Bennelongia Environmental Consultants

Earl Grey Lithium Project

Subterranean Fauna

Desktop Assessment

Prepared for:

Covalent Lithium

September 2023

Final Report

Short-Range Endemics I Subterranean Fauna

Waterbirds I Wetlands

Earl Grey Lithium Project Subterranean Fauna Desktop Assessment

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EXECUTIVE SUMMARY

Covalent Lithium is investigating expansion opportunities associated with the Earl Grey Project. Accordingly, Covalent Lithium has engaged Bennelongia Environmental Consultants to prepare a desktop assessment to examine the likelihood that subterranean invertebrate fauna species occur in the Project area and whether these species are likely to be impacted on by the proposed expansion.

This desktop assessment examines the likelihood that subterranean fauna species occur in the Project area, the potential distribution of such species based on available habitats, and whether the species may be affected by the proposed Project expansion.

Previous field survey records of subterranean fauna recorded in a search area of 100 km x 100 km surrounding the Project were collated from relevant databases, and the prospectivity of subterranean fauna habitats within the Project area is evaluated.

The desktop assessment identified the following outcomes for subterranean fauna:

- Troglofauna

  Thirty-six records representing fifteen troglofauna species were recovered in the desktop search. These include four species of isopods, three species of beetles, three species of pseudoscorpions, and one species each of araneomorph spider, symphylan, dipluran, centipede, and silverfish.

  Nil troglofauna species listed as Threatened under legislation, or listed as Priority by DBCA were recorded.

- Stygofauna

  Nil stygofauna species were recorded.

It is unlikely that troglofauna will occur in the Project. Geological features in the Project area are not prospective and do not provide suitable habitat for troglofauna species. The Project's localised effect to troglofauna (if present) is not likely to significantly affect any troglofauna species or habitat.

Water quality in the Project, although within tolerable parameters for certain stygofauna species, is hard and hypersaline which suggests that significant stygofauna communities are not expected to occur in the Project area. Given the water flow rates and projected water drawdown, even if there were stygofauna species in the Project area, these are unlikely to be significantly affected by the Project.

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1. INTRODUCTION

Covalent Lithium Limited is progressing and expansion the Earl Grey Lithium Project (henceforth `the Project`). The Project is located approximately 100 km south-east of Southern Cross in Western Australia (Figure 1) and is located on part of the historic (abandoned) Mt Holland Project. This desktop review assesses the likelihood that subterranean fauna occur in the Project area and updates the previous subterranean assessment carried out by Bennelongia (2018).

The specific aims of the assessment are:

- Review available geological information to assess the prospectivity of habitats for subterranean fauna in the vicinity of the Project.
- Compile and evaluate field survey records of subterranean fauna in the vicinity of the Project (including listed species), by reviewing ranges and other available information pertaining to recorded species, to characterise the likely subterranean fauna communities in the Project area.
- Assess the potential effects the Project may have on any subterranean fauna species, if present.

1.1. Project Background

Covalent Lithium is investigating expansion opportunities associated with the Earl Grey Project and requires a new desktop assessment to include the Life of Mine (LOM) Expansion area (henceforth, the Project) located approximately 100 km south-east of Southern Cross in Western Australia. The proposed development footprint associated with this application is approximately 1600 ha in size. Disturbance is associated with standard mining infrastructure which includes new waste dumps, tailing storage facilities, evaporation ponds, etc.

Due to the hypersaline nature of the groundwater, fresh water for operations is being transported from the Goldfields water pipeline located 130 km north of the site. Some hypersaline groundwater is being pumped from the shafts of the old underground mine for soil conditioning and limited dust suppression purposes (see section 1.4 for further details).

This desktop assessment examines the likelihood that subterranean fauna species occur in the Project area and whether these species are likely to be affected by the proposed development. Previous records of subterranean fauna in the local area surrounding the Project (search are 100 km x 100 km) were collated and the prospectivity of subterranean fauna habitats in the Project area is evaluated.

1.2. Geological context

The Project area lies within the Yilgran Craton (Figure 2) and is dominated by granite rock strata interrupted by parallel intrusions of Archaean greenstone from which drainage is occluded. Chains of saline playa lakes occur in valleys surrounded by samphire shrublands. Regolith around the Project is dominantly eolian sandplains (REGID 27440) with residual deposits and exposed saprolite rock (REGID 28985) (Figure 2-Inset). Alluvium deposits (REGID 28737) within drainage channels and floodplains and colluvium slope deposits (REGID 28622) lie near the Project area.

