APPENDIX F: SUBTERRANEAN FAUNA

F.1: West Angelas: 3D Subterranean Habitat Modelling and Assessment







West Angelas:
3D Subterranean Habitat Modelling and Assessment

Biologic Environmental Survey

Report to Rio Tinto Iron Ore

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GLOSSARY

2D	Two Dimensional
3D	Three Dimensional
AWT	Above water table
BWT	Below Water Table
BIF	Banded Iron Formations
BrIF	Brockman Iron Formation
Development Envelope	Deposits A, B, C, D, E, F and G approved under Ministerial Statements 1113, 1015, 0970 and 0514).
EIA	Environmental Impact Assessment
Extent	Lateral spatial extent of suitable habitat
FOR	Fortescue Group
GSWA	Geological Survey of Western Australia
GWDD	Groundwater drawdown
Inferred	Habitat suitability that has been deduced or concluded from evidence and reasoning
KNP	Karijini National Park
Leapfrog	Leapfrog® Geo – computing software
LOM	Life of Mine
mbgl	Metres below ground level
mesh	Leapfrog® model 3D surface
MAR	Managed Aquifer Recharge
MCS	Mt McRae Shale
MMIF	Marra Mamba Iron Formation
mRL	Metres Relative Level (groundwater elevation relative to sea level)
NEW	Mt Newman Member
Strand	Category of drill log coding indicating stratigraphic member
Suitable habitat	Categorisation of habitat suitable for troglofauna or stygofauna from 3D modelling
Thickness	vertical extent of suitable habitat within conceptual thresholds
Tag	Category of drill log coding showing lithology, mineralisation, or physical structure
WAN	West Angelas operations
WF	Wittenoom Formation
WT	Water table

1. INTRODUCTION

Rio Tinto Iron Ore Pty Ltd (Rio Tinto) operates the West Angelas Iron Ore mine located approximately 100 kilometres (km) north-west of the town of Newman in the Pilbara region of Western Australia. Rio Tinto is proposing to develop four new iron ore deposits (Section 1.1) and associated infrastructure to sustain the existing West Angelas (WAN) operations (Figure 1-2).The Proposal comprises both above water table (AWT) and below water table (BWT) mining (and construction of associated infrastructure) within the 41,483 hectare (ha) Development Envelope.

Biologic Environmental Survey (Biologic) was commissioned by Rio Tinto to provide 3D modelling of subterranean fauna habitats and assessment for troglofauna and stygofauna habitat values within the proposed deposit areas. The results of the modelling will be used to inform an environmental impact assessment (EIA) (Biologic, 2022a) of the subterranean fauna habitat values in relation to the potential impacts of the proposed mining operations and groundwater extraction.

Biologic worked extensively with Rio Tinto to develop an improved understanding of the associations between the geology and hydrogeology of the Development Envelope and the presence and diversity of subterranean fauna. This understanding informed the assessment of prospective suitability, extent, thickness, and connectivity of the subterranean fauna habitats, The habitat assessment, in turn, resulted in the detailed modelling of potential troglofauna habitat (AWT) and stygofauna habitat (BWT) of the Development Envelope and surrounds under several impact scenarios including before and after implementation of the Proposal.

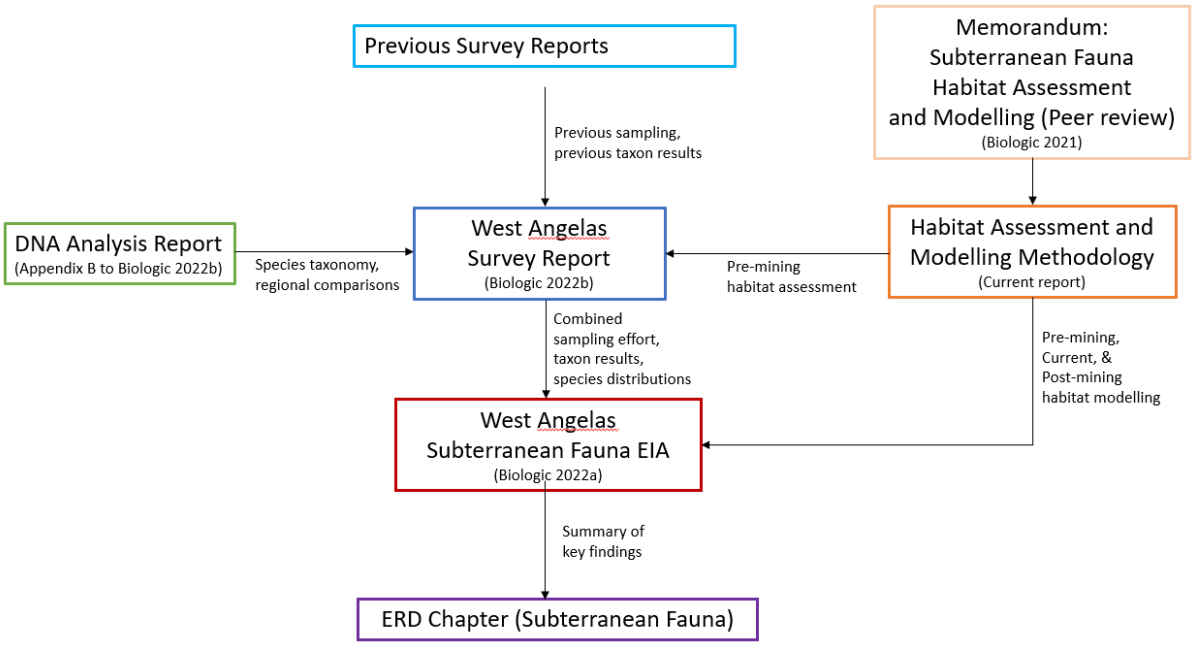


Figure 1-1: Document flow chart for West Angelas subterranean fauna EIA

This document provides:

- Methods, constraints and outputs of 3D habitat modelling of suitable subterranean fauna habitats within the West Angelas Development Envelope and surrounds;
- Assessment of impacts to troglofauna habitat from the proposed mining operations; and
- Assessment of impacts to stygofauna habitat from the proposed mining operations and groundwater abstractions and recharge.

1.1 Sections of the Development Envelope

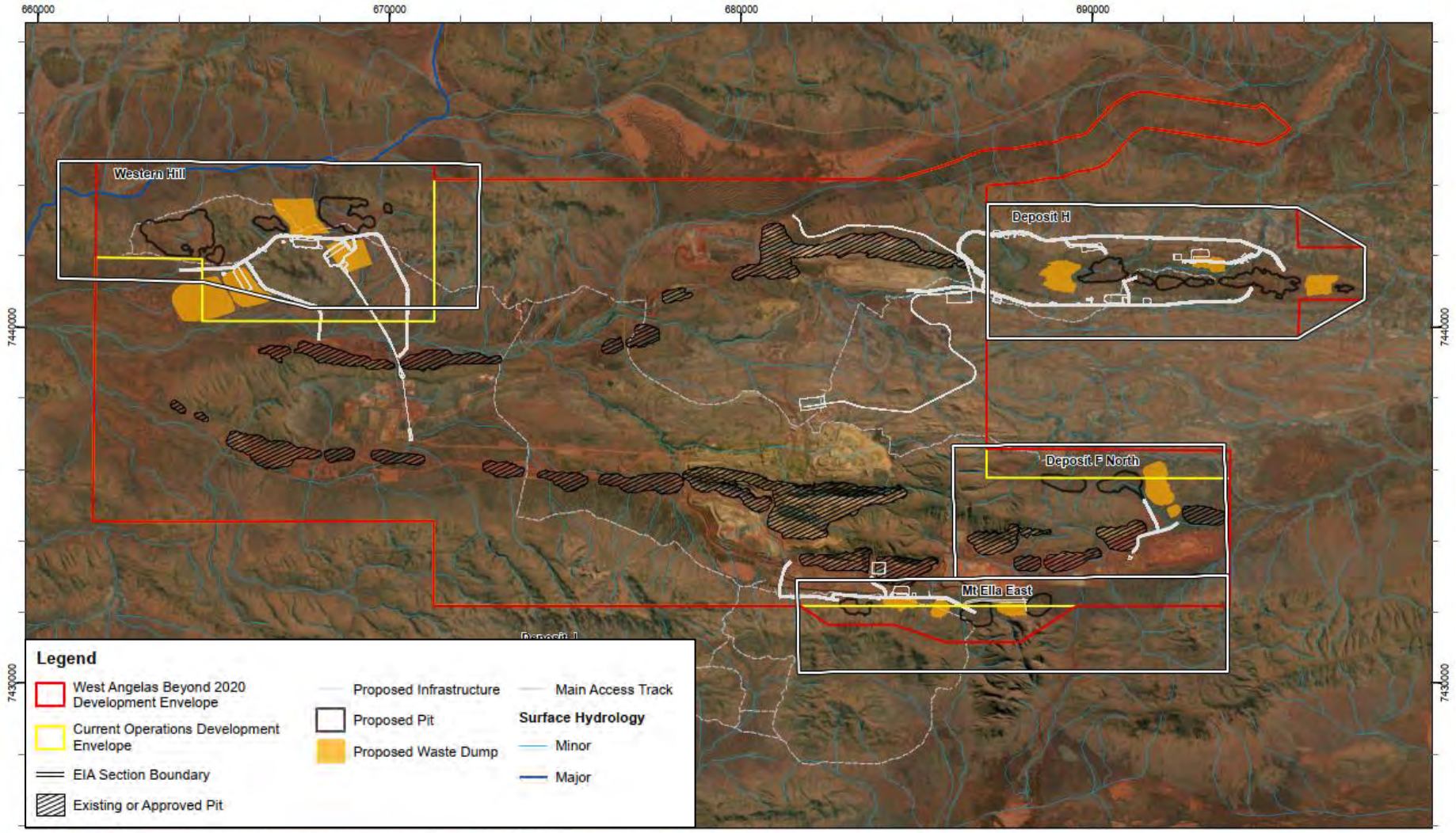
For the purposes of this assessment, the Development Envelope has been divided into four sections according to the proposed deposit area (Figure 1-2

Figure 1-2) as follows:

- **Western Hill**: Proposed AWT and supply abstraction;
- **Deposit H**: Proposed AWT and BWT mining;
- **Deposit F North**: Proposed predominantly AWT mining, minor percentage BWT mining; and
- **Mt Ella East**: Proposed AWT mining.

Deposit J reference area (Figure 1-2) represents a sampling area for the baseline survey (Biologic, 2022a) which will not be subject to any direct impacts from the Proposal. This area was reviewed, and information used as a reference area for habitat within the Development Envelope.

Figure 1-2: West Angelas Project Area



2. GEOLOGICAL SETTING

The West Angelas Development Envelope is centred on the Wonmunna Anticline with deposits situated on the north and southward limbs of the anticline in units of the Hamersley Group. The limbs are characterised by steeply plunging Marra Mamba Iron Formation (MMIF) including Nammuldi, MacLeod and Mt Newman Members (Figure 2-1). The Wittenoom Dolomite Formation, which is often overlain by detrital cover (mostly consisting of unconsolidated alluvial and colluvial layers with karstic calcrete deposits), characterises the valley between the MMIF anticline and the surrounding Brockman Iron Formation (BrIF) synformal ridges (Rio Tinto, 2020a, 2020b). Underlying the Hamersley Group units (beneath the lower Nammuldi Member of the MMIF) are the Fortescue Group volcano-sedimentary units, which form the regional geological basement.

Sub-regional north-west to south-east dolerite dykes cross-cut the bedrock geology, with at least one significant northeast-southwest oriented dyke intrusion that offsets stratigraphy in the anticline. Dykes may act as an aquitard, compartmentalising the bedded lithologies (Rio Tinto, 2020b), depending on the rheology and degree of weathering/ faulting within the host rock. Compartmentalisation is less likely to occur in the overlying detritals or within highly weathered regolith where the presence of the dykes becomes less obstructive - due to weathering or absence.

Structurally, the region is offset by a series of west to north-west thrust faults and conjugate fault systems that run sub-parallel to the folded limbs.

The generalised stratigraphy for the West Angelas Development Envelop and surrounding region is shown in Table 2-1 and Figure 2-1, with geological description and notes relating to subterranean fauna habitat suitability which are based on local sampling results and regional knowledge.

The deposits within the Development Envelope occur in different areas of the folded district, each having a unique combination of geological, hydrological, and topographical factors that have contributed to the size, extent, and complexity of the available prospective subterranean fauna habitat, above and below the water table.

Assessment of suitability for subterranean fauna habitat was based on an evaluation of the potential porosity, connectivity by cavernous features, hydration, oxidation, and mineralisation of the lithologies present (Table 2-1). Within the Development Envelope, the main geological formations which provide habitat for subterranean fauna comprise:

- Brockman Iron Formation (BrIF)
    - High to Medium suitability habitats (AWT and BWT) are prevalent in weathered and fractured Dales Gorge and Joffre Members of the BrIF, and pisolitic duricrust/ hardcap on the flanks of the ranges. Other members of the BrIF may also provide suitable habitat values where suitably weathered/ fractured (typically were occurring near surface or in the presence of faulting/ fracture zones).

Table 2-1: Generalised stratigraphy of major geological units occurring within the West Angelas Development Envelope and surrounds.

Age	Unit		Description	Typical suitability for subterranean fauna
Cainozoic and Quaternary	Detrital layers (Qa – alluvium, Qc - colluvium, Qw) Czc - Czk- calcrete)		Superficial deposits occupying lower flanks, valleys, drainage lines. Secondary calcrete, dolocrete, and CID common.	Medium to High – particularly in secondary deposits, well sampled throughout the Pilbara
	Channel Iron Deposits (CID) (Czc)		Secondarily weathered deposits of Robe Pisolite, mainly along drainage lines or in valley detritals.	High – well sampled throughout the Pilbara
Various	Dolerite Dykes (Fd)		Dolerite dykes intrude the bedrock (following fault planes) throughout the Syncline. Most strike NW to SE.	Low – mainly impervious, potential barriers
	Hamersley Group			
Proterozoic	Boolgeeda Formation		BIF, jaspilite, siltstone and shale.	Low – poorly sampled, typically low permeability.
	Woongarra Formation		Rhyolite lavas, pyroclastic rocks, and BIF	
	Weeli Wolli Formation (Hj)		Jaspilitic BIF, shale and siltstone.	
	Brockman Iron Formation (Hb)	Yandicoogina Shale	Interbedded chert, shale and BIF	Medium to Low – poorly sampled
		Joffre Member	BIF with shale bands	Medium to High – particularly mineralised/ hydrated, well sampled Low within impervious shale bands (e.g.J3)
		Whaleback Shale	Interbedded chert and shale bands, minor BIF.	Medium to Low – moderately sampled
		Dales Gorge	Interbedded BIF and shale bands	Medium to High – particularly mineralised/ hydrated, well sampled
	Mount McRae Shale Formation (Hs)		Shale and interbedded BIF	Low – mainly impervious, potential barrier, well sampled
	Mount Silvia Formation (Hs)		BIF, chert, and shale	Mostly Low – poorly sampled, typically low permeability.
	Wittenoom Formation (Hd)	Bee Gorge Member	Calcareous dolomite, chert, volcaniclastics and BIF.	Medium to High – particularly fractured/ weathered, moderately sampled
		Paraburdoo Member	Dolomite with minor chert.	Medium to High – particularly fractured/ weathered/ karstic, well sampled
		West Angela Member	Manganese rich shale, BIF, dolomite and chert.	Mostly Low – poorly sampled, moderate permeability, if fractured weathered
	Marra Mamba Iron Formation (Hm)	Mt Newman Member	BIF with thin shale bands	Medium to High – particularly mineralised/ hydrated, well sampled
		McLeod Member	BIF, chert, and carbonate, with interbedded shale.	Medium to Low – particularly if mineralised/ fractured, moderately sampled
		Nammuldi Member	Cherty BIF interbedded with thin shales.	Medium to Low – poorly sampled, typically lower permeability.
	Fortescue Group			
Lower Proterozoic	Jeerinah Formation (Fj)		Basaltic flows interbedded with shale, chert, BIF, mudstone, quartzite, and dolomite.	Mostly Low – poorly sampled. Some patches of higher suitability associated with detrital formations in the centre of the anticline.
	Bunjinah, Pyradie, and Boongal Formations (Fjb)		Metabasaltic flows and breccia.	Unknown/ uncertain.
	Hardey Formation		Sedimentary pelite, metasandstone and conglomerate.	

- Marra Mamba Iron Formation (MMIF)
    - High to Medium suitability habitats (AWT and BWT) are prevalent in weathered and fractured Mt Newman Member of the MMIF, and pisolitic duricrust/ hardcap on the flanks of the ranges. Other members of the MMIF may provide suitable habitat values where suitably weathered/ fractured (typically in the presence of faulting/ fracture zones).
- Wittenoom Dolomite Formation
    - High to Medium suitability habitats occur in weathered/ fractured porous Paraburdoo and Bee Gorge Members typically BWT in the Synclinal Valley. Porosity can be variable within the Wittenoom Formation due to the occurrence of shales and massive/ fresh Dolomite. Localised, West Angela Member can be High- Medium suitability from deep weathering, faults and fracturing.
- Detrital habitat units (mainly in the Synclinal Valley)
    - Unconsolidated and porous alluvial/ colluvial detritals (AWT/BWT).
    - Secondarily weathered calcrete deposits and pisolitic channel iron deposits (CID) occurring in patches throughout the valley detritals. One large patch of calcrete/ dolocrete occurs throughout the Synclinal Valley from Deposit C to D and beyond the Development Envelope to the west.

2.1 Hydrogeological context

Importantly, for BWT habitats, the hydrology and geology need to be evaluated together to understand the potential for stygofauna habitat. Understanding how the groundwater relates to the geological context explained above assists in evaluating the size and extent of saturated prospective subterranean habitats. Several groundwater systems exist throughout the different sections of the Development Envelope (Figure 2-2). A regional aquifer sits within the Turee Creek Valley while localised aquifers have been defined in the other Sections and are detailed below.

Western Hill and Synclinal Valley aquifer

The Western Hill area is defined by two aquifer systems, the mineralised orebody aquifer hosted within BrIF, and the 'regional' aquifer system hosted in Wittenoom Dolomite and detritals, further known as the Synclinal Valley aquifer.

The mineralised Dales Gorge Member of the BrIF at Western Hill is highly weathered and fractured, creating a highly porous aquifer. Groundwater occurs at considerable depth below surface between 50 – 80 mbgl) and the aquifer is split into east and west lenses by a large regional NW trending fault, which offsets the basement, Mt McRae Shale (MCS) layer (Figure 2-2). The east lens is elevated to around 670 mRL, perched above the west lens, which sits at approximately 624 mRL (approximately equivalent to the regional synclinal aquifer). The low permeability MCS layer forms a basement for the orebody aquifers and constrains its wider connectivity with the Synclinal Valley aquifer (Figure 2-2). Where major faulting has offset the MCS, there may be localised fractures which allow some potential leakage or

outflow to the Synclinal Valley, although the majority of hydrogeological information shows very limited connectivity between these systems (Rio Tinto 2020b).

Surrounding the MCS, the Synclinal Valley aquifer is fed by the Turee Creek catchment and subsidiary creeks and is primarily hosted in the Wittenoom Formation which has the potential for high permeability and medium to high habitat suitability for stygofauna. The dolomitic Paraburdoo Member and Bee Gorge Member are known to feature karstic dissolution of calcareous rock, and host highly porous regional aquifers throughout the Pilbara, including at West Angelas (Rio Tinto, 2020b). The Wittenoom Formation is hydraulically connected to the underlying Marra Mamba Iron Formation (MMIF) via moderate permeability West Angela Shales (which may be higher permeability where faulted/ fractured. Mineralised orebody aquifers within the MMIF also occur at the periphery of the Synclinal Valley at Deposit C and D, and aquifers in these areas are connected to the Synclinal Valley regional aquifer via saturated detritals.

A large calcrete/ dolocrete deposit extends from the western tip of the anticline (south of Western Hill) to the southwestern boundary of the Synclinal Valley aquifer in KNP (Figure 2-2). On average the detrital layers in the valley have been modelled as occurring to 40 mbgl. Permeability is variably medium to high in the superficial layers due to sediment textures, and the degree of weathering, but these layers are considered highly suitable habitat for stygofauna.

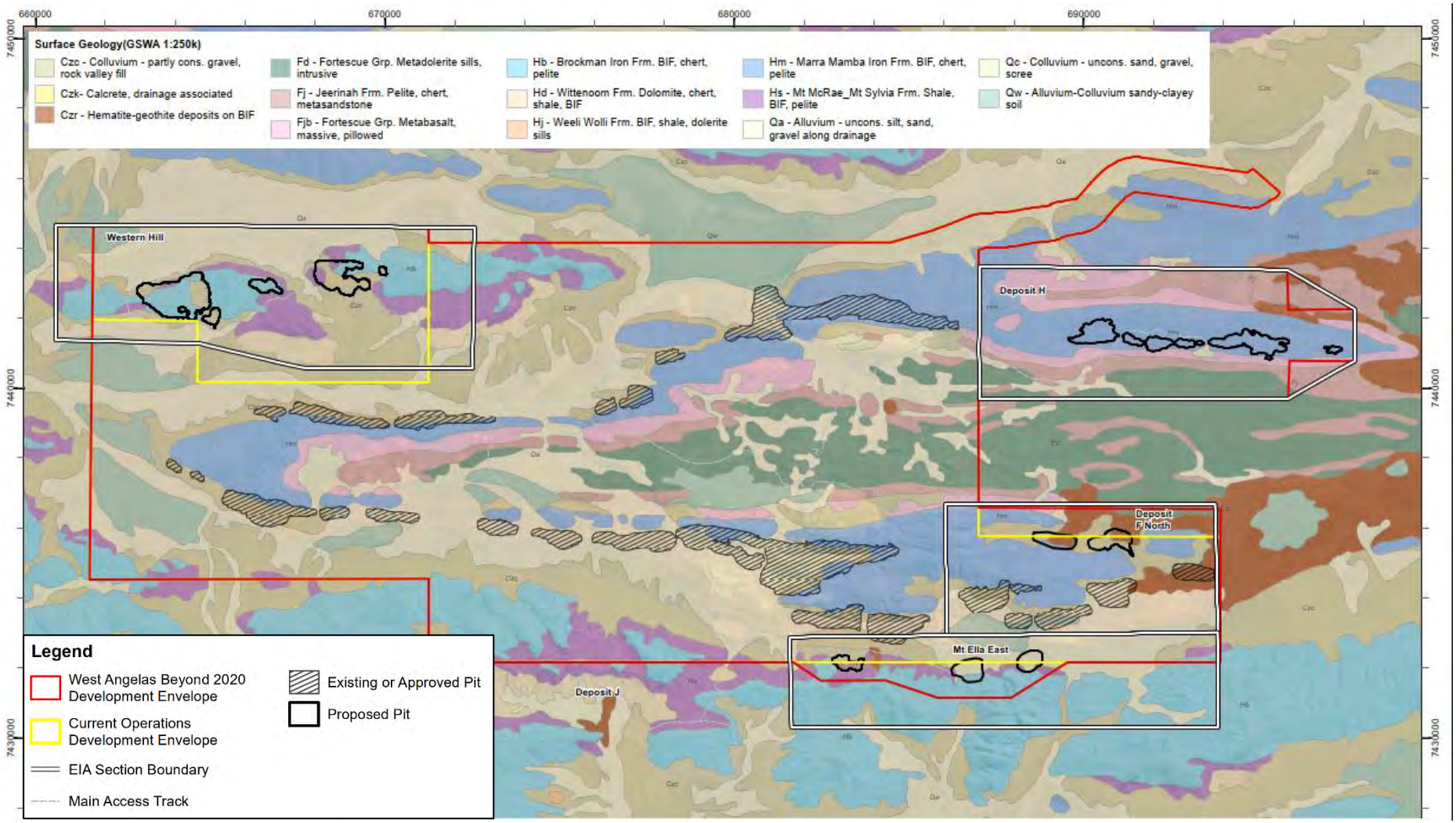
Several dykes occur within the bedrock in these areas, striking north-west to south-east. These dykes do not appear to affect groundwater flows or create compartmentalisation, due to the influence of faulting/ fracturing, and the occurrence of thick, porous detritals and calcrete layers occurring atop the dykes and bedrock in the Synclinal Valley.

Deposit H

Deposit H is in the upper catchment of Pebble Mouse Creek, part of the regional Weeli Wolli catchment to the north and east of the Development Envelope (Figure 2-2). It sits in an elevated and isolated position at around ~800 mRL, formed in an elongated basin of Wittenoom Formation (WF) and Marra Mamba Iron Formations (MMIF) that is constrained in all directions by low permeability Fortescue Group (FOR).

Groundwater is hosted within the deep folded and fractured/ mineralised WF and Mt Newman Member (NEW) of the MMIF (Figure 2-3). Despite considerable depth of the highly porous/ fractured lithology (from surface to >200 mbgl) the aquifer is restricted in size/ extent and is constrained on all sides. The vertical aquifer depth is variable across the deposit reaching a maximum depth around 135 m (Rio Tinto, 2020c). Occasional leakage/ outflow may occur to the north via fractures, but for the most part the groundwater at Deposit H is disconnected from other regional hydrogeological systems in the nearby area. The limited size and connectivity of this aquifer may provide a limitation for its suitability as stygofauna habitat (Biologic 2022).

Figure 2-1 Regional Geology (GSWA:250k) within and surrounding the West Angelas Development Envelope



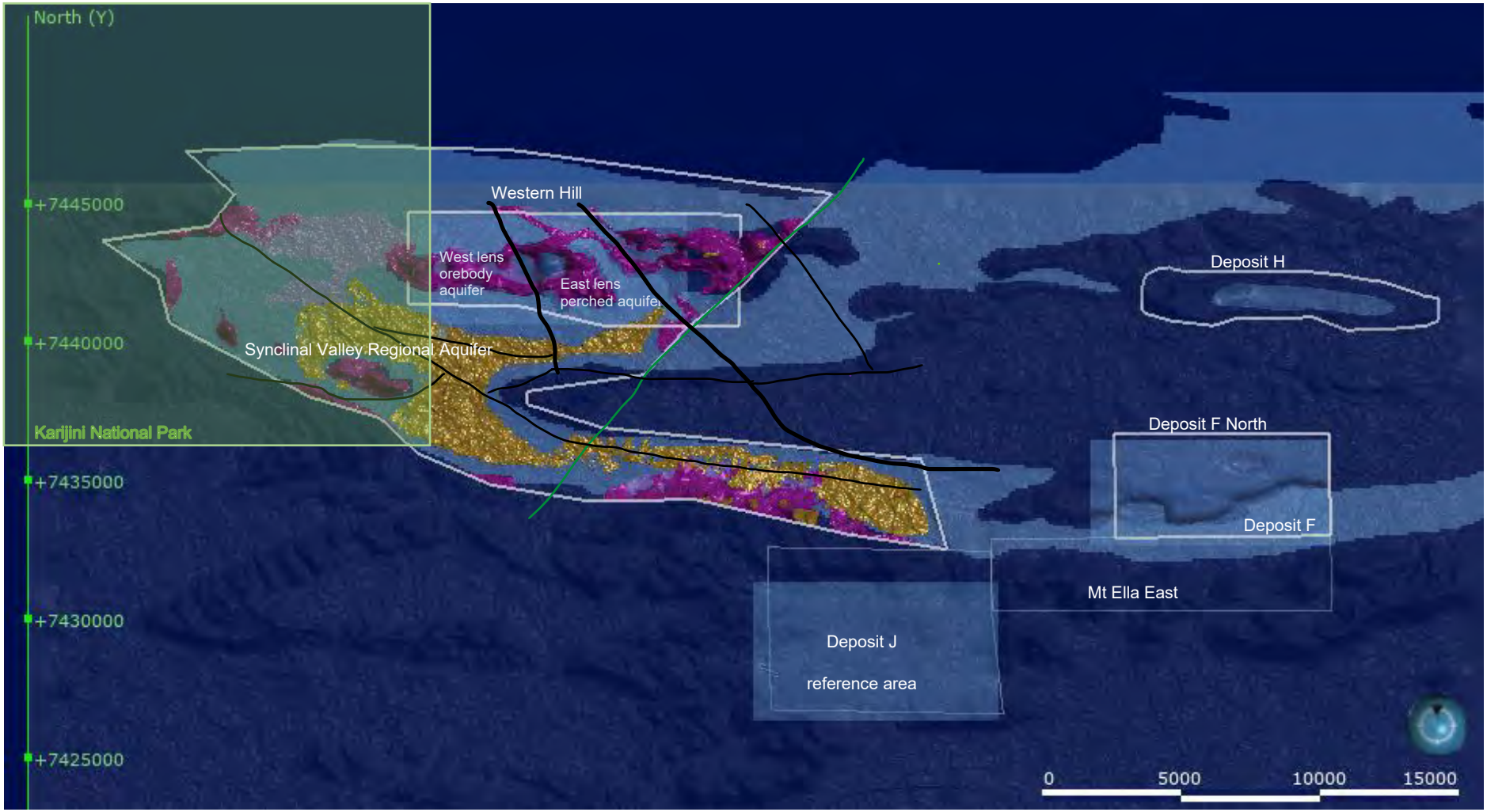


Figure 2-2 Regional hydrogeological interpretations (pale blue) within West Angelas Development Envelope and surrounding synclinal aquifer showing interpreted faults (blackline), significant dolerite dykes (green line) and significant hydrogeological lithologies MCS (purple) and Calcrete (Gold/brown)

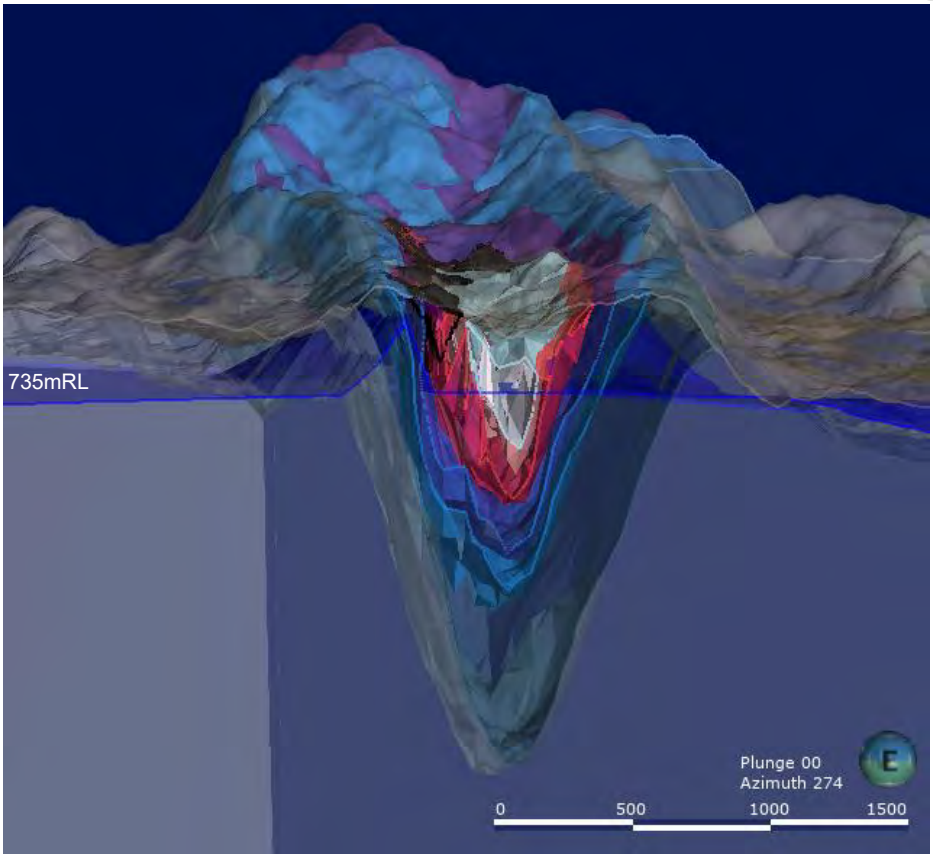


Figure 2-3: Deposit H hydrogeological concepts - Folded Wittenoom Formation -white (including West Angela member (red)) and MMIF (Mt Newman – purple, Macleod – light blue, Nammuldi– (pale green) and FOR – grey, looking westerly (vertical exaggeration 5x). **Water level (bright blue)**

Deposit F North

Groundwater at Deposit F North is known only from a small, highly constrained pocket of groundwater deep within the bedrock (>70 mbgl). This localised patch of groundwater is isolated within a synformal folded lens of MMIF and constrained by the lower permeability Macleod and Nammuldi Members at depth (Figure 2-4). Groundwater levels at Deposit F North and areas down slope to the north have been interpreted by Rio Tinto (2020c) from limited exploration hole geophysics and validated with water levels from two 2017 exploration grade holes by converted into monitoring bores (Figure 2-2). Groundwater levels at Deposit F North is elevated at around 716 mRL (~78m below ground) when compared to the Deposit F aquifer system to the south which sits at around 670 mRL (or 46m lower than Deposit F North). The two systems are not thought to be connected because of the constraining low permeability FOR which sits between them (Figure 2-4). The Deposit F North is unlikely to be suitable for stygofauna due to its isolation, low porosity, and limited throughflow.

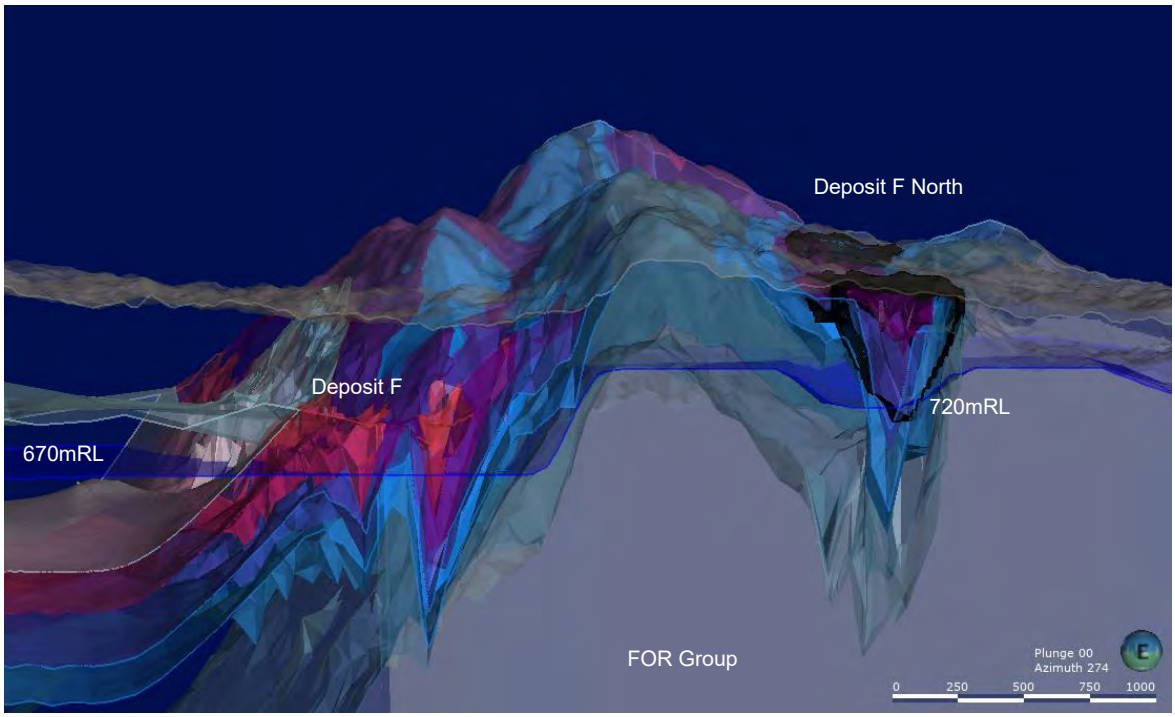


Figure 2-4: Deposit F North hydrogeological concepts - proposed pits constrained to synformal MMIF (Mt Newman – purple, Macleod– light blue, Nammuldi– pale green and FOR - grey) looking westerly (vertical exaggeration 5x**). Water level (bright blue) is perched in Deposit F North and sits well above and separated from the Deposit F by the FOR Group.**

Mt Ella East

Hydrogeological data has not been provided for Mt Ella East (Figure 2-2) and groundwater is not known to occur within the BrIF which forms the orebodies in this section. The groundwater table in the Synclinal Valley to the north of the deposits is very deep (>110 m below surface) and is anticipated not to form significant habitat for stygofauna in the vicinity of the Mt Ella East pits.

Other areas

Groundwater is known to occur in some other areas throughout the West Angelas hub, including in the central plateau of the Wonmunna Anticline, Turee Creek Borefield, and the Deposit J reference area (Figure 2-2). However, combined information from hydrogeological investigations (Rio Tinto 2020b) and subterranean fauna surveys (Biologic 2022) have shown that these groundwater areas are separated from the hydrogeological settings discussed above. Based on these findings, and the lack of potential groundwater impacts arising from the Proposed Development, the aquifers of the central plateau, Turee Creek Borefield, and the Deposit J reference area were not a focus of the 3D modelling described herein.

3. 3D HABITAT MODELLING

Overview

Assessing and modelling subterranean habitats in three-dimensions (3D) facilitates the visualisation and a quantitative estimation of the suitable habitats within specific modelled boundaries. The 3D modelling estimates include a representation of the likely depth or thickness of suitable geological/ hydrogeological strata (i.e., the 3D extent of subterranean habitat) throughout the modelling area. This methodology surpasses the accuracy and granularity of planar (2D) modelling which is traditionally used to estimate potential areas of occupancy for subterranean fauna. Once the habitat has been modelled in 3D, volumetric calculations can be made and then be used to quantify the modelled habitat present and impacted under a scenario. For example, 3D modelling can be used to quantify the proportion of suitable habitat that may be subjected to loss by proposed mining impacts (incorporating 3D pit designs) and provide this in context of the wider extent of modelled suitable habitat that remains unaffected.

Habitat Modelling Methodology

Three-dimensional models of subterranean habitat were created by compiling all available drill hole information throughout the Development Envelope and surrounds into the Leapfrog® Geo 2021.2.3 software (Leapfrog). The compiled data set was coded (High, Medium, Low, Inferred or Uncertain) to reflect the subterranean fauna habitat suitability categories that were based on the physical structure of the rock and its ability (where known) to provide suitable void spaces for subterranean fauna. The coded drilling information was then used to create 3D models of suitable subterranean habitats constrained by a 'boundary of confidence'. For example, the vertical extent of drilling in each drill location formed a limit to the maximum thickness (or depth from surface) of the suitable high confidence habitat modelling. Once the suitable subterranean habitat had been defined, volumetric calculations were applied and summarised for each category of the habitat and impact scenario. A simplified overview of the 3D habitat modelling process for subterranean fauna habitat values is provided in Figure 3-1.

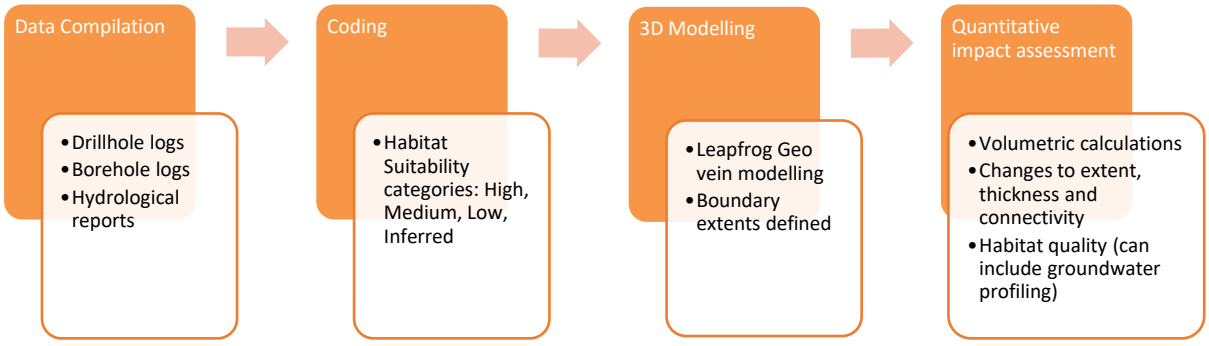


Figure 3-1: Flow diagram of the 3D habitat modelling and process

A separate, peer reviewed habitat modelling memorandum (Biologic, 2021) has defined the basic technical methodology for 3D habitat modelling undertaken in Leapfrog® Geo. Further information on methodology for the 3D habitat modelling and process for the Proposal is provided in the remainder of this section.

Data compilation

Compilation of several datasets for the West Angelas Development Envelope included reviewing lithology information from drill-hole logging data and bore logs, analysis of diamond drill cores, hydrogeological and geophysical data, as well as any available structural information from technical reports (Aquaterra, 2005; Dodson, 2006; Rio Tinto, 2018, 2020a, 2020b, 2021). The drill hole data from geological and hydrogeological databases were exported from Rio Tinto's AcQuire database and compiled in Microsoft Excel Power Query.

Data from more than 28,350 holes and over 2.1 million metres of drilling has been recorded throughout the Development Envelope (Table 3-1) with the vast majority being Reverse Circulation (or RC) type holes. Not all drill intervals were able to be incorporated into the final model due to validation issues, missing data, or incomplete logging mainly resulting from legacy datasets. The final drill statistics for each deposit or region are provided in Section 5 and 6.

Table 3-1:Summary of compiled drilling data for West Angelas Development Envelope by hole type

Hole Type	No. of Holes	Metres drilled
Water Bore / Monitoring Bore	563	66,825
Diamond	1474	128,877
Percussion	547	16,607
RC	21,528	1,675,631
Other	4264	249,041
Total	28,358	2,136,981

Habitat Suitability Coding

The compiled lithological data was coded by combining the stratigraphic unit (*strand*), and mineralisation/ geomorphology characteristics (*tag*), creating a unique "*strand_tag*" code that was classified into subterranean habitat suitability principally based on the lithologies, as summarised in Table 2-1. Due to differences in drill hole logging information provided, not all data (as with the hydrogeological logging) had strand or tag information available. In this case, the lithology codes and comments field were used to create a code that could be classified into the subterranean habitat suitability based on Table 2-1.

All code combinations were collaboratively assessed by suitably experienced Biologic and Rio Tinto technical personnel to determine the codes most likely suitability for supporting subterranean fauna (AWT and BWT). This assessment was based upon the following data and expertise:

- Subterranean fauna habitat features recorded in the available drill logging data (*e.g.* fissures and cavities, hydrated weathering, unconsolidated gravel textures, and occasionally cavities and core losses).
- Hydrogeological information regarding the porosity, transmissivity, and hydrogeological characteristics of coded units (assessment for BWT habitat units) which were validated against bore logs and hydrogeological reports.
- Visual assessment of diamond drill cores (where available) from each Deposit area.
- Consultation with a Technical Expert that had previous experience with subterranean habitat assessment in similar geological settings, and sampling information from similar geological settings (where available).

After a comprehensive review of all lithological drilling data, five subterranean fauna habitat suitability categories (Table 3-2) were applied.

Table 3-2 Habitat suitability code categories for subterranean fauna habitat modelling

Suitability Code	Description	Examples
High	• Geological unit known to frequently support subterranean fauna (AWT/ BWT) including rich and diverse assemblages almost always considered to be a key habitat for subterranean species or, • Records observation of subterranean habitat features such as fractures, pore spaces, cavities, or unconsolidated material.	Strand/ tag denotes unit that is always or almost always porous, weathered, vuggy, e.g. 'Hydrated', 'Cavity', 'Fractured' or 'High grade' within Dales Gorge, Mt Newman, Hematite, Goethite, CID, Pisolite, Calcrete, Silcrete, or Dolomite.
Medium	• Geological units known to support subterranean fauna (AWT/BWT) in some circumstances but not always expected to occur (such as fractured or weathered rock habitats) or, • Geological units known to support subterranean fauna less frequently, less consistently, or less diverse assemblages based on previous experience in similar geological contexts or • Fractures, pore spaces, cavities, and secondary weathering features are recorded as less well developed, less frequently occurring, or not specifically recorded but known to occur within this unit.	Tags which allow for potential fractures/ pore spaces including 'mineralised', 'unmineralised', 'low grade', 'waste', 'chert', 'quartz', and 'BIF' and others. Primarily Strands within Dales Gorge, Footwall zone, Hematite, Goethite, CID, Pisolite, Calcrete, Silcrete, or Dolomite. Mineralised iron-bearing detrital formations and unconsolidated detritals (e.g. gravels, cobbles, scree), and 'cavity fill'
Low	• Geological units that rarely support subterranean fauna, or lacks the physical characteristics required for supporting subterranean fauna (i.e. insufficient void spaces or porosity), no evidence or very little evidence occurrences within this geology, where sampling has occured. • Also used for known barriers to hydrogeological/ geological habitat connectivity such as clays, shales, dolerite dykes and sills.	Tags or strand/ tag combination denotes impermeable or fresh rock - e.g. Mt McRae Shales (MCS) black shales, Fortescue (FOR) group, dolerite (dyke/ sill), limonite. Tags relating to fresh BIF, chert, shale, or dolomite. Detrital layers dominated by fine textured silts and clays.
Inferred	• Some stratigraphic information available, however the strand/ tag information insufficient to classify as above, and suitability unable to be confirmed by sampling.	Infrequent/ atypical tags within otherwise suitable stratigraphic members. Also includes some areas within stratigraphic modelling where strand/ tag information not available due to data gaps.
Uncertain	• Units that lacked sufficient information or context to classify as above – lacking geology/ hydrogeology logging and/or stratigraphic information.	Typically, intervals with inconsistent or missing data.

In areas where no drilling data was available, broad stratigraphic units could be coded into Potential or Low potential habitat suitability (Table 3-3) based on geological or hydrogeological characteristics as described in

Table 2-1. The habitat suitability coding in Table 3-3 is much more generalised than the classifications given in Table 3-2 and was only used for regional scale, low data density areas.

Table 3-3: Habitat suitability coding for the stratigraphic model grouped for volumetric calculations

Lithology Code	Description	Potential Suitable Habitat	Low Potential Habitat
ANG	West Angela Member	Potential	
CALCRETE	Calcrete	Potential	
DET	Detritals	Potential	
DG	Dales Gorge Member	Potential	
DOR	Dolerite dykes		Low
FOR	Fortescue Group		Low
JOF	Joffre Member	Potential	
MCS	Mt McRae Shale (includes) Mt Silvia		Low
MM	Marra Mamba	Potential	
WF	Wittenoom Formation	Potential	
WS	Whaleback Shale	Potential	
Inferred	All stratigraphy below the base of the porous aquifer	Inferred	

Once classified, suitable habitat for troglofauna (AWT) or stygofauna (BWT) was grouped into Zone A and Zone B for later interpretations and volumetric calculations. Zone A is defined by the High and Medium classifications from Table 3-2 and, if applicable, Potential from Table 3-3 (when including the stratigraphic model). Zone B is the inferred classification which is included in the suitable BWT habitat volumetric calculations. Low Suitability is excluded from the volumetric calculations of suitable habitat.

Table 3-4: Habitat suitability classification grouping for volumetric calculations and interpretations

		AWT		BWT	
Model type	**Zone Group**	**Suitable Habitat**	**Low Suitability**	**Suitable Habitat**	**Low Suitability**
Vein	**Zone A**	High & Medium	Low	High & Medium	Low
	Zone B	n/a	Inferred	Inferred	Low
Stratigraphic	**Zone A**	n/a	n/a	Potential / porous units	Low potential impermeable units
	Zone B	n/a	n/a	Inferred	Low potential impermeable units

3D Modelling in Leapfrog

Habitat modelling was derived from the stratigraphic models and drilling data provided by Rio Tinto. Biologic reviewed the available Leapfrog models provided by Rio Tinto and identified a comprehensive 'regional' stratigraphic model which broadly covered the entire West Angelas Development Envelope as well as four deposit smaller scale models for Western Hill, Deposit H, Deposit F North and Mt Ella East.

As detailed in the peer-reviewed Memorandum: Subterranean Fauna Habitat Assessment and Modelling report (Biologic, 2021), the vein modelling technique was applied in Leapfrog. This allowed for spatial interpolation and linking of the same codes together throughout a modelling boundary, creating meshes or surfaces that were exported or quantified as volumes.

Habitat 'vein' model (all areas)

For the current assessment, the 'regional' stratigraphic model was updated with the compiled drilling data including collar, survey, downhole lithology, and habitat suitability. Once updated, the modelling of habitat 'veins' was completed using the suitability classifications as summarised in Table 3-2. The model was then subsequently split into AWT and BWT sections for impact analysis.

Any areas within the stratigraphic model between the upper and lower boundaries that were unable to be confidently modelled as high/ medium/ low were categorised as 'inferred' habitat zones. The absence of drilling data does not allow confirmation of this zone as suitable habitat 'vein' but suggests that some potential habitat suitability may exist.

The data processing settings within Leapfrog that define the resolution and way the vein model extrapolates the data are presented below (Table 3-5). Due to the density of the data and the size of the Development Envelope, resolutions were kept to 100 m to facilitate processing of the model.

Table 3-5: Leapfrog Geo Vein Model specifications

Specifications	Model	AWT SF HAB	BWT SF HAB	BWT STRATIGRAPHY
Geology Model: General tab	Surface resolution	100m	100m	50m
	Snap to data:	Drilling only	Drilling only	All Data
Vein Model: Surfacing tab	Boundary filter	Off	Off	-
	Maximum snap distance	50m	50m	-
	Snap to data	Inherit from GM (All data)	Inherit from GM (All data)	-
	Pinch out	Yes	Yes	-

Stratigraphic model - Synclinal Valley aquifer

Following the habitat 'vein' process, a review and validation of the modelled BWT habitat for the Synclinal Valley aquifer (

Figure **3-2**) noted that while modelling within the West Angelas Development Envelope had a high density of drilling that intercepted the water table and provided accurate modelling of high/ medium/ low suitability veins in the eastern part of the Synclinal Valley, the comparative lack of drilling outside of the Development Envelope to the west, especially within the bounds of Karijini National Park (KNP), limited the interpretation of the regional Synclinal Valley aquifer.

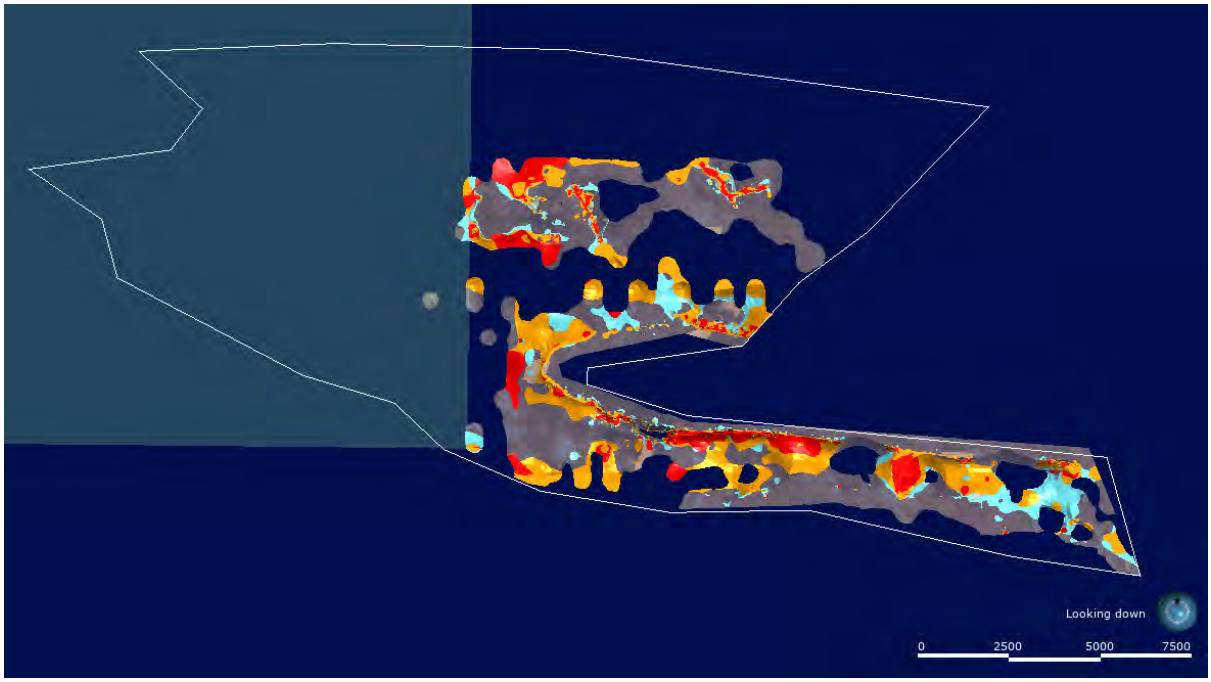


Figure 3-2**: Interpretation of BWT habitat extent within the Synclinal Valley aquifer (white) based on 'vein' modelling within the 300m boundary - demonstrating limitation of interpretation into the boundary and KNP.**

A refined stratigraphic model was created to cover the entire regional aquifer within the Synclinal Valley to the west of the Development Envelope, surrounding Western Hill.

The Synclinal Valley model was derived from Rio Tinto's 'regional' stratigraphic model with a 50 m resolution applied. Each lithological unit was modelled (Figure 3-3) and then characterised with a broader habitat classification of either potential or low potential habitat as summarised in Table 3-3. The stratigraphic model was exclusively for the assessment of BWT habitat, so the hydrogeological characteristics of the stratigraphic units were the primary focus of the suitable habitat classification. Potentially suitable lithologies versus less potentially suitable lithologies were then grouped for the volumetric analysis.

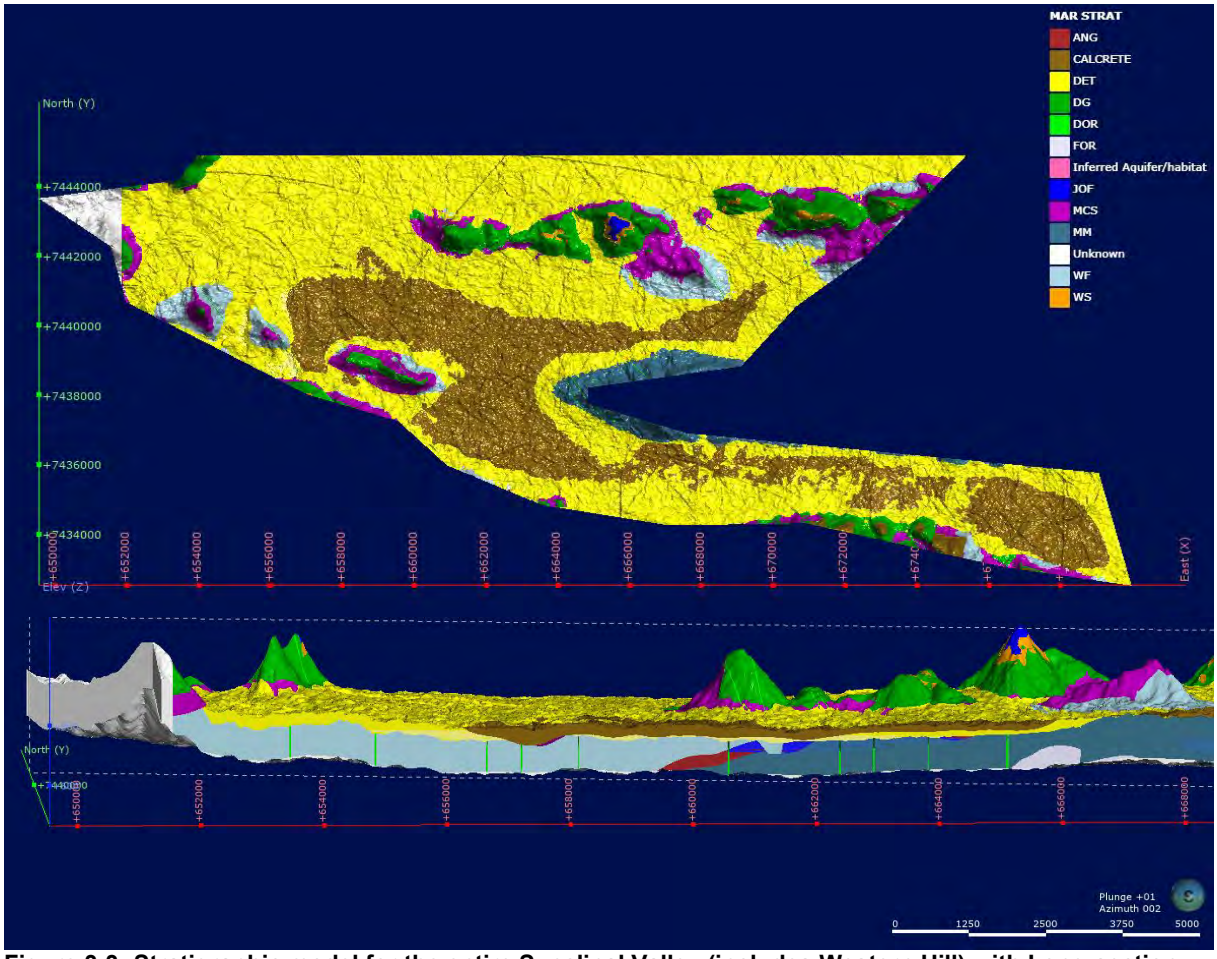


Figure 3-3: Stratigraphic model for the entire Synclinal Valley (includes Western Hill) with Long-section view below

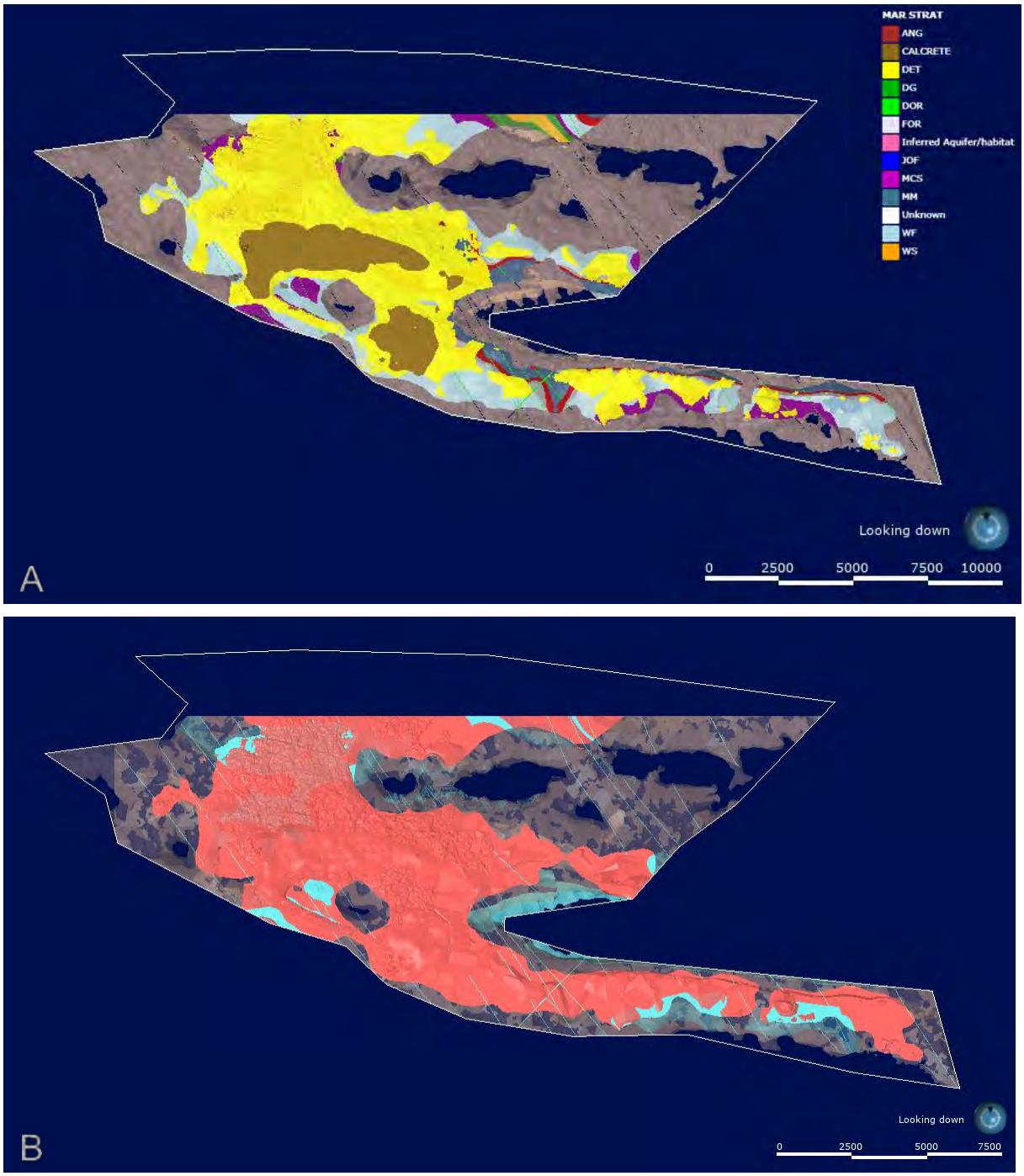


Figure 3-4: Synclinal Valley stratigraphic BWT model grouped into A) stratigraphy (colour legend in image) with inferred habitat(beige) and B) potential (pink), low potential (light blue) and inferred (biege) BWT habitats.

Modelling Boundaries

Besides the model specifications, spatial boundaries are defined in Leapfrog to limit the degree of extrapolation of the model away from the known data. Subterranean fauna habitats were modelled using the following lateral and vertical boundaries.

Topography

Topographic information (30 m resolution SRTM, provided by Rio Tinto) formed the upper vertical boundary of the habitat modelling. The approved existing pit shells (approved under MS 1113) were extracted from the topography as additional vertical boundaries for impact scenarios (described below).

Some corrections and exclusions were applied to this topographical data. Firstly, the resolution of topography was coarser than some of the deposit scale models. This created discrepancies in the modelled upper boundaries between the stratigraphy and the vein model. Areas of overlap appear as inferred habitat suitability in the model rather than the High-Medium-Low, which means there is a slight underestimation of prospective habitat in AWT.

Secondly, the topography did not cover the full extent to the north of the West Angelas Development Envelope (Figure 3-6 and Figure 3-9). This mostly impacted the northern lateral boundary of the Synclinal Valley aquifer that was clipped beyond 7445500mN. Since the hydrogeological interpretations north of Western Hill were considered to be data poor (IGS (2021), it was reasonable to limit BWT habitat modelling at this northing.

