRAC0029	CAM158	-27.26253054	120.0545879	29-June	4.92	15	Yes	No	0
YRAC0030	CAM160	-27.25620661	120.0498791	29-June	4.71	16	Yes	No	0
YU1	CAM144	-27.142735197	119.853174313	30-June	6.55	12	No	Yes	10
YU2	CAM146	-27.137306222	119.85316318	02-July	9.26	52	No	Yes	6
YUN1	CAM152	-27.189622128	119.853362979	30-June	9.02	17	No	Yes	1
YYHC0052A	CAM142	-27.11839723	119.85312815	02-July	5.84	33	No	No	0
YYHC0052B	CAM150	-27.118398694	119.853131511	02-July	5.68	8	No	Yes	1
YYHC0053A	CAM147	-27.136282348	119.853158266	02-July	10.06	25	No	Yes	1
YYHC0053C	CAM185	-27.1362348	119.8531539	02-July	9.82	12	No	Yes	9
YYHC0054A	CAM183	-27.1374169	119.8531436	02-July	9.89	38	No	No	0
YYHC0054C	CAM145	-27.137440458	119.853137277	02-July	9.8	12	No	Yes	4
YYHC0086A	CAM148	-27.137440458	119.853161757	02-July	10.34	34	No	Yes	1
YYHC0086B	CAM180	-27.1357118	119.8531406	01-July	10.2	23	No	Yes	1
YYHC0086D	CAM149	-27.135686246	119.85312379	01-July	10	12	No	Yes	6
YYHC0088A	CAM187	-27.1126101	119.8342756	03-July	7.67	25	No	No	0
YYHC0098A	CAM138	-27.137668235	119.823171207	30-June	8.34	39	No	Yes	1
YYHC0107A	CAM188	-27.112445898	119.83207977	03-July	8.51	22	Yes	No	0
YYHC0109	CAM190	-27.1122558	119.8299213	03-July	8.35	9.5	No	Yes	2
YYHC0111	CAM189	-27.1121741	119.8290522	03-July	8.75	12	No	Yes	3
YYHC0136	CAM179	-27.1352421	119.853169	01-July	9.85	14	No	Yes	3
YYHC0137	CAM186	-27.1359469	119.8531163	02-July	9.95	11	No	Yes	6
YYHC0138	CAM184	-27.1368039	119.8531179	02-July	9.57	12	No	Yes	6
YYHC0139	CAM167	-27.1381837	119.8531429	30-June	9.46	11	No	Yes	6

Appendix 3 – Samples used for DNA sequencing in 2015

Taxon represents the result of preliminary morphological identification.

