Bennelongia Environmental Consultants

Eramurra Solar Salt Project Subterranean Fauna Desktop Assessment

Prepared for:

Leichhardt Salt Pty Ltd

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Final Report

Short-Range Endemics | Subterranean Fauna

Waterbirds | Wetlands

Eramurra Solar Salt Project Subterranean Fauna Desktop Assessment

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EXECUTIVE SUMMARY

Leichhardt Salt Pty Ltd (Leichhardt) proposes to construct and operate the Eramurra Solar Salt Project (the Proposal), located 55 km west-south-west of Karratha. The Proposal will evaporate seawater to produce a concentrated salt product that could potentially increase salinity of local surface water and groundwater, with impacts on subterranean fauna habitats.

A square area of 120 km x 120 km was defined as the search area for this desktop assessment (extending from 20.448°S, 115.845°E to 21.532°S, 116.995°E). Geological and hydrogeological reports were reviewed to assess whether prospective habitat for subterranean fauna is likely to occur in and around the Proposal. Records of subterranean fauna were primarily compiled from Western Australian Museum and Bennelongia databases. Published research papers, available environmental reports, and online resources such as the Atlas of Living Australia were also reviewed.

The desktop assessment returned 157 species of subterranean fauna in the search area, including 119 species of stygofauna and 38 species of troglofauna. Twenty stygofaunal and 26 troglofaunal species are currently known only from the search area. While there are no records of troglofauna occurring inside the development envelope, 11 species of stygofauna were recorded there. However, these species present linear distributions that extend beyond the Proposal.

Based on local and regional geological and hydrogeological profiles, the Eramurra Solar Salt Project and surroundings may contain prospective habitat for stygofauna, particularly in the extensive alluvial plain. Unsaturated subterranean spaces, however, are likely to be limited except possibly in areas where depth to watertable is greatest. As a result, if present, the troglofauna community in the project area is likely to be very depauperate.

In conclusion, the desktop review shows that the geologies in the Proposal that are prospective for subterranean fauna extend to the surrounding areas, and that no restricted subterranean species have been recorded within the Proposal boundaries. Potential impacts resulting from operations are unlikely to have significant conservation impact on local subterranean fauna communities.

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1. INTRODUCTION

Leichhardt Salt Pty Ltd (Leichhardt) proposes to construct and operate the Eramurra Solar Salt Project (the Proposal), located in the western Pilbara region of Western Australia, approximately 55 km west-south-west of Karratha (Figure 1). The Proposal will evaporate seawater to produce a concentrated salt product for export from the Cape Preston East Port. The Proposal area will include 90 km^2 of concentrator area, 20 km^2 of crystalliser area and 2 km^2 bitterns, as well as the plant processing area and supporting infrastructure such as access roads, drainage channels, workshops and product dewatering facilities. The Proposal will also include dredging at the Cape Preston East Port and either offshore disposal of dredge material or the onshore use of dredge material in the ponds and elsewhere in the Infrastructure Development Envelope.

The highly saline water within the concentrator area could potentially increase salinity of local surface water and groundwater quality through overflow and leaching, thus potentially impacting subterranean fauna habitats. Accordingly, Bennelongia Environmental Consultants was engaged to undertake a desktop review of subterranean fauna with the objectives of:

- Reviewing the available regional and local geological and hydrogeological information to assess the suitability of habitats within the Proposal for subterranean fauna and also to determine the extent to which these habitats occur in the wider local area;
- Reviewing the results of previous subterranean fauna surveys that are in the public domain and searching the WAM (refer to Appendix 1 for acronyms and definitions) and Bennelongia databases for records of subterranean fauna collected in the vicinity of the Proposal; and
- Using the available information to assess the likelihood of the operations having significant conservation impact on any stygofauna or troglofauna species present.

2. SUBTERRANEAN FAUNA FRAMEWORK

2.1. Subterranean Fauna

The term subterranean fauna includes two distinct animal communities: aquatic stygofauna in aquifers and air-breathing troglofauna in the vadose zone between the surface and the watertable. Due to relatively uniform selection pressures in underground habitats, subterranean fauna typically exhibit many convergent morphological and physiological characteristics, such as reduced or absent eyes, lack of pigmentation, loss of wings, elongate sensory structures, a shift towards K-selection breeding strategy and decreased metabolism (Gibert and Deharveng 2002). The overwhelming majority of subterranean fauna species in Western Australia are invertebrates, apart from a few species of fish and snakes.

Some subterranean species spend their entire life cycles in groundwater (stygobites) or deep subterranean spaces above the watertable (troglobites). Other species, although still reliant on subterranean habitat for persistence, use surface habitats for a short part of their life history and are referred to as stygophiles and troglophiles (some stygophiles, mainly copepods and ostracods have both groundwater and surface populations). Species with some surface occurrence usually have larger distributions than obligate subterranean species as a result of greater dispersal opportunities.

Subterranean fauna contributes markedly to the overall biodiversity of Australia. The Pilbara and Yilgarn regions of Western Australia are recognised as hotspots of global subterranean faunal biodiversity with an estimated 4,500 or more subterranean species likely to occur in these regions (Guzik *et al.* 2010; Halse 2018), the majority of which are undescribed. A high proportion of subterranean species satisfy Harvey's (2002) criteria for short-range endemism, having total ranges of less than 10,000 km^2, with stygobites and especially troglobites often having ranges that are orders of magnitude smaller than terrestrial SREs (Eberhard *et al.* 2009; Halse and Pearson 2014).

Given that species with small ranges are more vulnerable to extinction following habitat degradation than wider ranging species (Ponder and Colgan 2002), it follows that many subterranean species are highly susceptible to anthropogenic threats. In Western Australia, EPA requires consideration of subterranean fauna as part of environmental impact assessments (EPA 2016, 2021).

2.2. Habitat Requirements

Geology influences the presence, richness and distribution of subterranean fauna by providing different types of habitat (Hose *et al.* 2015). Geologies with an extensive network of internal spaces support larger assemblages of subterranean fauna, both in terms of abundance and diversity, than consolidated geologies. The connectivity of these spaces both vertically and laterally is also important. Vertical connectivity facilitates water movement from the surface to recharge aquifers and to transport carbon and nutrients into the vadose zone and then into underlying aquifers. Lateral connectivity allows animals to move about and interact in viable-sized species populations. Early records of subterranean fauna were centred around cave environments (Holthuis 1960; Schneider and Culver 2004; Skubała *et al.* 2013; Whitley 1945), however more recently, it has become clear that subterranean species inhabit voids in geologies in the landscape matrix beyond the boundaries of cave systems (Eberhard *et al.* 2005; Guzik *et al.* 2010).

Some species of stygofauna occur in streambeds and in springs but, at least in the Pilbara and Yilgarn, most species occur in groundwater aquifers that are not directly connected to the surface. Outside the hyporheic zone, important habitats for stygofauna in the Pilbara are detritals (especially alluvium), calcrete and some iron formations. The aquifers in other fractured or vuggy rock formations also have the potential to support stygofauna. In general, stygofauna community richness declines with increasing depth to the watertable, principally because of reduced supply of carbon and nutrients (Humphreys 2006), with highest densities occurring at depths of less than 30 m, although animals have been recorded where depth to watertable is nearly 90 m (Halse *et al.* 2014). Stygofauna occur in varying salinities but are mostly found in fresh to moderately saline waters, with occurrences in conductivities up to 50,000 µS/cm (there are occasional occurrences in more saline situations). While oxygen levels are difficult to measure accurately, stygofauna are uncommon in hypoxic groundwater (<0.3 mg O2/L; Hose *et al.* 2015; Halse 2018).

Troglofauna is outcompeted by surface soil species in the uppermost soil layers but can be abundant at depth, where relative humidity is high (Halse 2018). Important habitats for troglofauna are mineralized or weathered iron formations and calcrete. Troglofauna species are also found in various detritals, including colluvium. Some other vuggy formations, especially mafic rock, are likely to support troglofauna but there has been insufficient survey to determine these geologies. The factors controlling troglofauna occurrence within preferred geologies are less well studied than is the case for stygofauna. Although relative humidity close to saturation is important, areas with very shallow watertables that can experience wetting fronts from the surface are unsuitable for troglofauna.

