# Greater Paraburdoo

# Subterranean Fauna Survey

Rio Tinto Iron Ore Pty Ltd

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# Greater Paraburdoo Subterranean Fauna Survey

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| 3 | S. Callan | B. Durrant | J. McShane | 10/05/2019 |



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# 1. EXECUTIVE SUMMARY

Rio Tinto Iron Ore Pty Ltd (Rio Tinto) owns and operates the Greater Paraburdoo mining operations in the Pilbara region of Western Australia, approximately 6 kilometres (km) to the south of the town of Paraburdoo. Rio Tinto, on behalf of the joint venture participants, is evaluating the development of several iron ore deposits within the Greater Paraburdoo Iron Ore Hub. This includes the development of a new iron ore mine at Western Range (mainly above water table - AWT), and the extension of existing operations at Paraburdoo (below water table - BWT) and Eastern Range (AWT).

Biologic Environmental Survey Pty Ltd (Biologic) was commissioned to undertake a survey and assessment for subterranean fauna (troglofauna and stygofauna) throughout a Study Area encompassing the Greater Paraburdoo Iron Ore Hub (approximately 17,422 ha). The survey was designed and conducted in accordance with relevant EPA guidelines for subterranean fauna assessments, and sampling included a balanced mix of sites in existing and proposed impact areas as well as reference (non-impact) sites. The survey aimed to provide a comprehensive assessment of all subterranean species and habitats occurring within the Study Area and immediate surrounds and assess the potential risks to subterranean species and habitats from the proposed developments at Greater Paraburdoo.

Prior to the current survey, a single, targeted troglofauna survey and limited stygofauna sampling has been conducted within the Study Area. Database searches (mainly comprising records from the WA Museum and Department of Biodiversity, Conservation and Attractions' Pilbara Stygofauna Survey) and records from previous sampling revealed two troglofauna/ potential troglofauna taxa (polyxenids and isopods) and 12 stygofauna/ potential stygofauna taxa (polychaetes, oligochaetes, ostracods, cyclopoids, amphipods, and isopods) previously recorded within the Study Area.

The current survey sampled a total of 290 bores and drill holes throughout the Study Area resulting in 431 troglofauna samples (143 trapping, and 288 scraping respectively) and 105 stygofauna samples (95 net haul, 3 Karaman, and 7 pump samples respectively). A total of 1415 subterranean fauna specimens were recorded comprising 180 troglofauna and 1235 stygofauna specimens.

Using morphological and genetic (DNA barcoding) methods, the troglofauna were identified as representatives from 39 species/ species level taxa and nine higher level indeterminate taxa comprising pseudoscorpions, palpigrades, schizomids, spiders, isopods, centipedes, millipedes, pauropods, symphylans, diplurans, proturans, silverfish, hemipteran bugs and beetles. In combination with previous records, a total of 186 troglofauna specimens representing 40 species/ species level taxa and nine higher level indeterminate taxa are known to occur within the Study Area. The majority of troglofauna taxa (25) were singletons or known only from single sites within the Study Area. Thirteen taxa were known from multiple locations within the Study Area and the remaining three represented widespread taxa known from beyond the Study Area.

The stygofauna were also identified using morphological and genetic methods, revealing 63 species/ species level taxa and eight higher level indeterminate taxa collected from the survey comprising polychaete and oligochaete worms, water mites, ostracods, cyclopoid and harpacticoid copepods, syncarids, amphipods and isopods. In combination with previous records, a total of 1245 stygofauna specimens representing 70 species/ morphospecies and nine higher level indeterminate taxa are known to occur within the Study Area. Half of the stygofauna taxa (29) were widespread taxa known to occur beyond the Study Area. A further 29 taxa were singleton taxa or taxa recorded only from single sites. The remaining taxa were locally widespread.

The risk assessment for subterranean fauna was based on current taxonomic and ecological information, available habitat information (including 3D habitat modelling based on detailed drill log data) and the likelihood that any species of troglofauna or stygofauna would be limited to habitats directly impacted by the proposed development. For troglofauna, the direct impact area comprised the proposed pit boundaries, while for stygofauna the extent of pits below water table (BWT) and the estimated groundwater drawdown (based on hydrogeological modelling) comprised the direct impact area.

Eight (8) troglofauna taxa are currently known only from the direct impact areas of the proposed development. The potential risks to these taxa from mining were characterised using a three-point risk classification system (*i.e.* high, moderate, or low risk) as follows:

- **Low risk** (3 taxa): *Eukoenenia* \`WAM-PALE002\`, *Decapauropus* \`WAM-PAUD004\`, and *Symphyella* \`WAM-SYMPH002\`.

These taxa were regarded as low risk because their known records are located near to the boundaries of proposed pits, while the 3D habitat modelling indicated that suitable, continuous AWT habitat will remain intact after mining (both below the proposed pit at their immediate location and extensively beyond the pit boundaries).

- **Moderate risk** (5 taxa): *Paraplatyarthrus* \`WAM-PARA001\`, *Decapauropus* \`WAM-PAUD003\`, *Scutigellera* \`WAM-SCUTI004\`, *Symphyella* sp. indet., and *Trinemura* \`WAM-ZYGS001\`.

These were all considered to represent potential troglobitic taxa and were regarded as a moderate risk because the 3D habitat modelling indicated that no high or medium (certain) suitability habitat will remain below the proposed pit at their immediate location. Nevertheless, 3D habitat modelling showed an extensive area of suitable habitat beyond the proposed pits in Western Range near the location of each of these taxa. Despite most of these taxa being singletons (except for *Trinemura* \`WAM-ZYGS001\`, whose wider occurrence supports the extent and connectivity shown in the habitat modelling), it is considered likely that they will occur elsewhere within the modelled extent of AWT habitat in Western Range.

One stygofauna taxon is currently known only from sites within the proposed groundwater drawdown at Paraburdoo, within the Orebody aquifer/ Detrital aquifer beneath Seven-Mile Creek.

Using a three-point classification, the risk to this taxon from the proposed mining/ drawdown was characterised as:

- **High risk** (1 taxon): *Bathynella* 'WAM-BATH001'

This taxon is regarded as a potential short-range endemic (SRE) stygobite as highly restricted ranges and limited dispersal capabilities are common throughout the group. The taxon is currently known only from a small, compartmentalised aquifer beneath Seven-Mile Creek limited by dolerite intrusives and impermeable layers (*e.g.* Mt McRae Shales). This compartmentalised aquifer is currently affected by drawdown from the existing 4W and 4E pits and the predicted drawdown for the proposed 4EE pit appears to completely dewater the remaining habitat.

Despite the current sampling detecting *Bathynella* 'WAM-BATH001' only within the compartmentalised aquifer in Seven-Mile Creek, it is possible that the species occurs more widely, as periodic connectivity with nearby hydrogeological habitats upstream and downstream is expected to occur during flood events. These nearby habitats, including detrital aquifers in Seven-Mile Creek north of Paraburdoo, and Duck Creek Dolomite aquifers in the Southern Borefield, are not expected to be dewatered under the 'worst-case scenario' habitat modelling of groundwater drawdown. However, based on current taxonomic/ ecological information, 3D habitat modelling and the extent of predicted drawdown in the location of the current records, the potential risks to *Bathynella* 'WAM-BATH001' are considered high.

## 2. INTRODUCTION

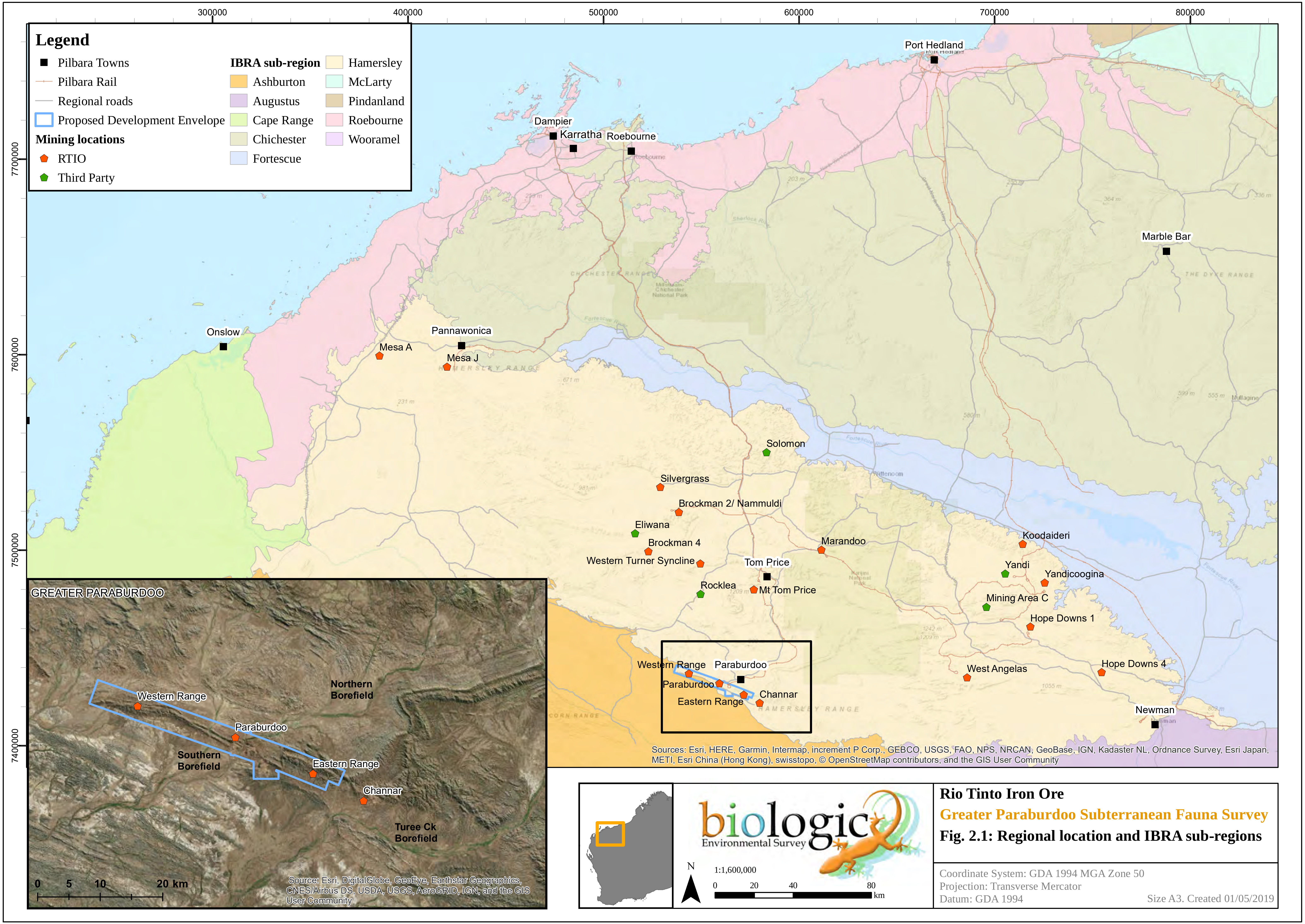
Rio Tinto Iron Ore Pty Ltd (Rio Tinto) owns and operates the Greater Paraburdoo mining operations in the Pilbara region of Western Australia, approximately 6 kilometres (km) to the south of the town of Paraburdoo (Figure 2.1).

Rio Tinto, on behalf of the joint venture participants, is evaluating the potential development of a number of iron ore deposits within the Greater Paraburdoo locality (the Greater Paraburdoo Iron Ore Hub). This includes the development of a new mine at Western Range, and the extension of existing operations at Paraburdoo and Eastern Range, and associated infrastructure.

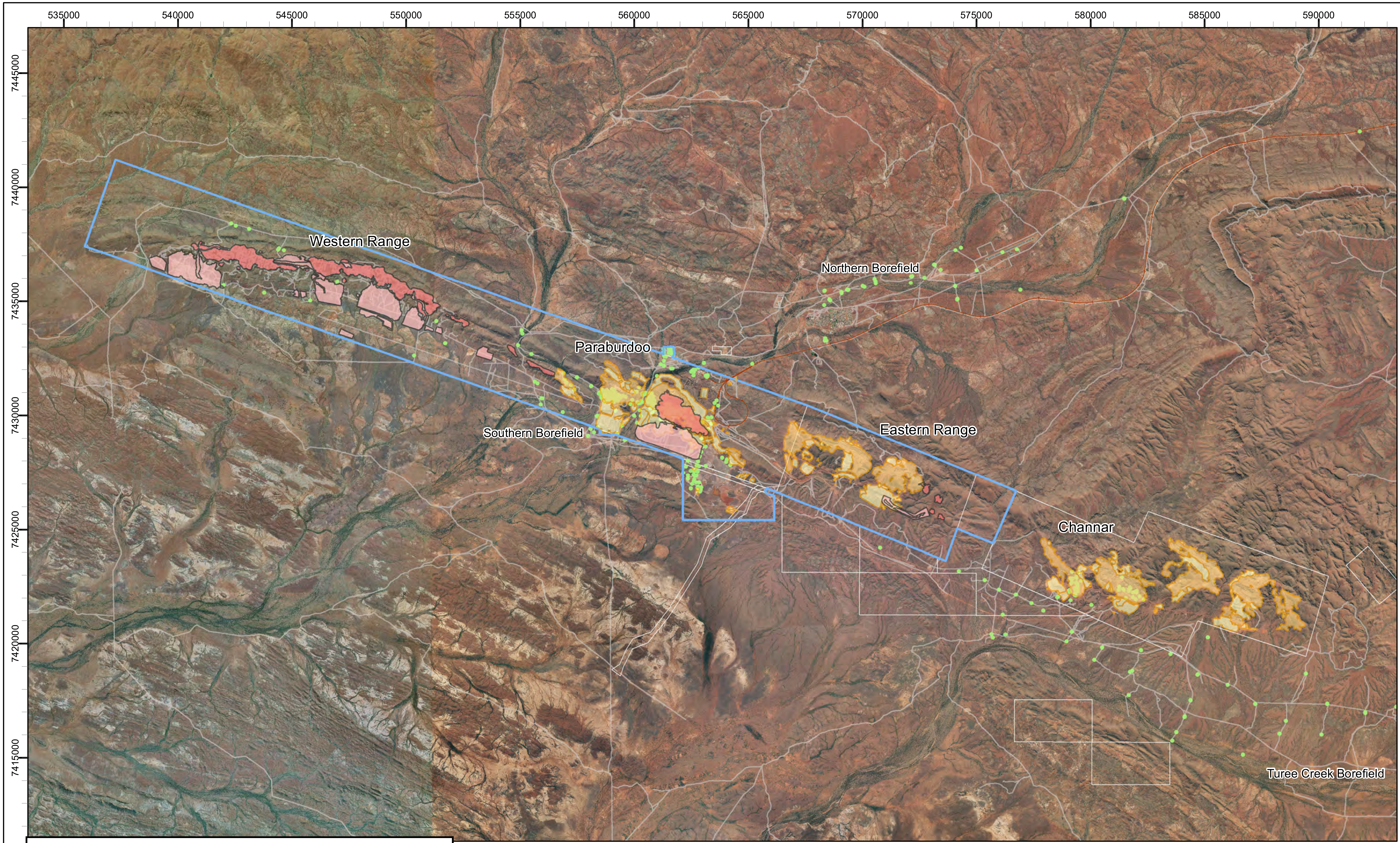
Rio Tinto has commissioned Biologic Environmental Survey Pty Ltd (Biologic) to undertake a two-phase Level 2 subterranean fauna (stygofauna and troglofauna) survey throughout the Greater Paraburdoo Iron Ore Hub development envelope (the Study Area, approximately 17,422 ha) (Figure 2.2). The survey was designed and conducted in accordance with relevant EPA guidelines for subterranean fauna assessments (EPA 2016*a*, 2016*b*, 2016*c*), and sampling included a balanced mix of sites in existing and proposed impact areas as well as reference (non-impact) sites (Figure 2.2).

This report provides:

- a desktop review of all previous subterranean fauna surveys in the vicinity of the Study Area and existing subterranean fauna databases on the local/ sub-regional scale;
- an assessment of the suitability and extent of subterranean habitats within the Study Area and potential wider connectivity beyond the Study Area, based on available geological and hydrogeological information, and three-dimensional habitat modelling above and below water table within the Study Area;
- results of a two-phase Level 2 stygofauna and troglofauna survey throughout the Study Area, including detailed identifications of all species collected;
- assessment of the likely local occurrence of stygofauna and troglofauna species relative to key habitat units and proposed impact areas, and a discussion of their conservation status and wider potential distribution with reference to regional taxonomic and genetic comparisons; and
- a detailed risk assessment of key subterranean fauna values (species and habitat) in relation to the potential impacts of the proposed mining development.



Legend
Pilbara Towns
Pilbara Rail
Regional roads
Proposed Development Envelope
Mining locations
RTIO
Third Party
IBRA sub-region
Ashburton
Augustus
Cape Range
Chichester
Fortescue
Hamersley
McLarty
Pindanland
Roebourne
Wooramel
300000
400000
500000
600000
700000
800000
7700000
7600000
7500000
7400000
Port Hedland
Dampier
Karratha
Roebourne
Marble Bar
Onslow
Pannawonica
Mesa A
Mesa J
HAMERSLEY RANGE
CHICHESTER RANGE
Solomon
Silvergrass
Brockman 2/ Nammuldi
Eliwana
Brockman 4
Western Turner Syncline
Marandoo
Tom Price
Rocklea
Mt Tom Price
Koodaideri
Yandi
Yandicoogina
Mining Area C
Hope Downs 1
West Angelas
Hope Downs 4
Newman
Western Range
Paraburdoo
Channar
Eastern Range
Sources: Esri, HERE, Garmin, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), swisstopo, © OpenStreetMap contributors, and the GIS User Community
GREATER PARABURDOO
Western Range
Northern Borefield
Paraburdoo
Southern Borefield
Eastern Range
Channar
Turee Ck Borefield
0 5 10 20 km
Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community
biologic Environmental Survey
N
1:1,600,000
0 20 40 80 km
Rio Tinto Iron Ore
Greater Paraburdoo Subterranean Fauna Survey
Fig. 2.1: Regional location and IBRA sub-regions
Coordinate System: GDA 1994 MGA Zone 50
Projection: Transverse Mercator
Datum: GDA 1994
Size A3. Created 01/05/2019




## Legend

RTIO Tenure
Proposed Development Envelope
Track
Pilbara Rail
Waterbores

**Existing and Approved Disturbance**

Existing Approved Disturbance
Existing Approved Mining Pits

**Conceptual Footprint**

Proposed Conceptual Disturbance
Proposed Conceptual Mining Pits

biologic Environmental Survey

N

1:150,000

0 2 4 8 km

**Rio Tinto Iron Ore**

**Greater Paraburdoo Subterranean Fauna Survey**

**Fig. 2.2: Greater Paraburdoo Study Area current and proposed development**

Coordinate System: GDA 1994 MGA Zone 50
Projection: Transverse Mercator
Datum: GDA 1994
Size A3. Created 01/05/2019

## 2.1 Project summary

The Greater Paraburdoo mining operations commenced production in 1972 and active iron ore mining is currently underway at a number of deposits at Paraburdoo and Eastern Range. A pre-feasibility study is currently underway to evaluate the potential development of a new iron ore mine at Western Range, and the extension of existing mining operations at Paraburdoo and Eastern Range (and associated infrastructure). The proposed Development Envelope encompasses an area of 17,422 ha and aims to sustain the current level of iron ore production at 25Mt/a from the Greater Paraburdoo locality.

The key components of the proposed Development Envelope are:

- development of new pits at Western Range (deposits 36 West to 66 West);
- development of the 4 East Extension (4EE) at Paraburdoo as an extension of the existing 4 East BWT pit, including new dewatering of the Wittenoom Formation;
- development of new AWT pits at Paraburdoo (deposits 14W-16W and 27 West); and
- development of new AWT pits at Eastern Range (deposits 42EE and 47 East).

Groundwater has been abstracted in the 4 East and 4 West area since 2001, resulting in the development of a cone of depression in the Brockman Iron Formation aquifer (RTIO 2018). Further groundwater drawdown associated with the proposed mining activities is expected to occur in the area, with groundwater abstraction not expected to exceed 14 GL/annum.

## 2.2 Legislation and guidance

Western Australia's subterranean fauna is considered globally-significant due to an unprecedented richness of species and high levels of short-range endemism (EPA 2016*a*). The EPA's environmental objective for subterranean fauna is to "protect subterranean fauna so that biological diversity and ecological integrity are maintained" (EPA 2016*d*, p2). In this context, the EPA defines ecological integrity as "the composition, structure, function and processes of ecosystems, and the natural range of variation of these elements" (EPA 2016*d*, p2).

Protection for conservation significant subterranean species and/ or Threatened or Priority Ecological Communities (TECs and PECs) is provided under State and Federal legislation, comprising:

- *Environmental Protection Act 1986* (*EP Act 1986*) (WA);
- *Biodiversity Conservation Act 2016* (*BC Act 2016*) (WA) (replacing the *Wildlife Conservation Act 1950)*; and
- *Environment Protection and Biodiversity Conservation Act 1999* (*EPBC Act 1999*) (Commonwealth).

Most subterranean species and assemblages are not listed under these Acts, due to incomplete taxonomic or ecological knowledge. Consideration of range-restricted subterranean fauna is therefore also important, including species that only occur within restricted habitats, as these have a higher potential of being Short-Range Endemic (SRE) species (Harvey 2002; Eberhard *et al.* 2009).

This assessment has been undertaken in consideration of the following EPA guidance statements:

- EPA (2016*a*) Technical Guidance Subterranean Fauna Survey;
- EPA (2016*b*) Technical Guidance Sampling Methods for Subterranean Fauna; and
- EPA (2016*c*) Environmental Factor Guidelines Subterranean Fauna.

## 2.3 Subterranean fauna

Subterranean fauna are animals that live underground. In Western Australia, subterranean fauna are mainly invertebrates such as crustaceans, insects, arachnids, myriapods, worms, and snails, but a small number of vertebrate taxa such as fish and reptiles have also been found (Humphreys 1999; EPA 2013). Subterranean fauna are grouped into two major ecological categories:

- stygofauna - aquatic animals that inhabit groundwater in caves, aquifers and water-saturated interstitial voids; and
- troglofauna - air-breathing animals that inhabit air-filled caves and smaller voids above the water table.

Nevertheless, there are some taxa which cross-over between these categories and are known to occur in groundwater as well as air-filled subterranean habitats (*e.g.* enchytraeid worms), and yet other species that occur within subterranean habitats for only part of their lifecycles (stygoxenes/ stygophiles, and trogloxenes/ troglophiles respectively).

Following EPA (2016*a*) guidelines, obligate subterranean fauna (known respectively as stygobites and troglobites) are defined as species that live their entire lives underground and are completely dependent upon, or restricted to, subterranean habitats. Such species are considered to have a high likelihood of being limited to very narrow ranges (*i.e.* short-range endemic (SRE) species), and therefore may be at greater risk of impacts from proposed developments (EPA 2016*a*). SRE species as described by (Harvey 2002), are species whose natural ranges are limited to <10,000 km$^2$ (or <100 km x 100 km), whereas Eberhard *et al.* (2009) regarded even this criterion as potentially too vast for range-restricted subterranean fauna, offering an alternative threshold of <1,000 km$^2$ for subterranean SRE species.

### 2.3.1 Key habitat characteristics for subterranean fauna

The lack of light within hypogean environments precludes photosynthesis; therefore most subterranean ecosystems are dependent upon inputs of nutrients and oxygen from the surface (Hahn 2009). Oxygen, energy and nutrients are generally transported into subterranean ecosystems by the infiltration of water (Howarth 1983; Malard and Hervant 1999; Poulson and Lavoie 2000; Humphreys 2006). The porosity (or otherwise) of the target and overlying geologies, the depth from the surface, and the presence of caves or tree roots that can provide conduits for water and nutrients are therefore important features that can influence the suitability of habitats for subterranean fauna (Strayer 1994; Hahn and Fuchs 2009).

In the iron-ore bearing formations of the Hamersley Ranges, potential habitats for troglofauna can include weathered and fractured rocks such as banded iron formations (BIF), dolomite, basalt, and metamorphosed sedimentary rocks, as well as secondarily weathered deposits such as pisolitic duricrust, detrital iron deposits (DID), channel iron deposits (CID) and karstic calcrete deposits. The suitability of habitat depends on the presence, abundance and interconnectedness of subterranean cavities, and on inputs of nutrients, water and oxygen from the surface *via* infiltration and conduits such as tree roots (Howarth 1983; Hahn and Fuchs 2009). Although troglofauna cannot live below the water table, they are particularly susceptible to desiccation and require a humid atmosphere close to 100 % saturation (Howarth 1983).

In the Hamersley Ranges, highly suitable habitats for stygofauna have been found within groundwater saturated CID, iron-enriched hardcap and karstic calcrete deposits in drainage valleys. However, stygofauna can also be found within fractured rock aquifers including BIF, basalt, schist, chert and metamorphosed sedimentary rocks, and in unconsolidated alluvial aquifers, particularly in groundwater-fed streams (*i.e.* hyporheic habitats) (Hancock *et al.* 2005). The differences in habitat suitability between different aquifers are partially attributed to the differences in hydraulic transmissivity (k) and storage potential (S) aquifers. In high transmissivity (high k) aquifers, rapid groundwater flows are facilitated by highly porous/ cavernous geologies and depth from the surface is not a limiting factor for stygofauna. Conversely, where aquifers are restricted by impermeable layers, or where transmissivity is low (low k, as in aquitard layers), the presence of stygofauna may be limited by a lack of porosity and dissolved oxygen.