Species ID (morphology)	Bore Code	Visit Date	DNA amplification successful?	Species ID (DNA results)
February sampling round				
Atopobathynella sp.	YU1	19-Feb-15	✓	*Atopobathynella* sp. S5
Atopobathynella sp.	YYHC0056B	19-Feb-15	✕	-
Bathynellidae sp.	YU1	19-Feb-15	✓	Bathynellidae sp. S2
Bathynellidae sp.	TPB33-1	19-Feb-15	✓	Bathynellidae sp. S2
Bathynellidae sp.	YYHC0047B	19-Feb-15	✓	Bathynellidae sp. S4
Enchytraeidae sp.	YU1	19-Feb-15	✓	Enchytraeidae sp. B03
Enchytraeidae sp.	YYHC0056B	19-Feb-15	✓	Enchytraeidae sp. B04
Halicyclops cf. *eberhardi*	YYHC0056B	19-Feb-15	✓	*Halicyclops* cf. *eberhardi* sp. D
Halicyclops cf. *eberhardi*	YU1	19-Feb-15	✓	*Halicyclops* cf. *eberhardi* sp. C
Halicyclops cf. *eberhardi*	YYHC0054C	19-Feb-15	✓	*Halicyclops* cf. *eberhardi* sp. C
Halicyclops cf. *eberhardi*	TPB33-1	19-Feb-15	✕	-
Halicyclops kieferi	YYHC0056B	19-Feb-15	✓	*Halicyclops kieferi*
Kinnecaris sp.	YU1	19-Feb-15	✓	*Kinnecaris uranusi*
Nitokra sp.	YYHC0056B	19-Feb-15	✓	*Nitokra* sp. B03
Phreodrilidae sp.	YU1	19-Feb-15	✓	Phreodrilidae sp. B06
Phreodrilidae sp.	YYHC0049B	19-Feb-15	✓	Phreodrilidae sp. B07
Phreodrilidae sp.	YYHC0048A	19-Feb-15	✕	-
Pseudectinosoma sp.	YU1	19-Feb-15	✕	-
Pseudectinosoma sp.	YYHC0056B	19-Feb-15	✓	*Pseudectinosoma* 'pentedicos' sp. D.
Schizopera akation	TPB33-1	19-Feb-15	✓	*Schizopera akation*
Schizopera akation	YYHC0056B	19-Feb-15	✓	*Schizopera akation*
Schizopera analspinosa	YYHC0056B	19-Feb-15	✓	*Schizopera* sp. B17
Schizopera kronosi	TPB33-1	19-Feb-15	✓	*Schizopera kronosi*
Schizopera sp. B16	YYHC0047B	19-Feb-15	✓	*Schizopera* sp. B16
Schizopera uranusi	YU1	19-Feb-15	✓	*Schizopera uranusi*
Schizopera uranusi	TPB33-1	19-Feb-15	✓	*Schizopera uranusi*
nr *Phreatochiltonia* sp.	YU1	19-Feb-15	✓	nr *Phreatochiltonia* sp. n. S1
nr *Phreatochiltonia* sp.	YYHC0054C	19-Feb-15	✓	nr *Phreatochiltonia* sp. n. S1
nr *Phreatochiltonia* sp.	YYHC0056B	19-Feb-15	✓	nr *Phreatochiltonia* sp. n. S1
June/July sampling round				
Enchytraeidae sp.	YUN1	30-June-2015	✓	Enchytraeidae sp. Y5
Enchytraeidae sp.	YYHC0052B	02-July-2015	✓	Enchytraeidae sp. B05
Enchytraeidae sp.	YU1	30-June-2015	✓	Enchytraeidae sp. Y5
Enchytraeidae sp.	YRAC0013	02-July-2015	✓	Enchytraeidae sp. B03
Halicyclops cf. *eberhardi*	YRAC0014	30-June-2015	✕	-
Halicyclops cf. *eberhardi*	YRAC0013	02-July-2015	✓	*Halicyclops* cf. *eberhardi* sp. C
Halicyclops cf. *eberhardi*	YRAC0002	30-June-2015	✓	*Halicyclops* cf. *eberhardi* sp. C
Kinnecaris sp.	YYHC0086D	01-July-2015	✓	*Kinnecaris uranusi*
Kinnecaris sp.	YYHC0138	02-July-2015	✓	*Kinnecaris uranusi*
Kinnecaris sp.	YYHC0053C	02-July-2015	✓	*Dussartstenocaris idioxenos*
Atopobathynella sp.	YYHC0137	02-July-2015	✓	*Atopobathynella* sp. Y3
Atopobathynella sp.	YRAC0014	30-June-2015	✓	*Atopobathynella* sp. Y3
Schizopera sp.	YRAC0014	30-June-2015	✓	*Schizopera leptafurca*
Schizopera sp.	YU1	30-June-2015	✕	-
Schizopera sp.	YRAC0002	30-June-2015	✓	*Schizopera uranusi*
Schizopera sp.	YY00053	02-July-2015	✓	*Schizopera uranusi*