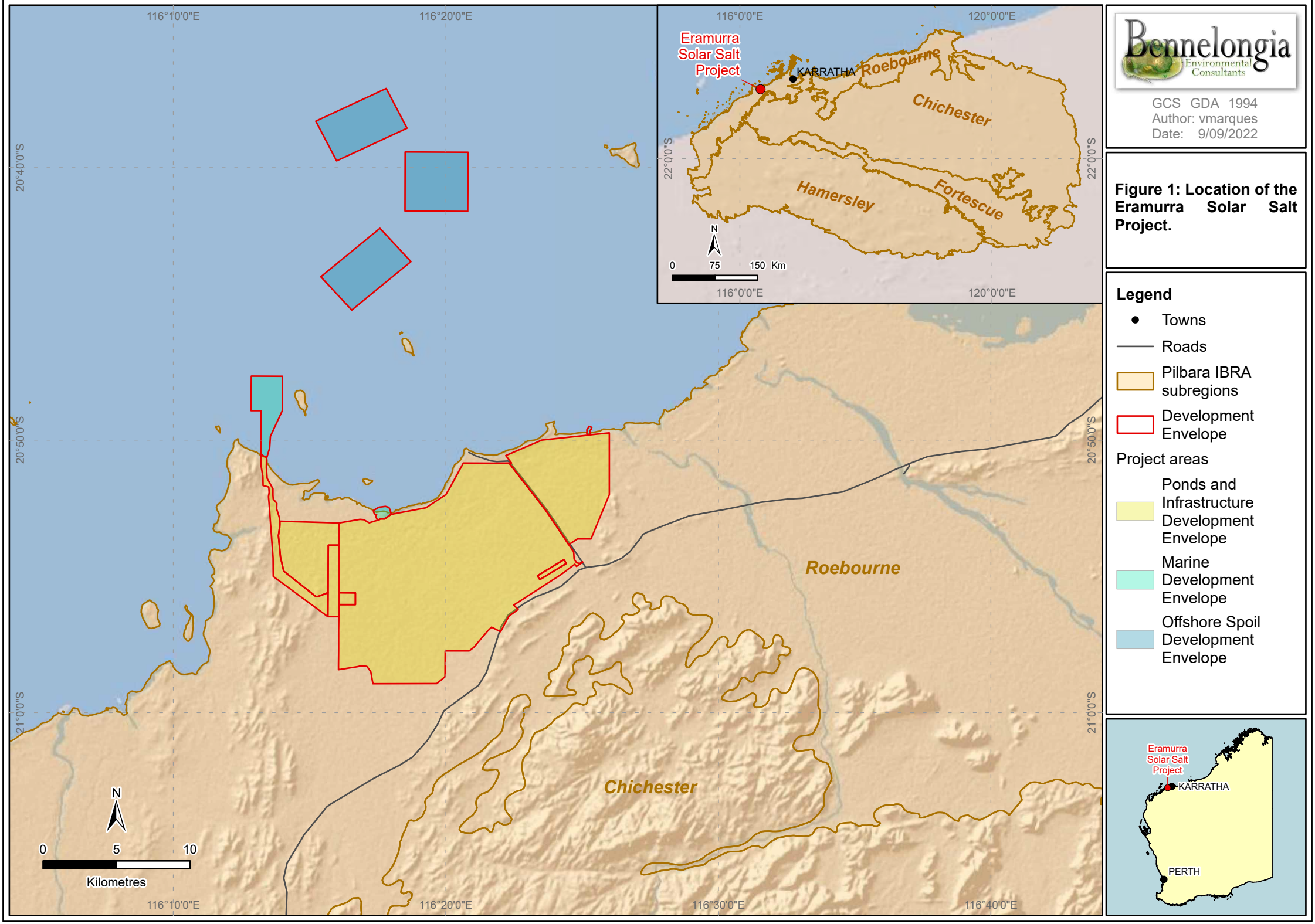

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Figure 1: Location of the Eramurra Solar Salt Project.

Legend

- Towns
- Roads
- Pilbara IBRA subregions
- Development Envelope

Project areas

- Ponds and Infrastructure Development Envelope
- Marine Development Envelope
- Offshore Spoil Development Envelope

2.3. Potential Impacts

The effects of mining operations on subterranean fauna conservation values can be broadly divided into two categories of impact:

1. Primary impacts are likely to cause possible extinction, or threat to the persistence of local populations, of any subterranean fauna restricted to the impacted area as a result of the direct removal of habitat. The most common primary impact is complete habitat loss, which can occur for troglofauna as a result of mine pit excavation and for stygofauna from water abstraction, as well as mine pit excavation.
2. Secondary impacts cause reduction in population densities of subterranean fauna rather than threatening population loss as a result of a range of disturbances that reduce habitat quality, for example pollutants, blast vibration, increased turbidity, and shadowing effects of surface infrastructure that reduce recharge. In an extreme form, some secondary impacts such as salinisation, can threaten species persistence through physiological stress.

2.4. Conservation Legislation

Native flora and fauna in Western Australia are protected at both State and Commonwealth levels. At the state level, the *BC Act 2016* provides a legal framework for protection of species, particularly species listed by the Minister for the Environment as threatened. At the national level, the *EPBC Act 1999* provides a legal framework to protect and manage nationally and internationally important flora, fauna and ecological communities. In addition to the formal list of threatened species under the *BC Act*, the DBCA maintains a list of priority fauna species that are of conservation importance but, for various reasons, do not meet the criteria for listing as threatened. Both the *EPBC* and *BC Acts* provide frameworks for the protection of TECs. Within Western Australia, DBCA also informally recognises communities of potential conservation concern, but for which there is little information, as PECs. The list of TECs recognised under the *BC Act* is larger than the *EPBC Act* list and has much greater focus on subterranean communities.

3. METHODS

A square of 120 km x 120 km was defined as the search area (defined by 20.448°S, 115.845°E and 21.532°S, 116.995°E) for examining the occurrence of subterranean fauna in the vicinity of the Proposal. A larger area than usual was searched because of the Proposal's coastal location, which results in some of the search area being marine and yielding no results. Geological and hydrogeological reports were reviewed to assess whether prospective habitat for subterranean fauna is likely to occur in and around the Proposal.

Search area records were primarily compiled from WAM and Bennelongia databases. Published research papers, available environmental reports and online resources such as the Atlas of Living Australia were also reviewed. Resultant species data were investigated spatially and cross-referenced with other records, including those outside the search area, to determine the likely distribution of each species relative to the Proposal.

4. RESULTS

4.1. Project Geology and Hydrogeology

The Eramurra Solar Salt Project is located within the low-lying coastal zone south of Karratha in the north-western part of the Pilbara Craton. The local surface geology (Figure 2) comprises predominantly quaternary deposits, such as alluvium, colluvium and other sand units, with alluvium being the most extensive unit in the Proposal area (52%). The alluvial outwash plain is almost entirely underlain by Archaean rock of the Dampier Granitoid Complex, which outcrops in few places due to rainwater erosion removing surficial weathered and residual materials (*marked as exposed in Figure 2*). Along the coast, a belt of dominantly marine sediments forms tidal mud flats and mangrove swamps (*tidal*), flanked by supratidal deposits of shelly sand, silt and clay (*coastal*). The inter and supra-tidal sediments are inundated by both seawater (high tide) and fresher water outflows from the creeks during rainfall.

The main aquifer in the area is found in surficial alluvial, littoral and eolian sediments and has low to moderate yields (Commander 1989). Groundwater monitoring conducted by LWC between December 2021 and May 2022 has provided a preliminary understanding of groundwater parameters within the Proposal (LWC 2022). In general, the area of shallow watertable (3.0 – 4.3 m btoc) in near tidal and coastal geologies has high salinities (above 129,000 µS/cm), while areas with a deeper watertable (5.2 – 7.9 m btoc) in alluvial outwash have lower salinities (below 5,100 µS/cm) (Table 1, Figure 2). On the other hand, with a deeper watertable of 9.9 m btoc, bore MBH06 in colluvium in the central area of the Proposal was more saline (approx. 33,000 µS/cm). Groundwater is expected to flow westerly/north-westerly towards the coast (LWC 2022).

Table 1: Groundwater quality parameters from the March 2022 monitoring event (LWC 2022).

Monitoring Wells	Mapped Geology	Groundwater Level (m btoc)	Electrical Conductivity (µS/cm)
MBH01	Alluvium	7.87	2,416
MBH03	Coastal	2.99	129,421
MBH06	Colluvium	9.09	33,008
MBH08	Coastal	4.25	148,037
MBH09	Alluvium	7.12	2,285
MBH10	Alluvium	5.38	3,060
MBH12	Sandplain	5.18	5,055
MBH13	Alluvium/Near coastal	4.33	40,982
MBH17	Alluvium	7.61	2,276
MBH19	Coastal	3.55	182,001
MBH20	Alluvium/Near coastal	3.92	150,414

4.2. Habitat Prospectivity

The watertable is sufficiently shallow for groundwater to harbour stygofauna across the area, with the alluvial plain the most prospective habitat in the Proposal. The water quality parameters recorded in alluvium are well within the tolerances of stygofauna and will not be a limiting factor on their occurrence. However, high salinities recorded on tidal and coastal deposits reveal unsuitable habitat for stygofauna in these geologies. It is also very unlikely that troglofauna occur in the northern areas of the project due to the lack of unsaturated interstitial spaces, as a result of very shallow groundwater and fine sediments that comprise the coastal formations. Troglofauna has been found in alluvium in the Yilgarn (Barranco and Harvey 2008), and in sand habitats on the Swan Coastal Plain (Biota 2005). However, it is unlikely that these geologies provide prospective habitat for troglofauna within the Proposal due to the relatively shallow watertable previously discussed. If present, troglofauna are most likely to occur in areas where deeper groundwater is observed.