Lateral boundaries

While the entire Development Envelope dataset was modelled in AWT, section boundaries were established to demonstrate the maximum lateral extent of the habitat vein model for each deposit area within the Proposal (Figure 3-5 and Figure 3-6).

For AWT models (Figure 3-5), the section boundaries are intended to define each deposit as discrete and separate based on its geological context for later volumetric calculations.

For BWT models, the deposit boundaries were redefined to better represent the groundwater system of the specific deposit (Figure 3-6). At Deposit H, the boundary was confined to the inner basin within the Mt Newman Member of the MMIF. At Western Hill, the same upper boundary was used for AWT and BWT models. At the Synclinal Valley a regional boundary was applied comparable to the boundary used by IGS (2021) for assessing the effects of Managed Aquifer Recharge (MAR). Each of the BWT models are discussed further under the hydrogeological boundaries section.

For the suitable habitat ‘veins’ a 300 m radial boundary (Figure 3-5 and Figure 3-6) was enforced around the location of each drill hole to limit habitat modelling extrapolation to a reasonable distance from each drilling data point. This boundary was chosen following consultation with geologists to determine a conservative estimate for extrapolation of geological information. In some areas where drilling was very sparse or infrequent (*e.g.* Mt Ella East, Deposit J), the generation of the radial boundary created gaps (artefacts) in the extent of habitat modelling. These gaps were taken into due consideration when evaluating connectivity of the suitable habitat for the affected areas. The 300 m radial boundary was not applied to the Synclinal Valley stratigraphic model as it would preclude modelling throughout the wider known extent of the aquifer west of the Development Envelope boundary.

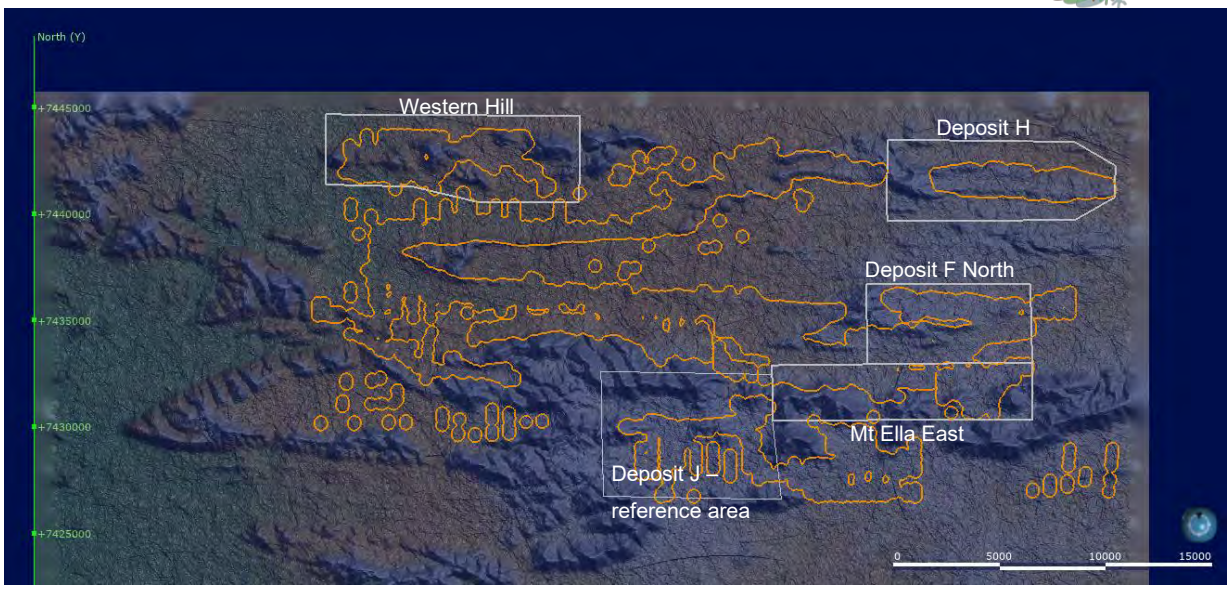


Figure 3-5: West Angelas topographic map with 3D habitat modelling AWT deposit boundaries (white) with 300m radial boundary (orange).

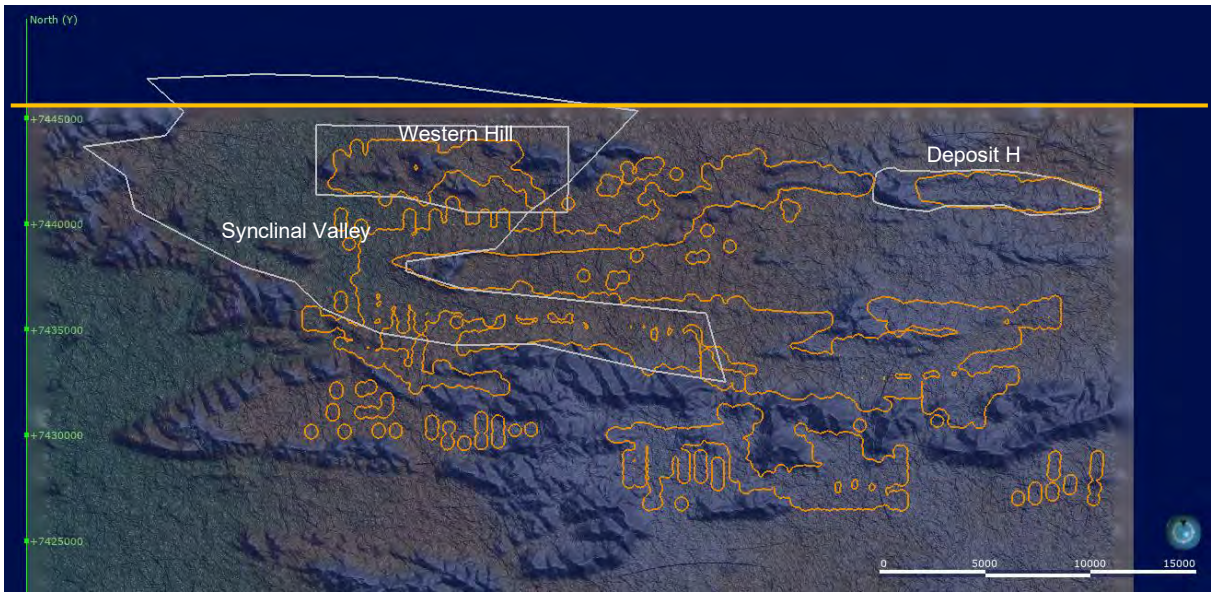


Figure 3-6 West Angelas topographic map with 3D habitat modelling BWT aquifer system boundaries (white) with 300m radial boundary (orange).

Hydrogeological boundaries

Several groundwater systems exist throughout the different areas of the Development Envelope as described in section 2.1. Slightly different modelling approaches and boundaries were required in each area, based on available data, to be able to create accurate representations of the aquifers present.

Deposit H

At Deposit H an inner boundary was applied to prevent extrapolation of BWT habitat outside of the basin structure and 300 m data boundary limit. This removed areas that did not have sufficient hydrogeological information – note the pre-mining water table (blue) outside of the white boundary to the north and southeast (Figure 3-7), making a more conservative estimate of BWT habitat in Deposit H.

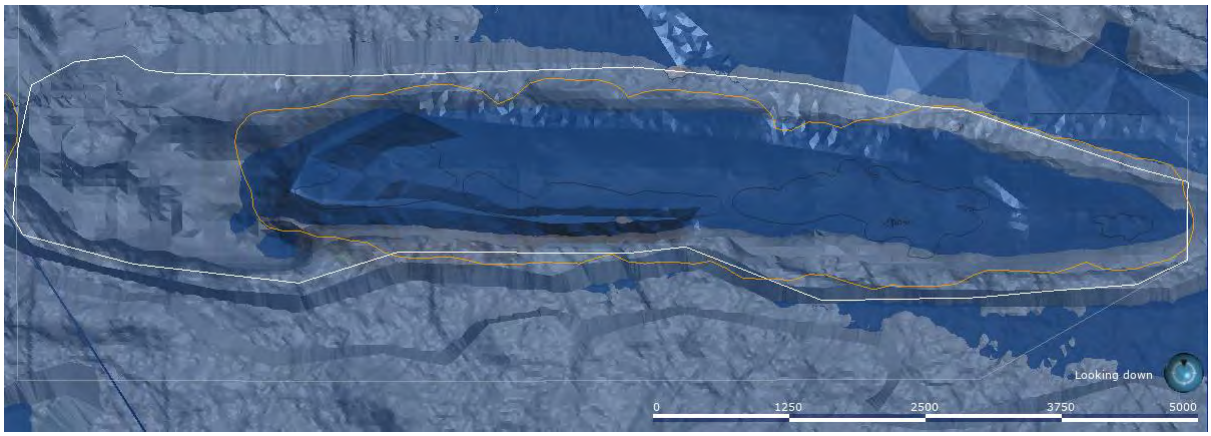


Figure 3-7: Deposit H Hydrogeological boundaries showing the pre-mining water table sitting within the FOR group basement (light grey) and 300m radial boundary (orange) limit of drilling.

Western Hill orebody aquifer

The mineralised Western Hill BrIF orebody aquifer is split into east and west lenses by a large regional NW trending fault (Figure 3-8). The fault offsets and perches the eastern lens above the western lens by 40m. The orebody aquifer is constrained in most directions by the low permeability MCS (Figure 3-8) which separates the orebody from the regional Wittenoom Formation aquifer. The lower surface of MCS was extracted as a mesh and was used as the conceptual basement constraint for the Western Hill orebody aquifers.

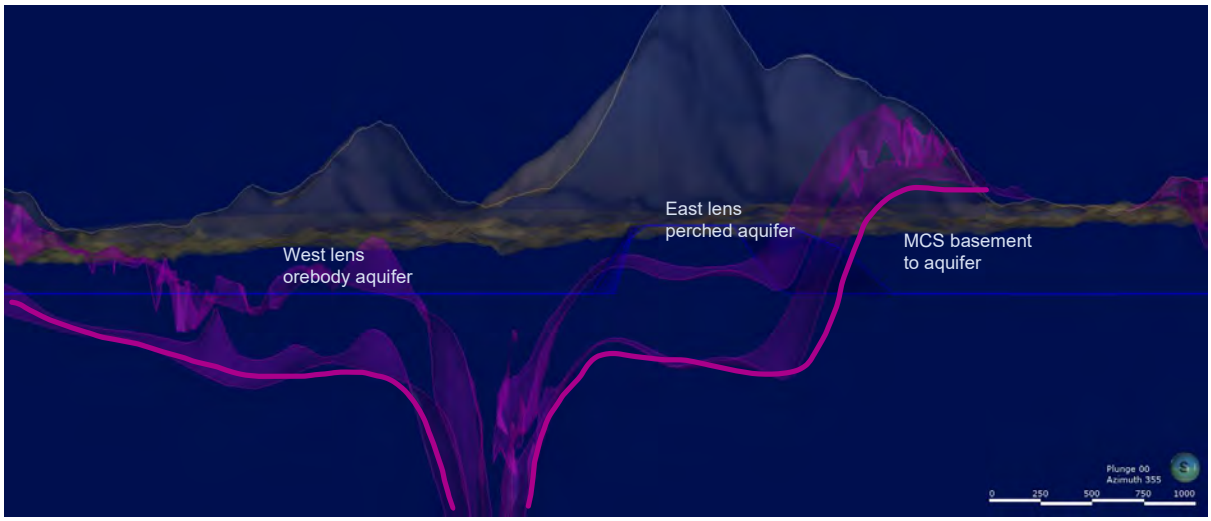


Figure 3-8: Western Hill orebody aquifer

Synclinal Valley aquifer

The Synclinal Valley aquifer is primarily hosted in the Wittenoom Formation and tertiary detritals which extend westward beyond the Development Envelope boundary into Karijini National Park (KNP) as described in section 2.1. At the eastern boundary of the Synclinal Valley aquifer is a regionally significant NE-SW trending dolerite dyke. This dyke acts as an aquitard on the northern limb of the syncline and correlates with a 13 m head difference in the water levels (Figure 3-9). There is a south-eastern limit to the aquifer model, close to a NW-SE trending dolerite dyke, which imparts a 25 m difference in water level and limits the Synclinal Valley aquifer (southern limb) to the south/ east.

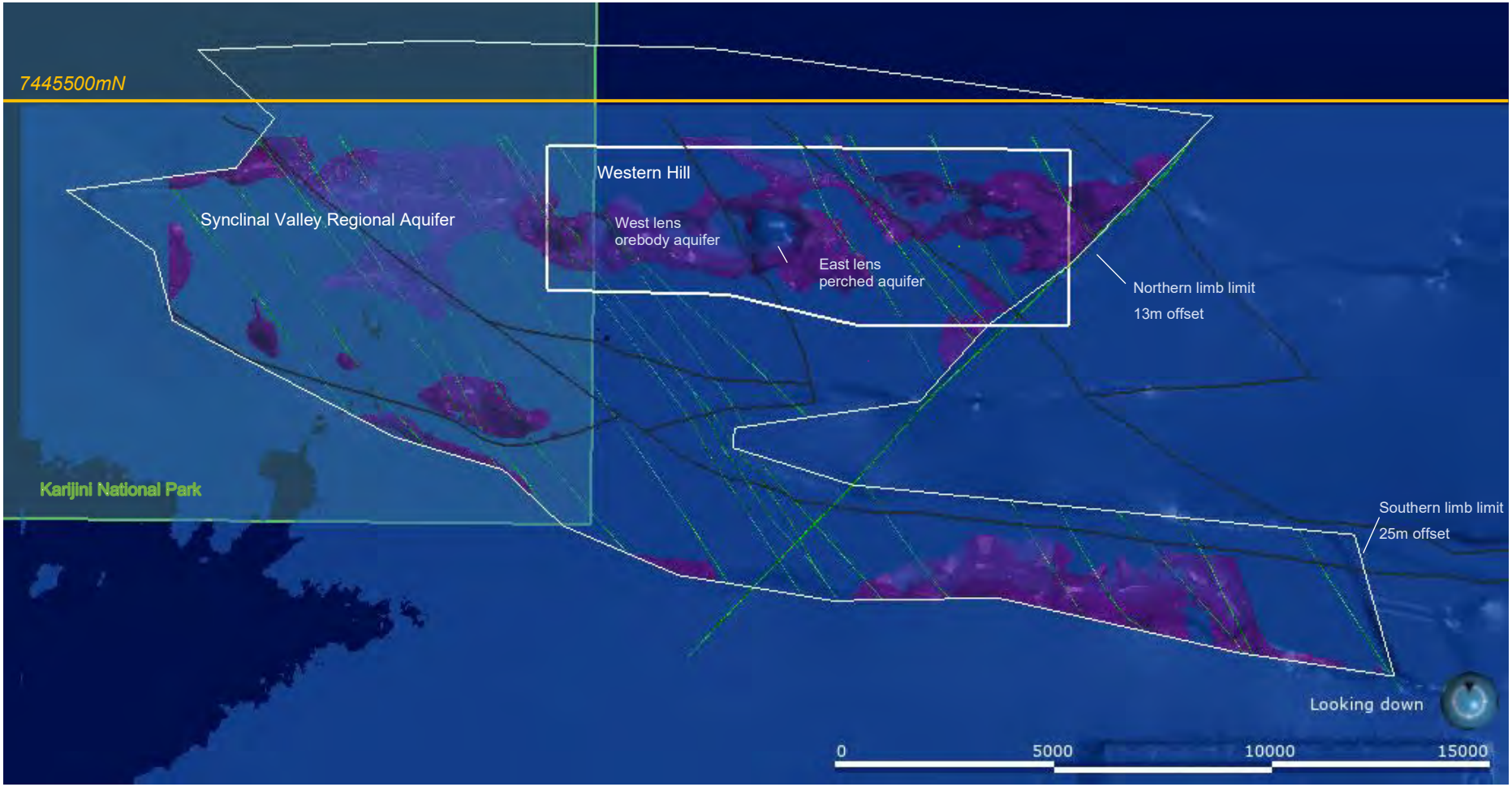


Figure 3-9: Synclinal Valley model boundary (thin white), Western Hill orebody aquifer boundary (thick white) on the pre-mining water table (blue surface) depicting limitations: dolerite dykes (green) and faults (dark grey) affecting the Western Hill region. MCS is shown in purple.

Note: topographic limitation to the north – mesh does not cover the full extent of the aquifer boundary, and KNP boundary limits the available drill data (light green shaded)

Deposit F North

Deposit F North and Deposit F were modelled within the same lateral boundary for AWT and BWT. However, there are significant hydrological differences between the two deposits. As described in Section 2.1, the higher water levels at Deposit F North indicate groundwater conditions that are stratigraphically restricted by the surrounding low permeability FOR group (Figure 3-10). Region-scale east-west faulting appears to have displaced and disconnected the deposit regions as demonstrated by a 50 m difference in water levels (shown by dark blue line). Hydraulic connectivity between Deposit F and Deposit F North is not considered possible because of these factors (Figure 3-10).

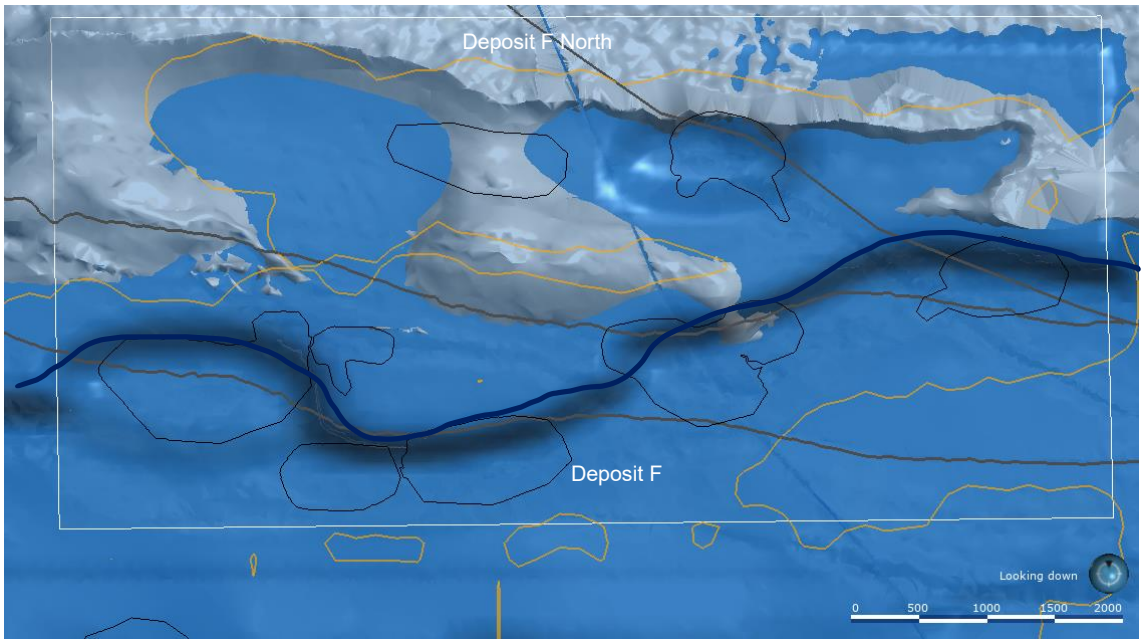


Figure 3-10: Deposit F North Hydrogeology, Pre-mining water table with proposed Deposit F North and current Deposit F pit boundaries (black), 300 m radial boundary (orange) and faults (dark grey).

System basement

Troglofauna (*above water table*)

The conceptual basement of troglofauna habitat is the pre-mining water table. The pre-mining water table is described in Section 3.1 (Figure 3-12) and was used as the basement for all AWT scenarios and volumetric calculations. This avoids any perceived 'increase' in AWT habitat volume when groundwater drawdown occurs in some scenarios.

Stygofauna (*below water table*)

Defining a conceptual basement of the aquifer system was an important step to limit the depth of potentially suitable BWT habitat. The primary information used to define the basement was the hydrogeological characteristics of the lower strata, including porosity and aquifer potential. Bore logs and diamond cores were also investigated, as well as groundwater yields, pump testing, and results of hydrogeological investigations (Rio Tinto, 2020a, 2020b, 2020c, 2021) to inform the basement limits.

The stratigraphic model in each deposit area was reviewed for aquifer potential and are outlined below.

- Deposit H – the upper surface of the Fortescue group was considered the absolute limit to aquifer potential, due to the low permeability of these lithologies.
- Western Hill orebody – the BrIF orebody aquifers are underlain by the Mount McRae Shale (MCS) which forms a low permeability basement to the system.
- Deposit F North – the upper surface of the Fortescue group was considered the absolute limit to aquifer potential, due to the low permeability of these lithologies.
- Synclinal Valley regional aquifer - the conceptual basement of weathered Wittenoom (developed by RTIO hydrogeologists, as shown in IGS 2021) was selected as a threshold of confidence in porous hydrogeological habitat. Lithologies known to form aquifers, occurring above this weathering surface, were considered most likely to provide suitable habitat for stygofauna throughout the synclinal aquifer model. Below the 'weathered Wittenoom' threshold, it was assumed that most lithologies would trend towards decreased porosity or aquitard conditions with increasing depth, to the maximum system basement (150 mbgl as described below).

Once the stratigraphic basements were defined, a further conceptual depth limitation of stygofauna habitat 'vein' modelling was implemented. Indications from research (Hose *et al.*, 2015) state that, on average, groundwater below 100 mbgl depth would be less likely to sustain stygofauna due to low levels of dissolved oxygen.

After cross-checking this depth with the stratigraphic model and the unconstrained modelling of habitat 'veins' based on drilling data, the 'final threshold' was increased to 150 mbgl, as a deeper mineralisation, water levels and/or weathering profile was demonstrated within each of the West Angelas deposits. A mesh mirroring the topography at 150 mbgl was created in Leapfrog to represent the maximum system basement for all BWT models. In most deposit areas, this aligns with the approximate stratigraphic basements described above, but the degree of alignment is variable in each area, subject to the topographic relief at surface.

3.1 Impact scenarios

Modelling impacts in Leapfrog involves combining the multiple facets described above into one model. For each scenario, the boundaries, stratigraphy or habitat vein model, water levels and pits, if any, (proposed or combined) are joined by using the "Combined Model" function and the respective components layered for a reportable volumetric and visual outcome.

The assessment of impacts from the Proposal to subterranean habitat values was considered for the following scenarios and detailed below:

- Pre-impact
- Post-impact: Current scenario
- Post-impact: Proposed scenario
- Post-impact: Combined LOM scenarios

- Pre-impact

The pre-impact scenario was used as a baseline reference for the impact assessment and models the AWT/ BWT habitat prior to any mining or groundwater drawdown impacts within the Development Envelope and surrounds.

Pre-impact water table

Where available, measured groundwater levels from monitoring data (Figure 3-11) across the Development Envelope were imported into Leapfrog as data points. Together with the pre-mining water levels provided in various formats across the Development Envelope, the meshes and data points were combined with the regional aquifer (provided as contours and meshes) to form one Leapfrog mesh using the Merge 2D function in Leapfrog and a 50 m surface resolution (Figure 3-12). Some boundary artefacts could not be merged without further drilling or hydrogeological information. However, the 300 m lateral modelling boundary minimised any potential inaccuracies to volumetric calculations.

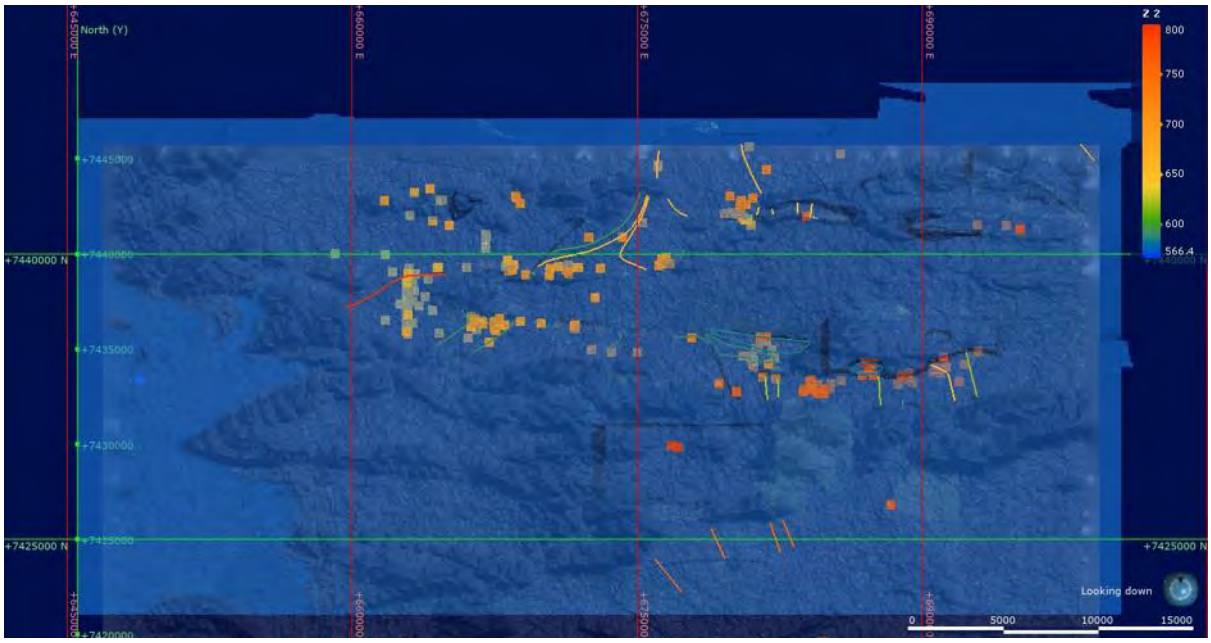


Figure 3-11: Measured water levels(squares) (mRL) from ground water monitoring data across West Angelas as well as regional pre-impact contours(coloured lines)

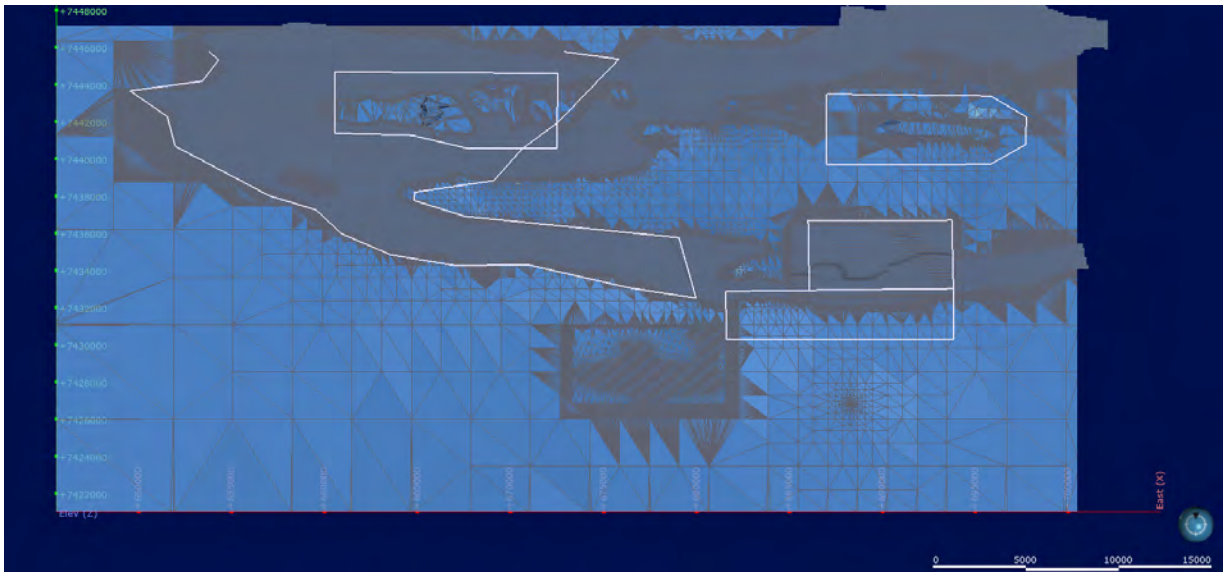


Figure 3-12: Pre-impact water table mesh surface. Compiled from regional and localised deposit scale water tables.

- Post-impact: Current scenario

The current scenario consisted of the AWT and BWT habitat remaining intact following mining of the existing and approved Rio Tinto operations within the Development Envelope. Volumetric calculations of direct impacts under the current scenario were not assessed herein as these impacts have already been assessed and approved. However, the current impacts (pits and drawdown) were used to calculate combined impacts for the assessment of the Proposal.

- Post-impact: Proposed scenario

The proposed scenario relates to habitat remaining following direct impacts arising from the Proposal (West Angelas Revised Proposal, EPA Assessment 2290) only at the end of Life of Mine (LOM) in 2050.

Troglofauna (above water table):

The proposed AWT scenario was modelled by removing the proposed pit model from the topography in Deposit H, Deposit F North, Mt Ella East and Western Hill.

Stygofauna (below water table):

The proposed BWT scenario was modelled by removing the proposed pit model from the topography and applying the drawdown contours provided by Rio Tinto (2020) to the deposits for Deposit H, and Western Hill orebody aquifers. No drawdown contours were provided for Deposit F North so only proposed pits were removed from topography.

Proposed scenarios are derived by subtracting the provided contour data from the pre-mining water table (Figure 3-13) to create the proposed drawdown meshes (Figure 3-14). The proposed groundwater levels are then applied to the stratigraphic model by creating “combined Models” in Leapfrog and volumetric impacts can be measured.

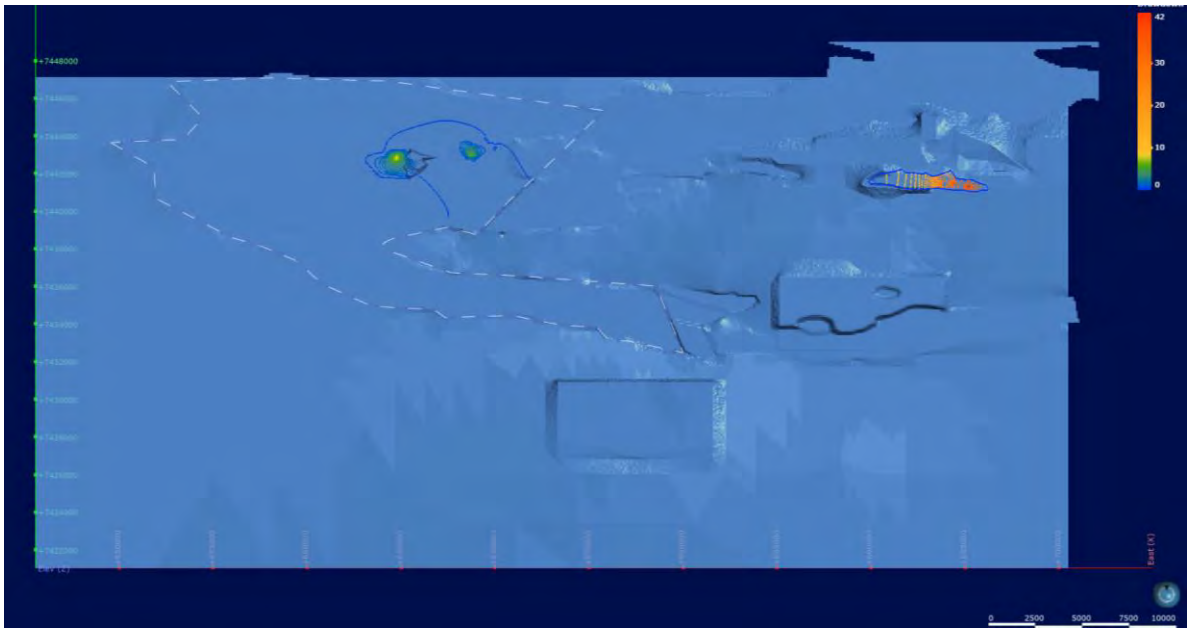


Figure 3-13 Proposed groundwater drawdown contours against the pre-mining water surface which includes approved water surfaces as well as measured existing water levels.

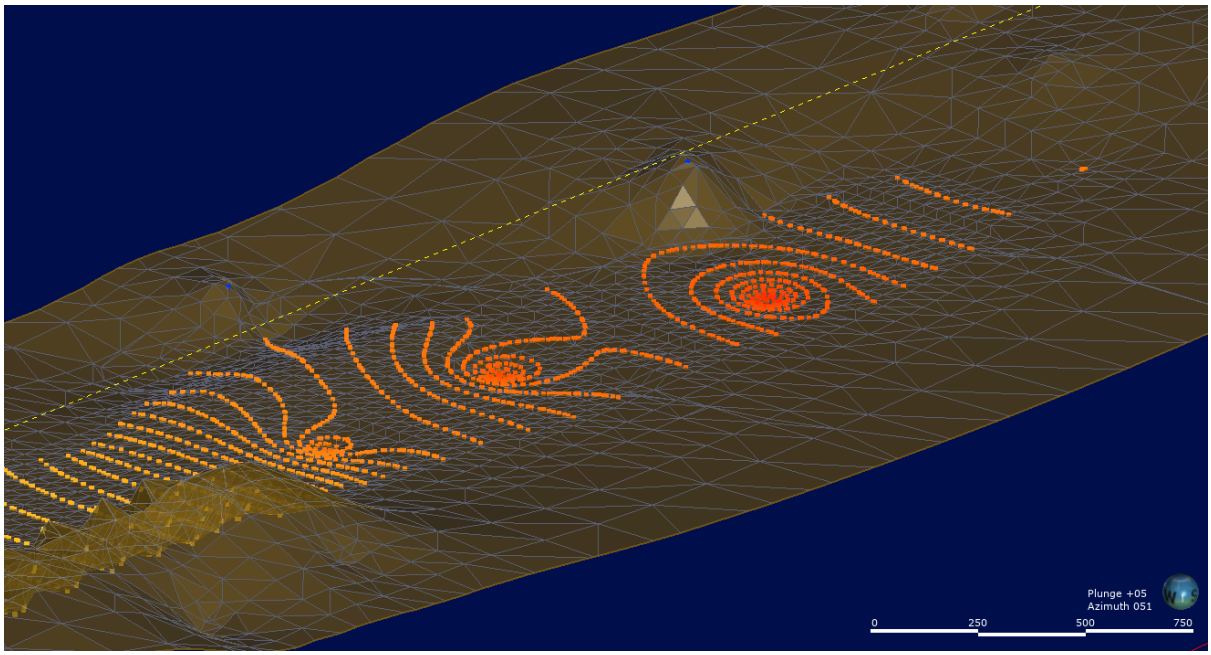


Figure 3-14: Construction of proposed drawdown mesh at Deposit H using drawdown contour points to define the drawdown surface

- Post-impact: Combined LOM scenarios

Troglofauna (above water table):

Combined impacts on troglofauna habitat AWT have been modelled using the direct impacts from current and approved Rio Tinto mining operations within the Development Envelope (refer 'current' scenario), as well as the proposed mining operations associated with the Proposal (refer 'proposed' scenario), at end of life of mine (2050).

Combined impacts were assessed for Deposit F North, and Mt Ella East. No combined impacts were modelled for Deposit H or Western Hill orebodies as they do not have connected habitat to other current deposits and do not have current impacts, therefore combined impacts and volumes are regarded as the same as proposed impacts for those deposits.

Stygofauna (below water table):

Combined impacts on stygofauna habitat BWT have been modelled using a combination of direct impacts from current and approved Rio Tinto mining operations within the Development Envelope (refer 'current' scenario), as well as the proposed mining operations and groundwater drawdown associated with the Proposal (refer 'proposed' scenario), at end of life of mine (2050). This represents a maximum, worst-case scenario.

No combined impacts were modelled for Deposit H as it does not have connected habitat to current operations or current impacts, therefore combined impacts and volumes are regarded as the same as proposed impacts for that orebody aquifer deposit. Similarly for Deposit F North, no combined impacts were modelled because the pit design provided only minimally touches the water table and no groundwater drawdown contours were provided.

Combined LOM impacts on BWT habitats were initially modelled and assessed together for the Western Hill orebody and synclinal valley regional aquifer, however the intricacies over overlapping hydrological systems, added to the limited availability of drilling data over most of the regional aquifer and led to reviewing the water systems separately. There was still some overlap however, this was approached by modelling the impacts of the approved drawdown (contours in Figure 3-15) separate to the proposed drawdown in the model and calculating (rather than modelling) the combined impact. The overlapping approved contours showed minimal impact to the south tip of modelled Western Hill orebodies and could be attributed to a boundary issue and therefore not considered to be of significance (Figure 3-16)



Figure 3-15; Western Hill orebody modelled BWT habitat showing minimal overlapping drawdown contours from the approved LOM data.

The Synclinal Valley regional aquifer was reviewed under two combined impact scenarios, one at the end of Life of Mine (LOM) (Figure 3-16) and another under the MAR Scheme scenario proposed by IGS (2021) (Figure 3-17) while the Orebody aquifer was only reviewed under the LOM scenario.

Drawdown contours provided by Rio Tinto were modelled in Leapfrog by lowering the pre-mining water table according to the contour values (metres). Manual adjustment was required to normalise the surface to the pre-mining water levels beyond the areas contoured. With drawdown extracted and approved pits removed, an adaptive 50 m resolution mesh was created.

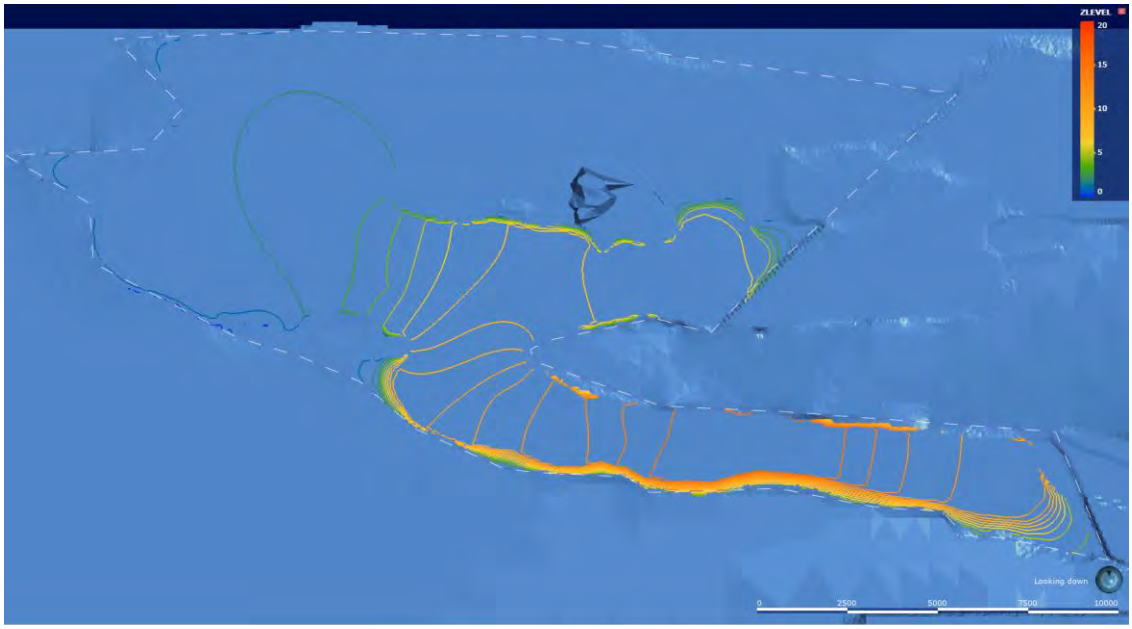


Figure 3-16: Approved groundwater drawdown contours (m) (GWDD_CDG_2050) for Life of Mine 2050 at Deposits C, D and G overlying pre-impact water table and used for calculating impact to the regional synclinal aquifer.

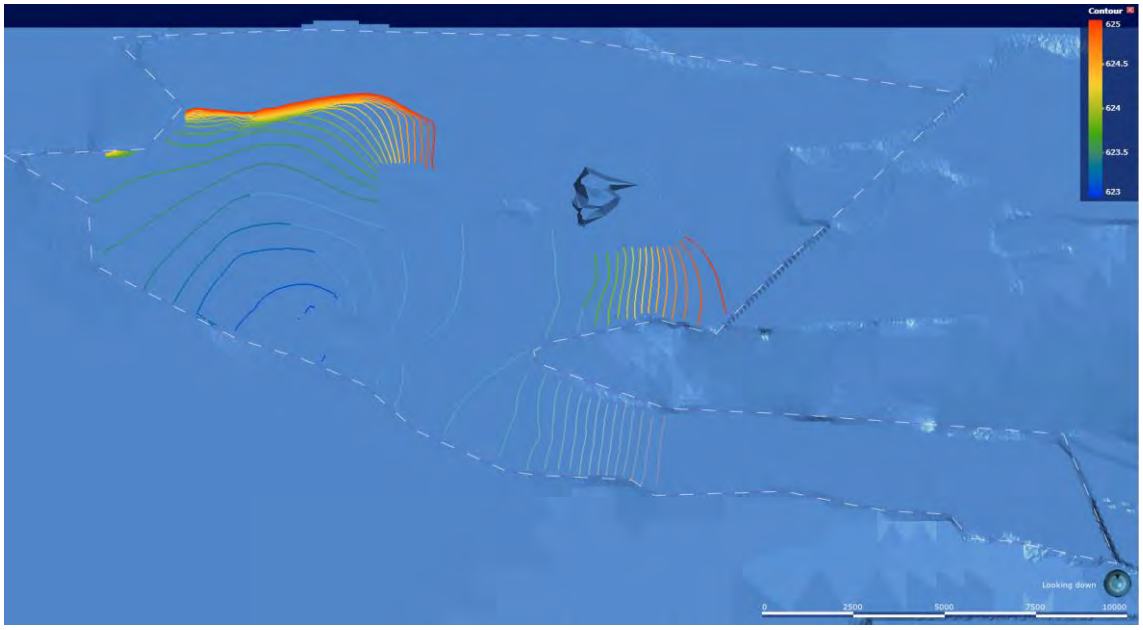


Figure 3-17: Managed Aquifer Recharge (MAR) contours in mRL overlying pre-impact water table and used for calculating impact to the regional synclinal valley aquifer.

3.2 Limitations and validations

Conservative estimation

Multiple strategies were employed to ensure the area and volume of habitat used as input for the EIA process was based on conservative estimates, by:

- Characterisation of habitat suitability within three categories (high, medium, low) where reasonably certain, and a separate category inferred. This system allows for a nuanced interpretation of habitat suitability based on regional sampling results and experience, rather than using absolute categories (habitat/ not habitat);
- Where vein shapes were modelled with potential artefacts, Leapfrog Geo overlaid the more highly suitable habitat categories with less suitable ones such as Low or Inferred, constraining the extrapolation of suitable habitat;
- Limiting the extrapolation of vein shapes to 300 m radius from drilling data points representing the area of maximum confidence in the drill logging information and interpretation of habitat suitability;
- Resolution of the modelling was set to 100 m in bedrock stratigraphy for efficiency without compromising precision; smaller blocks of 10 m were modelled and compared volumetrically to validate, with very little difference noted.

As such, it is likely that subterranean fauna habitat could occur outside of the modelled ‘High’ and ‘Medium’ habitat veins, within or beyond the conservative confidence boundaries. The inferred category is used to depict such zones beyond the conservative confidence boundaries.

Constraints and limitations

The assessment of habitat suitability and the resultant modelling was limited to the available information regarding physical characteristics of the lithology. Some lithologies that occur within the stratigraphy of the Hamersley Ranges have insufficient available information for habitat suitability for subterranean fauna to be assessed confidently.

Where available, Airborne Electromagnetics (AEM) data was reviewed in conjunction with the stratigraphic model to assist in visualising a potential basement to the aquifer system.

Due to the spatial distribution of drilling data points, it was not possible to precisely represent the occurrence, extent, and connectivity of fine scale voids that may provide habitat. Localised variability is likely to occur within the modelled habitat areas, which could affect the occurrence of subterranean fauna throughout the modelled habitat. Where known, structural influences such as major faults and shear zones, and potential barriers such as dykes and sills, were assessed against the habitat model at scales relevant to the potential impacts. Nevertheless, the ability of the model to show fine scale habitat interconnectivity or heterogeneity is limited to the drill hole interval data and the resolution size (100 m).

At the landscape scale, the modelled extent of the high and medium habitats is conceptualised as the indicative maximum area of potentially connected habitat (suitable habitat) within the relevant confidence boundary. For the impact assessment, this was understood to represent the potentially available extent of suitable habitat for subterranean fauna (within the modelling boundary) but does not precisely represent the occurrence or area of occupancy of each species that may be present.

BWT habitat modelling was subject to the extent and quality of water level data provided from Rio Tinto hydrogeological investigations, which in turn was limited to the density of available bores, extrapolation/ interpolation between data points, and third-party water modelling by IGS (2021).

In general, average water levels can be subject to considerable uncertainty, depending on the density of data points (bores) and the amount of information used to determine the averages. This may have a flow on effect on the interpretation and modelling of stygofauna habitat in areas of low data density, including volumetric calculations and assessment of impacts. Predictions and modelling of impact scenarios are subject to the data available at the time of assessment, and any significant updates to hydrogeological modelling over time or as a result of new information becoming available may change the conclusions of the stygofauna habitat modelling presented herein.

All appropriate measures have been taken to ensure habitat volumes under the various impact scenarios are conservatively estimated, however volumetric calculations extracted from Leapfrog inherently have a rounding factor of approximately 1% for each modelled component. The rounding presents an acceptable degree of error in these calculations.

Impact scenarios BWT at the Western Hill orebody aquifer and the Synclinal Valley aquifer were subject to the water level data provided by Rio Tinto and modelled by IGS (2021). At the time of assessment there was no unified water drawdown modelling across all aquifers/ areas of interest for each scenario, therefore Biologic's impact modelling relied on integration of available water level data derived independently for each aquifer unit under the various scenarios available. The Proposed scenario water levels included a 0.5m drawdown contour extending beyond the Western Hill orebody aquifer south into the Synclinal Valley aquifer, under a 'worst case scenario' assumption of limited propagation via fault zones. This degree of change is expected to be within the average annual fluctuation of the aquifers in question, but it is included in the modelling and calculations under the Proposed scenario.

Minor areas of boundary overlap between the Western Hill orebody model and the Synclinal Valley aquifer model were unavoidable along the flanks of Western Hill. The representation of the MCS layer in the stratigraphic model is limited in some areas by steep topography, deep folding, and the shallow drilling on the flanks and crest of Western Hill. This minor overlap between the Western Hill orebody aquifer and the Synclinal Valley aquifer may have also contributed to the modelled BWT habitat thickness and volumetric calculations under the Proposed scenario.

4. HABITAT IMPACT ASSESSMENT FRAMEWORK

Subterranean fauna habitats were assessed based on the 3D habitat modelling under multiple AWT and BWT impact scenarios. The 3D modelling facilitated assessment of potential impacts to subterranean fauna habitat values by providing:

- Predicted changes to habitat thickness, connectivity, and extent under each scenario,
- Quantification of the impacts to habitat– volume of habitat reduced in m^3, and volume of habitat remaining in-situ as a proportion of the pre-impact volume (% remaining).

4.1 Assessment of habitat suitability and extent

Suitable habitat was categorised and modelled as outlined in section 3. Assessment of habitat connectivity/ continuity for subterranean fauna (relative to impacts) was based on the visual assessment of the 3D Model considering three geological/ hydrogeological factors influencing habitat connectivity:

1. Geological disconformities such as folds, faults, and shears, in situations where these structures significantly interrupt the connectivity of the habitable stratigraphy.
2. Intrusives such as dykes and sills, where the intrusive geology is less porous/ less fractured, or otherwise less suitable as habitat than the remaining stratigraphy.
3. The thickness of modelled habitat (AWT or BWT) and position of the water table relative to the habitable stratigraphic layers.

Changes to habitat extent, thickness, and connectivity were assessed via 3D visual comparisons of the modelled habitat before and after the proposed mining/ groundwater drawdown, with a particular focus on areas where subterranean fauna are known to occur. Changes to the habitat extent and connectivity that could affect known assemblages are noted in Sections 5 and 6.

4.1 Quantification of habitat impacts

The 3D volumetric calculations of subterranean habitats have been used as the basis for quantitative impact assessment under multiple impact scenarios referred to in Section 3.1. The calculated in-situ (or remaining habitat) and volumetric loss of habitat is presented in m^3 and detailed in Sections 5 and 6 and Appendix A.

Calculations are summed into Zone A (Table 3-4), which refers to the modelled high and medium suitable habitat, and Zone B which refers to the inferred suitable habitat. Low suitable habitat is not considered or included in the volumetric calculations or impact assessments.

For AWT habitats, there was sufficient data density and coverage of habitat throughout the Development Envelope to only assess the impacts within Zone A.

For BWT habitat calculations, the data density (laterally and at depth) is much sparser and not considered as representative of all the potential suitable habitat if using just Zone A values. Adding Zone B to Zone A allows for a more representative combination of potential suitable habitat.

5. TROGLOFAUNA (AWT) 3D HABITAT AND IMPACT ASSESSMENT

Suitable habitat for troglofauna occurs within the AWT modelled High and Medium suitability categories, ultimately delimited by the topography as the upper potential threshold, and the modelled water level as the lower potential threshold. Impacts potentially arising from the proposed groundwater drawdown or mining of pit designs were assessed in each of the deposit areas, with a particular focus on sites where putatively restricted species were recorded.

The final 3D model of AWT troglofauna habitats was based on a large amount of drill-hole information, as shown in Table 5-1. In total, 23,609 drill holes were used to model the AWT habitats throughout the Development Envelope. More than 1.4 million metres of AWT downhole metres were categorised into troglofauna habitat suitability categories as described in section 3 (Table 3-2)

Table 5-1 Drillhole information used to model AWT habitats across the Development Envelope

Deposit/ Region	Number of holes	Total metres (m)	Mean drill interval (m)	Standard Deviation (m)	Maximum drill interval (single hole)
Western Hill	1,569	106,130	67.6	27.2	154
Deposit H	1,565	61,762	39.5	14.2	85
Deposit J reference area	450	31,662	70.4	28.7	145
Deposit F (includes Deposit F North)	2,861	202,554	70.8	32.4	143
Mt Ella East	675	50,635	75.0	30.9	145
Remaining West Angelas	16,489	1,033,725	63.8	23.7	200
Total	**23,609**	**1,486,468**	**63**	**29**	**200**

This information was used to model (Figure 5-1) and quantify habitat suitability across the Development Envelope (Table 5-2) and for each individual deposit (Table 5-3).

5.1 West Angelas Development Envelope

5.1.1 Habitat suitability and extent

The 3D habitat modelling showed that suitable AWT habitats for troglofauna occur widely throughout the West Angelas Development Envelope, hosted within a variety of geological settings (Figure 5-1). The BrIF and MMIF host the majority of suitable habitat, as supergene weathering processes associated with mineralisation have created highly suitable fractured and weathered rock habitats in these geologies. Suitable troglofauna habitats also extend along the flanks of the BrIF and MMIF ranges, hosted by hematite-goethite-martite hardcap (pisolitic duricrust). The valley between the BrIF and MMIF

ranges provides further troglofauna habitats within karstic calcrete deposits and fractured bedrock and weathered Wittenoom Dolomite Formation that are AWT.

Unconsolidated alluvial and colluvial layers in the valley, adjacent drainage lines, and flanking the main ranges host further suitable AWT habitats for troglofauna where sufficient pore spaces occur. These habitats can be vertically constrained by near surface groundwater tables, and if adjacent to drainage lines, may be subject to periodic inundation. Nevertheless, even shallow detrital deposits <5 m to groundwater are known to provide highly suitable AWT habitats for troglofauna.

Geological structures such as dykes, faults and shears strike the Development Envelope primarily in a north-west to south-east direction. These structures may influence local habitat connectivity either by increasing fracturing within the base rock or by providing impermeable/ fresh rock barriers. Nevertheless, the conceptualisation of the dykes is limited to the fresh bedrock, and AWT habitat connectivity is expected to be maintained via overlying detrital layers or highly weathered profiles occurring in the upper stratigraphic units.

5.1.1 Quantification

At West Angelas, implementation of the Proposal results in a volumetric reduction of approximately 216,239,000 m^3 of suitable AWT habitat within Zone A within the Development Envelope under the proposed scenario (Figure 5-2), or approximately 2.4% of the pre-existing suitable habitat as modelled (Table 5-2 and Table 5-3). Approximately 97.6% of the suitable habitat modelled is expected to remain in-situ under the proposed scenario (Table 5-2 and Table 5-3). The current approved proposal will result in a loss of up to 9.4% of Zone A habitat resulting in a combined current plus proposal impact of 11.7% of Zone A suitable habitat.

Table 5-2: Summary of AWT volumetric calculations - West Angelas Development Envelope (totals in bold)

	Volume ('000 m^3)				% of pre-impact total		
	Pre-impact	Current	Proposed	Combined	Current	Proposed	Combined
In-situ Habitat (remaining)	**23,012,586**	**21,936,652**	**22,769,586**	**21,693,652**	**95.3**	**98.9**	**94.3**
High	1,880,980	1,534,050	1,762,460	1,415,530	81.6	93.7	75.3
Medium	7,303,700	6,790,200	7,205,900	6,692,400	93.0	98.7	91.6
Low	1,815,810	1,750,220	1,803,440	1,737,850	96.4	99.3	95.7
Zone B: Inferred	12,012,096	11,862,182	11,997,786	11,847,872	98.8	99.9	98.6
Zone A: (H+M) Suitable habitat	**9,184,680**	**8,324,250**	**8,968,360**	**8,107,930**	**90.6**	**97.6**	**88.3**
Habitat Loss	**0**	**1,075,934**	**242,834**	**1,319,059**	**4.7**	**1.1**	**5.7**
High	0	346,930	118,482	465,400	18.4	6.3	24.7
Medium	0	513,500	97,757	611,240	7.0	1.3	8.4
Low	0	65,590	12,301	77,896	3.6	0.7	4.3

	Volume ('000 m^3)				% of pre-impact total		
	Pre-impact	**Current**	**Proposed**	**Combined**	**Current**	**Proposed**	**Combined**
Zone B: Inferred	0	149,914	14,294	164,527	1.2	0.1	1.4
Loss: Zone A Suitable Habitat (H+M)	**0**	**860,430**	**216,239**	**1,076,640**	**9.4**	**2.4**	**11.7**

The combined impacts result in a reduction of approximately 11.7% (Table 5-2 and Table 5-3) and are showing in (Figure 5-3)

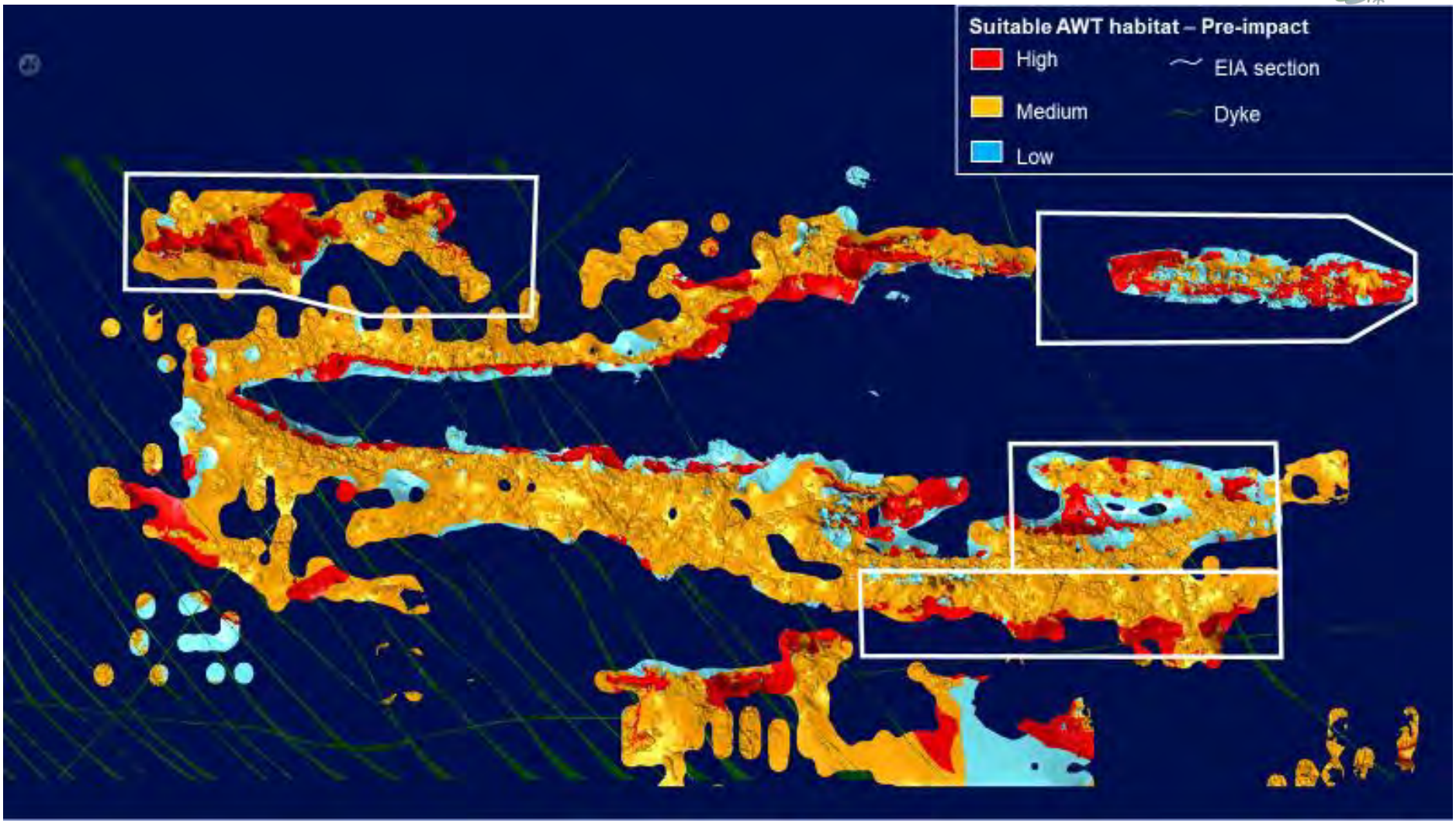


Figure 5-1: West Angelas subterranean AWT habitat modelling (high = red, medium=orange, low=blue), showing deposit model areas (white thick line) and dolerite dykes (green).

Table 5-3: Summary of AWT volumetric calculations - West Angelas Development Envelope by Section

	Volume ('000 m^3)				% of pre-impact total		
Deposit area	**Pre-impact**	**Current**	**Proposed**	**Combined**	**Current**	**Proposed**	**Combined**
Western Hill							
In-situ Suitable Habitat remaining	845,580	845,580	701,270	701,270	100.0	82.9	82.9
Loss of Suitable Habitat	0	0	144,310	144,310	0.0	17.1	17.1
Deposit H							
In-situ Suitable Habitat remaining	189,173	189,173	164,372	164,370	100.0	86.9	86.9
Loss of Suitable Habitat	0	0	24,801	24,803	0.0	13.1	13.1
Mt Ella East							
In-situ Suitable Habitat remaining	1,163,720	1,152,454	1,136,330	1,125,060	99.0	97.6	96.7
Loss of Suitable Habitat	0	11,266	27,390	38,660	1.0	2.4	3.3
Deposit F North							
In-situ Suitable Habitat remaining	727,330	590,812	707,570	571,047	81.2	97.3	78.5
Loss of Suitable Habitat	0	136,518	19,760	156,283	18.8	2.7	21.5
Remaining West Angelas							
In-situ Suitable Habitat remaining	6,258,877	5,546,231	6,258,820	5,546,183	88.6	100.0	88.6
Loss of Suitable Habitat	0	712,646	0	712,584	11.4	0.0	11.4
Total Habitat remaining	**9,184,680.0**	**8,324,250.0**	**8,968,360.0**	**8,107,930.0**	**90.6**	**97.6**	**88.3**
Total loss	**0.0**	**860,430.0**	**216,261.0**	**1,076,640.0**	**9.4**	**2.4**	**11.7**

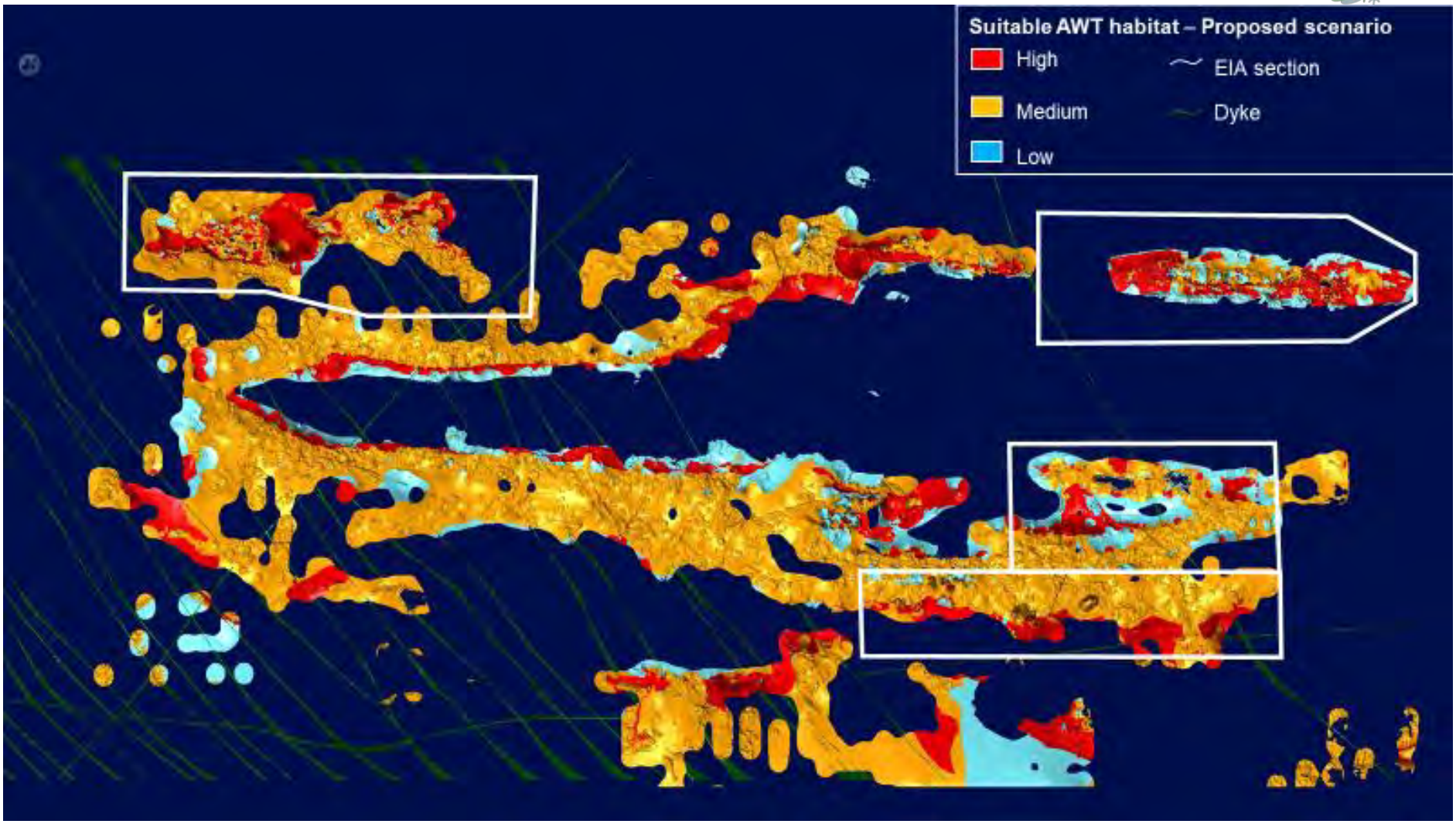


Figure 5-2: West Angelas subterranean AWT habitat modelling with proposed impacts (high = red, medium=orange, low=blue), showing deposit model areas (white thick line) and dolerite dykes (green).