Groundwater physicochemistry (including salinity, pH, dissolved oxygen, and redox potential) can also be an important factor in habitat suitability for stygofauna (Watts and Humphreys 2004; Humphreys 2008; Eberhard *et al.* 2009; Hahn 2009). Very high groundwater salinity (>60,000 mg/L TDS, or twice that of sea-water) is generally considered to be an upper limit for diverse stygofauna assemblages, but some saline-tolerant species have been found in groundwater in excess of 100,000 mg/L TDS (S. Thomas, DPaW pers. comm. 2011).

# 3. ENVIRONMENT

## 3.1 Climate

The current subterranean fauna survey was conducted as a two-phase, Level 2 survey in accordance with EPA guidelines for subterranean fauna assessments (EPA 2016*a*, 2016*b*, 2016*c*). The first phase of sampling was undertaken over the months June – August 2017, with the second phase being undertaken in April – July 2018.

The Pilbara region has a tropical semi-arid climate. Rainfall events within the region are sporadic and highly variable from year to year. Although considerable falls can occur within summer and winter months, most rainfall is during summer (Australian Natural Resource Atlas 2008). Detailed long-term climatic data is available for Paraburdoo Aero (Station 7185), approximately 10 km north east of the Study Area (Figure 3.1).

The daily maximum temperatures during Trip 1 (8 – 11 June 2017) to the Study Area ranged from 24.7°C to 25.8°C, whereas night time minima ranged from 6.4°C to 12°C (Figure 3.1). Paraburdoo received no rainfall in the five weeks prior to Trip 1 trap deployment, with 10 mm recorded in April 2017 representing the only rainfall two months prior to the survey. The daily maximum temperatures during Trip 2 (17 – 25 August 2017) ranged from 25.1°C to 35.4°C, and night time minima ranged from 12.0°C to 19.5°C (BoM 2018). In the time period between troglofauna trap deployment (Trip 1) and subsequent retrieval with scrape/haul sampling (Trip 2), only 3.2 mm of rainfall were recorded at Paraburdoo. These conditions reflected a slightly warmer and drier winter dry season than the long-term averages for Paraburdoo (BoM 2018) and may have potentially limited the abundance or activity levels of subterranean fauna at the time of Phase 1 of the survey.

The daily maximum temperatures during Trip 3 (17 April – 4 May 2018) ranged from 29.6°C to 39.1°C, reflecting the slightly warmer than long-term average temperatures experienced during April 2018. Daily maximum temperatures during Trip 4 (25 June – 4 July 2018) ranged from 23.3°C to 29.1°C and were on par with long-term averages for this period.

Paraburdoo recorded no rainfall in the two weeks prior to Trip 3; however, significant rainfall was recorded during the preceding summer wet season, particularly in January (107.2 mm). Despite somewhat lower than average rainfall in February and March, overall the wet season rainfall in 2018 would be expected to have significantly recharged the subterranean habitats, therefore fauna sampling during Phase 2 of the survey was unlikely to have been limited by a lack of wet season rainfall. In addition, the results from Trip 4 may have been boosted by above average early dry season rainfall received in June 2018 (75 mm).

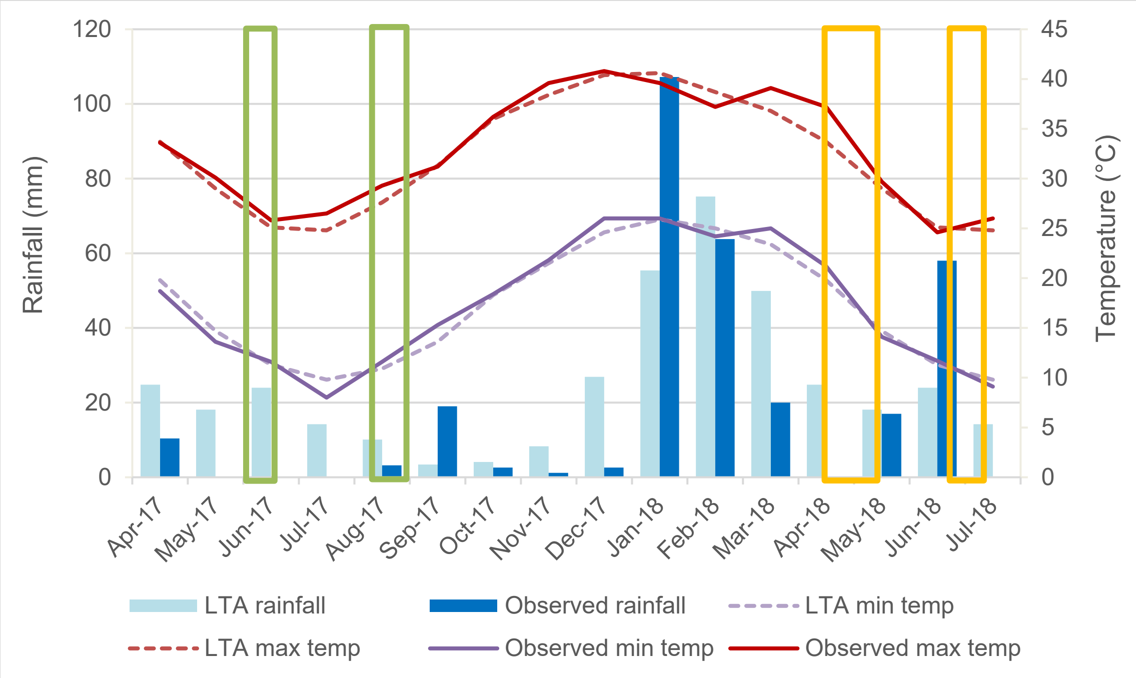



**Figure 3.1: Long term average (LTA) and current (2017-2018) climatic data for the Study Area (data from BoM 2018*)**

*Note: Data includes total monthly rainfall (mm) and average monthly maximum and minimum temperatures (°C). Approximate survey timing is indicated by green box (Trips 1 and 2) and orange box (Trips 3 and 4).

## 3.2 Geology

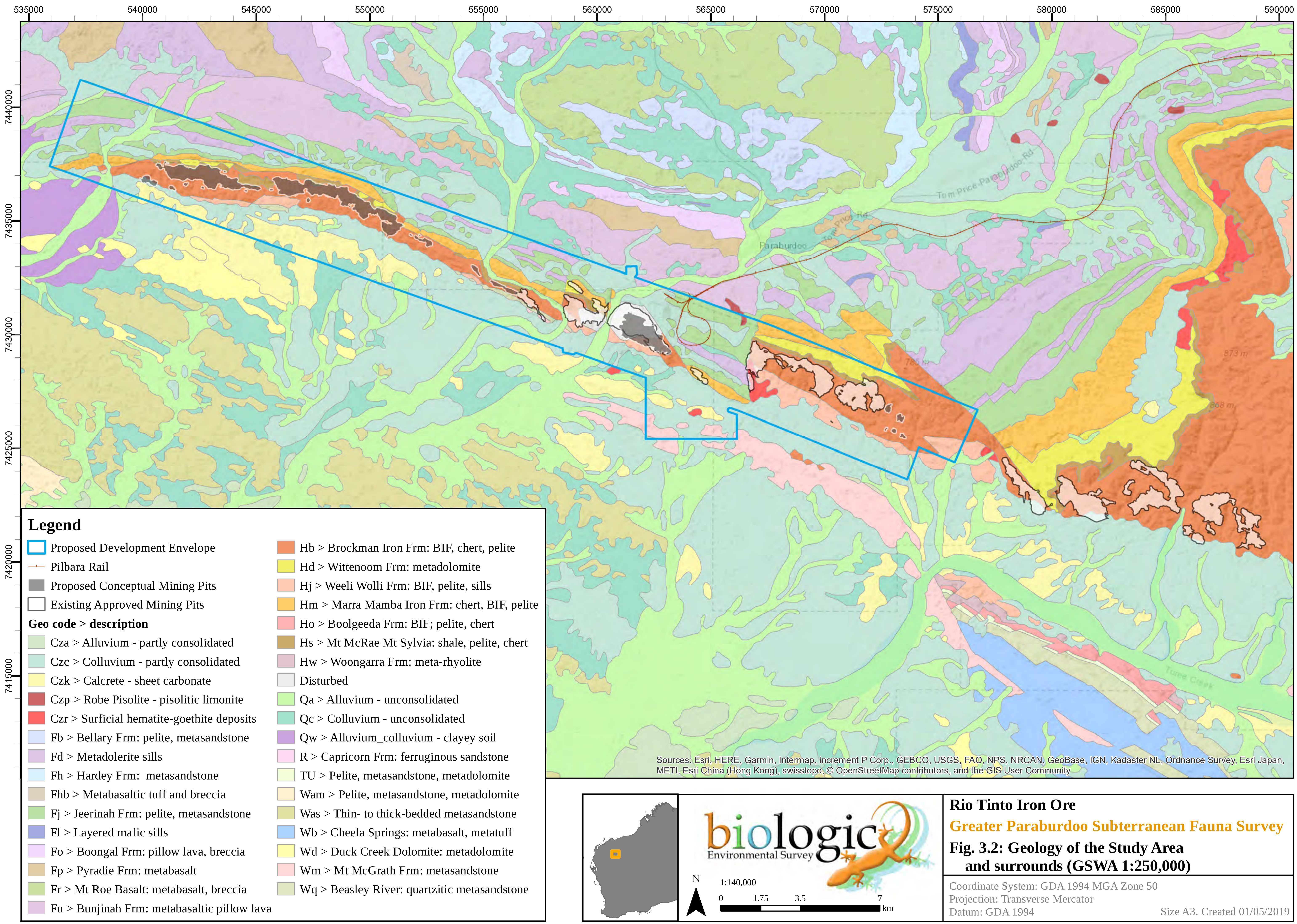
The Paraburdoo mining deposits are situated on the southern limb of the Bellary Anticline, along the southern margin of the Hamersley Province. The Paraburdoo Ranges consist of two major east-west striking ridges (dipping 40 to 50°), comprising the Marra Mamba Formation (northern side) and the Brockman Iron Formation (southern side). A valley exists between these ridges, comprising weathered and eroded Wittenoom Dolomite, and Mount McRae/ Mount Silvia Shales.

To the north of these ranges lies the Fortescue Group, predominately flood basalt and dolerite intruded formations. To the south of the ranges lies the Ashburton Formation, a mix of quartzites, ironstone and shales (RTIO 2015). Figure 3.2 shows the surface geology of the Greater Paraburdoo Development Envelope and proposed mining pits based on GSWA 1:250,000 mapping.

A generalised stratigraphy of Greater Paraburdoo is shown in Table 3.1, with notes relating to the generalised suitability for subterranean fauna, based on regional knowledge. Mineralisation within the Greater Paraburdoo deposits is mainly hosted by the Dales Gorge and Joffre Members of the Brockman Iron Formation (BrIF), and by the Mount Newman and MacLeod Members of the Marra Mamba Iron Formation (MMIF). Mineralisation also occurs within the Colonial Chert Member of the Mount McRae Shale Formation and, to a much lesser extent, within the Whaleback Shale and

Yandicoogina Shale Members of the BrIF. Minor detrital mineralisation further occurs as shallow fan shaped colluvial deposits on the southern side of the range (RTIO 2013).

Mineralisation is predominantly formed by supergene weathering/ enrichment of hematite-martite-goethite, which is largely controlled by faults and dolerite intrusions (RTIO 2013). The secondary weathering/ enrichment processes that drive mineralisation in the uppermost layers of the Marra Mamba, Wittenoom, and Brockman Iron Formations are also generally responsible for creating vugs and cavities that provide potential habitat for troglofauna and stygofauna. Secondary weathering processes also commonly create voids and cavities within Tertiary detrital deposits in the valley fill (both within CIDs and calcrete deposits) and, in some cases, within karstic dolomites of the Wittenoom Formation. Deeper habitats for subterranean fauna can also occur in proximity to faulting and folding zones because of large fractures within BIF and dolomite.




**Rio Tinto Iron Ore**

**Greater Paraburdoo Subterranean Fauna Survey**

**Fig. 3.2: Geology of the Study Area and surrounds (GSWA 1:250,000)**

Coordinate System: GDA 1994 MGA Zone 50
Projection: Transverse Mercator
Datum: GDA 1994
Size A3. Created 01/05/2019

**Table 3.1: Stratigraphy of Greater Paraburdoo and generalised suitability for subterranean fauna**

<table>
<tr><th colspan="3">Unit</th><th>Description</th><th>Generalised suitability for subterranean fauna AWT/ BWT</th></tr>
<tr><td colspan="3">Cainozoic/ Quaternary sediments</td><td>Tertiary and Quaternary age superficial deposits of scree, alluvium and colluvium occur over extensive areas at Greater Paraburdoo. Calcrete and silcrete is commonly found along drainage lines and buried within valley sediments.</td><td>Ranges from medium to high depending upon degree of cavities/ weathering/ consolidation and the proportions of gravel and calcrete present.</td></tr>
<tr><td colspan="3">Channel Iron Deposits (CID)</td><td>Robe Pisolite unaltered hematite-goethite pisoliths. Thickness is highly variable and dependent on associated beds and its exposure and erosion.</td><td>High (generally extensively porous/ weathered) – although this formation does not occur extensively within the Study Area.</td></tr>
<tr><td colspan="3">Wyloo Group (WQ, WM & WD)</td><td>Small outcrops of the Wyloo group have been mapped in the ‘flats’ area to the south of the Western Hill range. The Wyloo Group comprises the Beasley River Quartzite, the Mt McGrath Formation, and the Duck Creek Dolomite.</td><td>High where sufficient vugs, cavities, fractures, or void spaces occur in dolomite and calcrete.</td></tr>
<tr><td colspan="3">Dolerite dykes (PD)</td><td>The structural geology of much of Greater Paraburdoo is dominated by faulting, many of which have been intruded by dolerites. Other than the tilting of the whole sequence, folding is a relatively minor part of the orebodies.</td><td>Low (potential barrier to species dispersal).</td></tr>
<tr><td colspan="3">Dolerite sill (PS)</td><td>Located within the Joffre Member (J3 band). Faulting has caused repetition of the sill in some places.</td><td>Low (potential barrier to species dispersal).</td></tr>
<tr><td colspan="5">Hamersley Group</td></tr>
<tr><td colspan="3">Weeli Wolli Formation (HJ)</td><td>Comprises a sequence of BIF units (commonly jaspilitic), separated by shale and siltstone bands. Commonly interlayered by metadoleritic sills. It has been mapped at only a few locations at Greater Paraburdoo.</td><td>Medium, depending upon degree of cavities/ weathering/ enrichment and the proportions of shale to BIF/ chert. Shale bands expected to be less permeable.</td></tr>
<tr><td rowspan="10">Brockman Iron Formation (HB)</td><td colspan="2">Yandicoogina Shale Member (BY)</td><td>Consists of interbedded chert and shale bands which have been intruded by a number of dolerite sills. It is 40 to 60 m thick and is commonly mineralised.</td><td>Ranges from low to medium, depending upon degree of cavities/ weathering/ enrichment and the proportions of shale to BIF/ chert.</td></tr>
<tr><td rowspan="6">Joffre Member (BJ)</td><td>Unit 6 (J6)</td><td rowspan="6">The Joffre Member is the thickest member of the Brockman Iron Formation, being up to 250 m thick when unmineralised. It consists of BIF and shale bands; however, the shale bands are generally discontinuous. The Joffre Member has an informal subdivision into six strands (J1 to J6), with the ‘odd’ strands (J1, J3 and J5) being relatively shale rich and the ‘even’ strands (J2, J4 and J6) being relatively shale poor.</td><td rowspan="6">Ranges from medium to high, depending upon degree of cavities/ weathering/ enrichment and the proportions of shale to BIF/ chert.<br>Shale bands expected to be relatively impermeable (except where faulted) and may act as barrier to dispersal.<br>Dolerite sills occurring throughout the J3 band may form a potential barrier for subterranean species.</td></tr>
<tr><td>Unit 5 (J5)</td></tr>
<tr><td>Unit 4 (J4)</td></tr>
<tr><td>Unit 3 (J3)</td></tr>
<tr><td>Unit 2 (J2)</td></tr>
<tr><td>Unit 1 (J1)</td></tr>
<tr><td rowspan="2">Whaleback Shale Member (BW)</td><td>WS2</td><td rowspan="2">Approximately 50 m thick, this member comprises interbedded chert and shale bands, and some very minor BIF bands. It is subdivided from the base into Whaleback Shale 1 (WS1) and Whaleback Shale 2 (WS2). WS1 consists of two thick shale bands and a lower thin chert rich BIF and a thick (2-3 m) BIF band. WS2 consists of interbedded shale and chert bands.</td><td rowspan="2">Ranges from medium to high, depending upon degree of cavities/ weathering/ enrichment and the proportions of shale to BIF/ chert. Shale bands expected to be less permeable (except where faulted).</td></tr>
<tr><td>WS1</td></tr>
<tr><td colspan="2">Dales Gorge Member (BD)</td><td>The Dales Gorge Member is approximately 142 m thick and comprises 16 interbedded BIF and shale bands which have been labelled B0 to B16 and S0 to S16 respectively.</td><td>Ranges from medium to high, depending upon degree of cavities/ weathering/ enrichment and the proportions of shale to BIF/ chert. Shale bands expected to be relatively impermeable (except where faulted) and may act as barrier to dispersal.</td></tr>
</table>

| Unit | | Description | Generalised suitability for subterranean fauna AWT/ BWT |
|---|---|---|---|
| Mount McRae Shale Formation (HR) | | A 50 to 60 m thick shale sequence comprising two main strands, the lower shale rich (pyrite rich black shale when fresh) zone and the upper Colonial Chert Member (referred to as the Foot Wall Zone (FWZ)). | Low (potential barrier to species dispersal). |
| Mount Silvia Formation (HS) | | Comprises three BIF bands, separated by chert shale sequences. Thickness varies from 30 to 45 m. At Western Range, the Mt Sylvia Formation is largely covered by a thin scree layer. | Ranges from medium to low, as cavities/ weathering/ enrichment less prevalent than BrIF. Shale bands expected to be less permeable (except where faulted). |
| Wittenoom Formation (HD) | Bee Gorge Member (HG) | The Member ranges in thickness from 100 to 227 m and consists of an upper shale and dolomite sequence, also containing subordinate thickness of carbonate, chert, volcaniclastics and BIF. | Ranges from medium to high, depending upon degree of cavities/ weathering/ enrichment and the proportions of shale to BIF/ dolomite. Shale bands expected to be less permeable (except where faulted). |
| | Paraburdoo Member (HP) | Comprises a majority of dolomite with minor chert and argillite partings. The thickness ranges from 260 and 420 m. | Ranges from medium to high, depending upon degree of cavities/ weathering/ enrichment and the proportions of shale to BIF/ dolomite. Shale bands expected to be less permeable (except where faulted). |
| | West Angela Member (DA) | The member ranges in thickness from 30 to 50 m and consists of a basal shale and BIF section, interbedded with dolomite and dolomitic argillite. | Ranges from medium to low, as cavities/ weathering/ enrichment less prevalent than other Wittenoom Members. |
| Marra Mamba Iron Formation (HM) | Mount Newman Member (MN) | Banded iron interbedded with carbonate and shale, between 45 and 60 m thick containing eight identified shale bands. | Ranges from medium to high, depending upon degree of cavities/ weathering/ enrichment and the proportions of shale to BIF/ carbonate. Shale bands expected to be less permeable (except where faulted). |
| | McLeod Member (MM) | Banded iron, chert and carbonate along with interbedded shales, 25 to 45 m. The upper most beds contain the most shale units, closely spaced together. | Ranges from high to low, depending upon degree of cavities/ weathering/ enrichment and the proportions of shale to BIF/ carbonate. Shale bands expected to be less permeable (except where faulted). |
| | Nammuldi Member (MU) | Cherty, banded iron formation interbedded with thin shales. The un-mineralised Nammuldi Member is between 75 and 100 m thick | Ranges from medium to low, as typically massive and cavities/ weathering/ enrichment less prevalent than other MMIF Members. |
| **Fortescue Group** | | | |
| Jeerinah Formation (FJ) | | Consists of thin basalts flows interbedded with shale, chert, BIF, mudstone, quartzite and thinly bedded dolomite. A thin cover of calcrete and/or soil covers much of the Jeerinah Formation within the area. | Ranges from medium to low, as cavities/ weathering/ enrichment less prevalent than other BrIF/ MMIF. Calcrete and dolomite overlying the Jeerinah Formation regarded as high suitability. |

Note: Geological descriptions were obtained from RTIO (2013).

## 3.3 Potential troglofauna habitat summary

In summary, the existing geological information and regional stratigraphy indicate that prospective habitats for troglofauna (AWT) are likely to occur throughout the Study Area. Geological units that are known to provide highly suitable troglofauna habitat (where sufficiently weathered/ fractured), such as BrIF, MMIF, and potentially Wittenoom Dolomite span large areas of the Paraburdoo Ranges (Figure 3.2). Meanwhile other geologies that may provide some suitable habitat AWT occur in patches between and surrounding the main ranges, including calcrete, Robe Pisolite, surficial hematite-goethite deposits, and unconsolidated/ partly consolidated detrital deposits (see Figure 3.2 for surface expressions of these units). The Paraburdoo Ranges have been subjected to major fracturing/ faulting and structural deformations, which may enhance localised habitat values for troglofauna, but which may also cause localised compartmentalisation and habitat discontinuities throughout the Study Area.

## 3.4 Surface drainage and indicative catchments

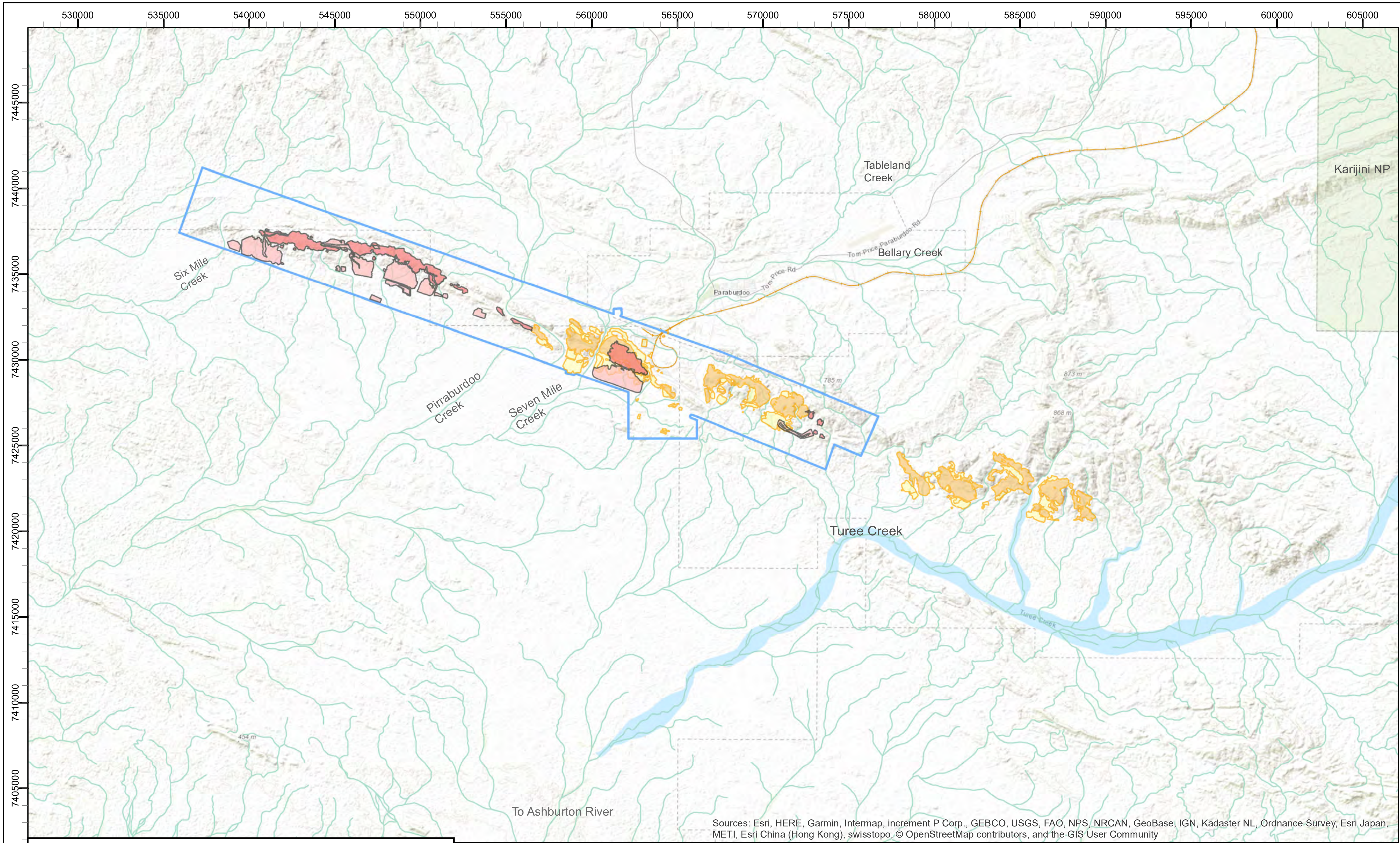
The Study Area is located within a series of ephemeral tributaries of the Ashburton River Basin, including Turee Creek, Six-Mile Creek, Seven-Mile Creek, and Pirraburdoo Creek. Flow directions are generally from north east to south west, intersecting the north west- south east trending Paraburdoo Ranges at roughly perpendicular angles (Figure 3.3).

Pirraburdoo Creek flows through the western portion of the Paraburdoo mining area, separating the 11W and 4W deposits before joining Seven-Mile Creek south west of the Paraburdoo Ranges (Figure 3.3). The Pirraburdoo catchment is located to the north of the Paraburdoo Ranges and spans roughly 482 km$^2$. The catchment has a geology dominated by largely impermeable volcanic rocks, therefore only modest rainfall is needed to generate substantial surface water flows (RTIO 2016*a*).