Appendix 4 – DNA barcoding results in 2015

A total of 23 genetic species were inferred by molecular analyses of the CO1 genetic data. There are fourteen widespread species: *Atopobathynella* sp. S5, *Atopobathynella* sp. Y3, Bathynellidae sp. S2, Bathynellidae sp. S4, *Dussartstenocaris idioxenos,* Enchytraeidae sp. Y5*, Halicyclops* cf. *eberhardi* sp. C*, Halicyclopus kieferi, Kinnecaris uranusi, Schizopera akation, S. leptofurca, S. kronosi, S. uranusi*, and nr *Phreatochiltonia* sp. n. S1. Nine species have not been recorded previously: five oligochaete worms, one *Halicyclops*, one *Nitokra*, one *Pseudectinosoma*, and two *Schizopera*.

***Atopobathynella*:** With a pairwise sequence divergence of 7.8 % between the sample from bore YU1 and the 2011 reference sequence, this specimen belongs to the widespread species *Atopobathynella* sp. S5. The pairwise divergences between the four *Atopobathynella* sp. Y3 sequences from 2011 and the recent samples from bores YYHC0137 and YRAC0014 is quite high (9.7% between six samples) but overall the genetic variation is indicative of a single evolutionary unit that is highly structured genetically across a range of at least **17.7 km**. The DNA amplification for the sample from bore YYHC0056B failed and the specimen cannot be identified further.

Bathynellidae: The two samples from bores YU1 and TPB33-1 are almost identical and belong to a common species Bathynellidae sp. S02 (<7.7% pairwise divergences between the 2011 and 2015 samples). The sample from bore YYHC0047B belongs to Bathynellidae sp. S4, previously known only from Snake Bore, and both specimens are genetically identical (0.0% sequence divergence). Both bathynellid species are widespread at Yeelirrie.

***Dussartstenocaris*:** A specimen belonging to this species was sampled from bore YYHC0053C. The sample was initially identified as *Kinnecaris* sp. but differs from the *Dussartstenocaris idioxenos* reference sequence from 2011 by only 0.4% in the genetic data.

Enchytraeidae: The two samples from bores YU1 and YYHC0056 clearly represent distinct species with 20.6 % pairwise sequence divergence between both samples. The sample from YYHC0052B differs from all other samples with more than 10.7% and is also a distinct species. All three species differ from the seven species that were recorded by Subterranean Ecology (2011). Enchytraeidae sp. B03 is closest to Enchytraeidae sp. Y5 but differs by at least 10.7%. Enchytraeidae sp. B04 is closest to Enchytraeidae sp. Y7 but differs by 11.3%. Enchytraeidae sp, B05 is closest to Enchytraeidae sp. Y2 but differs by 10.7%. Enchytraeidae sp. Y5 was previously known only from the area of groundwater drawdown but two additional samples from bores YU1 and YUN1 belong to this species. The genetic variation between these samples is moderate (4.3%) and Enchytraeidae sp. Y5 has a linear range of at least 23 km in the central calcrete.

***Halicyclops*:** Four species of *Halicyclops* have been recorded from Yeelirrie, *H. kieferi* and three genetic species in the *H. eberhardi* species-complex. *Halicyclops kieferi* was collected from bore YYHC0056B and differs from the cf. *eberhardi* species by >17% in the genetic data. The four samples from bores YU1, YYHC0054C, YRAC0013 and YRAC0002 belong to *Halicyclops* cf. *eberhardi* sp. C; a widespread species in the Yeelirrie pan. Genetically, these specimens are almost indistinguishable from the reference sequences (Subterranean Ecology 2011; <1.9 % sequence divergences for 13 samples). The sample from bore YYHC0056B is genetically distinct (>14% sequence divergence) from any of these species. It is the fourth species in the *eberhardi*-complex and is the fifth *Halicyclops* species in the survey area.