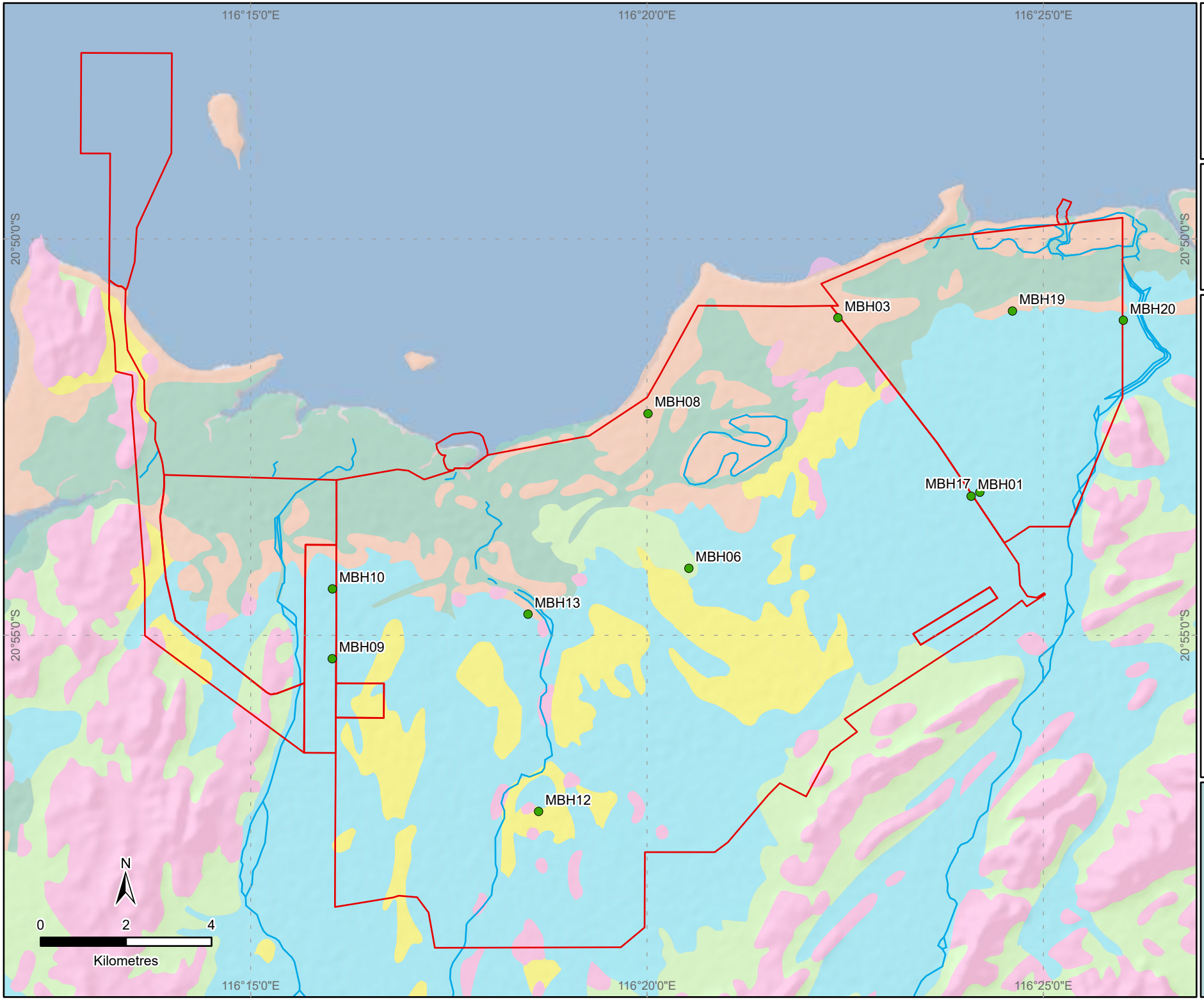

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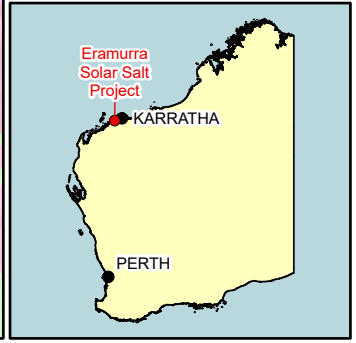
Figure 2: Regolith and groundwater monitoring wells within the Proposal area.

Legend

- Towns
- Groundwater monitoring wells
- Major drainage lines
- Development Envelope

Regolith

- Alluvium
- Coastal
- Colluvium
- Exposed
- Sandplain
- Tidal



4.3. Subterranean Fauna Records

A total of 157 species of subterranean fauna were recorded within the desktop search area (Figure 3). Higher level identifications were not included in counts of species within the search area unless it was certain they represented a species that was not already recorded (e.g., *Phaconeura* sp. was the only hemipteran recorded; therefore, it was included in the count). Most records are from sampling conducted by Bennelongia in the Maitland River catchment to the east, and Fortescue River and Robe Valley catchments to the southwest of the Proposal.

4.3.1. Stygofauna

Database and literature searches returned at least 119 species of stygofauna in the desktop search area (Appendix 2). Groups occurring included ostracods (40 species), copepods (21 species), oligochaete worms (20 species), amphipods (17 species), isopods (seven species), syncarids (three species), decapods (two species), thermosbaenaceans (two species), snails (two species), aphanoneurans (one species), polychaetes (one species), platyhelminthes (one species), rotifers (one species) and nematode worms (at least one species). As platyhelminthes, nematode worms and rotifers are typically not included in environmental impact assessments, these records are not considered further. Of the other 116 species, 41 have been described, 64 are vouchered but undescribed species (often called morphospecies) and 11 are high level identifications that must represent distinct species. Twenty of the species are currently known only from the search area and 11 species of these have been found inside the project development envelope.

4.3.2. Troglofauna

At least 38 species of troglofauna have been recorded in the desktop search area (Appendix 3). This includes diplurans (nine species), isopods (six species), silverfish (four species), centipedes (four species), spiders (three species), beetles (three species), schizomids (two species), millipedes (two species), hemipterans (one species), palpigrades (one species), pseudoscorpions (one species), pauropods (one species) and symphylans (one species). Only five species have been described, 26 are vouchered but undescribed species, and seven are high level identifications representing distinct species. Twenty-six species are currently known only from the search area, with known linear ranges varying between single locations (singletons) and less than 5 km. The desktop search did not return any troglofauna species from within the boundaries of the Proposal.

4.3.3. Listed and Threatened Species

The database search returned records of, or closely related to, three listed species: the amphipod *Nedsia hurlberti*, and the decapods *Stygiocaris lancifera* and *Stygiocaris stylifera* but more detailed taxonomic work makes it clear the amphipod species in the search area are different from the listed species (King *et al.* 2022). Records of amphipods of the genus *Nedsia* were collected from several locations in the Maitland River and Fortescue River catchments. Records of the shrimp *Stygiocaris* were collected south of Cape Preston while the names *Stygiocaris nr lancifera* s.l. and *Stygiocaris stylifera* have been applied to *Stygiocaris* specimens in the Fortescue River catchment (Figure 4). More information about these records and the listed species is provided below.

Nedsia hurlberti

Recent molecular analyses conducted by King *et al.* (2022), supported by morphologic and hydrographic data, have resulted in the description of 13 new *Nedsia* species across the Pilbara, the North West Cape peninsula, Barrow Island and the Gascoyne region, demonstrating that *Nedsia* is a speciose and diverse genus with various different lineages in Western Australia. Additionally, the study revealed that most *Nedsia* species can be considered ultra-short endemics (Eberhard *et al.* 2009), with individual species often showing distributions of less than 100 km^2. King *et al.* (2022) also synonymised six of the eight *Nedsia* species named on the Western Australian Threatened and Priority Fauna list. *Nedsia hurlberti* and *Nedsia macrosculptilis* are the valid species remaining; they are endemic to Barrow Island and listed as Vulnerable species. The desktop search returned the names of six species of *Nedsia* from the search area (Table 2), including records of *Nedsia* sp. `*sculptilis* group` inside the project development envelope.

However, the identifications preceded the taxonomic work of King *et al.* (2022) and, while likely to represent at least one distinct species each, *Nedsia* sp. `*sculptilis* group` and *Nedsia hurlberti* s.l. are accompanied by uncertainty. Neither represents the same species as found on Barrow Island. Further studies are needed to determine the total number of *Nedsia* species occurring in the vicinity of the Proposal, as well as their distributions and conservation status.

Stygiocaris lancifera* and *Stygiocaris stylifera

Two species of subterranean shrimp from the genus *Stygiocaris* are currently described from north-western Australia: *Stygiocaris stylifera* and *Stygiocaris lancifera*. To this date, *S. stylifera* is listed as a Priority 4 species and *S. lancifera* is considered Vulnerable. Both species occur on the Cape Range coastal plain, largely separated east and west by the range, but *Stygiocaris stylifera* has also been recorded on Barrow Island. The endemism observed is highly associated with the unique habitat present in these areas, characterised by extensive flooded underground karst wetland, found on the coastal plain and extending under foothills (Page *et al.* 2008). Although these species are difficult to distinguish from each other, morphological and molecular studies have confirmed their evolutionary differentiation and even suggested the presence of a cryptic species at the Bundera Sinkhole (Page *et al.* 2008). Additionally, intraspecific groups have been found to occur within both described species, with three subspecific groups within *S. stylifera* (~6% divergent in *COI* sequences) and two groups within *S. lancifera* (~2% divergent at *COI*) (Page *et al.* 2008). The desktop search returned records of *Stygiocaris stylifera* from five locations approximately 28-38 km southwest of the Proposal and one record of *Stygiocaris nr lancifera* s.l. from the same area (Table 2). In the absence of genetic sequences, the specimens are treated as *Stygiocaris stylifera* but there is some uncertainty about the identifications.

Table 2: Subterranean fauna records related to listed species.
Grey denotes high order identifications not included in species count.