The Project lies directly over the Youanmi Terrane of the Yilgarn Craton. The Youanmi Terrane comprises an extensive Archean granite-greenstone terrain hosting several palaeovalleys, including the Deborah, Camm, Lefroy, and Cowan Palaeovalleys. Conformed mainly by mafic volcanic rock with minor mafic and ultramafic intrusive rocks, it also has occasional deposits of subordinate felsic and metamorphosed rocks (Figure 2). Other rock associations include metasedimentary undivided rock, comprising sandstone, siltstone, shale, and chert and commonly deeply weathered; foliated metagranite including granodiorite to monzogranite; and undivided metamorphosed granite rocks (Figure 2).

GCS GDA 1994
Author: K. Sagastume
Date: 15/08/2023

Legend

- Project Point
- Desktop search area
- Yilgarn

Figure 1. Project location and desktop search area in relation to nearest towns.

1.3. Geological Setting

The Project is located on the Forrestania greenstone belt in the Southern Cross Domain of the Archean Youanmi Terrane, one of several major crustal blocks that form the Archean Yilgarn Craton of south-Western Australia. The Forrestania greenstone belt and its northern extension, the Southern Cross greenstone belt, form a 5–30-km wide curvilinear belt trending north–south over a distance of 250 km. The belt comprises mafic-ultramafic volcanic and an upper sedimentary succession intruded and bound by granitoid batholiths (Doublier 2013). Narrow horizons of sedimentary rock consisting of banded iron formation, chert, psammite, and quartz-muscovite schist are intercalated with the mafic-ultramafic succession.

Rare-element granitic pegmatites occur regionally and are primary structures of interest for mining development. The Mount Holland pegmatite field is located around the historic Bounty gold mining centre, extending from the Prince of Wales pegmatite group in the northwest to the Mount Hope pegmatite group in the southeast, and potentially further north to the Texas pegmatites. The Earl Grey pegmatite intrudes into the mafic and ultramafic lithologies of the Mid-Eastern ultramafic belt in the central Forrestania greenstone belt. The Archaean stratigraphy becomes younger to the west, displaying the typical mafic-ultramafic-sedimentary succession of the belt. The Mid-Eastern ultramafic belt is overlain to the west by a porphyroblastic garnet-actinolite schist, presumed to be a deformed basal unit of the upper sedimentary succession (Bennelongia 2018).

The weathered zone around the Earl Grey pegmatite is around 30–40 m deep, with few instances of outcrop or subcrop in the area. The area is mostly covered by a thin (up to 5 m) veneer of laterite which is underlain by a 10–15 m deep eluvial zone of pallid grey to mottled clay. The regolith becomes increasingly iron-rich toward the base of the weathered profile, with ferric induration common (Bennelongia 2018).

There is a clear thickening of the main pegmatite body as it approaches the western shear contact, where it averages 70 m in width and has a maximum known thickness of 90 m. The pegmatite thins to around 50 m in average thickness through the central zone before splitting into several bodies that average 25 m thickness in the eastern extent of the deposit. Faulting within the pegmatite has been observed in diamond drill cores, however no major offsets have been definitively observed (Bennelongia 2018).

1.4. Hydrogeological Setting

The Project occurs in the Westonia Groundwater Area of the Southern Cross Province. The main regional groundwater sources are catchment-controlled flow systems in weathered and fractured rock, Tertiary palaeovalley sands, calcretes overlying palaeovalley deposits, and shallow alluvial aquifers. Fractured rock aquifers are the dominant aquifer types in the Project are and are commonly heterogeneous with variable aquifer properties (GRM 2023).

Deep weathering of ultramafic and basaltic sequences of the region results in a thick siliceous caprock, in which only modest groundwater resources occur. Fractured basement aquifers are subject to complex fracturing and chemical dissolution, resulting in secondary permeability. The Project is hosted in a low to very-low permeability aquifer (GRM 2023). The storage capacity and hydraulic conductivity of these basement aquifers are largely related to the degree of fracturing. In the vicinity of the Project, sub-caprock fracturing is prevalent and saline to hypersaline aquifers occur, notably in the area of the historic borefield. No fresh water supplies have been identified near the Project area.

1.4.1. Water Quality

The aquifer levels in the Project area lies around 65-70 meters below ground level (mbgl), mostly below the base of the weathering profile. Permeability is low across the Project pit footprint, with airlift yields of 0.2–4.0 L s^{-1} and permeability estimates of 6 x 10^{-6}–0.02 m d^{-1}. Two of the 14 holes sampled in initial investigations were found to be dry (GRM 2017). Aquifers in the Project area are mostly hypersaline;

however, water quality can vary from brackish to hypersaline with areas of lower salinity groundwater, probably resulting from localised recharge areas. Away from recharge areas, groundwater becomes hypersaline reaching in excess of 100,000 mg/L Total Dissolved Solids (TDS) in the main palaeochannel drainages and ranging between 7,640–88,900 mg/L in the Project area (GRM 2023).