***Kinnecaris*:** With pairwise sequence divergences of less than 0.9% between the samples from bores YU1, YRAC0002 and YY00053 and the reference sequence, the specimens clearly belong to *K. uranusi.*

Nitokra: The specimen from bore YYHC0056B differs from both *Nitokra esbe* and *N. yeelirrie*. It is closest to *N. esbe* but differs with 12.0 % in the genetic data. It represents a new species *Nitokra* sp. B03.

Phreodrilidae: The two samples from bores YU1 and YYHC0049B clearly represent distinct species with 22.1 % pairwise sequence divergence between both samples. These new species, Phreodrilidae sp. B06 and B07, are also distinct from the widespread Phreodrilidae sp. S8 and differ with 20.7% and 22.9%, respectively.

***Pseudectinosoma*:** The specimen from bore YYHC0056B at Yeelirrie playa differs from the three species recorded from Yeelirrie (*Pseudectinosoma* \`*pentedicos*\` sp. A, B and C) by >16.9 % in the CO1 data. *Pseudectinosoma* *`pentedicos`* sp. D (B01) represents a fourth species of the genus and has not been recorded previously. The DNA amplification for the sample from bore YU1 failed and the sample cannot be identified further.

***Schizopera*:** The barcoding results confirm the morphological identifications for *S. akation* with divergences between samples from bores TPB33-1 / YYHC0056B and the reference data <8.8%. *Schizopera kronosi* is recorded here from bore TPB33-1 and this specimen is extremely similar (1.2% divergence) to the reference sequence. *Schizopera leptafurca* was sequenced from bore YRAC0014 and this specimen is also similar (1.5% sequence divergence) to the reference sequence. The presence of *Schizopera uranusi* is also confirmed for bores YU1 and TPB33-1 (< 1.1 % divergence to reference samples). Two new species have been collected: *Schizopera* sp. B16 from bore YYHC0047B is closest to *S. uranusi* but both species differ by 11.6%. *Schizopera* sp. B17 from bore YYHC0056B is very similar in morphology to *S. analspinulosa* but differs from this species by 13.4%.

nr *Phreatochiltonia* sp. n. S1: The three samples from bores across the survey area differ by less than 5.7% despite substantial morphological variability across the samples collected. Based on the DNA data, this is clearly a single, widespread species.

Appendix 5 – Species collected in 2015

Higher level identifications that probably represent other species in the table are shaded grey.