Higher classification	Lowest identification	No. of specimens	Distribution	Linear range	Distance from Proposal
Arthropoda					
Crustacea					
Malacostraca					
Eumalacostraca					
Amphipoda					
Eriopisidae	*Nedsia* `*sculptilis* group` sp. 1 spine	63	Maitland River catchment Potentially known only from search area	118 km	38 km
	Nedsia hurlberti s.l.	104	Fortescue River, Robe River Potentially known only from search area	Unknown	9 km
	Nedsia sp.	167	Unknown		
	Nedsia sp. 2 (PSS)	1	Unknown	Singleton	36 km
	Nedsia mcraeae	2	Robe River catchment, Barrow Island	98 km	75 km
	Nedsia sp. B09 (*hurlberti* group 1 spine)	65	Maitland River and Harding River catchments	41 km	44 km
	Nedsia sp. `*sculptilis* group`	39	Mardie, Fortescue River catchment Potentially known only from search area	34 km	Inside / Outside
Decapoda					
Atyidae	*Stygiocaris* nr *lancifera* s.l.	3	Unknown, species complex Potentially known only from search area	Singleton	29 km
	Stygiocaris stylifera	8	Uncertain species name Potentially known only from search area	18 km	28 km

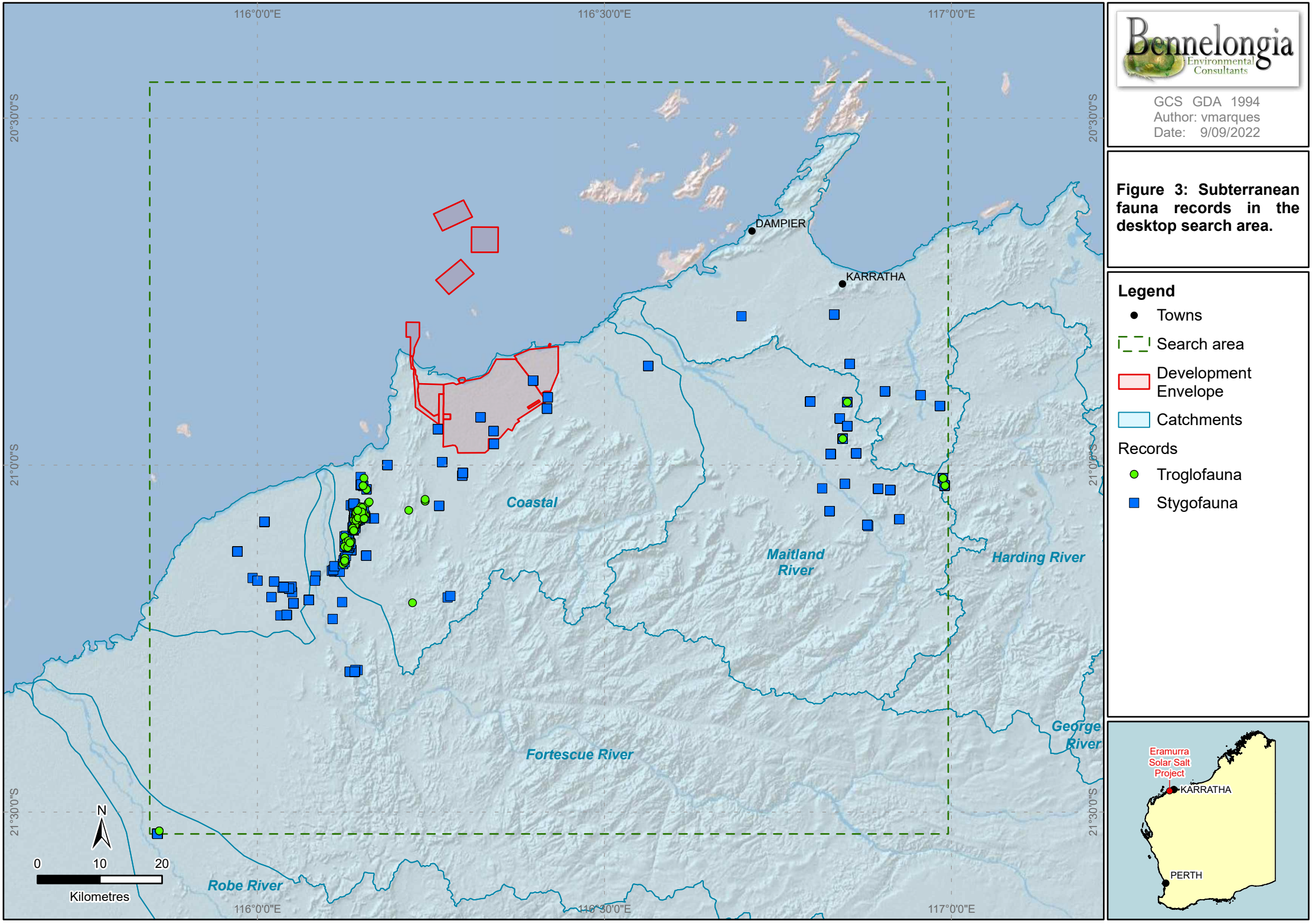


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Figure 3: Subterranean fauna records in the desktop search area.

Legend

- Towns
- Search area
- Development Envelope
- Catchments

Records

- Troglofauna
- Stygofauna

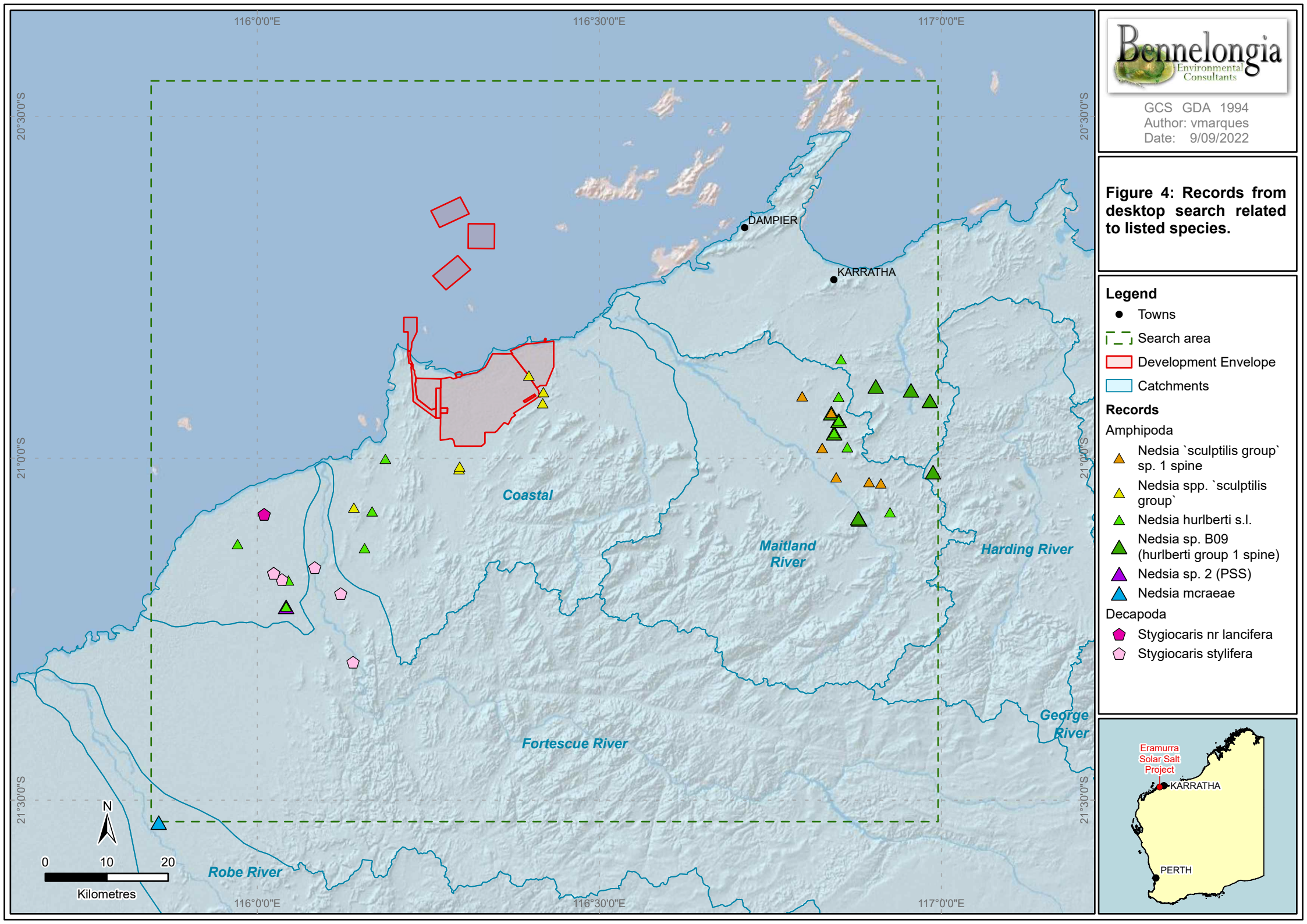

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Figure 4: Records from desktop search related to listed species.

Legend

- Towns
- Search area
- Development Envelope
- Catchments

Records

Amphipoda

- Nedsia `sculptilis group` sp. 1 spine
- Nedsia spp. `sculptilis group`
- Nedsia hurlberti s.l.
- Nedsia sp. B09 (hurlberti group 1 spine)
- Nedsia sp. 2 (PSS)
- Nedsia mcraeae

Decapoda

- Stygiocaris nr lancifera
- Stygiocaris stylifera

5. DISCUSSION

Geological and hydrogeological information alone suggests that habitat for subterranean fauna may occur in the search area, including within the Proposal. The salinity levels measured, except on and near coastal deposits, are well within the limits for stygofauna occurrence. Therefore, the overall habitat assessment indicates that a moderate to rich strygofaunal community is likely to be found at the Proposal and surroundings. Conversely, prospective habitat for troglofauna is unlikely to occur due to the local shallow watertable. Unsaturated voids and vughs that provide habitat for troglofauna may be present in places of deeper groundwater levels (e. g. colluvium deposits and exposed bedrock).

The species list returned from the desktop search supports the analyses above. At least 157 species of subterranean fauna were recorded in the search area, including 119 species of stygofauna and 38 species of troglofauna. While the closest troglofauna record is located approximately 8 km southwest of the Proposal, 11 stygofaunal species were found inside the project development envelope (Figures 5, 6 and 7). This includes species of oligochaete worm (four species), polychaete (one species), amphipod (one species), harpacticoid (two species), and ostracod (three species) (Table 3). Eight of these are described species, two are species complexes (Phreodrilidae sp. AP DVC s.l., and *Nedsia* spp. `*sculptilis* group`), and one species is currently known only from the search area (Tubificidae `WA21` (PSS)). None of the 11 species are restricted to the Proposal as they either have distributions that range from Pilbara widespread to cosmopolitan or have been recorded elsewhere within the search area. This suggests local habitat connectivity may be somewhat present.