1.4.2. Inflow, dewatering, and drawdown data

Palaeovalley sands occur to the east of the Project area, represented at the surface by a series of saline playas. An area of calcrete occurs in association with the palaeovalley approximately 5 km east of the Project. Hydrogeological properties of the calcrete and other surficial palaeovalley units, including the extent of connectivity between these units and the fractured rock aquifers at the Project, appear to be low based on numerical modelling (GRM 2017). This is presumably due the geological confinement of the fractured rock aquifers.

Maximum inflow rate estimates collected between 2017 and 2019 range between 10-15 L/s at the end of Year-12, with a 2019 estimate suggesting groundwater inflow could potentially increase up to 18 L/s from Year-13 to Year-15 (GRM 2023). Across the life of the mine, pit inflows will be moderate with an initial 1 to 2 L/s, building to a peak of around 12 L/s in Year-18, and reducing to around 6 L/s at the end of the mining. The groundwater inflow estimates predicted follow an overall low to very low permeability patter, characteristic of low storage nature of local groundwater system, a deep water table and low aquifer recharge (GRM 2023).

Mine dewatering will cause a cone of depression in the local groundwater table which will extend over time outside of the Project area. At the End of Mine (EoM) a 1 m drawdown contour potentially extending to around 2 km to north and south from the Project area will develop. As a result of dewatering in the pit area, residual mounding in the water table has been modelled to be up to 10 m above pre-mining water levels in the TSF 1 area, which will result in 1 m mounding contour in the local groundwater table extending around 1.5 km north and south of the TSF 1 (GRM 2023).

2. SUBTERRANEAN FAUNA FRAMEWORK

The term subterranean fauna refers to animals living essentially full-time underground. Subterranean taxa are divided into two main groups: troglofauna and stygofauna.

Troglofauna is made up of animals that live underground and breathe air (above the groundwater table) but require very high humidity (Gibson *et al.* 2019). Troglofauna inhabit similar spaces above the water table but with more emphasis on vugs, fissures, and relatively large interstitial spaces.

Stygofauna comprise aquatic animals that live below ground in water (Gibson *et al.* 2019). Stygofauna inhabit vugs, fissures, and interstitial spaces in groundwater aquifers, especially those in alluvium and calcretes.

Subterranean species share several convergent adaptations to life underground where it is dark and resources are limited. These include worm-shaped bodies, elongated chemosensory apparatus, and the loss of skin colouration and eyes. Western Australia supports a particularly rich subterranean fauna outside caves (Humphreys 2000; UNESCO World Heritage Centre 2022), with estimates of over 4,000 species, 90% of which remain to be described (Guzik *et al.* 2011; Halse 2018a). Almost all subterranean animals in Western Australia are invertebrates, but fishes (Whitely 1945) and one snake (Aplin 1998) have also been recorded.

The distribution of subterranean animals is largely determined by prevailing lithology. In Western Australia, subterranean animals probably mostly occupy spaces only a few millimetres in width (Halse 2018a, b; Halse *et al.* 2018) but the key characteristics of their habitat(s) is that it is rich in such spaces and that the spaces are well connected laterally and vertically. Lateral connectivity facilitates dispersal of animals, while vertical connectivity ultimately to the surface is crucial for delivering carbon and other nutrients to subterranean ecosystems (Korbel and Hose 2011). Connectivity may be disrupted by a range of factors, including dykes, major landscape features, and chemical barriers.

Subterranean animals tend to have limited distributions. Most stygofauna species exhibit short range endemism (SRE), having substantially smaller ranges than Harvey's (2002) SRE criterion of 10,000 km^2 (Cooper *et al.* 2007; Cooper *et al.* 2002; Eberhard *et al.* 2009). The ranges of troglofauna have yet to be investigated in detail but are mostly even more restricted than those of stygofauna, with many species having linear ranges less than 10 km (Halse and Pearson 2014; Lamoreux 2004).

2.1.1. Troglofauna

Western Australia appears to be almost unique for its diverse and widespread troglofauna inhabiting small spaces in the vadose zone (Halse and Pearson 2014). The Western Australian troglofauna comprises mostly arthropods, with a variety of isopods, insects, spiders, pseudoscorpions, and millipedes, centipedes, and their allies represented. Troglofauna are particularly likely to occur in weathered or mineralised iron formations, alluvium, or colluvium in valley-fill areas (including areas of karstic calcrete), and fractured sandstone (Halse 2018a).