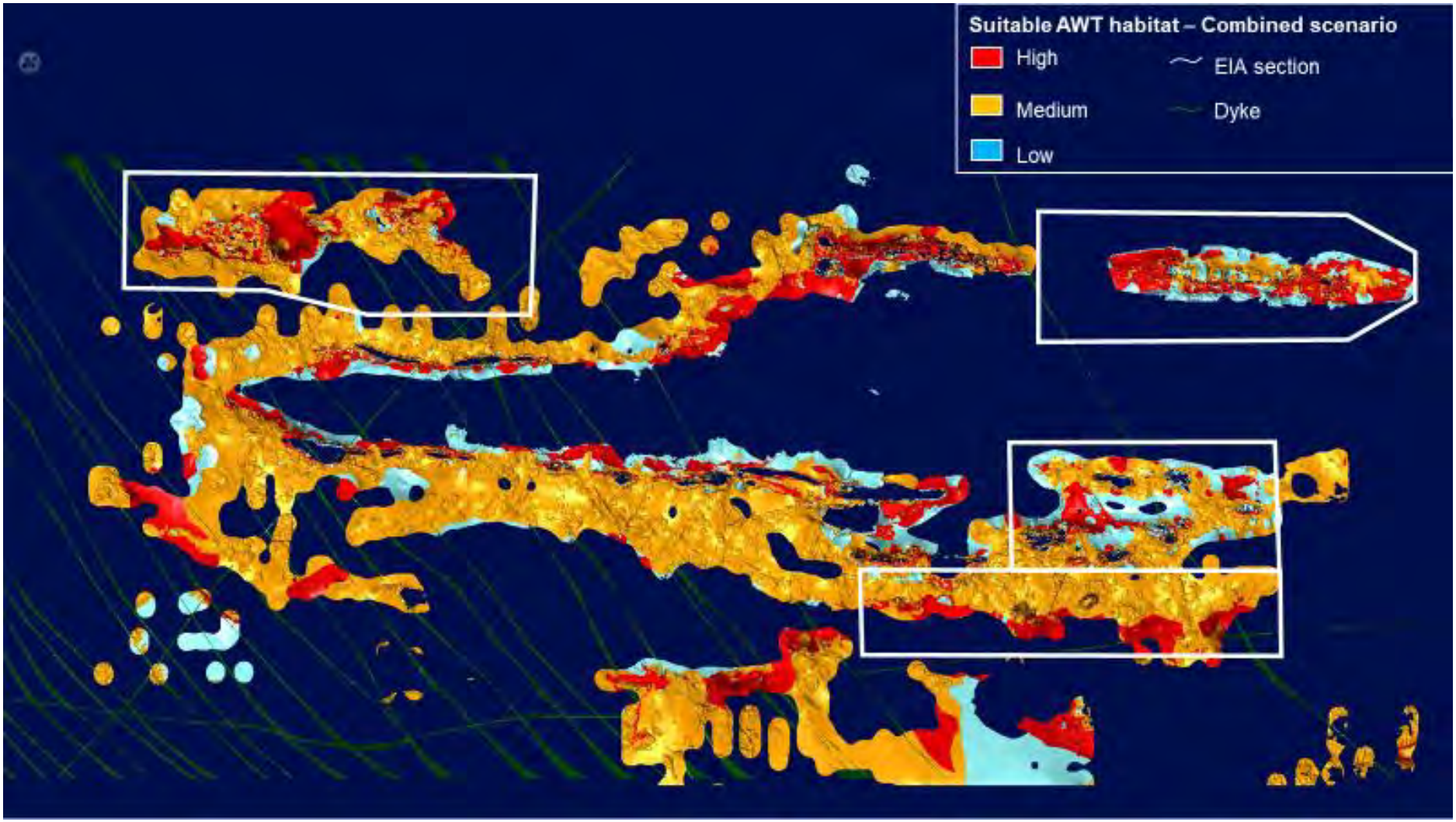


Figure 5-3: West Angelas subterranean AWT habitat modelling showing the combined impacts (high = red, medium=orange, low=blue), showing deposit model areas (white thick line) and dolerite dykes (green).

5.2 Western Hill

The Western Hill deposit is a Brockman Iron Formation (BrIF) hosted deposit of mineralised Dales Gorge Member with minor mineralisation present in overlying mature detritals. The deposit has undergone intense folding as part of the regional deformation events and sits within an E-W trending synclinal structure north of the Wonmunna Anticline.

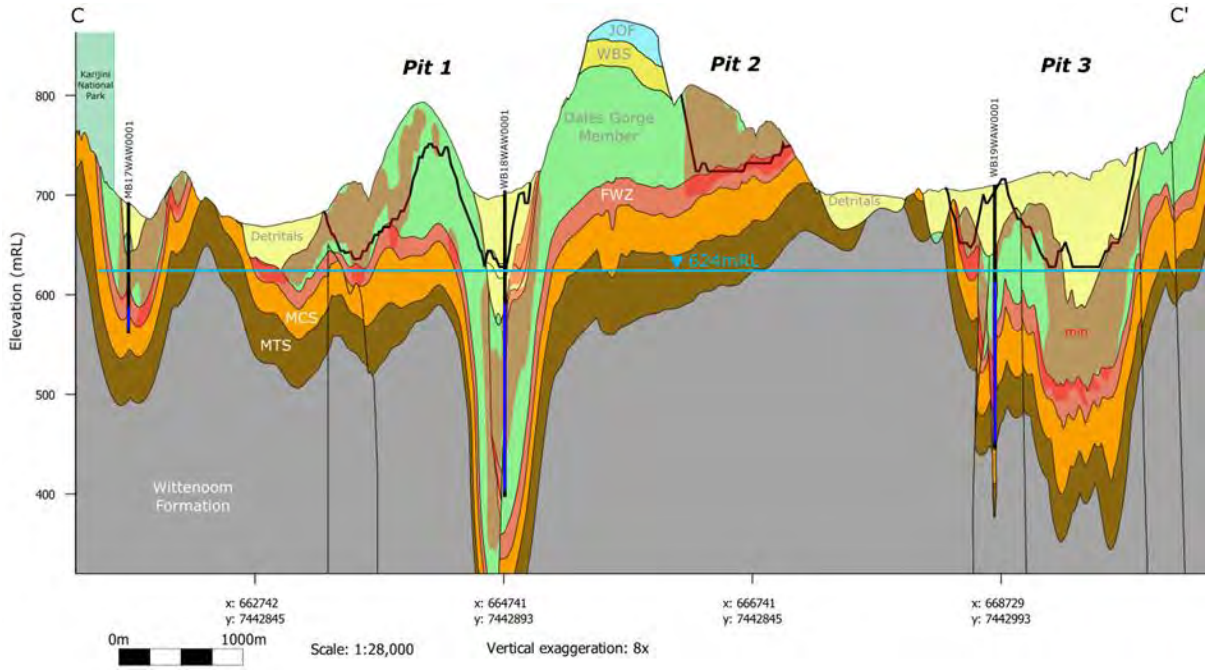


Figure 5-4 West-east long-section (facing north) through Western Hill showing the generalised stratigraphy of West Angelas Proposal Area Other features include water bores (shown in black and dark blue lines), faults(light grey lines), water table at 624mRL (light blue) and pit outlines (thick black lines). (Provided by RTIO).

There are three discrete lenses of the Western Hill orebody (west, east and further east). The western lens (Pits 1, Figure 5-4) comprises an east-west trending syncline with a significant normal fault offsetting the eastern lens (Pit 2) upwards relative to the western lens, resulting in a deep mineralised valley of Dales Gorge Member overlain by detrital units (Figure 5-5). Further to the east (Pit 3) consists of a northwest-southeast-east trending syncline of mineralised Dales Gorge Member overlain by a thick (up to 50 m) sequence of detritals. Northwest-southeast trending dolerite dykes are known to intersect the deposit.

Each lens is surrounded in all directions by Mount McRae Shale, with the underlying Wittenoom Formation comprising the regional aquifer unit (Figure 5-5). Significant faults existing in each lens result in offsets between geological units, as evidenced by modelled offset gaps in the Mount McRae Shale (Rio Tinto, 2020b).

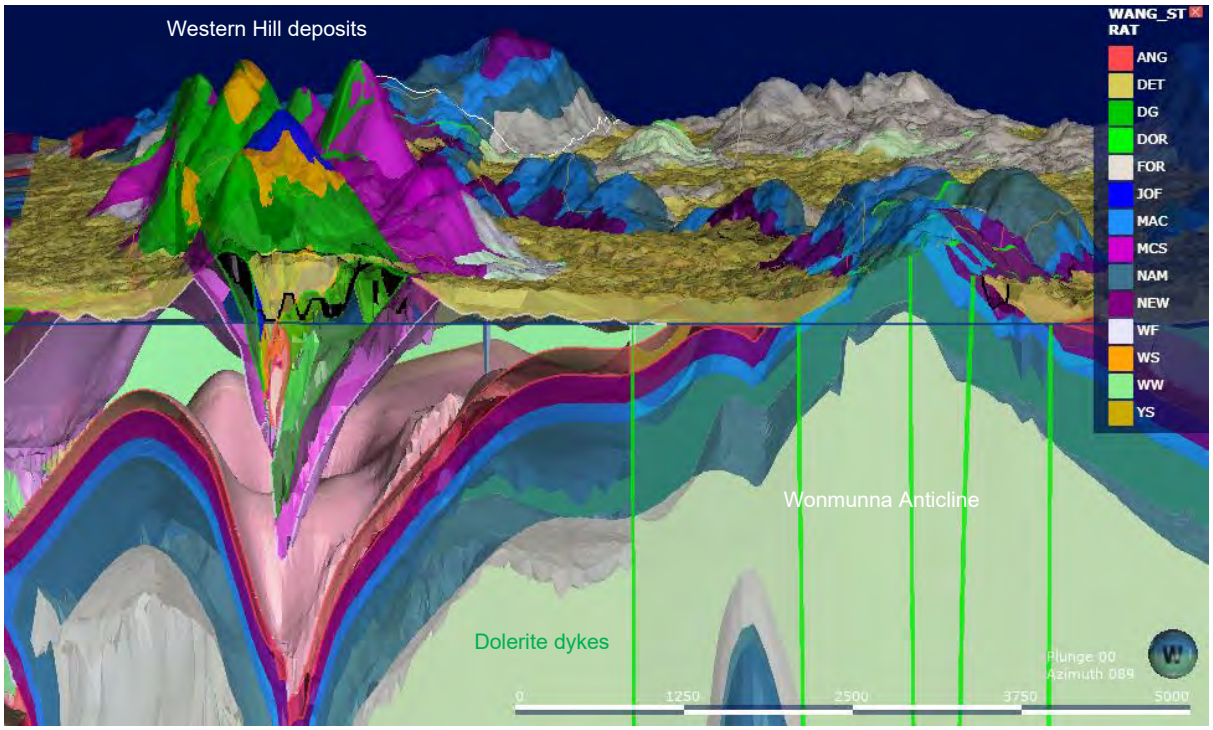


Figure 5-5: North-south section (facing east) through Western Hill and Wonmunna Anticline showing the generalised stratigraphy and structures (Leapfrog model 2022 *vertical exaggeration x5*)

The 3D modelling of AWT habitats in the Western Hill area is supported by 106 km of logging data from 1569 drillholes (Table 5-4), evaluation of diamond cores, geophysical data, and a recently revised stratigraphic model. Due to this high density of data, there is a very high level of confidence in the modelling of high and medium suitability 'veins' AWT throughout the Western Hill Deposit.

Table 5-4: Overview of drill hole data per habitat suitability category at Western Hill

Habitat Suitability category	Total metres (m)	% of Habitat	Mean thickness (m)	Standard Deviation (m)	Maximum thickness (m)
High	42,093	40	27.8	24.7	130.0
Medium	54,067	51	27.9	19.4	111.8
Low	7,035	7	14.4	11.6	78.8
Inferred	2,935	3	12.9	23.8	110.8
Total	**106,130**		**100**		**-**

5.2.1 Habitat suitability and extent

At Western Hill, the 3D modelling shows extensive, continuous and thick troglofauna habitats associated with the large hills and ridges of the Brockman Iron Formation (BrIF) range which trend east-west (Figure 5-6A and B, Figure 5-7 A and B). Where exposed to weathering and intense fracturing from faults and deformation, such units are well-known to provide suitable habitats for troglofauna.

The Synclinal valley to the immediate south of the BrIF range hosts thin to moderately thick AWT habitats comprised of colluvial detritals, calcrete, and weathered Wittenoom Dolomite Formation. AWT habitats within this valley are expected to connect to troglofauna habitats in the MMIF range further south (Figure 5-6A and B, Figure 5-7 A and B). However, due to low density of drill holes in this area, prospective AWT habitats in the valley between the BrIF and MMIF ranges could only be modelled using their broad stratigraphic interpretations. The detrital habitats AWT are continuous along the valley and are locally contiguous with the bedded ironstone habitats formed in BrIF within the hills and mountains.

Several dykes occur at Western Hill mostly projecting through the flats/valleys and striking in a north-west - south-east orientation (Figure 5-6A and B, Figure 5-7 A and B). AWT habitat connectivity is most likely not interrupted by these dykes as it is expected the intense deformation and weathering will have affected these structures as well. Most suitable habitat within the valley detritals would occur above these geological structures.

5.2.2 Quantification

Direct impacts to troglofauna habitat values

At Western Hill, implementation of the Proposal results in a volumetric reduction of approximately 144,310,000 m^3 of suitable habitat within Zone A under the proposed scenario. The proposed mining activities result in a reduction of approximately 17.1% of the pre-impact volume of suitable AWT habitat (based on conservative assessment of high and medium suitability combined) (Table 5-5). Approximately 83% of the pre-impact volume of suitable habitat AWT is expected to remain (Table 5-5).

Table 5-5: Volumetric impacts to troglofauna habitat at Western Hill under each impact scenario (totals in bold)

	Volume ('000 m^3)				% of pre-impact total		
	Pre-impact	Current	Proposed	Combined	Current	Proposed	Combined
In-situ Habitat (remaining)	**1,781,144**	**1,781,144**	**1,628,443**	**1,628,443**	**100.0**	**91.4**	**91.4**
High	216,650	216,650	127,660	127,660	100.0	58.9	58.9
Medium	628,930	628,930	573,610	573,610	100.0	91.2	91.2
Low	89,089	89,089	86,158	86,158	100.0	96.7	96.7
Zone B: Inferred	846,475	846,475	841,015	841,015	100.0	99.4	99.4
Zone A: Suitable habitat (H+M)	**845,580**	**845,580**	**701,270**	**701,270**	**100.0**	**82.9**	**82.9**
HABITAT LOSS	**0**	**0**	**152,701**	**152,701**	**0.0**	**8.6**	**8.6**
High	0	0	88,990	88,990	0.0	41.1	41.1
Medium	0	0	55,320	55,320	0.0	8.8	8.8
Low	0	0	2,931	2,931	0.0	3.3	3.3
Zone B: Inferred	0	0	5,460	5,460	0.0	0.6	0.6
Loss: Zone A: Suitable habitat (H+M)	**0**	**0**	**144,310**	**144,310**	**0.0**	**17.1**	**17.1**

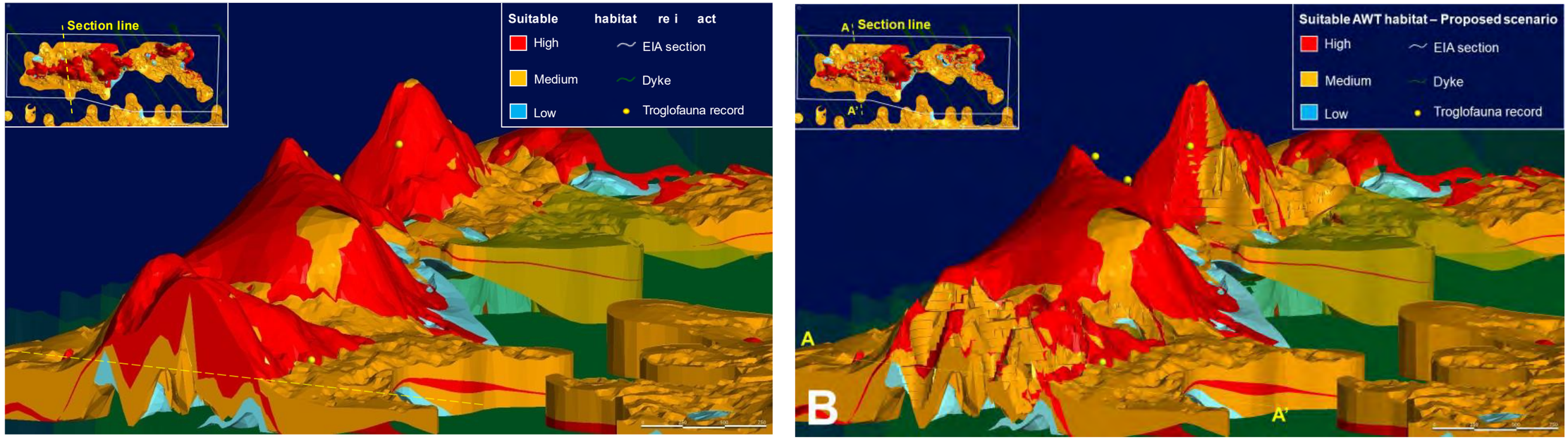


Figure 5-6: Modelled extent and thickness of (A) pre-impact, and (B) post-impact (proposed) troglofauna habitat at Western Hill – Cross-section view looking east (*vertical exaggeration x5*)

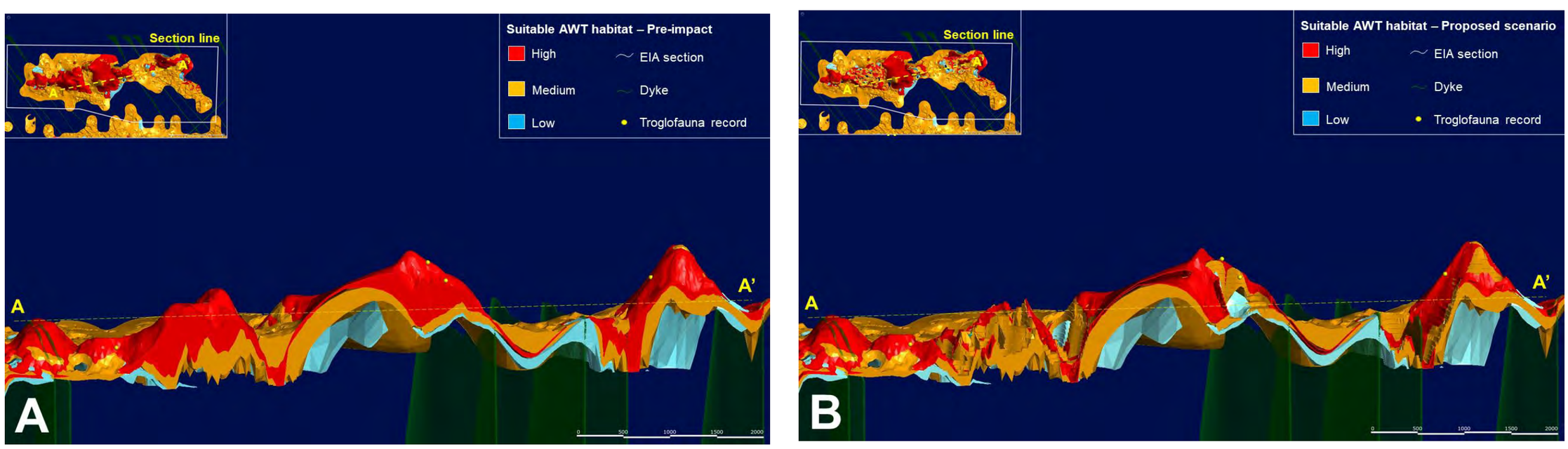


Figure 5-7: Modelled extent and thickness of (A) pre-impact, and (B) post-impact (proposed) troglofauna habitat at Western Hill – Long-section view looking north. (*vertical exaggeration x5*)

5.2.3 Impact Assessment

3D modelling shows a considerable reduction in highly suitable habitat thickness in the proposed pit areas, but a reasonable thickness of high to medium suitability habitat remains intact AWT below and surrounding each of the proposed pits (between 5 m and 100 m thick in patches) especially between Pits 1 and 2.

- The overall extent and connectivity of the AWT habitats outside of the proposed pit areas is maintained (compare A and B of Figure 5-6 and Figure 5-7).
- The volume, extent, thickness, and connectivity of suitable habitat remaining at Western Hill is expected to continue to support the troglofauna species and assemblages recorded.
- Owing to the lack of 'current' impacts to AWT habitat at the Western Hill area, there is no difference in the level of impact under the 'proposed' and 'combined' scenarios.

Overall, the direct impacts to troglofauna habitat at Western Hill appear relatively low, with an estimated reduction of approximately 17% of the modelled suitable habitat and retention of approximately 83% of the modelled suitable habitat AWT.

5.3 Deposit H

Deposit H is located within outcropping Marra Mamba Iron Formation MMIF (Nammuldi - NAM, Macleod - MAC and Mt Newman- NEW Members) that surrounds a long narrow centre of Wittenoom Formation (mostly West Angelas Shale Member) and is covered by thin detritals (DET) (Figure 5-8) (Rio Tinto 2020c).

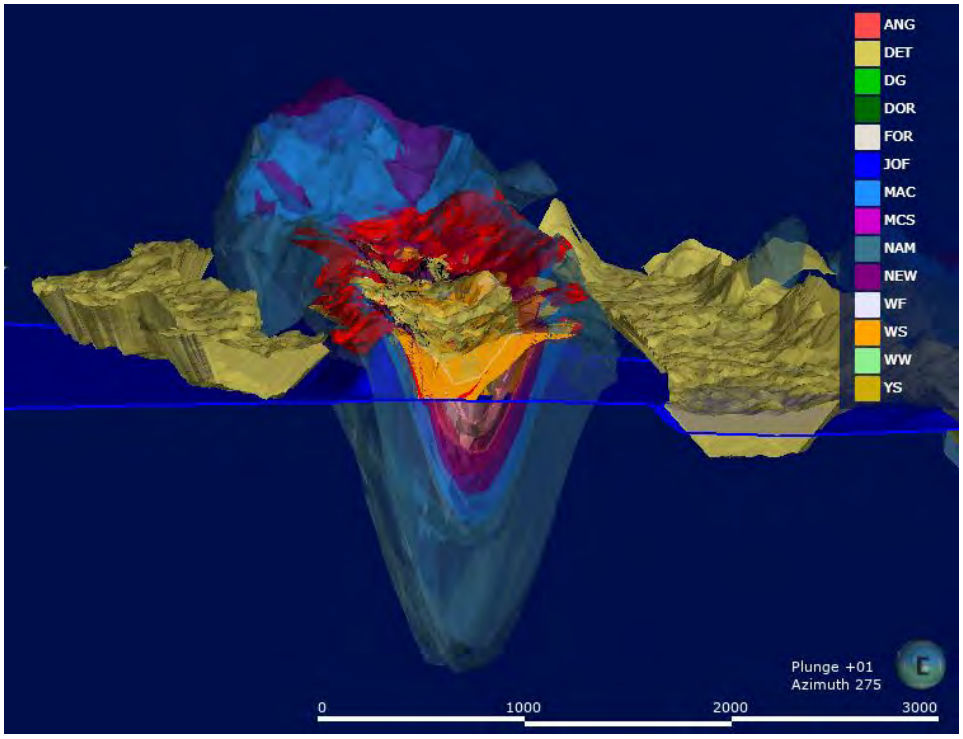


Figure 5-8: Stratigraphic model of Deposit H showing AWT habitat modelling, regional pre-mining water table (blue) and detritals(yellow). (*vertical exaggeration x5*)

The 3D modelling of AWT habitats in Deposit H is supported by 61 km of logging data (Table 5-6) from 1565 drillholes (Table 5-1), evaluation of diamond cores, geophysical data, and a recently revised stratigraphic deposit scale model. The mean vein thickness of suitable habitat averages between 16 m in High and 19 m in Medium but can be a up to 61 m thick and 75 m thick respectively. Due to the high density of data, there is a high level of confidence in the modelling of high and medium suitability 'veins' AWT throughout the Deposit H section.

Table 5-6: Overview of drill hole data per habitat suitability category at Deposit H

Habitat suitability category	Total AWT metres (m)	% of modelled Habitat	Mean vein thickness (m)	Standard Deviation (m)	Maximum vein thickness (m)
High	20,028	32	15.9	13.0	60.7
Medium	27,360	44	18.6	15.3	75.4
Low	13,862	22	16.8	11.7	68.0
Inferred	512	1	4.5	6.7	25.9
Total	**61,762**	**100**			

5.3.1 Habitat suitability and extent

At Deposit H, 3D modelling shows continuous, and moderately thick troglofauna habitats along the east-west striking range (Figure 5-9A, Figure 5-10A). The range is primarily comprised of deeply weathered MMIF and WF which includes the highly prospective Mt Newman member, known to commonly host highly suitable AWT habitats due to high porosity or weathering. The central part of the range also comprises the West Angela Member of the Wittenoom Formation which also hosts suitable troglofauna habitats when weathered.

Further AWT habitats are expected to occur in the valley to the north of the MMIF range. However, due to a lack of drill holes and groundwater information in this valley, prospective AWT habitats could not be modelled with confidence.

No regional dolerite dykes or significant fault structures are known to occur at Deposit H and therefore the troglofauna habitats are expected to be continuous along the MMIF range and surrounding detrital-rich valleys (Figure 5-8).

5.3.2 Quantification

Direct impacts to troglofauna habitat values

At Deposit H, implementation of the Proposal results in a volumetric reduction of approximately 24,800,000 m^3 of suitable habitat (Zone A; high and medium suitability) under the proposed scenario, or approximately 13.1% of the pre-existing suitable habitat as modelled (Table 5-7). Approximately 86.9% of the suitable habitat modelled is expected to remain in-situ under the proposed scenario (Table 5-7).

Table 5-7: Volumetric impacts to troglofauna habitat at Deposit H under each impact scenario (totals in bold)

	Volume ('000 m³)				Volume as % of Pre-impact		
	Pre-impact	Current	Proposed	Combined	Current	Proposed	Combined
In-situ Habitat (remaining)	**671,173**	**671,173**	**640,270**	**640,270**	**100.0**	**95.4**	**95.4**
High	68,343	68,343	49,322	49,320	100.0	72.2	72.2
Medium	120,830	120,830	115,050	115,050	100.0	95.2	95.2
Low	137,410	137,410	133,990	133,990	100.0	97.5	97.5
Zone B: Inferred	344,590	344,590	341,910	341,910	100.0	99.2	99.2
Zone A: Suitable habitat (H+M)	**189,173**	**189,173**	**164,372**	**164,370**	**100.0**	**86.9**	**86.9**
HABITAT LOSS	**0**	**0**	**30,903**	**30,903**	**0.0**	**4.6**	**4.6**
High	0	0	19,021	19,023	0.0	27.8	27.8
Medium	0	0	5,780	5,780	0.0	4.8	4.8
Low	0	0	3,420	3,420	0.0	2.5	2.5
Zone B: Inferred	0	0	2,680	2,680	0.0	0.8	0.8
Loss Zone A: Suitable habitat (H+M)	**0**	**0**	**24,801**	**24,803**	**0.0**	**13.1**	**13.1**

5.3.3 Impact Assessment

3D modelling shows a low to moderate reduction in habitat thickness in the proposed pit areas, with a reasonable thickness of high to medium suitability habitat remaining intact AWT surrounding each of the proposed pits.

- The overall extent and connectivity of the AWT habitats outside of the proposed pit areas is maintained (compare A and B of Figure 5-9 and Figure 5-10).
- The volume, extent, thickness, and connectivity of suitable habitat remaining at Deposit H is expected to continue to support the troglofauna species and assemblages recorded.

Overall, the direct impacts to troglofauna habitat at Deposit H appear to maintain the habitat integrity, with an estimated reduction of approximately 13% of the modelled suitable habitat and retention of approximately 87% of the modelled suitable habitat AWT.

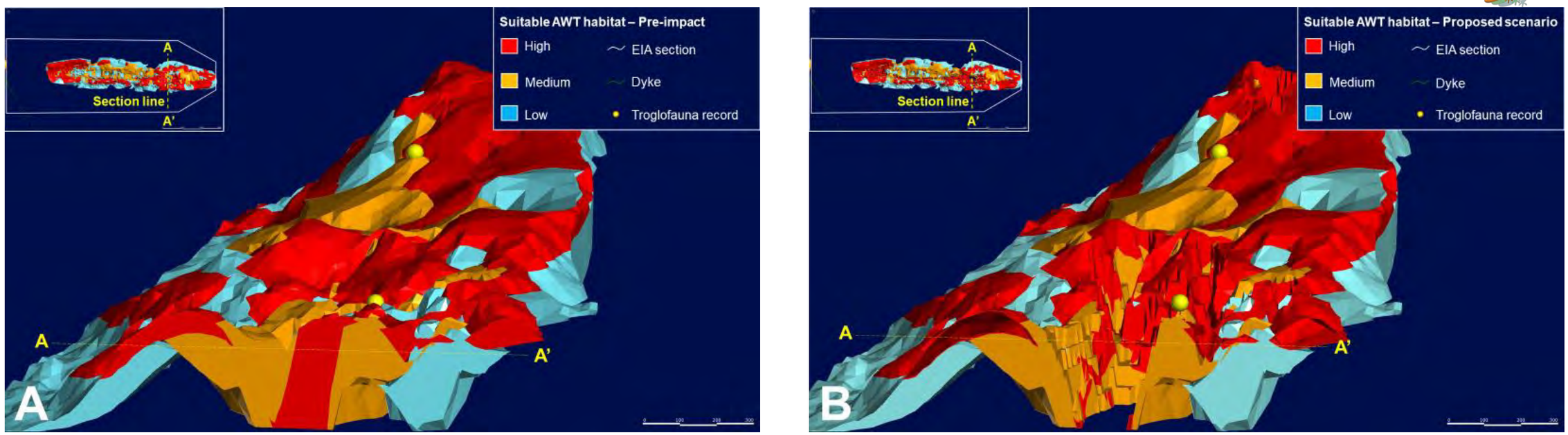


Figure 5-9: Modelled extent and thickness of (A) pre-impact, and (B) post-impact (proposed) troglofauna habitat at Deposit H – Cross-section view looking east (*vertical exaggeration x5*)

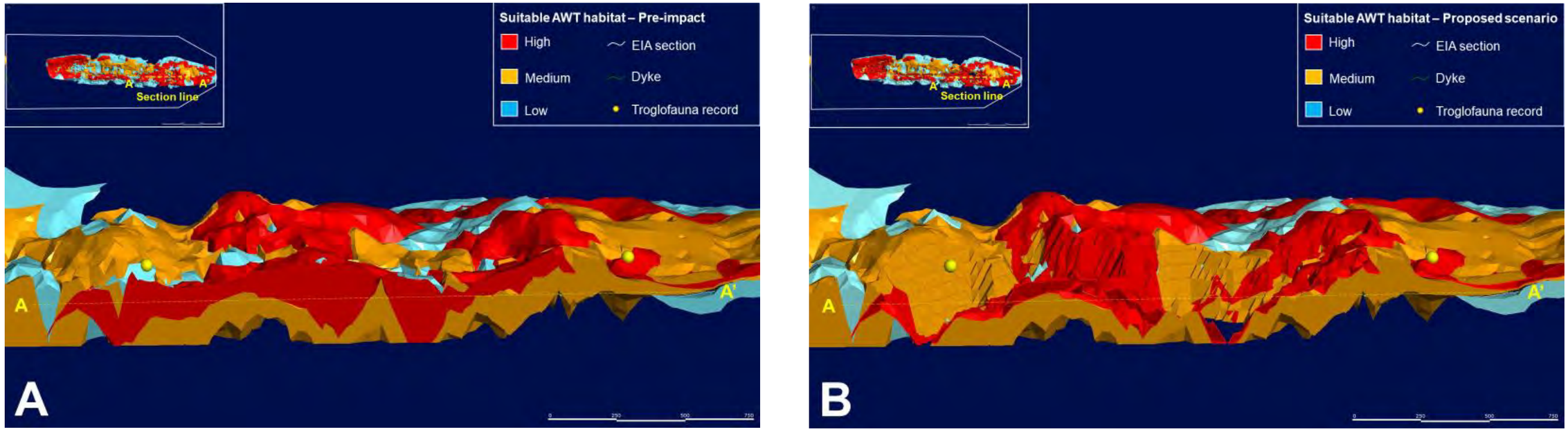


Figure 5-10: Modelled extent and thickness of (A) pre-impact, and (B) post-impact (proposed) troglofauna habitat at Deposit H – Long-section view looking north (*vertical exaggeration x5*)

5.4 Deposit F North

In the Deposit F North section, the hills are primarily comprised of the MMIF, Mt Newman Member as well as the West Angelas Member of the Wittenoom Formation (Figure 5-11) which are both known to host suitable troglofauna habitats due to their high porosity, especially when weathered.

Hydrogeological studies showed that the western proposed pit is entirely AWT, and while the eastern pit is both AWT and BWT intersects a small, locally restricted basinal type aquifer at depth (Figure 2-4).

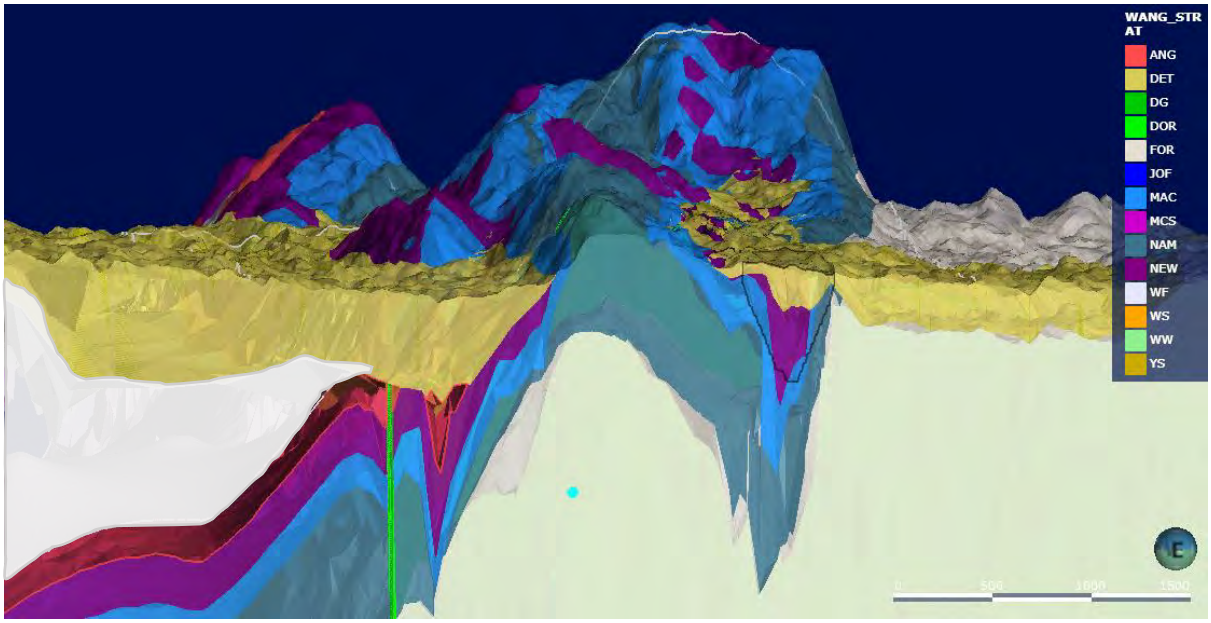


Figure 5-11: Deposit F north Section - cross section looking west showing lithology including MMIF hills and valley detritals

The 3D modelling of AWT habitats in Deposit F North (including Deposit F) was supported by 202 km of logging data from 2861 drillholes (Table 5-8), evaluation of diamond cores and a recently revised stratigraphic model. Due to this high density of data, there is a very high level of confidence in the modelling of high and medium suitability 'veins' AWT throughout the Deposit F North section.

Table 5-8: Overview of drill hole data per habitat suitability category at Deposit F North (including Deposit F)

Habitat suitability category	Total AWT metres (m)	% of modelled Habitat	Mean thickness (m)	Standard Deviation (m)	Maximum thickness (m)
High	48,043	24	20.4	17.1	89.7
Medium	122,087	60	31.2	27.3	129.7
Low	29,519	15	20.7	15.2	119.4
Inferred	2,861	1	7.6	10.9	83.8
Total	**202,554**	**100**		**-**	

5.4.1 Habitat suitability and extent

At Deposit F North, the 3D modelling shows extensive and variably thick troglofauna habitats associated with the hills of the Marra Mamba Iron Formation (MMIF) range which strike east-west in a synformal parasitic fold to the regional anticline (Figure 5-12A and Figure 5-13A). The MMIF hills are relatively low lying in the northern section of Deposit F North (at the location of the proposed pits), providing variably thin to thick AWT habitats in this section (Figure 5-12). AWT habitats are thicker at the location of the existing southern Deposit F pits which have been regionally offset by significant east-west trending faults, with a much lower water table increasing the modelled AWT habitat.

One regional dyke is known to occur at Deposit F North and runs northwest southeast between the proposed pits. Troglofauna habitats are expected to be continuous in this area through the weathered profile.

5.4.2 Quantification

Direct impacts to troglofauna habitat values

At Deposit F North, implementation of the Proposal results in a volumetric reduction of approximately 19,760,000 m^3 of suitable AWT habitat (Zone A; under the proposed scenario, or approximately 2.7% of the pre-existing suitable habitat as modelled (Table 5-9). Approximately 97.3% of the suitable habitat modelled is expected to remain in-situ under the proposed scenario (Table 5-9).

Table 5-9: Volumetric impacts to troglofauna habitat at Deposit F North under each impact scenario (totals in bold)

	Volume ('000 m^3)				% of Pre-impact total		
	Pre-impact	Current	Proposed	Combined	Current	Proposed	Combined
In-situ Habitat (remaining)	**1,891,706**	**1,743,616**	**1,860,812**	**1,712,719**	**92.2**	**98.4**	**90.5**
High	126,190	79,387	120,930	74,127	62.9	95.8	58.7
Medium	601,140	511,425	586,640	496,920	85.1	97.6	82.7
Low	327,110	321,109	321,250	315,250	98.2	98.2	96.4
Zone B: Inferred	837,266	831,695	831,992	826,422	99.3	99.4	98.7
Zone A: Suitable habitat (H+M)	**727,330**	**590,812**	**707,570**	**571,047**	**81.2**	**97.3**	**78.5**
HABITAT LOSS	**0**	**148,090**	**30,894**	**178,987**	**7.8**	**1.6**	**9.5**
High	0	46,803	5,260	52,063	37.1	4.2	41.3
Medium	0	89,715	14,500	104,220	14.9	2.4	17.3
Low	0	6,001	5,860	11,860	1.8	1.8	3.6
Zone B: Inferred	0	5,571	5,274	10,844	0.7	0.6	1.3
Loss: Zone A Suitable habitat (H+M)	**0**	**136,518**	**19,760**	**156,283**	**18.8**	**2.7**	**21.5**

5.4.3 Impact Assessment

3D modelling shows only a slight reduction in habitat thickness (2.7%) in the proposed pit areas with most of the impact occurring in the current and approved pits of Deposit F showing 18.8% reduction in habitat.

- The overall extent and connectivity of the AWT habitats outside of the proposed pit areas is maintained (compare A and B of Figure 5-12 and Figure 5-13).
- The volume, extent, thickness, and connectivity of suitable habitat remaining at Deposit F North is expected to continue to support the troglofauna species and assemblages recorded.

Overall, the direct impacts to troglofauna habitat at Deposit F North appear to maintain the habitat integrity, with an estimated reduction of approximately 2.7% of the modelled suitable habitat and retention of approximately 97.3% of the modelled suitable habitat AWT.

The combined direct impacts to troglofauna habitat at Deposit F North appear to be greater, with an estimated reduction of approximately 21% of the modelled suitable habitat and retention of approximately 79% of the modelled suitable habitat AWT.

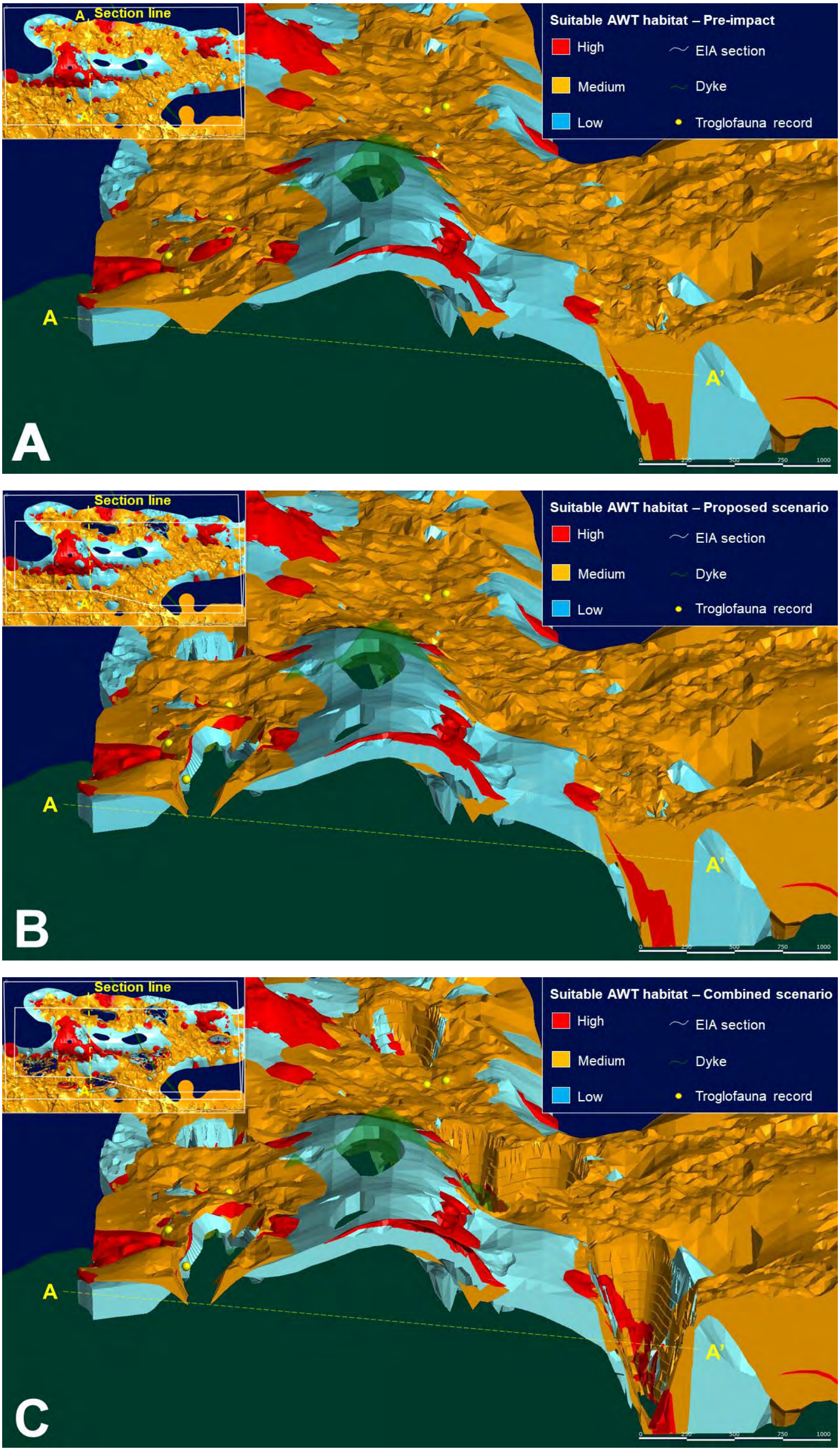


Figure 5-12: Modelled extent and thickness of (A) pre-impact, (B) post-impact (proposed) and (C) combined impact troglofauna habitat at Deposit F North – Cross-section view looking east (*vertical exaggeration x5*)

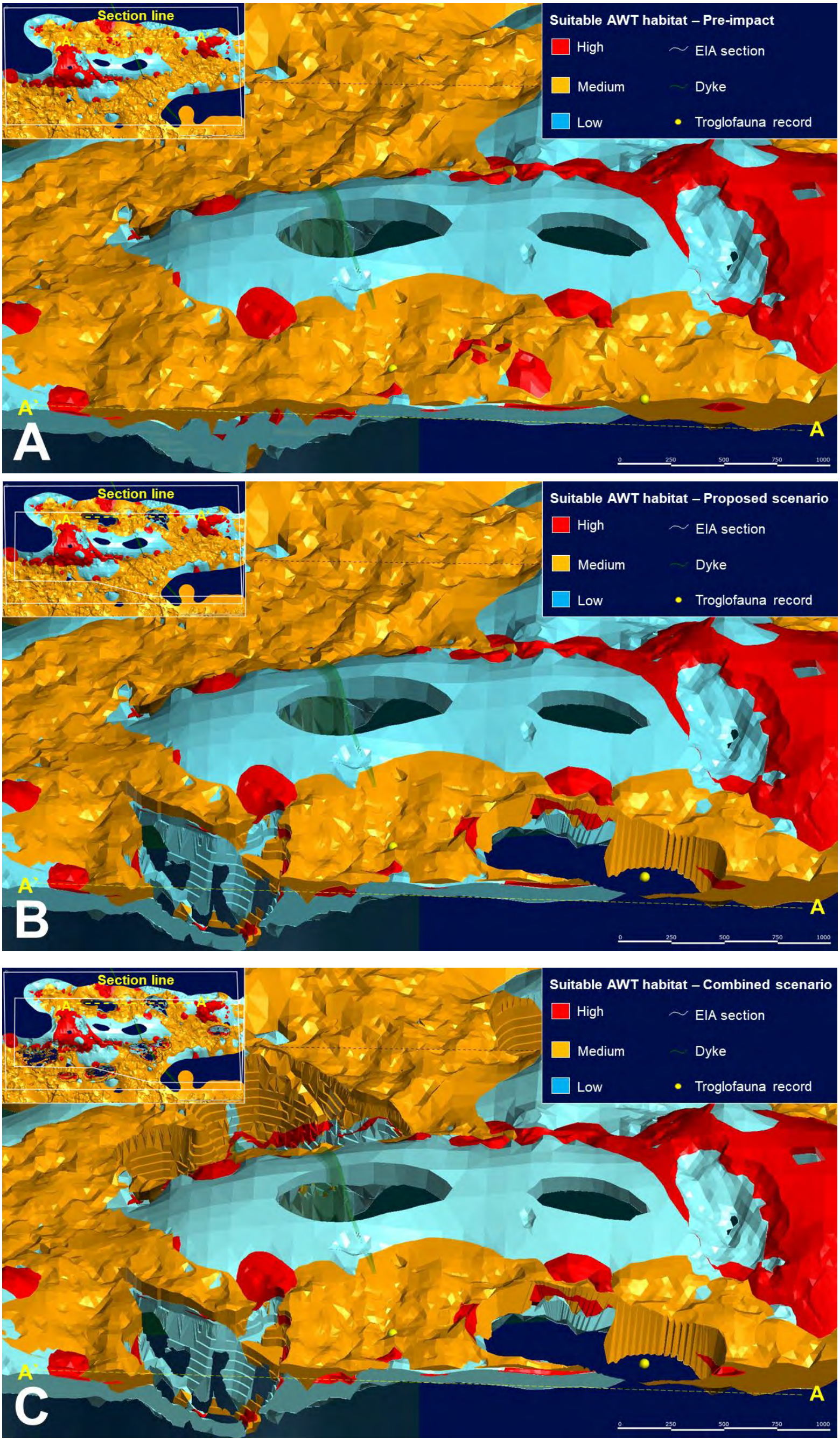


Figure 5-13: Modelled extent and thickness of (A) pre-impact, (B) post-impact (proposed) and (C) combined troglofauna habitat at Deposit F North – Long-section view looking south (*vertical exaggeration x5*)

5.5 Mt Ella East

Mt Ella East deposits sit on the northern flank of BrIF range to the south of Deposit F. The range comprises the Dales Gorge, Whaleback Shale and Joffre Members of BrIF (Figure 5-14) (as observed at Western Hill) which are known to provide highly suitable habitats for troglofauna where exposed to weathering and faulting/fracturing.

Very few dykes are known to occur at Mt Ella East. One regional dyke is modelled to trend east-west through the peak of the BrIF range which may appear to restrict habitat connectivity between the north and south of Mt Ella East (Figure 5-14).

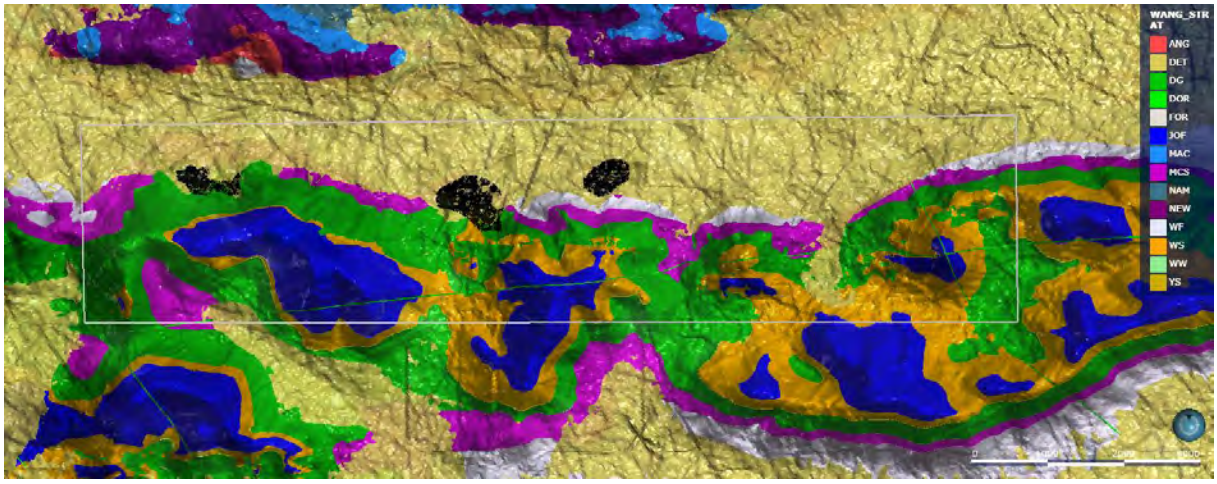


Figure 5-14: Mt Ella East Section – showing stratigraphy and east-west dolerite dyke (proposed pits in black)

The 3D modelling of AWT habitats in the Mt Ella East area was supported by 50.6 km of logging data from 675 drillholes (Table 5-10). While the quantity is lower than other deposit sections, there is a reasonable level of confidence in the modelling of high and medium suitability 'veins' AWT throughout the Mt Ella East section due to the consistent spacing of the drilling that averages 200 m over the entire deposit area.

Table 5-10: Overview of drill hole data per habitat suitability category at Mt Ella East

Habitat Suitability category	Total AWT metres (m)	% of Habitat	Mean thickness (m)	Standard Deviation (m)	Maximum thickness (m)
High	9,213	18	14.5	15.9	92.0
Medium	35,780	71	35.5	27.9	128.5
Low	5,318	11	14.0	11.1	98.0
Inferred	324	1	9.8	15.9	70.0
Total	**50,635**	**100**			-

5.5.1 Habitat suitability and extent

At Mt Ella East, the 3D modelling shows extensive, continuous, and thick troglofauna habitats associated with the hills and ridges of the Brockman Iron Formation (BrIF) range (Figure 5-15A and Figure 5-16A). Thick AWT habitat occurs in the valley immediately north of the BrIF range and location of the proposed pits, hosted by colluvial detritals, calcrete and weathered Wittenoom Dolomite Formation and eventually connecting to AWT habitats hosted in Deposit F to the north.

5.5.2 Quantification

Direct impacts to troglofauna habitat values

At Mt Ella East, implementation of the Proposal results in a volumetric reduction of approximately 27,390, 000 m^3 of suitable habitat (combined high and medium suitability) under the proposed scenario, or approximately 2.4% of the pre-existing suitable habitat as modelled (Table 5-11). Approximately 97.6% of the suitable habitat modelled is expected to remain in-situ under the proposed scenario (Table 5-11).

Table 5-11: Volumetric impacts to troglofauna habitat at Mount Ella East under each impact scenario (totals in bold)

	Volume ('000 m^3)				% of Pre-impact total		
	Pre-impact	Current	Proposed	Combined	Current	Proposed	Combined
In-situ Habitat (remaining)	**2,696,236**	**2,680,585**	**2,667,868**	**2,652,241**	**99.4**	**98.9**	**98.4**
High	160,220	157,694	155,010	152,480	98.4	96.7	95.2
Medium	1,003,500	994,760	981,320	972,580	99.1	97.8	96.9
Low	91,871	91,113	91,793	91,036	99.2	99.9	99.1
Zone B: Inferred	1,440,645	1,437,018	1,439,745	1,436,145	99.7	99.9	99.7
Zone A: Suitable habitat (H+M)	**1,163,720**	**1,152,454**	**1,136,330**	**1,125,060**	**99.0**	**97.6**	**96.7**
HABITAT LOSS	**0**	**15,650**	**28,368**	**28,345**	**0.6**	**1.1**	**1.1**
High	0	2,526	5,210	7,740	1.6	3.3	4.8
Medium	0	8,740	22,180	30,920	0.9	2.2	3.1
Low	0	758	78	835	0.8	0.1	0.9
Zone B: Inferred	0	3,627	900	4,500	0.3	0.1	0.3
Loss: Zone A Suitable habitat (H+M)	**0**	**11,266**	**27,390**	**38,660**	**1.0**	**2.4**	**3.3**

5.5.3 Impact Assessment

3D modelling shows a reduction in suitable habitat thickness in the proposed pit areas but a reasonable thickness of high to medium suitability habitat remains intact AWT surrounding each of the proposed pits and to the valley in the north.

- The overall extent and connectivity of the AWT habitats outside of the proposed pit areas is maintained (compare A and B of Figure 5-15 and Figure 5-16)
- The volume, extent, thickness, and connectivity of suitable habitat remaining at Mt Ella East is expected to continue to support the troglofauna species and assemblages recorded.

Overall, the direct impacts of the Proposal to troglofauna habitat at Mt Ella East appear negligible, with an estimated reduction of approximately 2.4% of the modelled suitable habitat and retention of approximately 97.6% of the modelled suitable habitat AWT.

The combined direct impacts to troglofauna habitat at Mt Ella East are only marginally greater, with an estimated reduction of approximately 3.3% of the modelled suitable habitat and retention of approximately 96.7% of the modelled suitable habitat AWT. This reduction is due to inclusion of the current and existing modelled impacts from Deposit E pits.

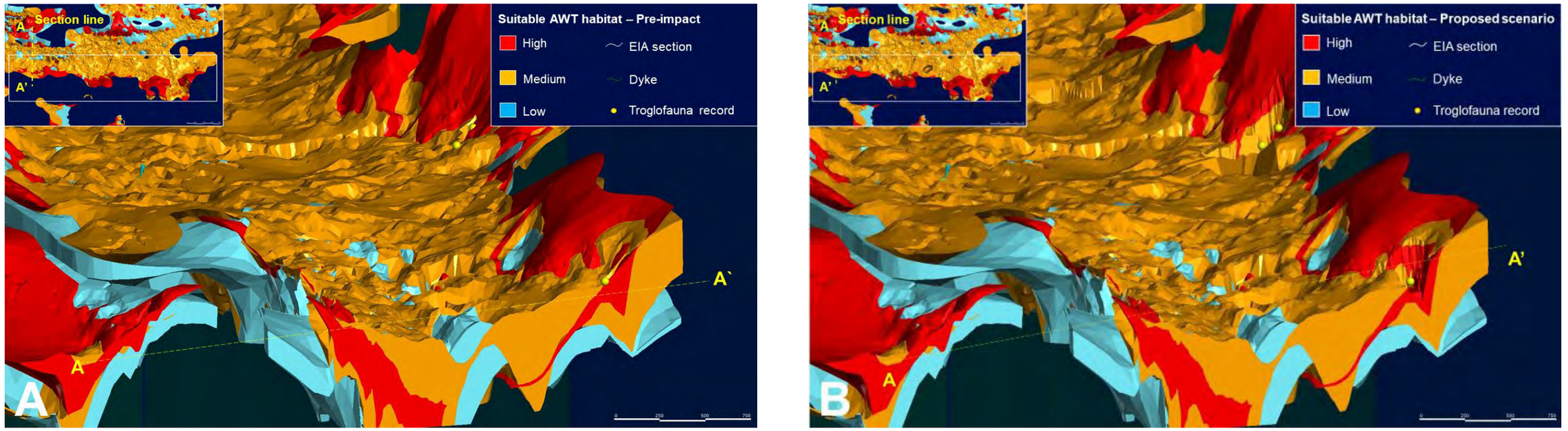


Figure 5-15: Modelled extent and thickness of (A) pre-impact, and (B) post-impact (proposed) troglofauna habitat at Mt Ella East – Cross-section view looking west (*vertical exaggeration x5*)

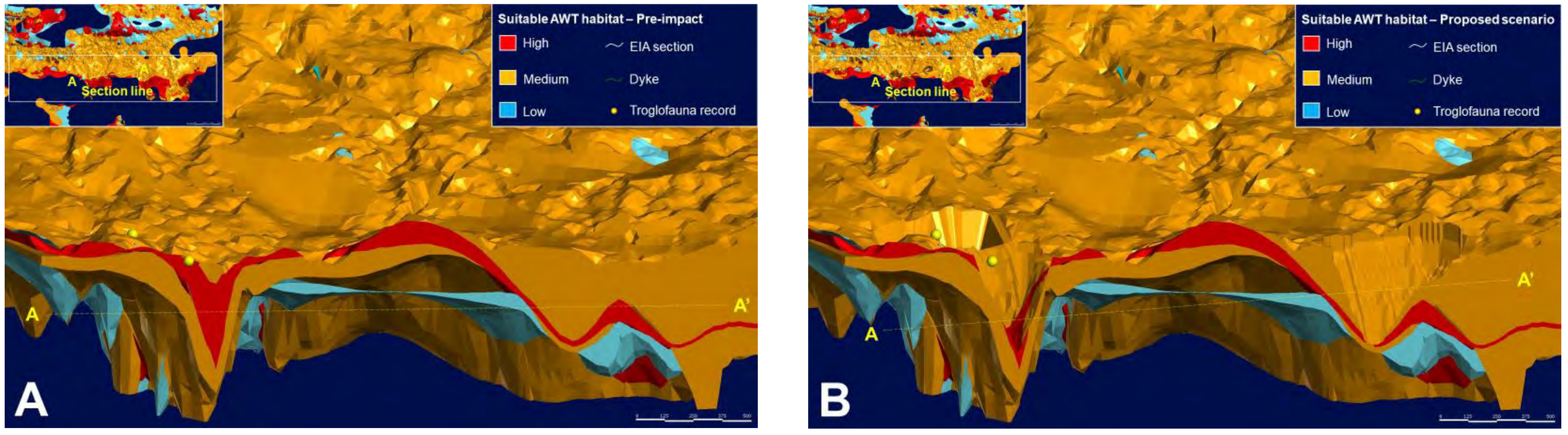


Figure 5-16: Modelled extent and thickness of (A) pre-impact, and (B) post-impact (proposed) troglofauna habitat at Mt Ella East – Long-section view looking west (*vertical exaggeration x5*)

5.6 Deposit J reference area

Deposit J reference area is located south of the main West Angelas deposits and sits within east-west trending pockets of mineralised Dales Gorge Member of the BrIF (Figure 5-17). The range comprises the Dales Gorge, Whaleback Shale and Joffre Members of Brockman Iron Formation (as observed at Western Hill and Mt Ella East) which are known to provide highly suitable habitats for troglofauna where exposed to weathering and faulting/fracturing.

The detrital habitats AWT are continuous along the valleys on either side of the BrIF range and are locally contiguous with the bedded ironstone habitats formed in BrIF within the hills and mountains. The valleys are hosted by colluvial detritals, calcrete and weathered Wittenoom Dolomite Formation (Figure 5-17).

Several northwest southeast dolerite dykes occur at Deposit J reference area and strike through BrIF range, particularly in the eastern section of Deposit J reference area. AWT habitat connectivity at Deposit J reference area likely continues within the deep modelled detritals that occur above the bedrock. It is unknown whether the dykes will compartmentalise the AWT habitat as mentioned in Rio Tinto 2020b.