Seven-Mile Creek passes through the Paraburdoo Ranges at ~340 mRL within a 200 m wide valley that separates Paraburdoo's 4W and 4E deposits (RTIO 2018). Seven-Mile Creek discharges into the Ashburton River at Deolan Pool, approximately 58 km downstream of the Study Area. Seven-Mile Creek periodically floods following heavy rainfall, with flows up to 2 m recorded. Ephemeral pools occur upstream and downstream of the mine as surface flows recede. The Seven-Mile Creek catchment is located to the north of the ranges, spanning roughly 1200 km$^2$, with the Bellary Creek as a major tributary (Figure 3.3) (RTIO 2016*a*).

The Western Range deposits are located west of the Paraburdoo mining area and straddle the catchment divide between Six-Mile Creek and Pirraburdoo Creek. A tributary of Six-Mile Creek cuts through the deposit at the western end of Western Range (Figure 3.3).

Turee Creek is located south of the Channar Mining Operations and hosts the Turee Creek Borefield (Figure 3.3). Turee Creek flows roughly from east to west along the southern edge of a valley bounded by the Brockman Iron Formation ridges to the north and the Wyloo Group to the south (RTIO 2017). Turee Creek is ephemeral, but large pools persist within the creek following surface flows. After turning southwards and then further westwards below the Channar Borefield, Turee Creek is sequentially joined by its tributaries from the north, including Seven-Mile Creek, Pirraburdoo Creek and Six-Mile Creek, before eventually merging with the Ashburton River.




**Legend**

- Local drainage
- Pilbara Rail
- Proposed Development Envelope

**Conceptual Footprint**

- Proposed Conceptual Disturbance
- Proposed Conceptual Mining Pits

**Existing and Approved Disturbance**

- Existing Approved Disturbance
- Existing Approved Mining Pits

N

1:200,000

0 2.5 5 10 km

biologic Environmental Survey

**Rio Tinto Iron Ore**

**Greater Paraburdoo Subterranean Fauna Survey**

**Fig. 3.3: Surface drainage of the Study Area and surrounds**

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

Size A3. Created 01/05/2019

## 3.5 Hydrogeology

The groundwater system around Greater Paraburdoo is relatively complex, with dolerite intrusions causing local compartmentalisation of groundwater catchments (Figure 3.4) (RTIO 2018). As is commonly found throughout the Hamersley Ranges, fractured rock aquifers dominate the hydrogeological setting of Greater Paraburdoo, as the underlying geology is mainly impermeable (RTIO 2018). A summary of local aquifers, aquitards and aquicludes appears below, as characterised by groundwater operating areas (bore fields) for the current mining operations.

### 3.5.1 Pirraburdoo Creek Borefield (PBCK)

The Pirraburdoo Creek Borefield is positioned where the Pirraburdoo Creek passes through the Paraburdoo Ranges, separating 11W and 4W deposits and then joining with Seven-Mile Creek south-west of the Ranges.

The direction of groundwater flow is from north-west to south-east and is influenced by water flow and subsequent groundwater recharge from Pirraburdoo Creek. Groundwater flow is likely constrained by the bedrock (Hedley and Hundi 2014) and the presence of dolerite dykes in Pirraburdoo Creek (RTIO 2016*b*), potentially inhibiting groundwater flow to support the groundwater dependent species. The groundwater level is approximately ~337 mRL (Rathbone 2005).

### 3.5.2 Seven-Mile Creek Borefield (7MCK)

The Seven-Mile Creek Borefield is positioned where the Seven-Mile Creek passes through the Hamersley Ranges at ~340 mRL, within a 200 m wide valley that separates Paraburdoo's 4E and 4W Deposits (RTIO 2018). At this point, interaction between the alluvial aquifer and the underlying and adjacent Orebody aquifers occurs, before the creek exits on the south-west side of the range. Hydrogeological information suggests potential groundwater throughflow between the Seven-Mile Creek Borefield aquifers and the Southern Borefield aquifers only when surface flows or flooding occurs in Seven-Mile Creek. Under most conditions, the aquifers within Seven-Mile Creek are locally restricted and compartmentalised by intrusives, faults and geological discontinuities (RTIO 2018).

The predominant regional groundwater flow direction is from north east to south west, influenced by surface water flows and subsequent groundwater recharge from Seven-Mile Creek. The groundwater levels range from ~345 mRL in the north to ~335 mRL where Seven-Mile Creek exits the Hamersley Range (RTIO 2018). Groundwater flow in the Seven-Mile Creek Borefield is currently influenced by dewatering in the 4E pit (RTIO 2018).

### 3.5.3 Southern Borefield (SBF)

The Southern Borefield (previously Mine Wellfield) is positioned to the south of the Paraburdoo Range and is bound between the neighbouring Pirraburdoo and Seven-Mile creeks (RTIO 2016*a*). It abstracts water from a sequence of alluvials and the Wyloo Group. Recharge is primarily *via* infiltration from rainfall runoff and potentially through adjacent alluvial aquifers. Groundwater flow received from the north of the ranges is suspected to be limited. This may be due to the presence of dolerite dykes in Pirraburdoo Creek (11W deposit) and Seven-Mile Creek inhibiting groundwater flow (RTIO 2016*b*), or due to groundwater flow being constrained by the bedrock within the Ranges (RTIO 2016*a*). The depth to water is approximately 4 to 50 metres below ground level (mbgl) (~294 - 343 mRL). Groundwater flow in the Southern Borefield is currently influenced by dewatering in the 4W and 4E pits (RTIO 2015).

#### 3.5.4 Channar Borefield (CHN)

The Channar Borefield is located within the Turee Creek catchment, with the Turee Creek located in the valley to the immediate south of the borefield. No permanent water features exist within the borefield.

The Channar Borefield is hosted within a sequence of alluvial, colluvial and chemical sediments, located central to the Turee Creek palaeovalley (RTIO 2017). It also extends into the underlying fractured basement rocks that are associated with a series of northwest trending shear zones. The present course of Turee Creek is along the southern edge of the valley, which is bounded by ridges of outcropping Brockman Iron Formation to the north and Wyloo Group rocks to the south. The depth to water is approximately 2 to 60 mbgl (RTIO 2017) and the dominant direction of groundwater flow within the palaeovalley follows the topography, that is, from east to west.

#### 3.5.5 Turee Creek Borefield (TCK)

The Turee Creek Borefield is located within the Turee Creek catchment, with the Turee Creek located in the valley to the immediate south of the borefield.

The Turee Creek Borefield aquifer is hosted within a sequence of alluvial, colluvial and chemical sediments, located central to the Turee Creek palaeovalley. It also extends into the underlying fractured basement rocks that are associated with a series of northwest trending shear zones. The depth to water is approximately 3 to 50 mbgl (~343 – 389 mRL), and the dominant direction of groundwater flow within the palaeovalley follows the topography (east to west) (RTIO 2015).

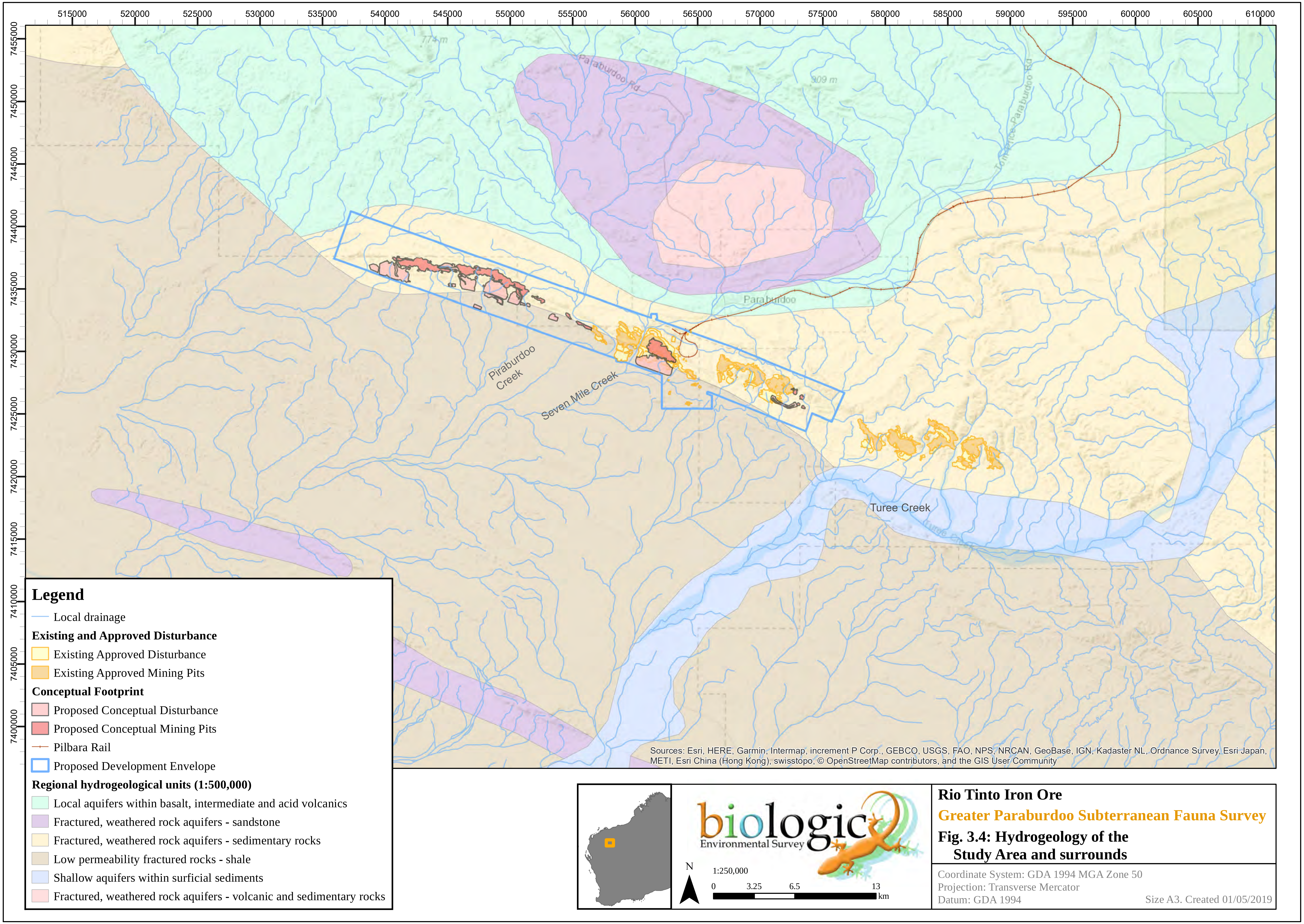
#### 3.5.6 Northern Borefield (NBF)

The Northern Borefield (previously Town Wellfield) is located within the Seven-Mile Creek catchment near Paraburdoo township. It draws water from the flood basalt and Hardey Sandstone of the Fortescue Group (and the calcrete and alluvial deposits overlying these formations in Seven-Mile Creek) for the purpose of potable water supply for the Paraburdoo township, airport and mine. The depth to water is approximately 9 to 27 mbgl (~354 – 401 mRL) and the dominant direction of groundwater flow follows the topography and Bellary Creek (east to west) (RTIO 2015).

## 3.6 Potential stygofauna habitat summary

In summary, the existing hydrogeological information indicates that several prospective groundwater habitats for stygofauna are likely to occur throughout the central and eastern parts of the Study Area. The groundwater habitats are known from six bore fields within the Paraburdoo, Channar/Turee Creek and Northern Borefield sampling areas, with limited groundwater investigations to date revealing potential stygofauna habitat at Western Range.

The Channar and Turee Creek Bore fields are adjacent to the Turee Creek in the south, suggesting that the stygofauna habitat within the groundwater of the two borefield is likely connected. Similarly, the Southern Borefield may be connected to the Pirraburdoo Creek and the Seven-Mile Creek bore fields; however, there is some evidence that groundwater flows between these habitats may be constrained by the presence of dolerite dykes in the area of the Paraburdoo Ranges (RTIO 2016*b*).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774 m
909 m
Paraburdoo Rd
Tom Price Paraburdoo Rd
Paraburdoo
Pirabordoo Creek
Seven Mile Creek
Turee Creek
Sources: Esri, HERE, Garmin, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), swisstopo, © OpenStreetMap contributors, and the GIS User Community
Legend
Local drainage
Existing and Approved Disturbance
Existing Approved Disturbance
Existing Approved Mining Pits
Conceptual Footprint
Proposed Conceptual Disturbance
Proposed Conceptual Mining Pits
Pilbara Rail
Proposed Development Envelope
Regional hydrogeological units (1:500,000)
Local aquifers within basalt, intermediate and acid volcanics
Fractured, weathered rock aquifers - sandstone
Fractured, weathered rock aquifers - sedimentary rocks
Low permeability fractured rocks - shale
Shallow aquifers within surficial sediments
Fractured, weathered rock aquifers - volcanic and sedimentary rocks
biologic
Environmental Survey
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Rio Tinto Iron Ore
Greater Paraburdoo Subterranean Fauna Survey
Fig. 3.4: Hydrogeology of the Study Area and surrounds
Coordinate System: GDA 1994 MGA Zone 50
Projection: Transverse Mercator
Datum: GDA 1994
Size A3. Created 01/05/2019

# 4. METHODS

## 4.1 Database search and review of previous reports

Five databases were searched for subterranean fauna records in July 2018 (Table 4.1):

- Department of Parks and Wildlife NatureMap database (DPaW 2018);
- Atlas of Living Australia (ALA 2018);
- Western Australian Museum (WAM) Arachnida/ Myriapoda database;
- WAM Crustacea database; and
- DBCA's Pilbara Stygofauna Survey species list (Halse *et al.* 2014).

All records were filtered based on collection methods and known stygofauna/ troglofauna taxonomic groups where information on subterranean status was not present in the data.

**Table 4.1. Databases searched for subterranean fauna records**

| Database | Parameters |
|---|---|
| NatureMap | 20 km radius around 23°13`50"S and 117°35`17"E |
| ALA | 10 km radius around 23°13`50"S and 117°35`17"E |
| WAM Arachnida/ Myriapoda<br>WAM Crustacea | Bounding box (approx.120 km x 80 km)<br>Northwest 22°40`00"S and 116°40`00"E<br>Southeast 23°49`60"S and 118°10`00"E |
| DBCA's Pilbara Stygofauna Survey | 40 km radius around 23°13`50"S and 117°35`17"E |

Reports from subterranean fauna surveys within and immediately surrounding the Study Areas were reviewed for local and regional context. Reports from relevant surveys are listed below:

- Hamersley Iron Stygofauna Sampling: 1998 – 2002 (Biota 2003);
- Western Range Troglofauna Survey (Biota 2009*a*);
- Turee Syncline Troglofauna Preliminary Assessment (Biota 2009*b*);
- Turee Syncline Iron Ore Project Troglofauna Survey (Bennelongia 2012); and
- Mining Area C – Southern Flank: Troglofauna Assessment (Bennelongia 2016).

## 4.2 Site selection and survey effort

Indicative locations of bores and drill holes sampled during the surveys are shown in Figure 4.1 and 4.2. The number and location of sampling holes were determined in consultation with RTIO field personnel and based upon;

- the location of suitably constructed, accessible drill holes and bores (and saturated river bed zones for Karaman sampling);
- ensuring good geographical spread throughout the Study Area in relation to impact, pre-impact, and reference areas;

- the extent of prospective geological and hydrogeological habitat units; and
- local knowledge of groundwater conditions within monitoring bores, based on the experience of RTIO site personnel.

A total of 290 bores and holes were sampled throughout the Study Area using the three major sampling methods (often including multiple methods at the same hole): 137 holes were sampled by troglofauna trapping, 210 holes were sampled by scraping, and 75 bores and holes were sampled by stygofauna net-hauling. Karaman sampling for stygofauna was performed at three sites, and an additional five active dewatering pump sites were sampled by running water from the pump release valve through a stygofauna net.

Treating each trap, scrape, net haul, Karaman, and pump sample separately, a total of 536 subterranean fauna samples were collected across five major sampling areas as follows:

- 175 samples at Western Range: including proposed deposits 33W to 66W;
- 209 samples at Paraburdoo: including proposed deposits 27W, 11W, and 4E extension; and water bores within the Pirraburdoo Creek (PBCK), Seven-Mile Creek (7MCK), and Southern Borefield (SBF);
- 115 samples at Eastern Range: reference areas 18EMM, 23EMM, and proposed deposits at 47E;
- 29 samples at the Channar/ Turee Creek bore fields (reference areas, respectively CHN and TCK); and
- Eight samples at the Northern/ Town Borefield (NBF) (reference area).

The number of troglofauna and stygofauna samples collected during each trip was as follows:

- Trip 1 (8 – 11 June 2017): 44 troglofauna traps deployed;
- Trip 2 (17 – 25 August 2017): 44 troglofauna traps, 67 troglofauna scrapes, 33 stygofauna haul nets, four stygofauna pumping samples and one Karaman sample collected;
- Trip 3 (in two parts, 17 – 25 April 2018 and 29 April – 4 May 201): 99 traps deployed, 120 troglofauna scrapes, 37 stygofauna haul nets, two stygofauna pumping samples and one Karaman samples collected; and
- Trip 4 (25 June – 4 July 2018): 99 troglofauna traps, 99 troglofauna scrapes and 24 stygofauna net haul samples collected.

In total, 431 troglofauna samples were collected by trapping (143) and scraping (288), and 105 stygofauna samples were collected by net-hauling (95), Karaman sampling (3) and pumping (7) during the survey.

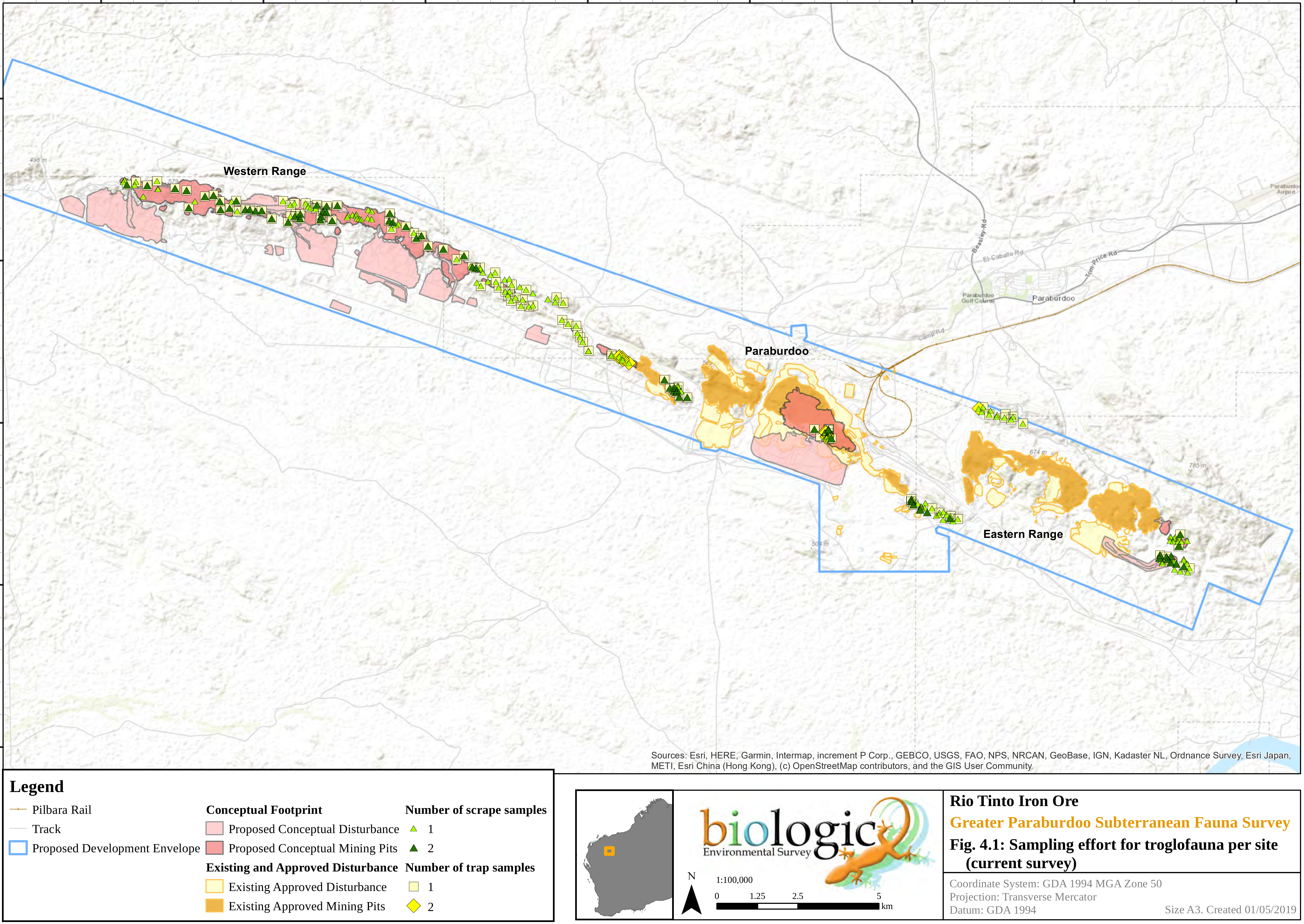
The ability to utilise different sampling methods at each site was dependent upon drill hole construction (uncased holes required for troglofauna), angle (near 90° dip required for scraping and net-hauling), groundwater presence (for stygofauna) and time-since drilling (>6 months required for stygofauna, following EPA 2016*b*).

Most stygofauna samples were obtained from the six bore fields at Paraburdoo (PBCK, 7MCK, and SBF), Channar/ Turee Creek (CHN and TCK) and the Northern Borefield (NBF), whereas troglofauna sampling was concentrated in the drill holes of the eastern (4E, 18EMM, 23EMM, 47E) and western deposits (11W, 27W, 36W-66W). Table 4.2 provides details of the number of samples collected within and nearby each sampling area with respect to the methods employed.

Full details of sampling sites can be found in Appendix 7a.

**Table 4.2: Numbers of samples collected within and near each sampling area**

| | Western Range | Paraburdoo | Eastern Range | Channar/Turee Creek | NBF | Total |
|---|---|---|---|---|---|---|
| Traps retrieved | 54 | 65 | 24 | 0 | 0 | **143** |
| Scrapes | 118 | 81 | 89 | 0 | 0 | **288** |
| Net hauls | 3 | 57 | 1 | 26 | 8 | **95** |
| Pump/ Karaman samples | 0 | 6 | 1 | 3 | 0 | **10** |
| **Troglofauna total** | **172** | **146** | **113** | **0** | **0** | **431** |
| **Stygofauna total** | **3** | **63** | **2** | **29** | **8** | **105** |




biologic Environmental Survey

**Rio Tinto Iron Ore**

**Greater Paraburdoo Subterranean Fauna Survey**

**Fig. 4.1: Sampling effort for troglofauna per site (current survey)**

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

Size A3. Created 01/05/2019

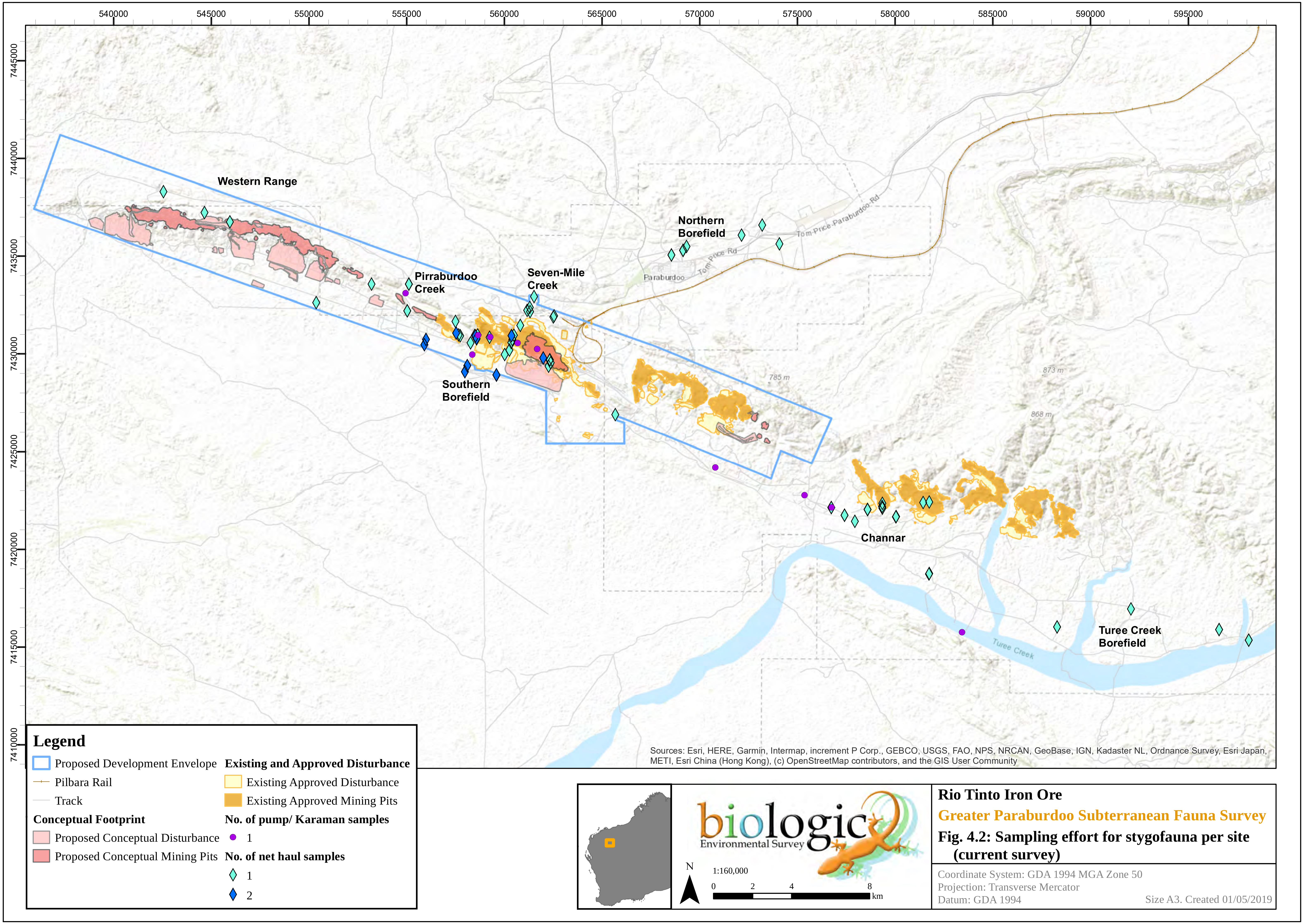


Fig. 4.2: Sampling effort for stygofauna per site (current survey)

## 4.3 Sampling methods

The sampling methods used were consistent with EAG #12 (EPA 2016*a*), Guidance Statement #54A (EPA 2016*b*) and the Stygofauna Sampling Protocol developed for the Pilbara Biodiversity Study Subterranean Fauna Survey (Eberhard *et al.* 2005, 2009). The field work was undertaken by Shae Callan, Erich Volschenk, Dean Main, Ray Lloyd and Syngeon Rodman. Laboratory sorting was undertaken by Shae Callan, Dean Main, Syngeon Rodman, Fabian Rudin, Mary van Wees, Dr Nihara Gunawardene, and Dr Erich Volschenk.