2.1.2. Stygofauna

Most stygofauna species in Western Australia are crustaceans, particularly ostracods and copepods, although other groups such as worms and beetles are sometimes abundant (DEC 2009; DPAW 2022; Matthews *et al.* 2019). Stygofauna typically inhabit aquifers in alluvium and colluvium and karstic limestones (Halse 2018b; Hyde *et al.* 2018) and are rarely abundant where depth to the water table is more than 30 m below ground level (Halse 2018a; Halse and Pearson 2014). Aquifers with higher transmissivity are more likely to host stygofauna than aquifers with lower transmissivity (Maurice and Bloomfield 2012). Stygofauna mostly occur in fresh to hyposaline water (Halse *et al.* 2014; Humphreys *et al.* 2009), but can occur in higher salinities. Area with saline or hypersaline groundwater typically do not contain stygofauna (as high salinity makes any habitat present unsuitable for stygofauna), although some halotolerant or halophilic species can be found in hypersaline groundwaters (Pinder *et al.* 2010).

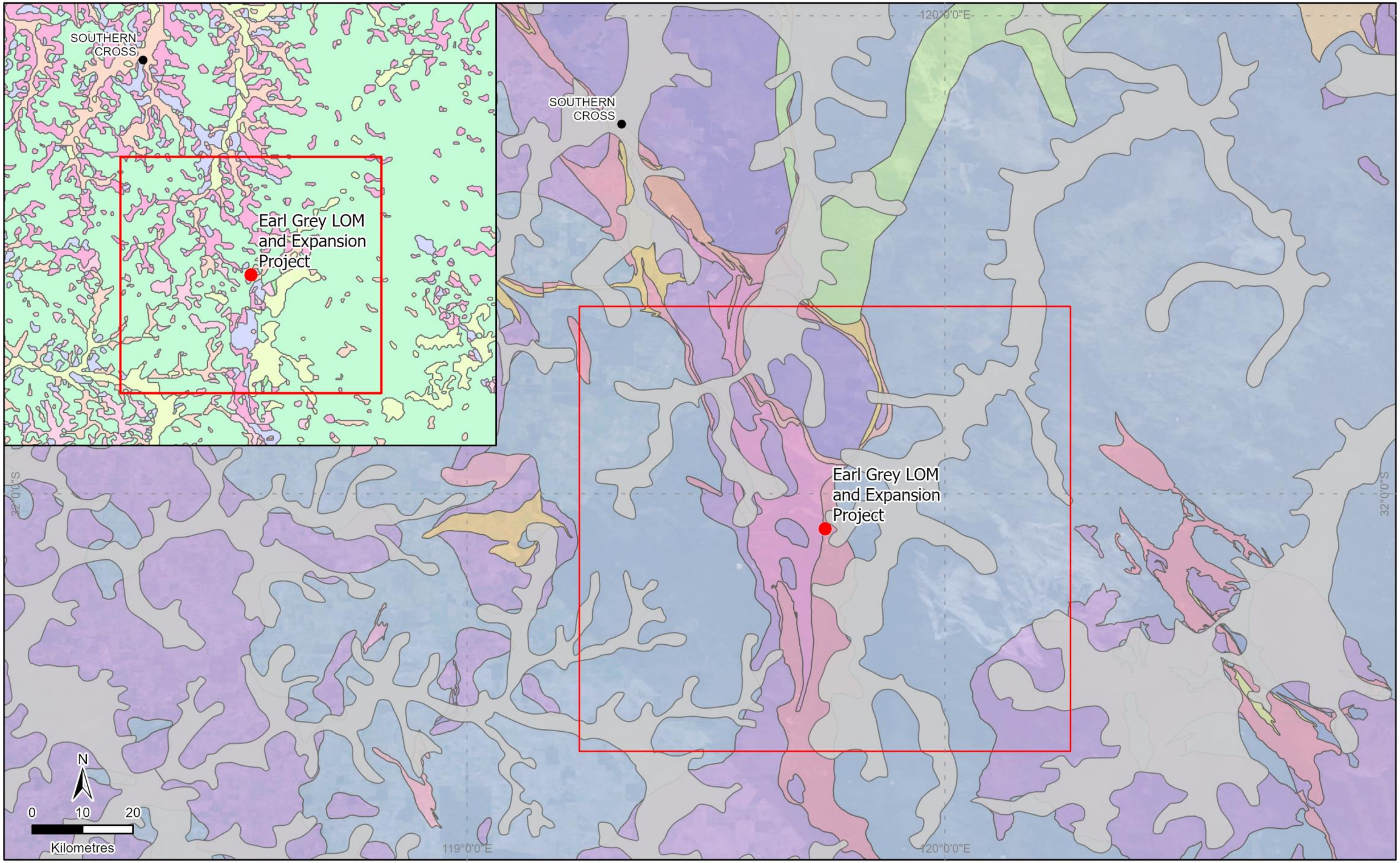

Figure 2. Bedrock geology and Palaeovalleys around the Project area.
Inset shows Regolith.