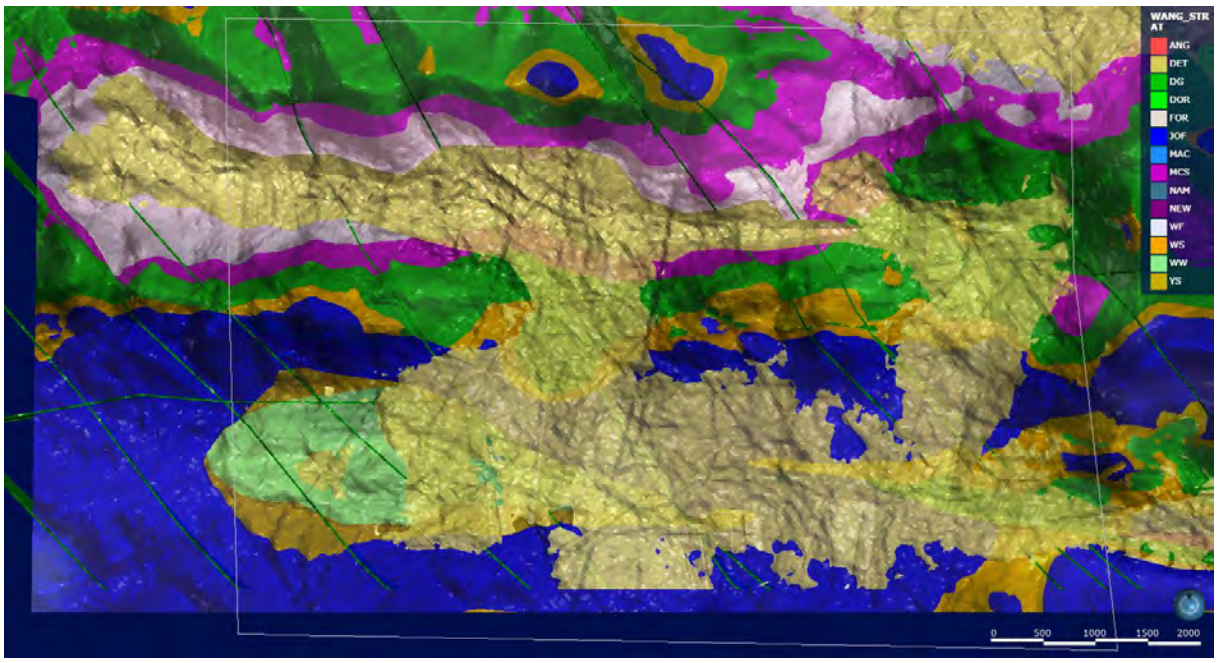


Figure 5-17: Deposit J reference area showing BrIF lithologies in ranges and valley detritals and dykes

The 3D modelling of AWT habitats in Deposit J reference area was supported by 31 km of logging data from 450 drillholes (Table 5-12). There is a moderate level of confidence in the modelling of high and medium suitability ‘veins’ AWT throughout the Deposit J reference area section which shows good stratigraphic continuity to the regional models. Further drilling would improve the model significantly.

Table 5-12: Overview of drill hole data per habitat suitability category at Deposit J reference area

Habitat Suitability category	Total AWT metres (m)	% of Habitat	Mean thickness (m)	Standard Deviation (m)	Maximum thickness (m)
High	11,723	37	29.8	25.0	104.0
Medium	15,348	48	25.0	16.2	104.0
Low	3,024	10	17.2	12.1	72.5
Inferred	1,567	5	10.4	12.1	65.9
Total	**31,662**	**100**			**-**

5.6.1 Habitat suitability and extent

At Deposit J reference area, the 3D modelling shows relatively continuous and moderately thick troglofauna habitats along the BrIF range which runs from west to east (Figure 5-18A and Figure 5-19A). Moderately thick AWT habitats occur in the valley immediately south of the BrIF range and are expected to be continuous and well-connected. These valley habitats appear patchy in the 3D model due to a lack of drill holes and wide spaced drilling that is beyond the 300 m radial boundary. Low suitability habitat is delineated by the Mount McRae Shale (MCS) unit immediately to the north of the proposed pits. Further AWT habitats are expected to occur in the valley to the north of the BrIF range (connecting to AWT habitats hosted in MMIF further north).

5.6.2 Quantification

At the time of writing, there is no development proposed for Deposit J reference area, therefore no volumes were reported.

5.6.3 Impact Assessment

At the time of writing, no development has been proposed for Deposit J reference area hence no impacts were assessed.

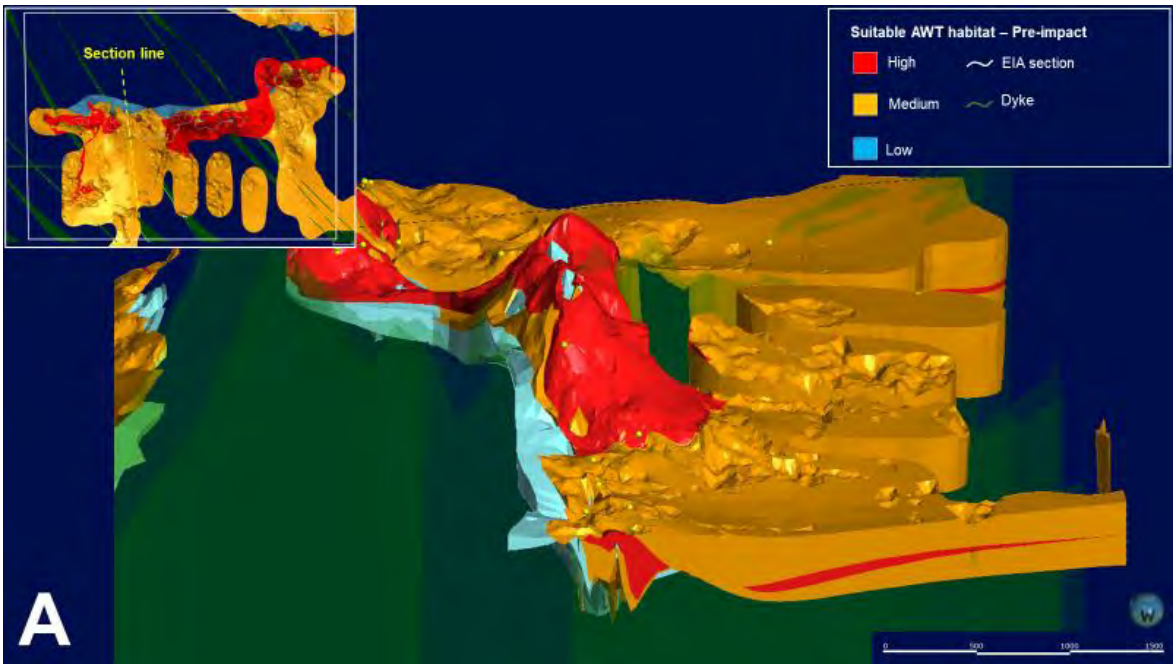


Figure 5-18: Modelled extent and thickness troglofauna habitat at Deposit J reference area – Cross-section view looking east. (*vertical exaggeration x5*)

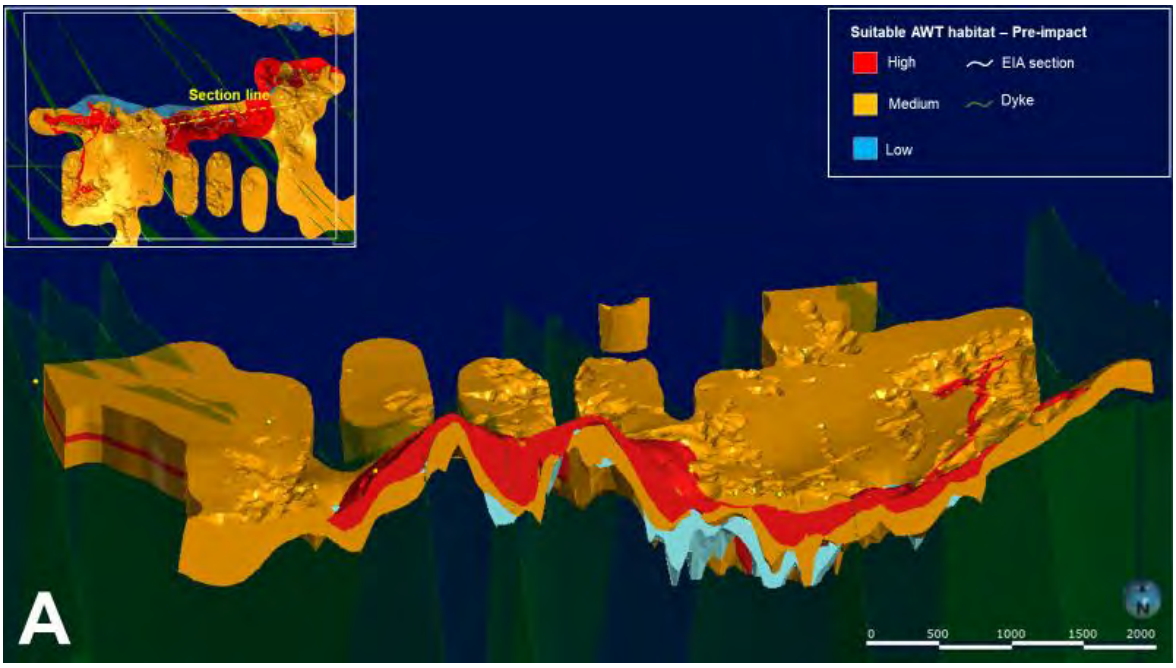


Figure 5-19: Modelled extent and thickness of troglofauna habitat at Deposit J reference area – Long-section view looking south. (*vertical exaggeration x5*)

6. STYGOFAUNA (BWT) 3D HABITAT AND IMPACT ASSESSMENT

Suitable habitat for stygofauna occurs within the BWT modelled High, Medium, and Inferred suitability categories, ultimately delimited by the groundwater level as the upper potential threshold, and the hydrogeological basement as the lower potential threshold. Impacts potentially arising from the proposed groundwater drawdown or mining of pit designs were assessed in each of the deposit areas, with a particular focus on sites where putatively restricted stygofauna species were recorded.

The final 3D model of BWT stygofauna habitats was based on a considerable amount of drill-hole information, as shown in Table 6-1. However, it was significantly less than the AWT drilling data (approximately one-third of the information) shown in Table 5-1.

Possible reasons for this difference in available information could be that: A) most holes are RC or percussion and may have been stopped before hitting the water table. Holes of this type can only go to blade refusal (fresh rock) or are stopped as they hit water (becoming too saturated to continue), or B) the mineralisation of interest was not targeted for drilling below the water table.

In total, 6,819 drill holes were used to calculate the BWT habitats throughout the Development Envelope. More than 231 kilometres of BWT downhole metres (Table 6-1) were categorised into stygofauna habitat suitability categories as described in section 3. This information was used to model and quantify (Table 6-2) habitat suitability across the Development Envelope and for each individual deposit.

Table 6-1: Drill hole information used to model BWT habitats across the Development Envelope

Deposit/ Region	Number of holes	Total metres (m)	Mean BWT Thickness (m)	Thickness Standard deviation (m)	Maximum drill depth (single hole)
Western Hill Orebody aquifer	417	16,506	39.6	30.6	110.2
Synclinal Valley aquifer	1,946	81,134	41.7	31.0	113.2
Deposit H	580	13,863	23.9	23.0	139.7
Deposit F North (and Deposit F)	742	16,104	21.7	15.8	101.2
Mt Ella East (and adjacent valley)	93	2,466	26.5	17.1	60.3
Remaining West Angelas	3,041	101,911	29.4	20.3	119.0
Note: Reference area J area (included in Remaining West Angelas)	49	1,126	23	23	139
Total	**6,819**	**231,984**	**46**	**23**	**212**

3D habitat modelling showed that suitable BWT habitats for stygofauna occur in the four EIA sections, (Figure 6-1) comprising Western Hill, Deposit H, Deposit F North and Mt Ella East, however most of the proposed pits for West Angelas affect only the above the water table (AWT) habitats. Mt Ella East has no impacts to BWT habitats from the Proposal and hence is not discussed further herein. Deposit F

North intersects the water table and will require dewatering however no hydrological drawdown data was provided. Furthermore, the proposed pits are not considered to have significant volumes of suitable habitat as it finishes in the lower permeability units (Macleod) of MMIF. A discussion on subterranean fauna habitat for Deposit F North is included in section 2.1 and under Hydrogeological boundaries in Section 3 and will not be discussed further herein. The remaining two sections; Deposit H and Western Hill have been modelled for potential impacts on below water table (BWT) habitat and are discussed in detail below.

Modelling and habitat assessment of the Synclinal Valley aquifer surrounding Western Hill was undertaken to review the potential impact, if any, of the implementation of the Proposal, and combined impacts of the Proposal and existing operations, on the regional aquifer habitat. A number of stygofauna species are known to occur within the synclinal valley BWT habitat, as such it was important to understand and evaluate potential impacts in this area.

Table 6-2: Summary of BWT volumetric calculations - West Angelas Development Envelope by Section

	Volume ('000 m^3)				
	Pre-impact	**Current**	**Proposed**	**Combined LOM**	**Combined MAR**
Western Hill					
In-situ Suitable Habitat Remaining	409,281	407,192	403,574	401,485	-
Loss of Suitable Habitat	0	2,089	5,707	7,796	-
Deposit H					
In-situ Suitable Habitat Remaining	598,930	598,930	463,102	463,102	-
Loss of Suitable Habitat	0	0	135,828	135,828	-
Synclinal Valley					
In-situ Suitable Habitat Remaining	13,996,582	-	13,657,038	11,600,313	13,731,382
Loss of Suitable Habitat	0	-	339,544	2,396,269	265,201
Total Habitat (Remaining)	**15,004,793**	**1,006,122**	**14,523,714**	**12,464,900**	**13,731,382**
Total Loss	**0**	**2,089**	**481,079**	**2,539,893**	**265,201**
	% of pre-impact total				
	Pre-impact	**Current**	**Proposed**	**Combined LOM**	**Combined MAR**
Western Hill					
In-situ Suitable Habitat Remaining	100	99.5	98.6	98.1	0.0
Loss of Suitable Habitat	100	0.5	1.4	1.9	0.0
Deposit H					
In-situ Suitable Habitat Remaining	100	100.0	77.3	77.3	0.0
Loss of Suitable Habitat	100	0.0	22.7	22.7	0.0
Synclinal Valley					
In-situ Suitable Habitat Remaining	100	-	97.6	82.9	98.1
Loss of Suitable Habitat	100	-	2.4	17.1	1.9
Total Remaining		**99.5**	**96.8**	**83.1**	**91.5**
Total Loss		**0.5**	**3.2**	**16.9**	**1.8**

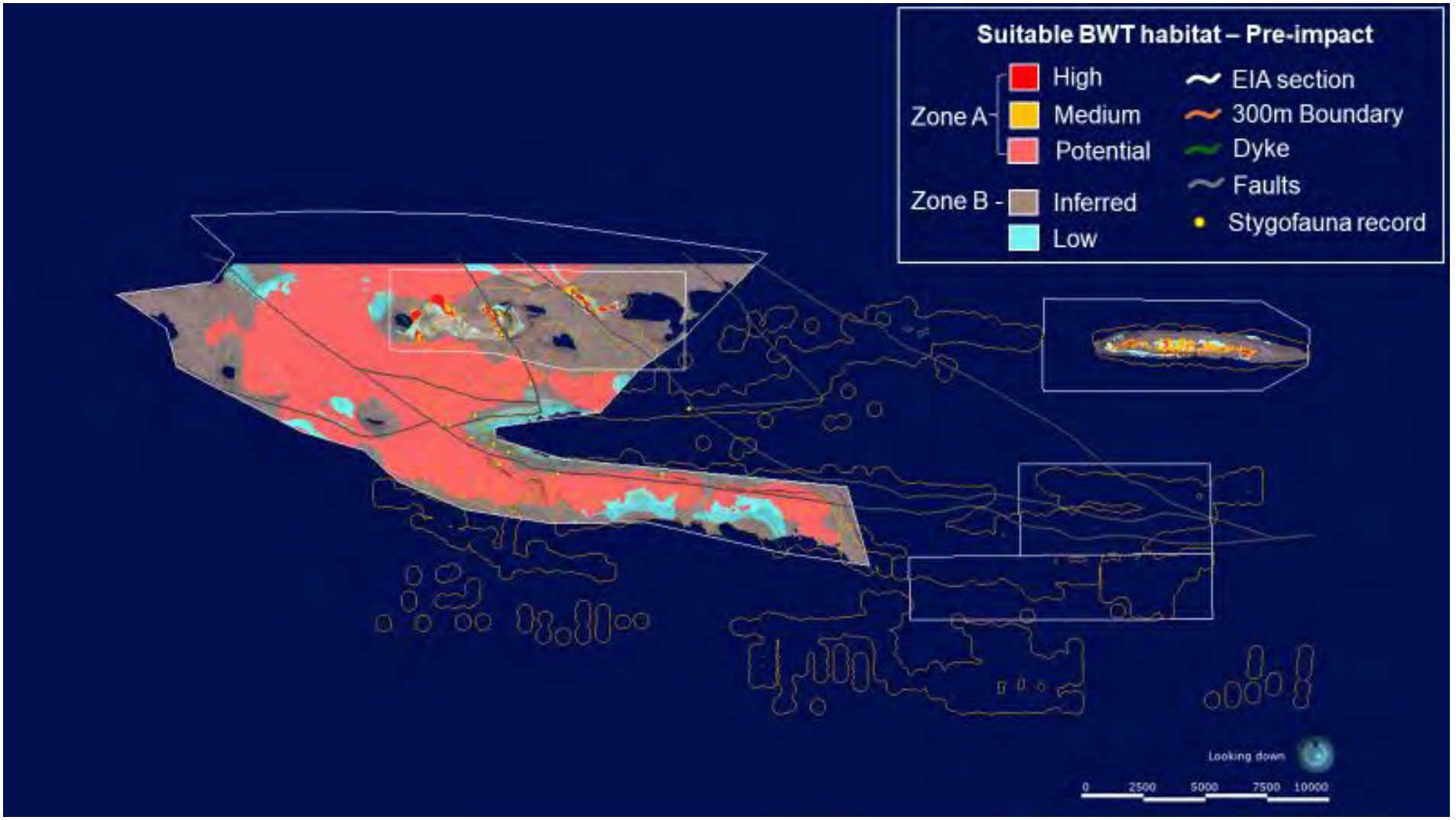


Figure 6-1: West Angelas subterranean BWT habitat modelling pre-impact (high = red, medium=orange, potential=pink, low=blue), showing deposit model areas (white thick line) and faults (dark grey) and 300 m radial boundary(orange).

6.1 Western Hill orebody aquifer

The 3D modelling of BWT habitats in the Western Hill orebody aquifer was supported by 16 km of logging data from 417 drillholes (Table 6-1 and Table 6-3). Because of the number of drilled metres there is a high level of confidence in the modelling of high and medium suitability 'veins' BWT throughout the Western Hill orebody deposits. The lower boundary is defined primarily by the base of the Mt McRae Shales (Figure 6-2) – considered an impervious layer - and to a maximum of 150mbgl. These depth constraints conservatively confine the habitat at depth and the 300 m buffer limits the lateral extrapolation of the Western Hill model.

Table 6-3: Overview of drill hole data per habitat suitability category at Western Hill BrIF Orebody Deposits

Habitat Suitability category	Total BWT metres (m)	% of Habitat	Mean thickness (m)	Standard Deviation (m)	Maximum thickness (m)
High	7,074	43	33.8	27.5	110.2
Medium	6,730	41	24.3	19.1	97.5
Low	1,695	10	10.6	9.9	61.0
Inferred	1,007	6	18.0	19.6	90.0
Total	**16,506**	**100**	**23.5**	**22.2**	**110.2**

6.1.1 Habitat suitability and extent

At Western Hill deposit, the Dales Gorge Member of the Brockman Iron Formation ranges host the majority of suitable habitat (Figure 5-5). These highly deformed and folded ranges coupled with supergene weathering and mineralisation processes have created highly suitable fractured and weathered rock habitats across the range. 3D modelling shows that BWT habitats within this mineralised bedrock aquifer are moderately extensive, continuous, and variably thick.

One significant fault traverses through the western lens deposit area and could influence local habitat connectivity by creating a deep weathering profile as well as increasing fracturing within the base rock. Several dykes crosscut the Western Hill orebodies which may also provide impermeable barriers however the minimal drawdown (6m) has not extended to those dykes (Figure 6-2).

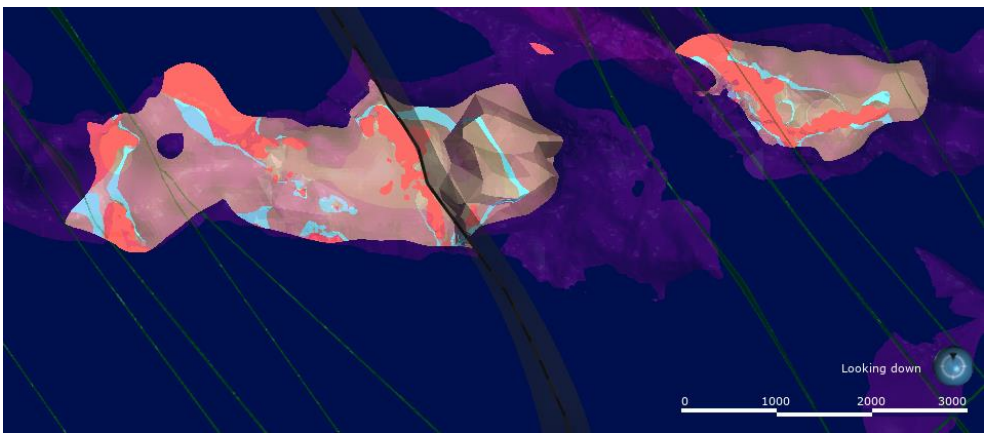


Figure 6-2: Western Hill BWT habitat of potential habitat (pink), low (light blue) and inferred (beige) with local structures and boundaries: fault (black), dolerite dykes (green) and MCS (purple).

6.1.2 Quantification

Direct impact to stygofauna habitat values

At Western Hill, the proposed mining and groundwater drawdown results in a volumetric reduction of approximately 5,707,000 m^3 of suitable habitat (combined high, medium and inferred suitability), or approximately 1.4% the pre-existing suitable habitat as modelled for the Western hill orebodies (Table 6-4). Approximately 98.6% of the suitable habitat modelled throughout Western Hill is expected to remain in-situ with only the western lens and the far eastern lens affected (Table 6-6).

Table 6-4: Volumetric impacts to BWT habitat at Western Hill orebody aquifer under each impact scenario (totals in bold)

	Volu e ('000 ^{3})				% of Pre-impact BWT habitat		
	Pre-impact	Current*	Proposed LOM	Combined LOM	Current	Proposed	Combined LOM*
In-situ Habitat to 150m basement	**433,748**	**431,314**	**427,581**	**425,147**	**99.4**	**98.6**	**98.0**
High	27,187	27,038	26,120	25,971	99.5	96.1	95.5
Medium	26,984	26,834	26,064	25,914	99.4	96.6	96.0
Low	24,467	24,122	24,007	23,662	98.6	98.1	96.7
Inferred	355,110	353,320	351,390	349,600	99.5	99.0	98.4
Zone A: Habitat (H+M)	**54,171**	**53,872**	**52,184**	**51,885**	**99.4**	**96.3**	**95.8**
All Suitable Habitat (Zone A +Zone B)	**409,281**	**407,192**	**403,574**	**401,485**	**99.5**	**98.6**	**98.1**
HABITAT LOSS	0	2,434	6,167	8,601	0.6	1.4	2.0
High	0	149	1,067	1,216	0.5	3.9	4.5
Medium	0	150	920	1,070	0.6	3.4	4.0
Low	0	345	460	805	1.4	1.9	3.3
Inferred	0	1,790	3,720	5,510	0.5	1.0	1.6
Loss Zone A: Habitat (H+M)	**0**	**299**	**1,987**	**2,286**	**0.6**	**3.7**	**4.2**
Loss Suitable Habitat (Zone A + Zone B)	**0**	**2,089**	**5,707**	**7,796**	**0.5**	**1.4**	**1.9**

*note the current scenario refers to approved drawdown from the synclinal valley aquifer and may not actually affect the orebody aquifers. The combined LOM Loss is the calculated from current and proposed loss.

6.1.3 Impact Assessment

Visual comparisons of the pre-impact and post-drawdown scenarios showed only minor changes to habitat extent, thickness, and connectivity:

- The reduction in habitat thickness is not expected to create any discontinuities or barriers to stygofauna movement throughout the habitable areas of Western Hill orebodies (based on current stygofauna records, and the 3D shape of the suitable habitat remaining in-situ) (compare A and B of Figure 6-7).

- The minor reduction in habitat thickness (max 6 m) does not appear to materially change the extent (i.e. breadth or length) of the suitable habitat throughout the aquifer (compare A and B of Figure 6-7).
- Suitable habitats for stygofauna are expected to remain intact at the locations of all recorded stygofauna species and throughout the aquifer (Figure 6-7B).

Overall, the direct impacts to BWT habitat at the Western Hill orebody aquifer appear negligible, with an estimated reduction of approximately 1% of the modelled suitable habitat and retention of approximately 99 % of the modelled suitable habitat BWT and a combined impact slightly higher at 2% with 98% of suitable habitat remining in situ.

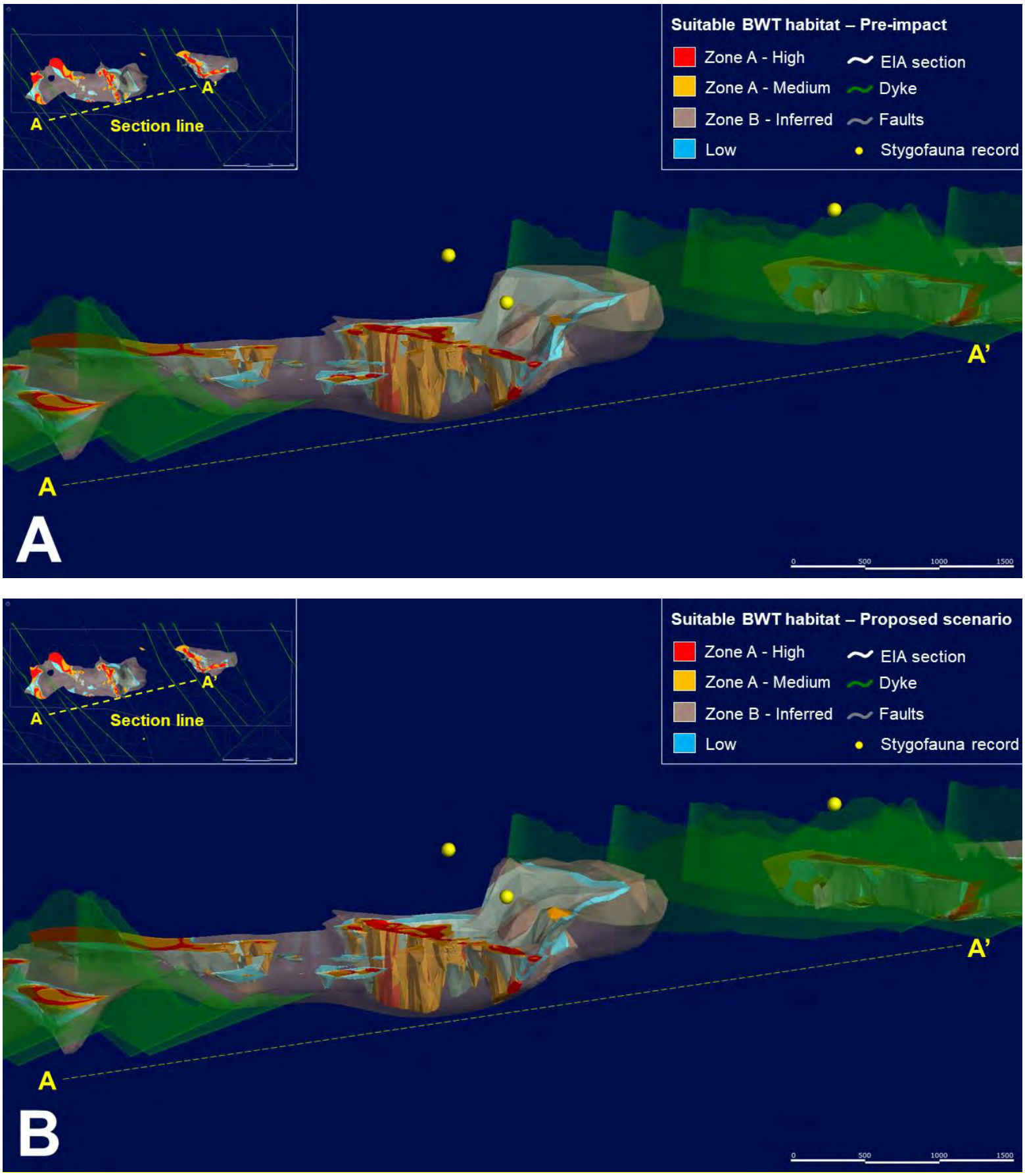


Figure 6-3: Cross-section of the 3D subterranean BWT habitat model showing (A) pre-impact (B) post-impact habitats and (C) combined post-impact habitats at Western Hill. (*vertical exaggeration x5***)**

6.2 Synclinal Valley regional aquifer

The Synclinal Valley between the Western Hill BrIF and main West Angelas MMIF ranges is comprised of colluvial detritals, calcrete, and weathered Wittenoom Dolomite Formation and MMIF sequences closer to the centre of Wonmunna Anticline as described in 2.1 Hydrogeological context.

The 3D modelling of BWT habitats in the Synclinal Valley regional aquifer was supported by 80 km of logging data from 1946 drillholes (Table 6-1 and Table 6-5) however these were based in the eastern part of the aquifer and did not cover the full extent of the aquifer system.

Table 6-5: Overview of drill hole data per habitat suitability category within the Synclinal Valley

Habitat Suitability category	Total BWT metres (m)	% of modelled Habitat	Mean thickness (m)	Standard Deviation (m)	Maximum thickness (m)
High	38,141	47	32.4	28.8	100.9
Medium	32,763	41	19.2	17.6	100.9
Low	6,599	8	16.9	17.8	104.9
Inferred	3,320	4	18.7	19.7	90.8
Total	80,823	100	23.3	23.1	104.9

Using the stratigraphic model as described in Section 3, lithologies were grouped into 'Potential Habitat' or 'Low Habitat' categories (Table 3-3) for units above the weathered Wittenoom boundary. Below this boundary all potential habitat lithologies were grouped as inferred, while 'Low' habitat was excluded. Volumetric calculations were provided under those grouped classifications (Table 6-6).

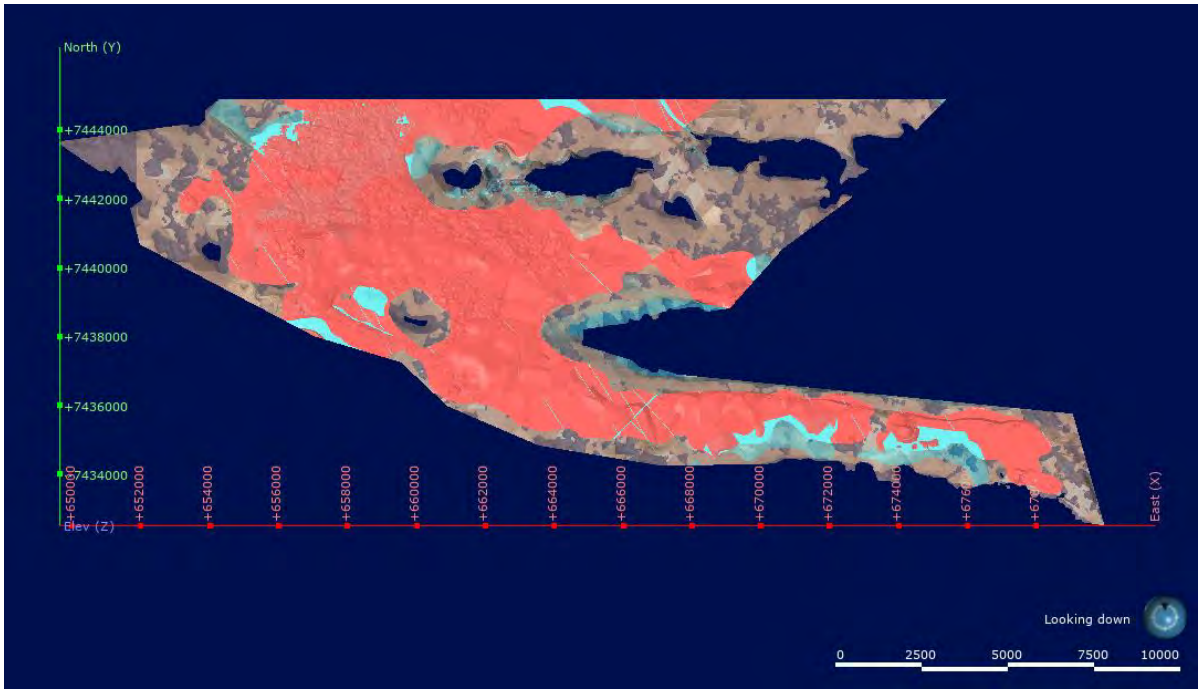


Figure 6-4: Pre-impact BWT Habitat modelling showing potential (pink) versus low (blue) habitats, with inferred potential habitats (beige) surrounding and at depth to 150m (basement).

6.2.1 Habitat suitability and extent

The valley provides thin to moderately thick (over 50m in places) stygofauna habitats within saturated unconsolidated alluvial and colluvial layers or deeper within karstic calcrete deposits and fractured bedrock and weathered Wittenoom Dolomite Formation. Potential BWT habitats are continuous along the valley centre especially in locations of modelled calcrete/dolocrete.

6.2.2 Quantification

The Synclinal Valley model shows the impact of the proposed mining and groundwater drawdown results under three scenarios.

- Under the proposed scenario, only impacts from the groundwater drawdown (less than 0.5m) generated from the Western Hill orebodies has been projected through with minimal impact 2.4% of suitable habitat.
- Under the combined proposed and currently approved scenario, a volumetric reduction of approximately 17.1% of potential habitat, or approximately 2,635,988,000 m^3 of the pre-existing suitable habitat occurs (Table 6-6). Approximately 82.9% of the potential habitat modelled throughout the valley is expected to remain in-situ (Table 6-1).
- By comparison, under the MAR scenario only a marginal volumetric reduction of approximately 1.9% occurs with a slight increase in Zone A: potential suitable habitat (1.1%). This slight increase is attributed to the mounding that occurs at the reinjection points of the managed aquifer recharge bores and is interpreted not materially change the overall habitat in terms of volume.

Table 6-6: Volumetric impacts to habitat in the Synclinal valley regional aquifer (stratigraphic model).

	Synclinal Valley Regional aquifer						
	Volume ('000 m^3)				% of Pre-impact BWT habitat		
	Pre-impact	Proposed	Combined LOM	Combined MAR	Proposed	Combined LOM	Combined MAR
In-situ Habitat remaining	15,025,691	14,629,900	13,003,890	15,483,872	97.4	86.5	103.0
Zone A: Potential Suitable habitat	2,465,385	2,447,459	1,966,096	2,492,810	99.3	79.7	101.1
Low	1,029,108	972,862	789,390	980,553	94.5	76.7	95.3
Zone B: Inferred (strat to 150m)	11,531,198	11,209,580	9,634,217	11,238,572	97.2	83.5	97.5
Suitable Habitat (Zone A +Zone B)	13,996,582	13,657,038	11,600,313	13,731,382	97.6	82.9	98.1
HABITAT LOSS	0	395,791	2,021,801	-458,181	2.6	13.5	-3.0
Zone A: Potential Suitable habitat (Porous Aquifer)	0	17,926	499,288	-27,425	0.7	20.3	-1.1
Low	0	56,247	239,719	48,555	5.5	23.3	4.7

Zone B: Inferred (Strat to 150m)	0	321,618	1,896,981	292,626	2.8	16.5	2.5
Loss: Suitable Habitat (Zone A +Zone B)	0	339,544	2,396,269	265,201	2.4	17.1	1.9

**under the combine MAR scenario an increase in potential habitat is show by the negative (in red) loss of 1.1%*

6.2.3 Impact Assessment

Visual comparisons of the pre-impact and post-impact scenarios showed only minor changes to habitat extent, thickness, and connectivity under the proposed scenario:

- The minor reduction in habitat does not appear to materially change the extent (i.e. breadth or length) of the suitable habitat throughout the aquifer (compare A to D of Figure 6-5).
- The reduction in habitat thickness is not expected to create any discontinuities or barriers to stygofauna movement throughout the habitable areas of the synclinal valley (based on current stygofauna records, and the 3D shape of the suitable habitat remaining in-situ) (compare A and B of Figure 6-5).

Under the combined LOM scenario most of the volumetric habitat loss centres around the current approved pits near the Wonmunna Anticline, where there is sufficient potential suitable habitat surrounds and is below the pit designs.

The 3D modelling also revealed a moderate extent of suitable habitat remaining east of the MAR despite proposed and combined impacts.

- Suitable habitats for stygofauna are expected to remain intact at the locations of all recorded stygofauna species and throughout the aquifer (Figure 6-5 D).

Overall, the direct impacts to BWT habitat at the synclinal valley appear negligible, with an estimated reduction of approximately 2.4% of the modelled suitable habitat and retention of approximately 97.6% of the modelled suitable habitat BWT.

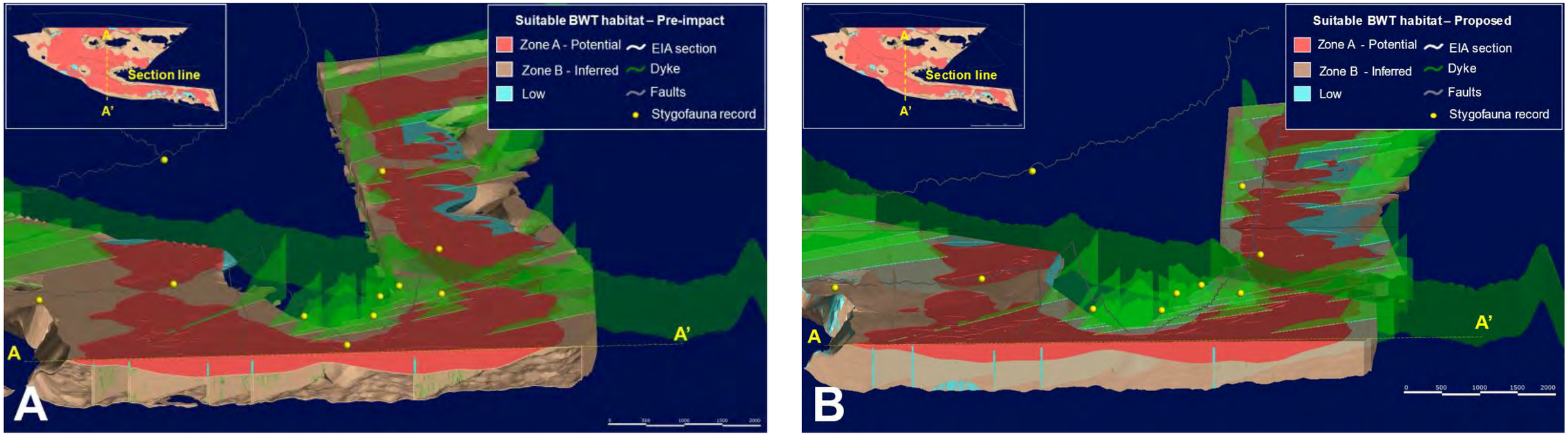


Figure 6-5: Synclinal Valley Potential habitat with A) pre-impact, B) post-impact proposed C) post-impact Combined LOM D) post-impact Combined MAR

6.3 Deposit H

As described in Section 5, Deposit H sits within weathered Marra Mamba Iron Formation (MMIF) and Wittenoom Formation (mostly West Angelas Shale Member) (Rio Tinto 2020c). This fractured/ weathered rock aquifer is formed by steep but intensely folded and fractured MMIF and constrained by the impermeable FOR Group units forming a basin structure (Figure 6-6). Other constraining boundaries were discussed in Section 3 Hydrogeological boundaries and include, the upper threshold for suitable BWT habitat as the water table (pre-mining or proposed) and the lower threshold being the 150 m basement making up the Inferred habitat (beige in Figure 6-6).

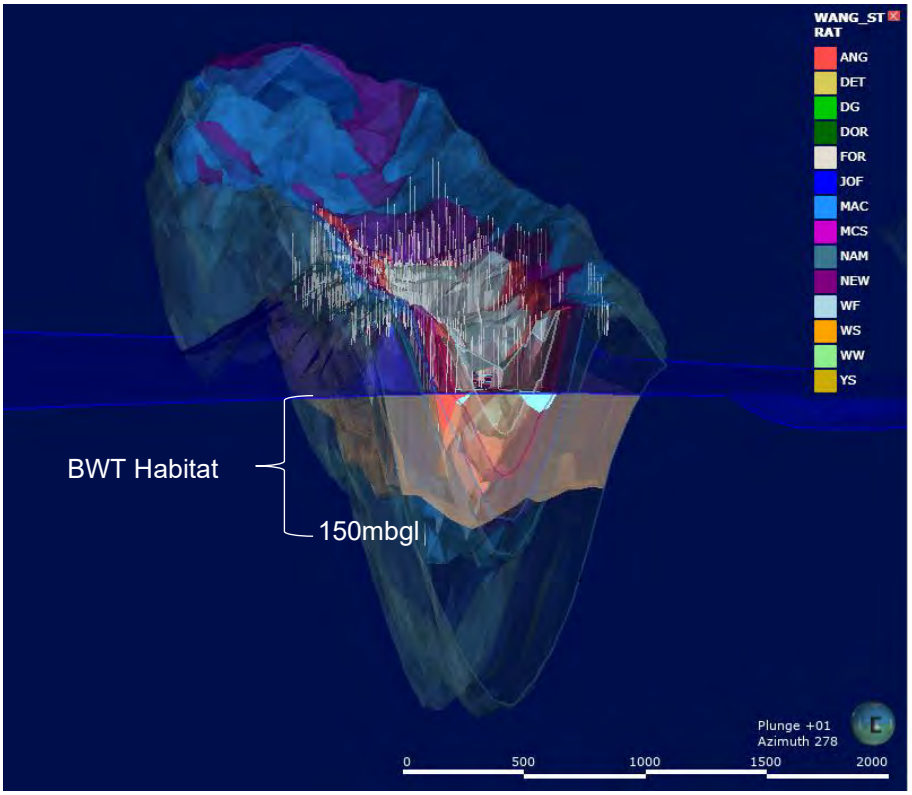


Figure 6-6: Stratigraphic model of Deposit H showing BWT habitat modelling, regional pre-mining water table (blue) and inferred habitat (beige) to a 150m basement. (*vertical exaggeration x5*)

The 3D modelling of BWT habitats in the Deposit H deposit was supported by 13.9 km of logging data from 580 drillholes (Table 6-1 and Table 6-7) and a recently revised stratigraphic/deposit model. There is a moderate level of confidence in the lateral extent of modelled high and medium suitability 'veins' given this forms over 75% (Table 6-7) of categorised habitat, however the depth extent and continuity is less well represented as drilling is limited at depth.

An indicative system basement of 150 m has been applied for conservative volumetric calculations, however drill hole and bore data shows high to medium porosity as deep as 200 mbgl. Therefore, it is probable that suitable habitat extends at depth beyond the modelling boundary. The inferred zone captures and quantifies this potential habitat in suitable stratigraphy within Deposit H.

Table 6-7: Overview of drill hole data per habitat suitability category at Deposit H

Habitat Suitability category	Total BWT metres (m)	% of Modelled Habitat	Mean thickness (m)	Standard Deviation (m)	Maximum thickness (m)
High	1,429	10	10.4	12.2	59.4
Medium	9,097	66	19.6	19.0	95.8
Low	2,798	20	13.6	12.9	73.9
Inferred	539	4	13.5	11.0	52.3
Total	**13,863**	**100**	**16**	**17**	**95.8**

6.3.1 Habitat suitability and extent

At Deposit H, suitable stygofauna habitats occur within a deep, porous, mineralised bedrock aquifer which is primarily formed within the Marra Mamba Iron Formation (Nammuldi, Macleod and Mt Newman Members) and runs from west to east. The MMIF has been deeply fractured and folded, creating highly suitable habitat for stygofauna. At the centre of the MMIF lies a long, narrow centre of porous Wittenoom Formation (mostly West Angelas Shale Member) which is overlain by detritals. Together these geological units provide relatively extensive and deep stygofauna habitats at Deposit H.

The mineralised bedrock aquifer is surrounded by low permeability Fortescue Group geologies on all sides which constrain the aquifer and make it a closed system which is supported only by local infiltration and is not connected to other nearby aquifer systems. Consequently, stygofauna habitat connectivity is restricted to the mineralised bedrock aquifer and does not extend beyond the MMIF.

Importantly, in Figure 6 1, the continuity of suitable MMIF stratigraphic units within the inferred habitat suggests with reasonable certainty that highly suitable habitat would continue in this area even though there is very little drilling. The likelihood of habitat existing within the inferred is greatly supported by the deep mineralisation profiles seen in the central parts of the deposit where the deepest drilling occurs, as well as a confirmed stratigraphic model which demonstrates lithological continuity under drilled areas. Therefore, the inferred modelling has been included into the suitable habitat calculations for BWT throughout the Deposit H section.

6.3.2 Quantification

Direct impact to stygofauna habitat values

At Deposit H, the proposed mining and groundwater drawdown results in a volumetric reduction of approximately 135,828,000 m^3 of suitable habitat (combined high, medium and inferred suitability), or approximately 22.7% of the pre-existing suitable habitat (Table 6-8). Approximately 77.3% of the suitable habitat modelled throughout Deposit H is expected to remain in-situ (Table 6-8).

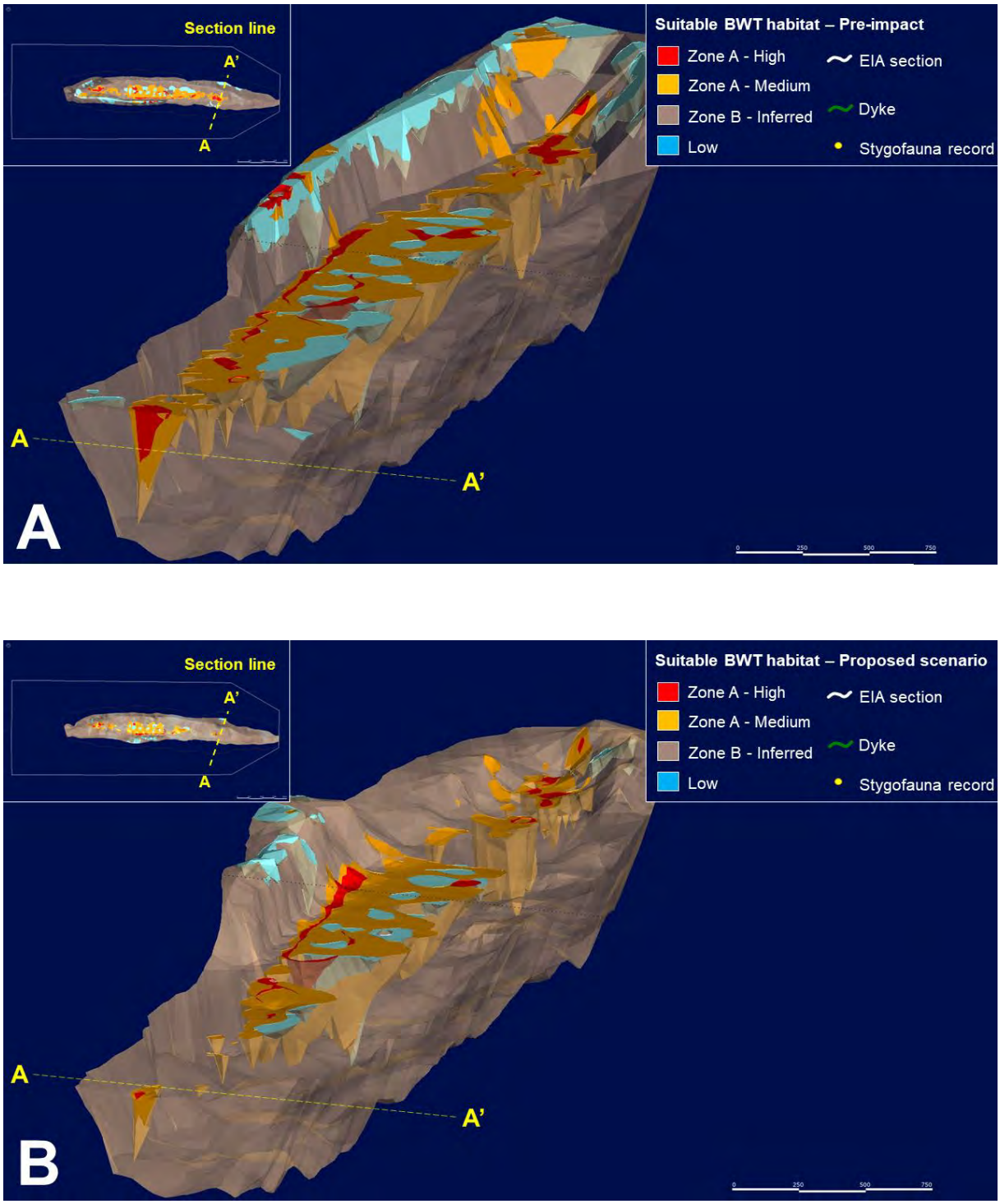


Figure 6-7: Cross-section of the 3D subterranean habitat model showing (A) pre-impact and (B) post-drawdown habitats at Deposit H. (*vertical scale exaggeration x5*)

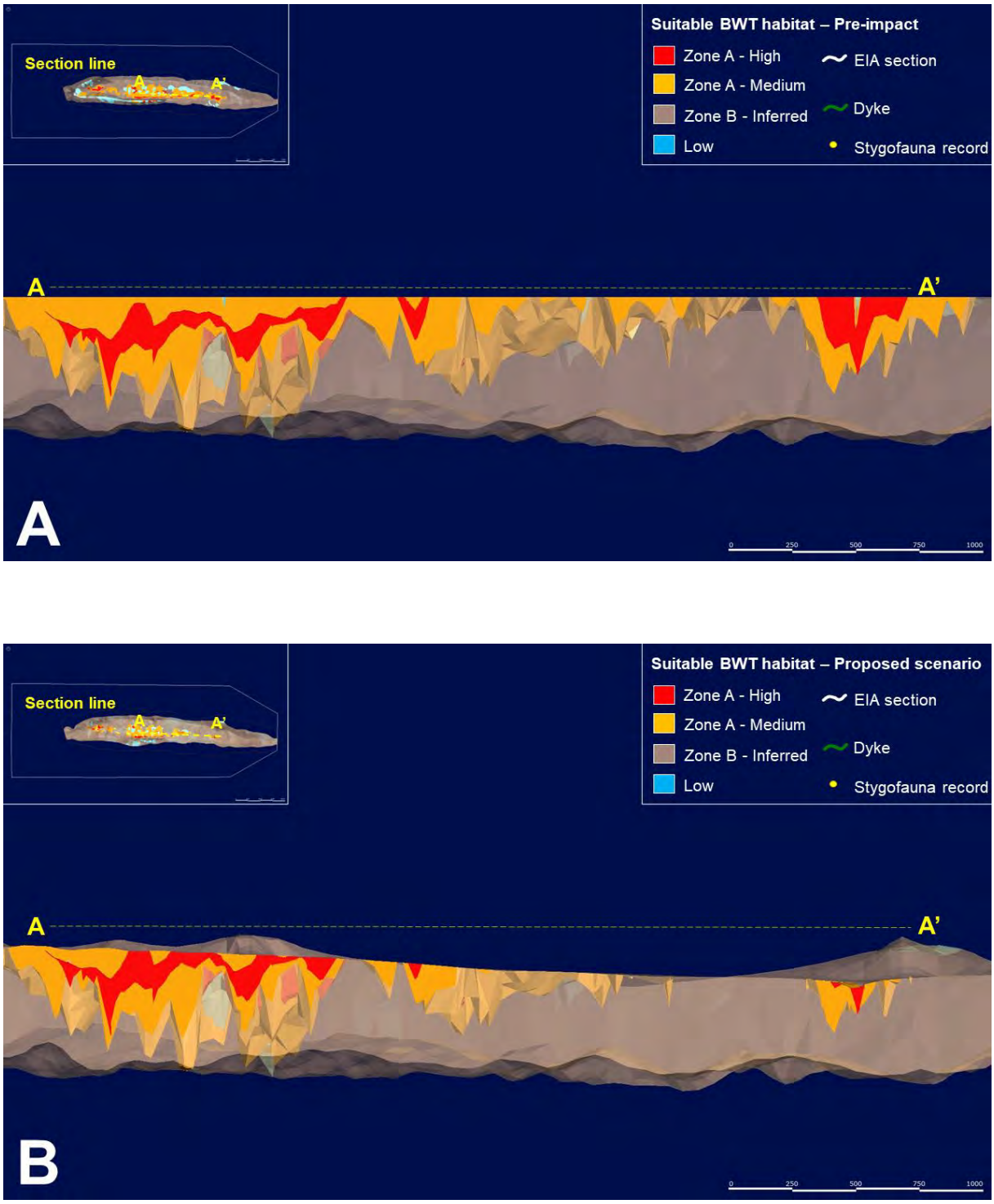


Figure 6-8: Long section of the 3D subterranean habitat model showing (A) pre-impact and (B) post-drawdown habitats at Deposit H. (*vertical scale exaggeration x5*)

Table 6-8: Volumetric impacts to stygofauna habitat at Deposit H under each impact scenario (totals in bold)

	Volume (m^3)			% of Pre-impact	
	Pre-impact	Proposed	Combined	Proposed	Combined
In-situ Habitat to 150m basement (remaining)	**611,264**	**466,123**	**466,123**	**76.3**	**76.3**
High	3,532	1,549	1,549	43.8	43.8
Medium	36,288	20,443	20,443	56.3	56.3
Low	12,334	3,021	3,021	24.5	24.5
Zone B: Inferred	559,110	441,110	441,110	78.9	78.9
Zone A: Habitat (H+M)	**39,820**	**21,992**	**21,992**	**55.2**	**55.2**
Suitable Habitat (Zone A + Zone B)	**598,930**	**463,102**	**463,102**	**77.3**	**77.3**
HABITAT LOSS	**0**	**145,141**	**145,141**	**23.7**	**23.7**
High	0	1,983	1,983	56.2	56.2
Medium	0	15,845	15,845	43.7	43.7
Low	0	9,313	9,313	75.5	75.5
Inferred	0	118,000	118,000	21.1	21.1
Loss Zone A: Habitat (H+M)		**17,828**	**17,828**	**44.8**	**44.8**
Loss: Suitable Habitat (Zone A + Zone B)	**0**	**135,828**	**135,828**	**22.7**	**22.7**

6.3.3 Impact Assessment

Visual comparisons of the pre-impact and post-impact scenarios showed moderate changes to habitat extent and connectivity, mostly in the east where there is little drilling at depth. Despite a moderate reduction in habitat thickness:

- The reduction in habitat thickness does not appear to materially change the overall extent (i.e. breadth or length) of the suitable habitat (compare A and B of Figure 6-7 and Figure 6-8).
- The reduction in habitat thickness is not expected to create any discontinuities or barriers to stygofauna movement throughout the areas of modelled habitat (based on current stygofauna records, and the 3D shape of the suitable habitat remaining in-situ) (Figure 6-7 A and B).

Overall, the direct impacts to potential BWT habitat at Deposit H appear to maintain habitat integrity, with an estimated reduction of approximately 23% of the modelled suitable habitat and retention of approximately 77% of the modelled suitable habitat BWT.

6.4 Deposit F North

In the Deposit F North section, the hills are primarily comprised of the MMIF, Mt Newman Member as well as the West Angelas Member of the Wittenoom Formation (Figure 5-11) which are both known to host suitable subfauna habitats due to their high porosity, especially when weathered.

Mining of the Deposit F North deposit eastern pit will extend approximately 20 m below the standing water table (approximately 716 mRL) and lowering of the water table will be achieved through the use of in-pit sumps (Rio Tinto 2018[P94]). Recovered groundwater will be used on site for dust suppression and other operational requirements.

The 3D modelling of BWT habitats was not undertaken in the Deposit F North deposit because there was limited drilling at depth within the proposed pit area. Although there was some 16.1 km of logging data from 742 drillholes across Dep F and Dep F North (Table 6-1 and Table 6-7) the majority of that drilling was over the Dep F area.

6.4.1 Habitat suitability and extent

The density of data BWT has not allowed for detailed interpretation of BWT habitats. The interpreted BWT stratigraphy at Deposit F North aquifer suggests a relatively small basinal system that is confined with an orebody aquifer that is not hydraulically connected to the regional aquifer.

6.4.2 Quantification

At the time of writing, no measurable groundwater drawdown values were provided, therefore no combined habitat volumes or impacts have been quantified.

6.4.3 Impact Assessment

At the time of writing, the maximum reduction of water level of approximately 20 m to dewater to the base of the proposed pit. As the orebody aquifer is bounded on all sides by low permeability unmineralised Macleod and Nammuldi Members, the drawdown will be restricted to the mineralised orebody aquifer. It will not propagate beyond the contact with the low permeability strata and therefore the impact to habitat has not been assessed.

6.5 Deposit J reference area

As described in Section 5.6, the Deposit J reference area sits within east-west trending pockets of mineralised Dales Gorge Member of the Brockman Iron Formation (BrIF).

The 3D modelling of BWT habitats in the Deposit J reference area is supported by 1,126 m of logging data from 49 drillholes (Table 6-9). The current habitat modelling results may be somewhat less certain due to the low number of bores and holes available for sampling and investigations.

Table 6-9: Overview of drill hole data per habitat suitability category at the Deposit J reference area

Habitat suitability category	Total drill metres (m)	BWT Thickness (m)
High	151	12.6
Medium	613	17.0
Low	158	11.3
Inferred	204	12.7
Total	1,126	14.4

6.5.1 Habitat suitability and extent

At Deposit J reference area, the 3D modelling indicates patchy high and medium suitability habitat with a relatively extensive and continuous inferred stygofauna habitat. The inferred zone is expected to occur within the weathered/fractured BrIF and deep detrital aquifer in the valley south of the main ridge (Figure 6-9). These stygofauna habitats occur at greater depths compared to the other Deposit areas, starting at approximately 100 m below the surface. BWT habitats are consequently comparatively thin at Deposit J, as the 3D model was capped at 150 mbgl. Nevertheless, despite the increased depth from surface of the BWT habitats, stygofauna have been recorded from this area.

To the north of the BrIF aquifer and at depth (forming the basement of the aquifer) lies the Mt McRae Shales unit which forms a functional groundwater barrier due to its low permeability. The Wittenoom Dolomite Formation to the north of the Mt McRae Shales is poorly conceptualised due to low number of drill holes in this area. Nevertheless, this unit is expected to provide further stygofauna habitats, outside of the 3D modelling boundary.

6.5.2 Quantification

At the time of writing, there is no development proposed for the Deposit J reference area, therefore no volumes were reported.

6.5.3 Impact Assessment

At the time of writing, no development has been proposed for the Deposit J reference area, therefore no impacts were assessed.

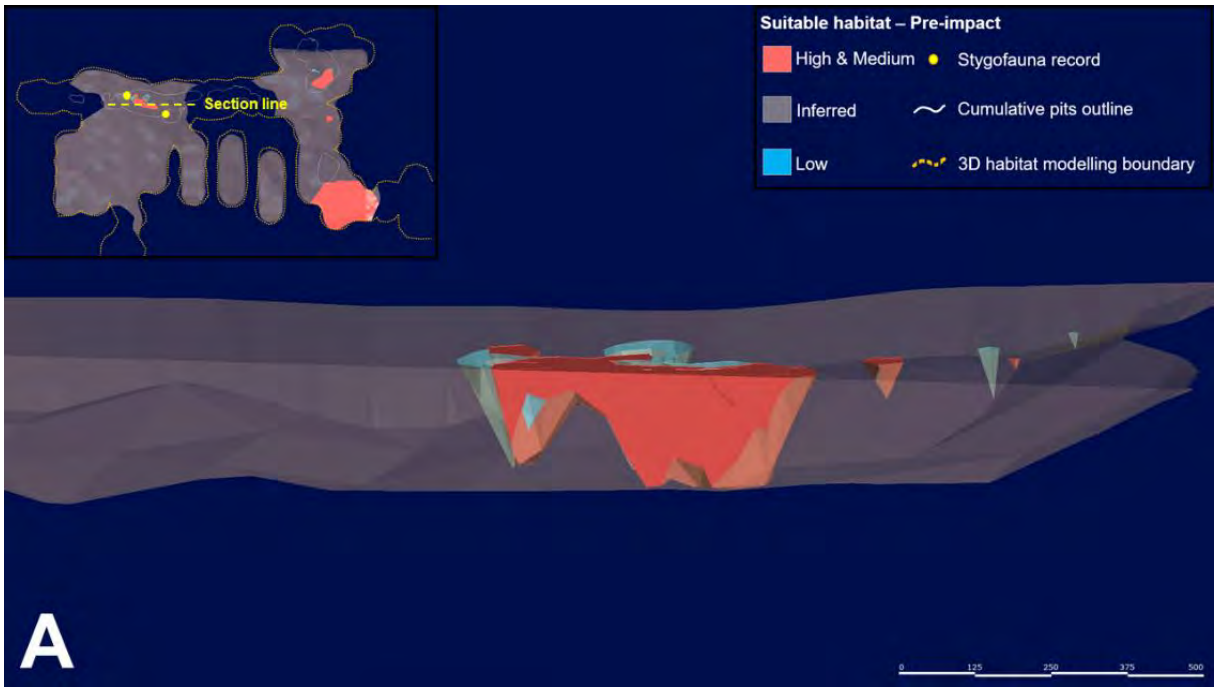


Figure 6-9: Cross-section of the 3D subterranean BWT habitat model showing habitat looking north (vertical scale exaggeration x5)

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7. SUMMARY

The 3D modelling has successfully modelled the suitability, extent, and thickness of subterranean fauna habitats throughout the Development Envelope and all four sections of the Development Envelope. 3D modelling showed that the West Angelas region contains extensive and highly suitable AWT and BWT habitats that can support diverse subterranean fauna assemblages.

7.1 Troglofauna habitats

The Development Envelope contains extensive, thick, and well-connected AWT habitats that are highly suitable for troglofauna. These habitats were able to be modelled confidently in 3D owing to the high density of drilling data utilised throughout all sections of the Development Envelope.