### 4.3.1 Troglofauna trapping

Trapping utilises custom made cylindrical PVC traps (approximately 50 mm x 300 mm) baited with decaying leaf litter (dead spinifex / acacia sourced from the Pilbara region), which were sterilised with boiling water. Traps are lowered *via* a nylon cord to a suitable depth and left in operation six to eight weeks, before being collected and transported back to the laboratory in Perth.

### 4.3.2 Troglofauna scraping

Scraping was undertaken at vertical, uncased drill holes (mainly at Greater Paraburdoo sites) using a reinforced 150 µm weighted stygofauna net, with a specialised scraping attachment used above the net to maximise gentle contact with the walls of the hole. The net was lowered and raised through the full length of the hole at least three (3) times for holes where no water was present, with each haul being emptied into a sample bucket as per net-hauling. Where the water table was intercepted, a combined net-haul / scrape sample was taken using the scraping attachment, comprising six (6) hauls throughout the full length of the hole from top to bottom, including both the air filled and below water subterranean habitats. The contents of the sample were elutriated, processed, and stored in 100 % ethanol as per net-hauling. Nevertheless, this technique can frequently result in stygofauna by-catch where scraping nets are lowered below the water table to collect any invertebrates that may have fallen past the net.

### 4.3.3 Stygofauna net-hauling

Stygofauna were sampled by standard net-hauling methods, using a plankton net of a diameter to suit each bore or drill hole (in most cases 30-80 mm). Each haul sample comprised a total of six hauls from the bottom of the hole to the top, with three hauls using a 150 µm mesh and three hauls using a 50 µm mesh. The base of the net was fitted with a lead weight and a sample receptacle with a base mesh of 50 µm. To stir up sediments, the net was raised and lowered at the bottom of the hole prior to retrieval and hauled at an even pace through the water column to maximise filtration of the water.

The sample from each haul was emptied into a bucket, which was elutriated after the final haul to remove coarse sediments and filtered back through the 50 µm net/ sample receptacle to remove as much water as possible. The sample was transferred to a 50-120 mL preservation vial (depending upon the quantity of sediment) and preserved in 100% ethanol. The ethanol and the samples were kept chilled on ice to facilitate cool-temperature DNA fixation.

#### 4.3.4 Karaman-Chappuis sampling

Stygofauna occupying shallow groundwater habitats beneath gravelly stream beds (hyporheos) were sampled by the Karaman-Chappuis (Karaman) method at sites where permanent pools or springs indicated the presence of near-surface groundwater. This technique involves excavation of a hole in the stream bed nearby a pool or flowing stream, approximately 50-100 cm diameter, and 30-50 cm depth below groundwater level. Care must be taken to choose substrates with mainly larger gravels and sand, rather than silt or clay. Water is bailed out of the hole using a bucket and sieved through a 150 µm stygofauna net as described above. As buckets of water are removed, care must be taken to avoid the same water flowing back into the hole – inflow of new hyporheic groundwater can usually be seen as clearer water entering from the upstream side of the hole. This process can be continued for any length of time depending on how quickly groundwater inflow continues to fill the hole, usually with the aim of sampling approximately 20-50 L in total.

Karaman sampling can be a very useful method of achieving samples where no or few bores/ drill holes exist (as long as there is near-surface groundwater) and can also be helpful to assess the potential for stygofauna species or communities to be more widely dispersed throughout the hyporheic zone of local drainage networks. These samples tend also to collect an abundance of surface fauna, which can be difficult to distinguish from stygofauna taxa where characters of eyelessness and pale cuticle are inherent throughout the group (*e.g.* worms, some crustaceans, some mites).

#### 4.3.5 Water physicochemistry

Prior to stygofauna sampling, a groundwater sample was collected using a 1m plastic cylindrical bailer, for the purposes of physicochemical measurements. The bailer was lowered down the hole until reaching groundwater and a water sample was collected at a depth of 2 m below the surface. As such the results were not indicative of water parameters throughout the entire bore (or aquifer) but rather provide a general indication of near surface conditions. Conditions sampled during pumping were measured using a sample collected from the pump outflow, which would have artificially increased the dissolved oxygen readings. Groundwater physicochemical data (including EC, pH, TDS, Redox ORP, and dissolved $O_2$) was measured using a multi-parameter water meter. Constrictions in piezometer bores, blockages from root material, or excessive depths to groundwater inhibited the collection of physicochemical readings at some sites.

### 4.4 Sorting and taxonomy

Sorting and parataxonomy were undertaken in-house using dissecting microscopes. The personnel involved (S. Callan, D. Main, S. Rodman, F. Rudin, M. van Wees, N. Gunawardene, and E. Volschenk) were all suitably trained and experienced in sorting and parataxonomy of subterranean fauna.

Parataxonomy of the specimens utilised published literature and taxonomic keys where available. Each morphospecies from each sample was assigned a separate labelled vial and labelled with a specimen tracking code. Taxonomic groups were examined in as much detail as possible using in-house expertise, before sending a reference collection to specialist taxonomists for detailed taxonomic advice. Species comparisons and alignments were performed using regional specimens collected beyond the Study Area throughout the wider sub-regional area. The taxonomists undertaking specialist identifications and regional alignments included J. McRae, S. Halse and M. Scanlon.

## 4.5 DNA analysis

Molecular genetic analysis (DNA barcoding using the mitochondrial gene COI) was conducted at the WA Museum on certain subterranean taxa to validate morphological identifications and provide a basis for species-level identifications and regional comparisons where taxonomic resolution was limited. Refer to Appendix 3 for further details regarding the methods of DNA extraction, choice of primers, sequencing, and analysis.

## 4.6 Conservation status and SRE classification

A few subterranean species and assemblages from the Pilbara region are listed under relevant legislation as threatened species, or as Threatened or Priority Ecological Communities in certain locations. Any listed subterranean species or community is regarded as conservation significant although, due to a lack of survey effort and taxonomic certainty for the majority of subterranean fauna in the Pilbara region, there are many potentially range-restricted (SRE) or conservation significant species and communities that do not appear on these lists.

The likelihood of taxa representing SRE species (*i.e.* distribution <10,000 km$^2$ following Harvey 2002, or <1,000 km$^2$ following Eberhard *et al.* 2009) was assessed based on the known local species distribution, and regional comparisons where data was available, following advice from the WAM and other relevant taxonomic specialists. The assessment of SRE status was highly dependent on:

1. the degree of taxonomic certainty at the genus and species levels;
2. the current state of taxonomic and ecological knowledge for each taxon (including whether a regional genetic context has been investigated);
3. the scale and intensity of the local and regional sampling effort; and
4. whether or not relevant taxonomic specialists were available to provide advice.

The SRE status categories used in this report follow the WAM's categorisation for SRE invertebrates. This system is based upon the 10,000 km$^2$ range criterion proposed by Harvey (2002), and uses three broad categories to deal with varying levels of taxonomic certainty that may apply to any given taxon (Table 4.3). Owing to the fact that the majority of subterranean fauna are poorly known taxonomically, and the general limitations to sampling subterranean fauna, the majority of morphospecies invariably fall within one (or several) of the five Potential SRE sub-categories.

**Table 4.3: SRE categorisation used by WAM taxonomists**

<table>
<tr><th></th><th>Taxonomic Certainty</th><th>Taxonomic Uncertainty</th></tr>
<tr><td>Distribution<br><10 000$km^2$</td><td>Confirmed SRE<br>• A known distribution of < 10,000$km^2$.<br>• The taxonomy is well known.<br>• The group is well represented in collections and/ or via comprehensive sampling.</td><td rowspan="2">Potential SRE<br>• Patchy sampling has resulted in incomplete knowledge of geographic distribution.<br>• Incomplete taxonomic knowledge.<br>• The group is not well represented in collections.<br>• Category applies where there are significant knowledge gaps.<br><br>SRE Sub-categories may apply:<br>A) Data Deficient<br>B) Habitat Indicators<br>C) Morphology Indicators<br>D) Molecular Evidence<br>E) Research & Expertise</td></tr>
<tr><td>Distribution<br>>10 000$km^2$</td><td>Widespread (not an SRE)<br>• A known distribution of > 10,000$km^2$.<br>• The taxonomy is well known.<br>• The group is well represented in collections and/ or via comprehensive sampling.</td></tr>
</table>

The degree of stygomorphy or troglomorphy (observable physical adaptations to subterranean habitats such as eyelessness, depigmentation, elongation of sensory appendages and thinning of the cuticle) assessed to determine each morphospecies' 'subterranean status', *i.e.* whether a taxon was more or less likely to be an obligate subterranean species (stygobite/ troglobite). It is acknowledged that the current EPA guideline for subterranean fauna does not account for non-obligate subterranean fauna, stating, *"…subterranean fauna are defined as fauna which live their entire lives (obligate) below the surface of the earth.... Fauna that use a subterranean environment for only part of the day or season (e.g. soil-dwelling or burrowing species, cave-dwelling bats and birds) are not considered as subterranean fauna for this EAG*" (EPA 2013).

Nevertheless, there may be fauna with restricted distributions <10,000 $km^2$ following Harvey (2002), or <1,000 $km^2$ following Eberhard *et al.* (2009) that are of interest because of their SRE status, regardless of whether they can be definitively regarded as 'obligate' subterranean fauna. For this reason, this report presents an assessment of both the subterranean status and the SRE status of each taxon collected, to the best available knowledge.

In some cases where thorough sampling has been conducted and sufficient habitat information and ecological information is available, the potential occurrence of a taxon at a local scale may be inferred *via* the extent of habitats, particularly where the rest of the assemblages are highly similar, and the habitats appear well-connected. Despite the suggestion within the current EPA (2013) guidelines that related species' ranges may be used as surrogates for poorly-known species' ranges, the level of evidence required to support the identification of an appropriate surrogate is almost prohibitively high for most subterranean fauna, therefore this would only be investigated as a last resort.

## 4.7 Habitat assessment

Assessment of the extent, thickness, and connectivity of local geological habitats above and below water table was undertaken by creating a three-dimensional habitat model based on drill-hole logging data in the program Leapfrog® Geo v4.3.1. Drilling log data from reverse circulation and diamond core drill holes throughout the Study Area was compiled into a database in Microsoft Excel®. The drill log data was codified to indicate commonly encountered stratigraphic units (strands), as well as mineralisation and geomorphology (tags), using consistent codes/ terminology across all drilling campaigns undertaken throughout the Study Area. All strand/ tag code combinations were collaboratively assessed by a team of Biologic and Rio Tinto personnel experienced with geology, hydrogeology, and subterranean fauna surveys/ ecology, to determine the most likely categorisation for each geological unit (combination of strand and tag) in relation to its general suitability for subterranean fauna. Where strand/ tag combinations or their descriptions in the database were unclear, further advice was sought from Rio Tinto geologists and hydrogeologists experienced in the local geological setting. The habitat suitability assessment used the following categorisation system:

- **High**: strand/ tag indicates a geological unit that is known to frequently support subterranean fauna (AWT/BWT), including rich assemblages, in similar geological contexts in the Hamersley Ranges/ Pilbara region;
- **Medium (certain):** strand/ tag indicates a geological unit that is known to sometimes support subterranean fauna (AWT/BWT), or may support less rich assemblages in similar geological contexts in the Hamersley Ranges/ Pilbara region;
- **Medium (uncertain):** strand/ tag indicates a geological unit that is poorly sampled or not often associated with subterranean fauna assemblages (AWT/BWT), but may have potential to support subterranean fauna, based on known characteristics. This category was also used for geology/ geomorphology combinations that were difficult to categorise as certainly High, certainly Medium, or certainly Low because of a lack of information, knowledge, personal experience, or regional context; and
- **Low:** strand/ tag indicates a geological unit that is known to very rarely support subterranean fauna in similar geological contexts in the Hamersley Ranges/ Pilbara region, or typically lacks the physical characteristics required for supporting subterranean fauna (*i.e.* sufficient void spaces or porosity).

The assessment of suitability (of the strand/ tag combinations) for subterranean fauna was based upon the following criteria:

- Presence or likelihood of subterranean voids, cavities, fractures, faults, vugs, or other geomorphological characteristics that typically form habitat for subterranean fauna;
- Permeability and/or likelihood of secondary weathering (including mineralisation by supergene enrichment, secondary weathering, and hydrated mineralisation);

- Geological formation/ stratigraphic unit, and the typical processes occurring within each unit that create and influence subterranean fauna habitat, within the local context of the Study Area; and
- Personal experience with subterranean fauna surveys and habitat assessment, and results from previous studies in similar geological contexts throughout the Hamersley Ranges/ Pilbara region.

Three-dimensional modelling of the extent of High and Medium (certain) habitats was undertaken by spatially linking the occurrence of High and Medium (certain) strands/tags within drill holes mapped in three-dimensional space throughout the Study Area, using Leapfrog® Geo software.

The resulting 3D volumes were then exported as 2D thickness grids of High and Medium (certain) habitats. These 2D grids were used to display the modelled thickness, spatial extent, and connectivity of High and Medium (certain) habitats throughout the drilled area of the Study Area. Low and Medium (uncertain) habitat units were not modelled or mapped as these were not considered significant habitat for subterranean fauna. ArcGIS® v10.6 was used for mapping. Pre-mining topography, bore/ drill hole locations, locations of sampling, and locations of key subterranean fauna species were added as separate layers for spatial reference.

The amount of High and Medium (certain) habitat available was modelled in 3D at three separate points in time to provide comparison of impacts:

a) Before any dewatering or mining activities (‘pre-mining’);
b) After current approved pits and dewatering activities (‘current’); and
c) After completion of all proposed pits and peak proposed dewatering (‘worst-case scenario’ (WCS)).

The ‘pre-mining’ modelling was based mainly upon data inference, as no baseline modelling was conducted prior to the commencement of the existing mining operations at Paraburdoo. The ‘current’ modelling (CUR) includes existing changes to AWT/ BWT habitat extent and impacts associated with current and existing approved mining, although there is no discernible difference between ‘pre-mining’ and ‘current’ habitat AWT at some areas, such as Western Range, which have not yet been approved for mining. The ‘worst-case scenario’ modelling (WCS) is based upon the full extent of mining and groundwater drawdown proposed under the current project proposal, with no allowance for groundwater recharge over time or any interactions with other groundwater processes beyond the scope of the modelling.

The inputs for the different scenarios came from 3D dewatering contours and mine pit shells modelled by other Rio Tinto internal technical teams. 3D volumes from all scenarios described above were then exported to 2D thickness grids.

The 3D volumes were also exported and viewed in Leapfrog® Viewer v4.11 so that 3D cross sections could be visualised and interrogated (see Appendices 4, 5 and 6).

Not all areas of the Study Area have been drilled, and the modelling is limited to the area within and immediately surrounding the locations of bores and drill holes; therefore, a 300 m buffer was used as a stopping point around the maximum extent of drilling, to provide a spatial indication of the area of confidence in the habitat modelling. Within this 300 m confidence boundary, the 3D habitat modelling is expected to be reasonably consistent with the data obtained from the drilling logs, while there is less confidence in habitat interpretations beyond this distance. Nevertheless, it is not suggested that suitable habitat ceases to occur beyond the 300 m confidence boundary; its occurrence is simply not supported by the same level of information. In addition, vertical threshold of 1 m was used as a conservative stopping point – any habitat modelled less than 1 m thick (AWT/ BWT) was omitted from the mapping/ cross sections.

## 4.8 Sampling adequacy

Sampling adequacy was assessed using species accumulation curves and species richness estimation models in the program EstimateS v 9.1.0 (Colwell 2013). Abundance data from the current survey was transformed into an appropriate matrix format for input into EstimateS using Microsoft Excel®, with each sample representing a unique combination of site/ visit/ method (*i.e.* traps and scrapes collected from the same hole were not combined). To adjust for the variabilities in taxonomic resolution and the effects of sub-sampling for DNA analysis, the stygofauna and troglofauna species data were filtered using a parsimonious approach to exclude higher-level identifications that could potentially represent other recorded species. In some instances, unique higher-level identifications were retained when it was determined that these could not potentially represent other recorded taxa (*e.g.* Aeolosomatidae worms, Pezidae water mites), although most higher-level taxa that were well-represented at lower taxonomic levels were excluded from the analysis (*e.g.* Hemiptera sp., Amphipoda sp.).

Data from previous Rio Tinto surveys in similar geological settings were also analysed using species accumulation curves to provide a comparison with the results from Greater Paraburdoo. Survey data used for this purpose comprised:

- Nammuldi – Silvergrass Troglofauna and Stygofauna Survey (Biota 2010, 2011), and
- Brockman Syncline 4 Marra Mambas Troglofauna Survey (Biota 2016a, 2016b).

Data from these surveys were chosen for being publicly available, covering similar geological settings, employing similar methods (trapping, scraping, and net hauling), and representing a reasonable sampling effort for stygofauna or troglofauna (exceeding the EPA minimum requirements). However, it was acknowledged that there were some considerable differences between these surveys and Greater Paraburdoo that may have limited the suitability of the data sets for comparison, particularly regarding the proportions of trapping to scraping sites, the widespread use of genetic analysis to confirm species identifications, and the multitude of potentially different habitat units sampled throughout Greater Paraburdoo in contrast to the other survey areas. These issues are discussed in more detail in section 5.6.

Data from the previous surveys was treated the same as Greater Paraburdoo data in the analysis and in terms of analysis settings, except that the parsimonious approach to filtering the species data was not required, and the stygofauna data from Nammuldi – Silvergrass (Biota 2010) was listed by site, not by sample; therefore the Greater Paraburdoo stygofauna data was also transformed to site based records for the species accumulation curves.

Species accumulation curves were plotted in Microsoft Excel® using EstimateS output data from S(est) and Coleman Rarefaction curves; separately for stygofauna and troglofauna and for each data set (Greater Paraburdoo, Nammuldi – Silvergrass, and Brockman Syncline 4). The analyses were run with the following settings in EstimateS:

- Abundance data by sample (troglofauna) or by site (stygofauna);
- 10,000 randomizations;
- No extrapolation;
- Estimate at every sample/ site;
- Classic formulas for Chao 1 & 2;
- Upper abundance limit for rare species = 2; and
- Randomizing individuals without replacement.

Species richness estimation was predicted from each dataset using coverage-based models ACE, Chao 1, Jackknife 1 (Jack 1), and Bootstrap (all mean values), while the Michaelis-Mentin (MMMeans 1 run) estimator was used to indicate a stopping point. The final value of S(est) (*i.e.* the observed species richness), was compared to each of the predicted species richness values from these models using a proportional bar chart in Microsoft Excel®, and values representing the observed species richness as a percentage of the predicted species richness under each model.

## 4.9 Limitations and constraints

Much remains uncertain regarding the taxonomy and ecological status of many subterranean fauna groups, and taxonomic frameworks are often poorly developed, which provides challenges for the interpretation of results and species distributions.

Many subterranean species (particularly troglofauna) are rare and difficult to detect throughout their potential range or extent of habitat. Subterranean fauna inhabit cryptic, concealed habitats which can only be accessed by bores/ drill holes that create an artificial disturbance to the habitat. As a result, surveys often show low detection rates, low survey completeness, and high numbers of infrequently detected species, even after relatively high sampling efforts featuring repeated sampling.

The results and conclusions of the survey are nevertheless based upon the best available information under these conditions, although in some cases, residual uncertainty is unavoidable.

Specific limitations relating to the current and previous survey data are listed below.

- The location of existing pits, groundwater drawdown, and disturbance from existing mining operations limited accessibility to drill holes in some areas (*e.g.* 42E, parts of 4E) and in active mining areas between the proposed deposits. Baseline information regarding subterranean fauna prior to mining was not available, due to the previous mining approvals preceding consideration of subterranean fauna during impact assessment.

- The location of existing drill holes and bores mainly within the proposed pits limited the ability to detect species and suitable habitats outside the impact areas in some areas such as Western Range. Excluding reference areas formed in MMIF at 18EMM and 23EMM, drilling in the Study Area has focussed on areas of BrIF. This has meant that most of the sampling and habitat assessment has been concentrated on BrIF habitats, limiting the ability to assess the wider occurrence of subterranean fauna species in other potentially suitable habitat strata.
- The availability and location of bores intercepting suitable groundwater (for stygofauna) and uncased holes (for troglofauna) were limiting factors in some areas. Despite the overall sampling effort meeting and exceeding EPA guidelines for consideration of subterranean fauna, the sampling effort per unit area or per habitat was uneven mainly due to the availability and location of suitable holes and bores for sampling.
- The planning of proposed mining areas and groundwater drawdown modelling was undertaken concurrently with the survey. All efforts were made to adaptively manage the layout of sampling sites between trips to target the areas of highest relevance to the proposed development; however, this increased the unevenness of sampling effort per unit area/ per habitat.
- The geological and hydrogeological complexity of the Study Area and the diversity of potential habitat units (AWT/BWT) were not well understood until after the habitat assessment results were available. In the context of the sampling effort constraints mentioned above, it is difficult to separate the potential effects of barriers/ habitat heterogeneity from potential sampling artefacts in order to assess species turnover and distribution ranges.
- Groundwater physicochemical measurements were limited by bailer sampling. Some bores/ holes were too deep (>70m) to allow a bailer sample to be successfully brought to the surface. Due care was taken to exclude obviously erroneous results, but the process of collecting a bailer sample can physically alter some physicochemical measurements (*e.g.* dissolved oxygen, temperature).
- Specimens unable to be identified to species level by morphology alone (damaged, juvenile or incorrect sex) were assessed by genetic analyses where possible. Success rates of genetic analyses are limited by the state of preservation of the specimens and their handling during collection, sorting and parataxonomy. Biologic follows best practices in the field and lab to ensure adequate specimen preservation for genetic analysis; however, some sequencing failure is unavoidable. The overall success rate of genetic sequencing was relatively high (75.6 %); most of the DNA failures (19.2% of all samples) occurred due to DNA not assembling, amplifying or sequencing; while 5.2 % of samples were contaminated (Appendix 3).

- Statistical analysis of survey adequacy was complicated by difficulties in sampling and identifying species-level taxa, particularly for troglofauna assemblages (*i.e.* those featuring many rare and few common species). Subterranean fauna surveys often result in insufficient data for statistical analyses and/or datasets that violate the assumptions of statistical models. The necessity of sub-sampling for genetic identifications further complicates this, as statistical techniques generally assume consistent probability of detection from the sampling methods and consistent taxonomic effort across all groups.

Limitations relating to the habitat assessment and 3D modelling are as follows.

- The habitat modelling is a conservative estimate within the limitations of what can be inferred about subterranean fauna habitats from geological strand/ tag data. Only High and Medium (certain) habitats were mapped and modelled throughout the 300 m confidence boundary. Intrusive features such as dolerite dykes/ sills and geomorphological features such as faults/ fractures are poorly represented in the model, except where intercepted by drill holes and characterised as 'Low suitability', or 'High' suitability respectively. Low and Medium (uncertain) habitat units may still have some limited potential for subterranean fauna to occur, particularly along undetected fault/ fracture zones.
- The modelling is also limited to the information detected via drilling and inferences made within the immediate vicinity of the drill holes and bores, as described above within the 300 m confidence boundary. The drilling was in higher density in some areas, providing a clearer picture of the available extent and thickness of habitat, than in others. This is particularly relevant for stygofauna (BWT) habitats, as most of the drilling for resource exploration and definition did not intercept the water table, therefore the modelling of BWT habitats is limited to bore fields and patchy areas of deeper drilling.
- The assessment was limited to the suitability of geology and geomorphology as indicated by the strand/ tag combinations, while other biotic and abiotic factors that may potentially influence the likelihood of subterranean fauna occurrence could not be included. The main limitation of this for the assessment of troglofauna habitat was in relation to depth from the surface – it would be reasonable to expect that troglofauna habitat quality would decline at depth from surface (in most geologies, except for highly cavernous/ karstic geologies) as greater depth increases the likelihood of sediments or pressure filling voids and reduces the amount of weathering. Nevertheless, the assessment found that most High suitability habitats were found to occur at the top of the geological profile, atop Medium (certain) and Medium (uncertain) habitats in any case, so this limitation may only apply to the Medium (certain) habitats at greater depths from surface.
- However, for stygofauna habitat there was a greater array of physical/ hydrogeological (*e.g.* depth from surface, impermeable barriers, aquifer setting, and flow rates) and physicochemical characteristics (*e.g.* pH, salinity, dissolved oxygen) that are known to have a strong influence on stygofauna likelihood and assemblage richness. Unfortunately,

these were unable to be incorporated into the assessment of groundwater habitat suitability, extent, and connectivity, which was based solely on the same combinations of strands/tags occurring below water table. For this reason, combined with the lower number and spatial spread of drill holes intercepting and extending beneath the water table (which reduced the area of BWT habitat modelling and created artificial patchiness), the BWT habitat modelling is considered less reliable overall than the AWT habitat modelling.