3. DESKTOP SURVEY

3.1. Methods

A search of databases and literature was undertaken to identify subterranean fauna records available from the local region surrounding the Project. The search covered an area of approximately 10,000 km^2 centred on the Project area (vertices 31.6079°S, 119.2351°E and 32.5385°S, 120.2626°E).

The Western Australia Museum and Bennelongia databases, as well as relevant consulting reports, were interrogated for information about subterranean species. For each identifiable species, the number of records (i.e. the number of times the species was found) and the total number of individuals collected from these sources were collated. Distribution patterns of identifiable species were cross-referenced with the Atlas of Living Australia.

Published research papers, available environmental reports and online resources such as the Atlas of Living Australia (ALA 2023) and the Australian Faunal Directory (ABRS 2023) were also reviewed.

Higher-order identifications were generally not included in the final list of recorded species unless they belonged to taxonomic units that were otherwise not recorded.

Analysis and mapping were undertaken using ArcGIS Pro v2.9.

3.2. Results

3.2.1. Troglofauna

Thirty-six records representing fifteen identifiable species of troglofauna have been recorded in the search area. These include four species of isopods, three species of beetles, three species of pseudoscorpions, and one species each of araneomorph spider, symphylan, dipluran, centipede, and silverfish (Figure 4). All records of troglofauna, except the three records of Carabidae sp., come from a survey in banded ironstone formation (BIF) geology in the Parker Range approximately 45–55 km north-west of the Project area (Cazaly (2010); Figure 3). The three records of Carabidae sp. come from Rockwater-Spotted Quoll nickel deposit located 45 km south-west from the Project area.

Troglofauna species are typically restricted to single geological formations or else are limited to associated geological structures that share connectivity (Halse and Pearson 2014). Accordingly, most troglofauna species identified in the search area are likely to be confined to BIFs of the Parker Range; and therefore, the same troglofauna are not expected to occur within the Project area. Similarly, the records of Carabidae sp. come from Rockwater-Spotted Quoll nickel deposit and are not expected to be found in the Project area or to represent species with restricted distributions.

3.2.2. Stygofauna

Nil Stygofauna records were yielded from within the search area. The nil records reflect a combination of few surveys conducted around the Project area and poor stygofauna communities in the local hydrogeological landscape due to hypersaline and hard water quality.

Stygofauna records in the Yilgarn can be found in saline calcrete aquifers (Humphreys 2001), however, surveys in consolidated geologies in the southern Yilgarn have recorded absent or depauperate stygofaunal communities (Bennelongia 2009; Cazaly 2010).

Table 1. Troglofauna species recorded in the search area around the Project.

No.	Higher Classification	Lowest Identification	No. of Records	Comments on Distribution
	Arachnida			All records are from Mt Caudan, approximately 60–70 km north of the Project, except for Carabidae sp. which was collected from Rockwater. All species currently only known from Mt Cauden were collected in BIF and are likely to be confined to that formation.
1	**Araneae**	Araneomorphae sp. B16	1	
	Pseudoscorpiones			
2	Chthoniidae	*Austrochthonius* \`PSE034\`	2	
3		*Tyrannochthonius* \`PSE048\`	1	
4		*Tyrannochthonius* \`PSE049\`	2	
	Entognatha			
	Diplura			
5	Japygidae	*Japygidae* sp. B01	1	
	Insecta			
	Coleoptera			
6	Curculionidae	Curculionidae Genus 3 sp. B06	1	
7	Staphylinidae	Staphylinidae sp. B02	4	
8	Carabidae	Carabidae sp.	3	
	Zygentoma			
9	Nicoletiidae	*Lepidospora* sp. B03	1	
	Crustacea			
	Isopoda			
10	Armadillidae	*Buddelundia* sp. B03	1	
11		*Buddelundia* sp. B04	1	
12	Philosciidae	Philosciidae sp. B14	1	
13	Platyarthridae	*Paraplatyarthrus* sp. B06	11	
	Isopoda	Isopoda sp.	2	
	Symphyla			
14	Scutigerellidae	*Hanseniella* sp. B05	3	
	Scolopendrida			
15	Cryptopidae	*Cryptops* sp. B12	1	
	TOTAL		36	