Troglofauna habitats within the Development Envelope are hosted within a variety of geological units. Weathered BrIF and MMIF provide well-connected troglofauna habitats in the ranges, and unconsolidated alluvial and colluvial layers, weathered Wittenoom Formation, and karstic calcrete deposits provide AWT habitats in the valleys.

The implementation of the Proposal will result in a limited direct reduction of AWT habitat, with a predicted loss of approximately 216,239,000 m3, or 2.4% of the pre-existing suitable habitat within the Development Envelope under the proposed scenario. The remaining modelled habitat (97.6% of the pre-impact habitat) is extensive, of medium to high suitability, and well-connected throughout the landscape.

Under the combined scenario, there will be a loss of approximately 1,076,640,000 m3, or 11.7% of the pre-existing suitable habitat within the Development Envelope. Nevertheless, the remaining modelled habitat (89.3% of the pre-impact habitat) is still extensive, of medium to high suitability, and well-connected throughout the landscape. Areas of similarly suitable, well-connected, contiguous geological habitats are also known to occur beyond the modelling boundaries.

7.2 Stygofauna habitats

Suitable BWT habitats for stygofauna were modelled in two of the four EIA areas, comprising Western Hill and Deposit H as well as within the regional synclinal valley aquifer. No significant aquifer was modelled at Mt Ella East and at Deposit F North, and the limited BWT habitat that was modelled is highly constrained and is not expected to hold significant stygofauna habitat.

Suitable BWT habitats for stygofauna are hosted by fractured/weathered and karstic BrIF and MMIF bedrock aquifers, and within karstic Wittenoom Dolomite (overlain by detritals) which forms a large regional aquifer surrounding the central anticline at West Angelas.

Stygofauna habitats relied more heavily on data collected more sparsely at depth and the interpretation of stratigraphic trends. Nevertheless, despite these challenges, the final model of BWT stygofauna habitats is based on a considerable amount of drill-hole information (6,819 drill holes) and these habitats were able to be modelled confidently in 3D.

The implementation of the Proposal will result in a limited direct reduction of BWT habitat, with a predicted loss of approximately 2% of the pre-existing suitable habitat at Western hill and 23% at Deposit H under the proposed scenario. The remaining modelled habitat is extensive and relatively well-connected throughout the landscape.

Under the combined scenario, there will be a loss of approximately 143,624,000 m^3, or 14.2% of the pre-existing suitable habitat as modelled within the 300 m boundary 3D model, and a loss of approximately 2,539,893,000 m^3, or 17% of habitat modelled in the stratigraphic model (regional aquifer).

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9. APPENDIX

9.1 Volumetric habitat assessment details – AWT by Section

	Deposit H							Deposit F North						
	Volume ('000 m³)				% of Pre-impact habitat			Volume (m³)				% of Pre-impact habitat		
	Pre-impact	Current	Proposed	Combined	Current	Proposed	Combined	Pre-impact	Current	Proposed	Combined	Current	Proposed	Combined
In-situ Habitat (remaining)	671,173	671,173	640,262	640,262	100.0	95.4	95.4	1,891,706	1,743,616	1,860,812	1,712,719	92.2	98.4	90.5
High	68,343	68,343	49,322	49,322	100.0	72.2	72.2	126,190	79,387	120,930	74,127	62.9	95.8	58.7
Medium	120,830	120,830	115,050	115,050	100.0	95.2	95.2	601,140	511,425	586,640	496,920	85.1	97.6	82.7
Low	137,410	137,410	133,980	133,980	100.0	97.5	97.5	327,110	321,109	321,250	315,250	98.2	98.2	96.4
Inferred	344,590	344,590	341,910	341,910	100.0	99.2	99.2	837,266	831,695	831,992	826,422	99.3	99.4	98.7
Suitable habitat (H+M)	189,173	189,173	164,372	164,372	100.0	86.9	86.9	727,330	590,812	707,570	571,047	81.2	97.3	78.5
HABITAT LOSS	0	0	30,911	30,911	0.0	4.6	4.6	0	148,090	30,894	178,987	7.8	1.6	9.5
High	0	0	19,021	19,021	0.0	27.8	27.8	0	46,803	5,260	52,063	37.1	4.2	41.3
Medium	0	0	5,780	5,780	0.0	4.8	4.8	0	89,715	14,500	104,220	14.9	2.4	17.3
Low	0	0	3,430	3,430	0.0	2.5	2.5	0	6,001	5,860	11,860	1.8	1.8	3.6
Inferred	0	0	2,680	2,680	0.0	0.8	0.8	0	5,571	5,274	10,844	0.7	0.6	1.3
Suitable habitat (H+M)	0	0	24,801	24,801	0.0	13.1	13.1	0	136,518	19,760	156,283	18.8	2.7	21.5
	Western Hill							**Mt Ella East**						
	Volume ('000 m³)				Volume as % of Pre-impact			Volume (' 000 m³)				Volume as % of Pre-impact		
	Pre-impact	Current	Proposed	Combined	Current	Proposed	Combined	Pre-impact	Current	Proposed	Combined	Current	Proposed	Combined
In-situ Habitat (remaining)	1,781,144	1,781,144	1,628,443	1,628,443	100.0	91.4	91.4	2,696,236	2,680,585	2,667,868	2,652,241	99.4	98.9	98.4
High	216,650	216,650	127,660	127,660	100.0	58.9	58.9	160,220	157,694	155,010	152,480	98.4	96.7	95.2
Medium	628,930	628,930	573,610	573,610	100.0	91.2	91.2	1,003,500	994,760	981,320	972,580	99.1	97.8	96.9
Low	89,089	89,089	86,158	86,158	100.0	96.7	96.7	91,871	91,113	91,793	91,036	99.2	99.9	99.1
Inferred	846,475	846,475	841,015	841,015	100.0	99.4	99.4	1,440,645	1,437,018	1,439,745	1,436,145	99.7	99.9	99.7
Suitable habitat (H+M)	**845,580**	**845,580**	**701,270**	**701,270**	**100.0**	**82.9**	**82.9**	**1,163,720**	**1,152,454**	**1,136,330**	**1,125,060**	**99.0**	**97.6**	**96.7**
HABITAT LOSS	0	0	152,701	152,701	0.0	8.6	8.6	0	15,650	28,368	28,345	0.6	1.1	1.1
High	0	0	88,990	88,990	0.0	41.1	41.1	0	2,526	5,210	7,740	1.6	3.3	4.8
Medium	0	0	55,320	55,320	0.0	8.8	8.8	0	8,740	22,180	30,920	0.9	2.2	3.1
Low	0	0	2,931	2,931	0.0	3.3	3.3	0	758	78	835	0.8	0.1	0.9
Inferred	0	0	5,460	5,460	0.0	0.6	0.6	0	3,627	900	4,500	0.3	0.1	0.3
Suitable habitat (H+M)	**0**	**0**	**144,310**	**144,310**	**0.0**	**17.1**	**17.1**	**0**	**11,266**	**27,390**	**38,660**	**1.0**	**2.4**	**3.3**

9.2 Volumetric habitat assessment details – BWT summary by section

	Volume (m^3) ('000)					% of pre-impact total			
	Pre-impact	**Current**	**Proposed**	**Combined LOM**	**Combined MAR**	**Current**	**Proposed**	**Combined LOM**	**Combined MAR**
Western Hill									
In-situ Suitable Habitat Remaining	409,281	407,192	403,574	401,485	-	99.5	98.6	98.1	0.0
Loss of Suitable Habitat	0	2,089	5,707	7,796	-	0.5	1.4	1.9	0.0
Deposit H									
In-situ Suitable Habitat Remaining	598,930	598,930	463,102	463,102	-	100.0	77.3	77.3	0.0
Loss of Suitable Habitat	0	0	135,828	135,828	-	0.0	22.7	22.7	0.0
Synclinal Valley									
In-situ Suitable Habitat Remaining	13,996,582	0	13,657,038	11,600,313	13,731,382	0	97.6	82.9	98.1
Loss of Suitable Habitat	0	0	339,544	2,396,269	265,201	0	2.4	17.1	1.9
Total Remaining	15,004,793	1,006,122	14,523,714	12,464,900	13,731,382	99.5	96.8	83.1	91.5
Total Loss	0	2,089	481,079	2,539,893	265,201	0.5	3.2	16.9	1.8

F.2: West Angelas Subterranean Fauna Survey







West Angelas:

Subterranean Fauna Survey

Biologic Environmental Survey

Report to Rio Tinto Iron Ore

December 2022



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GLOSSARY

AWT	Above Water Table
BC Act	Western Australian *Biodiversity Conservation Act 2016*
BIF	Banded Iron Formation
BrIF	Brockman Iron Formation, includes BIF, chert, mudstone, siltstone and crocidolite
BoM	Bureau of Meteorology
BWT	Below Water Table
CALC	Calcrete bores
cf.	In taxonomy, cf. refers to a species that closely matches the species following the designation, but differs morphologically in some minor ways
CID	Channel-iron deposits (e.g. Robe Pisolite)
COI	Cytochrome Oxidase subunit 1, a mitochondrial gene used as a DNA barcode to identify species
CWB	Central Water Bores
DBCA	Department Biodiversity, Conservation and Attractions
EIA	Environmental Impact Assessment
EPA	Western Australian Environmental Protection Authority
EP Act	*Environmental Protection Act 1986*
EPBC Act	*Environment Protection and Biodiversity Conservation Act 1999*
indet.	Indeterminate; lower-level taxonomy of specimens with this designation could not be determined
LTA	Long-term average
m AHD	Metres Australian Height Datum – the AHD is the vertical height of 0.000 m above mean sea level
mbgl	Metres below ground level
MMIF	Marra Mamba Iron Formation, includes BIF, chert, mudstone, siltstone and shale
nr	In taxonomy, nr refers to a potentially undescribed species nearest to the species following the designation
OoM Study	Order of Magnitude Study, a front-end study typically used to guide corporate decision making
OTU	Operational taxonomic unit – species-equivalent taxonomic unit based on COI or 12S cluster similarity
PEC	Priority Ecological Communities
Singleton/ single site	Species/OTU known only from a single specimen or single site
SRE	Short-range Endemism
TCBF	Turee Creek Borefield
TDS	Total Dissolved Solids
TEC	Threatened Ecological Communities
WAM	Western Australian Museum
WC Act	*Wildlife Conservation Act 1950*

EXECUTIVE SUMMARY

Rio Tinto Iron Ore Pty Ltd (Rio Tinto) operates the West Angelas Iron Ore mine, located approximately 100 km north-west of the town of Newman in the Pilbara region of Western Australia (WA). Rio Tinto, on behalf of the joint venture participants, is evaluating the potential development of several iron ore deposits within the West Angelas locality. An Order of Magnitude Study (OoM Study) has commenced to evaluate the potential development of additional deposits near the existing West Angelas operations and associated infrastructure.

Biologic Environmental Survey Pty Ltd (Biologic) was commissioned by Rio Tinto to undertake a two-season Level 2 subterranean fauna (stygofauna and troglofauna) survey at the West Angelas OoM Study Area (the Study Area), which covers approximately 13,162 hectares. The survey was designed and conducted in accordance with relevant EPA guidelines for subterranean fauna assessment, and aims to provide a comprehensive assessment of subterranean species and habitats occurring within the Study Area and surrounding reference areas.

Comprehensive searches of relevant fauna databases (WA Museum, Atlas of Living Australia and NatureMap) and a review of previous survey data revealed 72 troglofauna (includes potential troglofauna) taxa and 31 stygofauna (includes potential stygofauna) taxa occurring within the wider local area surrounding the Study Area. Of these, 10 troglofauna and 16 stygofauna taxa were recorded inside or near (<1.5 km) the Study Area.

The survey (including baseline and targeted surveys between September 2018 and October 2020) sampled a total of 324 bores and holes throughout the Study Area and nearby reference areas, resulting in 575 troglofauna samples and 94 stygofauna samples. The survey sampled troglofauna and stygofauna at four deposit areas (Western Hill, Deposit H, Deposit F North and Mt Ella East) and at four additional reference areas (Deposit J reference area, Calcrete bores/synclinal aquifer, Central Water Bores and Turee Creek borefield). A total of 672 subterranean fauna specimens was recorded, comprising 328 stygofauna specimens and 344 troglofauna specimens.

The specimens represented 70 troglofauna species (and species-level taxa) and 20 stygofauna species (and species-level taxa). A further 17 indeterminate troglofauna taxa and six indeterminate stygofauna taxa were omitted from further consideration, as specimens in these groups could not be resolved to species-level due to immaturity, poor specimen condition, inadequate diagnostic characters, or incomplete information.

Taxonomic and ecological information, regional genetic comparisons, and the recorded linear ranges of the troglofauna and stygofauna species/taxa were used to assess the potential for each species/taxon to be short range endemic (SRE), and to categorise the species/taxon in relation to its distribution within and beyond the Study Area and known habitat units.

The assessment identified 40 troglobitic species and 16 stygobitic species as key species values, i.e. taxa known from limited records within the Study Area, within a sampling area or habitat, and therefore potentially of interest for future EIA. The 40 key troglofauna taxa belonged to groups

often known to be SRE (e.g. spiders, pseudoscorpions, palpigrades) or sometimes found to be SRE (e.g. isopods, pauropods, symphylans, diplurans, beetles and silverfish). The 16 key stygofauna taxa represented taxonomic groups often known to include SRE (bathynellaceans) and sometimes found to be SRE (e.g. amphipods, ostracods, harpacticoid copepods).

Assessment of the suitability, extent and connectivity of subterranean habitats above water table (AWT) and below water table (BWT) was undertaken based on available geological and hydrogeological information. The habitat assessment showed a variety of suitable habitats occurring in different geological contexts (e.g., Brockman Iron Formation vs Marra Mamba Iron Formation), and/or associated with discrete aquifer units, at each of the four sampling areas and four additional reference areas.

The troglofauna assemblages contained a relatively high proportion (57%) of species recorded only from one sampling area, although this is not unusual for troglofauna owing to infrequent occurrence and dispersal limitations. Approximately 23% of the troglofauna species were shared between two or more deposit areas, and 36% were found to occur beyond the Study Area, based on regional genetic comparisons from extensive unpublished surveys in the wider surrounding area. This suggests reasonably widespread potential connectivity of suitable AWT habitats within and beyond the Study Area boundaries.

Conversely, the stygofauna assemblages of each sampling area were largely distinct, with few species shared across the Study Area or across different hydrogeological habitats (except for a few locally and regionally widespread species, mainly oligochaete worms). This trend appeared to support the conceptualisation of distinct groundwater habitats occurring in each sampling area.

Despite the overall survey effort having met and exceeded the minimum sampling guidelines at the time of survey, there were some constraints on the BWT sampling effort due to the numbers of available bores and drill holes that intercepted groundwater. These constraints may have limited the assessment of stygofauna richness and distributions, but there were also a range of potential natural limitations to the occurrence of rich stygofauna assemblages in all but the largest groundwater habitats. These natural potential constraints included the limited spatial extent of aquifer units at Western Hill orebody, Deposit F North and Deposit H, and the considerable depth from surface of the watertable at Mt Ella East, Deposit F North, Deposit J reference area, Turee Creek borefield and parts of Western Hill orebody aquifer.

Some of the habitat areas were known or inferred to extend well beyond the Study Area boundaries (e.g. AWT habitats at all sampling areas except for Deposit H, and BWT habitats at the Synclinal valley, the Central Water Bores area, Deposit J reference area and Turee Creek borefield). Consequently, there is some potential that some of the stygofauna and troglofauna species recorded from the Study Area may have larger ranges than currently recorded and may occur throughout the wider connected extent of AWT or BWT habitats within and potentially beyond the Study Area boundaries.

1. INTRODUCTION

1.1 Background

Rio Tinto Iron Ore Pty Ltd (Rio Tinto) operates the West Angelas Iron Ore mine on behalf of the participants in the Robe River Joint Venture. The West Angelas Iron Ore mine is located approximately 110 km north-west of the town of Newman in the Pilbara region of Western Australia (Figure 1.1).

Rio Tinto, on behalf of the joint venture participants, is evaluating the potential development of several iron ore deposits within the West Angelas locality. An Order of Magnitude Study (OoM Study) was undertaken to evaluate the potential development of additional mining areas and associated infrastructure near the existing West Angelas operations. The four prospective 'deposit' areas targeted for investigations are:

- Western Hill
- Deposit H
- Deposit F North
- Mt Ella East.

Rio Tinto commissioned Biologic Environmental Survey Pty Ltd (Biologic) to undertake a Level 2 subterranean fauna (stygofauna and troglofauna) survey in 2018 and 2019 at the West Angelas OoM Study Area ('the Study Area', approximately 13,162 ha, Figure 1.2), following EPA Guidance (EPA, 2016b, 2016c) at the time of survey. The survey targeted troglofauna and stygofauna values at the four deposit areas noted above, as well as four reference areas, consisting of:

- Central Water Bores (CWB) – old monitoring bores within the central plateau of the Wonmunna Anticline
- Turee Creek Borefield (TCBF) – monitoring bores at the operational Turee Creek Borefield to the west of the West Angelas Hub
- Calcrete bores (CALC)/ Synclinal valley – monitoring bores in a calcrete deposit within the synclinal valley south of Western Hill and west of operational Deposits C and D
- Deposit J reference area.

Collectively, the eight deposit and reference areas are hereafter referred to as 'sampling areas'.

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. This report consolidates previous subterranean fauna survey results from the Study Areas listed above.
- results of a Level 2 (September 2018 – May 2019) and a targeted (March 2020 – October 2020) stygofauna and troglofauna survey throughout the Study Area and immediate surrounds.

- 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 above and below watertable.
- a summary of key findings relevant for future EIA in relation to subterranean fauna values within the Study Area.

1.2 Subterranean fauna regulatory framework

Subterranean fauna are animals that live underground in habitats such as caves, cavities and aquifers. The defining feature of all these habitats is the absence of light (Culver & Pipan, 2019). The Pilbara and Yilgarn regions are recognised as globally significant 'hot-spots' of subterranean fauna biodiversity and endemism (Eberhard & Howarth, 2021; EPA, 2016a). Estimates of species richness for the subterranean fauna of WA range from nearly 3,000 in the Pilbara alone (Halse, 2018) to over 4,000 in Western Australia (Guzik *et al.*, 2010). Apart from three fish species (*Ophisternon candidum*, *Milyeringa veritas* and *M. justitia*) and a blind snake (*Ophisternon candidum*), all other currently known species of subterranean fauna in Western Australia are invertebrates such as arachnids, crustacea, insects and myriapods (Alpin, 1998; EPA, 2016a; Larson *et al.*, 2013; Moore, 2019).

All fauna (including subterranean fauna) are protected under State and Federal legislation:

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

In Western Australia, the Environmental Protection Authority (EPA) guides how subterranean fauna is considered in Environmental Impact Assessment. It requires that fauna obligate to the underground, i.e. adapted to and only occurring underground, are considered, with the objective "to protect subterranean fauna so that biological diversity and ecological integrity are maintained". EPA guidelines for subterranean fauna consist of:

- *Environmental factor guideline: subterranean fauna* (EPA, 2016)
- *Technical Guidance – Subterranean fauna surveys for environmental impact assessment* (EPA, 2021).

Subterranean fauna are ecologically categorised based on where they live. Air-breathing species that reside above the water table are troglofauna and aquatic species that inhabit groundwater systems are stygofauna. Both types of fauna can be classified into three categories according to the extent of their morphological adaptation (troglomorphy) and their dependence on underground environments:

- Troglobites and stygobites – complete dependence/adaptation, no part of life cycle spent above ground

- Troglophiles and stygophiles – partial adaptation, part of life cycle relies on underground and part spent above ground
- Trogloxenes and stygoxenes – opportunistic visitors to the underground environments, no dependence/adaptation
- amphibious – animals able to live above and below the water table; morphological features consistent with surface representatives making it difficult to determine level of adaptation to underground; predominantly comprises enchytraeid annelids.

Obligate subterranean fauna can have very restricted geographic ranges because of the limited extent and connectivity of suitable habitat within the underground landscape. These 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, 2016c). SRE species, as described by Harvey (2002), are species whose natural ranges are limited to <10,000 km^2 (or less than 100 km × 100 km). Eberhard *et al.* (2009) regarded even this criterion as potentially too vast for range-restricted subterranean fauna, instead offering an alternative threshold of <1,000 km^2 for subterranean SRE species.

664000
676000
688000
700000
7440000
7428000

Western Hill
Karijini National Park
Deposit H
Great Northern Hwy
Deposit F North
Mt Ella East
Deposit J reference area
Port Hedland
Karratha
Newman

Legend

DE_Areas
West Angelas Beyond 2020 Development Envelope
Current Operations (MS1113)
Karijini National Park

State Road
Main Access Track
Rail
Major Surface Hydrology

IBRA Region
Pilbara

IBRA Subregion
Chichester
Fortescue
Hamersley
Roebourne

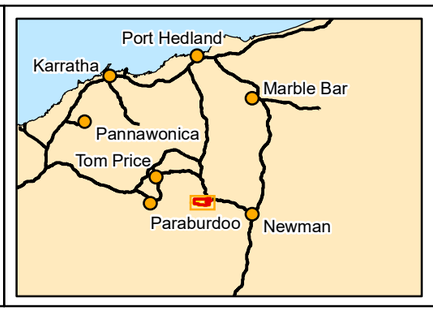
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Projection: Transverse Mercator
Datum: GDA 1994 Created 16/08/2022



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West Angelas: Subterranean Fauna Survey

Figure 1.1: Regional location of West Angelas Study Area and Development Envelope

650000 660000 670000 680000 690000 700000

7450000 7440000 7430000

Great Northern Hwy

Western Hill

Deposit H

Central Waterbores

Calcrete Bores

Deposit F North

Mt Ella East

Deposit J

Turee Creek

Legend

- West Angelas Beyond 2020 Development Envelope
- Current Operations Development Envelope
- Subterranean Fauna Reference Area
- State Road
- Main Access Track
- Rail

Priority Ecological Community

- Brockman Iron cracking clay communities of the Hamersley Range - Priority 1
- Coolibah - Lignum Flats: sub type 1: Coolibah and mulga woodland over lignum and tussock grasses on clay plains (Coondewanna and Wanamunna flats and Mt Bruce Flats) - Priority 3
- West Angelas Cracking-Clays - Priority 1

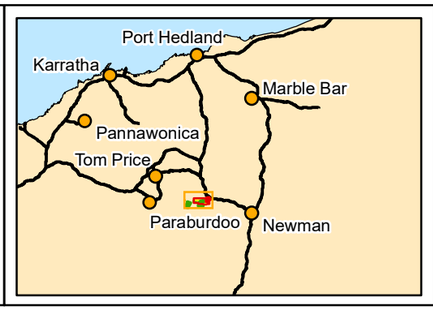
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Datum: GDA 1994 Created 19/12/2022



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West Angelas: Subterranean Fauna Survey

Figure 1.2: West Angelas Development Envelope, Study Areas and PECs

2. ENVIRONMENT

2.1 Climate

The Pilbara bioregion has a semi-desert to tropical climate, with rainfall occurring sporadically throughout the year, although mostly during summer (Thackway & Cresswell, 1995). Summer rainfall is usually the result of tropical storms in the north or tropical cyclones that impact upon the coast and move inland (Leighton, 2004). The winter rainfall is generally lighter and is the result of cold fronts moving north-easterly across the state (Leighton, 2004). The average annual rainfall ranges from 200–350 mm, although there are significant fluctuations between years (BoM, 2021), with up to 1,200 mm falling in some locations in some years (McKenzie *et al.*, 2009).

Dodson (2006) suggested that average annual rainfall at West Angelas is in the order of 415 mm, based on mine-site records. More detailed long-term climatic data is not available for the Study Area itself; however, long-term climatic data is available from the Bureau of Meteorology (BoM) weather station at Newman Aero (Station 7176), ~110 km east of the Study Area. The data from this station provides an indication of the long-term climatic conditions experienced at West Angelas (Figures 2.1 & 2.2; BoM, 2021). A recently (early 2018) installed BoM weather station at Coondewanna airport (approximately 25 km north-east of West Angelas) provided an accurate indication of conditions in the months leading up to and during the survey. These measurements were compared to long-term averages (LTAs) at Newman Aero (Figure 2.1).

Mean daily maximum temperatures during Phase 1 at the Study Area (Trip 1, September 2018: 30.2 °C; Trip 2 November 2018: 36.6 °C) were slightly cooler than LTA temperatures at Newman Aero. Mean maximum temperatures during Phase 2 (Trip 3, March 2019: 36.8 °C; Trip 4, May 2019: 28.9 °C) were slightly warmer than LTA temperatures (Figure 2.1). The mean temperature in February just prior to Trip 3 (41.2 °C) was substantially warmer than the LTA (37.3 °C). Rainfall at the Study Area in the 6 months prior to Phase 1 (119.6 mm) was comparable to LTA rainfall (117.5 mm) for the area. Rainfall at the Study Area in the 6 months prior to Phase 2 (31.8 mm) was substantially lower than LTA rainfall (198.7 mm) for the area (Figure 2.1). However, in the month prior to and during Trip 4, the Study Area received roughly twice the amount of LTA rainfall (86.0 vs 40.1 mm). Overall, climatic conditions prior to and during Phase 1 are not expected to have negatively affected the activity levels and abundance of subterranean fauna. The dry climatic conditions prior to Phase 2 could be expected to reduce the activity levels and abundance of subterranean fauna, but this was somewhat alleviated by the above-average rainfall prior to Trip 4, which may have allowed groundwater levels to recharge to some degree.

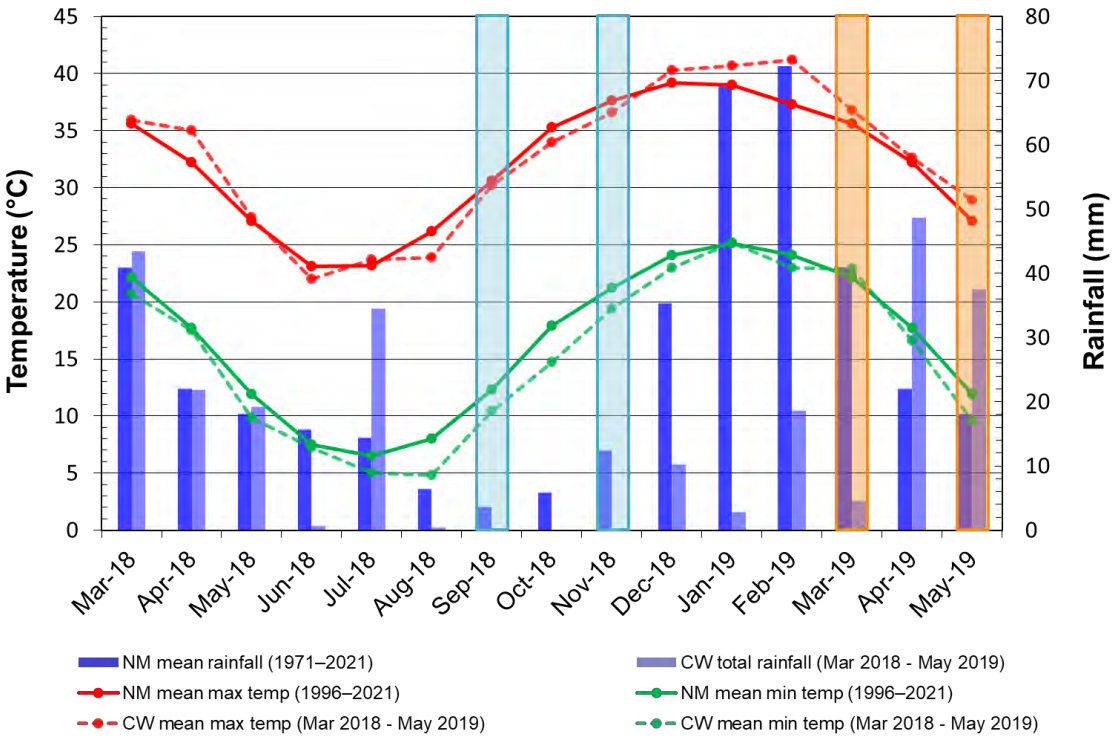


Figure 2.1: Long term average (LTA) climate data for Newman Aero (NM) compared against recent (2018) observations for Coondewanna (CW) (data from BoM 2018*)

*Note: Data includes total monthly rainfall (mm) and average monthly maximum and minimum temperatures (°C) at the Study Area. Approximate survey timing is indicated by blue (Phase 1) and orange (Phase 2).

During the targeted survey (March–October 2020), daily maximum temperatures during Phase 3 (Trip 1: 36.8 °C; Trip 2: 24.7 °C) and Phase 4 (Trip 1: 27.2 °C; Trip 2: 34.0 °C) at the Study Area were comparable to LTA temperatures. Monthly rainfall amounts throughout both phases were closely similar to LTAs. Overall, the climatic conditions prior and during the targeted survey are not expected to have influenced the activity and abundance of subterranean fauna.

2.2 Topography and landforms

The West Angelas Deposits occur within the Wonmunna Anticline. The anticline dominates the topography of the Study Area, and consists of a low, east–west striking, rounded range extending from the west corner of the Study Area to the eastern parts (splitting into a northern and a southern limb in the area of the Deposit J reference area) (Figure 2.2). The centre of the anticline has eroded to form a low and mostly flat central plateau.

Two taller ranges flank the northern and southern margins of the Study Area. The northern range comprises several rounded hills (up to approximately 1,000 metres Australia Height Datum; m AHD), which rise moderately steeply from the valley floor (below 700 m AHD). The northern range is incised by a series of steep south, south-west and south-east facing gullies on its southern flank, which is a target area for mining. The range to the south is a much steeper and taller range, rising to over 1,080 m AHD, and also striking approximately east to west. The valley floors that dominate the majority of the Study Area decrease gradually in slope to the western section of the Study Area and beyond (Figure 2.2).

650000 660000 670000 680000 690000 700000

7450000 7440000 7430000 7420000

Western Hill

Deposit H

Central Waterbores

Calcrete Bores

Deposit F North

Mt Ella East

Deposit J

Turee Creek

1164 m 1045 m 1080 m 1116 m 879 m

Legend

- West Angelas Beyond 2020 Development Envelope
- Current Operations Development Envelope
- Subterranean Fauna Reference Area

Contours (10m Interval)

Height (mAHD)

- 500 - 630
- 640 - 690
- 700 - 760
- 770 - 830
- 840 - 900
- 910 - 990
- 1000 - 1090
- 1100 - 1240

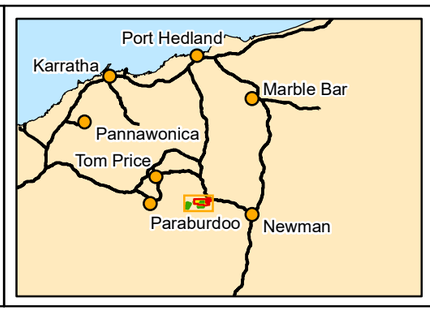
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Coordinate System: GDA 1994 MGA Zone 50
Projection: Transverse Mercator
Datum: GDA 1994 Created 16/08/2022



RIO TINTO IRON ORE

West Angelas: Subterranean Fauna Survey

Figure 2.2: Topography of the Study Area

2.3 Surface drainage and indicative catchments

The Study Area is located in the upper Turee Creek East Catchment, adjacent to the regional catchment divide between the Ashburton River and Fortescue River catchments (Dodson, 2006). The watershed between Turee Creek and Weeli Wolli Creek catchments occurs near Deposit F and H (Aquaterra, 2005). On average, 0.5% to 1% of rainfall is thought to recharge the groundwater system within the Study Area (Rio Tinto, 2018b).

Deposits Western Hill, Mt Ella East and F North are in the upper reaches of Turee Creek and are intersected by minor creeks that flow west into Turee Creek (Figure 2.3). Deposit H is in the Weeli Wolli catchment, with minor creeks flowing east into Weeli Wolli Creek. The Deposit J reference area is in the Angelo River catchment where minor creeks flow south. The major ranges within and adjacent to the Study Area dominate the local runoff patterns, shedding water from their flanks via steep gullies onto the valley floor (Figure 2.3).

Turee Creek East extends from the relatively low-lying hills and central plateau formed in the Jeerinah Formation (in the centre of the Anticline), flowing north-east to exit the plateau in the vicinity of Deposit H. The main creek line meanders past the northern margin of Deposits H and Western Hill in a westerly direction, before joining other tributaries coming from the southern flanking valley adjacent to Deposit J reference area and Mt Ella East, and further to the south. To the west of the Study Area, Turee Creek East turns south-westerly and descends through a gorge within Karijini National Park, emptying onto a wide floodplain several kilometres across (where the Turee Creek Borefield is located), before merging with the main arm of Turee Creek (Figure 2.3).

2.4 Geology

The geology of the West Angelas area is dominated by the Wonmunna Anticline, which has an east-west axis and plunges towards the west. The proposed mining deposits are distributed on the northern and southern limbs of the anticline in units of the Hamersley Group. Western Hill is located on the north side near the western tip. Deposit H is further to the east on the north side of the Anticline. The Deposit J reference area is located on the south side near the western tip and Mt Ella East is further east on the south side of the Anticline (Figure 2.4). Deposit F North is situated within the central eroded part of the Anticline (central plateau) and is located between Deposit H and Mt Ella East (Figure 2.4).

The centre of the Anticline is a low-lying plateau of the Jeerinah Formation (mudstone and siltstone with sills of metabasalt), which is bound to the north and south by younger units of the Hamersley Group (Dodson, 2006). A northern and southern flanking valley lie either side of the anticline. Both run roughly east to west and are composed of Tertiary detrital infill. On the southern and northern catchment margins, the valleys are bound by high ridges of Brockman Iron Formation (Figure 2.4).

640000 652000 664000 676000 688000 700000

7452000 7440000 7428000 7416000

Karijini National Park

Western Hill

Deposit H

Weeli Wolli Creek

Turee Creek East Branch

Calcrete Bores

Central Waterbores

Deposit F North

Turee Creek East Branch

Turee Creek East Branch

Turee Creek

Mt Ella East

Deposit J

Spearhole Creek

Angelo River

Indabiddy Creek

Legend

- West Angelas Beyond 2020 Development Envelope
- Current Operations Development Envelope
- Karijini National Park
- Subterranean Fauna Reference Area

Surface Hydrology

- Minor
- Major
- Direction

Subcatchment

- Angelo River
- Ophthalmia Dam
- Turee Creek
- Weeli Wolli/Marillana

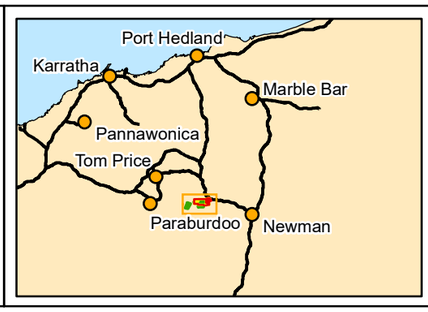
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Coordinate System: GDA 1994 MGA Zone 50
Projection: Transverse Mercator
Datum: GDA 1994 Created 16/08/2022



RIO TINTO IRON ORE

West Angelas: Subterranean Fauna Survey

Figure 2.3: Subcatchments and surface drainage of the Study Area

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7450000 7440000 7430000 7420000

Western Hill
Deposit H
Central Waterbores
Calcrete Bores
Deposit F North
Mt Ella East
Deposit J
Turee Creek

Surface Geology (GWSA 1:250k)

- Czc - Colluvium - partly cons. gravel, rock valley fill
- Czk- Calcrete, drainage associated
- Czr - Hematite-geothite deposits on BIF
- Fd - Fortescue Grp. Metadolerite sills, intrusive
- Fj - Jeerinah Frm. Pelite, chert, metasandstone
- Fjb - Fortescue Grp. Metabasalt, massive, pillowed
- Hb - Brockman Iron Frm. BIF, chert, pelite
- Hd - Wittenoom Frm. Dolomite, chert, shale, BIF
- Hj - Weeli Wolli Frm. BIF, shale, dolerite sills
- Hm - Marra Mamba Iron Frm. BIF, chert, pelite
- Hs - Mt McRae_Mt Sylvia Frm. Shale, BIF, pelite
- Hw - Woongarra Volcanics- Rhyolite, rhyodacite, tuff
- Qa - Alluvium - uncons. silt, sand, gravel along drainage
- Qc - Colluvium - uncons. sand, gravel, scree
- Qw - Alluvium-Colluvium sandy-clayey soil

Legend

- West Angelas Beyond 2020 Development Envelope
- Current Operations Development Envelope
- Subterranean Fauna Reference Area

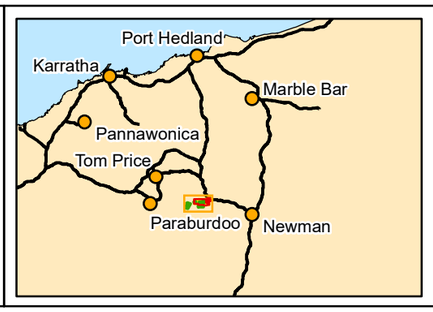
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Scale: 1:150,000

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Coordinate System: GDA 1994 MGA Zone 50
Projection: Transverse Mercator
Datum: GDA 1994 Created 16/08/2022



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Figure 2.4 Surface geology of the Study Area

The West Angelas deposits are formed in the Marra Mamba Iron Formation (MMIF), which is overlain by the West Angela Member of the Wittenoom Formation (Rio Tinto 2018). The MMIF comprises three major members from top to bottom: Mt Newman Member, MacLeod Member and Nammuldi Member. Most of the mineralisation at West Angelas is hosted by the uppermost Mt Newman Member, comprising banded iron formation (BIF) with interbedded carbonate and discrete shale bands. The lower MMIF Members contain significant proportions of shale, chert and dolomites. Weathering of the MMIF has also produced a significant hydrated/mineralised zone (goethite-martite hardcap) over the bedrock. In contrast to the West Angelas deposits, the Deposit J reference area is formed in the Brockman Iron Formation (BrIF).

Tertiary and quaternary detritals (colluvium and alluvium) cover the lower slopes and valley floors, and occasionally feature secondary deposits such as pisolite or channel iron deposit (CID) and calcrete deposited in areas near the historic (and in some cases present) water table (Figure 2.4).

2.5 Hydrogeology

The local hydrogeology around West Angelas is relatively complex and comprises several different aquifers of various permeability and depth, some of which appear to be discontinuous (Figure 2.5). The three major aquifer types occurring within the Study Area are discussed below.

Central plateau (Jeerinah Formation)

Groundwater levels on the low-lying central plateau are relatively shallow, ranging between 10–20 metres below ground level (mbgl) in the Jeerinah Formation – in stark contrast to the greater depths to water (up to 140 mbgl) within the flanking alluvial valleys (Rio Tinto, 2014). Groundwater levels decline steeply between the Jeerinah Formation of the central plateau and the mineralised Marra Mamba formation on its flanks (i.e. in a north–south cross section), indicating either very low permeabilities across the basal Marra Mamba Members, or potentially a lack of hydraulic connection altogether between the plateau and the southern flanking valley (Dodson, 2006). Water flows from the Jeerinah Formation into the north and south flanking valleys, probably following surface watercourses, where groundwater levels are higher and permeability may be increased by unconsolidated alluvial deposits.

Flanking valleys (Tertiary detritals)

Within the flanking valleys groundwater levels are deep (generally 90–140 mbgl) and no major regional aquifer has been encountered to date. Groundwater flow in the flanking valleys is from east to west, and is generally characterised by very flat hydraulic gradients, with smaller areas of very steep gradients between deposits (Rio Tinto, 2014). These anomalies suggest a series of discontinuous porous zones at the bottom of the valley, separated by barriers of low permeability shale or banded iron as a result of structural folding (as if in a series of subterranean terraces or basins) (Dodson, 2006).

650000 660000 670000 680000 690000 700000

7450000 7440000 7430000 7420000

Western Hill

Deposit H

Central Waterbores

Calcrete Bores

Deposit F North

Mt Ella East

Turee Creek

Deposit J

Legend

- West Angelas Beyond 2020 Development Envelope
- Current Operations Development Envelope
- Subterranean Fauna Reference Area
- Surface Drainage

Hydraulic Barriers

- Anticline
- Dyke
- Groundwater Divide
- Interpreted calcrete/ dolocrete

Regional Aquifer - higher permeability

- Tertiary Detritals/ Wittenoom Frm/ Marra Mamba Frm Aquifer

Regional Aquitard- lower permeability

- Macleod Member/ Nammuldi Member/ Fortescue Group
- Weeli Wolli Frm/ Brockman Iron Frm/ Mt McRae Shale Frm/ Mt Sylvia Frm

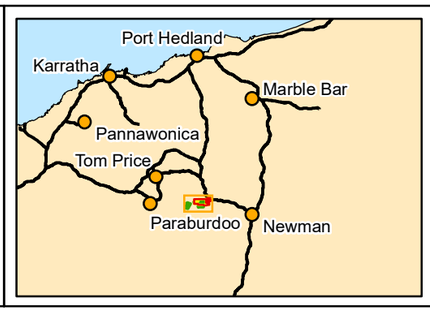
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Coordinate System: GDA 1994 MGA Zone 50
Projection: Transverse Mercator
Datum: GDA 1994 Created 16/08/2022



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Figure 2.5: Hydrogeology and hydraulic barriers of the Study Area

Groundwater within the southern flanking valley has a salinity of between 400–800 mg/L TDS (Total Dissolved Solids). The deep water-table and low permeability Tertiary overburden would indicate very low recharge rates. Groundwater modelling indicates recharge rates in the order of 0.7% of annual rainfall, consistent with other sites across the Pilbara (Dodson, 2006).

Ore bodies (Marra Mamba and Wittenoom Formations)

The orebody aquifers are characterised by considerable depths to water (often exceeding 100 m). The highest permeabilities are associated with the ore bodies (i.e. the Newman Member of the Marra Mamba Iron Formation and West Angelas Member of the Wittenoom Formation) (Rio Tinto, 2018b). Recharge to the groundwater flow system would be anticipated from direct rainfall on outcropping Marra Mamba and as infiltration from ephemeral creek flows. Geological cross sections show that these orebodies variably extend below the Tertiary detritals along the flanks of the ranges (Rio Tinto, 2015). Orebody aquifers may become confined at depth by clays or other low-permeability substrates in such cases.

2.6 Suitability for subterranean fauna habitat

Subterranean fauna habitats rely on the occurrence and interconnectedness of subterranean voids, cavities, cracks, porosity, aperture spaces and caverns, both below and above the water table (see Section 1.2). The occurrence and distribution of subterranean fauna are influenced or limited by the geological and hydrogeological settings in which they occur. Dispersal limitations mean that species' ranges are often small and fragmented, which leads to high levels of endemism (references within EPA, 2003; Harms *et al.*, 2018; Porter, 2007). Thus, it is important to identify the type and extent of habitats that are likely to host subterranean fauna.

2.6.1 Troglofauna

The two major geologies providing suitable habitat for troglofauna at West Angelas are the Brockman Iron Formation (BrIF) and the Marra Mamba Iron Formation (MMIF). Both are known to provide habitat for troglofauna throughout the region (Figure 2.5). Supergene weathering processes associated with mineralisation provide aperture and void spaces throughout the exposed sections of the rock by dissolving the rock to create cavities, vugs and pore spaces and via opening fractures created by faulting and folding.

Habitable cavities and pore spaces are also prevalent within the hematite-goethite-martite hardcap (pisolitic duricrust) that occur on the flanks of the BIF and MMIF ranges, and within karstic calcrete deposits and weathered Wittenoom Dolomite Formation where they occur AWT in the valleys.

Unconsolidated alluvial and colluvial layers in the valleys may provide medium-suitability habitats for troglofauna where sufficient pore spaces occur. These habitats can be vertically constrained by near-surface groundwater tables and, if adjacent to drainage lines, may be subject to periodic inundation. Nevertheless, even shallow detrital deposits <5 m to groundwater are known to provide highly suitable AWT habitats for troglofauna elsewhere in the Pilbara region.

The Jeerinah Formation (JF) at the centre of the Wonmunna Anticline and Mt McRae Shale/Mt Sylvia Formation (MCS) found throughout the Study Area are generally considered to be of low suitability for the occurrence of troglofauna due to the infrequent occurrence of cavities and pore spaces. These types of rock tend to degrade to clays and finer sediments that often fill cracks and cavities.

Structural elements, such as dykes, may influence local habitat connectivity in some areas. In addition, the variable habitat characteristics of the overlying detrital units and the local effects of fracturing and faulting complicates the assessment of habitat connectivity and potential barriers to troglofauna movement.

2.6.2 Stygofauna

Suitable hydrogeological habitat for stygofauna at West Angelas occurs within high permeability fractured and weathered rock aquifers within the BrIF and MMIF orebodies. These orebody aquifers represent highly suitable prospective stygofauna habitat due to the presence of cavities, vugs, pore spaces and fractures BWT.

In the synclinal valley surrounding the Wonmunna Anticline (i.e. between the BrIF and the MMIF ranges containing the orebody deposits), aquifers are hosted within deep detritals, calcrete (i.e. Calcrete Bores reference area) and weathered Wittenoom Dolomite (Figure 2.5). These geologies represent highly suitable prospective BWT habitats for stygofauna, as is found elsewhere throughout the region. Intrusive dykes and sills occur within the bedrock in certain areas, although groundwater flows and connectivity may be maintained above low-permeability dykes via the saturated detritals and calcrete.

The Jeerinah Formation at the centre of the Wonmunna Anticline and Mt McRae Shale/Mt Sylvia Formation found throughout the Study Area are generally considered to be of low to medium suitability for the occurrence of stygofauna, except where they are fractured/faulted or overlain by tertiary detritals.

2.6.3 Priority Ecological Communities

Two Priority 1 Ecological Communities occur within or in the vicinity of the Study Area, namely the Brockman Iron cracking-clay communities of the Hamersley Range, ca. 1 km north-west of Western Hill, and the West Angelas cracking-clays in the centre of the Study Area (Figure 1.2). Neither of these PECs are relevant to subterranean fauna and are therefore not further considered.

Further afield in the wide local area there are some PECs with relevance to subterranean fauna, such as the Coolibah Lignum Flats (Coondewanna and Wanamunna flats) (Priority 3) that occur ca. 4 km north-northwest of Deposit H, and the Weeli Wolli Spring Community ca. 20 km east of Deposit H. However, these communities occur well beyond the Study Area in different geological and hydrogeological settings and are unlikely to share species or habitats with the assemblages of the Study Area (with the exception of some regionally widespread species).

3. METHODS

3.1 Survey timing

The survey originated as a two-phase Level 2 subterranean fauna survey, in accordance with EPA guidelines for subterranean fauna assessments at the time of survey (EPA, 2016a, 2021). The first phase (dry season) was undertaken over September to November 2018, with the second phase (wet season) undertaken between March and May 2019. Additional phases of targeted survey work were conducted in the immediate vicinity of Mt Ella East following the development of additional drill holes. Previous survey results at Deposit H (Eco Logical, 2013) were also included as a first phase of survey for Deposit H.

Baseline survey:

Phase 1

- Trip 1 (6–14 September 2018): trap deployment and scrape/haul sampling; and
- Trip 2 (4–9 November 2018): trap retrieval and scrape/haul sampling.

Phase 2

- Trip 3 (11–18 March 2019): trap deployment and scrape/haul sampling; and
- Trip 4 (29 April – 10 May 2019): trap retrieval and scrape/haul sampling.

Targeted survey:

- Trip 4 (4–6 October 2020): scrape sampling.

3.2 Site selection and survey effort

Within the Study Area, site selection for subterranean fauna sampling was limited to accessible, vertical bores (i.e., cased, production or monitoring bores) and drill holes (uncased holes). The ratios of troglofauna trapping to scraping and net hauling within and near each deposit were dependent upon drill hole construction (uncased required for troglofauna), angle (ideally 90° for scraping and net hauling), time since drilling (>6 months required for stygofauna, following EPA, 2016a), and whether the holes intercepted groundwater (required for stygofauna).

A total of 324 bores and drill holes were sampled throughout the Study Area during the baseline and the targeted surveys. The sampling effort was adapted between the various phases to fill spatial gaps as much as practicable within the limitations of the available holes andbores. Selected sites were also repeatedly sampled to account for seasonal variability. In total, 204 holes were sampled by troglofauna trapping (44 holes, or 22%, sampled repeatedly), 276 via scraping for troglofauna (51 holes, or 18%, sampled repeatedly), 68 via net-hauling for stygofauna (26 holes, or 38%, sampled repeatedly). Two bores were sampled using a stygofauna net to filter the outflow from pumping infrastructure (both sampled once).

Targeted stygofauna sampling was conducted at Mt Ella East and the Deposit J reference area (Figure 3.1). For troglofauna, the number of samples outside indicative pit boundaries pits, i.e. reference samples, were as follows (see Figure 3.1):

- Western Hill: 30 of 156 samples outside indicative pit boundaries (19%)
- Deposit H: 33 of 60 samples outside indicative pit boundaries (55.0%)
- Deposit J reference area: 121 samples throughout the reference area (100%)
- Deposit F North: 70 of 83 samples outside indicative pit boundaries (84%)
- Mt Ella East: 87 of 155 samples outside indicative pit boundaries (56%).

A total of 669 subterranean fauna samples were collected. This comprised 575 troglofauna samples collected by trapping (248 samples) and scraping (327 samples), and 94 stygofauna samples collected by net hauling. Table 3.1 provides details of the number of samples collected within and nearby each sampling area with respect to the methods employed. Figure 3.1 shows historic subterranean fauna sample sites, Figure 3.2 shows troglofauna sample sites for the current study, and Figure 3.3 shows stygofauna sample sites for the current study. Details of bores and drill holes visited during the survey are provided in Appendix A.

Table 3.1: Numbers of samples collected from each deposit/reference area

	W Hill	Calc.	Dep H*	Dep FN	MTEE	Dep J ref. area	CWB^	TCBF^	Total
Phase1	**82**		*	**39**	**55**	**63**	**5**		**244**
Hauling	7			4	4	4	5		24
Scraping	42			20	28	33			123
Trapping	33		*	15	23	26			97
Phase2	**89**	**16**	**67**	**49**	**58**	**64**	**9**	**22**	**374**
Hauling	8	16	7	1	1	4	9	22	68
Scraping	41		32	24	28	30			155
Trapping	40		28	24	29	30			151
Targeted					**47**	**4**			**51**
Hauling						2			2
Scraping					47	2			49
Trog total	**156**	**-**	**60**	**83**	**155**	**121**	**-**	**-**	**575**
Stygo total	**15**	**16**	**7**	**5**	**5**	**10**	**14**	**22**	**94**
Overall total	**171**	**16**	**67**	**88**	**160**	**131**	**14**	**22**	**669**

Note: *Ecologia (2013) previously sampled Dep H via 21 trapping samples, resulting in a total of 81 troglofauna samples at Dep H. ^ Previous sampling results from CWB and TCBF are not included as the specimen material was not identified to species level.

664000
676000
688000
7440000
7428000

Western Hill
Deposit H
Deposit F North
Mt Ella East
Deposit J

Legend

- West Angelas Beyond 2020 Development Envelope
- Current Operations Development Envelope
- Main Access Track
- Existing Pit
- Proposed Pit
- Stygofauna
- Troglofauna

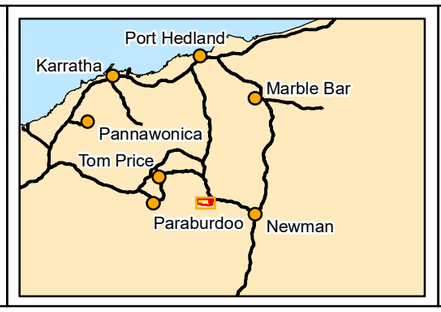
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Projection: Transverse Mercator
Datum: GDA 1994 Created 16/08/2022



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West Angelas: Subterranean Fauna Survey

Figure 3.1: Previous subterranean fauna sampling

664000

676000

688000

7440000

7428000

Western Hill

Deposit H

Deposit F North

Mt Ella East

Deposit J

Legend

- West Angelas Beyond 2020 Development Envelope
- Current Operations Development Envelope
- Main Access Track
- Existing Pit
- Proposed Pit

Sampling Method

- Scrape
- Trap
- Scrape and Trap

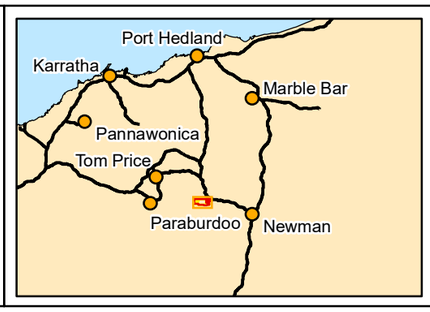
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Projection: Transverse Mercator
Datum: GDA 1994 Created 16/08/2022



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West Angelas: Subterranean Fauna Survey

Figure 3.2: Sites sampled for troglofauna during the current survey

652000 664000 676000 688000

7440000

7428000

Western Hill

Deposit H

Central Waterbores

Calcrete Bores

Deposit F North

Mt Ella East

Turee Creek

Deposit J

Legend

- West Angelas Beyond 2020 Development Envelope
- Current Operations Development Envelope
- Subterranean Fauna Reference Area
- Main Access Track
- Existing Pit
- Proposed Pit

Sampling Method

- Haul

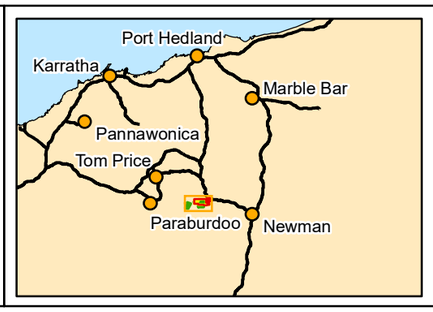
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Coordinate System: GDA 1994 MGA Zone 50
Projection: Transverse Mercator
Datum: GDA 1994 Created 16/08/2022



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West Angelas: Subterranean Fauna Survey

Figure 3.3: Sites sampled for stygofauna during the current survey

3.3 Sampling methods

The sampling methods used were consistent with the Technical Guidance for subterranean fauna surveys (EPA, 2021) and the Stygofauna Sampling Protocol developed for the Pilbara Biodiversity Study Subterranean Fauna Survey (Eberhard *et al.*, 2005; Eberhard *et al.*, 2009). The survey was conducted under a Department of Biodiversity, Conservation and Attractions (DBCA) Regulation 17 license 08-002749-1 and Regulation 27 license BA27000214 (Appendix H). The field work was undertaken by Shae Callan, Fabian Rudin, Syngeon Rodman and Phil Runham.

3.3.1 Troglofauna trapping

Trapping utilises custom -made cylindrical PVC traps (approximately 50 mm × 300 mm) baited with decaying leaf litter (dead spinifex and acacia sourced from the Pilbara region). Before use, the traps were sterilised with boiling water. Traps are lowered with a nylon cord to a suitable depth (~20 mbgl; closer to surface and ~1 m above water where the water table was <20 mbgl) and left in operation for six to eight weeks, before being collected and transported back to the laboratory in Perth.

3.3.2 Troglofauna scraping

Scraping was undertaken at vertical (or near vertical), uncased drill holes 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 four times for holes where no water was present, with each haul emptied into a sample bucket. Where the water table was intercepted, a combined net-haul/scrape sample was taken (including the water column). Each combined net-haul/scrape sample comprised six hauls from the bottom of the hole to the top (including AWT and BWT habitats), with three hauls using a 150 µm mesh and three hauls using a 50 µm mesh. When bore conditions were unsuitable (lots of debris, drilling lubes or constrictions), only the 150 µm mesh was used and fewer hauls were conducted. The contents of the sample were then elutriated, processed and immediately stored in 95% ethanol. The ethanol and samples were stored on ice or refrigerated to promote cool-temperature DNA fixation.

3.3.3 Stygofauna net-hauling

Stygofauna were sampled by net-hauling using conical, weighted plankton nets. The diameter of the sampling nets was based on the diameter of each hole and chosen to maximise the collection of stygofauna while also considering the need to reduce equipment damage and loss via snagging. For example, 120–150 mm holes were sampled using nets with diameters of 90 mm, while 50 mm piezometer bores were sampled with 35 mm diameter nets. Each haul sample consisted of six hauls along the entire depth of the water column, with three hauls using a 150 µm mesh net and three hauls using a 50 µm mesh net. The base of each net was fitted with a sinker and a sample receptacle with a mesh base (50 µm) to allow filtration. The net was raised and lowered at the bottom of the hole prior to retrieval to agitate sediments and maximise the collection of benthic animals, and then retrieved at a moderate pace to collect animals from the water column. The contents of the net and receptacle were flushed into a bucket after each haul. After the final haul

was collected and emptied, the composite sample was elutriated to remove coarse sediments and filtered through a 50 µm mesh net to reduce water content. The sample was transferred to a 120 mL polycarbonate vial and preserved in 95% ethanol. The ethanol and samples were stored on ice or refrigerated to promote cool-temperature DNA fixation. Samples containing large amounts of sediment or organic matter were split between two or more vials to optimise preservation.

3.3.4 Pumping (stygofauna)

At sites where pumping equipment or headworks prevented sampling by net-hauling, samples were collected by pumping water from bores and running the water from the pump release valve through a stygofauna net for a total of approximately 15 minutes at each site.

3.3.5 Water physicochemistry

Prior to stygofauna sampling, a basic suite of physicochemical water quality parameters including temperature, EC, pH and Redox (ORP) was measured with a multiparameter water quality meter from a groundwater sample collected from the top of the water table using a plastic bailer. At sites that were sampled via pumping, water quality was measured in a water sample collected from the pump outflow. Pumping/monitoring infrastructure, constrictions in piezometer bores, blockages from root material, or excessive depths to groundwater inhibited the collection of physicochemical readings at some sites (35 bores; Appendix F).

3.3.6 Sorting and taxonomy

Sorting of subterranean fauna from the preserved samples was done with forceps and pipettes under dissecting microscopes. Subsequent parataxonomy and taxonomic identification was completed under dissecting microscopes and compound microscopes, as necessary. The personnel who undertook in-house sorting and parataxonomy (D. Main, S. Callan, N. Gunawardene, S. Rodman, F. Rudin, M. van Wees, J. Pille Arnold, M. Lythe, T. Rudin and S. Floeckner) were all suitably trained and experienced in parataxonomy of subterranean fauna.

Specimens were identified using published literature and taxonomic keys for each group, where available. Each morphospecies from each sample was assigned a separate labelled vial and labelled with a specimen tracking code. Species comparisons and alignments were performed using available specimens collected throughout the wider sub-regional area. Dr Giulia Perina (from Biologic) provided specialist taxonomic identifications and regional alignments.

Genetic analysis (DNA barcoding using the mitochondrial genes COI and where appropriate 16s) was completed by Biologic on a subset of specimens from each taxon at each site to validate morphological identifications. Regional genetic alignments were undertaken based on available public genetic databases (GenBank) and Rio Tinto's genetic databases for each genetically determined taxonomic unit (OTU). Dr Joel Huey and Stephanie Floeckner (both from Biologic) completed the genetic analyses and regional comparisons. Appendix B provides further detail regarding the methods of DNA extraction, sequencing and analysis.

3.4 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 short-range endemic (SRE) species that do not appear on these lists.

The likelihood of taxa representing SRE species (i.e. distribution <10,000 km^2 following Harvey, 2002) was assessed based on the known distribution of local species and regional comparisons, where data were 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
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 uses three broad categories to deal with varying levels of taxonomic certainty that may apply to any given taxon (Table 3.2). Because most subterranean fauna are poorly known taxonomically, and given 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 3.2: SRE categorisation used by WAM taxonomists

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

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; refer Section 1.2) was 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 ... Other fauna groups, including terrestrial short-range endemic (SRE) invertebrates, are addressed in the relevant EPA guidance documents". (EPA, 2021).

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 from 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 (2021) 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.

3.5 Constraints and limitations

Subterranean fauna taxonomy and ecology is an emerging field for many groups. Much remains unknown, and this creates challenges for the interpretation of results from sampling. Many subterranean species (particularly troglofauna) are difficult to detect throughout their habitat. Subterranean fauna inhabit cryptic habitats that are sampled only via bores or drill holes developed in targeted locations for mineral exploration. As a result, surveys often reveal only part of the diversity and abundance of the fauna present, and generally feature low detection rates and high numbers of 'rare' species. The results and conclusions of this survey are based upon the best available information despite these general constraints, although in some cases a degree of residual uncertainty is unavoidable.

Additional limitations relating to this survey and report are listed below:

- Spatial/geographical spread of sampling – sampling was limited to the locations of available drill holes and bores, which varied between different sampling areas, and for AWT vs BWT sampling. Best efforts were made to refine the sampling plan between surveys to enhance spatial coverage and fill gaps, but not all sampling areas contained a

high number of suitable bores or holes in all desirable areas. Water bores were sparse, with large distances between them in the Central Water Bores area and Turee Creek Borefield, while few water bores were available at Mt Ella East, Deposit H, the Deposit J reference area, and Deposit F North. Available drill holes were somewhat clustered in patches at Mt Ella East and Western Hill, although the sampling coverage throughout all patches was high.

- Depth of drilling – the depth of drilling in some areas limited the number of drill holes that intercepted groundwater habitats for stygofauna sampling (e.g. at Mt Ella East, the Deposit J reference area, Deposit F North, and localised mountainous areas of Western Hill and Deposit H), as well as the constraints owing to the limited number of available water bores. Best efforts were made to repeatedly sample bores andholes where groundwater was intercepted, across multiple surveys.
- Stygofauna sampling – stygofauna sampling was limited to the accessible bores and drill holes that intercepted groundwater at the time of survey, which was relatively low at Mt Ella East, Deposit F Nth, the Deposit J reference area, and Deposit H. To complement stygofauna sampling at Western Hill, additional stygofauna work in similar nearby groundwater habitat was undertaken at the Calcrete bores (Synclinal Valley). Additional sampling at the Central Water Bores (Wonmunna anticline) and Turee Creek Borefield was undertaken to complement the stygofauna sampling at the other sampling areas, and to provide an opportunity to detect wider species distributions in the wider local context.
- EPA Guidance – The survey was conducted in alignment with EPA guidance available at the time of survey (2016), and therefore the sampling rates and number of phases of survey reflect the guidance available at that time, within the other limitations listed.
- Groundwater measurements from bailer sampling – some bores and holes were too deep, constricted or jagged to sample successfully with bailers. Care was taken to exclude erroneous results, but bailer sampling can sometimes alter physicochemical measurements (e.g. dissolved oxygen, temperature). The water conditions sampled in bores may not reflect the conditions of the wider aquifer and were interpreted accordingly.
- Taxonomy and genetics – specimen identifications were made by a combination of morphology and genetic analyses wherever possible. Best practices were followed in the field and lab to enhance genetic success rates; however, some sequencing failure is unavoidable. Appendix B contains full details and the specific constraints and limitations of the genetic analyses undertaken for the survey.
- Sub-sampling for genetic (and morphological) analysis – the high specimen load collected at some sites necessitated sub-sampling for detailed genetic analysis and morphological taxonomy. Parataxonomic work was undertaken to identify taxa down to the lowest taxonomic rank possible without dissection, based on available information. Individuals were then targeted for genetic analysis or detailed morphological identifications. Taxon groups were sub-sampled with consideration of spatial spread throughout and between habitats, and replication to allow for variability in success. Two subsequent rounds of sub-

sampling were undertaken to fill key knowledge gaps in the spatial understanding of species distributions within and between sampling areas/ habitats.