Table 3: Subterranean fauna records inside the Proposal.

Higher classification	Lowest identification	No. of specimens	Distribution	Linear range	Sites in project area
Annelida					
Clitellata					
Oligochaeta					
Haplotaxida					
Naididae	*Dero* (*Aulophorus*) *furcatus*	7	Cosmopolitan	-	Inside
	Pristina longiseta	257	Cosmopolitan	-	Inside / Outside
Phreodrilidae	Phreodrilidae sp. AP DVC s.l.	74	Unknown, species complex Pilbara widespread	810 km	Inside / Outside
Tubificidae	Tubificidae `WA21` (PSS)	3	Mardie **Known only from search area**	53 km	Inside / Outside
Polychaeta					
Aciculata					
Phyllodocida					
Nereididae	*Namanereis pilbarensis*	10	Pilbara widespread	620 km	Inside
Arthropoda					
Crustacea					
Malacostraca					
Eumalacostraca					
Amphipoda					
Eriopisidae	*Nedsia* spp. `*sculptilis* group`	39	Mardie, Fortescue River catchment **Potentially known only from search area**	34 km	Inside / Outside
Maxillopoda					

Higher classification	Lowest identification	No. of specimens	Distribution	Linear range	Sites in project area
Copepoda					
Harpacticoida					
Ameiridae	*Megastygonitocrella unispinosa*	164	Pilbara widespread	665 km	Inside / Outside
Parastenocarididae	*Parastenocaris jane*	149	Pilbara widespread	600 km	Inside / Outside
Ostracoda					
Podocopa					
Podocopida					
Candonidae	*Humphreyscandona fovea*	126	Pilbara coastal	265 km	Inside / Outside
Cyprididae	*Cypretta seurati*	363	Pilbara* widespread	1000 km	Inside / Outside
	Sarscypridopsis ochracea	21	Pilbara* widespread	1050 km	Inside

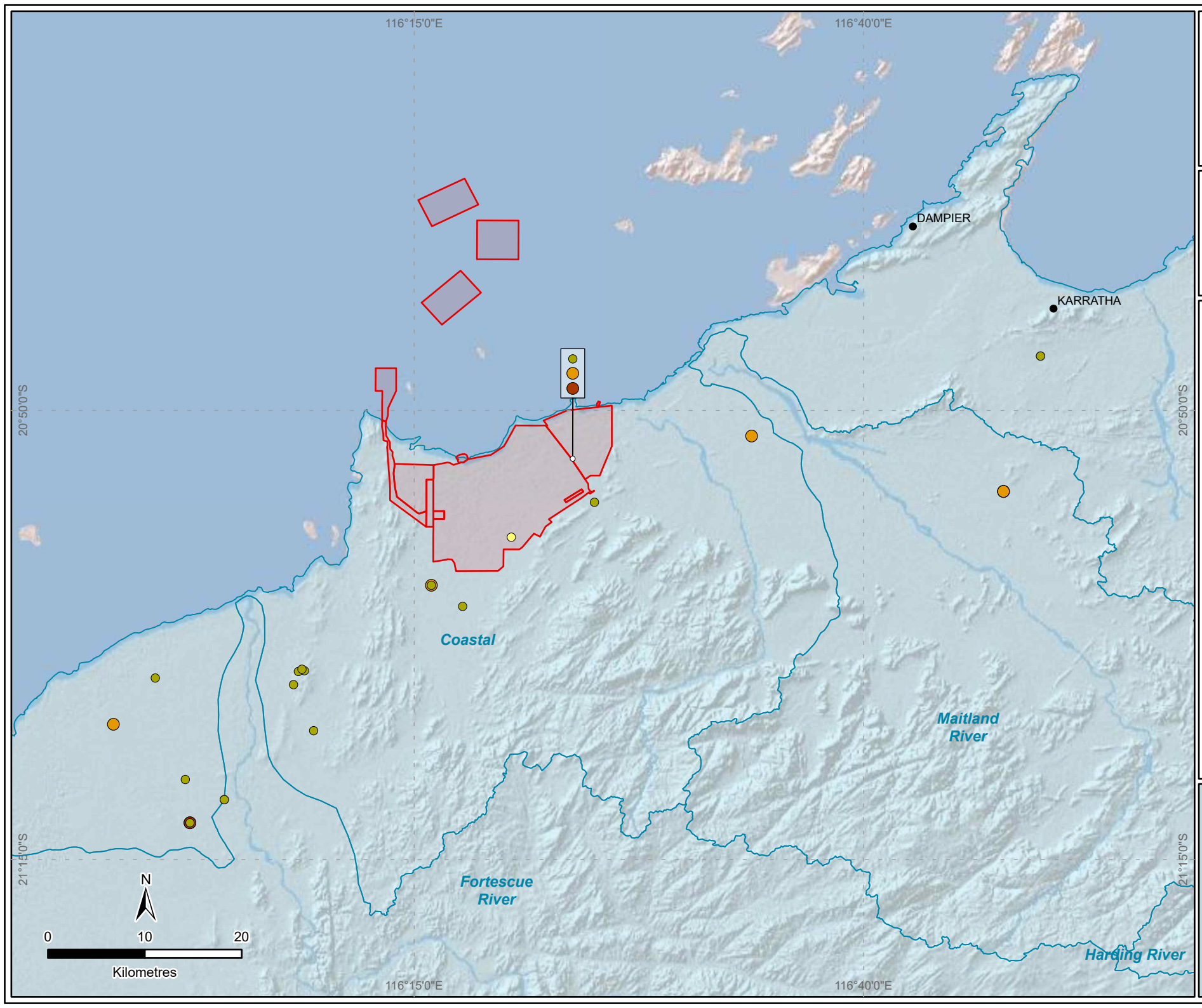
*More or less cosmopolitan species, although perhaps name is misapplied to WA species

Evaporation ponds are known for having the potential to increase the salinity of surface water and impact groundwater quality (LWC 2022). Although this impact is currently unknown, it may adversely affect subterranean fauna habitat and potentially threaten species persistence. Given the coastal location of the Proposal and predicted westerly/north-westerly groundwater flow, any potential increase in groundwater salinity within the development is expected to flow downstream towards the ocean, rather than affecting surrounding areas. As a result, together with the currently known ranges of species recorded and potential habitat connectivity described above, species that may not persist *in situ* are likely to occur outside the development.

6. CONCLUSIONS

Based on local and regional geological and hydrogeological profiles, the Eramurra Solar Salt Project and surroundings may harbour prospective habitat for stygofauna, particularly in the extensive alluvium plain. Unsaturated subterranean spaces, however, are likely to be limited within the Proposal development envelope. As a result, if present at the Proposal, the troglofauna community is likely to be very depauperate. This is reflected in no troglofaunal records being found inside the Proposal compared with 11 species of stygofauna recorded within its boundaries. All these stygofauna species have linear distributions that extend beyond the Proposal, and they are unlikely to be significantly impacted by development.

In summary, the Proposal area is unlikely to contain troglofauna. Stygofauna is likely to be present but existing information suggests the species present will have ranges an order of magnitude (or more) greater than the scale of the Proposal. While there may be some increase in groundwater salinity associated with the Proposal, this seems unlikely to have a significant detrimental effect on stygofauna. Accordingly, it is concluded that Eramurra Solar Salt Project will not have significant impacts on subterranean fauna conservation values.



Bennelongia Environmental Consultants

GCS GDA 1994
Author: vmarques
Date: 9/09/2022

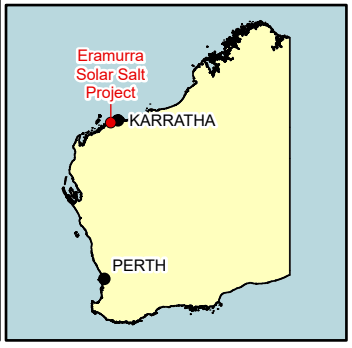
Figure 5: Distribution of oligochaete worm species found inside the Proposal.