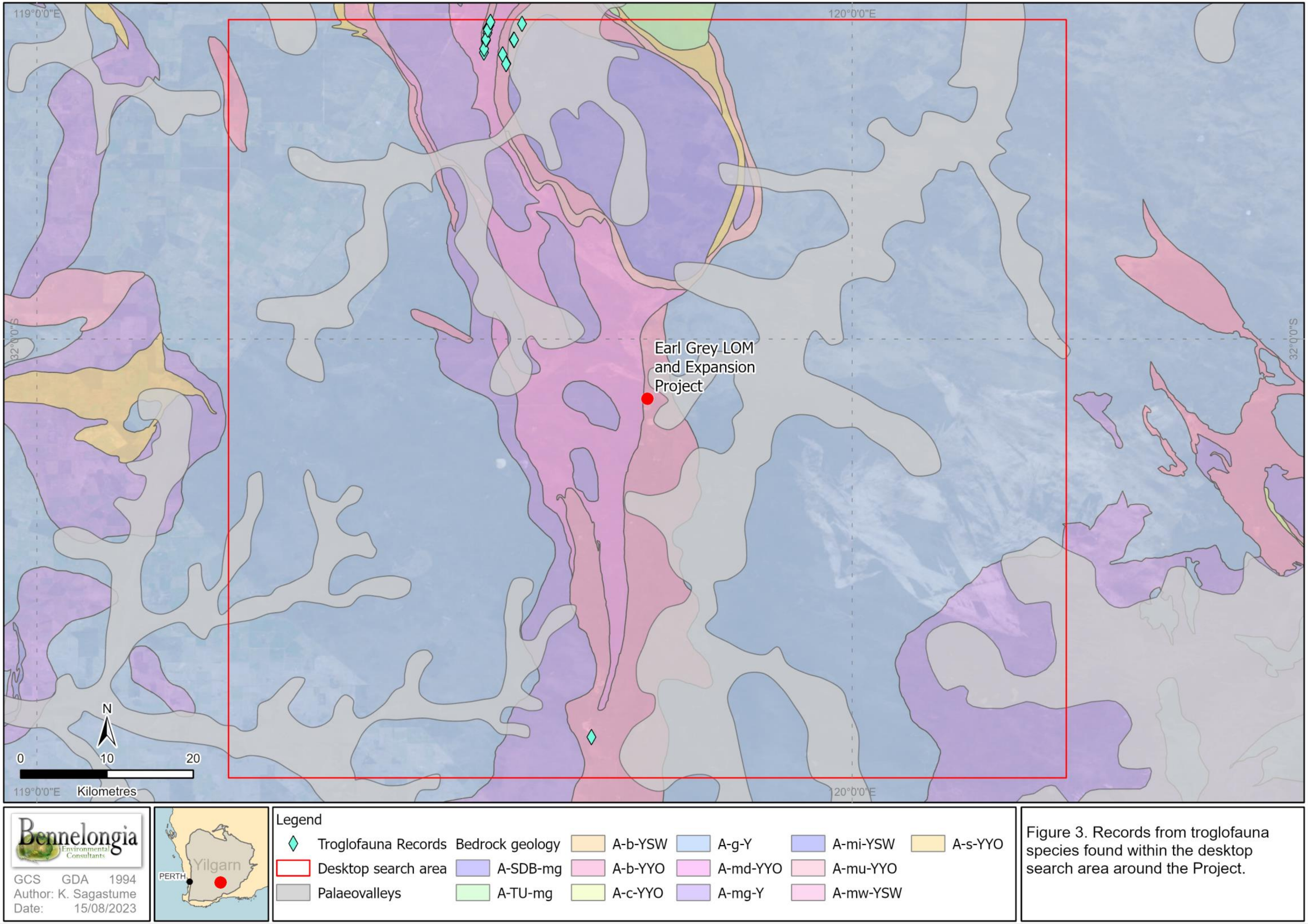

Figure 3. Records from troglofauna species found within the desktop search area around the Project.

4. SUBTERRANEAN HABITAT

4.1. Assessment of Habitat

The occurrence of subterranean fauna depends on the presence of suitable underground spaces, such as those formed by interstices, voids, vugs, cavities, and fissures. Consolidated geologies do not offer such habitats and additionally limit movement of carbon, nutrients, and oxygen into the subterranean environment.

The Project area consists of laterite, saprolite, saprock, and mafic and ultramafic rock intruded by veins of pegmatite (Figure 3). While previous surveys in mafic, ultramafic and saprolite have sometimes recorded both troglofauna and stygofauna, yields have been low, and the geologies are generally considered to provide poor habitat for subterranean fauna (Bennelongia 2016; ecologia 2009; GHD 2009). The hydrogeological units in the vicinity of the Project that are most likely to support subterranean fauna are surficial palaeovalley deposits, particularly calcretes, of the Deborah palaeovalley (Figure 3). Based on numerical modelling results (GRM 2023), 1 m drawdowns will extend up to 2 km from the pit area during mining, where there is no significant stygofauna communities expected, and even if there were stygofauna species, those are unlikely to be affected and as they are expected to occur within the regional calcretes and the wider palaeovalleys.