# 5. RESULTS

## 5.1 Database searches

The NatureMap search revealed three potential troglofauna taxa from Araneae, Coleoptera, and Hemiptera within 20 km surrounding the Greater Paraburdoo area (Table 5.1). The ALA database search did not reveal any additional records of potentially subterranean invertebrates.

**Table 5.1: Troglofauna and stygofauna morphospecies recorded in the NatureMap and ALA online databases (search parameters as per Table 4.1)**

| Higher taxon | Morphospecies | Likely subterranean status | SRE status where known |
|---|---|---|---|
| Araneae | Gnaphosidae sp. indet. | Potential troglofauna | Uncertain |
| Coleoptera | Carabidae sp. indet. | Potential troglofauna | Uncertain |
| Hemiptera | Phaconeura sp. indet. | Potential troglofauna | Uncertain |

The WAM and DBCA's Pilbara Stygofauna Survey records within 40 km of the Study Area revealed six troglofauna/ potential troglofauna taxa comprising cockroaches, millipedes, pauropods, pseudoscorpions, and isopods, and 78 stygofauna/ potential stygofauna taxa comprising mites, amphipods, aphanoneurans, gastropod snails, rotifers, cyclopoid and harpacticoid copepods, isopods, nematodes, oligochaetes, ostracods, syncarids, and flat worms (Table 5.2). Of these, two troglofauna taxa and 12 stygofauna taxa were recorded within the Study Area (Table 5.2, taxa marked with an asterisk). The locations of all troglofauna and stygofauna WAM records within 40 km of the Study Area are shown in Figure 5.1.

Based on current knowledge, none of the named troglofauna or stygofauna taxa recorded from the database searches appear on any threatened species lists. Particularly for the stygofauna taxa, the majority of the records comprise widespread species that are known to occur beyond the Study Area. However, owing to the indeterminate identifications of many of the taxa recorded, a number of records cannot be assessed for wider local/ regional distributions.

Full records within the search parameters from the WAM and DBCA's Pilbara Stygofauna Survey can be found in Appendix 7b.

**Table 5.2: Troglofauna and stygofauna morphospecies recorded in the WAM and DBCA's Pilbara Stygofauna Survey databases within 40 km of the Study Area (search parameters as per Table 4.1)**

| Taxonomy | Likely subterranean status | SRE status where known | Source |
|---|---|---|---|
| **Pseudoscorpiones** | | | |
| *Lagynochthonius* \`PSE038\` | Troglofauna | Potential SRE | WAM |
| **Pauropoda** | | | |
| Pauropodidae \`sp. B19\` | Troglofauna | Potential SRE | WAM |
| **Blattodea** | | | |
| *Nocticola* \`sp. BLA001\` | Troglofauna | Potential SRE | WAM |
| **Polyxenida** | | | |
| Lophoproctidae \`Helix clade A\` | Potential troglofauna | Widespread | WAM |
| Lophoproctidae \`Helix clade B\`* | Potential troglofauna | Widespread | WAM |
| **Gastropoda** | | | |
| Planorbidae sp. indet. | Stygofauna | Uncertain | DBCA |
| **Rotifera** | | | |
| Bdelloidea sp. indet. | Stygofauna | Uncertain | DBCA |
| **Platyhelminthes** | | | |
| Turbellaria sp. D4: ED4: E278 | Stygofauna | Widespread | DBCA |
| **Nematoda** | | | |
| Nematoda sp. 10 | Stygofauna | Potential SRE | DBCA |
| **Polychaeta** | | | |
| *Aeolosoma* sp. 1* | Stygofauna | Widespread | DBCA |
| *Aeolosoma* sp. 4 (cf. *travancorense*) | Stygofauna | Widespread | DBCA |
| **Oligochaeta** | | | |
| Phreodrilid DVC (dissimilar ventral chaetae) | Stygofauna | Widespread | DBCA |
| Phreodrilid SVC (similar ventral chaetae) | Stygofauna | Widespread | DBCA |
| *Pristina aequiseta** | Stygofauna | Widespread | DBCA |
| *Pristina longiseta* | Stygofauna | Widespread | DBCA |
| Tubificidae stygo type 2A | Stygofauna | Widespread | DBCA |
| Phreodrilidae sp. indet. | Stygofauna | Uncertain | DBCA |
| **Acari** | | | |
| *Arrenurus* \`Janine 2\` | Potential stygofauna | Uncertain | WAM |
| *Arrenurus* \`Janine 3\` | Potential stygofauna | Uncertain | WAM |
| *Arrenurus* sp. S3 | Stygofauna | Widespread | DBCA |
| *Arrenurus* sp. S4 | Stygofauna | Potential SRE | DBCA |
| *Guineaxonopsis* sp. indet. | Potential stygofauna | Uncertain | WAM |
| Halacaridae sp. 1 | Stygofauna | Widespread | WAM & DBCA |
| Halacaridae sp. S3 | Stygofauna | Potential SRE | DBCA |
| Oribatida group 1 | Stygofauna | Widespread | DBCA |
| *Recifella* \`sp. 1\` | Potential stygofauna | Widespread | WAM |
| *Tiramideopsis lictus* | Potential stygofauna | Widespread | WAM |
| *Tiramideopsis* sp. indet. | Stygofauna | Uncertain | DBCA |
| Arrenuridae sp. indet. | Stygofauna | Uncertain | DBCA |

| Taxonomy | Likely subterranean status | SRE status where known | Source |
|---|---|---|---|
| Acariformes sp. indet. | Stygofauna | Uncertain | DBCA |
| **Ostracoda** | | | |
| *Areacandona astrepte* | Stygofauna | Widespread | DBCA |
| *Areacandona atomus* | Stygofauna | Widespread | WAM |
| *Areacandona scanloni* | Stygofauna | Widespread | DBCA |
| *Areacandona* sp. 5* | Stygofauna | Potential SRE | DBCA |
| *Areacandona* sp. 8 | Stygofauna | Potential SRE | DBCA |
| *Candonopsis pilbarae* | Stygofauna | Widespread | WAM & DBCA |
| Darwinulidae sp. indet. | Stygofauna | Uncertain | DBCA |
| *Deminutiocandona aporia* | Stygofauna | Widespread | WAM & DBCA |
| *Deminutiocandona atope* | Stygofauna | Widespread | DBCA |
| *Deminutiocandona mica* | Stygofauna | Widespread | DBCA |
| *Deminutiocandona quasimica* | Stygofauna | Widespread | DBCA |
| *Deminutiocandona stomachosa* | Stygofauna | Widespread | WAM & DBCA |
| *Deminutiocandona* sp. 1 | Stygofauna | Widespread | DBCA |
| *Gomphodella hirsuta* | Stygofauna | Widespread | DBCA |
| *Gomphodella* sp. 1 | Stygofauna | Potential SRE | DBCA |
| *Gomphodella* sp. 3 | Stygofauna | Widespread | DBCA |
| *Gomphodella* sp. 4 | Stygofauna | Widespread | DBCA |
| *Gomphodella* sp. 5* | Stygofauna | Potential SRE | DBCA |
| *Gomphodella* cf. sp. 5 | Stygofauna | Potential SRE | DBCA |
| *Humphreyscandona adorea* | Stygofauna | Widespread | DBCA |
| *Humphreyscandona imperfecta* | Stygofauna | Widespread | DBCA |
| *Humphreyscandona* sp. 2 | Stygofauna | Widespread | DBCA |
| *Leicacandona carinata* | Stygofauna | Widespread | DBCA |
| *Origocandona inanitas** | Stygofauna | Widespread | DBCA |
| *Pilbaracandona* sp. 3* | Stygofauna | Potential SRE | DBCA |
| *Pilbaracandona* sp. 4 | Stygofauna | Potential SRE | DBCA |
| *Gomphodella* sp. indet. | Stygofauna | Uncertain | DBCA |
| Ostracoda (Unident.)* | Stygofauna | Uncertain | DBCA |
| **Cyclopoida** | | | |
| *Apocyclops dengizicus* | Stygofauna | Widespread | DBCA |
| *Diacyclops cockingi* | Stygofauna | Widespread | WAM & DBCA |
| *Diacyclops humphreysi humphreysi** | Stygofauna | Widespread | WAM & DBCA |
| *Diacyclops sobeprolatus* | Stygofauna | Widespread | DBCA |
| *Mesocyclops brooksi* | Stygofauna | Widespread | DBCA |
| *Microcyclops varicans* | Stygofauna | Widespread | DBCA |
| *Thermocyclops* sp. indet. | Stygofauna | Uncertain | WAM |
| **Harpacticoida** | | | |
| *Abnitocrella halsei* | Stygofauna | Widespread | WAM & DBCA |
| *Parapseudoleptomesochra tureei* | Stygofauna | Widespread | WAM & DBCA |
| *Parastenocaris jane* | Stygofauna | Widespread | WAM & DBCA |
| *Parastenocaris* nr jane | Stygofauna | Potential SRE | WAM |

| Taxonomy | Likely subterranean status | SRE status where known | Source |
|---|---|---|---|
| *Parastenocaris* sp. 3 | Stygofauna | Widespread | DBCA |
| *Rockleanitocrella'* ms sp. 1 | Stygofauna | Potential SRE | DBCA |
| *Schizopera cooperi* | Stygofauna | Widespread | WAM |
| *Schizopera roberiverensis* | Stygofauna | Widespread | WAM & DBCA |
| *Schizopera* sp. 3 | Stygofauna | Potential SRE | DBCA |
| *Schizopera* sp. 4 | Stygofauna | Potential SRE | DBCA |
| *Parastenocaris* sp. indet. | Stygofauna | Uncertain | DBCA |
| **Syncarida** | | | |
| *Atopobathynella* sp. A | Stygofauna | Widespread | DBCA |
| **Amphipoda** | | | |
| *Chydaekata breviclava* | Stygofauna | Widespread | WAM |
| *Chydaekata nudula* | Stygofauna | Widespread | WAM |
| Bogidiellidae sp. 1 | Stygofauna | Widespread | DBCA |
| Melitidae sp. 1 | Stygofauna | Widespread | DBCA |
| *Nedsia nr hurlberti** | Stygofauna | Widespread | DBCA |
| *Nedsia* sp. 24* | Stygofauna | Widespread | DBCA |
| *Nedsia* sp. 176 | Stygofauna | Potential SRE | DBCA |
| Paramelitidae sp. 2* | Stygofauna | Widespread | DBCA |
| *Pilbarus millsi** | Stygofauna | Widespread | DBCA |
| Paramelitidae sp. indet. | Stygofauna | Uncertain | DBCA |
| *Chydaekata* sp. indet. | Stygofauna | Uncertain | DBCA |
| *Nedsia* sp. indet.* | Stygofauna | Uncertain | DBCA |
| **Isopoda** | | | |
| *Haptolana yarraloola* | Stygofauna | Widespread | DBCA |
| *Kagalana tonde* | Stygofauna | Widespread | WAM & DBCA |
| Oniscidae sp. indet.* | Potential troglofauna | Uncertain | WAM |
| *Pygolabis eberhardi* | Stygofauna | Widespread | WAM & DBCA |
| *Pygolabis paraburdoo** | Stygofauna | Widespread | WAM & DBCA |
| *Pygolabis* sp. indet. | Stygofauna | Uncertain | DBCA |

Note: *Asterisk indicates taxon record/s from within the Proposed Development Envelope. Indeterminate taxa such as ‘*Symphyella* sp. indet.’ are not included in species counts as they represent specimens that cannot be allocated to the other known species based on current taxonomic information.

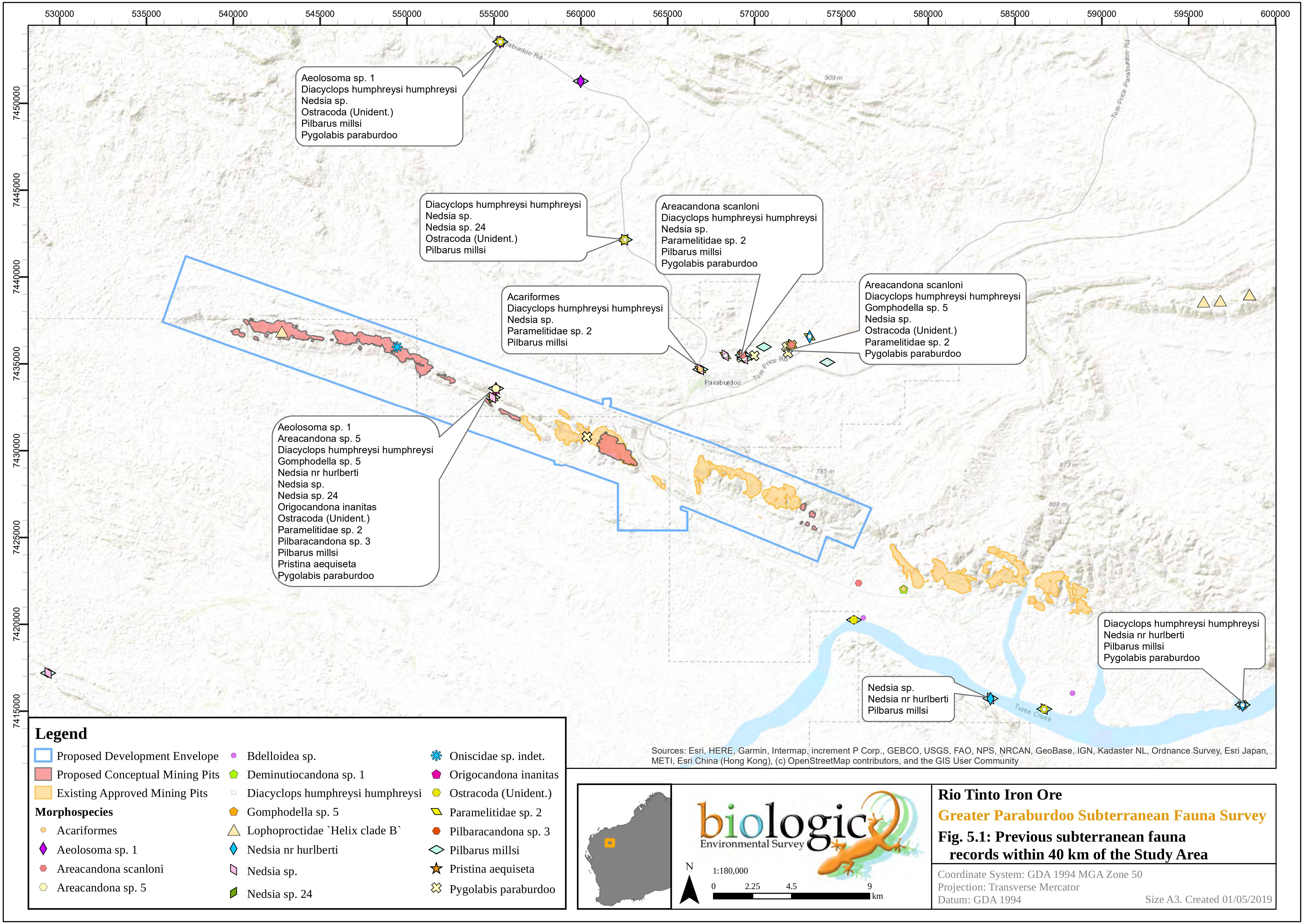



Fig. 5.1: Previous subterranean fauna records within 40 km of the Study Area

## 5.2 Previous survey results

Reports from subterranean fauna surveys within and immediately surrounding the Study Area were reviewed for local and regional context. Little previous subterranean fauna work has been conducted at Greater Paraburdoo, with only two surveys sampling bores/ drill holes within the Study Area. Owing mainly to the low number of nearby mining operations (*i.e.* within 50 km), previous sampling within the immediate local area has been relatively low, except for sites sampled in Seven-Mile Creek as part of the DBCA's Pilbara Stygofauna Survey (Halse *et al.* 2014). Table 5.3 provides key sampling details for the studies included in the comparison.

**Table 5.3: Summary of previous subterranean fauna survey effort and results at Greater Paraburdoo**

| **Previous survey**<br>**Author, year** | Hamersley Iron Stygofauna Sampling: 1998 - 2002<br>**Biota 2003** | Western Range Troglofauna Survey<br>**Biota 2009** | Turee Syncline Troglofauna Preliminary Assessment<br>**Biota 2009** | Turee Syncline Iron Ore Project, Troglofauna Survey<br>**Bennelongia 2012** | Mining Area C – Southern Flank: Troglofauna Assessment (EIA)<br>**Bennelongia 2016** |
|---|---|---|---|---|---|
| **Fauna targeted** | Stygofauna | Troglofauna | Troglofauna | Troglofauna | Troglofauna |
| **Areas sampled** | Paraburdoo, Giles Mini, Homestead, Marandoo | Western Range | Turee Syncline | Turee Syncline | Mining Area C (Southern Flank, Packsaddle & Jirrpalpur Range) |
| **Bores sampled** | 44 (at Greater Paraburdoo) | 34 (at Greater Paraburdoo) | 17 | 122 | 2746 samples (bore hole number not provided) |
| **Bores sampled in current deposits** | Approx. 19 | 34 | 0 | 0 | 0 |
| **Methods** | Net hauling | Trapping | Trapping | Trapping, Scraping | Trapping, Scraping |
| **Trog collected** | No | Yes | Yes | Yes | Yes |
| Araneae | | | | • | • |
| Blattodea | | | • | • | • |
| Coleoptera | | | | | • |
| Diplura | | | | • | • |
| Diptera | | | | | • |
| Geophilida | | | | • | • |
| Hemiptera | | | • | • | • |
| Isopoda | | | • | | • |
| Opiliones | | | | | • |
| Palpigradi | | | | | • |
| Pauropoda | | • | | | • |
| Polydesmida | | | | | • |
| Polyxenida | | • | • | • | • |
| Pseudoscorpiones | | | | • | • |

| Previous survey<br>Author, year | Hamersley Iron Stygofauna Sampling: 1998 - 2002<br>**Biota 2003** | Western Range Troglofauna Survey<br>**Biota 2009** | Turee Syncline Troglofauna Preliminary Assessment<br>**Biota 2009** | Turee Syncline Iron Ore Project, Troglofauna Survey<br>**Bennelongia 2012** | Mining Area C – Southern Flank: Troglofauna Assessment (EIA)<br>**Bennelongia 2016** |
|---|---|---|---|---|---|
| Schizomida | | | | | • |
| Scolopendrida | | | | • | • |
| Spirobolida | | | | | • |
| Symphyla | | | | | • |
| Thysanura | | | | • | • |
| **Stygo collected** | Yes | No | No | No | No |
| Amphipoda | • | | | | |
| Copepoda | • | | | | |
| Isopoda | • | | | | |
| Oligochaeta | • | | | | |
| Ostracoda | • | | | | |
| Platyhelminthes | • | | | | |

**Surveys within the Study Area**

Biota's (2009*a*) Western Range survey sampled 34 bores for troglofauna (trapping) within the Western Range deposit at the western end of the Study Area (Table 5.3). Three specimens from two orders were recognised as potential troglofauna at the time of survey:

- Polyxenida sp. indet. (two specimens from bore RC03WR096);
- Pauropoda sp. indet. (single specimen from bore RC02WR123).

Due to the indeterminate identifications of these taxa, their likely SRE status is uncertain. Cross examination of the WAM data for Western Range revealed an additional specimen that could possibly represent troglofauna from Biota's (2009*a*) survey, although it was not recognised as such at the time. Figure 5.1 shows a single record of Oniscidae sp. indet. (an isopod from the WAM records) collected from a troglofauna trap by Biota, which aligns spatially with site RC02WR0130 in Western Range. This indicates that of three specimens of isopods collected during Biota's (2009*a*) survey, at least one may possibly represent an additional troglofauna record. Figure 5.1 also shows a single record of Lophoproctidae `Helix clade B` in the western part of Western Range – this record's location aligns spatially with bore RC03WR096, and therefore is likely to represent a taxonomic update of Polyxenida sp. indet. as listed above. Lophoproctidae `Helix clade B` was also recorded in the WAM data from approximately 50 km east of Western Range (Figure 5.1) and is therefore not restricted to the Study Area.

Biota (2003) conducted a stygofauna study between 1998-2002 within the Study Area, focusing on the middle and western half of the Greater Paraburdoo Development Envelope. 107 bores were sampled for stygofauna (net hauling), 44 of which were located at Greater Paraburdoo (Paraburdoo, Channar & Turee Creek deposits). Specimens from six orders (Amphipoda, Copepoda, Isopoda, Oligochaeta, Ostracoda, and Platyhelminthes) were recorded as potential stygofauna. However, as the survey was conducted at a time when identifications to species-level were not readily available, no assessment regarding likely SRE status can be made.

**Surveys within 50km of the Study Area**

Based on available reports, three troglofauna surveys have previously been conducted in the wider local area, namely:

- Biota's (2009*b*) troglofauna survey of Turee Syncline;
- Bennelongia's (2012) troglofauna survey at Turee Syncline; and
- Bennelongia's (2016) troglofauna survey at Mining Area C/ South Flank.

Biota's (Biota 2009*b*) survey sampled 17 bores for troglofauna (trapping) at Turee Syncline (Table 5.3). Specimens from four orders had troglomorphic features: Blattodea (*Nocticola* sp. indet.), Hemiptera, Isopoda and Polyxenida (Polyxenidae sp. indet.), however, the SRE status of these taxa cannot be assessed due to indeterminate identifications.

Bennelongia (2012) sampled 122 drill holes at Turee Syncline and collected 13 troglofauna species from nine orders in total (Table 5.3). A third of these species (Hemiptera sp. B2, Atelurinae sp. B2, *Nocticola* sp. B1, and Lophophrocitidae sp. B1) were found to have wide ranging distributions extending beyond Turee Syncline. The nine remaining species were only known to occur locally at Turee Syncline.

At Mining Area C, 126 troglofauna species from 19 orders were collected from 2746 samples between 2007 and 2016 (Bennelongia, 2016). Over 80% of these species (105 species) were found to have wide ranging distributions extending beyond Mining Area C, while 16 species were known only from Mining Area C and the immediate surrounding area. Four species (*Prethopalpus julianneae*, *Prethopalpus* sp. B15, nr *Andricophiloscia* sp. B16, and Philosciidae sp. B03) were regarded as potentially restricted to Mining Area C deposits, and one species (Parajapygidae 'DPL024') was known only from a single drill-hole.

## 5.3 Current survey results

The current survey recorded a total of 1415 subterranean fauna specimens from 96 bores and holes throughout the Study Area. Full specimen collection details are available in Appendix 7c.

### 5.3.1 Troglofauna results

A total of 180 troglofauna and potential troglofauna specimens were collected during the current survey, representing 39 species/ morphospecies and nine indeterminate taxa from the following taxonomic groups: Pseudoscorpiones, Palpigradi, Schizomida, Araneae, Isopoda, Scolopendrida, Polyxenida, Pauropoda, Symphyla, Diplura, Protura, Zygentoma, Hemiptera, and Coleoptera (Table 5.4). The locations of subterranean troglofauna collected during the survey are shown further below in Figure 5.2 (section 5.4.1).

**Table 5.4: Troglofauna taxa detected from the Study Area (current survey)**

| Class | Order | Morphospecies | Number of putative taxa, Identification status |
|---|---|---|---|
| **Arachnida** | | | **8** |
| | Pseudoscorpiones | *Tyrannochthonius* `WAM-CHTH001` | Genetic lineage |
| | | *Tyrannochthonius* `WAM-CHTH002` | Genetic lineage |
| | | *Lechytia* `WAM-LECYT001` | Genetic lineage |
| | Palpigradi | *Eukoenenia* `WAM-PALE001` | Genetic lineage |
| | | *Eukoenenia* `WAM-PALE002` | Genetic lineage |
| | | Palpigradi `B25` | Morphological |
| | Schizomida | *Draculoides* `WAM-DRAC001` | Genetic lineage |
| | Araneae | Araneae `WAM-ARAN001` | Genetic lineage |
| **Crustacea** | | | **4** |
| | Isopoda | *Troglarmadillo* `WAM-ARMD004` | Genetic lineage |
| | | *Troglarmadillo* sp. B67 | Morphological |
| | | Armadillidae `WAM-ARMD003` | Genetic lineage |
| | | *Paraplatyarthrus* `WAM-PARA001` | Genetic lineage |
| | | Armadillidae sp. indet.* | Indeterminate |
| **Myriapoda** | | | **12** |
| | Scolopendrida | *Cryptops* sp. indet. | Treated as unique |
| | | Scolopendrida sp. indet.* | Indeterminate |
| | Polyxenida | *Lophoturus madecassus* | Morphological |
| | | Polyxenida sp. indet.* | Indeterminate |
| | Pauropoda | *Decapauropus* `WAM-PAUD001` | Genetic lineage |
| | | *Decapauropus* `WAM-PAUD002` | Genetic lineage |
| | | *Decapauropus* `WAM-PAUD003` | Genetic lineage |
| | | *Decapauropus* `WAM-PAUD004` | Genetic lineage |
| | | *Decapauropus* `WAM-PAUD005` | Genetic lineage |
| | | Pauropoda sp. indet.* | Indeterminate |
| | Symphyla | *Scutigellera* `WAM-SCUTI002` | Genetic lineage |
| | | *Scutigellera* `WAM-SCUTI003` | Genetic lineage |
| | | *Scutigellera* `WAM-SCUTI004` | Genetic lineage |
| | | *Scutigellera* `WAM-SCUTI005` | Genetic lineage |
| | | *Scutigerella* sp. indet.* | Indeterminate |
| | | *Symphyella* `WAM-SYMPH002` | Genetic lineage |
| | | *Symphyella* sp. indet. | Morphological |
| **Entognatha** | | | **2** |
| | Diplura | Japygidae `WAM-DPLJ005` | Genetic lineage |
| | | Japygidae sp. indet.* | Indeterminate |
| | Protura | Protura `WAM-PROT001` | Genetic lineage |
| **Insecta** | | **3** | **12** |
| | Zygentoma | *Dodecastyla* `WAM-ZYGA001` | Genetic lineage |
| | | *Lepidospora* `WAM-ZYGC001` | Genetic lineage |
| | | *Trinemura* `WAM-ZYGS001` | Genetic lineage |
| | | *Trinemura* `WAM-ZYGS002` | Genetic lineage |
| | | *Trinemura* `WAM-ZYGS002-A` | Genetic lineage |
| | | *Trinemura* `WAM-ZYGS003` | Genetic lineage |
| | | *Trinemura* `WAM-ZYGS004` | Genetic lineage |

| Class | Order | Morphospecies | Number of putative taxa, Identification status |
|---|---|---|---|
| | | *Trinemura* `WAM-ZYGS005` | Genetic lineage |
| | | Nicoletiidae sp. indet.* | Indeterminate |
| | Hemiptera | *Oliarus?* `WAM-CIXO001` | Genetic lineage |
| | | *Phaconeura* `WAM-PHAC001` | Genetic lineage |
| | | *Phaconeura* `WAM-PHAC002` | Genetic lineage |
| | | *Phaconeura* sp. indet.* | Indeterminate |
| | | Hemiptera sp. indet.* | Indeterminate |
| | Coleoptera | *Gracilanillus* sp. B10 | Morphological |

*Note indeterminate taxa such as 'Nicoletiidae sp. indet.' are not included in the species counts as they represent specimens that cannot be allocated to the other known species based on current taxonomic information.