- Incorporation of previous results – subterranean fauna records from historical surveys (pre-2012, and some of the WAM data) were unresolved to species level and/or relied upon outdated taxonomic knowledge, therefore could not be directly compared to current taxa. There is some potential for synonyms and data artefacts in the combined species lists, and some of the earlier records may be unfit for use in EIA.
- Putatively unique taxa – certain taxa were taxonomically unique to the survey (i.e. distinct from all other groups detected), but nonetheless unable to be resolved to species level. Such taxa were treated as 'putatively unique' taxa following a precautionary approach. All efforts were made to assess local and regional species comparisons, but there were limits to available information. The putatively unique taxa were confidently assessed as subterranean and warranted inclusion in the fauna results. Meanwhile other indeterminate specimens (e.g. damaged or juvenile specimens) from groups that were not unique amongst the collection could not be resolved as one or another species and were thus excluded.
- As an example of the above, "Candonidae sp. indet." was the only ostracod found from the survey, was a good quality specimen and a stygobitic group, but failed to sequence and could not be resolved morphologically. Following a precautionary approach, this was treated as a putative unique species; Candonidae `sp. WAN`. This type of approach was necessary for 3 troglofauna taxa (*Cryptops* `sp. WAW`, Philosciidae `sp. WAF`, *Pseudodiploexochus* `sp. WAH`) and 2 stygofauna taxa (Candonidae `sp. WAN` *Pygolabis* `sp. WAN`), as described in Tables 5.2 and 5.5 in section 5.

While the above constraints and limitations frame the current understanding of subterranean fauna at the Study Area, none of these factors have compromised the survey or hampered the ability to use the survey data and information in future EIA of subterranean fauna. Overall, there is a high level of confidence in the results presented in this report, and in the contribution of this work to the wider understanding of subterranean fauna species and habitats in the West Angelas area.

4. DESKTOP ASSESSMENT

4.1 Database search methods

Seven databases were searched for subterranean fauna records in February 2022 (NatureMap and Atlas of Living Australia) and March 2021 (WAM database searches) (Table 4.1):

- DBCA's NatureMap database (DBCA, 2022)
- Atlas of Living Australia (ALA, 2022)
- Western Australian Museum (WAM) Arachnida/ Myriapoda database (WAM, 2021a)
- WAM Crustacea database (WAM, 2021b)
- WAM Insecta database (WAM, 2021c)
- WAM Mollusca database (WAM, 2021d)
- Biologic's internal database of publicly available records.

All records were filtered based on collection methods and known stygofauna or troglofauna taxonomic groups where information on subterranean status (i.e. subterranean/soil fauna/surface fauna) was not present in the data.

Table 4.1: Databases searched for subterranean fauna records

Database	Parameters
NatureMap	20 km radius around 23°10`34"S and 118°44`55"E
ALA	10 km radius around 23°10`34"S and 118°44`55"E
WAM Arachnida/ Myriapoda, Crustacea, Insecta, Mollusca	100 km radius around 23°10`28"S and 118°43`43"E
Biologic's internal database	20 km radius around 23°10`34"S and 118°44`55"E

4.2 Review of previous reports

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

- West Angelas Iron Ore Project Stygofauna Assessment Survey (Ecologia, 1998)
- West Angelas Iron Ore Project Stygofauna Assessment Survey (Ecologia, 2002)
- West Angelas Stygofauna Survey (Biota, 2003)
- Subterranean Fauna Survey West Angelas Expansion Deposits E and F (Biota, 2004)
- West Angelas Stygofauna Monitoring Programme Report (Ecologia, 2005)
- West Angelas and Deposit A Stygofauna Survey (Biota, 2008a)
- West Angelas Operations Stygofauna Compliance Review (Biota, 2008b)
- Angelo River Subterranean Fauna (Pilot) Survey (Subterranean Ecology, 2012)
- West Angelas Stygofauna Survey 2012 (Biota, 2012)
- Greater West Angelas Subterranean Fauna Assessment (Ecologia, 2013)
- Rio Tinto Iron Ore Regional Troglofaunal Sampling (Biota, 2013b)
- West Angelas Deposit B Stygofauna Assessment (Ecologia, 2015)

- West Angelas Subterranean Fauna Assessment (Eco Logical, 2015)
- West Angelas Deposit F Stygofauna Monitoring 2016 (Biologic, 2016a)
- West Angelas Deposits C, D & G Subterranean Fauna Survey 2016 (Biologic, 2016b).

4.3 Database search results

The Western Australian Museum (WAM), Atlas of Living Australia (ALA) and NatureMap (NM) database searches revealed 130 troglofauna (including potential troglofauna) taxa from 15 taxonomic groups and 33 stygofauna taxa (including potential stygofauna and amphibious fauna) from 9 taxonomic groups within and surrounding the Study Area (Table 4.2; see Table 4.1 for search parameters). Figure 4.1 and Figure 4.2 show the locations of these records. None of the ALA and NM records were mapped because these databases do not provide coordinates with search results. Of these records, 9 troglofauna and 16 stygofauna taxa from the database searches were recorded within or near (<1.5 km) the current Study Area (Table 4.2, highlighted records). A further 46 (28 troglofauna and 18 stygofauna) records were not included in the assessment due to indeterminate and/or outdated taxonomy (Appendix D).

Based on current knowledge, none of the described troglofauna or stygofauna species appear on any threatened species lists. Particularly in relation to the stygofauna taxa, many of the records are widespread species known to occur beyond the Study Area. However, owing to the indeterminate identifications of some of the taxa recorded, several records cannot be assessed for wider local or regional distributions. A list of all database search records is presented in Appendix C.

Table 4.2: Stygofauna and troglofauna records from database searches within and surrounding the Study Area (search parameters as per Table 4.1) Highlighted records occur within a 1.5 km radius of the Study Area.

Taxonomy	Likely subterranean status	SRE status where known	Source
Stygofauna			
Platyhelminthes			
Platyhelminthes sp. indet.	Uncertain	Uncertain	NM, Biota (2003), Ecologia (2005), Biologic (2016a)
Oligochaeta			
Enchytraeidae `sp. Helix-OLE026` *	Stygophile (amphibious)	Uncertain	Biologic (2016a)
Enchytraeidae `sp. Helix-OLE028`	Stygophile (amphibious)	Uncertain	Biologic (2016a)
Enchytraeidae `sp. Helix-OLE029` *	Stygophile (amphibious)	Uncertain	Biologic (2016a)
Enchytraeidae `sp. Helix-OLE030` *	Stygophile (amphibious)	Uncertain	Biologic (2016b)
Insulodrilus angela	Stygofauna	Widespread	NM
Phreodrilidae `sp. Helix-OLP12`	Stygofauna	Widespread	Biologic (2016)
Pristina longiseta	Stygofauna	Widespread	Biologic (2016)
Polychaeta			
Aeolosomatidae sp. indet.	Stygofauna	Uncertain	Biologic (2016a)
Acari			
Neumania sp. indet.	Potential Stygofauna	Uncertain	WAM
Pezidae sp. indet.	Potential Stygofauna	Uncertain	NM
Ostracoda			
Notacandona gratia	Stygobite	Widespread	WAM, Biologic (2016a)
Cyclopoida			
Diacyclops humphreysi s. l.	Stygoxene/phile	N/A	NM, SubEcol (2012)
Diacyclops sobeprolatus	Stygoxene/phile	Widespread	SubEcol (2012)

Taxonomy	Likely subterranean status	SRE status where known	Source
Dussartcyclops `sp. B10`	Stygobite	Potential SRE	WAM
Metacyclops `sp. B01` (nr *pilbaricus*)	Stygoxene/phile	Widespread	WAM, Biologic (2016a)
Microcyclops varicans	Stygoxene/phile	Widespread	WAM, Biologic (2016a)
Thermocyclops `sp. WA`	Stygoxene/phile	Widespread	Biologic (2016a)
Harpacticoida			
Australocamptus `sp. B13`	Stygobite	Potential SRE	WAM, Biologic (2016a)
Parastenocaris sp. indet.	Stygobite	Uncertain	WAM, Biologic (2016a)
Syncarida			
Atopobathynella `sp. Helix-BAP027/WA`	Stygobite	Potential SRE	Biologic (2016a)
Bathynellidae `1614-01`	Stygobite	Potential SRE	WAM
Bathynellidae `sp. Helix-BAB018`	Stygobite	Potential SRE	Biologic (2016a)
Billibathynella `sp. AR`	Stygobite	Potential SRE	SubEcol (2012)
Billibathynella `sp. S1`	Stygobite	Potential SRE	WAM
nr *Billibathynella* `sp. B02`	Stygobite	Potential SRE	WAM
Parabathynellidae `won1`	Stygobite	Potential SRE	WAM
Amphipoda			
Kruptus `sp. AR`	Stygobite	Potential SRE	SubEcol (2012)
Kruptus `sp. Helix-AMP035`	Stygobite	Potential SRE	Biologic (2016a)
Maarrka `sp. Helix-AMP037`	Stygobite	Potential SRE	Biologic (2016a)
Paramelitidae `sp. B03`	Stygobite	Potential SRE	WAM
Paramelitidae `sp. Helix-AMP036`	Stygobite	Potential SRE	Biologic (2016a)
Troglofauna			
Isopoda			
Acanthodillo `won1`	Troglofauna	Potential SRE	WAM
Armadillo `sp. AR`	Troglofauna	Potential SRE	SubEcol (2012)
Armadillidae `sp. B06`	Likely troglobite	Potential SRE	WAM
Armadillidae `sp. B13`	Likely troglobite	Potential SRE	WAM
Armadillidae `sp. B14`	Likely troglobite	Potential SRE	WAM
Armadillidae `sp. Helix-ISA049`	Likely troglobite	Potential SRE	Biologic (2016a)
Buddelundia `sp. 19`	Likely troglophile	Potential SRE	WAM
Troglarmadillo `DNA03`	Troglobite	Potential SRE	WAM
Philosciidae `sp. AR`	Likely troglophile	Potential SRE	SubEcol (2012)
Philosciidae `sp. B03`	Likely troglophile	Potential SRE	WAM
Philosciidae `sp. B04`	Likely troglophile	Potential SRE	WAM
Pseudodiploexochus sp. indet.	Troglobite	Potential SRE	ecologia (2013)
Geophilida			
Geophilida sp. indet.	Uncertain	Uncertain	Biota (2013)
Scolopendrida			
Cormocephalus pyropygus	Trogloxene/phile	Widespread	WAM, ecologia (2013)
Cryptopidae `sp. SER`	Potential troglobite	Potential SRE	WAM, SubEcol (2012)
Cryptops `DNA17`	Potential troglobite	Potential SRE	WAM
Cryptops `sp. SV` (= *Cryptops* `sp. B06`)	Potential troglobite	Potential SRE	WAM, SubEcol (2012)
Symphyla			
Cephalostigmata `DNA06`	Potential troglobite	Potential SRE	WAM
Cephalostigmata `DNA08`	Potential troglobite	Potential SRE	WAM
Scutigerellidae `sp. Helix-SYM027`	Potential troglobite	Potential SRE	Biologic (2016b)
Scutigerellidae `sp. Helix-SYM028`	Potential troglobite	Potential SRE	Biologic (2016a)
Scutigerellidae `sp. Helix-SYM029`	Potential troglobite	Potential SRE	Biologic (2016a)
Polyxenida			
Polyxenidae `DNA01`	Likely troglophile	Uncertain	WAM
Lophoproctidae sp. indet.	Likely troglophile	Likely widespread	ALA
Pauropoda			
Allopauropus `sp. B11`	Uncertain	Uncertain	WAM
Pauropodidae `sp. B14`	Uncertain	Uncertain	WAM
Polypauropus `sp. B01`	Uncertain	Uncertain	WAM
Palpigradi			
Palpigradi sp. indet.	Potential troglobite	Uncertain	Biologic (2016b)

Taxonomy	Likely subterranean status	SRE status where known	Source
Pseudoscorpiones			
Lagynochthonius `PSE039`	Troglobite	Potential SRE	WAM
Lagynochthonius `PSE041`	Troglobite	Potential SRE	WAM
Lagynochthonius `PSE101`	Troglobite	Potential SRE	WAM, Biologic (2016a)
Tyrannochthonius `DNA05`	Troglobite	Potential SRE	WAM
Tyrannochthonius `PSE102`	Troglobite	Potential SRE	WAM, Biologic (2016a)
Indohya `PSE005`	Troglobite	Potential SRE	WAM
Indohya `PSE147`	Troglobite	Potential SRE	WAM
Lechytia `wonmunna`	Troglobite	Potential SRE	WAM
Beierolpium `DNA01`	Uncertain	Uncertain	WAM
Euryolpium sp. indet.	Uncertain	Uncertain	ALA
Indolpium sp. indet.	Uncertain	Uncertain	ALA, NM, WAM, Biota (2013)
Linnaeolpium `w1`	Uncertain	Uncertain	WAM
Xenolpium sp. indet.	Uncertain	Uncertain	ALA
Schizomida			
Draculoides `SCH022`	Troglobite	Potential SRE	WAM
Draculoides `SCH023`	Troglobite	Potential SRE	WAM
Draculoides `SCH051`	Troglobite	Potential SRE	WAM, Biologic (2016a)
Draculoides `sp. B16`	Troglobite	Potential SRE	WAM
Draculoides `sp. B20`	Troglobite	Potential SRE	WAM
Draculoides `sp. B32`	Troglobite	Potential SRE	WAM
Draculoides `sp. B55`	Troglobite	Potential SRE	WAM
Araneae			
Araneus sp. indet.	Uncertain	Uncertain	ALA
Gnaphosidae `wonmunna`	Potential troglobite	Potential SRE	WAM
Prethopalpus `DNA01`	Troglobite	Potential SRE	WAM
Prethopalpus julianneae	Troglobite	Potential SRE	WAM
Prethopalpus maini	Troglobite	Potential SRE	WAM
Theridiidae sp. indet.	Uncertain	Uncertain	WAM
Blattodea			
Blattidae `sp. B06`	Potential troglobite	Uncertain	WAM
Blattidae `sp. S1`	Potential troglobite	Uncertain	WAM
Blattidae `sp. S2`	Potential troglobite	Uncertain	WAM
Blattodea `sp. B02`	Potential troglobite	Uncertain	WAM
Nocticola `BLA001`	Potential troglobite	Uncertain	WAM
Nocticola `BLA003`	Potential troglobite	Uncertain	WAM
Nocticola `BLA004`	Potential troglobite	Uncertain	WAM
Nocticola `BLA005`	Potential troglobite	Uncertain	WAM
Nocticola `sp. S1`	Potential troglobite	Uncertain	WAM
Nocticola `sp. S3`	Potential troglobite	Uncertain	WAM
Nocticola `sp. B07`	Potential troglobite	Uncertain	WAM
Nocticola `sp. B20`	Potential troglobite	Uncertain	WAM
Nocticola `sp. B29 (nr sp. B10)`	Potential troglobite	Uncertain	WAM
Nocticola `sp. B31`	Potential troglobite	Uncertain	WAM
Nocticola `Won1`	Potential troglobite	Uncertain	WAM
Nocticolidae `sp. MA`	Potential troglobite	Uncertain	WAM
Coleoptera			
Zuphium `sp. AR`	Potential troglobite	Potential SRE	SubEcol (2012)
Anillini sp. indet.	Uncertain	Uncertain	ecologia (2013)
Hydrobiomorpha sp. indet.	Uncertain	Uncertain	ecologia (2013)
Ptinella `sp. B01`	Uncertain	Uncertain	WAM
Carabidae `Won1`	Uncertain	Uncertain	WAM
Cryptorhynchinae `sp. MA`	Uncertain	Uncertain	WAM
Cyclominae `sp. MA`	Uncertain	Uncertain	WAM
Curculionidae `sp. B02`	Uncertain	Uncertain	WAM
Curculionidae `sp. B07`	Uncertain	Uncertain	WAM
Curculionidae `sp. MJ`	Uncertain	Uncertain	WAM
Pselaphinae `sp. B02`	Uncertain	Uncertain	WAM
Pselaphinae `sp. UM`	Uncertain	Uncertain	WAM

Taxonomy	Likely subterranean status	SRE status where known	Source
Zopheridae `sp. MJ1`	Uncertain	Uncertain	WAM
Zopheridae `sp. MJ2`	Uncertain	Uncertain	WAM
Coleoptera `sp. B06`	Uncertain	Uncertain	WAM
Hemiptera			
Meenoplidae `sp. B02`	Likely troglophile	Unlikely SRE	WAM
Meenoplidae `sp. B08`	Likely troglophile	Unlikely SRE	WAM
Meenoplidae `sp. Helix-HEM003`	Likely troglophile	Unlikely SRE	Biologic (2016a)
Meenoplidae `sp. MA`	Likely troglophile	Unlikely SRE	WAM
Meenoplidae `sp. MJ-UM-OP-CAS`	Likely troglophile	Unlikely SRE	WAM
Meenoplidae `Won1`	Likely troglophile	Unlikely SRE	WAM
Meenoplidae `Won2`	Likely troglophile	Unlikely SRE	WAM
Meenoplidae `Won3`	Likely troglophile	Unlikely SRE	WAM
Nisia sp. indet.	Likely troglophile	Unlikely SRE	WAM
Phaconeura `sp. B04`	Likely troglophile	Unlikely SRE	WAM
Zygentoma			
Dodecastyla crypta	Likely troglophile	Unlikely SRE	WAM
Trinemura `sp. AR`	Potential troglobite	Potential SRE	WAM, SubEcol (2012)
Trinemura `sp. B15`	Potential troglobite	Potential SRE	WAM
Trinemura `sp. B18`	Potential troglobite	Potential SRE	WAM
Trinemura `sp. B25`	Potential troglobite	Potential SRE	WAM
Trinemura `sp. MC`	Potential troglobite	Potential SRE	WAM
Trinemura `sp. UM?`	Potential troglobite	Potential SRE	WAM
Ateluridae `sp. MJ_UM_MA`	Likely troglophile	Unlikely SRE	WAM
Nicoletiidae `sp. B02`	Potential troglobite	Potential SRE	WAM
Nicoletiidae `Won1`	Potential troglobite	Potential SRE	WAM
Nicoletiidae `Won2`	Potential troglobite	Potential SRE	WAM
Diplura			
Japygidae `DPL002`	Potential troglobite	Potential SRE	WAM
Japygidae `DPL005`	Potential troglobite	Potential SRE	WAM
Japygidae `DPL007`	Potential troglobite	Potential SRE	WAM
Japygidae `DPL011`	Potential troglobite	Potential SRE	WAM
Japygidae `DPL017`	Potential troglobite	Potential SRE	WAM
Japygidae `sp. B04`	Potential troglobite	Potential SRE	WAM
Japygidae `sp. B29`	Potential troglobite	Potential SRE	WAM
Japygidae `sp. B34`	Potential troglobite	Potential SRE	WAM
Japygidae `sp. S2_MJ`	Potential troglobite	Potential SRE	WAM
Japygidae `Won1`	Potential troglobite	Potential SRE	WAM
Parajapygidae `DPL019`	Potential troglobite	Potential SRE	WAM
Parajapygidae `DPL020`	Potential troglobite	Potential SRE	WAM
Parajapygidae `DPL023`	Potential troglobite	Potential SRE	WAM
Parajapygidae `DPL024`	Potential troglobite	Potential SRE	WAM
Parajapygidae `DPL029`	Potential troglobite	Potential SRE	WAM
Parajapygidae `DPL030`	Potential troglobite	Potential SRE	WAM
Parajapygidae `DPL031`	Potential troglobite	Potential SRE	WAM
Parajapygidae `sp. B24`	Potential troglobite	Potential SRE	WAM
Parajapygidae `sp. MJ1`	Potential troglobite	Potential SRE	WAM
Parajapygidae `sp. MJ2`	Potential troglobite	Potential SRE	WAM
Projapygidae `sp. B09`	Potential troglobite	Potential SRE	WAM
Projapygidae `sp. B12`	Potential troglobite	Potential SRE	WAM
Projapygidae `sp. MJ`	Potential troglobite	Potential SRE	WAM
Projapygidae `Won1`	Potential troglobite	Potential SRE	WAM
Projapygidae `Won3`	Potential troglobite	Potential SRE	WAM

Note: *Enchytraeidae OLE026, OLE029, and OLE030 match sequences from (Brown *et al.*, 2015) considered to be a potential species complex.

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760000
7500000
7440000

Marandoo
Yandi
Yandicoogina
Mining Area C
West Angelas
Hope Downs 4

Legend

- West Angelas Beyond 2020 Development Envelope
- Current Operations Development Envelope
- Subterranean Fauna Reference Area

Operating Mine

- Rio Tinto
- Third Party

Number of unique troglofauna species/ OTUs

- 1
- 2
- 3
- 4
- 5 - 6

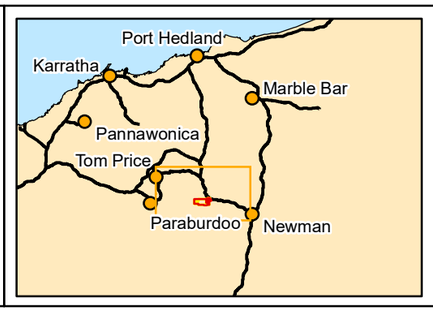
N

biologic Environmental Survey

Scale: 1:500,000

0 10 20 30 Km

Coordinate System: GDA 1994 MGA Zone 50
Projection: Transverse Mercator
Datum: GDA 1994 Created 16/08/2022



RIO TINTO IRON ORE

West Angelas: Subterranean Fauna Survey

Figure 4.1: Previous troglofauna recorded in the Study Area

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7380000

Yandi

Yandicoogina

Mining Area C

Hope Downs 1

Hope Downs 4

Legend

- West Angelas Beyond 2020 Development Envelope
- Current Operations Development Envelope
- Subterranean Fauna Reference Area

Operating Mine

- Rio Tinto
- Third Party

Number of unique stygofauna species/ OTUs

- 1
- 2
- 3
- 4
- 5 - 6

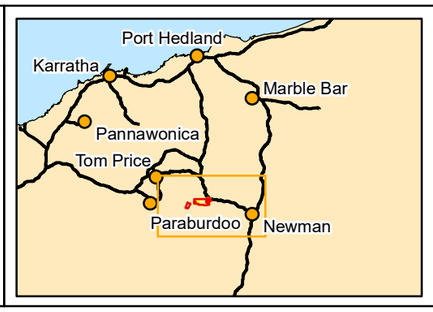
N

biologic Environmental Survey

Scale: 1:570,000

0 10 20 30 Km

Coordinate System: GDA 1994 MGA Zone 50
Projection: Transverse Mercator
Datum: GDA 1994 Created 16/08/2022



RIO TINTO IRON ORE

West Angelas: Subterranean Fauna Survey

Figure 4.2: Previous stygofauna recorded in the Study Area

4.4 Previous survey results

Reports from 15 previous subterranean fauna surveys within and immediately surrounding the West Angelas Study Area were reviewed for local and regional context. Of the fifteen previous surveys, specimens and/or sequence data were lodged with the WAM for the following seven surveys and therefore show up in the database searches: Biota (2003), Biologic (2016a, 2016b); Biota (2013a); ecologia (2005, 2013); Subterranean Ecology (2012). The remaining eight surveys did not result in specimens vouchered at the WAM (Biota, 2004, 2008a, 2008b, 2012; Eco Logical, 2015; ecologia, 1998, 2002, 2015). Only fauna results lodged with the WAM were able to be mapped (Section 4.2, Figures 4.1 and 4.2).

Of the 15 previous surveys conducted at and in the vicinity of West Angelas, eight have sampled bores or drill holes within the current deposits (Table 4.3 and Table 4.4). Some surveys were conducted in areas near the current deposits (e.g. Deposits A, B, E, F and G), and a number of the previous stygofauna surveys sampled extensively throughout the central plateau between Deposit C and D (and further east) (Table 4.3 and Table 4.4). Several surveys (e.g. Biota, 2012; ecologia, 1998) sampled within the Turee Creek Borefield.

Five of the previous surveys targeted troglofauna (Table 4.3 and 4.4). Of these, four surveys were conducted in the West Angelas area (Biologic, 2016b; Biota, 2013b; Eco Logical, 2015; ecologia, 2013) which recorded 35 troglofauna species from fourteen higher level taxonomic groups within or nearby the Study Area (Table 4.3 and 4.4). The other troglofauna survey (Subterranean Ecology, 2012) was conducted at Angelo River ca. 13 km south of Deposit J reference area and Mt Ella East which recorded thirteen troglofauna species from ten higher level taxonomic groups.

Fourteen of the previous surveys targeted stygofauna. Four of these (Biologic, 2016a, 2016b; Biota, 2003; ecologia, 2005) recorded 29 stygofauna species from eight higher-level taxonomic groups within and nearby the Study Area. The survey at Angelo River (Subterranean Ecology 2012) found six stygofauna species from four higher level taxonomic groups. Two surveys ecologia (1998 and 2002) at Turee Creek Borefield found six stygofauna species from five higher level taxonomic groups, and one survey at Deposit A and B (Biota, 2008b) found six stygofauna species. The remaining surveys targeting stygofauna did not reveal any stygofauna records.

Apart from Thermosbaenacea (recorded at bore WB51 in Biota, 2003), the higher level stygofauna taxa detected in the local area of West Angelas broadly reflect the groups known throughout the Pilbara region (such as amphipods, bathynellaceans, copepods, oligochaetes and ostracods). In contrast, Thermosbaenacea are currently only known from Cape Range, Barrow Island, and the Robe Valley (Eberhard *et al.*, 2005). Owing to the absence of this taxon from any previous or subsequent surveys outside of the aforementioned locations this record is either a result of misidentification or contamination.

Table 4.3: Summary of previous subterranean fauna survey effort and results (1998–2013) within and immediately surrounding the Study Area

Previous survey	West Angelas Iron Ore Project Stygofauna Assessment Survey	West Angelas Iron Ore Project Stygofauna Assessment Survey	West Angelas Stygofauna Survey	West Angelas Expansion Deposits E/ F Subterranean Fauna Survey	West Angelas Stygofauna Monitoring Programme Report	West Angelas and Deposit A Stygofauna Survey	West Angelas Operations Stygofauna Compliance Review	Angelo River Subterranean Fauna (Pilot) Survey	West Angelas Stygofauna Survey 2012	Greater West Angelas Subterranean Fauna Assessment	Rio Tinto Iron Ore Regional Troglofauna Sampling
Author (year)	**ecologia (1998)**	**ecologia (2002)**	**Biota (2003)**	**Biota (2004)**	**ecologia (2005)**	**Biota (2008a)**	**Biota (2008b)**	**Subterranean Ecology (2012)**	**Biota (2012)**	**ecologia (2013)**	**Biota (2013)**
Fauna targeted	Stygofauna	Stygofauna	Stygofauna	Stygofauna	Stygofauna	Stygofauna	Stygofauna	Stygofauna & Troglofauna	Stygofauna	Stygofauna & Troglofauna	Troglofauna
Areas sampled	Dep. A, B, C CWB, TCBF	Dep. A, B CWB, TCBF	Dep. A, B CWB, TCBF	Dep. E, F	Dep. A, B CWB, TCBF	Dep. A	Dep. A, B CWB	Angelo River Study Area	Dep. A TCBF	Dep. C, D, G, F, H	WH, Mt Ella, beyond Study Area
Bores successfully sampled	44	12	24	20	14	13	unknown (3 records)	78	12	42	53
Bores adjacent proposed deposit areas	12	7	8	0	4	1	0	0	0	21	25
Methods	Net hauling, Trapping	Net hauling	Net hauling	Net hauling	Net hauling	Net hauling	Net hauling	Net hauling, Trapping, Scraping	Net hauling	Net hauling, Trapping, Scraping	Trapping, Scraping
Stygo collected	Yes	Yes	Yes	No	Yes	No	Yes	Yes	No	No	N/A
Acari		•									
Amphipoda	•	•	•		•		•	•			
Bathynellacea	•	•					•	•			
Copepoda	•	•	•		•		•	•			
Isopoda		•									
Oligochaeta	•	•	•				•	•			
Ostracoda	•										
Platyhelminthes	•		•								
Thermosbaenacea*			•*								

* Note: Thermosbaenacea is likely a misidentification or contamination. 'CWB' = Central Water Bores, 'TCBF' = Turee Creek Borefield.

Table 4.3: Continued

Previous survey	West Angelas Iron Ore Project Stygofauna Assessment Survey	West Angelas Iron Ore Project Stygofauna Assessment Survey	West Angelas Stygofauna Survey	West Angelas Expansion Deposits E/ F Subterranean Fauna Survey	West Angelas Stygofauna Monitoring Programme Report	West Angelas and Deposit A Stygofauna Survey	West Angelas Operations Stygofauna Compliance Review	Angelo River Subterranean Fauna (Pilot) Survey	West Angelas Stygofauna Survey 2012	Greater West Angelas Subterranean Fauna Assessment	Rio Tinto Iron Ore Regional Troglofauna Sampling
Author (year)	**ecologia (1998)**	**ecologia (2002)**	**Biota (2003)**	**Biota (2004)**	**ecologia (2005)**	**Biota (2008a)**	**Biota (2008b)**	**Subterranean Ecology (2012)**	**Biota (2012)**	**ecologia (2013)**	**Biota (2013)**
Trog collected	N/A	N/A	N/A	N/A	N/A	N/A	N/A	Yes	N/A	Yes	Yes
Araneae								•		•	•
Blattodea								•		•	
Chilopoda								•		•	•
Coleoptera								•		•	
Diplopoda								•			•
Hemiptera								•		•	
Isopoda								•		•	•
Palpigradi										•	
Pseudoscorpiones								•		•	•
Symphyla								•			
Zygentoma								•		•	•

Table 4.4: Summary of previous subterranean fauna survey effort and results (2015–2016) within and immediately surrounding the Study Area

Previous survey	West Angelas Deposit B Stygofauna Assessment	West Angelas Subterranean Fauna Assessment - Report Excerpt	West Angelas Deposits C, D & G Subterranean Fauna Survey 2016	West Angelas Deposit F Stygofauna Monitoring 2016
Author (year)	**ecologia (2015)**	**Eco Logical (2015) (survey by Ecologia)**	**Biologic (2016b)**	**Biologic (2016a)**
Fauna targeted	Stygofauna	Stygofauna & Troglofauna	Stygofauna & Troglofauna	Stygofauna
Areas sampled	Dep. B	Dep. A West, F	Dep. C, D, G	Dep. F
Bores successfully sampled	7	38	92	9
Bores adjacent proposed deposit areas	0	0	4	0
Methods	Net hauling	Trapping, net hauling	Trapping, net hauling, scraping	Net hauling
Stygo collected	No	No	Yes	No
Amphipoda			•	
Bathynellacea			•	
Copepoda			•	
Isopoda			•	
Oligochaeta			•	•
Ostracoda			•	
Platyhelminthes			•	
Polychaeta			•	
Trog collected	N/A	Yes	Yes	Yes
Araneae			•	
Chilopoda				•
Collembola			•	
Diplura			•	
Hemiptera			•	
Palpigradi				•
Pseudoscorpiones			•	
Schizomida			•	
Symphyla			•	•
Zygentoma			•	

5. SURVEY RESULTS

5.1 Troglofauna

The current survey recorded a total of 344 troglofauna and potential troglofauna specimens. Of these, 70 troglofauna species (or species-level taxa) were identified from 137 specimens suitable for species-level identifications (Table 5.1, 5.2, Figure 5.1). Fifteen (15) taxonomic orders were represented, as shown in Table 5.1.

A further 207 specimens grouped in 17 indeterminate taxa (denoted as 'sp. indet.', Appendix E) could not be resolved to species-level, due to immaturity, poor specimen condition, inadequate diagnostic characters, or incomplete taxonomic information. These indeterminate taxa were omitted from further consideration as they could not be resolved to one or another species.

Table 5.1: Number of troglofauna species/taxa and specimens recorded during the survey

Higher taxon	No. species/ OTUs	No. specimens
Araneae	9	22
Blattodea	3	19
Cephalostigmata (Symphyla)	6	8
Coleoptera	3	4
Diplura	2	3
Diptera	1	2
Hemiptera	7	18
Isopoda	3	5
Palpigradi	7	11
Pauropoda	9	10
Polyxenida	3	8
Pseudoscorpiones	9	14
Scolopendrida	2	2
Spirobolida	1	1
Zygentoma (Thysanura)	5	10
Grand total	**70**	**137**

The troglofauna taxa were classified as "troglobite" or "potential troglobite" (26 taxa); "trogloxene/ troglophile" or "likely trogloxene/ troglophile" (28 taxa); based on a combination of available taxonomic and ecological information, and their linear ranges in relation to the extent of geological habitats (Table 5.2). Where available information was inconclusive, subterranean status was considered 'uncertain' (16 taxa) (Table 5.2). Nevertheless, these "uncertain" taxa were not omitted, as morphological characters identified them as part of the troglofauna assemblage, and some potential to be troglobitic was recognised within their respective taxonomic groups.

The known occurrence/ linear ranges of the troglofauna taxa were categorised as (Table 5.2):

- ‘singleton’ / ‘single site’
- ‘multiple local sites’ (recorded from multiple sites, linear range often less than 5 km but up to 10 km)
- ‘locally widespread’ (frequently recorded throughout the Study Area, linear range 10 km to 50 km, often across different geological habitats)
- ‘regionally widespread’ (recorded throughout the wider region, >50 km range, across different geological settings).

These distribution categories were taken into consideration in the assessment of short-range endemism, categorised as ‘Confirmed SRE’ (0 taxa), ‘potential SRE’ (55 taxa), ‘unlikely SRE’ (8 taxa), or ‘widespread’ (7 taxa) following the WAM categorisation and Harvey’s (2002) range criterion as a guide (Table 5.2).

The collection locations for troglofauna collected during the survey can be seen in Figure 5.1 (overview) and Figures 5.2 to 5.9 (detailed). A full list of subterranean fauna collected during the current survey, including collection site/date, can be found in Appendix G.

Table 5.2: Troglofauna species/OTUs detected from the Study Area (current survey), taxonomic and distribution comments, known linear ranges and collection locations.

Taxonomy	No. spms	Identification	Unique to Study Area/ found outside Study Are	Sub-fauna status	SRE status	Sampling areas	No. sites recorded	Distribution, known linear range
ARACHNIDA								
Araneae								
Araneae `sp. Biologic-ARAN008`	1	DNA, morpho	Unique lineage	Troglobite	Potential SRE	Dep F	1	Singleton
Araneae `sp. Biologic-ARAN009`	2	DNA, morpho	Unique lineage	Troglobite	Potential SRE	Dep J ref area	1	Single site
Araneae `sp. Biologic-ARAN017`	2	DNA, morpho	Unique lineage	Troglobite	Potential SRE	MTEE	1	Single site
Araneae `sp. Biologic-ARAN030`	1	DNA, morpho	Unique lineage	Troglobite	Potential SRE	W Hill	1	Singleton
Oonopidae `sp. Biologic-ARAN011`	2	DNA, morpho	Unique lineage	Troglobite	Potential SRE	Dep J ref area	2	Multiple local sites (1.0 km)
Oonopidae `sp. Biologic-ARAN018`	1	DNA, morpho	External match Angelo River (Biologic, 2021a) and Rhodes Ridge (Biologic, 2021c)	Potential Troglobite	Potential SRE	MTEE, external*	1	Locally widespread (7.6 km)
Prethopalpus `sp. Biologic-ARAN012`	1	DNA, morpho	Unique lineage	Troglobite	Potential SRE	Dep H	1	Singleton
Prethopalpus `sp. Biologic-ARAN013`	1	DNA, morpho	Unique lineage	Troglobite	Potential SRE	Dep J ref area	1	Singleton
Theridiidae `sp. Biologic-ARAN010`	11	DNA, morpho	External match Angelo River (Biologic, 2021a)	Trogloxene/ Troglophile	Unlikely SRE	Dep H, Dep J ref area, MTEE, external*	9	Locally widespread (17.6 km)
Palpigradi								
Palpigradi `sp. Biologic-PALP015`	1	DNA	Unique lineage	Troglobite	Potential SRE	Dep J ref area	1	Singleton
Palpigradi `sp. Biologic-PALP016`	1	DNA	Unique lineage	Troglobite	Potential SRE	W Hill	1	Singleton
Palpigradi `sp. Biologic-PALP017`	1	DNA	Unique lineage	Troglobite	Potential SRE	Dep H	1	Singleton
Palpigradi `sp. Biologic-PALP018`	5	DNA	Unique lineage	Potential Troglobite	Potential SRE	Dep F, MTEE	5	Multiple local sites (8.7 km)
Palpigradi `sp. Biologic-PALP019`	1	DNA	Unique lineage	Troglobite	Potential SRE	MTEE	1	Singleton
Palpigradi `sp. Biologic-PALP020`	1	DNA	Unique lineage	Troglobite	Potential SRE	Dep H	1	Singleton
Palpigradi `sp. Biologic-PALP021`	1	DNA	Unique lineage	Troglobite	Potential SRE	Dep J ref area	1	Singleton
Pseudoscorpiones								
Indohya `sp. Biologic-PSEU016`	1	DNA, morpho	Unique lineage	Troglobite	Potential SRE	Dep H	1	Singleton
Indolpium `sp. Biologic-PSEU017`	1	DNA, morpho	External match terrestrial West Angelas survey (Biologic, 2020), Angelo River (Biologic, 2021a)	Trogloxene/ Troglophile	Potential SRE	MTEE, external*	1	Locally widespread (19.5 km)
Tyrannochthonius `sp. Biologic-PSEU010`	2	DNA, morpho	Unique lineage	Troglobite	Potential SRE	Dep J ref area	2	Multiple local sites (0.6 km)
Tyrannochthonius `sp. Biologic-PSEU011`	2	DNA, morpho	Unique lineage	Troglobite	Potential SRE	MTEE	2	Multiple local sites (0.4 km)
Tyrannochthonius `sp. Biologic-PSEU012`	2	DNA, morpho	Unique lineage	Troglobite	Potential SRE	Dep J ref area, MTEE	2	Multiple local sites (3.5 km)

Taxonomy	No. spms	Identification	Unique to Study Area/ found outside Study Are	Sub-fauna status	SRE status	Sampling areas	No. sites recorded	Distribution, known linear range
Tyrannochthonius `sp. Biologic-PSEU013`	1	DNA, morpho	Unique lineage	Troglobite	Potential SRE	Dep H	1	Singleton
Tyrannochthonius `sp. Biologic-PSEU014`	2	DNA, morpho	Unique lineage	Troglobite	Potential SRE	Dep H	2	Multiple local sites (0.8 km)
Tyrannochthonius `sp. Biologic-PSEU015`	1	DNA, morpho	Unique lineage	Troglobite	Potential SRE	W Hill	1	Singleton
Chthoniidae `sp. Biologic-PSEU029`	1	DNA, morpho	Unique lineage	Troglobite	Potential SRE	MTEE	1	Singleton
MYRIAPODA								
Chilopoda								
Cryptops `sp. Biologic-CHIL008`	1	DNA, morpho	External match Angelo River (Biologic, 2021a)	Likely trogloxene/ troglophile	Potential SRE	Dep J ref area, external*	1	Locally widespread (11.2 km)
Cryptops `sp. WAWH`	1	Morpho ID only, DNA failed	Putative unique taxon – genetic testing failed, treated as unique following a precautionary approach	Uncertain status	Potential SRE	W Hill	1	Singleton
Pauropoda								
Decapauropus `sp. WAM-PAUD002`	1	DNA, morpho	External match Paraburdoo (Cullen & Harvey, 2018)	Trogloxene/ Troglophile	Widespread	W Hill, external*	1	Regionally widespread (100+ km)
Pauropoda `sp. Biologic-PAUR014`	1	DNA	Unique lineage	Uncertain status.	Potential SRE	W Hill	1	Singleton
Pauropoda `sp. Biologic-PAUR015`	2	DNA	Unique lineage	Likely trogloxene/ troglophile	Potential SRE	Dep J ref area, Dep F	2	Locally widespread (11.4 km)
Pauropoda `sp. Biologic-PAUR016`	1	DNA	External match Angelo River (Biologic, 2021a)	Trogloxene/ Troglophile	Potential SRE	W Hill, external*	1	Locally widespread (37.2 km)
Pauropoda `sp. Biologic-PAUR017`	1	DNA	Unique lineage	Uncertain status	Potential SRE	Dep H	1	Singleton
Pauropoda `sp. Biologic-PAUR018`	1	DNA	Unique lineage	Uncertain status	Potential SRE	W Hill	1	Singleton
Pauropoda `sp. Biologic-PAUR019`	1	DNA	Unique lineage	Uncertain status	Potential SRE	Dep F	1	Singleton
Pauropoda `sp. Biologic-PAUR020`	1	DNA	Unique lineage	Uncertain status	Potential SRE	W Hill	1	Singleton
Pauropoda `sp. Biologic-PAUR027`	1	(Biologic, 2021a)	Unique lineage	Uncertain status	Potential SRE	MTEE	1	Singleton
Spirobolida								
Speleostrophus `sp. Biologic-DPLO001`	1	DNA, morpho	External match Angelo River (Biologic, 2021a)	Potential Troglobite	Potential SRE	Dep J ref area, external*	1	Multiple sites, external (10.6 km)
Polyxenida								
Lophoproctidae `sp. Biologic-POLX002`	3	DNA	External match Nammuldi, Robe Headwaters, Turee Syncline, Western Turner Syncline, Cabbage Gum Bore, Hope Downs & Beasley River (Biologic, 2020; Biota, 2009, 2013, 2014)	Trogloxene/ Troglophile	Widespread	Dep F, Dep J ref area, MTEE, external*	3	Regionally widespread (300+ km)
Lophoproctidae `sp. Biologic-POLX003`	4	DNA	External match Turee Syncline, Western Range, & Mesa G (Biota, 2009, 2013, 2006)	Trogloxene/ Troglophile	Widespread	Dep J ref area, W Hill, external*	4	Regionally widespread (300+ km)

Taxonomy	No. spms	Identification	Unique to Study Area/ found outside Study Are	Sub-fauna status	SRE status	Sampling areas	No. sites recorded	Distribution, known linear range
Lophoproctidae `sp. Biologic-POLX005`	2	DNA	External match Nammuldi Lens G (Biologic, 2020)	Trogloxene/ Troglophile	Widespread	Dep F, Dep J ref area, external*	2	Regionally widespread (300+ km)
Symphyla								
Hanseniella `sp. Biologic-SYMP010`	2	DNA, morpho	External match Angelo River (Biologic, 2021a)	Trogloxene/ Troglophile	Potential SRE	Dep J ref area, external*	2	Locally widespread, external (27.8 km)
Hanseniella `sp. Biologic-SYMP017`	1	DNA, morpho	Unique lineage	Uncertain status	Potential SRE	MTEE	1	Singleton
Hanseniella `sp. Biologic-SYMP018`	1	DNA, morpho	Unique lineage	Uncertain status	Potential SRE	MTEE	1	Singleton
Symphylella `sp. Biologic-SYMP019`	1	DNA, morpho	External match Angelo River (Biologic, 2021a)	Likely trogloxene/ troglophile	Potential SRE	Dep J ref area, external*	1	Locally widespread (11.5 km)
Scolopendrellidae `sp. Biologic-SYMP012`	1	DNA, morpho	Unique lineage	Uncertain status	Potential SRE	W Hill	1	Singleton
Scutigerellidae `sp. Biologic-SYMP011`	2	DNA, morpho	Local match Deposit C (Biologic, 2016b)	Trogloxene/ Troglophile	Potential SRE	Dep F, Dep H, Dep C*	2	Locally widespread (24.1 km)
ENTOGNATHA								
Diplura								
Japygidae `sp. Biologic-DIPL017`	3	DNA, morpho	External match Angelo River (Biologic, 2021a)	Trogloxene/ Troglophile	Potential SRE	Dep F, Dep J ref area, external*	2	Locally widespread (29.4 km)
Parajapygidae `sp. Biologic-DIPL016`	1	DNA, morpho	Unique lineage	Uncertain status	Potential SRE	Dep H	1	Singleton
INSECTA								
Blattodea								
Nocticola quartermainei	3	DNA, morpho	External match Hope Downs (Biologic, 2019b)	Trogloxene/ Troglophile	Unlikely SRE	Dep H, W Hill, external*	3	Locally widespread (50+ km)
Nocticola `sp. Biologic-BLAT014`	17	DNA, morpho	External match Angelo River (Biologic, 2021a) and Rhodes Ridge (Biologic, 2021c)	Trogloxene/ Troglophile	Unlikely SRE	Dep F, Dep J ref area, MTEE, W Hill, external*	17	Locally widespread (50+ km)
Nocticola `sp. Biologic-BLAT015`	1	DNA, morpho	Unique lineage	Uncertain status	Potential SRE	Dep H	1	Singleton
Diptera								
Sciaridae `sp. Biologic-DIPT001`	2	DNA	External match Angelo River (Biologic, 2021a) and Rhodes Ridge (Biologic, 2021c)	Trogloxene/ Troglophile	Unlikely SRE	Dep J ref area, W Hill, external*	2	Locally widespread (38.4 km)
Hemiptera								
Oliarus `sp. WAM-CIXO001`	1	DNA, morpho	External match Greater Paraburdoo (Biologic, 2019a)	Trogloxene/ Troglophile	Widespread	MTEE, external*	1	Regionally widespread (100+ km)
Phaconeura `sp. WAM-PHAC001`	4	DNA, morpho	External match Greater Paraburdoo & Deposit C (Biologic, 2016b, 2020; Cullen & Harvey, 2018)	Trogloxene/ Troglophile	Widespread	Dep J ref area, MTEE, W Hill, external*	3	Regionally widespread (300+ km)

Taxonomy	No. spms	Identification	Unique to Study Area/ found outside Study Are	Sub-fauna status	SRE status	Sampling areas	No. sites recorded	Distribution, known linear range
Phaconeura `sp. Biologic-HEMI003`	9	DNA, morpho	External match Hope Downs (Biologic, 2019b) and Angelo River (Biologic, 2021a)	Trogloxene/ Troglophile	Unlikely SRE	Dep F, Dep H, Dep J ref area, MTEE, external*	9	Locally widespread (67.0 km)
Meenoplidae `sp. Biologic-HEMI001`	1	DNA, morpho	External match Hope Downs (Biologic, 2019)	Trogloxene/ Troglophile	Widespread	Dep J ref area, external*	1	Regionally widespread (300+ km)
Meenoplidae `sp. Biologic-HEMI002`	1	DNA, morpho	External match Hope Downs (Biologic, 2019) and Angelo River (Biologic, 2021a)	Trogloxene/ Troglophile	Unlikely SRE	Dep H, external*	1	Locally widespread (30.9 km)
Meenoplidae `sp. Biologic-HEMI006`	2	DNA, morpho	External match Rhodes Ridge (Biologic, 2021c)	Trogloxene/ Troglophile	Unlikely SRE	Dep J ref area, external*	2	Locally widespread (58.6 km)
Meenoplidae `sp. Biologic-HEMI010`	1	DNA, morpho	External match Angelo River (Biologic, 2021a)	Trogloxene/ Troglophile	Unlikely SRE	W Hill, external*	1	Locally widespread (28.4 km)
Zygentoma								
Dodecastyla `sp. Biologic-ZYGE011`	3	DNA, morpho	External match Angelo River (Biologic, 2021a)	Trogloxene/ Troglophile	Potential SRE	Dep F, Dep J ref area, MTEE, external*	3	Locally widespread (27.9 km)
Trinemura `sp. Biologic-ZYGE013`	1	DNA, morpho	Unique lineage	Potential Troglobite	Potential SRE	W Hill	1	Singleton
Trinemura `sp. Biologic-ZYGE017`	1	DNA, morpho	Unique lineage	Potential Troglobite	Potential SRE	MTEE	1	Singleton
Atelurinae `sp. Biologic-ZYGE012`	2	DNA, morpho	Unique lineage	Trogloxene/ Troglophile	Potential SRE	W Hill	1	Single site
Atelurinae `sp. Biologic-ZYGE014`	3	DNA, morpho	DNA close (~7-10% 12S) to specimens from Greater Paraburdoo (Cullen & Harvey, 2018), Hope Downs (Biologic, 2019), Yandi/ Gudai-Darri (Biota, 2016). Treated as separate OTU as precaution.	Trogloxene/ Troglophile	Potential SRE	Dep J ref area, MTEE	3	Multiple local sites (4.0 km)
Coleoptera								
Pselaphinae `sp. Biologic-COLE006`	2	DNA, morpho	Unique lineage	Uncertain status	Potential SRE	MTEE	2	Multiple local sites (2.0 km)
Pselaphinae `sp. Biologic-COLE008`	1	DNA, morpho	External match Angelo River (Biologic, 2021a)	Likely trogloxene/ troglophile	Potential SRE	MTEE, external*	1	Multiple local sites (8.3 km)
Coleoptera `sp. Biologic-COLE007`	1	DNA	Unique lineage	Uncertain status	Potential SRE	MTEE	1	Singleton
MALACOSTRACA								
Isopoda								
Philosciidae `sp. Biologic ISOP015`	1	DNA, morpho	Unique lineage	Uncertain status	Potential SRE	MTEE	1	Singleton
Philosciidae `sp. WAF`	2	Morpho, Spatial info; no genetic confirmation.	Putative unique taxon – genetic testing failed, treated as unique following a precautionary approach. Possible match to ISOP015, unable to be confirmed.	Uncertain status	Potential SRE	Dep F	1	Single site

Taxonomy	No. spms	Identification	Unique to Study Area/ found outside Study Are	Sub-fauna status	SRE status	Sampling areas	No. sites recorded	Distribution, known linear range
Pseudodiploexochus `sp. WAH`	2	Morpho ID only, DNA unavailable	Current and previous specimens of a unique genus, considered the same species due to uniqueness, spatial proximity, and morphological similarities.	Potential troglobite	Potential SRE	Dep H	2	Multiple local sites (0.8 km)

Note: Records highlighted in green were exclusively recorded from reference areas.

664000

676000

688000

7440000

7428000

Western Hill

Deposit H

Deposit F North

Mt Ella East

Deposit J

Legend

West Angelas Beyond 2020 Development Envelope

Current Operations Development Envelope

Indicative Proposed Pit

Troglofauna Sample Site

Order

- Araneae
- Blattodea
- Cephalostigmata (Symphyla)
- Coleoptera
- Diplura
- Diptera
- Hemiptera
- Isopoda
- Palpigradi
- Polyxenida
- Pseudoscorpiones
- Scolopendrida
- Spirobolida
- Tetramerocerata (Pauropoda)
- Zygentoma

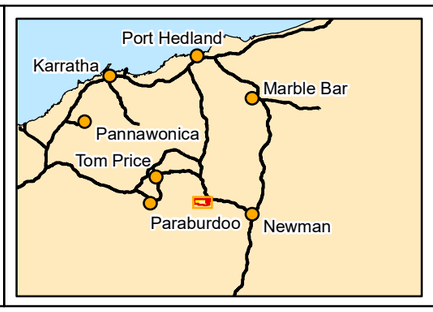
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biologic Environmental Survey

Scale: 1:100,000

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Coordinate System: GDA 1994 MGA Zone 50
Projection: Transverse Mercator
Datum: GDA 1994 Created 16/08/2022



RIO TINTO IRON ORE

West Angelas: Subterranean Fauna Survey

Figure 5.1: Troglofauna recorded during the current survey (Overview)

662000 664000 666000 668000 670000

7444000 7442000 7440000

Western Hill

Qw Qa Hb Hs Hd Czc

Araneae
- Araneae `sp Biologic-ARAN030`

Cephalostigmata
- Scutigerellidae `sp. Biologic-SYMP012`

Palpigradi
- Palpigradi `sp. Biologic-PALP016`

Polyxenida
- Lophoproctidae `sp. Biologic-POLX003`
- Polyxenida sp. indet.

Pseudoscorpiones
- Tyrannochthonius `sp. Biologic-PSEU015`

Scolopendrida
- Cryptops `sp. WAW`

Tetramerocerata
- Decapauropus `sp. WAM-PAUD002`
- Pauropoda `sp. Biologic-PAUR014`
- Pauropoda `sp. Biologic-PAUR016`
- Pauropoda `sp. Biologic-PAUR018`
- Pauropoda `sp. Biologic-PAUR020`
- Pauropoda sp. indet.

Surface Geology (GWSA 1:250k)
- Czc - Tertiary detritals- Colluvium - sand, gravel, valley fill
- Hb - Brockman Iron Frm. BIF, chert, pelite
- Hd - Wittenoom Frm. Dolomite, chert, shale, BIF
- Hm - Marra Mamba Iron Frm. BIF, chert, pelite
- Hs - Mt McRae_Mt Sylvia Frm. Shale, BIF, pelite
- Qa - Quaternary detritals- unconsolidated alluvium
- Qw - Quaternary detritals- Alluvial soil, sand, clay

Legend
- West Angelas Beyond 2020 Development Envelope
- Current Operations Development Envelope
- Indicative Proposed Pit
- Troglofauna Sample Site
- Previous Troglofauna Sampling

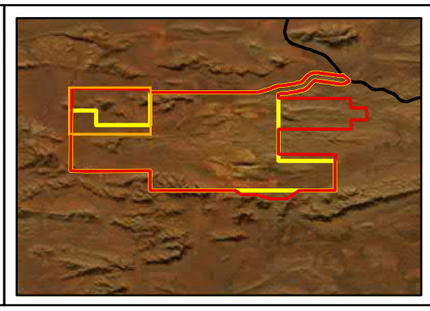
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biologic Environmental Survey

Scale: 1:25,000

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Coordinate System: GDA 1994 MGA Zone 50
Projection: Transverse Mercator
Datum: GDA 1994 Created 19/12/2022



RIO TINTO IRON ORE

West Angelas: Subterranean Fauna Survey

Figure 5.2: Troglofauna recorded at Western Hill (Chelicerata, Crustacea and Myriapoda)

688000 690000 692000 694000 696000 698000

7444000 7442000 7440000 7438000

Deposit H

Hm Qa Fjb Fj Czr Fd

Araneae
- Prethopalpus `sp. Biologic-ARAN012`
- Theridiidae `sp. Biologic-ARAN010`

Cephalostigmata
- Scutigerellidae `sp. Biologic-SYMP011`
- Hanseniella sp. indet.

Isopoda
- Pseudodiploexochus `sp. WAH`

Palpigradi
- Palpigradi `sp. Biologic-PALP017`
- Palpigradi `sp. Biologic-PALP020`
- Palpigradi sp. indet.

Pseudoscorpiones
- Indohya `sp. Biologic-PSEU016`
- Pseudoscorpiones sp. indet.
- Tyrannochthonius `sp. Biologic-PSEU013`
- Tyrannochthonius `sp. Biologic-PSEU014`

Tetramerocerata
- Pauropoda `sp. Biologic-PAUR017`

Surface Geology (GWSA 1:250k)
- Czc - Tertiary detritals- Colluvium - sand, gravel, valley fill
- Czr - Tertiary deposits- Hematite-geothite duricrust on slopes
- Fd - Fortescue Grp. Metadolerite sills, intrusive
- Fj - Jeerinah Frm. Pelite, chert, metasandstone
- Fjb - Fortescue Grp. Metabasalt, massive, pillowed
- Hm - Marra Mamba Iron Frm. BIF, chert, pelite
- Qa - Quaternary detritals- unconsolidated alluvium

Legend
- West Angelas Beyond 2020 Development Envelope
- Current Operations Development Envelope
- Indicative Proposed Pit
- Troglofauna Sample Site
- Previous Troglofauna Sampling

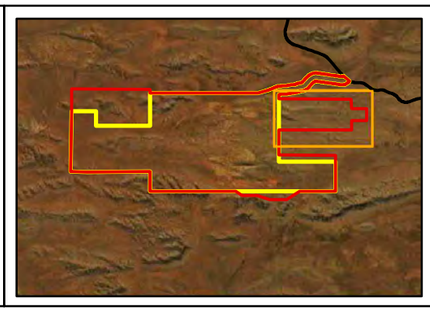
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Scale: 1:30,000

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Coordinate System: GDA 1994 MGA Zone 50
Projection: Transverse Mercator
Datum: GDA 1994 Created 16/08/2022



RIO TINTO IRON ORE

West Angelas: Subterranean Fauna Survey

Figure 5.3: Troglofauna recorded at Deposit H (Chelicerata, Crustacea and Myriapoda)

688000 690000 692000 694000

7436000 7434000

Deposit F North

Fjb Fd Hm Czc Czr Qa

Araneae
- Araneae `sp. Biologic-ARAN008`

Cephalostigmata
- Scutigerellidae `sp. Biologic-SYMP011`
- Scutigerellidae `sp. Helix-SYMP027` (prev. survey)

Isopoda
- Philosciidae `sp. WAF`

Palpigradi
- Palpigradi `sp. Biologic-PALP018`
- Palpigradi sp. indet.

Polyxenida
- Lophoproctidae `sp. Biologic-POLX002`
- Lophoproctidae `sp. Biologic-POLX005`
- Polyxenida sp. indet.

Tetramerocerata
- Pauropoda `sp. Biologic-PAUR015`
- Pauropoda `sp. Biologic-PAUR019`
- Pauropoda sp. indet.

Surface Geology (GWSA 1:250k)
- Czc - Tertiary detritals- Colluvium - sand, gravel, valley fill
- Czr - Tertiary deposits- Hematite-geothite duricrust on slopes
- Fd - Fortescue Grp. Metadolerite sills, intrusive
- Fj - Jeerinah Frm. Pelite, chert, metasandstone
- Fjb - Fortescue Grp. Metabasalt, massive, pillowed
- Hb - Brockman Iron Frm. BIF, chert, pelite
- Hm - Marra Mamba Iron Frm. BIF, chert, pelite
- Hs - Mt McRae_Mt Sylvia Frm. Shale, BIF, pelite
- Qa - Quaternary detritals- unconsolidated alluvium
- Qw - Quaternary detritals- Alluvial soil, sand, clay

Legend
- West Angelas Beyond 2020 Development Envelope
- Current Operations Development Envelope
- Indicative Proposed Pit
- Troglofauna Sample Site
- Previous Troglofauna Sampling

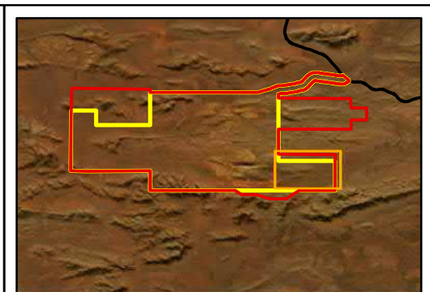
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biologic Environmental Survey

Scale: 1:20,000

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Coordinate System: GDA 1994 MGA Zone 50
Projection: Transverse Mercator
Datum: GDA 1994 Created 19/12/2022



RIO TINTO IRON ORE

West Angelas: Subterranean Fauna Survey

Figure 5.4: Troglofauna recorded at Deposit F North (Chelicerata, Crustacea and Myriapoda)

676000 679000 682000 685000 688000 691000 694000

7431000

7428000

7425000

Mt Ella East

Czc Qw Hb Hs Hd Qa Czc Hb Qa Hb Czc Czc Qa Czc Hb Qa Czc Hb Qw

Araneae
- Araneae `sp. Biologic-ARAN009`
- Araneae `sp. Biologic-ARAN017`
- Araneae sp. indet.
- Oonopidae `sp. Biologic-ARAN011`
- Oonopidae `sp. Biologic-ARAN018`
- Prethopalpus `sp. Biologic-ARAN013`
- Theridiidae `sp. Biologic-ARAN010`
- Theridiidae sp. indet.

Cephalostigmata
- Hanseniella `sp. Biologic-SYMP010`
- Hanseniella `sp. Biologic-SYMP017`
- Hanseniella `sp. Biologic-SYMP018`
- Hanseniella sp. indet.
- Symphylella `sp. Biologic-SYMP019`

Isopoda
- Philosciidae `sp. Biologic ISOP015`

Palpigradi
- Palpigradi `sp. Biologic-PALP015`
- Palpigradi `sp. Biologic-PALP018`
- Palpigradi `sp. Biologic-PALP019`
- Palpigradi `sp. Biologic-PALP021`
- Palpigradi sp. indet.

Polyxenida
- Lophoproctidae `sp. Biologic-POLX002`
- Lophoproctidae `sp. Biologic-POLX003`
- Lophoproctidae `sp. Biologic-POLX005`
- Polyxenida sp. indet.