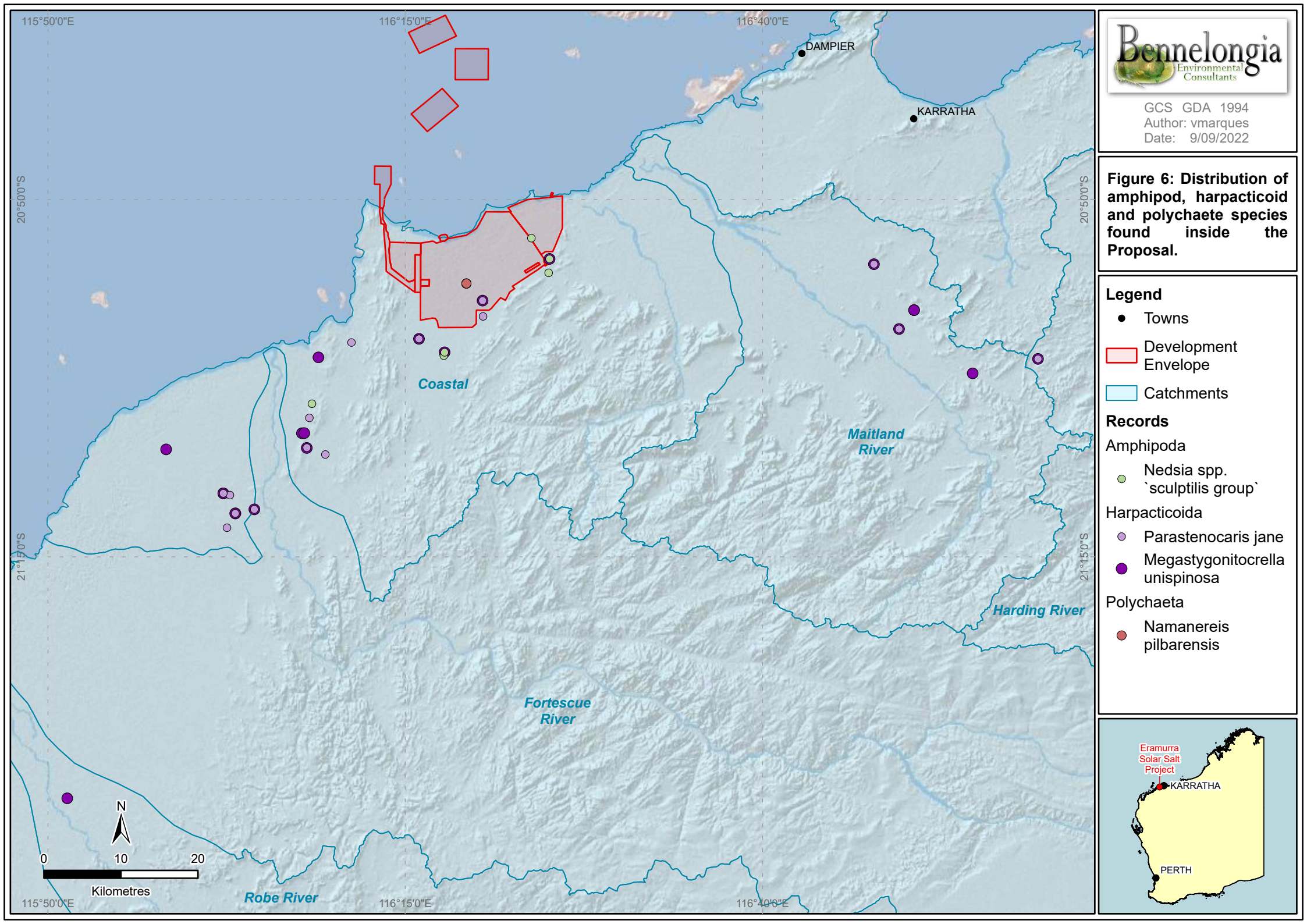
Legend

- Towns
- Development Envelope
- Catchments

Oligochaeta

- Dero (Aulophorus) furcatus
- Phreodrilidae sp. AP DVC s.l.
- Pristina longiseta
- Tubificidae `WA21` (PSS)





Bennelongia Environmental Consultants

GCS GDA 1994
Author: vmarques
Date: 9/09/2022

Figure 6: Distribution of amphipod, harpacticoid and polychaete species found inside the Proposal.

Legend

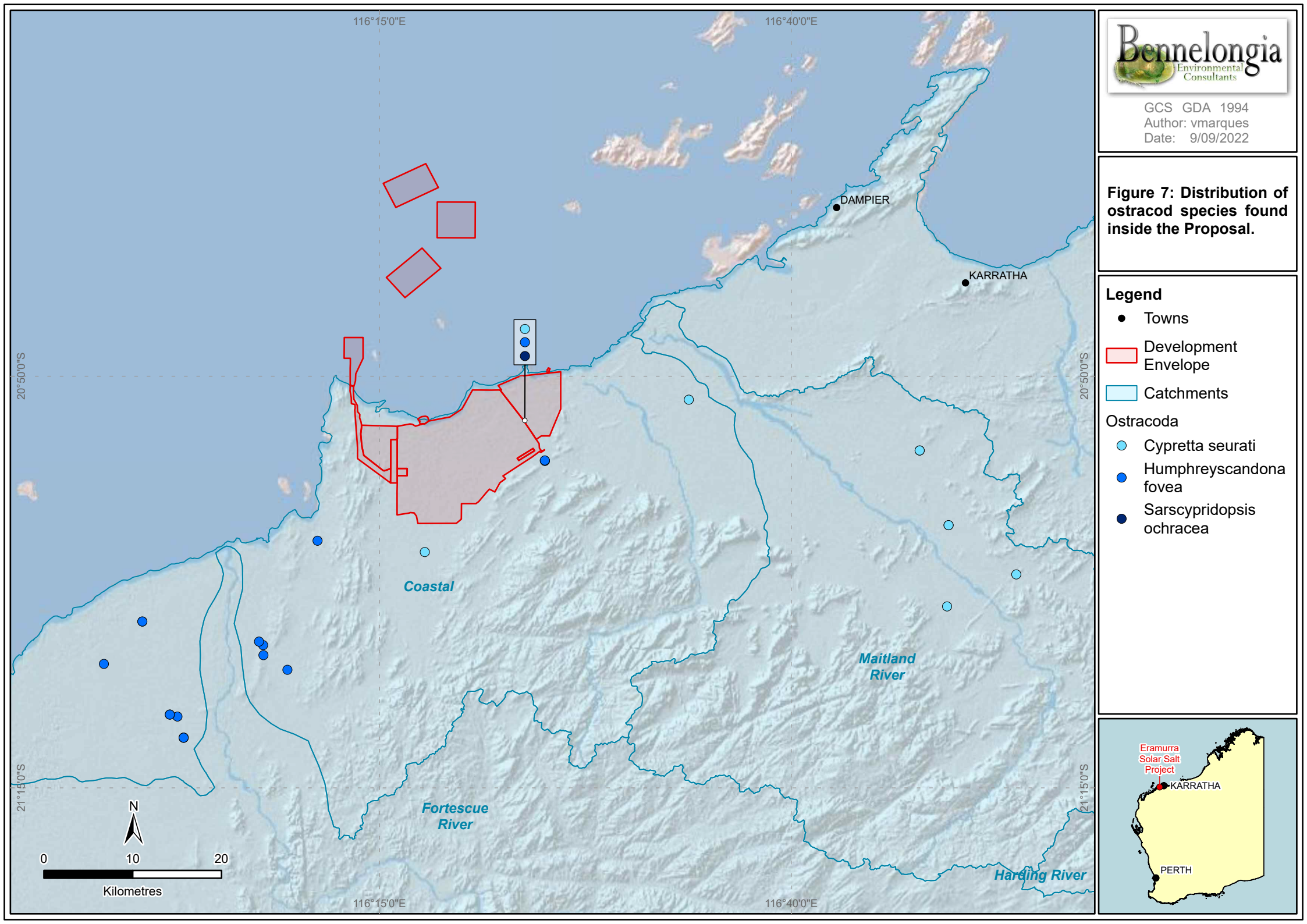
- Towns
- Development Envelope
- Catchments

Records

Amphipoda
- Nedsia spp. `sculptilis group`

Harpacticoida
- Parastenocaris jane
- Megastygonitocrella unispinosa

Polychaeta
- Namanereis pilbarensis



Bennelongia Environmental Consultants

GCS GDA 1994
Author: vmarques
Date: 9/09/2022

Figure 7: Distribution of ostracod species found inside the Proposal.

Legend

- Towns
- Development Envelope
- Catchments

Ostracoda

- Cypretta seurati
- Humphreyscandona fovea
- Sarscypridopsis ochracea

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Appendix 1 – Acronyms and definitions

Acronym	Definition
WAM	Western Australian Museum
SRE	Short-range endemic
EPA	Environmental Protection Authority
BC Act	Biodiversity Conservation Act
EPBC Act	Environment Protection and Biodiversity Conservation Act
DBCA	Department of Biodiversity, Conservation and Attractions
TECs	Threatened Ecological Communities
PECs	Priority Ecological Communities
LWC	Land & Water Consulting
m btoc	Metres below top of casing
EIA	Environmental Impact Assessment

Appendix 2 – Stygofauna records from desktop search area surrounding the Eramurra Solar Salt Project

Grey denotes high order identifications not included in species count.

Higher classification	Lowest identification	No. of specimens	Distribution	Linear range	Distance from Proposal
Annelida					
Aphanoneura					
	Aphanoneura sp.	1	Unknown		75 km
Clitellata					
Oligochaeta					
Enchytraeida					
Enchytraeidae	Enchytraeidae `BOL030` (3 bundle, short sclero)	1	Maitland River catchment	30 km	44 km
	Enchytraeidae `BOL031` (2 bundle, short sclero)	2	Maitland River and Harding River catchments	31 km	47 km
	Enchytraeidae sp.	467	Unknown		
	Enchytraeus sp. AP PSS1 s.l.	128	Unknown, species complex Widespread in the Pilbara	1180 km	18 km
	Enchytraeus sp. AP PSS2 s.l.	77	Unknown, species complex Widespread in the Pilbara	1120 km	14 km
Haplotaxida					
Naididae	*Allonais ranauana*	7	Widespread in the Pilbara	540 km	14 km
	Dero (*Aulophorus*) *furcatus*	7	Cosmopolitan		**Inside**
	Pristina aequiseta	65	Cosmopolitan		35 km
	Pristina longiseta	257	Cosmopolitan		**Inside** / Outside
Phreodrilidae	Phreodrilidae sp.	4	Unknown		
	Phreodrilidae sp. AP DVC B01	1	Maitland River and Harding catchments	24 km	45 km
	Phreodrilidae sp. AP DVC B05	1	Maitland River catchment **Known only from search area**	Singleton	39 km
	Phreodrilidae sp. AP DVC s.l.	74	Unknown, species complex Widespread in the Pilbara	809 km	**Inside** / Outside
	Phreodrilidae sp. AP SVC B01	16	Maitland River catchment **Known only from search area**	9 km	40 km
	Phreodrilidae sp. AP SVC s.l.	21	Unknown, species complex Widespread in the Pilbara	1300 km	21 km