### 5.3.2 Stygofauna results

A total of 1235 stygofauna and potential stygofauna specimens were collected during the current survey, representing 63 species/morphospecies and eight indeterminate taxa from the following higher order groups: Polychaeta, Oligochaeta, Acari, Ostracoda, Cyclopoida, Harpacticoida, Syncarida, Amphipoda, and Isopoda (Table 5.5). The locations of subterranean stygofauna collected during the survey are shown further below in Figures 5.3, 5.4 and 5.5 (section 5.4.2).

**Table 5.5: Stygofauna taxa detected from the Study Area (current survey).**

| Order | Family | Morphospecies | Number of putative taxa, Identification status |
|---|---|---|---|
| **Polychaeta** | | | **1** |
| | Aelosomatidae | *Aeolosoma* sp. indet. | Treated as unique |
| **Oligochaeta** | | | **13** |
| | Enchytraeidae | Enchytraeidae `sp. E6 (11)` | Genetic lineage |
| | | Enchytraeidae `sp. E6 (2-4)` | Genetic lineage |
| | | Enchytraeidae `WAM-ENCH001` | Genetic lineage |
| | | Enchytraeidae `WAM-ENCH002` | Genetic lineage |
| | | Enchytraeidae `WAM-ENCH003` | Genetic lineage |
| | Naididae | Naididae` WAM NAID002` | Genetic lineage |
| | | *Pristina* `WAM-NAIDP001` | Genetic lineage |
| | | *Pristina longiseta* | Morphological |
| | | Naididae AP 5 sp. (Tubificoid) | Morphological |
| | | Naididae AP1A sp. (Tubificoid) | Morphological |
| | Phreodrilidae | Phreodrilidae `WAM-PHRE001` | Genetic lineage |
| | | Phreodrilidae `WAM-PHRE002` | Genetic lineage |
| | | Phreodrilidae sp. AP DVC s.l. | Morphological |
| | | Phreodrilidae sp. indet.* | Indeterminate |
| | Family unknown | Oligochaeta sp. indet.* | Indeterminate |
| **Acari** | | | **1** |
| | Pezidae | Pezidae sp. indet. | Treated as unique |
| **Ostracoda** | | | **11** |
| | Candonidae | *Deminutiocandona aporia* | Morphological |
| | | *Deminutiocandona stomachosa* | Morphological |
| | | *Deminutiocandona quasimica* | Morphological |

| Order | Family | Morphospecies | Number of putative taxa, Identification status |
|---|---|---|---|
| | | *Deminutiocandona* sp. BOS1149 nr *atope* | Morphological |
| | | *?Deminutiocandona* n. sp. `BOS1158` | Morphological |
| | | *?Deminutiocandona* n. sp. `BOS1160` | Morphological |
| | Darwinulidae | *Penthesilenula brasiliensis* | Morphological |
| | | *Vestalenula marmonieri* | Morphological |
| | Limnocytheridae | *Gomphodella* `WAM-OSTR001` | Genetic lineage |
| | | *Gomphodella* n. sp. `BOS1156` | Morphological |
| | | *Limnocythere dorsosicula* | Morphological |
| | Family unknown | Ostracoda sp. indet.* | Indeterminate |
| **Cyclopoida** | | | **13** |
| | Cyclopidae | *Australoeucyclops karaytugi* | Morphological |
| | | *Diacyclops* `WAM-CYLD001` | Genetic lineage |
| | | *Diacyclops* `WAM-CYLD002` | Genetic lineage |
| | | *Diacyclops humphreysi humphreysi* | Morphological |
| | | *Diacyclops cockingi* | Morphological |
| | | *Dussartcyclops mortoni* | Morphological |
| | | *Eucyclops australiensis* | Morphological |
| | | *Metacyclops* sp. B1 nr pilbaricus | Morphological |
| | | *Pescecyclops* `WAM-CYLP001` | Genetic lineage |
| | | *Microcyclops varicans* | Morphological |
| | | *Paracyclops chiltoni* | Morphological |
| | | *Thermocyclops* `WAM-CYLT001` | Genetic lineage |
| | | *Thermocyclops aberrans* | Morphological |
| | Family unknown | Cyclopoida sp. indet.* | Indeterminate |
| **Harpacticoida** | | | **10** |
| | Ameiridae | *Abnitocrella halsei* | Morphological |
| | | Ameiridae gen. nov. sp. B7 | Morphological |
| | | *Parapseudoleptomesochra tureei* | Morphological |
| | Miraciidae | *Schizopera roberiverensis* | Morphological |
| | | *Schizopera* `WAM-SCHZ001` | Genetic lineage |
| | | *Schizopera* `WAM-SCHZ002` | Genetic lineage |
| | Parastenocarididae | *Parastenocaris jane* | Morphological |
| | | *Parastenocaris* `WAM-PARA001` | Genetic lineage |
| | | *Parastenocaris* `WAM-PARA002` | Genetic lineage |
| | | *Parastenocaris* sp. indet.* | Indeterminate |
| | Family unknown | Harpacticoida sp. indet.* | Indeterminate |
| | | Copepoda sp. indet.* | Indeterminate |
| **Syncarida** | | | **1** |
| | Bathynellidae | *Bathynella* `WAM-BATH001` | Genetic and morphological |
| **Amphipoda** | | | **12** |
| | Bogidiellidae | Bogidiellidae `WAM-AMPB001` | Genetic lineage |
| | | Bogidiellidae `WAM-AMPB002` | Genetic lineage |
| | | Bogidiellidae `WAM-AMPB003` | Genetic lineage |
| | Eriopisidae | *Nedsia* `WAM-AMPE001` | Genetic lineage |
| | | *Nedsia* `WAM-AMPE002` | Genetic lineage |
| | | *Nedsia* `WAM-AMPE003` | Genetic lineage |

| Order | Family | Morphospecies | Number of putative taxa, Identification status |
|---|---|---|---|
| | | *Nedsia* `*hulberti* group` indet. | Genetic lineage |
| | | *Nedsia* sp. indet.* | Indeterminate |
| | Paramelitidae | `*Pilbarus* sp. G` | Genetic lineage |
| | | `*Pilbarus* sp. H` | Genetic lineage |
| | | `*Yilgarus*` `WAM-AMPP001` | Genetic lineage |
| | | `*Yilgarus*` `WAM-AMPP002` | Genetic lineage |
| | | `*Yilgarus*` `WAM-AMPP003` | Genetic lineage |
| **Isopoda** | | | **1** |
| | Tainisopidae | *Pygolabis paraburdoo* (`WAM-PYGO001`) | Genetic and morphological |

*Note indeterminate taxa such as '*Nedsia* sp. indet.' are not included in the species counts as they represent specimens that cannot be allocated to the other known species based on current taxonomic information.

## 5.4 Subterranean fauna distributions

### 5.4.1 Troglofauna distributions

The combined troglofauna results (including current and previous survey results within the Study Area) revealed a total of 186 troglofauna specimens representing 40 species/ species- level taxa and nine higher level indeterminate taxa (Table 5.6).

Species distributions in troglofauna may be affected by a variety of factors such as habitat heterogeneity/ discontinuities, dispersal limitations, and ecological factors, but the patterns are not always consistent between, or within taxonomic groups. It is also difficult to remove the possibility of sampling artefacts from the current data, especially due to the prevalence of rare and poorly represented species, the inherent difficulties in achieving a comprehensive sample, and the necessity of sub-sampling for genetic identifications. Current records of all troglofauna taxa detected to date throughout the Study Area are shown in Figures 5.2 (a-d).

Three taxa were troglophiles/ trogloxenes known to be widespread beyond the Study Area: *Lophotorus madecassus* (cosmopolitan, 1000+ km linear range), Lophoproctidae 'Helix clade B' (50+ km linear range), and *Oliarus?* 'WAM-CIXO001' (410 km linear range) (Table 5.6). Conversely, the majority of troglofauna taxa (25 taxa) were potential troglobites and known from either single individuals (singletons) or multiples from single sites (Table 5.6).

Thirteen (13) taxa were recorded from multiple locations within the Study Area, as shown in Table 5.6. Of these, the meenoplid bugs *Phaconeura* `WAM-PHAC001` and *Phaconeura* `WAM-PHAC002` (respectively 32 km and 5 km linear range) and the silverfish *Dodecastyla* `WAM-ZYGA001` (31 km linear range), were recorded very widely throughout the Study Area, and because these taxa may represent troglophiles/ trogloxenes (based on current taxonomic/ ecological knowledge), they are also considered likely to occur beyond the Study Area.

Many of the other species recorded from multiple locations showed more moderate linear distances within potentially continuous habitats, particularly Nicoletiinae silverfish *Lepidospora* `WAM-ZYGC001`, *Trinemura* `WAM-ZYGS001`, *Trinemura* `WAM-ZYGS002`, *Trinemura* `WAM-

ZYGS004`, and *Trinemura* `WAM-ZYGS005` (ranging from 2-8km linear ranges) and also the palpigrade *Eukoenenia* `WAM-PALE001` (8 km linear range) (Table 5.6, Figures 5.2a, 5.2b, 5.2c, and 5.2d). The occurrence of more restricted taxa such as *Draculoides* `WAM-DRAC001`, and *Scutigellera* `WAM-SCUTI003` (respectively 1 km, and 0.5 km linear ranges) aligned broadly with the very short-ranges known for most taxa in these groups.

Twelve taxa were detected only within the proposed pits, as shown in red font in Table 5.6: *Eukoenenia* `WAM-PALE002, Araneae `WAM-ARAN001`, Oniscidae sp. indet., *Paraplatyarthrus* `WAM-PARA001`, *Cryptops* sp. indet., Scolopendrida sp. indet., *Decapauropus* `WAM-PAUD003`, *Decapauropus* `WAM-PAUD004`, *Scutigellera* `WAM-SCUTI004, *Symphyella* `WAM-SYMPH002`, *Symphyella* sp. indet., and *Trinemura* `WAM-ZYGS001`. Further details relating to these taxa are discussed in section 7.3.

**Table 5.6: Combined troglofauna results to date, taxonomic and distribution comments, known linear ranges and collection locations. Red fonts indicate taxa detected only within proposed impact areas**

| Taxonomy | No. spmns | ID Status | Taxonomic comments | Subterranean status, SRE status | Distribution comments | Bore/ hole codes | Known linear range (km) |
|---|---|---|---|---|---|---|---|
| **ARACHNIDA** | | | | | | | |
| **Pseudoscorpiones** | | | | | | | |
| *Tyrannochthonius* \`WAM-CHTH001\` | 1 | DNA | Genetically identified (unique lineage) | Troglobite, Potential SRE | Singleton, ER | RC1347E0020 | - |
| *Tyrannochthonius* \`WAM-CHTH002\` | 1 | DNA | Genetically identified (unique lineage) | Troglobite, Potential SRE | Singleton, WR | RC02WR103 | - |
| *Lechytia* \`WAM-LECYT001\` | 1 | DNA | Genetically identified (unique lineage) | Troglobite, Potential SRE | Singleton, Para | PMO3A | - |
| **Palpigradi** | | | | | | | |
| *Eukoenenia* \`WAM-PALE001\` | 2 | DNA | Genetically identified (unique lineage) | Troglobite, Potential SRE | 2 sites, WR, Para | RC12WR0141, RC1527W0094 | 8 |
| *Eukoenenia* \`WAM-PALE002\` | 1 | DNA | Genetically identified (unique lineage) | Troglobite, Potential SRE | Singleton, Para | RC1527W0142 | - |
| *Palpigradi* \`B25\` | 2 | Morpho, DNA fail | Morphologically identified to unique morphospecies (DNA unsuccessful). May represent other *Eukoenenia* sp. lineages listed above. | Troglobite, Potential SRE | Single site, ER | RC1318E0027 | - |
| **Schizomida** | | | | | | | |
| *Draculoides* \`WAM-DRAC001\` | 3 | DNA | Genetically identified (unique lineage) | Troglobite, Potential SRE | 3 sites, ER | RC1323E0024, RC1323E0043, RC1323E0051 | 1 |
| **Araneae** | | | | | | | |
| *Araneae* \`WAM-ARAN001\` | 1 | DNA | Unknown if troglobitic (damaged fragment). Unique lineage, from limited genetic comparisons - closest match terrestrial Theridiidae from Mesa A (10.1% COI). | Uncertain if troglofauna, Uncertain | Singleton, WR | RC02WR072 | - |
| **CRUSTACEA** | | | | | | | |
| **Isopoda** | | | | | | | |
| *Armadillidae* \`WAM-ARMD003\` | 1 | DNA | Genetically identified (unique lineage) | Troglobite, Potential SRE | Singleton, ER | RC1323E0027 | - |
| *Troglarmadillo* \`WAM-ARMD004\` | 3 | DNA | Genetically identified (unique lineage) | Troglobite, Potential SRE | Single site, ER | RC1147E022 | - |

| Taxonomy | No. spmns | ID Status | Taxonomic comments | Subterranean status, SRE status | Distribution comments | Bore/ hole codes | Known linear range (km) |
|---|---|---|---|---|---|---|---|
| *Troglarmadillo* sp. B67 | 1 | Morpho | Unique morphospecies (DNA not tested). May represent *T.* 'WAM-ARMD004' listed above (12 km distance). | Troglobite, Potential SRE | Singleton, Para | MB13 | - |
| *Paraplatyarthrus* \`WAM-PARA001\` | 1 | DNA | Genetically identified morphospecies (unique lineage). Potential troglobite (depigmented, reduced eye spot). | Potential Troglobite, Potential SRE | Singleton, WR | RC03WR116 | - |
| **MYRIAPODA** | | | | | | | |
| **Scolopendrida** | | | | | | | |
| *Cryptops* sp. indet.* | 1 | Morpho | Indeterminate genus-level taxon. Unknown if troglobitic (specimen fragment). DNA not tested. May represent other Scolopendrida listed below. | Uncertain if troglofauna, Uncertain | Putative Singleton, WR | RC11WR166 | Uncertain |
| **Polyxenida** | | | | | | | |
| *Lophoturus madecassus* | 5 | Morpho | Morphologically identified to named, cosmopolitan species. | Troglophile/xene, Widespread | Widespread, cosmopolitan | RC02WR003, RC02WR287, RC03WR148, RC1518E0070 | 1000+[1] |
| Lophoproctidae 'Helix clade B' | 5 | Morpho | Record from the WAM database, collected at a time when status of Lophoproctidae was uncertain. | Troglophile/xene, Widespread | 4 sites, WR and east of Study Area | RC3WR096 | 50+[2] |
| **Pauropoda** | | | | | | | |
| *Decapauropus* \`WAM-PAUD001\` | 1 | DNA | Genetically identified (unique lineage) | Troglobite, Potential SRE | Singleton, ER | RC1318E0032 | - |
| *Decapauropus* \`WAM-PAUD002\` | 4 | DNA | Genetically identified (unique lineage) | Troglobite, Potential SRE | 4 sites, Para, ER | RC1323E0018, RC1527W0091, RC1527W0133 | 15 |
| *Decapauropus* \`WAM-PAUD003\` | 1 | DNA | Genetically identified (unique lineage) | Troglobite, Potential SRE | Singleton, WR | RC03WR002 | - |
| *Decapauropus* \`WAM-PAUD004\` | 1 | DNA | Genetically identified (unique lineage) | Troglobite, Potential SRE | Singleton, WR | RC02WR269 | - |
| *Decapauropus* \`WAM-PAUD005\` | 1 | DNA | Genetically identified (unique lineage) | Troglobite, Potential SRE | Singleton, ER | RC1318E0004 | - |
| **Symphyla** | | | | | | | |
| *Scutigellera* \`WAM-SCUTI002\` | 1 | DNA | Genetically identified (unique lineage) | Troglobite, Potential SRE | Singleton, CHN/ TCK | COB14 | - |

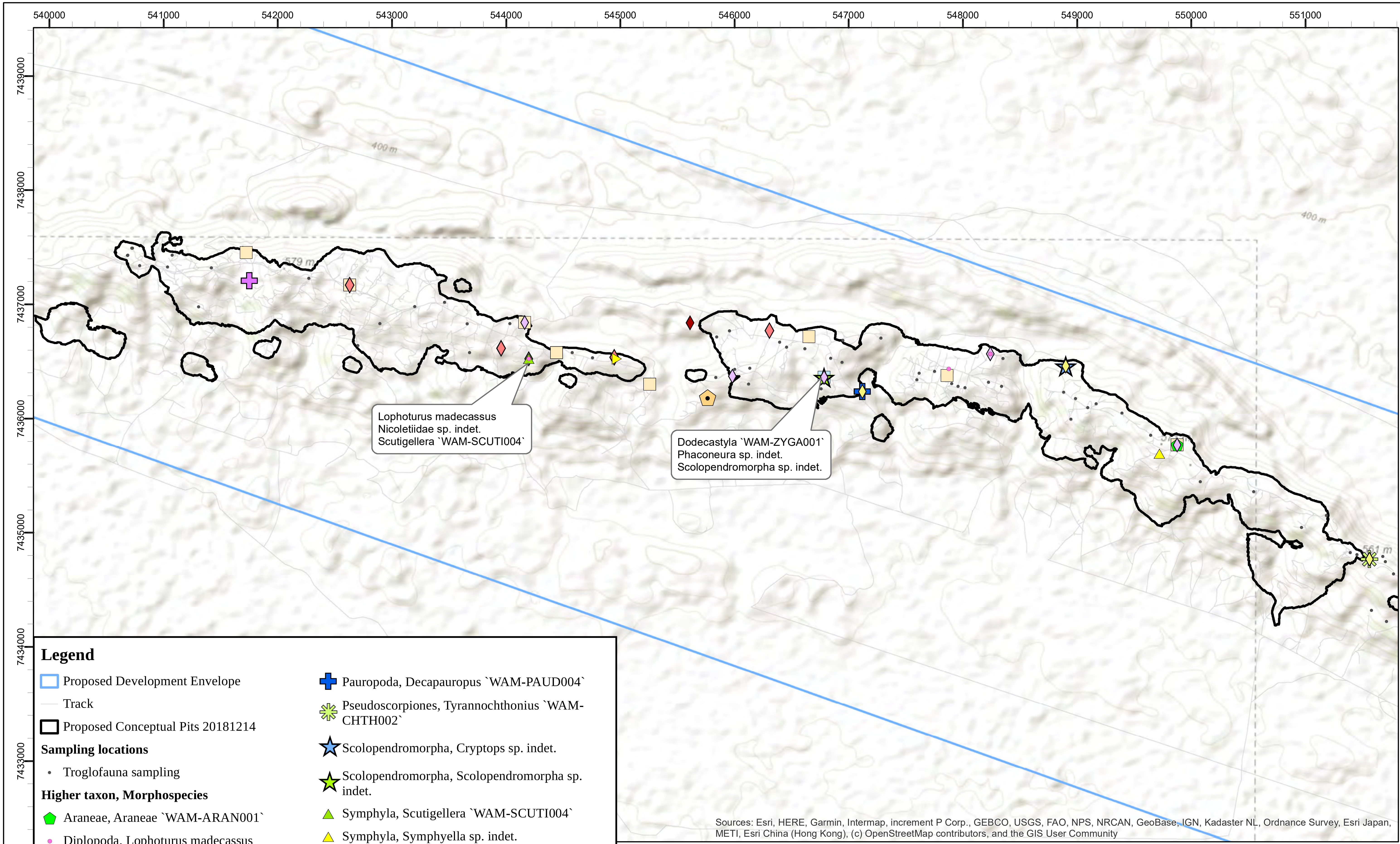
| Taxonomy | No. spmns | ID Status | Taxonomic comments | Subterranean status, SRE status | Distribution comments | Bore/ hole codes | Known linear range (km) |
|---|---|---|---|---|---|---|---|
| *Scutigellera* \`WAM-SCUTI003\` | 2 | DNA | Genetically identified (unique lineage) | Troglobite, Potential SRE | 2 sites, ER | RC1323E0026, RC1323E0049 | 0.5 |
| *Scutigellera* \`WAM-SCUTI004\` | 1 | DNA | Genetically identified (unique lineage) | Troglobite, Potential SRE | Singleton, WR | RC03WR148 | - |
| *Scutigellera* \`WAM-SCUTI005\` | 1 | DNA | Genetically identified (unique lineage) | Troglobite, Potential SRE | Singleton, NBF | PTO9 | - |
| *Symphyella* \`WAM-SYMPH002\` | 1 | DNA | Genetically identified (unique lineage) | Troglobite, Potential SRE | Singleton, ER | RC1747E0002 | - |
| *Symphyella* sp. indet.* | 1 | Morpho | Indeterminate genus-level taxon. Specimen lost. Unable to be compared, but distance from \`WAM-SYMPH002\` and disjunct habitat suggests different species. Conservatively treated as unique species, singleton. | Troglobite, Potential SRE | Putative singleton, WR | RC02WR126 | - |
| **ENTOGNATHA** | | | | | | | |
| **Diplura** | | | | | | | |
| Japygidae \`WAM-DPLJ005\` | 1 | DNA | Genetically identified (unique lineage) | Troglobite, Potential SRE | Singleton, ER | DD1518E0003 | - |
| **Protura** | | | | | | | |
| *Protura* \`WAM-PROT001\` | 2 | DNA | Genetically identified (unique lineage). Uncertain taxonomy (no regional sequences available for comparison), poorly known as troglofauna. | Potential troglofauna, Uncertain | Para | PMO3A | Uncertain |
| **INSECTA** | | | | | | | |
| **Zygentoma** | | | | | | | |
| *Dodecastyla* \`WAM-ZYGA001\` | 19 | DNA | Genetically identified (unique lineage). Atelurinae known to inhabit termite nests/ soil fauna as well as subterranean habitats. | Potential troglofauna, Potential SRE | 7 sites, WR, ER:<br>D03WR005, RC02WR003, RC02WR071, RC1147E022, RC12WR0116, RC1518E0070, WR61W01 | | 31 |
| *Lepidospora* \`WAM-ZYGC001\` | 2 | DNA | Genetically identified (unique lineage) | Troglobite, Potential SRE | 2 sites, ER | RC1147E022, RC1323E0047 | 7 |
| *Trinemura* \`WAM-ZYGS001\` | 6 | DNA | Genetically identified (unique lineage) | Troglobite, Potential SRE | 4 sites, WR | RC02WR151, RC03WR086, RC03WR116, RC12WR0199 | 4 |

| Taxonomy | No. spmns | ID Status | Taxonomic comments | Subterranean status, SRE status | Distribution comments | Bore/ hole codes | Known linear range (km) |
|---|---|---|---|---|---|---|---|
| *Trinemura* `WAM-ZYGS002` | 6 | DNA | Genetically identified (unique lineage) | Troglobite, Potential SRE | 4 sites, WR, Para | 99RS1, RC02WR103, RC02WR268, RC11WR166 | 8 |
| *Trinemura* `WAM-ZYGS002-A` | 1 | DNA | Genetically identified (unique lineage) | Troglobite, Potential SRE | Singleton, WR | RC12WR0137 | - |
| *Trinemura* `WAM-ZYGS003` | 3 | DNA | Genetically identified (unique lineage) | Troglobite, Potential SRE | 2 sites, ER | RC1147E022, RC1347E007 | 0.3 |
| *Trinemura* `WAM-ZYGS004` | 2 | DNA | Genetically identified (unique lineage) | Troglobite, Potential SRE | 2 sites, Para, ER | H_GC084EST001, RC1323E0046 | 6 |
| *Trinemura* `WAM-ZYGS005` | 4 | DNA | Genetically identified (unique lineage) | Troglobite, Potential SRE | 2 sites, Para | PMO3A, RC1711W0037 | 2 |
| **Hemiptera** | | | | | | | |
| *Oliarus?* `WAM-CIXO001` | 6 | Morpho, DNA | Genetic identification of well-known widespread morphospecies. Hemiptera sp. B2 (=Fulgoridae sp. S1=cixidae S1) | Troglophile/xene, Widespread | 2 sites, Para, ER | RC1347E0013, RC1527W0069 | 410[3] |
| *Phaconeura* `WAM-PHAC001` | 31 | DNA | Genetically identified (unique lineage). Meenoplidae known to include regionally wide ranging troglophiles/trogloxenes as well as more restricted lineages/ species. | Potential troglofauna, Potential SRE | 14 sites, WR, ER: RC02WR070, RC02WR142, RC02WR288, RC03WR005, RC03WR086, RC03WR119, RC03WR146, RC1147E022, RC1318E0041, RC1323E0043, RC1323E0046, RC1323E0048, RC1518E0067, WR61W01 | | 32 |
| *Phaconeura* `WAM-PHAC002` | 4 | DNA | Genetically identified (unique lineage). Meenoplidae known to include regionally wide ranging troglophiles/trogloxenes as well as more restricted lineages/ species. | Potential troglofauna, Potential SRE | 2 sites, WR | RC02WR070, RC03WR119 | 5 |
| **Coleoptera** | | | | | | | |
| *Gracilanillus* sp. B10 | 1 | Morpho | Morphologically identified, unique morphospecies (DNA not tested) | Potential Troglobite, Potential SRE | Singleton, NBF | PTO10 | - |
| **Indeterminate taxa (unresolved)** | | | | | | | |
| Scolopendrida sp. indet. | 1 | DNA fail | Indeterminate higher-level taxon; specimen damaged, DNA unsuccessful. Unknown if troglobitic (specimen fragment). May represent *Cryptops* listed above. | Uncertain if troglofauna, Uncertain | Putative singleton, WR | D03WR005 | Uncertain |