Stygofauna are also unlikely to occur due to habitat limitations, particularly the low water table (65–70 mbgl) and high salinity (7,640–88,900 mg/L, maximum of 100,000 mg/L in the main palaeochannel). Depth to groundwater is a major constraint on the complexity and abundance of stygofauna communities, with reduced richness observed in the Pilbara where groundwater was more than 32 mbgl (Halse *et al.* 2014). It is also uncommon for stygofauna to be found in salinities >50,000 mg L^{-1}, which is the case for much of the aquifer in the Project area. In combination, the lack of subterranean spaces, high salinity, and depth to groundwater make the occurrence of stygofauna within the proposed pit highly unlikely.

Bennelongia (2018) identified that although the Project area is composed of ultramafic rock formations overlain by clay, which are likely to hold both stygofauna and troglofauna species, the relative depth of the water table, hardened water, and high salinity of its aquifers (GRM 2023) suggests that it is unlikely that stygofauna occur in the Project area.

Interpretation of drill core samples within the Project area (Appendix 1) suggest that troglofauna communities are also unlikely to occur in the Project area. Local geology within the Project appears to be composed of a mostly dry compressed clay upper strata (first 3 to 4 m; Appendix 1A) followed by seriously compacted laterite in the lower strata (from 4 m to 10 m; Appendix 1B). These geologies result in insufficient spaces to support troglofauna communities and therefore, based on the habitat characteristics present in the Project area it is considered unlikely that troglofauna occur in the Project area.

5. POTENTIAL IMPACTS

The effects on subterranean fauna communities of developing mining infrastructure and subsequent mining operations can be broadly divided into two categories:

1. Primary impacts: possible threat to the persistence of local populations, of subterranean fauna through the direct removal of habitat; and
2. Secondary impacts: reduction of population densities of subterranean fauna through a range of environmental factors, for example pollutants and increased groundwater turbidity (Appendix 2).

Disturbances such as mine pits fit within the area of primary impacts as the subterranean fauna habitat is removes. Disturbances associated standard mining infrastructure such as waste dumps, tailing storage facilities, and evaporation ponds fit within the secondary impacts. Secondary impacts are detailed in Appendix 2.

5.1. Potential Impacts of the Project

The main sources of potential impacts to subterranean fauna at the Project are:

- Earl Grey Life of Mine expansion - total area of approximately 1600 ha in size; and
- Groundwater abstraction from mine pit dewatering, or for groundwater supply from shafts of old underground mine.

As outlined in Section 4, the lack of suitable geology renders it unlikely that troglofauna occur in the proposed Project expansion area. Although troglofauna have been recorded relatively nearby at Mt Caudan (approximately 50 km north) and Rockwater-Spotted Quoll (approximately 50 km south), those species are highly likely to be confined to BIF features at their collection locations and are not expected to occur in the Project area.

No troglofauna assemblages are expected to occur at the Project. Even if there were troglofauna species, these are likely to be depauperate as has been found in other analogous geologies. Any troglofauna in the Project area are not expected to be threatened by Project activities. Overall, it is unlikely that the Project will significantly impact the conservation status of troglofauna species, if any, either locally or regionally.

Given the lack of suitable habitat combined with the depth to groundwater and the high groundwater salinity, it is unlikely that stygofauna occur in the Project area. Any communities present are likely to be depauperate and species are likely to be widespread, as has been found in other fractured rock aquifers in the Yilgarn. Excavations, waste dumps, and groundwater abstraction are therefore unlikely to threaten stygofauna in the development area.

Both stygofauna and troglofauna may occur in calcrete east of the Project, but Project development will not extend to this unit. Numerical modelling results predict that the spatial extent of drawdowns associated with groundwater production will be small and will not reach regionally prospective stygofauna habitats in calcretes and other palaeovalley deposits. The inferred risk to subterranean fauna in regional calcretes and the wider palaeovalley is therefore low.

6. CONCLUSIONS

Thirty-six records representing fifteen identifiable species of troglofauna have been recorded in the 100 km x 100 km search area surrounding the Project. This represents an addition of four troglofauna species to the eleven previously identified by Bennelongia (2018). None of the recorded species are expected to occur within the Project area as they are likely confined to the banded iron formation where they have been previously collected.