Pseudoscorpiones
- Chthoniidae `sp. Biologic-PSEU029`
- Indolpium `sp. Biologic-PSEU017`
- Tyrannochthonius `sp. Biologic-PSEU010`
- Tyrannochthonius `sp. Biologic-PSEU011`
- Tyrannochthonius `sp. Biologic-PSEU012`

Scolopendrida
- Scolopendrida `sp. Biologic-CHIL008`

Spirobolida
- Speleostrophus `sp. Biologic-DPLO001`

Tetramerocerata
- Pauropoda `sp. Biologic-PAUR015`
- Pauropoda `sp. Biologic-PAUR027`

Surface Geology (GWSA 1:250k)
- Czc - Tertiary detritals- Colluvium - sand, gravel, valley fill
- Czr - Tertiary deposits- Hematite-geothite duricrust on slopes
- Fd - Fortescue Grp. Metadolerite sills, intrusive
- Fj - Jeerinah Frm. Pelite, chert, metasandstone
- Hb - Brockman Iron Frm. BIF, chert, pelite
- Hd - Wittenoom Frm. Dolomite, chert, shale, BIF
- Hj - Weeli Wolli Frm. BIF, shale, dolerite sills
- Hm - Marra Mamba Iron Frm. BIF, chert, pelite
- Hs - Mt McRae_Mt Sylvia Frm. Shale, BIF, pelite
- Qa - Quaternary detritals- unconsolidated alluvium
- Qw - Quaternary detritals- Alluvial soil, sand, clay

Legend
- West Angelas Beyond 2020 Development Envelope
- Current Operations Development Envelope
- Indicative Proposed Pit
- Troglofauna Sample Site
- Previous Troglofauna Sampling

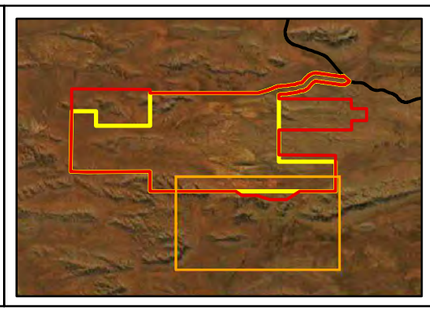
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Scale: 1:50,000

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Coordinate System: GDA 1994 MGA Zone 50
Projection: Transverse Mercator
Datum: GDA 1994 Created 16/08/2022



RIO TINTO IRON ORE

West Angelas:
Subterranean Fauna Survey

Figure 5.5: Troglofauna recorded at Deposit J reference area and Mt Ella East (Chelicerata, Crustacea and Myriapoda)

662000 664000 666000 668000 670000

7444000 7442000 7440000

Western Hill

Qw Qa Czc Hs Hb Hd

Blattodea
- Nocticola `sp. Biologic-BLAT014`
- Nocticola quartermainei
- Nocticola sp. indet.

Diptera
- Sciaridae `sp. Biologic-DIPT001`
- Sciaridae sp. indet.

Hemiptera
- Meenoplidae `sp. Biologic-HEMI010`
- Meenoplidae sp. indet.
- Phaconeura `sp. WAM-PHAC001`

Zygentoma
- Atelurinae `sp. Biologic-ZYGE012`
- Subnicoletiinae sp. indet.
- Trinemura `sp. Biologic-ZYGE013`

Surface Geology (GWSA 1:250k)
- Czc - Colluvium - partly cons. gravel, rock valley fill
- Hb - Brockman Iron Frm. BIF, chert, pelite
- Hd - Wittenoom Frm. Dolomite, chert, shale, BIF
- Hm - Marra Mamba Iron Frm. BIF, chert, pelite
- Hs - Mt McRae_Mt Sylvia Frm. Shale, BIF, pelite
- Qa - Alluvium - uncons. silt, sand, gravel along drainage
- Qw - Alluvium-Colluvium sandy-clayey soil

Legend
- West Angelas Beyond 2020 Development Envelope
- Current Operations Development Envelope
- Indicative Proposed Pit
- Troglofauna Sample Site
- Previous Troglofauna Sampling

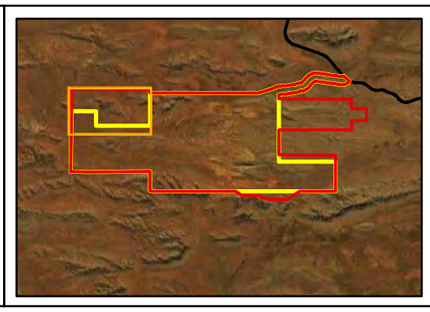
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Scale: 1:25,000

0 0.5 1 1.5 Km

Coordinate System: GDA 1994 MGA Zone 50
Projection: Transverse Mercator
Datum: GDA 1994 Created 16/08/2022



RIO TINTO IRON ORE

West Angelas: Subterranean Fauna Survey

Figure 5.6: Troglofauna recorded from Western Hill (Entognatha, Insecta)

688000 690000 692000 694000 696000 698000

7444000 7442000 7440000 7438000

Deposit H

Hm Qa Fjb Fj Czr Fd

Blattodea
- Nocticola `sp. Biologic-BLAT015`
- Nocticola quartermainei
- Nocticola sp. indet.

Diplura
- Parajapygidae `sp. Biologic-DIPL016`

Hemiptera
- Phaconeura `sp. Biologic-HEMI002`
- Phaconeura `sp. Biologic-HEMI003`

Zygentoma
- Atelurinae sp. indet.

Surface Geology (GWSA 1:250k)
- Czc - Tertiary detritals- Colluvium - sand, gravel, valley fill
- Czr - Tertiary deposits- Hematite-geothite duricrust on slopes
- Fd - Fortescue Grp. Metadolerite sills, intrusive
- Fj - Jeerinah Frm. Pelite, chert, metasandstone
- Fjb - Fortescue Grp. Metabasalt, massive, pillowed
- Hm - Marra Mamba Iron Frm. BIF, chert, pelite
- Qa - Quaternary detritals- unconsolidated alluvium

Legend
- West Angelas Beyond 2020 Development Envelope
- Current Operations Development Envelope
- Indicative Proposed Pit
- Troglofauna Sample Site
- Previous Troglofauna Sampling

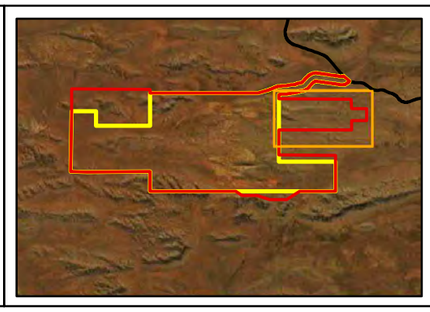
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Scale: 1:30,000

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Coordinate System: GDA 1994 MGA Zone 50
Projection: Transverse Mercator
Datum: GDA 1994 Created 16/08/2022



RIO TINTO IRON ORE

West Angelas: Subterranean Fauna Survey

Figure 5.7: Troglofauna recorded from Deposit H (Entognatha, Insecta)

688000 690000 692000 694000

7436000 7434000

Deposit F North

Fjb Fd Hm Czc Czr Qa Qw

Blattodea
- Nocticola `sp. Biologic-BLAT014`

Diplura
- Japygidae `sp. Biologic-DIPL017`

Hemiptera
- Meenoplidae sp. indet.
- Phaconeura `sp. Biologic-HEMI003`

Zygentoma
- Atelurinae `sp. Biologic-ZYGE011`
- Atelurinae sp. indet.

Surface Geology (GWSA 1:250k)
- Czc - Tertiary detritals- Colluvium - sand, gravel, valley fill
- Czr - Tertiary deposits- Hematite-geothite duricrust on slopes
- Fd - Fortescue Grp. Metadolerite sills, intrusive
- Fj - Jeerinah Frm. Pelite, chert, metasandstone
- Fjb - Fortescue Grp. Metabasalt, massive, pillowed
- Hb - Brockman Iron Frm. BIF, chert, pelite
- Hm - Marra Mamba Iron Frm. BIF, chert, pelite
- Hs - Mt McRae_Mt Sylvia Frm. Shale, BIF, pelite
- Qa - Quaternary detritals- unconsolidated alluvium
- Qw - Quaternary detritals- Alluvial soil, sand, clay

Legend
- West Angelas Beyond 2020 Development Envelope
- Current Operations Development Envelope
- Indicative Proposed Pit
- Troglofauna Sample Site
- Previous Troglofauna Sampling

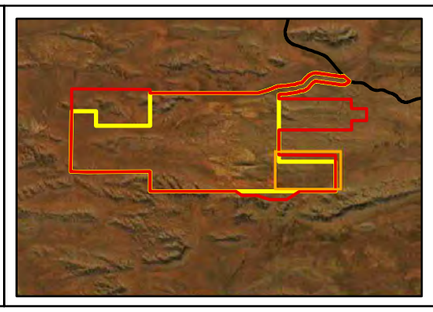
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biologic Environmental Survey

Scale: 1:20,000

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Coordinate System: GDA 1994 MGA Zone 50
Projection: Transverse Mercator
Datum: GDA 1994 Created 16/08/2022



RIO TINTO IRON ORE

West Angelas: Subterranean Fauna Survey

Figure 5.8: Troglofauna recorded from Deposit F North (Entognatha, Insecta)

676000 679000 682000 685000 688000 691000 694000

7431000

7428000

7425000

Mt Ella East

Czc Qw Hb Hs Hd Qa

Surface Geology (GWSA 1:250k)

- Czc - Tertiary detritals- Colluvium - sand, gravel, valley fill
- Czr - Tertiary deposits- Hematite-geothite duricrust on slopes
- Fd - Fortescue Grp. Metadolerite sills, intrusive
- Fj - Jeerinah Frm. Pelite, chert, metasandstone
- Hb - Brockman Iron Frm. BIF, chert, pelite
- Hd - Wittenoom Frm. Dolomite, chert, shale, BIF
- Hj - Weeli Wolli Frm. BIF, shale, dolerite sills
- Hm - Marra Mamba Iron Frm. BIF, chert, pelite
- Hs - Mt McRae_Mt Sylvia Frm. Shale, BIF, pelite
- Qa - Quaternary detritals- unconsolidated alluvium
- Qw - Quaternary detritals- Alluvial soil, sand, clay

Blattodea

- Nocticola `sp. Biologic-BLAT014`
- Nocticola sp. indet.

Coleoptera

- Coleoptera `sp. Biologic-COLE007`
- Coleoptera sp. indet.
- Pselaphinae `sp. Biologic-COLEO006`
- Pselaphinae `sp. Biologic-COLEO008`
- Pselaphinae sp. indet.

Diplura

- Japygidae `sp. Biologic-DIPL017`
- Japygidae sp. indet.
- Parajapygidae sp. indet.

Diptera

- Sciaridae `sp. Biologic-DIPT001`

Hemiptera

- Meenoplidae `sp. Biologic-HEMI001`
- Meenoplidae `sp. Biologic-HEMI006`
- Meenoplidae sp. indet.
- Oliarus `sp. WAM-CIXO001`
- Phaconeura `sp. Biologic-HEMI003`
- Phaconeura `sp. WAM-PHAC001`

Zygentoma

- Atelurinae `sp. Biologic-ZYGE011`
- Atelurinae `sp. Biologic-ZYGE014`
- Atelurinae sp. indet.
- Subnicoletiinae sp. indet.
- Trinemura `sp. Biologic-ZYGE017`
- Trinemura sp. indet.

Legend

- West Angelas Beyond 2020 Development Envelope
- Current Operations Development Envelope
- Indicative Proposed Pit
- Troglofauna Sample Site
- Previous Troglofauna Sampling

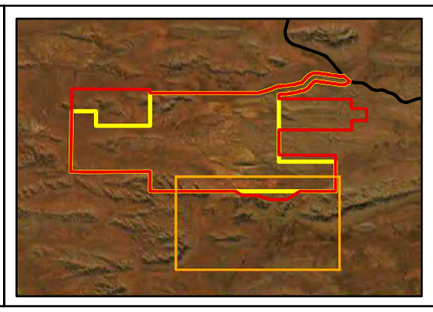
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biologic Environmental Survey

Scale: 1:50,000

0 1.5 3 Km

Coordinate System: GDA 1994 MGA Zone 50
Projection: Transverse Mercator
Datum: GDA 1994 Created 16/08/2022



RIO TINTO IRON ORE

West Angelas: Subterranean Fauna Survey

Figure 5.9: Troglofauna recorded from Deposit J reference area and Mt Ella East (Entognatha, Insecta)

5.2 Stygofauna

The current survey recorded a total of 328 stygofauna specimens, with 93 specimens identified (by morphological and molecular data) as belonging to 20 stygofauna species (or species level taxa) in seven taxonomic orders (Table 5.4 and 5.3).

A further 235 specimens were grouped in six indeterminate taxa (Appendix E) that could not be resolved to species-level, due to immaturity, poor specimen condition, inadequate diagnostic characters, or incomplete taxonomic information. Indeterminate taxa were omitted from further consideration as they could not be resolved to one or another species. Part of the indeterminate material also resulted from sub-sampling for genetic analyses and was almost certain to represent known taxa from the 20 established species. These have been omitted from further consideration.

Table 5.3: Number of stygofauna species/taxa and specimens recorded during the survey

Higher taxon	No. species/ taxa	No. specimens
Amphipoda	6	16
Bathynellacea (Syncarida)	2	3
Isopoda	1	4
Cyclopoida (Copepoda)	1	54
Harpacticoida (Copepoda)	1	1
Podocopida (Ostracoda)	1	2
Tubificida (Oligochaeta)	8	13
Grand Total	**20**	**93**

Stygofauna taxa were classified as “stygobite” / “potential stygobite” (12 taxon), “stygoxene/ stygophile” (3 taxa), or “amphibious stygoxene” (5 taxa, all Enchytraeidae), based on available taxonomic and ecological information, and regional distribution patterns where known (Table 5.4).

Species known to be widespread throughout catchments (or regionally) were classified as stygoxenes/ stygophiles because their ability to disperse beyond spatially restricted hydrogeological habitats is confirmed (possibly via hyporheic habitats or surface waters during flooding). Enchytraeid worms were classified as amphibious stygoxenes based on ecological knowledge that these worms can inhabit water films within air-filled subterranean cavities and are not strictly limited to groundwater habitats. Regional comparisons also frequently reveal regionally widespread or catchment-wide distributions for enchytraeids (e.g. Biologic, 2021b; Brown et al., 2015).

The known linear ranges of the stygofauna taxa were classified as (Table 5.4):

- ‘singleton’ / ‘single site’;
- ‘multiple local sites’ (range up to 15 km, in the same/ connected hydrogeological habitats);
- ‘locally widespread’ (range 15 km to 60 km, across different hydrogeological habitats); and
- ‘regionally widespread’ (recorded throughout the wider region, >100 km range, across different catchments).

These distribution categories were also taken into consideration in the assessment as ‘confirmed SRE’ (0 taxa), ‘potential SRE’ (9 taxa), or ‘widespread’ (8 taxa) following the WAM categorisation and Harvey’s (2002) range criterion as a guide (Table 5.4). Where regional comparisons were not available due to inconclusive taxonomy or a lack of available data, SRE status was classed as ‘uncertain’ (3 taxa).

The collection locations for stygofauna collected during the survey can be seen in Figure 5.10 (overview) and Figures Figure 5.11 to Figure 5.15 (detailed). A full list of subterranean fauna collected during the current survey, including collection site/date, can be found in Appendix G.

Table 5.4: Stygofauna species/OTUs detected from the Study Area (current survey), taxonomic and distribution comments, known linear ranges and collection locations.

Taxonomy	No. spms	Identification	Unique to Study Area/ found outside Study Area	Sub-fauna status	SRE status	Sampling areas	No. sites	Distribution, known linear range
Oligochaeta								
Enchytraeidae								
Enchytraeidae `sp. E6`	1	DNA	External match Marillana & Boolgeeda creeks, Synclinal valley (Biologic, 2016b, 2020; Brown et al., 2015)	Amphibious stygoxene	Widespread	Dep J ref area	1	Regionally widespread (100+ km)
Enchytraeidae `sp. E11`	1	DNA	External match McPhee, Boolgeeda & Weelumurra creeks (Biologic, 2021b; Brown *et al.*, 2015)	Amphibious stygoxene	Widespread	Dep F Nth	1	Regionally widespread (100+ km)
Enchytraeidae `sp. Biologic-OLIG006`	1	DNA	External match Greater Brockman (Biologic, 2021b)	Amphibious stygoxene	Widespread	Dep H	1	Regionally widespread (100+ km)
Enchytraeidae `sp. Biologic-OLIG007`	1	DNA	External match Rhodes Ridge (Biologic, 2021c)	Amphibious stygoxene	Widespread	Dep J ref area	1	Locally widespread (52.6 km)
Enchytraeidae `sp. Biologic-OLIG008`	2	DNA	External match Angelo River (Biologic, 2021a)	Amphibious stygoxene	Widespread	W Hill	2	Locally widespread (21.0 km)
Phreodrilidae								
Phreodrilidae `sp. Biologic-OLIG010`	1	DNA	Unique lineage	Potential Stygobite	Potential SRE	TCBF	1	Singleton
Phreodrilidae `sp. P1`	3	DNA	External match Weeli Wolli Creek (Brown *et al.*, 2015)	Stygophile/ Stygoxene	Widespread	CWB	1	Locally widespread (53.2 km)
Phreodrilidae `sp. P12`	3	DNA	External match Greater Brockman, Fortescue, & Synclinal valley (Biologic, 2016b, 2020; Brown et al., 2015)	Stygophile/ Stygoxene	Widespread	CWB, TCBF	2	Regionally widespread (100+ km)
Ostracoda								
Candonidae `sp. WAN`	2	Morphological. DNA unable to be tested.	Potentially unique family	Stygobite	Uncertain	CALC	1	Single site
Cyclopoida								
Diacyclops humphreysi	54	Morphological, named species complex	Known widespread species/complex (Pesce & De Laurentiis, 1996)	Stygophile/ Stygoxene	Widespread	CWB	1	Regionally widespread (100+ km)
Harpacticoida								
Parastenocaris cf. *jane*	1	Morpho-only. Similar to P. *jane*; uncertain	Potentially unique to Study Area (group lacks genetic work; recent sequencing indicates high diversity in line with narrow ranges of harpacticoids)	Stygobite	Uncertain	CWB	1	Singleton
Bathynellacea								
Atopobathynella `sp. Biologic-PBAT008`	1	DNA, morpho	External match Angelo River (Biologic, 2021a)	Stygobite	Potential SRE	Dep J ref area	1	Multiple local sites (13.2 km)
Billibathynella `sp. Biologic-PBAT007`	2	DNA, morpho	Unique lineage	Stygobite	Potential SRE	CWB	1	Single site

Taxonomy	No. spms	Identification	Unique to Study Area/ found outside Study Area	Sub-fauna status	SRE status	Sampling areas	No. sites	Distribution, known linear range
Amphipoda								
Kruptus `sp. Helix-AMP035`	1	DNA, morpho	Previous records in Synclinal valley (Biologic, 2016b)	Stygobite	Potential SRE	W Hill	1	Multiple local sites (6.2 km)
Kruptus? `sp. Biologic-AMPH016`	1	DNA, morpho	Unique lineage	Stygobite	Potential SRE	TCBF	1	Singleton
Maarrka `sp. Helix-AMP037`	1	DNA, morpho	Previous records in Synclinal valley (Biologic, 2016b)	Stygobite	Potential SRE	CALC	1	Multiple local sites (2.5 km)
Paramelitidae `sp. Biologic-AMPH017`	7	DNA, morpho	Unique lineage	Stygobite	Potential SRE	CWB	2	Multiple local sites (4.6 km)
Paramelitidae `sp. Biologic-AMPH018`	2	DNA, morpho	Unique lineage	Stygobite	Potential SRE	CALC	2	Multiple local sites (2.0 km)
Paramelitidae `sp. Helix-AMP036`	4	DNA, morpho	Previous records in Synclinal valley (Biologic, 2016b).	Stygobite	Potential SRE	CALC	2	Multiple local sites (10.3 km)
Isopoda								
Pygolabis `sp. WAN`	4	Morphological. Genus level ID. DNA failed	Potentially unique to Study Area, external comparisons limited by specimens/ DNA availability	Stygobite	Uncertain	CALC	2	Multiple local sites (1.1 km)

Note: Records highlighted in green were exclusively recorded from reference areas.

652000
664000
676000
688000
7440000
7428000

Western Hill
Calcrete Bores
Central Waterbores
Deposit H
Deposit F North
Mt Ella East
Deposit J
Turee Creek

Legend

West Angelas Beyond 2020 Development Envelope
Current Operations Development Envelope
Subterranean Fauna Reference Area
Indicative Proposed Pit
Stygofauna Sample Site

Order

Amphipoda
Cyclopoida
Enchytraeida
Haplotaxida (Oligochaeta)
Harpacticoida
Isopoda
Podocopida (Ostracoda)
Syncarida (Bathynellacea)

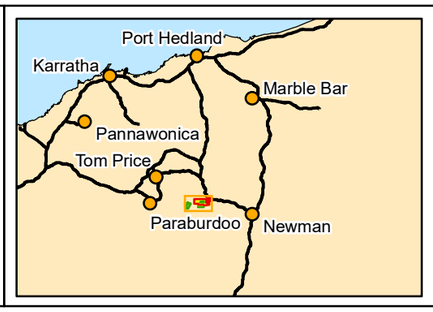
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biologic Environmental Survey

Scale: 1:143,000

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Coordinate System: GDA 1994 MGA Zone 50
Projection: Transverse Mercator
Datum: GDA 1994 Created 17/08/2022



RIO TINTO IRON ORE
West Angelas:
Subterranean Fauna Survey

Figure 5.10: Stygofauna recorded during the current survey (Overview)

660000 664000 668000 672000

7444000 7440000 7436000

Western Hill

Calcrete Bores

Central Waterbores

Amphipoda
- Amphipoda sp. indet
- Kruptus `sp. Helix-AMP035`
- Maarrka `sp. Helix-AMP037`
- Paramelitidae `sp. Biologic-AMPH018`
- Paramelitidae `sp. Helix-AMP036`
- Paramelitidae sp. indet.

Isopoda
- Pygolabis `sp. WAN`

Popocopida
- Candonidae `sp. WAN`

Tubificida
- Enchytraeidae `sp. Biologic-OLIG008`
- Enchytraeidae sp. indet.

Surface Geology (GWSA 1:250k)
- Czc - Tertiary detritals- Colluvium - sand, gravel, valley fill
- Czk- Tertiary deposits- Calcrete, drainage associated
- Fd - Fortescue Grp. Metadolerite sills, intrusive
- Fj - Jeerinah Frm. Pelite, chert, metasandstone
- Fjb - Fortescue Grp. Metabasalt, massive, pillowed
- Hb - Brockman Iron Frm. BIF, chert, pelite
- Hd - Wittenoom Frm. Dolomite, chert, shale, BIF
- Hm - Marra Mamba Iron Frm. BIF, chert, pelite
- Hs - Mt McRae_Mt Sylvia Frm. Shale, BIF, pelite
- Qa - Quaternary detritals- unconsolidated alluvium
- Qw - Quaternary detritals- Alluvial soil, sand, clay

Legend
- West Angelas Beyond 2020 Development Envelope
- Current Operations Development Envelope
- Subterranean Fauna Reference Area
- Indicative Proposed Pit
- Stygofauna Sample Site

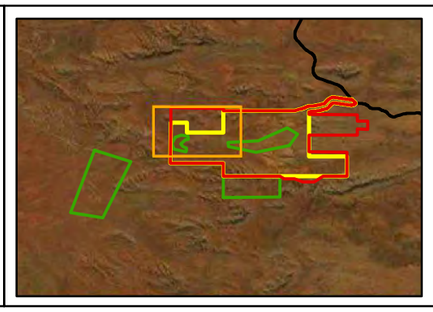
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biologic Environmental Survey

Scale: 1:40,000

0 1 2 Km

Coordinate System: GDA 1994 MGA Zone 50
Projection: Transverse Mercator
Datum: GDA 1994 Created 17/08/2022



RIO TINTO IRON ORE

West Angelas: Subterranean Fauna Survey

Figure 5.11: Stygofauna recorded at Western Hill and Calcrete Bores

672000 676000 680000

7440000

7436000

Amphipoda
- Amphipoda sp. indet
- Paramelitidae `sp. Biologic-AMPH017`
- Paramelitidae sp. indet.

Bathynellacea
- Billibathynella `sp. Biologic-PBAT007`
- Parabathynellidae sp. indet.

Cyclopoida
- Cyclopoida sp. indet.
- Diacyclops humphreysi

Harpacticoida
- Parastenocaris `sp. cf. jane`

Tubificida
- Enchytraeidae sp. indet.
- Phreodrilidae `sp. Biologic-OLIG009`
- Phreodrilidae `sp. P12`
- Phreodrilidae sp. indet.

Central Waterbores

Surface Geology (GWSA 1:250k)
- Czc - Tertiary detritals- Colluvium - sand, gravel, valley fill
- Fd - Fortescue Grp. Metadolerite sills, intrusive
- Fj - Jeerinah Frm. Pelite, chert, metasandstone
- Fjb - Fortescue Grp. Metabasalt, massive, pillowed
- Hd - Wittenoom Frm. Dolomite, chert, shale, BIF
- Hm - Marra Mamba Iron Frm. BIF, chert, pelite
- Hs - Mt McRae_Mt Sylvia Frm. Shale, BIF, pelite
- Qa - Quaternary detritals- unconsolidated alluvium
- Qc - Quaternary detritals- unconsolidated colluvium
- Qw - Quaternary detritals- Alluvial soil, sand, clay

Legend
- West Angelas Beyond 2020 Development Envelope
- Current Operations Development Envelope
- Subterranean Fauna Reference Area
- Indicative Proposed Pit
- Stygofauna Sample Site

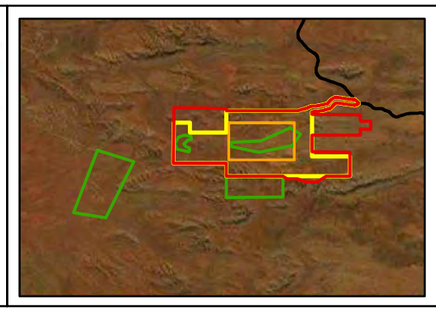
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Scale: 1:30,000

0 0.5 1 1.5 Km

Coordinate System: GDA 1994 MGA Zone 50
Projection: Transverse Mercator
Datum: GDA 1994 Created 17/08/2022



RIO TINTO IRON ORE

West Angelas: Subterranean Fauna Survey

Figure 5.12: Stygofauna recorded at Central Water Bores

688000 692000 696000 700000

7440000

7436000

Deposit H

Deposit F North

Central Waterbores

Hm Fjb Fj Czr Fd Qa Qw Czc

Legend

- West Angelas Beyond 2020 Development Envelope
- Current Operations Development Envelope
- Subterranean Fauna Reference Area
- Indicative Proposed Pit
- Stygofauna Sample Site

Tubificida

- Enchytraeidae `sp. Biologic-OLIG003`
- Enchytraeidae `sp. Biologic-OLIG006`

Surface Geology (GWSA 1:250k)

- Czc - Tertiary detritals- Colluvium - sand, gravel, valley fill
- Czr - Tertiary deposits- Hematite-geothite duricrust on slopes
- Fd - Fortescue Grp. Metadolerite sills, intrusive
- Fj - Jeerinah Frm. Pelite, chert, metasandstone
- Fjb - Fortescue Grp. Metabasalt, massive, pillowed
- Hm - Marra Mamba Iron Frm. BIF, chert, pelite
- Qa - Quaternary detritals- unconsolidated alluvium
- Qw - Quaternary detritals- Alluvial soil, sand, clay

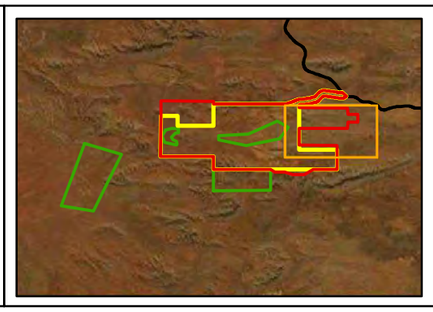
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Scale: 1:42,000

0 1 2 Km

Coordinate System: GDA 1994 MGA Zone 50
Projection: Transverse Mercator
Datum: GDA 1994 Created 17/08/2022



RIO TINTO IRON ORE

West Angelas: Subterranean Fauna Survey

Figure 5.13: Stygofauna recorded at Deposit F North and Deposit H

676000 680000 684000 688000 692000

7432000

7428000

Mt Ella East

Deposit J

Czc Hm Czr Qw Hb Hd Hs Qa

Surface Geology (GWSA 1:250k)

- Czc - Tertiary detritals- Colluvium - sand, gravel, valley fill
- Czr - Tertiary deposits- Hematite-geothite duricrust on slopes
- Hb - Brockman Iron Frm. BIF, chert, pelite
- Hd - Wittenoom Frm. Dolomite, chert, shale, BIF
- Hj - Weeli Wolli Frm. BIF, shale, dolerite sills
- Hm - Marra Mamba Iron Frm. BIF, chert, pelite
- Hs - Mt McRae_Mt Sylvia Frm. Shale, BIF, pelite
- Qa - Quaternary detritals- unconsolidated alluvium
- Qw - Quaternary detritals- Alluvial soil, sand, clay

Legend

- West Angelas Beyond 2020 Development Envelope
- Current Operations Development Envelope
- Subterranean Fauna Reference Area
- Indicative Proposed Pit
- Stygofauna Sample Site

Bathynellacea

- Atopobathynella `sp. Biologic-PBAT008`

Tubificida

- Enchytraeidae `sp. Biologic-OLIG003`
- Enchytraeidae `sp. Biologic-OLIG005`
- Enchytraeidae `sp. Biologic-OLIG007`
- Enchytraeidae sp. indet.

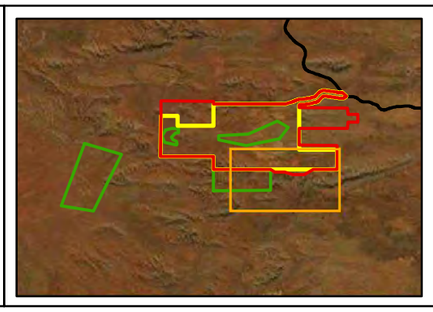
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Scale: 1:50,000

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Coordinate System: GDA 1994 MGA Zone 50
Projection: Transverse Mercator
Datum: GDA 1994 Created 17/08/2022



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West Angelas: Subterranean Fauna Survey

Figure 5.14: Stygofauna recorded at Deposit J reference area and Mt Ella East

640000 644000 648000 652000 656000

7436000 7432000 7428000

Turee Creek

Hb Hj Qa Qw Czl Czc Hs Hd Hw Hb

Surface Geology (GWSA 1:250k)

- Czc - Tertiary detritals- Colluvium - sand, gravel, valley fill
- Hb - Brockman Iron Frm. BIF, chert, pelite
- Hd - Wittenoom Frm. Dolomite, chert, shale, BIF
- Hj - Weeli Wolli Frm. BIF, shale, dolerite sills
- Hs - Mt McRae_Mt Sylvia Frm. Shale, BIF, pelite
- Hw - Woongarra Volcanics- Rhyolite, rhyodacite, tuff
- Qa - Quaternary detritals- unconsolidated alluvium
- Qw - Quaternary detritals- Alluvial soil, sand, clay

Legend

- West Angelas Beyond 2020 Development Envelope
- Current Operations Development Envelope
- Subterranean Fauna Reference Area
- Stygofauna Sample Site

Amphipoda

- Kruptus? `sp. Biologic-AMPH016`

Tubificida

- Phreodrilidae `sp. Biologic-OLIG010`
- Phreodrilidae `sp. P12`
- Phreodrilidae sp. indet.

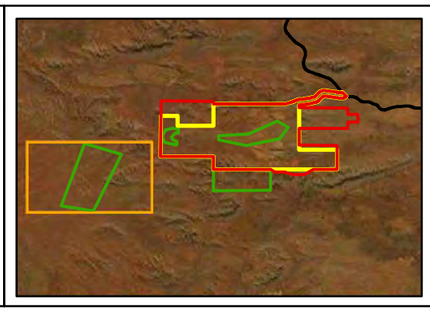
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biologic Environmental Survey

Scale: 1:57,000

0 1 2 3 Km

Coordinate System: GDA 1994 MGA Zone 50
Projection: Transverse Mercator
Datum: GDA 1994 Created 17/08/2022



RIO TINTO IRON ORE

West Angelas: Subterranean Fauna Survey

Figure 5.15: Stygofauna recorded at Turee Creek Borefield

6. SUBTERRANEAN HABITAT ASSESSMENT

Information on the subterranean fauna habitats within the Study Area is based upon available geological/ hydrogeological reports and surface geology maps (GSWA 1:250,000; DMIRS, 2019). Groundwater physicochemical measurements taken during the survey were incorporated into the stygofauna habitat assessment where appropriate. Where available, depth to groundwater was accounted for when assessing the extent of troglofauna habitat. Cross-comparisons of surface geology and bore logs revealed several lithologies that are likely to provide suitable habitat within each of the sampling areas (Rio Tinto, 2018a). These units are described further below in reference to troglofauna habitats (AWT) and stygofauna habitats (BWT).

6.1 Troglofauna habitat

Geology alone is not a precise predictor of suitable subterranean fauna habitat, but generally in most geological settings within the Hamersley sub-region of the Pilbara, it is reasonable to assume that certain stratigraphic layers tend to be structurally suitable due to the prevalence of fractures, cavities from secondary weathering, and pore spaces under certain conditions. Those conditions commonly include proximity to the surface (below approximately 150 m cavities can become rarer due to pressure and infill), extent of secondary weathering / mineralisation, and proximity to structural elements such as faults, shears, and fracture zones.

6.1.1 AWT habitats – major geologies

Two of the most common geologies that frequently meet these criteria in the Hamersley Ranges are the Brockman Iron Formation (BrIF) and Marra Mamba Iron Formation (MMIF), which have been well-sampled for troglofauna and are known to provide highly suitable AWT habitat throughout the region. Habitable fractures, cavities and pore spaces are prevalent throughout the Dales Gorge and Joffre Members of the BrIF, the Mt Newman Member of the MMIF and in pods of hematite-goethite-martite hardcap (pisolitic duricrust) which regularly form on the flanks of BrIF and MMIF ranges. These pisolitic duricrust pods comprise enriched, 'hydrated mineralisation' orebodies, which are often the focus of mining, along with the higher-grade zones of the BrIF or MMIF bedrock.

Secondary and tertiary detrital deposits occurring in valleys between such ranges frequently contain unconsolidated colluvium/ alluvium, calcrete, and Robe Pisolite (also known as channel iron deposits or CID). CID deposits are frequently porous and subject to secondary weathering (or karstification in the case of calcrete) and may provide suitable habitats in cavities and pore spaces AWT. The Wittenoom Dolomite Formation, typically occurring deeper in the valleys between the BrIF and the MMIF, may also be weathered or karstified (particularly the Paraburdoo and Bee Gorge Members), and can provide habitat where occurring AWT.

Faulting creates fracture zones throughout the basement rocks, providing potentially interconnected networks of suitable AWT habitat for troglofauna between different stratigraphic layers. Habitat connectivity between superficial layers of the bedrock and detrital habitats in valleys may occur in some areas where the flanks of ranges are covered in thick unconsolidated colluvium. In some areas

impermeable intrusives such as dykes and sills may provide barriers to fauna movement and thus disconnect areas of suitable habitat. Less permeable layers within the stratigraphy (e.g. Mt McRae Shales, the West Angela Member of the Wittenoom Formation, and the fresh BIF and shale bands within the BrIF, MMIF, and Weeli Wolli Iron Formation) may also cause interruptions to habitat connectivity where the stratigraphy changes at geological contact zones. In some areas, major faulting and shear zones may disrupt the connectivity of otherwise suitable habitat layers by altering the stratigraphic pattern in complex ways.

Wider habitat connectivity beyond or around faulting and shear structures may be possible throughout the overlying detrital formations (particularly in valleys), depending on pore size and the granularity of detrital material. However, alluvial plains have been found to present phylogeographic barriers to the dispersal of *Trinemura* silverfish (Smith *et al.*, 2012). Valley fill detrital habitats can be vertically constrained by near surface groundwater tables, and if adjacent to drainage lines they may be subject to periodic inundation. Nevertheless, shallow detrital deposits (approx. 5-10 m to groundwater) are known to provide highly suitable AWT habitats for troglofauna (Bennelongia, 2015; Biota, 2017).

A summary of the prospective AWT habitats relevant to each sampling area is provided in Table 6.1.

Table 6.1: Prospective geological AWT habitats within each sampling area

Sampling Area	Brockman Iron Formation	Marra Mamba Iron Formation	Detritals	Wittenoom Formation	Other
Western Hill	Series of BrIF hills extending to the east.	Not present.	Tertiary detritals (colluvium, alluvium) occur widely in valley surrounding Western Hill.	Occurs at depth in the synclinal valley, mainly BWT.	Calcrete occurs AWT and BWT throughout the synclinal valley
Deposit J reference area	East-west striking ridgeline which has been locally eroded.	Not present.	Tertiary detritals (colluvium, alluvium) widely overlay the BrIF.	Occurs to the north-west, poorly drilled	Negligible.
Deposit H	Not present.	East-west striking band extending west beyond the deposit area	Superficial deposits of laterite and alluvium flank the MMIF	Not present.	Low suitability Jeerinah Formation surrounds the MMIF.
Mt Ella East	Extensive east-west striking ridgeline. Deposits are located along the northern flank.	Not present.	Superficial deposits of laterite flank the BrIF range and colluvium/ alluvium is found in the valley below.	Not present.	Negligible.
Deposit F North	Not present.	East-west striking ridge extending west beyond the deposit area	Superficial deposits of colluvium and laterite overlay the MMIF over large areas	Not present.	Negligible.

6.1.2 AWT habitats – sampling areas

Western Hill

Geological mapping indicates that at Western Hill, prospective suitable AWT habitats for troglofauna mainly occur within the Brockman Iron Formation (BrIF). The BrIF forms a series of rounded hills which extend to the east of Western Hill. The hills are separated by a small valley in the west and a broad valley in the east of the sampling area. At the location of the deposits, a well-developed hydrated zone occurs within the BrIF which is the main target for mining and represents highly suitable prospective troglofauna habitat (Rio Tinto, 2018a). The BrIF is bound by the Mount McRae Shale (shale sequence) and Mount Sylvia Formations (BIF bands separated by chert shale sequences), both to the south as well as to the north of Western Hill. Habitat suitability for troglofauna within these lower permeability geological units is generally considered low and they may represent potential barriers for species dispersal. However, localised troglofauna habitat may still occur where geologies are sufficiently fractured and/ or faulted.

Calcrete has been mapped in the synclinal valley between the BrIF and the MMIF to the south of Western Hill. Calcrete deposits may be weathered and karstified and can therefore provide further suitable troglofauna habitat where occurring AWT.

Superficial detrital deposits (colluvium, alluvium) occur widely in the valleys surrounding Western Hill. These deposits have the potential to provide further suitable troglofauna habitat near subsurface and may provide wider habitat connectivity beyond the BrIF. Shallow, superficial deposits of laterite/ pisolitic duricrust also occur in localised areas on the flanks of the BrIF and may represent further suitable troglofauna habitat near subsurface.

Deposit J reference area

At the Deposit J reference area, prospective suitable habitats for troglofauna occur primarily within the Brockman Iron Formation which forms a prominent east-west striking ridgeline that extends well beyond the sampled area. The ridgeline has been largely eroded and is overlain by tertiary detritals (colluvium and alluvium) which provide further prospective AWT habitats throughout the local area, as the water table is at approximately 80-115 mbgl. Localised patchiness of detrital habitats AWT is expected (due to variabilities in sediment texture), but there is a reasonable likelihood that the suitable habitats in the Brockman Iron Formation and the surrounding detrital habitats on the flanks of the ridges (inclusive of superficial laterite/ pisolitic duricrust pods) are well connected.

Deposit H

At Deposit H, prospective suitable AWT habitats for troglofauna mainly occur within the Marra Mamba Iron Formation. The Marra Mamba Iron Formation (MMIF) forms an east-west striking band hosting the proposed deposit and extending well beyond the deposit to the west and, to a lesser degree, to the east. Weathering of the MMIF has produced significant hydrated/ mineralised zones in the vicinity of the deposit (Rio Tinto, 2018a). These well-developed hydrated mineralisation zones represent highly suitable prospective troglofauna habitat as they contain many voids, vugs and cavities.

The MMIF band is bound to the north and south by the Jeerinah Formation (mudstone and siltstone with sills of metabasalt). This geological unit is less likely to host significant AWT habitats for troglofauna, as enrichment and weathering (and consequently vugs, voids and cavities) are less prevalent in this unit compared to BrIF and MMIF, and its permeability is generally considered low. However, localised troglofauna habitat may still occur where geologies are sufficiently fractured and/or faulted.

Shallow, superficial deposits of laterite and alluvium flank the MMIF in localised areas which have the potential to represent further suitable troglofauna habitat near subsurface.

Mt Ella East

The Mt Ella East deposits are located along the northern flanks of the east-west striking Brockman Iron Formation ridgeline. Consequently, the main prospective AWT habitats for troglofauna occur within the BrIF, within superficial laterite/ pisolite deposits flanking the ridgeline as well as within tertiary detrital deposits that are associated with the valley below.

Mount McRae Shale and Mount Sylvia Formations occur along the northern flank which may represent potential barriers to troglofauna species dispersal due to their generally low permeabilities (unless sufficiently fractured and/or faulted).

Deposit F North

This deposit is primarily hosted by the Marra Mamba Formation (MMIF) which forms an east-west striking band that extends well beyond the deposit to the west. Whilst the MMIF represents medium to highly suitable habitat for troglofauna, the prospective habitable zone suitable for troglofauna is relatively thin, as the groundwater table in this area is close to the surface (10-20 mbgl). Consequently, the main prospective AWT habitats at this deposit comprise superficial detrital layers which widely overlay the MMIF.

6.2 Stygofauna habitat

The hydrogeological settings of the Study Area are characterised by a variety of fractured/ weathered rock aquifers within mineralised iron formations, variably porous detrital valley fill aquifers with patchy karstic calcrete deposits and fractured/ weathered/ karstic dolomites of the Wittenoom Formation deeper in the valley profile. Several different hydrogeological zones are formed by the underlying bathymetry of the basement rocks of the regional syncline-anticline formation, including the orebody aquifers, synclinal valley aquifers, and central anticline aquifers. Local differences in the topography, hydrostratigraphy, surface drainage patterns, and catchment sizes influence groundwater flows and connectivity of BWT habitats for stygofauna within and between these three major areas.

6.2.1 BWT habitat – major aquifer types

The following are detailed descriptions of the three aquifers of importance (Dodson, 2006; Rio Tinto, 2018b):

Orebody aquifers

The hydrated and mineralised orebodies within each of the survey areas are associated with high permeability fractured/ weathered rock aquifers where occurring BWT, particularly in the Newman Member (MMIF) and the Dales Gorge and Joffre Members (BrIF). Adjacent porous/ fractured rock layers of a similar type may form interconnected BWT habitats with the orebody aquifers, including the Paraburdoo and Bee Gorge Members of the Wittenoom Formation (and in some areas the more permeable portions of the West Angelas Shales), as well as any hydrated hardcap occurring BWT on the lower flanks of the MMIF and BrIF orebodies. Groundwater flows in these types of systems are variable, with recharge being localised to the upper slope sections of the same geology, and lateral flows often constrained to the strike of the stratigraphic layer by less permeable shales and dolerites within other nearby layers. In some areas, intrusive dykes and sills at various angles may disrupt lateral flows along strike. Geological disconformities (faulting and shearing) can complicate flow patterns by creating fracture zones (increasing connectivity) and by disrupting the stratigraphic continuity (potentially decreasing connectivity). Orebody aquifers may be variably connected to the nearby synclinal valley aquifers where permeability is maintained throughout all of the various rock/ detrital layers; or in some cases, fresh rock, shales, and clays may interrupt this wider connectivity.

Synclinal valley aquifers

Within the synclinal valleys adjacent the orebody deposits (i.e. between the BrIF and the MMIF), aquifers are hosted within deep tertiary detritals, calcrete deposits, and the upper, weathered layers of the Wittenoom Dolomite Formation. Permeability is variable in the detritals due to changes in sediment texture from gravel to clays, and the degree of karstification/ weathering of the calcrete and dolomite deposits. There are two arms of the synclinal valley surrounding the central Wonmunna Anticline; the northern arm begins at Deposit G, and continues westward between Deposit C and Western Hill, and the southern arm, which begins north of Mt Ella East and continues westward to the south of Deposit D.

Groundwater in both arms flows from east to west, and recharge is received from a combination of local infiltration, and also from surface drainage lines that capture flows from the nearby BrIF and MMIF ridges. Surface flows from tributaries exiting the centre of the anticline may also be received, but the groundwater of the central anticline area is a separate system, not directly connected to the synclinal valley. While the groundwater table in the northern arm of the synclinal valley is reasonably shallow throughout (ranging from 5-20 mbgl), the water table is comparatively deep in the southern arm (ranging from approximately 140 mbgl at the far eastern end near Deposit E, to 40 mbgl south of Deposit D).

A large calcrete deposit occurs in the synclinal valley from the western tip of the anticline (south of Western Hill) to the western boundary of the West Angelas Development Envelope and beyond. The eastern extent of this calcrete deposit, which forms a large BWT habitat, was sampled in the current survey via the Calcrete bores to the west of Deposits C and D, as no bores or drill holes were available further to the west. This calcrete deposit is highly connected/ continuous with other detrital BWT habitats in the northern and southern synclinal valleys.

Central anticline aquifers

The hydrogeological setting of the central anticline is dominated by volcanic rocks of the Fortescue Group (e.g. Jeerinah Formation, Bunjinah Formation), which are mostly of low permeability. There is a thin layer of detrital material lying atop this area, which is thicker and more well developed in the vicinity of drainage lines that flow outwards towards the synclinal valley. Several old water bores targeting fractures in the Jeerinah and detritals associated with drainage lines in this area have revealed stygofauna assemblages from sampling; therefore, moderate habitat suitability is confirmed, despite the geological setting not being well-known for supporting subterranean fauna.

Groundwater levels in the central anticline are relatively shallow, ranging between 10-20 metres below ground level (mbgl). Groundwater levels between the anticline and the southern orebody aquifers decline steeply, suggesting a lack of hydraulic connection (Dodson 2006).

6.2.2 BWT habitats – sampling areas

Throughout the Study Area, each of the seven sampling areas has its own separate hydrogeological habitat that is not related to the other sampling areas. This is attributed to the different hydrological catchments occurring throughout the Study Area, the spatial distances between the various deposits/ sampling areas, and the different geological/ hydrogeological settings that occur in each area. The differences between the potential BWT habitats occurring at each sampling area are considered to be a major factor in the different stygofauna results revealed by sampling to date, with some areas having significantly greater stygofauna diversity and abundance than others.

Further details regarding the suitable BWT habitats at each sampling area are provided below, with an overall summary shown in Table 6.2 (further below the text).

Western Hill & Calcrete Bores (synclinal aquifer)

Two different hydrogeological settings occur at Western Hill; with deep groundwater hosted in mineralised/ weathered bedrock of the Dales Gorge Member (Brockman Iron Formation), and a broad regional aquifer hosted in deep detritals and weathered/ fractured Wittenoom Formation of the synclinal valley surrounding Western Hill.

The mineralised Dales Gorge Member within/ beneath Western Hill is highly weathered and intensively faulted/ fractured, creating a highly porous aquifer. However, groundwater occurs at considerable depth below Western Hill (approx. 75-120 mbgl) where the ridge is at its highest point, and the intense faulting complicates broader groundwater connectivity in this area. A thick band of low porosity Mt McRae Shales underlies the Dales Gorge Member, and outcrops to the south of Western Hill, forming a low suitability barrier between the mineralised orebody aquifer and the wider synclinal aquifer in the valley to the south. Limited habitat connectivity may exist where the Mt McRae Shales have also been subject to deep faulting/ fracturing.

The regional synclinal aquifer surrounding Western Hill in three directions (south, west, north) is hosted in deep tertiary detritals, calcrete deposits, and fractured/ weathered Wittenoom Dolomite. The synclinal

aquifer is unconstrained and extensive within and beyond the Study Area, and is likely to provide highly suitable, well-connected stygofauna habitats.

Several dykes occur within the bedrock in these areas, striking from the north-west to the south-east. These dykes do not appear to affect groundwater flows or create compartmentalisation, due to the influence of faulting/ fracturing, and the occurrence of thick, porous detritals and calcrete layers occurring atop the dykes in the synclinal valley.

Deposit H

Deposit H hosts a deep mineralised orebody aquifer in the Mt Newman Member of the Marra Mamba Iron Formation. The MMIF has been deeply fractured and folded in this area, creating a highly porous/ fractured bedrock aquifer that is constrained in all directions by low permeability Fortescue Group geologies. The Deposit H aquifer is deep and porous, and with groundwater occurring between 20-50 m from surface, it would be expected to be suitable for stygofauna. However, the aquifer is a moderately sized, enclosed 'bath-tub' type system which is not connected to other nearby aquifers or drainage, and is supported only by local infiltration through the MMIF. Consequently, this type of aquifer setting would be expected to have some limitations in terms of the diversity or abundance of stygofauna assemblages that it can support.

Mt Ella East

No significant aquifer or suitable groundwater habitat is known to occur to occur within the BrIF at Mt Ella East. The groundwater table in the synclinal valley to the north of the deposit is very deep (approx. 113 - 120 mbgl). Groundwater at such depths is generally considered low suitability for stygofauna due to low input of nutrients and oxygen from the surface above (Hose et al., 2015). The Mt Ella East deposit is elevated on the northern flank of a tall and extensive mountain range formed in BrIF and is expected to be entirely AWT. No stygofauna have been recorded from sampling at Mt Ella East, and consequently this area is not expected to support suitable stygofauna habitat.

Deposit F North

Deposit F North sits on the northern flank of a MMIF ridge, opposite the existing operations at Deposit F. The MMIF ridge sits atop a hydrological divide between the Weeli Wolli Creek catchment (draining to the north-east to the Fortescue River) and the Turee Creek catchment (draining south-west towards the Ashburton River). Groundwater in the area south of Deposit F (existing operations) area is very deep from surface (approx. >120 mbgl) and is of low habitat value for stygofauna. Meanwhile the area north/ east of Deposit F North is dominated by the low porosity Fortescue Group geologies similar to the central anticline.

No regional aquifer or extensive potential BWT habitat has been shown to occur in the vicinity of Deposit F North. At Deposit F North, groundwater occurs as small, locally constrained patch in the mineralised Mt Newman Member of the Marra Mamba Formation. Groundwater is located deep below the surface at ~716 mRL (~78 m below ground), interpreted from exploration hole geophysics and validated with water levels from two 2017 exploration grade holes converted into monitoring bores. The water table is approximately 46 m higher than in Deposit F to the south, which suggests a disconnect between these

orebodies. The patch of groundwater at Deposit F North is functionally disconnected from other groundwater systems as it is surrounded by low permeability unmineralized MacLeod and Nammuldi Members of the Marra Mamba Iron Formation on all sides. No stygofauna species have been recorded from sampling and this habitat is not expected to be suitable for stygofauna due to its isolation, low porosity, and low throughflow of water.

Deposit J reference area

Groundwater in the Deposit J reference area is primarily hosted within the orebody aquifers of the east-west extending BrIF (e.g. mineralised Dales Gorge Member). Further prospective BWT habitats may occur within tertiary detritals which overlay the BrIF throughout the local area, although the depth of the water table at approx. 87 -115 mbgl means that the majority of groundwater is likely to be hosted in fractured/ mineralised orebody aquifers below the detritals. The Wittenoom Dolomite Formation occurs north-west of the sampling area and may also host suitable habitat (where weathered/ fractured), but this area is poorly drilled therefore habitat quality and groundwater depth from surface is uncertain.

A low permeability layer of Mt McRae Shales occurs to the immediate north of the Dales Gorge Member in this area and plunges steeply to underlie the orebody aquifer at depth. The Mt McRae Shales are likely to divide any groundwater in the Wittenoom Formation in the northwest from the Dales Gorge aquifer to the south/ east. The Mt McRae Shales also form a basement layer that dips steeply and gets progressively deeper with distance south from the main BrIF ridge. The depth of groundwater in the orebody aquifer starting at approximately 100 m below the surface may be a limiting factor for stygofauna abundance and diversity in this area.

Based on catchment boundaries, it is expected that the Deposit J aquifer continues beyond the Study Area to the south, although drilling in this area is patchy and the conceptualisation is preliminary.

Central Water Bores

The hydrogeological setting at the Central Water Bores is within the Wonmunna anticline which is dominated by volcanic rocks of the Fortescue Group (e.g. Jeerinah and Bunjinah Formations). The Bunjinah Formation is regarded as low porosity and low storage capacity and does not form aquifers. The Jeerinah Formation is mostly of low permeability; however, localised patches of potential groundwater habitat may occur where fractures/faults occur, and where overlying detritals connect with fractured Jeerinah. A relatively thin detrital layer lies atop the Jeerinah Formation (10-20 mbgl), which tends to be thicker and more well developed along drainage lines and is known to provide localised suitable habitats for stygofauna.

Turee Creek Borefield

The Turee Creek Borefield is located to the west of the West Angelas Study Area within the Turee Creek catchment. The borefield area is underlain by weathered and fractured basement rocks of the Boolgeeda Iron Formation, Weeli Wolli Formation and Wongarra Volcanics which host deep aquifers of high storage but moderate porosity (Rio Tinto, 2009; Woodward-Clyde, 1997). These deep aquifers are overlain by widespread tertiary detritals (alluvium and colluvium) which also host moderately suitable groundwater

habitat for stygofauna. Vertical connectivity between the aquifers can be limited due to the presence of clays which limit groundwater flow. The depth to groundwater varies between 31 and 57 mbgl.

Table 6.2: Prospective hydrogeological BWT habitats within each sampling area

Sampling Area	Brockman Iron Formation	Marra Mamba Iron Formation	Detritals	Wittenoom Formation	Calcrete	Other
Western Hill orebody	Mineralised/ weathered Dales Gorge aquifer at depth beneath Western Hill	Not present.	Some tertiary detritals between hills of WH – unknown whether saturated.	Not present.	Not present.	McRae Shales provides low-porosity barrier between Dales Gorge (WH) and Wittenoom/ detrital aquifer
Calcrete bores/ synclinal aquifer	Minor, only in the periphery of W Hill OB aquifer	Occurs at depth beneath the Wittenoom, and in the periphery. Suitability uncertain	Extensive tertiary detritals aquifer throughout synclinal valley. Large calcrete deposits south of WH	Extensive fractured/ weathered aquifer at depth in the synclinal valley	Highly suitable BWT habitats in the synclinal valley, extending beyond the Study Area.	As above
Deposit J reference area	Mineralised/ weathered Dales Gorge aquifer at depth beneath & south of deposit	Not present.	Detritals mostly AWT, not a significant aquifer	Occurs to the north-west, poorly drilled	Negligible.	McRae Shales provides low-porosity barrier in some areas
Deposit H	Not present.	Mineralised/ weathered Mt Newman aquifer deep, porous, enclosed system	Negligible	Not present.	Negligible.	Low porosity Fortescue Group geologies surround/ enclose the MMIF.
Mt Ella East	Mainly AWT. Groundwater occurs at significant depth (150m) in valley to north	Not present.	Very deep detrital aquifer to the north (in valley) – not a significant habitat for stygofauna	Not present.	Not present.	Negligible.
Deposit F North	Not present.	Minor, localised pockets of groundwater at depth in MMIF – not a significant habitat for stygofauna	Very deep detrital aquifer to the south (in valley) – not a significant habitat for stygofauna	Not present.	Negligible.	Low porosity Fortescue Group geologies occur north of MMIF.
Central Water Bores	Not present.	Not present.	Thin detritals associated with drainage lines - localised suitable habitats	Not present.	Negligible.	Low porosity Fortescue group geologies provide basement to detrital aquifer.
Turee Creek Borefield	Not present.	Not present.	Extensive suitable habitats within deep tertiary detritals.	Not present.	Not present.	Deep aquifers in Boolgeeda, Weeli Wolli and Wongarra Formations. Uncertain suitability.

6.3 Groundwater characteristics

Figures 6.1A-D show mean (with standard deviations as error bars) temperature, pH, electric conductivity (EC; a proxy for salinity), and redox potential (ORP) for bores within Turee Creek Borefield (TCB), Central Water Bores (CWB), Calcrete bores (Calc), Western Hill (WHill), Deposits F North and H (Dep F/H), and Deposit J reference area (Dep J). The interpretation of these data is somewhat affected by the unequal sample sizes between areas due to differences in the availability of bores that intercepted groundwater. Twenty-one groundwater samples were obtained at TCB, 13 samples at CWB, 16 samples at Calc, 4 samples at WHill, 4 samples at Dep F North/H, and a single sample from Deposit J reference area. The groundwater of the Study Area is generally consistent with the central Pilbara groundwater (circumneutral pH, fresh to brackish salinity, and positive/near-positive ORP).

Average groundwater temperatures ranged from 26.4 to 29.9 °C (Figure 6.1A). The pH of the groundwater (Figure 6.1B) ranged from 6.6 to 7.50 across all sites, indicating neutral conditions suitable for stygofauna. The EC measurements (Figure 6.1C) showed that the average salinity of the groundwater ranged from fresh to slightly brackish in three sampling areas; with TCB, Calc, Dep F North/H and Dep J reference area containing mostly fresh water (EC <1,500 µS/cm), and WHill and CWB being slightly brackish (EC ~1700 to 1800 µS/cm). These levels are well within the range suitable for stygofauna and can support rich stygofauna assemblages.

Redox measurements (Figure 6.1D) are typically variable between sites due to individual bore conditions rather than representative of overall aquifer conditions. The redox potential of groundwater is a non-specific measure of the system's capacity to oxidise or reduce materials through chemical reactions and has important implications for metal mobility, bio-availability and toxicity (Schuring *et al.*, 1999). The groundwater in sampling areas showed positive average ORP's (range: 1.6 – 159.2) indicating an oxidizing environment suitable for stygofauna occurrence.

Overall, the groundwater chemistry measured throughout the Study Area was found to be suitable for stygofauna and is not expected to negatively affect abundances at West Angelas.

The full range of physicochemical data for all bores/drill holes measured during the survey can be found in Appendix F.

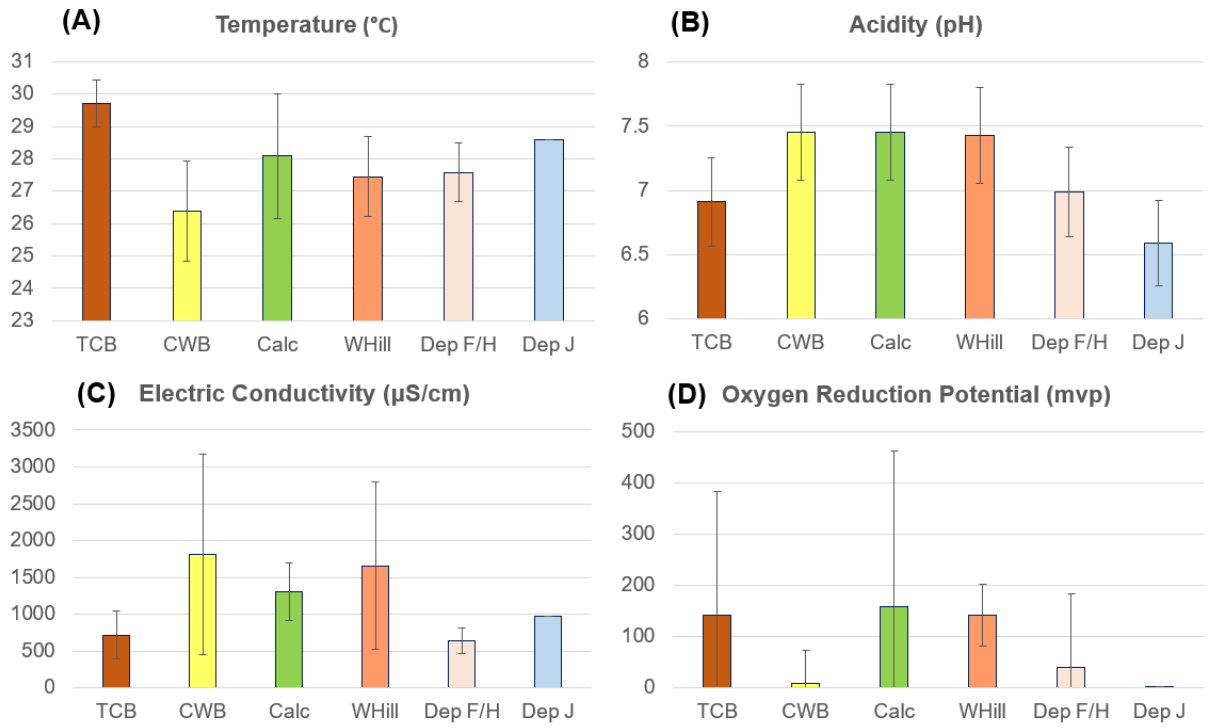


Figure 6.1: Groundwater physicochemical measurements recorded during sampling at Turee Creek Borefields (TCBF), Central Water Bores (CWB), Calcrete bores / Western Hill (Calc/WHill), Deposits F North/H, and Deposit J reference area. Mean values are shown as bars, standard deviations as error bars

7. DISCUSSION

7.1 Distributions of subterranean taxa/ assemblages

The troglofauna taxa recorded at West Angelas showed a variety of different distribution patterns, as is commonly found in troglofauna assemblages throughout the Pilbara region. Table 7.1 shows that different taxonomic groups had differing patterns of occurrence. Some troglofauna groups were predominantly recorded as singletons (e.g. Araneae, Palpigradi, Pauropoda, and to a lesser degree Isopoda and Zygentoma), while other groups were predominantly widespread (Blattodea and Hemiptera locally widespread, Polyxenida regionally widespread), and other groups showed mixed patterns (e.g. Symphyla). For the stygofauna, patterns were less clear due to lower numbers of species detected, apart from the Amphipoda (which were mainly recorded from multiple local sites), and the Oligochaeta (mainly regionally widespread).

Table 7.1 Number of troglofauna and stygofauna taxa per taxonomic group with various distribution patterns (shaded cells indicate the highest number of taxa per group)

Taxonomic group	Singleton	Multiple local sites	Locally widespread	Regionally widespread	Total
TROGLOFAUNA					
Araneae	6	1	2		9
Blattodea	1		2		3
Chilopoda	1		1		2
Coleoptera	1	2			3
Diplura	1		1		2
Diptera			1		1
Hemiptera			4	3	7
Isopoda	2	1			3
Palpigradi	6	1			7
Pauropoda	6		2	1	9
Polyxenida				3	3
Pseudoscorpiones	4	4	1		9
Spirobolida		1			1
Symphyla	3		3		6
Zygentoma	3	1	1		5
Total	**34**	**11**	**18**	**7**	**70**
STYGOFAUNA					
Amphipoda	1	5			6
Bathynellacea	1	1			2
Isopoda		1			1
Cyclopoida				1	1
Harpacticoida	1				1
Ostracoda	1				1
Oligochaeta	1		3	4	8
Total	**5**	**7**	**3**	**5**	**20**

Meanwhile each of the various sampling areas (Western Hill, Dep H, F North, Mt Ella East, plus Dep J reference area, CWB, TCBF and calcrete bores/ synclinal aquifer) showed reasonably different subterranean fauna assemblages, as shown by the number of species shared between deposit areas versus the numbers of species recorded only at single deposit areas (Appendix I).