Group	Species	No.	Bores	Linear range (km)	Comment
Rotifera					
	Bdelloidea sp. 2:2	50	Midnight Bore	–	New but not assessed
Nematoda					
	Nematoda sp.	107	3 Mile Bore, Bore 2, YRAC0002, YRAC0006, YRAC0008, YRAC0026		New but not assessed
Platyhelminthes					
Turbellaria	Turbellaria sp.	1	YYHC0056B	–	New but not assessed
Oligochaeta					
Clitellata	Enchytraeidae sp. B03	4	YU1, YRAC0013	0.8	New record
	Enchytraeidae sp. B04	5	YYHC0056B	–	New record
	Enchytraeidae sp. B05	5	YYHC0052B	–	New record
	Enchytraeidae sp. Y5	39	YU1, YUN1	23	Also in 2011
Naididae	Naididae sp. indet.	3	YU1, YYHC0139	NA	Prob. in 2011
Phreodrilidae	Phreodrilidae sp. B06	2	YU1	–	New record
	Phreodrilidae sp. B07	2	YYHC0049B	–	New record
	Phreodrilidae sp. indet.	5	YYHC0048A, YYHC0053C, YYHC0139, YYHC0136	NA	
Family indet.	Gen. and Sp. indet. (fragments)	2	Bore 2	–	
Crustacea					
Amphipoda	nr *Phreatochiltonia* sp. n. S1	182	TPB33-1, YRAC001, YRAC002, YRAC0013, YRAC0014, YRAC0019,, YU1, YU2, YYHC0053C, YYHC0054C, YYHC0056B, YYHC0086D, YYHC0109, YYHC0111, YYH0136, YYHC017, YYHC0138	61.0	Also in 2011
Syncarida	*Atopobathynella* sp. Y3	2	YYHC0137, YRAC0014, YYHC0053C	13.7	Also in 2011
	Atopobathynella sp. S5	11	YU1, YU2, YYHC0139, YRA0002, YYHC0053C	17.4	Also in 2011
	Atopobathynella sp. indet. (fragment)	1	YYHC0056B	–	
	Bathynellidae sp. S2	6	TPB33-1, YU1	2.8	Also in 2011
	Bathynellidae sp. S4	1	YYHC0047B	0.5	Also in 2011
	Bathynellidae sp. indet.	1	YRAC0002	–	
Cyclopoida	*Dussartcyclops* 'dostoyevskyi'	12	YU2, YYHC0109, YRAC0013	59.4	Also in 2011
	Halicyclops cf. *eberhardi* sp. A	149	YU1, YYHC0054C, YRAC0002, YYHC0054C, YRAC0013	25.9	Also in 2011
	Halicyclops cf. *eberhardi* sp. D	41	YYHC0056B	–	New record
	Halicyclops cf. *eberhardi* sp.	40	TPB33-1, YRAC0014	–	Prob. in 2011
	Halicyclops kieferi	3	YYHC0056B	–	New but widespread
Harpacticoida	*Dussartstenocaris idioxenos*	2	YU1, YYHC0086D	24.4	Also in 2011
	Kinnecaris uranusi	13	YU1, YYHC0138, YYH0086D, YYHC0137	25.9	Also in 2011
	Kinnecaris sp.	1	YU2	–	
	Nitokra yeelirrie	39	YU1, YYHC0053C, YYHC0137, YRAC0013, YRAC0002	53.1	Also in 2011
	Nitokra sp. B03	4	YYHC0056B	–	New record
	Pseudectinosoma `pentedicos` sp. D (B01)	3	YYHC0056B	–	Also in 2011
	Pseudectinosoma sp.	8	YU1, TPB33-1	–	
	Schizopera akation	11	TPB33-1, YYHC0056B, YRAC0014	36 (2 km extension)	Also in 2011
	Schizopera kronosi	5	TPB33-1, YRAC0014	25.8	Also in 2011
	Schizopera leptafurca	14	YRAC0014	23.2	Also in 2011
	Schizopera sp. B16	33	YYHC0047B	–	New record
	Schizopera sp. B17	17	YYHC0056B	–	New record
	Schizopera uranusi	163	TPB33-1, YU1, YYHC0136, YYHC0139, YRAC0002, YYHC0054C, YRAC0019, YU1, YU2, YRAC0013, YRAC0006, YYHC0137, YRAC0014, YYHC0138, YYHC0086D, YYHC0053C	24.4	Also in 2011

	Schizopera sp. (juveniles)	8	YU1, YYHC0056B	–	
Ostracoda	*Candonopsis* sp. Y1	53	TPB33-1, YU1, YU2, YYHC0054C, YYHC0086D	5.8	Also in 2011
	Cyprididae sp.	1	YYHC0086B	–	New record
	?*Strandesia* sp.	1	YYHC0054C	–	New record
	Ostracoda indet. (fragment)	1	TPB33-1	–	
Insecta					
Coleoptera	*Limbodessus* sp. S1	5	YRAC0014, YYHC0053C, YRAC0002, TPB33-1		Also in 2011
	Limbodessus sp. n. 'yeelirriensis'	7	YU1, YRAC0002	9.0	Also in 2011
	Limbodessus sp. indet. (fragments)	1	YYHC0086D	–	
	Paroster sp. n. 'angustus'	2	TPB33-1, YRAC0002	9.0	Also in 2011
	Coleoptera sp. indet. (fragments only)	5	TPB33-1	–	

Appendix 6 – Revised distribution of Enchytraeidae sp. Y5

Two additional specimens were collected in 2015 outside the area of predicted groundwater drawdown.