Higher classification	Lowest identification	No. of specimens	Distribution	Linear range	Distance from Proposal
	Phreodrilus peniculus	8	Widespread in the Pilbara	542 km	0.8 km
	Phreodrilus sp. nov. WA32 (PSS)	4	Fortescue River catchment and Peedamulla	90 km	32 km
Tubificidae	*Monopylephorus* sp. nov. WA29 (ex Pristina WA3) (PSS)	4	Widespread in the Pilbara	455 km	44 km
	Tubificidae `stygo type 2` (PSS)	10	Widespread in the Pilbara	534 km	33 km
	Tubificidae `stygo type 4`	1	Widespread in the Pilbara	486 km	29 km
	Tubificidae `stygo type 5`	3	Pilbara and Gascoyne	974 km	75 km
	Tubificidae `WA21` (PSS)	3	Mardie **Known only from search area**	53 km	**Inside** / Outside
	Tubificidae sp.	56	Unknown		
Unknown order	Oligochaeta sp.	1782	Unknown		
Polychaeta					
Aciculata					
Phyllodocida					
Nereididae	*Namanereis pilbarensis*	10	Widespread in the Pilbara	620 km	**Inside**
Arthropoda					
Crustacea					
Malacostraca					
Eumalacostraca					
Syncarida					
Bathynellacea					
Bathynellidae	Bathynellidae sp.	1	Unknown		33 km
Parabathynellidae	*Atopobathynella schminkei*	13	Fortescue River **Known only from search area**	Singleton	48 km
	Chilibathynella sp.	3	Unknown		
	Parabathynellidae sp.	4	Unknown		
Unknown order	Syncarida sp.	5	Unknown		
Amphipoda					
Bogidiellidae	*Bogidiella* sp.	1	Unknown		

Higher classification	Lowest identification	No. of specimens	Distribution	Linear range	Distance from Proposal
	Bogidiellidae sp.	20	Unknown		
	Bogidiellidae sp. 1 (PSS)	4	Mardie, Robe River	470 km	1 km
Eriopisidae	*Nedsia* `*sculptilis* group` sp. 1 spine	63	Maitland River catchment Potentially known only from search area	118 km	38 km
	Nedsia hurlberti s.l.	104	Unknown, species complex Potentially known only from search area		9 km
	Nedsia sp.	167	Unknown		
	Nedsia sp. 2 (PSS)	1	Unknown, species complex	Singleton	36 km
	Nedsia mcraeae	2	Robe River catchment, Barrow Island	98 km	75 km
	Nedsia sp. B09 (*hurlberti* group 1 spine)	65	Maitland River and Harding River catchments	41 km	44 km
	Nedsia spp. `*sculptilis* group`	39	Mardie, Fortescue River catchment Potentially known only from search area	34 km	**Inside** / Outside
Melitidae	*Melita* sp.	2	Unknown		75 km
	Melitidae `Helix-F`	1	Robe River catchment	Singleton	75 km
	Melitidae sp. 1 group (PSS) s.l.	2	Unknown, species complex Widespread in the Pilbara	517 km	55 km
	Melitidae sp.	1	Unknown		
Neoniphargidae	Neoniphargidae sp.	1	Unknown		33 km
Paramelitidae	*Molina* sp.	1	Unknown		
	Molina sp. B01	13	Maitland River catchment **Known only from search area**	2 km	44 km
	Paramelitidae Genus 2 sp. B20	2	Harding River and Maitland River catchments	38 km	44 km
	Paramelitidae sp.	3	Unknown		
	Paramelitidae sp. 2 s.l. (PSS)	13	Unknown, species complex Widespread in the Pilbara	519 km	44 km
	Pilbarus millsi s.l.	2	Unknown, species complex Widespread in the Pilbara	526 km	32 km
	Pilbarus sp.	39	Unknown		
	Pilbarus sp. B11	25	Maitland River and Harding River catchments	33 km	45 km
Unknown family	Amphipoda sp.	2	Unknown		
Decapoda					

Higher classification	Lowest identification	No. of specimens	Distribution	Linear range	Distance from Proposal
Atyidae	*Stygiocaris* nr *lancifera* s.l.	3	Unknown, species complex Potentially known only from search area	Singleton	29 km
	Stygiocaris stylifera	8	Species name uncertain Potentially known only from search area	18 km	28 km
Isopoda					
Amphisopodidae	*Pilbarophreatoicus* sp.	15	Unknown		
	Pilbarophreatoicus sp. B04	3	Maitland River catchment **Known only from search area**	Singleton	44 km
Cirolanidae	*Haptolana* sp.	5	Unknown		
	Haptolana yarraloola	4	Fortescue River, Robe River, and Hardey River catchments	84 km	29 km
	Kagalana `BIS340`	2	Maitland River catchment **Known only from search area**	7 km	45 km
	Kagalana sp.	1	Unknown		
	Kagalana tonde	5	Robe River catchment, Western Hub, Rocklea	180 km	75 km
	Speocirolana sp.	1	Unknown		29 km
Microcerberidae	Microcerberidae sp.	1	Unknown		17 km
Tainisopidae	*Pygolabis* `sp.`	2	Unknown		34 km
Unknown family	Isopoda `sp.`	2	Unknown		
Thermosbaenacea					
Thermosbaenacidae	*Halosbaena* sp.	9	Unknown		
	Halosbaena sp. PL	2	Fortescue River catchment **Known only from search area**	0.6 km	38 km
	Halosbaena spp. `*tulki* group`	124	Widespread in the western Pilbara	220 km	33 km
Unknown family	Thermosbaenacea sp.	2	Unknown		
Maxillopoda					
Copepoda					
Calanoida					
Ridgewayiidae	*Stygoridgewayia trispinosa*	783	Widespread in the Pilbara, Barrow Island, Cape Range	545 km	1 km
Unknown family	Calanoida sp.	3	Unknown		

Higher classification	Lowest identification	No. of specimens	Distribution	Linear range	Distance from Proposal
Cyclopoida					
Cyclopidae	*Diacyclops cockingi*	27	Widespread in the Pilbara	740 km	32 km
	Diacyclops humphreysi	94	Cape Range, Mardie, Maitland River and Robe River catchments	535 km	16 km
	Diacyclops humphreysi s. str X *unispinosus*	11	Cape Preston, Cooya Pooya, Fortescue River catchment, Rocklea, Robe River catchment	470 km	17 km
	Diacyclops humphreysi unispinosus	137	Widespread in the Pilbara	550 km	0.7 km
	Diacyclops sobeprolatus	12	Widespread in the Pilbara	615 km	33 km
	Diacyclops sp.	5	Unknown		
	Diacyclops sp. B01 = *Diacyclops* sp. 4 (PSS)	2	Harding River and Maitland River catchments	180 km	60 km
	Halicyclops rochai	172	Widespread in the Pilbara	390 km	0.8 km
	Halicyclops sp.	5	Unknown		
	Halicyclops sp. B03 (nr calm)	2	Maitland River **Known only from search area**	Singleton	46 km
	Mesocyclops brooksi	3	Widespread in WA	2400 km	42 km
	Microcyclops varicans	33	Widespread in the Pilbara and WA	2400 km	14 km
	Thermocyclops sp.	6	Unknown		47 km
Unknown family	Cyclopoida sp.	24	Unknown		
Harpacticoida					
Ameiridae	*Abnitocrella halsei*	10	Fortescue River, Mardie, Paraburdoo, Rocklea	290 km	0.8 km
	Ameiridae sp.	1	Unknown		
	Megastygonitocrella unispinosa	164	Widespread in the Pilbara	665 km	**Inside** / Outside
	Megastygonitocrella unispinosa s.l.	27	Bungaroo, Harding River and Maitland River catchments	300 km	38 km
Canthocamptidae	*Elaphoidella humphreysi*	134	Widespread in the Pilbara	560 km	1 km
	Elaphoidella sp.	2	Unknown		
Ectinosomatidae	*Pseudectinosoma galassiae*	7	Widespread in the Pilbara	555 km	33 km
Parastenocarididae	*Parastenocaris* `BHA249`	1	Maitland River catchment	10 km	53 km
	Parastenocaris jane	149	Widespread in the Pilbara	600 km	**Inside** / Outside
	Parastenocaris jane s.l.	60	Unknown, species complex	420 km	39 km

Higher classification	Lowest identification	No. of specimens	Distribution	Linear range	Distance from Proposal
			Widespread in the Pilbara		
	Parastenocaris sp. B41	3	Maitland River catchment **Known only from search area**	Singleton	39 km
Unknown family	Harpacticoida sp.	119	Unknown		
Unknown order	Copepoda sp.	11	Unknown		
Ostracoda					
Podocopa					
Podocopida					
Candonidae	?Candoninae sp.	3	Unknown		
	Areacandona `BOS1009`	4	Harding River and Maitland River catchments	32 km	44 km
	Areacandona `BOS1010`	96	Harding River and Maitland River catchments	26 km	45 km
	Areacandona `BOS660`	2	Bungaroo, Harding River and Maitland River catchments	117 km	51 km
	Areacandona astrepte	3	Fortescue River and Robe River catchments, Mardie, Rocklea	315 km	1.1 km
	Areacandona clementia	7	Mardie **Known only from search area**	Singleton	29 km
	Areacandona cylindrata	4	Mardie and Fortescue River catchment	50 km	33 km
	Areacandona fortescueiensis	120	Cape Preston, De Grey, Fortescue River catchment, Mardie	85 km	0.8 km
	Areacandona nr *iuno*	1	Widespread in the Pilbara	605 km	34 km
	Areacandona nr *lepte*	5	Cane, Cooya Pooya, Mardie, Robe River catchment	280 km	36 km
	Areacandona scanloni	7	Widespread in the Pilbara	540 km	9 km
	Areacandona sp.	20	Unknown		
	Candonidae sp.	30	Unknown		
	Deminutiocandona aenigma	9	Fortescue River catchment and Robe River catchments, Mardie, Nanutarra	225 km	32 km
	Deminutiocandona nr *atope*	4	Fortescue River catchment, Mardie, Nanutarra, Rocklea	300 km	35 km
	Humphreyscandona `BOS1007`	1	Harding River and Maitland River catchments	41 km	44 km
	Humphreyscandona `BOS1268`	6	Maitland River catchment **Known only from search area**	Singleton	45 km