No stygofauna records were found within the 100 km x 100 km search area surrounding the Project.

Based on the unsuitability of geology for hosting either troglofauna or stygofauna within the Project area, it is unlikely that either category of animals occurs at the Project site.

Potential subterranean fauna habitat in palaeovalley units, including calcrete occurring approximately 2 km east of the Project, will not be removed through excavations, and the drawdown risk in these units is low. No subterranean fauna is expected to occur within the Project area. Any communities that might be present are likely to be depauperate and are not expected to be threatened by the proposed expansion. Overall, the Project is not considered to pose a significant threat to subterranean fauna.

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APPENDIX 1. IMAGES OF DRILL CORES SHOWING LOCAL GEOLOGY AT THE PROJECT AREA.

*Note: only selected bore sections are shown to reference geological strata referred in text.

Appendix 1A. Upper strata (0.0 - <3.5 m) geology.

- WBYD001: 0.0 – 3.2 m

- WBYD002: 0.0 – 3.5 m

- WBYD003: 0.0 – 3.4 m

Appendix 1B. Lower strata (>3.0 - 10 m) geology.

- WBYD003: 7.1 - 9.9 m

- WBYD004: 3.3 – 6.8 m

- WBYD005: 3.2 - 6.8 m

APPENDIX 2. SECONDARY IMPACT OF MINING ON SUBTERRANEAN FAUNA.

Mining activities that may result in secondary impacts to subterranean fauna include:

1. *De-watering below troglofauna habitat*. The impact of a lowered water table on subterranean humidity and, therefore, the quality of troglofauna habitat is poorly studied but it may represent risk to troglofauna species in some cases. The extent to which humidity of the vadose zone is affected by depth to the water table is unclear. Given that pockets of residual water probably remain trapped throughout de-watered areas and keep the overlying substrate saturated with water vapour, de-watering may have minimal impact on the humidity in the unsaturated zone. In addition, troglofauna may be able to avoid undesirable effects of a habitat drying out by moving deeper into the substrate if suitable habitat exists at depth. Overall, de-watering outside the proposed mine pits is not considered to be a significant risk to troglofauna.
2. *Percussion from blasting*. Impacts on both stygofauna and troglofauna may occur through the physical effect of explosions. Blasting may also have indirect detrimental effects through altering underground structure (usually rock fragmentation and collapse of voids) and transient increases in groundwater turbidity. The effects of blasting are often referred to in grey literature but are poorly quantified and have not been related to ecological impacts. Any effects of blasting are likely to dissipate rapidly with distance from the pit and are not considered to be a significant risk to either stygofauna or troglofauna outside the proposed mine pits.
3. *Overburden stockpiles and waste dumps*. These artificial landforms may cause localised reduction in rainfall recharge and associated inflow of dissolved organic matter and nutrients because water runs off stockpiles rather than infiltrating through them and into the underlying ground. The effects of reduced carbon and nutrient input are likely to be expressed over many years and are likely to be greater for troglofauna than stygofauna (because lateral movement of groundwater should bring in carbon and nutrients). The extent of impacts on troglofauna will largely depend on the importance of chemoautotrophy in driving the subterranean system compared with infiltration-transported surface energy and nutrients. Stockpiles are unlikely to cause species extinctions, although population densities of species may decrease under them.
4. *Aquifer recharge with poor quality water*. It has been observed that the quality of recharge water declines during, and after, mining operations as a result of rock break up and soil disturbance. Impacts can be minimised through management of surface water and installing drainage channels, sumps and pump in the pit to prevent of recharge though the pit floor.
5. *Aquifer salinisation*. This may result from aquifer mixing during reinjection or from the disposal of high salinity water into fresher aquifers. Most freshwater invertebrates are not able to maintain body fluid solute concentrations lower than the external aquatic environment, making them vulnerable to dehydration, as salinity increases. Rare species tend to be more sensitive with narrower ranges of salinity tolerance than common species and are therefore more likely to drop out of assemblages following salinisation. Prolonged (chronic) exposure to sub-lethal doses of salinity has been shown to affect a range of ecologically-significant biologically responses in aquatic invertebrates. The level of risk posed by aquifer salinisation to each stygofauna species that is potentially unable to withstand increased salinity will depend on the spatial distribution of that species relative to the spatial extent of elevated salinity.
6. *Contamination of groundwater by hydrocarbons*. This may occur as a result of the drilling process. The spatial extent of contamination around each hole is usually unclear but is likely to depend on the volume of contaminant, its viscosity and toxicity, and aquifer characteristics including transmissivity and rates of lateral movement. Contamination may be minimised by engineering and management practices to ensure the removal or containment of hydrocarbon products.