| Taxonomy | No. spmns | ID Status | Taxonomic comments | Subterranean status, SRE status | Distribution comments | Bore/ hole codes | Known linear range (km) |
|---|---|---|---|---|---|---|---|
| Armadillidae sp. indet. | 1 | Morpho | Indeterminate higher-level taxon. Unknown if troglobitic (specimen fragment). DNA not tested. Likely to represent other Isopoda (exc. *Paraplatyarthrus*) listed above. | Potential Troglobite, Uncertain | CHN/ TCK | COB14 | Uncertain |
| Oniscidae sp. indet. | 1 | Morpho | Indeterminate higher-level taxon. Unknown if troglobitic (record from the WAM database, collected at a time when taxonomy was more limited) | Uncertain if troglofauna, Uncertain | Singleton, WR | RC02WR0130 | Uncertain |
| Pauropoda sp. indet. | 2 | Morpho, DNA fail | Indeterminate higher-level taxa. Damaged fragments. DNA failed to sequence. Likely to represent other Pauropoda listed above. | Potential Troglobite, Uncertain | ER | RC1323E0043, RC1347E0008 | Uncertain |
| Polyxenida sp. indet. | 9 | Morpho DNA fail | Indeterminate higher-level taxa; DNA unsuccessful. Likely to represent other Polyxenida listed above | Potential Troglobite, Uncertain | WR | RC1323E0047, RC1323E0016, RC03WR004, RC03WR148 | Uncertain |
| *Scutigellera* sp. indet. | 3 | Morpho, DNA fail | Indeterminate genus-level taxa. DNA unsuccessful. Likely to represent other *Scutigellera* listed above | Troglobite, Potential SRE | ER | RC1347E007 | Uncertain |
| Japygidae sp. indet. | 1 | Morpho | Indeterminate higher-level taxon. Specimen fragment only. DNA not tested. May represent other Japygidae listed above (14.5 km distance). | Potential Troglobite, Uncertain | Para | RC1527W0094 | Uncertain |
| Nicoletiidae sp. indet. | 23 | DNA fail | Indeterminate higher-level taxa; DNA unsuccessful. Likely to represent other Zygentoma listed above (exc. *Dodecastyla*). | Potential Troglobite, Uncertain | WR, ER | RC03WR148, RC1323E0018, RC1323E0022, RC1323E0024 | Uncertain |
| *Phaconeura* sp. indet. | 11 | Morpho, DNA fail | Indeterminate taxa; juvenile specimens, DNA unsuccessful. Likely to represent other *Phaconeura* sp. listed above. Some records from same locations as above. | Potential Troglofauna, Uncertain | WR, Para, ER: D03WR005, RC03WR119, RC03WR146, RC1147E022, RC1527W0124 | | Uncertain |
| Hemiptera sp. indet. | 2 | Indet. | Indeterminate higher-level taxa; moult/ exoskeleton only. Uncertain if troglofauna. | Uncertain if troglofauna, Uncertain | Para, ER | RC1318E0031, RC154E0008 | Uncertain |

Note: only indeterminate taxa with asterisk (*) were included in species count, as they were regarded as distinct taxa. All other indeterminate taxa were not included, as there was insufficient information to exclude the possibility that they may be the same as other specimens collected. Red font indicates taxon included in risk assessment (section 7).

Known linear range based on [1] Car *et al.* (2013), [2] WAM occurrence records, [3] Halse *et al.* (2014).

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N

1:30,000

0 0.4 0.8 1.6 km

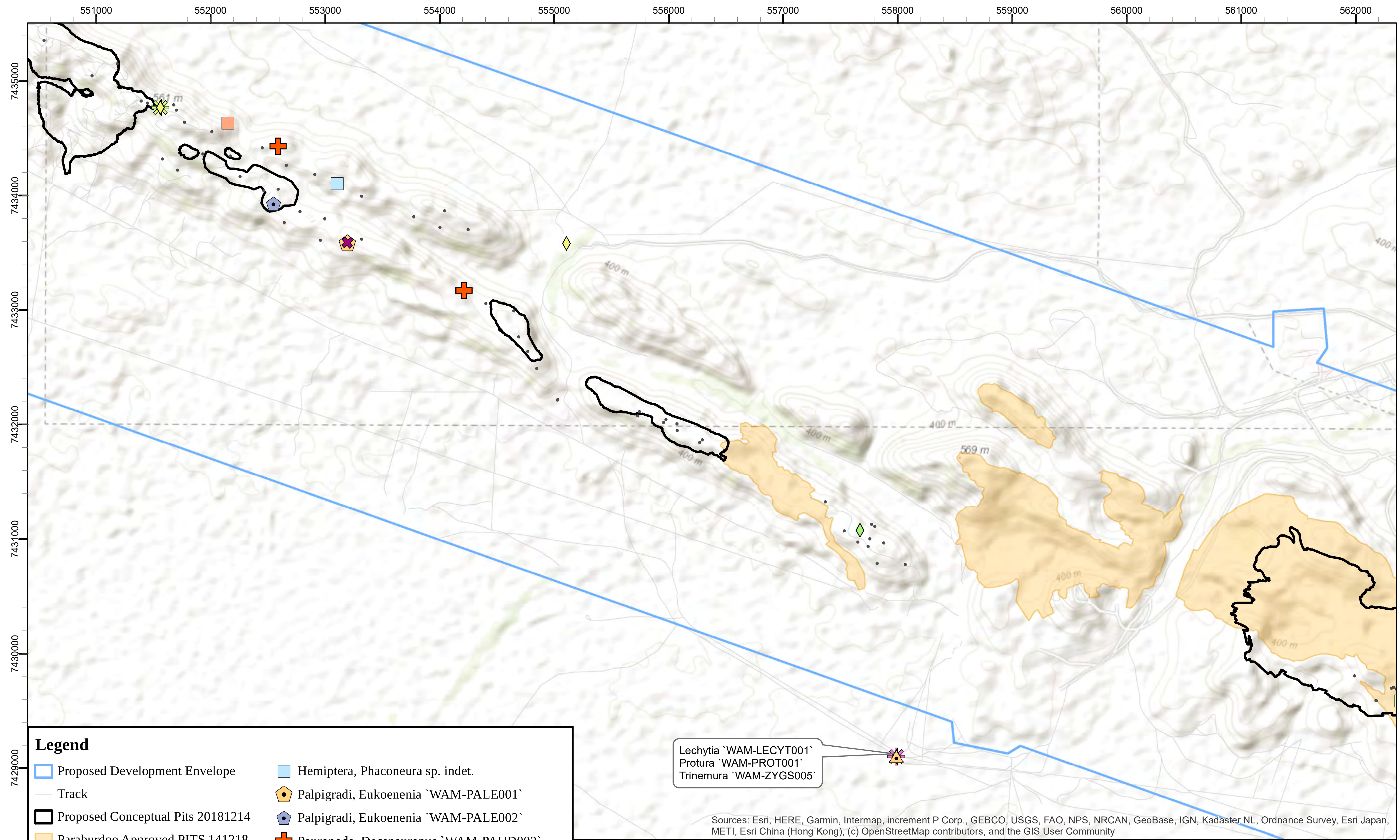
**Rio Tinto Iron Ore**

**Greater Paraburdoo Subterranean Fauna Survey**

**Fig. 5.2a: Locations of troglofauna taxa recorded during the current survey (Western Range)**

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

Size A3. Created 01/05/2019




**Legend**

- Proposed Development Envelope
- Track
- Proposed Conceptual Pits 20181214
- Paraburdoo Approved PITS 141218

**Sampling locations**

- Troglofauna sampling

**Higher taxon, Morphospecies**

- Diplura, Japygidae sp. indet.
- Hemiptera, Hemiptera sp. indet.
- Hemiptera, Oliarus? `WAM-CIXO001`
- Hemiptera, Phaconeura sp. indet.
- Palpigradi, Eukoenenia `WAM-PALE001`
- Palpigradi, Eukoenenia `WAM-PALE002`
- Pauropoda, Decapauropus `WAM-PAUD002`
- Protura, Protura `WAM-PROT001`
- Pseudoscorpiones, Lechytia `WAM-LECYT001`
- Pseudoscorpiones, Tyrannochthonius `WAM-CHTH002`
- Zygentoma, Trinemura `WAM-ZYGS002`
- Zygentoma, Trinemura `WAM-ZYGS005`

N

1:30,000

0 0.4 0.8 1.6 km

biologic Environmental Survey

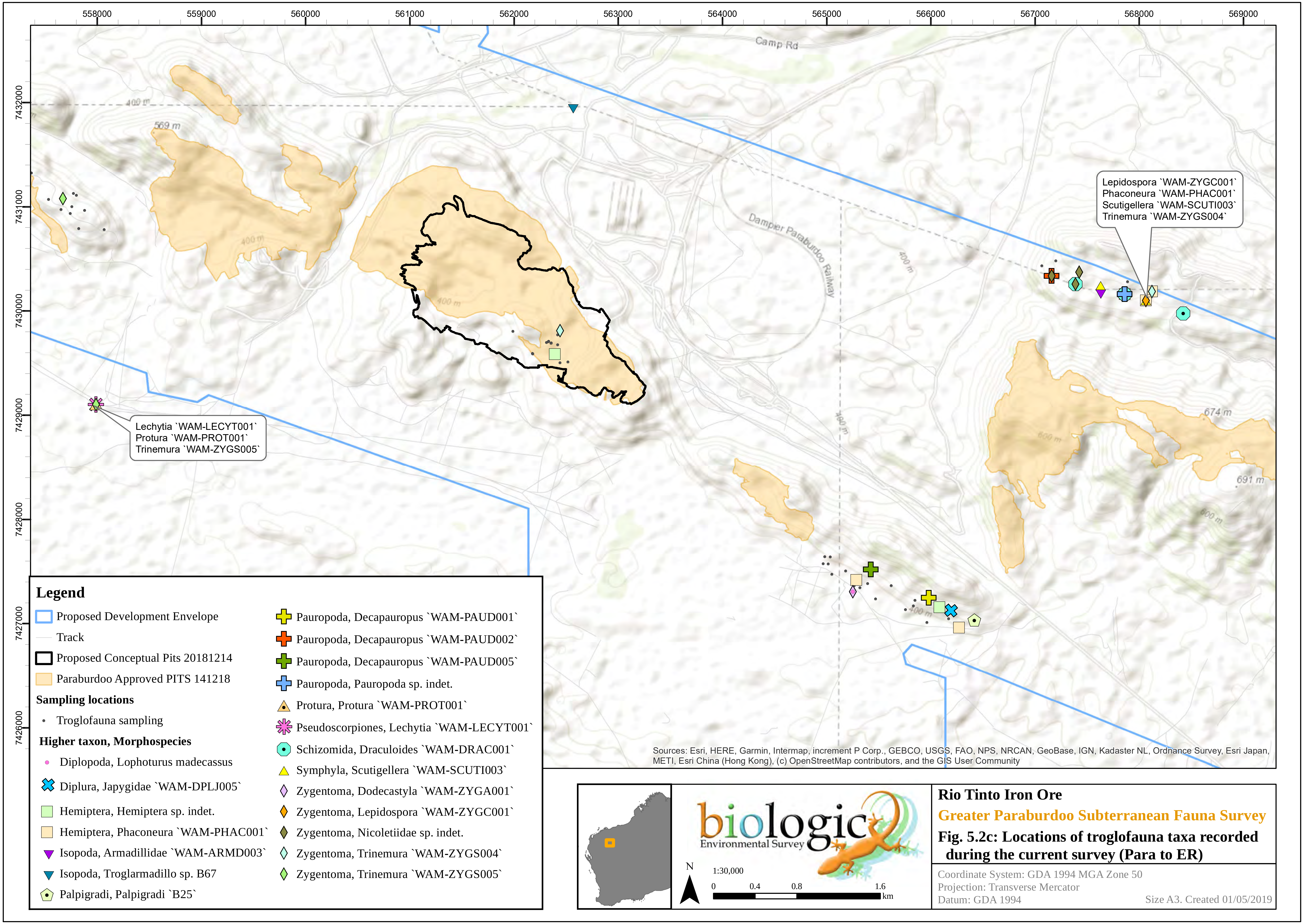
**Rio Tinto Iron Ore**

**Greater Paraburdoo Subterranean Fauna Survey**

**Fig. 5.2b: Locations of troglofauna taxa recorded during the current survey (WR to Para)**

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

Size A3. Created 01/05/2019

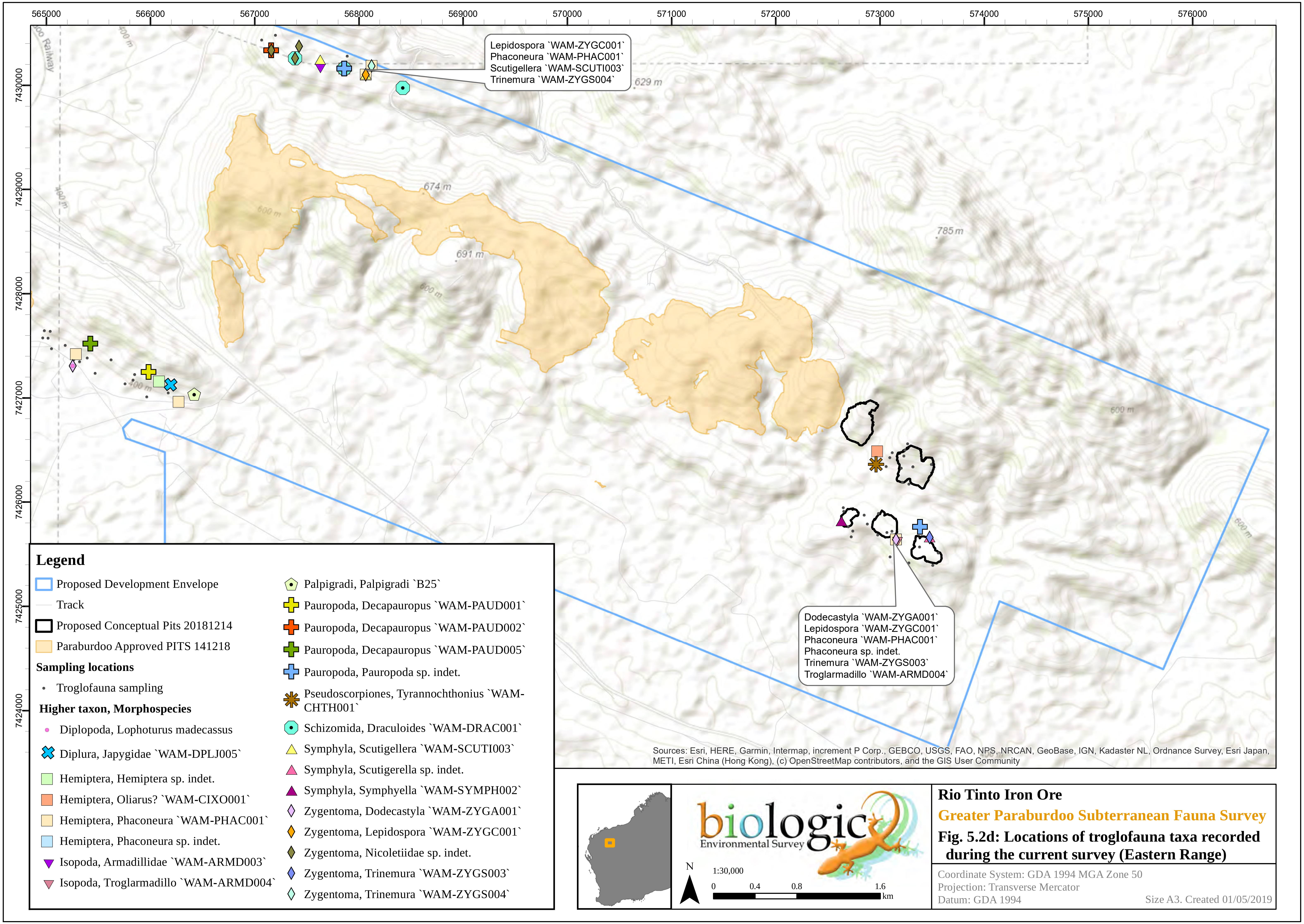



**Rio Tinto Iron Ore**

**Greater Paraburdoo Subterranean Fauna Survey**

**Fig. 5.2c: Locations of troglofauna taxa recorded during the current survey (Para to ER)**

Coordinate System: GDA 1994 MGA Zone 50
Projection: Transverse Mercator
Datum: GDA 1994
Size A3. Created 01/05/2019



565000
566000
567000
568000
569000
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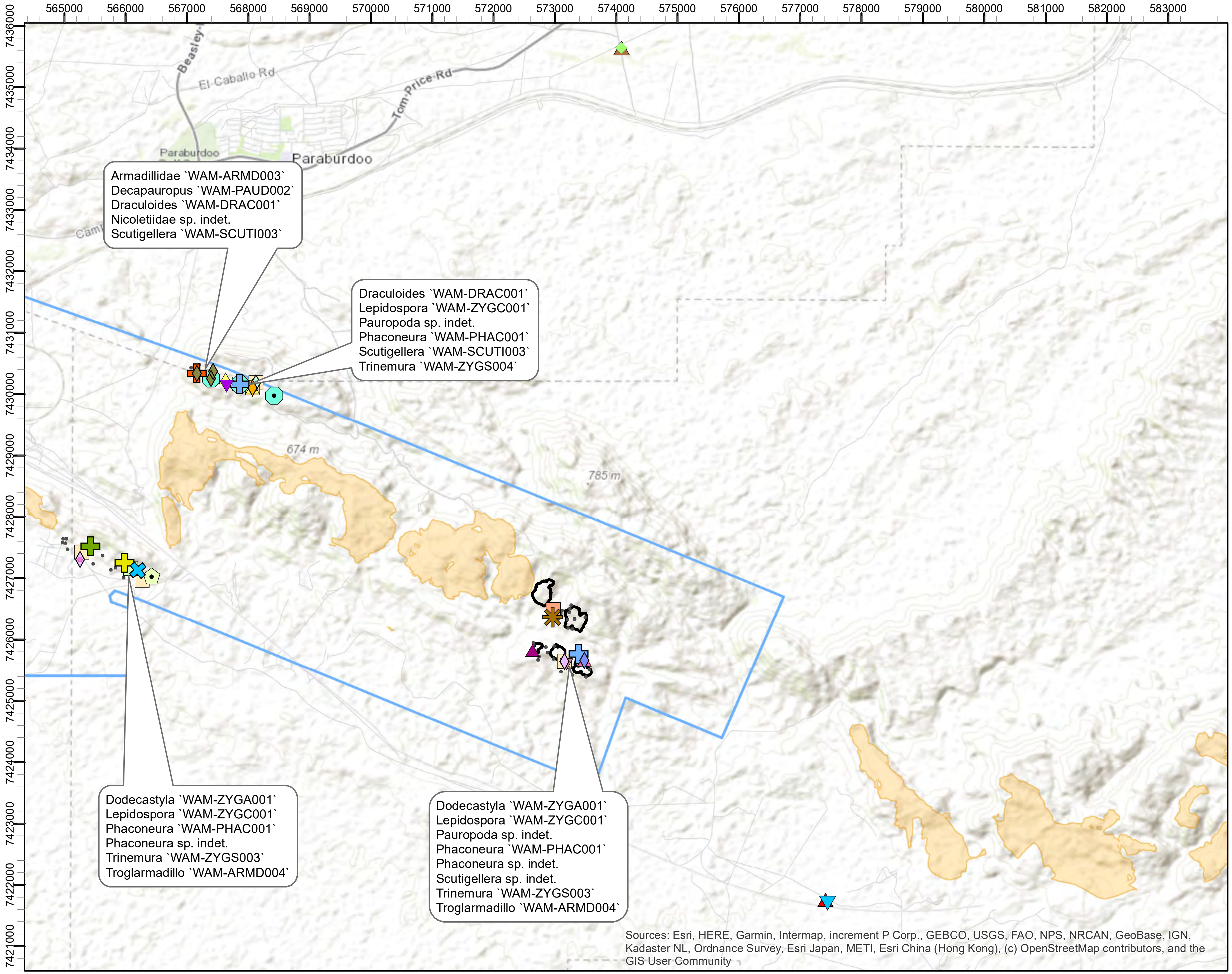
571000
572000
573000
574000
575000
576000
7430000
7429000
7428000
7427000
7426000
7425000
7424000
629 m
674 m
691 m
785 m
600 m
Lepidospora `WAM-ZYGC001`
Phaconeura `WAM-PHAC001`
Scutigellera `WAM-SCUTI003`
Trinemura `WAM-ZYGS004`
Dodecastyla `WAM-ZYGA001`
Lepidospora `WAM-ZYGC001`
Phaconeura `WAM-PHAC001`
Phaconeura sp. indet.
Trinemura `WAM-ZYGS003`
Troglarmadillo `WAM-ARMD004`
Legend
Proposed Development Envelope
Track
Proposed Conceptual Pits 20181214
Paraburdoo Approved PITS 141218
Sampling locations
Troglofauna sampling
Higher taxon, Morphospecies
Diplopoda, Lophoturus madecassus
Diplura, Japygidae `WAM-DPLJ005`
Hemiptera, Hemiptera sp. indet.
Hemiptera, Oliarus? `WAM-CIXO001`
Hemiptera, Phaconeura `WAM-PHAC001`
Hemiptera, Phaconeura sp. indet.
Isopoda, Armadillidae `WAM-ARMD003`
Isopoda, Troglarmadillo `WAM-ARMD004`
Palpigradi, Palpigradi `B25`
Pauropoda, Decapauropus `WAM-PAUD001`
Pauropoda, Decapauropus `WAM-PAUD002`
Pauropoda, Decapauropus `WAM-PAUD005`
Pauropoda, Pauropoda sp. indet.
Pseudoscorpiones, Tyrannochthonius `WAM-CHTH001`
Schizomida, Draculoides `WAM-DRAC001`
Symphyla, Scutigellera `WAM-SCUTI003`
Symphyla, Scutigerella sp. indet.
Symphyla, Symphyella `WAM-SYMPH002`
Zygentoma, Dodecastyla `WAM-ZYGA001`
Zygentoma, Lepidospora `WAM-ZYGC001`
Zygentoma, Nicoletiidae sp. indet.
Zygentoma, Trinemura `WAM-ZYGS003`
Zygentoma, Trinemura `WAM-ZYGS004`
Sources: Esri, HERE, Garmin, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), (c) OpenStreetMap contributors, and the GIS User Community
biologic Environmental Survey
N
1:30,000
0 0.4 0.8 1.6 km
Rio Tinto Iron Ore
Greater Paraburdoo Subterranean Fauna Survey
Fig. 5.2d: Locations of troglofauna taxa recorded during the current survey (Eastern Range)
Coordinate System: GDA 1994 MGA Zone 50
Projection: Transverse Mercator
Datum: GDA 1994
Size A3. Created 01/05/2019




## Legend

- Proposed Development Envelope
- Track
- Proposed Conceptual Pits 20181214
- Paraburdoo Approved PITS 141218

**Sampling locations**

- Troglofauna sampling

**Higher taxon, Morphospecies**

- Coleoptera, Gracilanillus sp. B10
- Diplopoda, Lophoturus madecassus
- Diplura, Japygidae `WAM-DPLJ005`
- Hemiptera, Hemiptera sp. indet.
- Hemiptera, Oliarus? `WAM-CIXO001`
- Hemiptera, Phaconeura `WAM-PHAC001`
- Hemiptera, Phaconeura sp. indet.
- Isopoda, Armadillidae `WAM-ARMD003`
- Isopoda, Armadillidae sp. indet.
- Isopoda, Troglarmadillo `WAM-ARMD004`
- Palpigradi, Palpigradi `B25`
- Pauropoda, Decapauropus `WAM-PAUD001`
- Pauropoda, Decapauropus `WAM-PAUD002`
- Pauropoda, Decapauropus `WAM-PAUD005`
- Pauropoda, Pauropoda sp. indet.
- Pseudoscorpiones, Tyrannochthonius `WAM-CHTH001`
- Schizomida, Draculoides `WAM-DRAC001`
- Symphyla, Scutigellera `WAM-SCUTI002`
- Symphyla, Scutigellera `WAM-SCUTI003`
- Symphyla, Scutigellera `WAM-SCUTI005`
- Symphyla, Scutigerella sp. indet.
- Symphyla, Symphyella `WAM-SYMPH002`
- Zygentoma, Dodecastyla `WAM-ZYGA001`
- Zygentoma, Lepidospora `WAM-ZYGC001`
- Zygentoma, Nicoletiidae sp. indet.
- Zygentoma, Trinemura `WAM-ZYGS003`
- Zygentoma, Trinemura `WAM-ZYGS004`

N

1:65,000

0 0.75 1.5 3 km

biologic Environmental Survey

**Rio Tinto Iron Ore**

**Greater Paraburdoo Subterranean Fauna Survey**

**Fig. 5.2e: Locations of troglofauna taxa recorded during the current survey (other locations)**

Coordinate System: GDA 1994 MGA Zone 50
Projection: Transverse Mercator
Datum: GDA 1994
Size A3. Created 01/05/2019

### 5.4.2 Combined stygofauna results

The combined stygofauna results (including current and previous survey results within the Study Area) recorded a total of 1245 stygofauna specimens representing 70 species/ species level taxa and nine higher level indeterminate taxa (Table 5.7).