Higher classification	Lowest identification	No. of specimens	Distribution	Linear range	Distance from Proposal
	Humphreyscandona adorea	4	Millstream-Chichester National Park, Palm Springs, Mardie, Rocklea	235 km	32 km
	Humphreyscandona akaina	7	Cane, Mardie, Fortescue Regional, Nanutarra, Robe Valley	147 km	35 km
	Humphreyscandona fovea	126	Widespread in the Pilbara	265 km	**Inside** / Outside
	Humphreyscandona imperfecta	14	Fortescue River catchment, Robe River catchment, Mardie	75 km	4 km
	Humphreyscandona nr *imperfecta*	2	Fortescue River catchment, Mardie, Rocklea	240 km	33 km
	Humphreyscandona nr *woutersi*	13	Robe River and Fortescue River catchments, Barrow Island	145 km	75 km
	Humphreyscandona pilbarae	11	Robe River catchment **Known only from search area**	0.9 km	38 km
	Humphreyscandona woutersi	154	Widespread in the Pilbara	345 km	0.8 km
	Origocandona `2` (PSS)	1	Mardie and Fortescue 2A	45 km	34 km
	Origocandona posteriorecta	15	Cane, Mardie, Fortescue Robe 2A	95 km	32 km
	Pilbaracandona rosa	24	Cooya Pooya, Fortescue, Mardie, Robe Valley	145 km	34 km
Cyprididae	*Cypretta* `BOS866`	217	Harding River and Maitland River catchments, Port Hedland Coastal	45 km	38 km
	Cypretta seurati	363	Widespread in the Pilbara	1000 km	**Inside** / Outside
	Cypretta sp.	3	Unknown		
	Cypridopsis vidua	37	Marble Bar, Capricorn, Mardie	520 km)	35 km
	Riocypris fitzroyi	7	Widespread in the Pilbara	645 km	43.6 km
	Sarscypridopsis ochracea	21	Widespread in the Pilbara	1050 km	**Inside**
Darwinulidae	Darwinulidae sp.	11	Unknown		14 km
Limnocytheridae	*Gomphodella* `BOS1008`	4	Harding River and Maitland River catchments	35 km	49 km
	Gomphodella hirsuta	52	Widespread in the Pilbara	470 km	1 km
	Gomphodella sp.	4	Unknown		
	Limnocythere ?dorsosicula	3	Harding River and Maitland River catchments	40 km	38 km
	Limnocythere `BOS1264`	1	Maitland River catchment **Known only from search area**	Singleton	46 km
Unknown order	Ostracoda `BOS1246`	4	Maitland River (Mt Welcome) **Known only from search area**	5 km	43 km

Higher classification	Lowest identification	No. of specimens	Distribution	Linear range	Distance from Proposal
	Ostracoda `BOS1266`	2	Port Hedland Coastal **Known only from search area**	Singleton	58 km
	Ostracoda `BOS1269`	7	Port Hedland Coastal **Known only from search area**	Singleton	55 km
	Ostracoda `BOS1271`	2	Port Hedland Coastal **Known only from search area**	Singleton	49 km
	Ostracoda `BOS1272`	1	Port Hedland Coastal **Known only from search area**	Singleton	49 km
	Ostracoda sp. unident.	145	Unknown		
Mollusca					
Gastropoda					
Caenogastropoda					
Hypsogastropoda					
Hydrobiidae	Hydrobiidae `BGA041`	10	Harding River and Maitland River catchments	32 km	38 km
	Hydrobiidae sp. B07	12	Maitland River catchment **Known only from search area**	17 km	38 km
Nematoda					
Unknown family	Nematoda spp.	380	Unknown Not included in EIA		
Platyhelminthes					
Turbellaria					
Unknown family	Turbellaria sp.	39	Unknown Not included in EIA		
Rotifera					
Eurotatoria					
Bdelloidea					
Unknown family	Bdelloidea sp. 2:2	22	Widespread in the Pilbara and WA Not included in EIA		
Grand Total		**7845**			

Appendix 3. Troglofauna records from desktop search area surrounding the Eramurra Solar Salt Project

Grey denotes high order identifications not included in species count.

Higher classification	Lowest identification	No. of specimens	Distribution	Linear range	Distance from Proposal
Arthropoda					
Chelicerata					
Arachnida					
Araneae					
Gnaphosidae	Gnaphosidae `sp.`	1	Unknown		75 km
Linyphiidae	Linyphiidae `sp.`	2	Unknown		75 km
Oonopidae	*Prethopalpus* sp.	1	Unknown		61 km
Palpigradi					
	Palpigradi sp. B22	1	Maitland River catchment **Known only from search area**	Singleton	44 km
Pseudoscorpiones					
Syarinidae	*Ideoblothrus westi*	1	Fortescue River catchment **Known only from search area**	Singleton	14 km
Schizomida					
Hubbardiidae	`SCHAAA` `SCH006`	29	Cape Preston **Known only from search area**	6 km	16 km
	Draculoides sp.	2	Unknown		17 km
Unknown family	Schizomida sp.	8	Unknown		
Crustacea					
Malacostraca					
Eumalacostraca					
Isopoda					
Armadillidae	Armadillidae sp. B02	1	Cape Preston **Known only from search area**	Singleton	16 km
	Troglarmadillo sp. B02	8	Cape Preston **Known only from search area**	12 km	14 km
Oniscidae	*Hanoniscus* `BIS344`	2	Harding River **Known only from search area**	Singleton	61 km
	Hanoniscus `ISO012`	30	Cape Preston **Known only from search area**	5 km	17 km

Higher classification	Lowest identification	No. of specimens	Distribution	Linear range	Distance from Proposal
	Hanoniscus sp.	1	Unknown		
Philosciidae	nr *Andricophiloscia* sp. B01	9	Cape Preston **Known only from search area**	Singleton	17 km
	Philosciidae sp. B01	1	Cape Preston **Known only from search area**	Singleton	16 km
Hexapoda					
Entognatha					
Diplura					
Campodeidae	Campodeidae sp. B01	2	Cape Preston **Known only from search area**	2 km	16 km
Japygidae	Japygidae `DPL001`	7	Cape Preston **Known only from search area**	1 km	16 km
	Japygidae `DPL004`	1	Cape Preston **Known only from search area**	Singleton	23 km
	Japygidae sp. B02	1	Cape Preston **Known only from search area**	Singleton	16 km
	Japygidae sp. B03	1	Cape Preston **Known only from search area**	Singleton	16 km
	Japygidae sp.	1	Unknown		
Parajapygidae	Parajapygidae sp. B01	4	Cape Preston **Known only from search area**	2 km	16 km
	Parajapyx swani	1	Cape Preston and Orebody 32	445 km	16 km
Procampodeidae	Procampodeidae sp.	1	Unknown		16 km
Projapygidae	Projapygidae sp. B01	1	Cape Preston **Known only from search area**	Singleton	17 km
Unknown family	Diplura sp.	1	Unknown		
Insecta					
Coleoptera					
Curculionidae	Cryptorhynchinae sp. B07	1	Harding River **Known only from search area**	Singleton	61 km
	Cryptorhynchinae sp. B09	14	Cape Preston **Known only from search area**	2 km	16 km
Carabidae	*Gracilanillus* `BCO237`	32	Cape Preston **Known only from search area**	3 km	16 km

Higher classification	Lowest identification	No. of specimens	Distribution	Linear range	Distance from Proposal
Hemiptera					
Meenoplidae	*Phaconeura* sp.	6	Unknown		17.5 km
Zygentoma					
Nicoletiidae	Atelurinae sp.	1	Unknown		
	Dodecastyla rima	57	Cape Preston **Known only from search area**	8 km	13 km
	Hemitrinemura sp. B01	3	Cape Preston **Known only from search area**	5 km	17 km
	Lepidospora (Brinckina) relicta	6	Cape Preston **Known only from search area**	1 km	17 km
	Trinemura sp.	1	Unknown		
	Trinemura sp. B01 (nr *Troglophila*)	5	Cape Preston **Known only from search area**	2 km	19 km
Myriapoda					
Chilopoda					
Geophilida					
Schendylidae	*Australoschendyla* sp. B01	1	Cape Preston and Pippingarra	280 km	13 km
	Australoschendyla sp. B05	1	Cape Preston	Singleton	18 km
Scolopendrida					
Cryptopidae	*Cryptops* (*Trigonocryptops*) sp. B01 (nr *spinipes*)	1	Cape Preston **Known only from search area**	Singleton	13 km
	Cryptops sp. B02 (nr *australis*)	8	Cape Preston and Cape Preston Regional	16 km	8 km
	Cryptops sp.	1	Unknown		
Unknown order	Chilopoda sp.	1	Unknown		
Diplopoda					
Polyxenida					
Lophoproctidae	*Lophoturus madecassus*	2	Cosmopolitan		21 km
Polyxenidae	Polyxenidae `sp.`	10	Unknown		25 km
Pauropoda					
Tetramerocerata					

Higher classification	Lowest identification	No. of specimens	Distribution	Linear range	Distance from Proposal
Pauropodidae	Pauropodidae sp. B03	1	Cape Preston **Known only from search area**	Singleton	11 km
Symphyla					
Cephalostigmata					
Scutigerellidae	*Hanseniella* sp. B02	1	Cape Preston **Known only from search area**	Singleton	19 km
Grand Total		**271**			