Equal proportions of stygofauna taxa (29) were widespread (known to occur throughout the wider catchment or regionally) as were singleton taxa or taxa recorded only from single sites (29) (Table 5.7). The remaining taxa included locally widespread groups such as the paramelitid amphipods '*Yilgarus* WAM-AMPP001', *Pilbarus* \`sp. G\`, and *Pilbarus* sp. 'B09', with 21-34 km linear ranges across multiple groundwater areas. These taxa would be expected to occur more widely throughout the local area or sub-catchment, as their current recorded distribution suggests that they may be able to disperse throughout the hyporheic zone of the interconnected drainage lines during floods or flow events.

Other groups such as ostracods (*Deminutiocandona* sp. BOS1149 nr *atope*, *?Deminutiocandona* n. sp. \`BOS1158\`, and *Gomphodella* n. sp. \`BOS1156\`) and harpacticoids *Schizopera* 'WAM-SCHZ001' and *Schizopera* 'WAM-SCHZ002' were recorded at more moderate linear ranges (between 2-6 km), typically within a single borefield or continuous hydrogeological area. It may be more likely that some of these taxa are less widely occurring beyond the Study Area; although owing to the patchiness of previous sampling and the inconsistent taxonomic and genetic effort between current and previous surveys, it is also difficult to exclude the possibility that the current distributions of these taxa are attributed to sampling artefacts or incomplete taxonomy.

One stygobite species, *Bathynella* 'WAM-BATH001' was detected from three sites (0.2 km linear range) within the proposed drawdown area in Seven-Mile Creek (red font, Table 5.7). Owing to the local compartmentalisation of the hydrogeological habitat in this area of Seven-Mile Creek, and the fact that sampling further upstream and downstream did not detect this species more widely, there is a chance that the species could potentially be restricted.

Current records of all stygofauna taxa detected to date throughout the Study Area are shown in Figures 5.3 (a-f). Further details relating to the potential wider occurrence of these taxa are discussed in section 7.3

**Table 5.7: Combined stygofauna results to date, taxonomic and distribution comments, known linear ranges and collection locations. Red fonts indicate taxa known only from within proposed impact areas.**

| Taxonomy | No. spmns | ID Status | Taxonomic comments | Subterranean status, SRE status | Distribution comments | Bore/ hole codes | Known linear range (km) |
|---|---|---|---|---|---|---|---|
| **POLYCHAETA** | | | | | | | |
| **Aeolosomatidae** | | | | | | | |
| *Aelosoma* sp. 1 | 1 | Morpho | Collected during DBCA PSS at a time when taxonomy was more limited. | Potential Stygophile/xene, Widespread | Widespread, Para | 99RS2 | 630[1] |
| **OLIGOCHAETA** | | | | | | | |
| **Enchytraeidae** | | | | | | | |
| \`Enchytraeidae sp. E6 (11)\` | 3 | DNA | Genetic alignment with widespread lineage 11, species group E6 | Potential Stygobite, Widespread | Widespread, CHN/ TCK | WB2/90 | 350[2] |
| \`Enchytraeidae sp. E6 (2-4)\` | 69 | DNA | Genetic alignment with widespread lineages 2,3,4, species group E6 | Potential Stygobite, Widespread | Widespread, Para, ER, NBF | DD1718E0001, PMO3A, PTO3A, RC1323E0016 | 260[3] |
| *Enchytraeidae* \`WAM-ENCH001\` | 1 | DNA | Genetically identified (unique lineage) | Potential Stygobite, Potential SRE | Singleton, CHN/ TCK | PFO9-4 | - |
| *Enchytraeidae* \`WAM-ENCH002\` | 7 | DNA | Genetically identified (unique lineage) | Potential Stygobite, Potential SRE | 2 sites, WR, Para | RC03WR146, RC1527W0069 | 8 |
| *Enchytraeidae* \`WAM-ENCH003\` | 22 | DNA | Genetically identified (unique lineage) | Potential Stygobite, Potential SRE | 3 sites, ER | RC1147E022, RC1747E0021, RC1747E0035 | 0.3 |
| **Naididae** | | | | | | | |
| *Naididae* \`WAM NAID002\` | 1 | DNA | Genetically identified (unique lineage) | Stygobite, Potential SRE | Hyporheic, likely widespread, Para | RSFLOW | - |
| *Pristina* \`WAM-NAIDP001\` | 1 | DNA | Genetically identified (unique lineage). Potential cryptic species, morphologically similar to *Pristina longiseta* (17.8% divergence COI). | Potential Stygobite, Uncertain | Singleton, CHN/ TCK | PFO16-1 | - |
| *Pristina longiseta* | 7 | Morpho | Widespread surface-dwelling and stygal species | Stygophile/xene, Widespread | Hyporheic, widespread, Para CHN/ TCK | GPKC02, RSFLOW | 1000+[4] |
| *Pristina aequiseta* | 1 | Morpho | Collected during DBCA PSS at a time when taxonomy was more limited. | Stygophile/xene, Widespread | Hyporheic, widespread, Para | 99RS2 | 1000+[5] |
| Naididae AP 5 sp. (Tubificoid) | 5 | Morpho | Morphologically aligned to known morphospecies (DNA not tested) | Stygobite, Widespread | Widespread, CHN/ TCK | PFO9-4 | ~660[6] |

| Taxonomy | No. spmns | ID Status | Taxonomic comments | Subterranean status, SRE status | Distribution comments | Bore/ hole codes | Known linear range (km) |
|---|---|---|---|---|---|---|---|
| Naididae AP 1A sp. (Tubificoid) | 5 | Morpho, DNA fail | Morphologically aligned to known morphospecies (DNA unsuccessful) | Stygobite, Widespread | Widespread, CHN/ TCK | MB1464E5002s | ~220[1] |
| **Phreodrilidae** | | | | | | | |
| Phreodrilidae `WAM-PHRE001` | 1 | DNA | Genetically identified (unique lineage) | Stygobite, Potential SRE | Singleton, Para | PMO4A | - |
| Phreodrilidae `WAM-PHRE002` | 14 | DNA | Genetically identified (unique lineage) | Stygobite, Potential SRE | Single site, CHN/ TCK | COB14 | - |
| Phreodrilidae sp. AP DVC s.l. | 10 | Morpho, DNA fail | Indeterminate higher-level taxon (not species-level); DNA unsuccessful. | Potential Stygobite, Uncertain | Para, CHN/ TCK | COB16D, MB1464E5002s, PMP02, WB2/90 | Uncertain |
| **ACARI** | | | | | | | |
| **Pezidae** | | | | | | | |
| Pezidae sp. indet.* | 2 | Morpho | Indeterminate higher-level taxon (unique family); DNA not tested. | Potential Stygobite, Uncertain | Para | PMO1, PMP4 | Uncertain |
| **OSTRACODA** | | | | | | | |
| **Candonidae** | | | | | | | |
| *Deminutiocandona aporia* | 15 | Morpho | Morphologically identified, named species. | Stygobite, Widespread | Locally widespread, Para | PMP02, PMP4, MB16, PM08 | 35[1] |
| *Deminutiocandona stomachosa* | 1 | Morpho | Morphologically identified, named species. | Stygobite, Widespread | Widespread, Para | MB13 | 150[1] |
| *Deminutiocandona quasimica* | 21 | Morpho | Morphologically identified, named species. | Stygobite, Widespread | Widespread, Para | MB15PAFL002 | 440[1] |
| *Deminutiocandona* sp. BOS1149 nr *atope* | 4 | Morpho | Morphologically aligned to known morphospecies (DNA not tested) | Stygobite, Potential SRE | 3 sites, Para | 99RS2, PMO1, PMP02 | 6.5 |
| *?Deminutiocandona* n. sp. `BOS1158` | 2 | Morpho | Morphologically aligned to known morphospecies (DNA not tested) | Stygobite, Potential SRE | 2 sites, Para | PM04A, PMP02 | 4 |
| *?Deminutiocandona* n. sp. `BOS1160` | 1 | Morpho | Morphologically aligned to known morphospecies (DNA not tested) | Stygobite, Potential SRE | Singleton, Para | PMP4 | - |
| *Penthesilenula brasiliensis* | 3 | Morpho | Morphologically identified, named species. | Stygophile/xene, Widespread | Widespread, cosmopolitan | PM08 | 1000+[14] |
| *Vestalenula marmonieri* | 1 | Morpho | Morphologically identified, named species. | Stygophile/xene, Widespread | Widespread, cosmopolitan | PT02 | 1000+[15] |
| *Areacandona* sp. 5 | 1 | Morpho | Collected during DBCA PSS at a time when taxonomy was more limited. | Potential Stygobite, Potential SRE | Singleton, Para | 99RS2 | - |

| Taxonomy | No. spmns | ID Status | Taxonomic comments | Subterranean status, SRE status | Distribution comments | Bore/ hole codes | Known linear range (km) |
|---|---|---|---|---|---|---|---|
| *Origocandona inanitas* | 1 | Morpho | Collected during DBCA PSS at a time when taxonomy was more limited. | Potential Stygobite, Widespread | Widespread, Para | 99RS2 | 260[1] |
| *Pilbaracandona* sp. 3 | 1 | Morpho | Collected during DBCA PSS at a time when taxonomy was more limited. | Potential Stygobite, Widespread | Widespread, Para | 99RS2 | 146[1] |
| **Limnocytheridae** | | | | | | | |
| *Gomphodella* \`WAM-OSTR001\` | 2 | DNA | Genetically identified (unique lineage). May represent *Gomphodella* sp. 5 previously collected in the same borehole DBCA (PSS) | Stygobite, Potential SRE | Single site, Para | 99RS2 | - |
| *Gomphodella* n. sp. \`BOS1156\` | 2 | Morpho | Morphologically aligned to known morphospecies (DNA not tested) | Stygobite, Potential SRE | 2 sites, Para | MB13, MB16PAF002 | 1.5 |
| *Gomphodella* sp. 5 | 1 | Morpho | Collected during DBCA PSS at a time when taxonomy was more limited. | Potential Stygobite, Potential SRE | Para single site and nearby previous record | 99RS2 | 17[1] |
| *Limnocythere dorsosicula* | 8 | Morpho | Morphologically aligned to known morphospecies (DNA not tested) | Stygophile/xene, Widespread | Widespread, Para | PM08 | 1000+[16] |
| **CYCLOPOIDA** | | | | | | | |
| **Cyclopidae** | | | | | | | |
| *Australoeucyclops karaytugi* | 1 | Morpho | Morphologically identified, named species. | Stygobite, Widespread | Hyporheic, likely widespread, Para | RSFLOW | 172[7] |
| *Diacyclops* \`WAM-CYLD001\` | 24 | DNA | Genetically identified (unique lineage). Morphologically aligned to *D. humphreysi humphreysi.* | Stygobite, Potential SRE | Singleton, Para | 99RS2 | - |
| *Diacyclops* \`WAM-CYLD002\` | 231 | DNA | Genetically identified (2nd unique lineage). Morphologically aligned to *D. humphreysi humphreysi.* | Stygobite, Potential SRE | 7 sites, Para, NBF: 99RS2, MB13, MB16, MB16PAFL001, PMO4A, PMP02, PTO2 | | 14 |
| *Diacyclops humphreysi humphreysi* | 192 | Morpho | Morphologically identified, named species. May be cryptic morphospecies within material from Study Area, as listed above. *D. humphreysi humphreysi* also collected during DBCA PSS, borehole 99RS2. | Stygophile/xene, Widespread | Widespread, Para, NBF, CHN/ TCK: MB15PAFL002, PFO9-4, PMO1, PMO4A, PMP02, PMP4, PTO2, WB17NLC0001 (RTIOD2) | | 700[8] |
| *Diacyclops cockingi* | 35 | Morpho | Morphologically identified, named species. | Stygobite, Widespread | Widespread, Para, CHN/ TCK | 99RS2, MB13, MB15PAFL002, MB16, MB16PAFL001, PFO9-4, PMP4 | 670[1] |
| *Dussartcyclops mortoni* | 1 | Morpho | Morphologically identified, named species. | Stygobite, Widespread | Widespread, Para | MB15NLC005 | 400+[9] |

| Taxonomy | No. spmns | ID Status | Taxonomic comments | Subterranean status, SRE status | Distribution comments | Bore/ hole codes | Known linear range (km) |
|---|---|---|---|---|---|---|---|
| *Eucyclops australiensis* | 1 | Morpho | Morphologically identified, named species. | Stygophile/xene, Widespread | Hyporheic, widespread, CHN/ TCK | GPKC02 | 1000+[10] |
| *Metacyclops* sp. B1 nr *pilbaricus* | 1 | Morpho | Morphologically aligned to known morphospecies (DNA not tested). | Stygobite, Widespread | Widespread, CHN/ TCK | WB2/90 | 250[11] |
| *Pescecyclops* `WAM-CYLP001` | 39 | DNA | Unique genetic lineage from specimens morphologically identified as *Metacyclops* sp. B1 nr *pilbaricus.* No external sequence of M. sp. B1 nr *pilbaricus* available for comparison. | Stygobite, Uncertain | Potentially widespread, Single site, CHN/ TCK | WB2/90 | Uncertain |
| *Microcyclops varicans* | 1 | Morpho | Morphologically identified, named species. | Stygophile/xene, Widespread | Hyporheic, widespread, CHN/ TCK | GPKC02 | 1000+[1] |
| *Paracyclops chiltoni* | 1 | Morpho | Morphologically identified, named species. | Stygophile/xene, Widespread | Hyporheic, widespread, CHN/ TCK | GPKC02 | 290[1] |
| *Thermocyclops* `WAM-CYLT001` | 1 | DNA | Unique genetic lineage from specimens morphologically identified as *Thermocyclops aberrans*. No external sequence of *Thermocyclops aberrans* available for comparison. | Stygophile/xene, likely Widespread | Potentially widespread, Singleton, Para | 99RS1 | Uncertain |
| *Thermocyclops aberrans* | 3 | Morpho | Named species. Likely same as *Thermocyclops* 'WAM-CYLT001' (500 m distance) | Stygophile/xene, Widespread | Hyporheic, widespread, Para | RSFLOW | 200[12] |
| **HARPACTICOIDA** | | | | | | | |
| **Ameiridae** | | | | | | | |
| *Abnitocrella halsei* | 1 | Morpho | Morphologically identified, named species | Stygobite, Widespread | Widespread, Para | PMP4 | 270[1] |
| Ameiridae gen. nov. sp. B7 | 2 | Morpho | Unique amerid genus. May represent unnamed species 'Rockleanitocrella sp.', previously collected at 7-Mile Creek (DBCA PSS, Karanovic unpublished). | Stygobite, Potential SRE | Single site, CHN/ TCK | PFO9-4 | - |
| *Parapseudoleptomesochra tureei* | 1 | Morpho | Morphologically identified, named species. | Stygobite, Widespread | Widespread, CHN/ TCK | PFO9-4 | 410[1] |
| **Miraciidae** | | | | | | | |
| *Schizopera roberiverensis* | 15 | Morpho | Named species. Appears to include morphologically cryptic species, lineages 'WAM-SCHZ001' and 'WAM-SCHZ002' listed below. | Stygobite, Widespread | Widespread, Para | MB16, PMP02, PMP4, WB17NLC0001 (RTIOD2) | 260[1] |
| *Schizopera* `WAM-SCHZ001` | 4 | DNA | Unique genetic lineage within *S. roberiverensis*. | Stygobite, Potential SRE | 2 sites, Para | 99RS2, PMP4 | 3 |

| Taxonomy | No. spmns | ID Status | Taxonomic comments | Subterranean status, SRE status | Distribution comments | Bore/ hole codes | Known linear range (km) |
|---|---|---|---|---|---|---|---|
| *Schizopera* `WAM-SCHZ002` | 26 | DNA | Second unique genetic lineage within *S. roberiverensis*. | Stygobite, Potential SRE | 3 sites, Para | MB16, MB16PAFL001, PMP02 | 4 |
| **Parastenocarididae** | | | | | | | |
| *Parastenocaris* jane | 20 | Morpho | Specimens morphologically identified as *P. jane* (not genetically tested). Likely represents either cryptic species listed below 'WAM-PARA001' or 'WAM-PARA002'. | Stygobite, Widespread | Widespread, Para | PMP02, PMP4 | 500[1] |
| *Parastenocaris* `WAM-PARA001` | 11 | DNA | Unique genetic lineage within *P. jane*. Genetically divergent from external *P. jane* sequence (18.7 % COI). | Stygobite, Potential SRE | Single site, Para | PMP4 | - |
| *Parastenocaris* `WAM-PARA002` | 4 | DNA | Second unique genetic lineage within *P. jane*. Genetically divergent from external *P. jane* sequence (19.4 % COI). | Stygobite, Potential SRE | Single site, Para | MB16PAFL001 | - |
| **SYNCARIDA** | | | | | | | |
| Bathynellidae | | | | | | | |
| *Bathynella* `WAM-BATH001` | 74 | DNA | Genetic update of morphospecies *Bathynella* sp. 'B39', may represent a new genus (G. Perina, pers. comm.). Unique lineage found only within Study Area | Stygobite, Potential SRE | 3 sites, Para | MB15NLC001, MB15NLC005, WB17NLC0001 (RTIOD2) | 0.2 |
| **AMPHIPODA** | | | | | | | |
| **Bogidiellidae** | | | | | | | |
| Bogidiellidae `WAM-AMPB001` | 2 | DNA | Genetically identified (unique lineage) | Stygobite, Potential SRE | Single site, NBF | PTO2 | - |
| Bogidiellidae `WAM-AMPB002` | 3 | DNA | Genetically identified (unique lineage) | Stygobite, Potential SRE | Singleton, Para | MB16 | - |
| Bogidiellidae `WAM-AMPB003` | 2 | DNA | Genetically identified (unique lineage) | Stygobite, Potential SRE | Singleton, Para | PMP4 | - |
| **Eriopisidae** | | | | | | | |
| *Nedsia* `WAM-AMPE001` | 2 | DNA | Genetically identified (unique lineage) | Stygobite, Potential SRE | Single site, Para | MB13 | - |
| *Nedsia* `WAM-AMPE002` | 1 | DNA | Genetically identified (unique lineage) | Stygobite, Potential SRE | Single site, Para | PMP4 | - |
| *Nedsia* `WAM-AMPE003` | 82 | DNA | Genetically identified (unique lineage) | Stygobite, Potential SRE | Single site, Para | PMO4A | - |

| Taxonomy | No. spmns | ID Status | Taxonomic comments | Subterranean status, SRE status | Distribution comments | Bore/ hole codes | Known linear range (km) |
|---|---|---|---|---|---|---|---|
| *Nedsia* `*hulberti* group` indet. | 3 | Morpho, DNA fail | Morphologically identified as known morphospecies group (DNA unsuccessful). *Nedsia 'hulberti'* group also collected during DBCA PSS, borehole 99RS2 | Stygobite, Widespread | Group widespread, Para | MB16, MB16PAFL001, 99RS2 | 130+[1] |
| *Nedsia* sp. 24 | 1 | Morpho | Collected during DBCA PSS at a time when taxonomy was more limited. | Stygobite, Widespread | Widespread, Para | 99RS3 | 240[1] |
| **Paramelitidae** | | | | | | | |
| `*Pilbarus* sp. G` | 16 | DNA | Genetically identified (unique lineage) | Stygobite, Potential SRE | 6 sites, Para, NBF, CHN/ TCK: MB15NLC005, PMO1PVC01, PTO2, PTO7, WB17NLC0001 (RTIOD2), WB2/90 | | 21 |
| `*Pilbarus* sp. H` | 1 | DNA | Genetically identified (unique lineage) | Stygobite, Potential SRE | Singleton, CHN/ TCK | PFO9-4 | - |
| *Pilbarus millsi* | 2 | Morpho | Collected during DBCA PSS at a time when taxonomy was more limited. | Potential Stygobite, Widespread | Single site, Para | 99RS3 | 250+[13] |
| *Paramelitidae* sp. 2 | 1 | Morpho | Collected during DBCA PSS at a time when taxonomy was more limited. | Potential Stygobite, Widespread | Singleton, Para | 99RS3 | 550[1] |
| `*Yilgarus*` `WAM-AMPP001` | 118 | DNA | Genetically identified (unique lineage) | Potential Stygobite, Potential SRE | Hyporheic and stygal, 9 sites Para, NBF, CHN/ TCK: 99RS2, GPKC02, MB16, MB16PAFL001, PMO4A, PMP02, PMP4, PTO7, PTO8 | | 34 |
| `*Yilgarus*` `WAM-AMPP002` | 1 | DNA | Genetically identified (unique lineage) | Stygobite, Potential SRE | Singleton, CHN/ TCK | PFO9-4 | - |
| `*Yilgarus*` `WAM-AMPP003` | 1 | DNA | Genetically identified (unique lineage) | Stygobite, Potential SRE | Singleton, Para | MB15PAFL002 | - |
| **ISOPODA** | | | | | | | |
| **Tainisopidae** | | | | | | | |
| *Pygolabis paraburdoo* (`WAM-PYGO001`) | 9 | DNA | Likely genetic update of named species *Pygolabis paraburdoo*, No external sequence of *P. paraburdoo* available for comparison. *P. paraburdoo* also collected during DBCA PSS, borehole 99RS3. | Stygobite, Potential SRE | Multiple sites, Para | PMP4, 99RS3 | 70[14] |
| **Indeterminate taxa (unresolved)** | | | | | | | |
| *Aeolosoma sp. indet.* | 1 | Morpho, DNA fail | Indeterminate higher-level taxon, DNA unsuccessful. May represent Aeolosoma sp. 1, DBCA Pilbara Stygo Survey, bore 99RS02. | Potential Stygophile/xene, Uncertain | Singleton Para. Hyporheic, likely widespread | RSFLOW | Uncertain |

| Taxonomy | No. spmns | ID Status | Taxonomic comments | Subterranean status, SRE status | Distribution comments | Bore/ hole codes | Known linear range (km) |
|---|---|---|---|---|---|---|---|
| Phreodrilidae sp. indet. | 1 | Morpho, DNA fail | Indeterminate higher-level taxon; fragment only, DNA unsuccessful. Likely represents Phreodrilidae `WAM-PHRE001` collected from the same site. | Potential Stygobite, Uncertain | Paraburdoo | PMO4A | Uncertain |
| Oligochaeta sp. indet. | 23 | DNA fail | Juvenile/damaged specimens. May represent other Oligochaeta as listed above. | Potential Stygofauna, Uncertain | WR, Para, ER | 99RS2, RC03WR138, RC1323E0016 | Uncertain |
| Ostracoda sp. indet. | 13 | Morpho, DNA fail | Indeterminate higher-level taxon; shells only, DNA unsuccessful. May represent other Ostracoda sp. listed above. Ostracoda sp. indet. also collected during DBCA PSS, borehole 99RS2. | Stygofauna, Uncertain | Para, NBF: | 99RS2, MB13, MB16, MB16PAFL0002, PMO4A, PMO8, PMP02, PMP4, PTO2 | Uncertain |
| Cyclopoida sp. indet. | 29 | Morpho, DNA fail | Indeterminate higher-level taxon, juveniles, DNA unsuccessful. Likely juvenile *Thermocyclops aberrans* (Jane McRae, pers. communication), same location. | Potential Stygofauna, Uncertain | Para | RSFLOW (hyporheic sample) | Uncertain |
| *Parastenocaris* sp. indet. | 3 | Morpho, DNA fail | Indeterminate higher-level taxon; could not be identified to *P. jane*; DNA unsuccessful. | Potential Stygobite, Uncertain | Para | MB15PAFL002 | Uncertain |
| Harpacticoida sp. indet. | 5 | DNA fail | Indeterminate higher-level taxon; DNA unsuccessful. May represent other Harpacticoida species listed above. | Potential Stygofauna, Uncertain | Para | 99RS2 | Uncertain |
| Copepoda sp. indet. | 10 | DNA fail | Juvenile specimens unable to be identified. May represent other Copepoda species listed above. | Potential Stygofauna, Uncertain | Para | RSFLOW (hyporheic sample) | Uncertain |
| Nedsia sp. indet. | 12 | DNA fail | Indeterminate higher-level taxon; DNA unsuccessful. Likely represents other Nedsia listed above | Potential Stygobite, Uncertain | Paraburdoo, NBF | PMP02, PTO1B, PTO2, PTO7 | Uncertain |

Note: only indeterminate taxa with asterisk (*) were included in species count, as they were regarded as distinct taxa. All other indeterminate taxa were not included, as there was insufficient information to exclude the possibility that they may be the same as other specimens collected. Red font indicates taxon included in risk assessment (section 7).

Known linear range based on [1] Halse *et al.* (2014), [2] Brown *et al.* (2015), [3] Harman and McMahan (1975), [4] Pinder (2010, [5] Bennelongia (2017), [6] Karanovic (2006), [7] Pesce and De Laurentils (1996), [8] Karanovic *et al.* (2011), [9] Morton (1990), [10] Bennelongia (2013), [11] Lindberg (1952) , [12] Finston *et al.* (2005), [13] Keable *et al.* (2006), [14] Pinto *et al.* (2004), [15] Rossetti and Martens (1999), and [16] De Deckker (1982).