For troglofauna, this pattern is very commonly observed throughout the region, owning mainly to high numbers of troglofauna taxa collected from single sites or few sites in close proximity to each other. The relative spatial spread between each deposit area, and the geologically distinct habitats (e.g. BrIF *vs.* MMIF), would generally be expected to increase the likelihood of species and assemblage turnover for troglofauna across the Study Area.

Appendix I shows that, out of a total 70 troglofauna species, 40 (approx. 57%) were recorded at only one deposit area, 16 taxa (approx. 23%) were shared between two or more deposit areas, and interestingly, 25 taxa (approx. 36%) have been found externally beyond West Angelas based on regional genetic comparisons. The relatively high proportion of external matches is attributed to the ability to undertake comprehensive regional comparisons based on genetic data collected extensively from unpublished Biologic surveys in the surrounding region. It is likely that many of the taxa occurring widely throughout and beyond the Study Area are troglophiles/ trogloxenes, or potential soil fauna (particularly amongst the insect groups, polyxenid millipedes, and certain other myriapods, refer Table 5.2) with more generalist habitat requirements than obligate troglobitic taxa. Nevertheless, based on regional geological information it is also reasonably likely that suitable AWT habitats occur widely throughout and beyond the Study Area boundaries, and some of the distributions of the troglofauna taxa may reflect this.

Some of the deposit areas within the Study Area are also likely to be somewhat connected, either via AWT detrital habitats (e.g. Dep F North and Mt Ella East), or the same geological settings (e.g. Mt Ella East and Dep J reference area). Nevertheless, it is common to find some troglofauna species (particularly obligate/ troglobitic fauna such as arachnids and some myriapods, isopods, refer Table 7.1) that do not or cannot disperse as widely as others, and show stronger patterns of turnover with spatial distance or different geological settings. The current results provide a reasonable snapshot of such trends between the different deposit areas; further analysis in combination with more detailed habitat assessment may be warranted for future EIA.

These types of patterns were more distinct for stygofauna than for troglofauna; the assemblages detected at each deposit/ sampling area showed very few shared across the Study Area, and only locally/ regionally widespread oligochaetes (Appendix I). This is relatively unusual for stygofauna surveys in the Pilbara region, which commonly feature a variety of widely occurring crustacean species (such as Amphipoda, Ostracoda, Isopoda, and others). At West Angelas, each of the sampled groundwater habitats is spatially separated and disconnected from the others (except perhaps Western Hill orebody and the surrounding Synclinal valley). This pattern supports the conceptualisation of a series of different, discontinuous groundwater habitats occurring in each different sampling area.

However, the assemblages also are relatively species poor in each aquifer unit/ deposit area, compared to other areas of the Pilbara. The sampling limitations with regards to bore/ drill hole availability

(discussed previously in section 3.5 and below in section 7.2) are a complicating factor in this analysis, as is the inability to utilise some older historical survey results due to poor taxonomic resolution. Despite this, it may be reasonable to infer some potential natural constraints to habitat suitability or the occurrence of rich stygofauna assemblages. Reasons for this may include a combination of the size and extent of some of the BWT habitats (e.g. Deposit F North, the Western Hill orebody aquifer, and to some degree Deposit H), hydrogeological isolation (Deposit H), and the considerable depth of groundwater from surface (approx. 70 – 120 mbgl, refer section 6.2.2) at Mt Ella East, Deposit F North, Deposit J reference area, and the Western Hill orebody. In contrast, groundwater habitat areas which were found to be less constrained in extent/ connectivity, and depth from surface (i.e. the regional Synclinal aquifer and the Central Water Bores area), featured higher stygofauna fauna diversity and abundance (Table 5.4, Appendix I).

7.2 Sampling effort and taxonomic effort

The distribution patterns discussed above are inherently related to the sampling effort and taxonomic effort undertaken, which was of a generally high standard across all deposit areas, despite some limitations in respect to the numbers of bores and drill holes available for sampling (particularly BWT for stygofauna). Table 7.2 shows the summary details of sampling effort across all deposit areas and reference areas in the current survey. The survey methods and overall sampling effort met and exceeded the EPA guidance at the time of survey (EPA 2016), and particularly for troglofauna no constraints or limitations in this regard were apparent (refer sections 3.3, 3.5).

For stygofauna, each of the sampling areas were somewhat constrained in terms of the number of available bores and drill holes intercepting groundwater at the time of survey (refer section 3.5). While the overall survey effort met EPA (2016) guidance expectations for stygofauna, given the separation between different aquifers/ habitat units at each deposit and sampling area, the sampling effort at each of the deposit areas/ reference areas could be considered limited in respect to 2016 guidance expectations. This is unlikely to provide challenges for future EIA of some of the current deposit areas such as Mt Ella East and Deposit F North which are mostly devoid of significant aquifers that can form habitat for stygofauna (refer section 6.2). For the other deposit areas/ reference areas where stygofauna and suitable habitats have been recorded, the current stygofauna results must be considered in the context of the limitations to available sampling sites experienced at the time of survey.

Table 7.2 Sampling effort for troglofauna and stygofauna throughout all deposit areas/reference areas

Row Labels	Samples	Sites	Phases	Sampling methods	Comment
Troglofauna					
Western Hill	156	76	2	Scraping (83); Trapping (73)	Inside & outside indicative pits, sites somewhat clustered throughout habitat
Deposit H	60	32	1*	Scraping (32); Trapping (28)	*Additional phase previously undertaken by Ecologia (2013). Inside & outside indicative pits, throughout habitat
Deposit FN	83	38	2	Scraping (44); Trapping (39)	Inside & outside indicative pits, throughout habitat
Mt Ella East	155	92	2 & targeted	Scraping (103); Trapping (52)	Inside & outside indicative pits, sites clustered throughout habitat

Row Labels	Samples	Sites	Phases	Sampling methods	Comment
Deposit J ref area	121	53	2 & targeted	Scraping (65); Trapping (56)	Reference area, sites somewhat clustered
Total	**575**	**290**	**2 & targeted**	**Scraping (327); Trapping (227)**	**EPA (2016) guidance met/ exceeded**
Stygofauna					
Western Hill	15	14	2	Hauling	Few available bores/ holes intercepting groundwater
Deposit H	7	7	1	Hauling	Few available bores/ holes intercepting groundwater
Deposit FN	5	5	2	Hauling	No significant aquifer. Groundwater at significant depth from surface.
Mt Ella East	5	4	2	Hauling	No significant aquifer. Groundwater at significant depth from surface.
Deposit J ref area	10	8	2	Hauling	Reference area. Groundwater at significant depth from surface.
CWB	14	9	2	Hauling (12); Pumping (2)	Reference area. Historical sampling taxonomically unresolved.
Calcrete/ Syncline	16	9	1^	Hauling	^Two additional phases previously undertaken by Biologic (2016).
TCBF	22	12	2	Hauling	Reference area. Historical sampling taxonomically unresolved.
Total	**94**	**68**	**2 & targeted**	**Hauling (92); Pumping (2)**	**EPA (2016) guidance met overall, some limitations to bore/ hole availability**

The taxonomic effort for troglofauna and stygofauna included parataxonomic sorting, detailed morphological identifications, and comprehensive molecular genetic sampling. Taxonomic work was undertaken by suitably trained and experienced personnel using available keys and resources, and no constraints or limitations on the taxonomic effort were apparent (refer sections 3.3).

A high proportion of troglofauna and stygofauna records were sub-sampled for genetic analyses, resulting in 132 successful DNA sequences from 213 troglofauna records (approximately 62% of the total records), and 32 successful DNA sequences from 73 stygofauna species records (approx. 44% of the total records). This high level of molecular genetic work undertaken to confirm species identifications also facilitated extensive regional comparisons with other Rio Tinto sampling areas and published sequences on GenBank. The high degree of genetic analyses for troglofauna and stygofauna, and the extensive regional comparisons this enabled met and exceeded contemporary guidance expectations at the time of survey.

7.3 Key troglofauna values

Key troglofauna values that may be of interest to future EIA include troglobitic species that are not known to occur widely within or beyond the Study Area, and the extent of suitable habitats for these taxa. The survey identified 40 troglobites (or potential troglobites) that are not currently recorded beyond a single sampling area, and most at single sites only. Two of these species were identified from previous survey work, namely *Pseudodiploexochus* `sp. WAH` (ecologia, 2013) and Scutigerellidae `sp. Helix-SYM027` (Biologic, 2016b). Table 7.3 shows the key troglofauna species with a summary of the key habitat values supporting these species and their extent/ connectivity (based on geological habitat assessment). Some key species are known exclusively outside of direct impact areas and are highlighted in green (Table 7.3).

Table 7.3: Key troglofauna values for each sampling area

Key species values	Key habitat values	Habitat connectivity
Western Hill		
Araneae `sp. Biologic-ARAN030` Atelurinae `sp. Biologic-ZYGE012` *Cryptops* `sp. WAWH` Palpigradi `sp. Biologic-PALP016` Pauropoda `sp. Biologic-PAUR014` Pauropoda `sp. Biologic-PAUR018` Pauropoda `sp. Biologic-PAUR020` Scolopendrellidae `sp. Biologic-SYMP012` *Trinemura* `sp. Biologic-ZYGE013` *Tyrannochthonius* `sp. Biologic-PSEU015`	Brockman Iron (Dales Gorge Member) - Major habitat. Tertiary detritals - likely secondary habitat.	BrIF extends throughout ridges, slopes, flanks. Well connected to surrounding Tertiary detritals. No dykes or discontinuity between BrIF hills (east-west). Mt McRae Shales may complicate north-south connectivity
Deposit H		
Indohya `sp. Biologic-PSEU016` *Nocticola* `sp. Biologic-BLAT015` Palpigradi `sp. Biologic-PALP017` Palpigradi `sp. Biologic-PALP020` Parajapygidae `sp. Biologic-DIPL016` Pauropoda `sp. Biologic-PAUR017` *Prethopalpus* `sp. Biologic-ARAN012` *Pseudodiploexochus* `sp. WAH` *Tyrannochthonius* `sp. Biologic-PSEU013` *Tyrannochthonius* `sp. Biologic-PSEU014`	Marra Mamba (Mt Newman Member) - Major habitat. Detritals patchy, not extensive.	Marra Mamba extends further to the west beyond Deposit H. No dykes/ shales barriers present. Fortescue Group geologies (low suitability habitat) constrain Marra Mamba north, east, south.
Mt Ella East		
Araneae `sp. Biologic-ARAN017` Chthoniidae `sp. Biologic-PSEU029` *Hanseniella* `sp. Biologic-SYMP017` *Hanseniella* `sp. Biologic-SYMP018` Palpigradi `sp. Biologic-PALP019` Pauropoda `sp. Biologic-PAUR027` Philosciidae `sp. Biologic ISOP015` *Trinemura* `sp. Biologic-ZYGE017` *Tyrannochthonius* `sp. Biologic-PSEU011` Pselaphinae `sp. Biologic-COLE006` Coleoptera `sp. Biologic-COLE007`	Brockman Iron (Dales Gorge Member) - Major habitat. Tertiary detritals - likely secondary habitat.	BrIF extensive beyond sampling area (south, east, west). Well connected to surrounding Tertiary detritals. No dykes or discontinuity throughout BrIF ridge.
Deposit F North		
Araneae `sp. Biologic-ARAN008` Pauropoda `sp. Biologic-PAUR019` Scutigerellidae `sp. Helix-SYM027`	Marra Mamba (Mt Newman Member) - Major habitat. Detritals may provide some habitat.	Marra Mamba extends further to the south/west (between existing Deposit F and F North). No dykes/ shales present. Tertiary detritals extend further north/ east.
Deposit J reference area		
Araneae `sp. Biologic-ARAN009` Oonopidae `sp. Biologic-ARAN011` Palpigradi `sp. Biologic-PALP015` Palpigradi `sp. Biologic-PALP021` Prethopalpus `sp. Biologic-ARAN013` *Tyrannochthonius* `sp. Biologic-PSEU010`	Brockman Iron (Dales Gorge Member) - Major habitat. Tertiary detritals - likely secondary habitat.	BrIF extensive beyond sampling area (north, east, west). Well connected to surrounding Tertiary detritals. No dykes or discontinuity throughout BrIF ridge.

Note: Key species exclusively known from outside of direct impact areas are highlighted in green.

Western Hill

Ten key troglofauna taxa comprising arachnids, myriapods and insects were recorded only from Western Hill Table 7.3, Figure 5.2). Troglobitic arachnids are frequently known to contain highly range-restricted taxa and there is a high likelihood that these taxa are SREs. Myriapods and insects from the groups shown in Table 7.3 are less certainly troglobitic or SRE, but based on current information, there is a reasonable potential that that these taxa could represent troglobitic, range-restricted/ SRE taxa.

The major AWT habitat values provided by the Dales Gorge Member of the Brockman Iron Formation are highly suitable and well connected throughout the sampling area. Tertiary detritals located in the valleys between the BrIF hills and to the north and south surrounding them are expected to provide further suitable troglofauna habitat where coarse textured, potentially providing wider habitat connectivity between/ beyond the BrIF hills.

Deposit H

Ten key taxa comprising arachnids, isopods, myriapods, and diplurans were recorded from Deposit H (Table 7.3, Figure 5.3). Troglobitic arachnids are often found to be range-restricted SRE taxa, while the other taxa shown in Table 7.1 have a reasonable potential to represent troglobitic SRE taxa.

The major AWT habitat values provided by the Mt Newman Member of the Marra Mamba Iron Formation are highly suitable and well connected throughout the sampling area. The extent of this habitat is mostly constrained by the low suitability Fortescue Group geologies surrounding the ridge (north, east, south). However, the MMIF band continues extensively to the west, and may provide wider AWT habitat connectivity beyond the sampling area at Deposit H.

Mt Ella East

Eleven key troglofauna taxa were recorded only from Mt Ella East, representing arachnids, myriapods, and insects. Most of these taxa (as shown in Table 7.3, Figure 5.5) have a reasonable potential to represent troglobitic SRE taxa, although this is slightly more certain for the troglobitic arachnids, which are more often found to be range restricted.

The highly suitable AWT habitat values provided by the Brockman Iron Formation (Dales Gorge Member) are well connected throughout the sampling area and beyond, as represented by the extensive Mt Ella Range. Tertiary detritals located in the valley to the north are expected to provide further suitable troglofauna habitat where coarse/ unconsolidated detritals potential provide wider habitat connectivity between other habitats to the north (e.g. the Marra Mamba Iron Formation at Deposit F/ F North). Furthermore, some troglofauna species distributions support the inference of habitat connectivity between Deposit J reference area to Mt Ella East, and Mt Ella East to F North (Figures 5.4 and 5.5).

Deposit F North

Three key taxa, comprising an arachnid, a pauropod, and a symphylan were recorded only from Deposit F North (Table 7.3, Figure 5.4). Most of these taxa have at least a reasonable potential to represent troglobitic SRE taxa, (slightly higher for troglobitic arachnids, as stated previously).

Suitable AWT habitat values are hosted in the Marra Mamba Formation which forms an east-west striking hill that extends well beyond the sampling area to the west, and south towards the existing Deposit F. Tertiary detritals may also provide suitable AWT habitats extending beyond the sampling area to the north and east. The distributions of several troglofauna taxa occurring at Deposit F North and Mt Ella East, appear to support the inference of connected AWT habitats throughout the detrital valley to the south (Figures 5.4 and 5.5).

Deposit J (reference area)

Six key taxa comprising arachnids and insects were recorded only from the Deposit J reference area (Table 7.3, Figure 5.5). Troglobitic arachnids are frequently known to represent range-restricted, SRE taxa.

The highly suitable AWT habitat values provided by the Brockman Iron Formation (Dales Gorge Member) are well connected throughout the sampling area and beyond, throughout an extensive mountain range (Mt Ella). Tertiary detritals located in the valleys between the BrIF hills and to the south are expected to provide further suitable troglofauna habitat, potentially providing wider habitat connectivity between/ beyond the BrIF mountains. Furthermore, some troglofauna species distributions support the inferred habitat connectivity between Deposit J reference area and Mt Ella East to the north and east (Figure 5.5).

7.4 Key stygofauna values

Key stygofauna values that may be of interest to future EIA include stygobitic species that are not known to occur beyond the Study Area, and the extent of suitable habitats for these taxa. The survey identified 16 stygobites (or potential stygobites) that are not currently known to occur beyond the Study Area based on available information (Table 7.4). Three of the species were identified from previous survey work, namely *Australocamptus* `sp. B13`, *Atopobathynella* `sp. Helix-BAP027_WA` and Bathynellidae `sp. Helix-BAB018`. Some key species are known exclusively outside of direct impact areas and are highlighted in green (Table 7.4).

Table 7.4 shows the key stygofauna species with a summary of the key habitat values supporting these species and their extent/ connectivity (based on hydrogeological habitat assessment).

Table 7.4: Key stygofauna values for each sampling area

Key species values	Key habitat values	Habitat connectivity
Western Hill/ Calc Bores (Synclinal valley)		
Australocamptus `sp. B13` (prev. survey) *Atopobathynella* `sp. Helix-BAP027_WA` (prev. survey) Bathynellidae `sp. Helix-BAB018` (prev. survey) Candonidae `sp. WAN` Enchytraeidae `sp. Biologic-OLIG008` *Kruptus* `sp. Helix-AMP035` *Maarrka* `sp. Helix-AMP037` Paramelitidae `sp. Biologic-AMPH018` Paramelitidae `sp. Helix-AMP036` *Pygolabis* `sp. WAN`	Western Hill (WH) orebody aquifer (mineralised Dales Gorge Member) occurs at depth beneath WH. Synclinal valley (SV) aquifer (tertiary detritals, calcrete, and weathered Wittenoom Formation) surrounds WH and central anticline Deposits C, D.	WH aquifer constrained by geological deformation and faulting. Mt McRae Shales (low permeability) separate WH habitat from SV habitat. SV habitat extensive and unconstrained, continues westward well beyond Study Area. Different hydrogeological catchment to the other sampling areas.
Deposit H		
No key stygofauna values recorded.	Deep orebody aquifer in Marra Mamba (Mt Newman Member) not considered high value habitat for stygofauna, based on a lack of key stygofauna values.	Fortescue Group geologies (low permeability) constrain Marra Mamba to the north, east, south. Habitat completely isolated within the Marra Mamba Formation (Mt Newman Member).

Key species values	Key habitat values	Habitat connectivity
Deposit J (reference area)		
Atopobathynella `sp. Biologic-PBAT008`	Deep orebody aquifer (mineralised Dales Gorge Member) provides suitable habitat	Groundwater habitat likely to extend south beyond Deposit J reference area (based on local catchment). Different hydrogeological catchment to the other sampling areas.
Mt Ella East		
No key stygofauna values recorded	No significant stygofauna habitat identified	n/a
Deposit F North		
No key stygofauna values recorded	No significant stygofauna habitat identified	n/a
Central Water Bores (reference area)		
Billibathynella `sp. Biologic-PBAT007` Paramelitidae `sp. Biologic-AMPH017` *Parastenocaris* cf. *jane*	Shallow detrital aquifers atop Jeerinah Formation, associated with drainage lines.	Detrital aquifers somewhat limited in extent – along drainage lines. Surrounding Fortescue Group geologies low permeability. Apparently not connected to synclinal aquifer (stygofauna results).
Turee Creek Borefield (reference area)		
Kruptus? `sp. Biologic-AMPH016` Phreodrilidae `sp. Biologic-OLIG010`	Deep detrital aquifer and fractured bedrock aquifer (Boolgeeda, Weeli Wolli, Wongarra Formations).	Unconstrained, broad-scale aquifers. Vertical connectivity patchy in some areas due to clays. Different hydrogeological catchment to the other sampling areas.

Note: Key species exclusively known from outside of direct impact areas are highlighted in green.

Three sampling areas (Dep H, Mt Ella East, and Dep F North) did not record any key stygofauna values or high value stygofauna habitats based on current information. The limitations of current information at these areas in relation to the low number of available bores/ holes intercepting water table and related constraints on BWT sampling are detailed in section 7.2 above and section 3.5.

Western Hill/ Calcrete bores (synclinal aquifer)

Ten key stygofauna taxa comprising amphipods, ostracods, and syncarids (bathynellaceans) were recorded from Western Hill and the surrounding synclinal aquifer (Table 7.4, Figure 5.11). Stygobitic syncarids are very frequently found to be range-restricted where aquifers are discontinuous or partitioned by dykes and flow barriers, while stygal amphipods and ostracods are known to contain species with variable ranges from regionally widespread to highly range restricted (SREs). There is a reasonable potential that all of the stygobitic taxa found at Western Hill and the synclinal aquifer could represent SRE taxa based on the nominal range criteria (10,000 km^2 as in Harvey 2002).

Nevertheless, all of these taxa were recorded in the synclinal aquifer (with one amphipod, *Kruptus* `sp. Helix-AMP035`) also recorded from Western Hill orebody aquifer), and the synclinal aquifer is locally extensive beyond the sampling area and the Study Area, to the west within Karijini National Park (refer Figure 2.5). Transverse dykes (striking southeast to northwest) are known to occur in the bedrock formations of this area, however the intense faulting of the bedrock between the central anticline, the synclinal valley, and Western Hill has apparently increased the permeability of these dykes by fracturing (Rio Tinto 2018b).

In combination with the porous detritals and calcrete formations that occur above the bedrock and below the water table throughout the synclinal valley, this provides confidence that the synclinal aquifer provides well connected BWT habitats throughout its known extent. Despite sampling limitations caused

by a lack of available bores west of the Study Area, it is reasonable to infer that well-connected, highly suitable BWT habitats facilitate the wider occurrence of these key stygofauna species throughout the western extent of the synclinal aquifer within Karijini National Park.

Conversely, the Western Hill orebody aquifer occurs deeper from surface, and is much more limited in extent due to the folding and faulting of the mineralised Dales Gorge Member that is constrained beneath Western Hill. The low porosity Mt McRae Shales layer outcrops to the south, providing a virtual barrier that prevents significant groundwater flow between the orebody aquifer and the synclinal valley aquifer further south. Only one key stygofauna species was recorded within the orebody aquifer (the amphipod, *Kruptus* `sp. Helix-AMP035`), and this species is also known to occur at several sites in the synclinal aquifer based on previous sampling (Biologic 2016b). While the Western Hill orebody aquifer provides some suitable habitat for stygofauna, it is not considered as important or high value for stygofauna assemblages as the habitats within the synclinal valley.

Deposit J

One stygobitic syncarid (*Atopobathynella* `sp. Biologic-PBAT008) was recorded from Deposit J reference area (Table 7.4, Figure 5.14), but a genetic match was confirmed with a specimen collected approximately 13 km further south (Biologic unpublished data), supporting the conceptualisation of the wider extent of the Deposit J aquifer. While this taxon is still within the nominal range limits for an SRE species, it is known to occur locally beyond the Study Area boundaries and is therefore not considered to be a key species value for future EIA.

The BWT habitat at Deposit J reference area comprises a deep (80-115 mbgl) orebody aquifer within the mineralised Dales Gorge Member. Such depths often correspond with a reduction in dissolved oxygen and porosity; however, the sampling and groundwater data available to date revealed moderate dissolved oxygen levels and at least one stygobitic species occurring in this area. Sampling was limited by the depth to water and the number of available bores intercepting the groundwater habitat, which may affect the current understanding of stygofauna values in this area. The wider extent of the mineralised Dales Gorge aquifer at Deposit J reference area is poorly defined but appears to continue southwards locally beyond the Study Area, based on available hydrogeological information and current fauna results.

Central Water Bores

Three stygobitic taxa are known to occur in the detrital aquifers atop the Jeerinah Formation in the Central Water Bores area (central plateau/ Wonmunna anticline); a syncarid, an amphipod, and a harpacticoid copepod (Table 7.4, Figure 5.12). These taxa have not been recorded anywhere else in the Study Area or in the region to date (based on available genetic comparisons). As the central anticline area is hosted in a different geological and hydrogeological setting, and the stygofauna occurring therein are apparently unique, the available information supports the conceptualisation of this area as a distinct groundwater area, not connected to any of the other surrounding sampling areas at West Angelas.

Sampling in this area was limited by the low number of available bores intercepting the groundwater habitat, and the poor taxonomic resolution of historical surveys at these bores, which may have affected the understanding of stygofauna values in this area.

Turee Creek Borefield

Two stygobitic taxa are known to occur in the deep detrital aquifers of the Turee Creek Borefield; an amphipod, and a phreodrilid worm (Table 7.4, Figure 5.15). These taxa are not known to occur within the other sampling areas to date, although the poor taxonomic resolution of historical surveys in this borefield is a limitation to the knowledge of the stygofauna values in this area (including species distributions).

The aquifer in Turee Creek Borefield is broadly (sub-regionally) extensive beyond the Study Area to the south and west, eventually joining with Turee Creek. There is a reasonable potential that any stygofauna species occurring therein may range more widely than currently sampled, within the broader Turee Creek hydrogeological area.

Sampling in this area was somewhat limited by the low number of available bores, and the long history of abstraction from bores in this aquifer, which may have affected the understanding of stygofauna values in this area.

8. KEY FINDINGS

The survey collected 669 subterranean fauna samples from 324 bores/ drill holes throughout four sampling areas (Western Hill, Deposit H, Deposit F North, and Mt Ella East) and four reference areas (Deposit J reference area, Calcrete bores, Central Water Bores, and Turee Creek borefield). The samples recorded a total of 344 troglofauna specimens and 328 stygofauna specimens, which were identified using a combination of morphological and genetic taxonomy.

The survey and data review concluded that 70 troglofauna species/ taxa and 20 stygofauna species/ taxa occur within the Study Area. Of these, 40 troglobitic taxa and 16 stygobitic taxa are currently known only from limited records within the Study Area and may be considered key species values: i.e. species of potential interest for future EIA. The remaining troglofauna and stygofauna taxa represented species known to be locally or regionally widespread beyond the Study Area, or indeterminate taxa unresolved at the species level.

The 40 key troglofauna taxa sampled within the Study Area belonged to groups often known to be SRE (e.g. spiders, pseudoscorpions, palpigrades) or sometimes found to be SRE (*e.g.* isopods, pauropods, symphylans, diplurans, beetles, and silverfish). Most of the key troglofauna taxa were recorded only from single sites, while others were recorded from a few sites within localised spatial areas (e.g. at Western Hill, Deposit J, Deposit H, Deposit F North, or Mt Ella East). Beyond the key taxa, approximately one third of the overall total troglofauna species were found to occur more widely beyond the Study Area as a result of extensive regional genetic comparisons.

The 16 key stygofauna taxa sampled within the Study Area were similarly represented by groups with high SRE potential (e.g. syncarids/ bathynellaceans) or moderate SRE potential (e.g. amphipods, ostracods, harpacticoid copepods). Most of the key stygofauna taxa were detected from single aquifer units – sometimes from single sites or throughout wider extents up to several kilometres (where connected habitat allowed), but none of the key stygofauna species were distributed across different aquifer units/ sampling areas.

Habitat assessment showed four major groundwater habitats for stygofauna: orebody aquifers of the Marra Mamba and Brockman Iron Formations (separately, at Western Hill, Deposit H and Deposit J), in the Synclinal valley surrounding Western Hill (tertiary detritals and weathered Wittenoom Formation), in the central anticline (thin detritals above Jeerinah Formation), and at Turee Creek Borefield (deep detritals above fractured rocks). Each of these groundwater habitats is largely discontinuous with, and spatially separated from, the next. The stygofauna assemblages appeared to support this conceptualisation, with different stygobitic species present in each sampling area/ groundwater habitat, and fewer shared species or regional matches beyond the Study Area. These patterns may be affected by sampling limitations resulting from the sparsity of available bores and drillholes intercepting groundwater at the time of survey, and the limited extent and considerable depth from surface of many of the deposit aquifer settings. Several of the larger groundwater habitats (e.g. the Synclinal valley, the Central Water Bores area, Deposit J, Turee Creek borefield) were expected to extend well beyond the Study Area boundaries, therefore there may be some potential for wider occurrence beyond the current sampling for some of the stygofauna species recorded from these aquifers.

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10. APPENDICES

Appendix A – Sampling effort

APPENDIX A: Bores and drill holes visited during the survey

Hole ID	Easting	Northing	Sampling Area	Sampling Method	Date	Phase
DD16WAJ0001	677003.961	7429950.614	J	Scraping	08/11/2018	1
DD16WAJ0001	677003.961	7429950.614	J	Trapping	08/11/2018	1
DD16WAJ0001	677003.961	7429950.614	J	Scraping	03/05/2019	2
DD16WAJ0001	677003.961	7429950.614	J	Trapping	03/05/2019	2
DD16WAX0003	683098.639	7432246.569	MTEE	Scraping	07/11/2018	1
GD16WAW0003	668798.492	7442695.489	Western Hill	Scraping	14/09/2018	1
GD17WAJ0001	676812.011	7429993.155	J	Hauling	06/10/2020	4
GD17WAJ0001	676812.011	7429993.155	J	Scraping	06/10/2020	4
GD18WAX0001	682945.455	7432278.506	MTEE	Trapping	07/11/2018	1
GR17WAF0014	692247.555	7434614.118	F North	Hauling	12/09/2018	1
GR17WAF0014	692247.555	7434614.118	F North	Scraping	12/09/2018	1
MB14WAE006	680233.174	7432777.575	MTEE	Hauling	12/09/2018	1
MB14WAF0001	692507.806	7434605.093	F North	Hauling	12/09/2018	1
MB16WAW0001	664253.118	7437049.177	CALC	Hauling	15/03/2019	2
MB16WAW0002	663543.861	7437250.997	CALC	Hauling	19/03/2019	2
MB16WAW0002	663543.861	7437250.997	CALC	Hauling	07/05/2019	2
MB16WAW0003	662994.179	7439245.351	CALC	Hauling	14/03/2019	2
MB16WAW0004	662980.308	7438658.812	CALC	Hauling	14/03/2019	2
MB16WAW0004	662980.308	7438658.812	CALC	Hauling	09/05/2019	2
MB16WAW0006	662967.163	7438265.466	CALC	Hauling	14/03/2019	2
MB16WAW0006	662967.163	7438265.466	CALC	Hauling	09/05/2019	2
MB16WAW0008	662506.082	7437348.797	CALC	Hauling	19/03/2019	2
MB16WAW0008	662506.082	7437348.797	CALC	Hauling	09/05/2019	2
MB16WAW0009	663849.013	7437754.167	CALC	Hauling	19/03/2019	2
MB16WAW0009	663849.013	7437754.167	CALC	Hauling	07/05/2019	2
MB16WAW0012	663999.13	7438652.58	CALC	Hauling	19/03/2019	2
MB16WAW0012	663999.13	7438652.58	CALC	Hauling	09/05/2019	2
RC13ANR0081	680197.966	7429782.972	J	Scraping	03/05/2019	2
RC13ANR0081	680197.966	7429782.972	J	Trapping	03/05/2019	2
RC13ANR0083	680200.995	7429698.598	J	Scraping	03/05/2019	2
RC13ANR0083	680200.995	7429698.598	J	Trapping	03/05/2019	2
RC13WAX0011	686597.982	7432200.185	MTEE	Scraping	01/05/2019	2
RC13WAX0011	686597.982	7432200.185	MTEE	Trapping	01/05/2019	2
RC14ANR0006	679998.625	7431159.689	J	Scraping	02/05/2019	2
RC14ANR0006	679998.625	7431159.689	J	Trapping	02/05/2019	2
RC14ANR0025	680202.918	7430201.39	J	Scraping	03/05/2019	2
RC14ANR0025	680202.918	7430201.39	J	Trapping	03/05/2019	2
RC14WAH0009	690944.003	7441548.019	H	Hauling	06/05/2019	2
RC14WAH0009	690944.003	7441548.019	H	Scraping	06/05/2019	2
RC14WAH0009	690944.003	7441548.019	H	Trapping	06/05/2019	2
RC14WAH0030	691745.037	7441650.264	H	Hauling	06/05/2019	2
RC14WAH0030	691745.037	7441650.264	H	Scraping	06/05/2019	2
RC14WAH0030	691745.037	7441650.264	H	Trapping	06/05/2019	2
RC14WAH0035	692547.124	7441350.605	H	Hauling	05/05/2019	2
RC14WAH0035	692547.124	7441350.605	H	Scraping	05/05/2019	2
RC14WAH0035	692547.124	7441350.605	H	Trapping	05/05/2019	2
RC14WAH0039	692543.911	7441796.828	H	Scraping	05/05/2019	2
RC14WAH0039	692543.911	7441796.828	H	Trapping	05/05/2019	2
RC14WAH0047	693942.592	7441457.31	H	Scraping	05/05/2019	2
RC14WAH0047	693942.592	7441457.31	H	Trapping	05/05/2019	2
RC14WAH0081	694455.17	7441572.953	H	Hauling	05/05/2019	2
RC14WAH0081	694455.17	7441572.953	H	Scraping	05/05/2019	2
RC14WAH0081	694455.17	7441572.953	H	Trapping	05/05/2019	2
RC14WAJ0005	679197.113	7430008.349	J	Scraping	03/05/2019	2
RC14WAJ0005	679197.113	7430008.349	J	Trapping	03/05/2019	2
RC14WAJ0022	677217.344	7429761.09	J	Hauling	03/05/2019	2
RC14WAJ0022	677217.344	7429761.09	J	Scraping	03/05/2019	2
RC14WAJ0022	677217.344	7429761.09	J	Trapping	03/05/2019	2
RC14WAX0028	685795.01	7432252.1	MTEE	Scraping	02/05/2019	2

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RC14WAX0028	685795.01	7432252.1	MTEE	Trapping	02/05/2019	2
RC14WAX0030	685796.422	7432050.471	MTEE	Scraping	02/05/2019	2
RC14WAX0030	685796.422	7432050.471	MTEE	Trapping	02/05/2019	2
RC15WAF0020	690695.383	7435942.174	F North	Trapping	09/11/2018	1
RC15WAF0020	690695.383	7435942.174	F North	Scraping	04/05/2019	2
RC15WAF0020	690695.383	7435942.174	F North	Trapping	04/05/2019	2
RC15WAJ0004	676807.684	7429995.149	J	Scraping	08/11/2018	1
RC15WAJ0004	676807.684	7429995.149	J	Trapping	08/11/2018	1
RC15WAW0018	667802.737	7443650.929	Western Hill	Scraping	01/05/2019	2
RC15WAW0018	667802.737	7443650.929	Western Hill	Trapping	01/05/2019	2
RC15WAW0020	668198.381	7443153.273	Western Hill	Scraping	01/05/2019	2
RC15WAW0020	668198.381	7443153.273	Western Hill	Trapping	01/05/2019	2
RC15WAW0023	666205.042	7442345.811	Western Hill	Scraping	30/04/2019	2
RC15WAW0023	666205.042	7442345.811	Western Hill	Trapping	30/04/2019	2
RC15WAW0028	664755.949	7441998.964	Western Hill	Scraping	30/04/2019	2
RC15WAW0028	664755.949	7441998.964	Western Hill	Trapping	30/04/2019	2
RC15WAW0044	663297.098	7443396.464	Western Hill	Hauling	30/04/2019	2
RC15WAW0044	663297.098	7443396.464	Western Hill	Scraping	30/04/2019	2
RC15WAW0044	663297.098	7443396.464	Western Hill	Trapping	30/04/2019	2
RC15WAW0048	663299.648	7443002.069	Western Hill	Scraping	30/04/2019	2
RC15WAW0048	663299.648	7443002.069	Western Hill	Trapping	30/04/2019	2
RC15WAX0012	688196.955	7432098.445	MTEE	Scraping	01/05/2019	2
RC15WAX0012	688196.955	7432098.445	MTEE	Trapping	01/05/2019	2
RC15WAX0016	688596.454	7432187.246	MTEE	Scraping	01/05/2019	2
RC15WAX0016	688596.454	7432187.246	MTEE	Trapping	01/05/2019	2
RC15WAX0057	687002.541	7432151.793	MTEE	Scraping	11/09/2018	1
RC15WAX0057	687002.541	7432151.793	MTEE	Trapping	07/11/2018	1
RC15WAX0057	687002.541	7432151.793	MTEE	Scraping	01/05/2019	2
RC15WAX0057	687002.541	7432151.793	MTEE	Trapping	01/05/2019	2
RC16WAH0030	695952.399	7441349.075	H	Scraping	05/05/2019	2
RC16WAH0030	695952.399	7441349.075	H	Trapping	05/05/2019	2
RC16WAH0060	694302.158	7441410.982	H	Scraping	05/05/2019	2
RC16WAH0060	694302.158	7441410.982	H	Trapping	05/05/2019	2
RC16WAH0065	695352.405	7441150.029	H	Scraping	05/05/2019	2
RC16WAH0065	695352.405	7441150.029	H	Trapping	05/05/2019	2
RC16WAH0071	695153.404	7441253.76	H	Scraping	05/05/2019	2
RC16WAH0071	695153.404	7441253.76	H	Trapping	05/05/2019	2
RC16WAH0081	694745.497	7441147.399	H	Scraping	05/05/2019	2
RC16WAH0081	694745.497	7441147.399	H	Trapping	05/05/2019	2
RC16WAH0095	692953.85	7441711.538	H	Hauling	05/05/2019	2
RC16WAH0095	692953.85	7441711.538	H	Scraping	05/05/2019	2
RC16WAH0095	692953.85	7441711.538	H	Trapping	05/05/2019	2
RC16WAH0103	692154.762	7441747.857	H	Hauling	05/05/2019	2
RC16WAH0103	692154.762	7441747.857	H	Scraping	05/05/2019	2
RC16WAH0103	692154.762	7441747.857	H	Trapping	05/05/2019	2
RC16WAJ0002	681058.193	7431152.848	J	Scraping	03/05/2019	2
RC16WAJ0002	681058.193	7431152.848	J	Trapping	03/05/2019	2
RC16WAJ0007	681061.122	7430899.656	J	Scraping	03/05/2019	2
RC16WAJ0007	681061.122	7430899.656	J	Trapping	03/05/2019	2
RC16WAJ0019	680606.126	7430747.644	J	Scraping	04/05/2019	2
RC16WAJ0019	680606.126	7430747.644	J	Trapping	04/05/2019	2
RC16WAJ0028	677713.448	7429722.45	J	Scraping	03/05/2019	2
RC16WAJ0028	677713.448	7429722.45	J	Trapping	03/05/2019	2
RC16WAJ0030	677597.824	7429663.092	J	Hauling	03/05/2019	2
RC16WAJ0030	677597.824	7429663.092	J	Scraping	03/05/2019	2
RC16WAJ0030	677597.824	7429663.092	J	Trapping	03/05/2019	2
RC16WAJ0030	677597.824	7429663.092	J	Hauling	06/10/2020	4
RC16WAJ0030	677597.824	7429663.092	J	Scraping	06/10/2020	4
RC16WAX0004	682501.001	7432400.515	MTEE	Scraping	02/05/2019	2
RC16WAX0004	682501.001	7432400.515	MTEE	Trapping	02/05/2019	2

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RC16WAX0005	682503.971	7432502.797	MTEE	Scraping	02/05/2019	2
RC16WAX0005	682503.971	7432502.797	MTEE	Trapping	02/05/2019	2
RC16WAX0007	682701.888	7432299.062	MTEE	Trapping	07/11/2018	1
RC16WAX0007	682701.888	7432299.062	MTEE	Scraping	12/09/2018	1
RC16WAX0007	682701.888	7432299.062	MTEE	Scraping	02/05/2019	2
RC16WAX0007	682701.888	7432299.062	MTEE	Trapping	02/05/2019	2
RC16WAX0009	682701.484	7432501.256	MTEE	Scraping	02/05/2019	2
RC16WAX0009	682701.484	7432501.256	MTEE	Trapping	02/05/2019	2
RC16WAX0016	683001.755	7432100.091	MTEE	Scraping	07/11/2018	1
RC16WAX0016	683001.755	7432100.091	MTEE	Scraping	02/05/2019	2
RC16WAX0016	683001.755	7432100.091	MTEE	Trapping	02/05/2019	2
RC16WAX0041	687200.299	7431854.252	MTEE	Scraping	01/05/2019	2
RC16WAX0041	687200.299	7431854.252	MTEE	Trapping	01/05/2019	2
RC16WAX0044	687204.154	7431950.641	MTEE	Trapping	07/11/2018	1
RC16WAX0044	687204.154	7431950.641	MTEE	Scraping	11/09/2018	1
RC16WAX0047	687000.397	7431653.567	MTEE	Trapping	07/11/2018	1
RC16WAX0047	687000.397	7431653.567	MTEE	Scraping	11/09/2018	1
RC16WAX0055	686503.663	7431650.363	MTEE	Scraping	02/05/2019	2
RC16WAX0055	686503.663	7431650.363	MTEE	Trapping	02/05/2019	2
RC16WAX0064	684100.683	7432350.745	MTEE	Scraping	02/05/2019	2
RC16WAX0064	684100.683	7432350.745	MTEE	Trapping	02/05/2019	2
RC16WAX0072	683801.034	7432448.313	MTEE	Scraping	02/05/2019	2
RC16WAX0072	683801.034	7432448.313	MTEE	Trapping	02/05/2019	2
RC17WAF0002	691952.849	7435051.275	F North	Scraping	12/09/2018	1
RC17WAF0002	691952.849	7435051.275	F North	Scraping	04/05/2019	2
RC17WAF0002	691952.849	7435051.275	F North	Trapping	04/05/2019	2
RC17WAF0012	692154.551	7434951.784	F North	Scraping	12/09/2018	1
RC17WAF0055	687898.717	7435697.346	F North	Scraping	13/09/2018	1
RC17WAF0055	687898.717	7435697.346	F North	Trapping	09/11/2018	1
RC17WAF0055	687898.717	7435697.346	F North	Scraping	04/05/2019	2
RC17WAF0055	687898.717	7435697.346	F North	Trapping	04/05/2019	2
RC17WAF0056	688697.86	7435599.435	F North	Trapping	09/11/2018	1
RC17WAF0063	689500.117	7435797.831	F North	Scraping	13/09/2018	1
RC17WAF0068	690098.978	7435599.719	F North	Scraping	04/05/2019	2
RC17WAF0068	690098.978	7435599.719	F North	Trapping	04/05/2019	2
RC17WAF0088	690900.006	7435669.339	F North	Trapping	09/11/2018	1
RC17WAF0088	690900.006	7435669.339	F North	Hauling	04/05/2019	2
RC17WAF0088	690900.006	7435669.339	F North	Scraping	04/05/2019	2
RC17WAF0088	690900.006	7435669.339	F North	Trapping	04/05/2019	2
RC17WAF0097	690999.157	7435816.393	F North	Hauling	13/09/2018	1
RC17WAF0098	690996.654	7435595.34	F North	Hauling	13/09/2018	1
RC17WAF0144	692406.214	7434651.953	F North	Scraping	04/05/2019	2
RC17WAF0144	692406.214	7434651.953	F North	Trapping	04/05/2019	2
RC17WAF0147	692406.406	7434502.994	F North	Scraping	12/09/2018	1
RC17WAF0147	692406.406	7434502.994	F North	Trapping	09/11/2018	1
RC17WAF0147	692406.406	7434502.994	F North	Scraping	04/05/2019	2
RC17WAF0147	692406.406	7434502.994	F North	Trapping	04/05/2019	2
RC17WAF0160	692555.13	7434907.721	F North	Scraping	12/09/2018	1
RC17WAF0160	692555.13	7434907.721	F North	Trapping	09/11/2018	1
RC17WAF0162	692555.323	7434802.567	F North	Scraping	04/05/2019	2
RC17WAF0162	692555.323	7434802.567	F North	Trapping	04/05/2019	2
RC17WAF0168	692356.743	7434906.038	F North	Scraping	04/05/2019	2
RC17WAF0168	692356.743	7434906.038	F North	Trapping	04/05/2019	2
RC17WAF0170	691097.716	7435614.773	F North	Scraping	12/09/2018	1
RC17WAF0180	692352.314	7434806.075	F North	Scraping	12/09/2018	1
RC17WAF0180	692352.314	7434806.075	F North	Trapping	09/11/2018	1
RC17WAF0182	692250.477	7434853.39	F North	Scraping	04/05/2019	2
RC17WAF0182	692250.477	7434853.39	F North	Trapping	04/05/2019	2
RC17WAF0191	691351.339	7435654.428	F North	Scraping	12/09/2018	1
RC17WAF0197	691649.913	7435257.372	F North	Trapping	09/11/2018	1

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RC17WAF0197	691649.913	7435257.372	F North	Scraping	04/05/2019	2
RC17WAF0197	691649.913	7435257.372	F North	Trapping	04/05/2019	2
RC17WAH0001	689452.686	7441420.702	H	Scraping	06/05/2019	2
RC17WAH0001	689452.686	7441420.702	H	Trapping	06/05/2019	2
RC17WAH0002	689440.72	7441348.307	H	Scraping	06/05/2019	2
RC17WAH0003	689461.656	7441683.152	H	Scraping	06/05/2019	2
RC17WAH0003	689461.656	7441683.152	H	Trapping	06/05/2019	2
RC17WAH0005	689423.173	7441873.471	H	Scraping	06/05/2019	2
RC17WAH0005	689423.173	7441873.471	H	Trapping	06/05/2019	2
RC17WAH0007	689857.149	7441793.492	H	Scraping	06/05/2019	2
RC17WAH0008	696799.386	7441196.218	H	Scraping	05/05/2019	2
RC17WAH0008	696799.386	7441196.218	H	Trapping	05/05/2019	2
RC17WAH0009	696998.619	7441146.548	H	Scraping	05/05/2019	2
RC17WAH0009	696998.619	7441146.548	H	Trapping	05/05/2019	2
RC17WAH0011	697398.474	7441102.355	H	Scraping	05/05/2019	2
RC17WAH0011	697398.474	7441102.355	H	Trapping	05/05/2019	2
RC17WAJ0001	677098.355	7429949.627	J	Trapping	08/11/2018	1
RC17WAJ0002	677105.657	7429902.592	J	Trapping	08/11/2018	1
RC17WAJ0002	677105.657	7429902.592	J	Scraping	08/11/2018	1
RC17WAJ0013	675605.064	7429950.034	J	Trapping	08/11/2018	1
RC17WAJ0013	675605.064	7429950.034	J	Scraping	08/11/2018	1
RC17WAJ0013	675605.064	7429950.034	J	Scraping	03/05/2019	2
RC17WAJ0013	675605.064	7429950.034	J	Trapping	03/05/2019	2
RC17WAJ0028	676397.626	7430003.254	J	Scraping	03/05/2019	2
RC17WAJ0028	676397.626	7430003.254	J	Trapping	03/05/2019	2
RC17WAJ0042	677403.372	7429798.026	J	Trapping	08/11/2018	1
RC17WAJ0042	677403.372	7429798.026	J	Scraping	08/09/2018	1
RC17WAJ0057	677995.751	7430051.165	J	Scraping	03/05/2019	2
RC17WAJ0057	677995.751	7430051.165	J	Trapping	03/05/2019	2
RC17WAJ0074	679791.448	7429886.821	J	Scraping	03/05/2019	2
RC17WAJ0074	679791.448	7429886.821	J	Trapping	03/05/2019	2
RC17WAJ0080	681448.589	7430952.141	J	Trapping	08/11/2018	1
RC17WAJ0080	681448.589	7430952.141	J	Scraping	10/09/2018	1
RC17WAJ0081	681449.287	7430851.761	J	Scraping	08/11/2018	1
RC17WAJ0083	681256.419	7430847.824	J	Trapping	08/11/2018	1
RC17WAJ0083	681256.419	7430847.824	J	Scraping	08/11/2018	1
RC17WAJ0109	680396.905	7430559.605	J	Scraping	04/05/2019	2
RC17WAJ0109	680396.905	7430559.605	J	Trapping	04/05/2019	2
RC17WAJ0112	680202.352	7430800.808	J	Trapping	08/11/2018	1
RC17WAJ0112	680202.352	7430800.808	J	Scraping	10/09/2018	1
RC17WAJ0112	680202.352	7430800.808	J	Scraping	03/05/2019	2
RC17WAJ0112	680202.352	7430800.808	J	Trapping	03/05/2019	2
RC17WAJ0122	678694.654	7429949.619	J	Scraping	03/05/2019	2
RC17WAJ0122	678694.654	7429949.619	J	Trapping	03/05/2019	2
RC17WAJ0165	680898.347	7430650.843	J	Scraping	04/05/2019	2
RC17WAJ0165	680898.347	7430650.843	J	Trapping	04/05/2019	2
RC17WAJ0170	680901.378	7430401.304	J	Trapping	08/11/2018	1
RC17WAJ0170	680901.378	7430401.304	J	Scraping	10/09/2018	1
RC17WAW0047	669898.161	7443305.035	Western Hill	Scraping	01/05/2019	2
RC17WAW0047	669898.161	7443305.035	Western Hill	Trapping	01/05/2019	2
RC17WAW0072	667997.536	7443595.551	Western Hill	Hauling	01/05/2019	2
RC17WAW0072	667997.536	7443595.551	Western Hill	Scraping	01/05/2019	2
RC17WAW0072	667997.536	7443595.551	Western Hill	Trapping	01/05/2019	2
RC17WAW0116	669497.795	7443005.448	Western Hill	Trapping	05/11/2018	1
RC17WAW0116	669497.795	7443005.448	Western Hill	Hauling	05/11/2018	1
RC17WAW0116	669497.795	7443005.448	Western Hill	Scraping	05/11/2018	1
RC17WAW0137	663546.13	7442747.811	Western Hill	Trapping	30/04/2019	2
RC17WAW0137	663546.13	7442747.811	Western Hill	Scraping	30/04/2019	2
RC17WAW0167	664356.017	7442252.585	Western Hill	Trapping	30/04/2019	2
RC17WAW0167	664356.017	7442252.585	Western Hill	Scraping	30/04/2019	2

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RC17WAW0181	664746.174	7442447.562	Western Hill	Hauling	06/11/2018	1
RC17WAW0181	664746.174	7442447.562	Western Hill	Scraping	06/11/2018	1
RC17WAW0181	664746.174	7442447.562	Western Hill	Trapping	30/04/2019	2
RC17WAW0181	664746.174	7442447.562	Western Hill	Hauling	30/04/2019	2
RC17WAW0181	664746.174	7442447.562	Western Hill	Scraping	30/04/2019	2
RC17WAW0211	666249.256	7442477.555	Western Hill	Scraping	05/11/2018	1
RC17WAW0222	666556.258	7442886.021	Western Hill	Trapping	30/04/2019	2
RC17WAW0222	666556.258	7442886.021	Western Hill	Scraping	30/04/2019	2
RC17WAW0236	666356.03	7443000.597	Western Hill	Trapping	30/04/2019	2
RC17WAW0236	666356.03	7443000.597	Western Hill	Scraping	30/04/2019	2
RC17WAX0029	683403.811	7432388.463	MTEE	Trapping	07/11/2018	1
RC17WAX0029	683403.811	7432388.463	MTEE	Scraping	11/09/2018	1
RC17WAX0033	683601.242	7432401.505	MTEE	Trapping	07/11/2018	1
RC17WAX0033	683601.242	7432401.505	MTEE	Scraping	11/09/2018	1
RC18WAF0006	692517.34	7435003.366	F North	Trapping	09/11/2018	1
RC18WAF0015	691800.638	7434952.378	F North	Scraping	04/05/2019	2
RC18WAF0015	691800.638	7434952.378	F North	Trapping	04/05/2019	2
RC18WAF0024	691346.513	7435505.626	F North	Scraping	04/05/2019	2
RC18WAF0024	691346.513	7435505.626	F North	Trapping	04/05/2019	2
RC18WAF0030	690597.712	7435597.306	F North	Scraping	13/09/2018	1
RC18WAF0037	690303.715	7435508.789	F North	Trapping	09/11/2018	1
RC18WAF0038	690101.413	7435890.32	F North	Scraping	13/09/2018	1
RC18WAF0047	689703.649	7435505.647	F North	Trapping	09/11/2018	1
RC18WAF0050	689504.762	7435902.253	F North	Scraping	04/05/2019	2
RC18WAF0050	689504.762	7435902.253	F North	Trapping	04/05/2019	2
RC18WAF0052	689498.592	7435296.724	F North	Scraping	13/09/2018	1
RC18WAF0052	689498.592	7435296.724	F North	Scraping	04/05/2019	2
RC18WAF0052	689498.592	7435296.724	F North	Trapping	04/05/2019	2
RC18WAF0057	689295.995	7435347.427	F North	Trapping	09/11/2018	1
RC18WAF0058	688902.875	7435797.974	F North	Scraping	13/09/2018	1
RC18WAF0058	688902.875	7435797.974	F North	Scraping	04/05/2019	2
RC18WAF0058	688902.875	7435797.974	F North	Trapping	04/05/2019	2
RC18WAF0061	688498.837	7435893.631	F North	Scraping	13/09/2018	1
RC18WAF0061	688498.837	7435893.631	F North	Scraping	04/05/2019	2
RC18WAF0061	688498.837	7435893.631	F North	Trapping	04/05/2019	2
RC18WAF0062	688501.343	7435392.781	F North	Scraping	13/09/2018	1
RC18WAF0062	688501.343	7435392.781	F North	Scraping	04/05/2019	2
RC18WAF0062	688501.343	7435392.781	F North	Trapping	04/05/2019	2
RC18WAF0065	687893.872	7435146.173	F North	Trapping	09/11/2018	1
RC18WAF0070	688101.184	7435997.231	F North	Scraping	13/09/2018	1
RC18WAF0070	688101.184	7435997.231	F North	Scraping	04/05/2019	2
RC18WAF0070	688101.184	7435997.231	F North	Trapping	04/05/2019	2
RC18WAF0074	687691.88	7436048.513	F North	Scraping	13/09/2018	1
RC18WAF0074	687691.88	7436048.513	F North	Scraping	04/05/2019	2
RC18WAF0074	687691.88	7436048.513	F North	Trapping	04/05/2019	2
RC18WAF0076	687307.685	7435707.646	F North	Scraping	13/09/2018	1
RC18WAF0077	687291.32	7435903.846	F North	Scraping	04/05/2019	2
RC18WAF0077	687291.32	7435903.846	F North	Trapping	04/05/2019	2
RC18WAF0079	687300.31	7436197.613	F North	Trapping	09/11/2018	1
RC18WAF0079	687300.31	7436197.613	F North	Scraping	04/05/2019	2
RC18WAF0079	687300.31	7436197.613	F North	Trapping	04/05/2019	2
RC18WAH0078	690204.371	7441503.813	H	Scraping	06/05/2019	2
RC18WAH0078	690204.371	7441503.813	H	Trapping	06/05/2019	2
RC18WAH0117	690501.641	7441847.274	H	Scraping	06/05/2019	2
RC18WAH0117	690501.641	7441847.274	H	Trapping	06/05/2019	2
RC18WAH0124	690749.118	7442097.529	H	Scraping	06/05/2019	2
RC18WAH0124	690749.118	7442097.529	H	Trapping	06/05/2019	2
RC18WAH0132	690956.823	7441995.159	H	Scraping	06/05/2019	2
RC18WAH0194	690800.413	7441539.971	H	Scraping	06/05/2019	2
RC18WAH0273	692948.043	7441197.127	H	Scraping	05/05/2019	2

Hole ID	Easting	Northing	Sampling Area	Sampling Method	Date	Phase
RC18WAH0273	692948.043	7441197.127	H	Trapping	05/05/2019	2
RC18WAH0343	691050.272	7441259.287	H	Scraping	05/05/2019	2
RC18WAH0343	691050.272	7441259.287	H	Trapping	05/05/2019	2
RC18WAH0409	691296.656	7441298.158	H	Scraping	06/05/2019	2
RC18WAH0409	691296.656	7441298.158	H	Trapping	06/05/2019	2
RC18WAH0523	694947.213	7440998.462	H	Scraping	05/05/2019	2
RC18WAH0523	694947.213	7440998.462	H	Trapping	05/05/2019	2
RC18WAH0576	691652.062	7441354.134	H	Hauling	06/05/2019	2
RC18WAH0576	691652.062	7441354.134	H	Scraping	06/05/2019	2
RC18WAH0576	691652.062	7441354.134	H	Trapping	06/05/2019	2
RC18WAH0586	696046.416	7441201.753	H	Scraping	05/05/2019	2
RC18WAH0586	696046.416	7441201.753	H	Trapping	05/05/2019	2
RC18WAJ0001	680699.84	7430451.079	J	Trapping	08/11/2018	1
RC18WAJ0001	680699.84	7430451.079	J	Hauling	08/11/2018	1
RC18WAJ0001	680699.84	7430451.079	J	Scraping	08/11/2018	1
RC18WAJ0004	680702.19	7430299.481	J	Trapping	08/11/2018	1
RC18WAJ0004	680702.19	7430299.481	J	Hauling	10/09/2018	1
RC18WAJ0004	680702.19	7430299.481	J	Scraping	10/09/2018	1
RC18WAJ0004	680702.19	7430299.481	J	Hauling	04/05/2019	2
RC18WAJ0004	680702.19	7430299.481	J	Scraping	04/05/2019	2
RC18WAJ0004	680702.19	7430299.481	J	Trapping	04/05/2019	2
RC18WAJ0005	680409.183	7431002.375	J	Trapping	08/11/2018	1
RC18WAJ0005	680409.183	7431002.375	J	Scraping	10/09/2018	1
RC18WAJ0006	680492.147	7430953.605	J	Trapping	08/11/2018	1
RC18WAJ0006	680492.147	7430953.605	J	Scraping	10/09/2018	1
RC18WAJ0006	680492.147	7430953.605	J	Scraping	04/05/2019	2
RC18WAJ0006	680492.147	7430953.605	J	Trapping	04/05/2019	2
RC18WAJ0009	680503.761	7430758.863	J	Trapping	08/11/2018	1
RC18WAJ0009	680503.761	7430758.863	J	Scraping	08/11/2018	1
RC18WAJ0009	680503.761	7430758.863	J	Scraping	03/05/2019	2
RC18WAJ0009	680503.761	7430758.863	J	Trapping	03/05/2019	2
RC18WAJ0010	680501.218	7430697.579	J	Scraping	08/11/2018	1
RC18WAJ0013	680501.027	7430548.331	J	Trapping	08/11/2018	1
RC18WAJ0013	680501.027	7430548.331	J	Scraping	08/11/2018	1
RC18WAJ0015	680289.622	7431001.66	J	Trapping	08/11/2018	1
RC18WAJ0015	680289.622	7431001.66	J	Scraping	08/11/2018	1
RC18WAJ0018	680302.211	7430854.648	J	Trapping	08/11/2018	1
RC18WAJ0018	680302.211	7430854.648	J	Scraping	10/09/2018	1
RC18WAJ0020	680093.449	7431001.739	J	Trapping	08/11/2018	1
RC18WAJ0020	680093.449	7431001.739	J	Scraping	10/09/2018	1
RC18WAJ0020	680093.449	7431001.739	J	Scraping	02/05/2019	2
RC18WAJ0020	680093.449	7431001.739	J	Trapping	02/05/2019	2
RC18WAJ0021	680100.32	7430955.293	J	Scraping	08/11/2018	1
RC18WAJ0022	680099.954	7430905.785	J	Scraping	10/09/2018	1
RC18WAJ0024	677305.152	7429951.186	J	Trapping	08/11/2018	1
RC18WAJ0024	677305.152	7429951.186	J	Scraping	08/11/2018	1
RC18WAJ0024	677305.152	7429951.186	J	Scraping	03/05/2019	2
RC18WAJ0024	677305.152	7429951.186	J	Trapping	03/05/2019	2
RC18WAJ0025	676895.624	7430055.318	J	Trapping	08/11/2018	1
RC18WAJ0025	676895.624	7430055.318	J	Scraping	08/11/2018	1
RC18WAJ0025	676895.624	7430055.318	J	Scraping	03/05/2019	2
RC18WAJ0025	676895.624	7430055.318	J	Trapping	03/05/2019	2
RC18WAJ0028	676896.56	7429899.889	J	Hauling	08/09/2018	1
RC18WAJ0028	676896.56	7429899.889	J	Scraping	08/09/2018	1
RC18WAJ0029	676894.698	7429745.536	J	Trapping	08/11/2018	1
RC18WAJ0029	676894.698	7429745.536	J	Scraping	08/11/2018	1
RC18WAJ0029	676894.698	7429745.536	J	Scraping	03/05/2019	2
RC18WAJ0029	676894.698	7429745.536	J	Trapping	03/05/2019	2
RC18WAJ0032	676699.265	7429801.193	J	Scraping	08/09/2018	1
RC18WAJ0032	676699.265	7429801.193	J	Scraping	03/05/2019	2

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RC18WAJ0032	676699.265	7429801.193	J	Trapping	03/05/2019	2
RC18WAJ0034	676698.991	7429899.807	J	Trapping	08/11/2018	1
RC18WAJ0034	676698.991	7429899.807	J	Hauling	08/09/2018	1
RC18WAJ0034	676698.991	7429899.807	J	Scraping	08/09/2018	1
RC18WAJ0036	676697.659	7430004.943	J	Scraping	08/09/2018	1
RC18WAJ0037	676699.947	7430050.957	J	Trapping	08/11/2018	1
RC18WAJ0037	676699.947	7430050.957	J	Scraping	08/11/2018	1
RC18WAJ0037	676699.947	7430050.957	J	Scraping	03/05/2019	2
RC18WAJ0037	676699.947	7430050.957	J	Trapping	03/05/2019	2
RC18WAJ0038	676499.077	7429799.476	J	Trapping	08/11/2018	1
RC18WAJ0038	676499.077	7429799.476	J	Scraping	08/11/2018	1
RC18WAJ0038	676499.077	7429799.476	J	Hauling	03/05/2019	2
RC18WAJ0038	676499.077	7429799.476	J	Scraping	03/05/2019	2
RC18WAJ0038	676499.077	7429799.476	J	Trapping	03/05/2019	2
RC18WAJ0040	676500.83	7429896.384	J	Scraping	08/09/2018	1
RC18WAJ0042	676500.441	7430054.115	J	Trapping	08/11/2018	1
RC18WAJ0042	676500.441	7430054.115	J	Scraping	08/11/2018	1
RC18WAW0002	670019.764	7443311.563	Western Hill	Trapping	05/11/2018	1
RC18WAW0002	670019.764	7443311.563	Western Hill	Scraping	05/11/2018	1
RC18WAW0008	669700.905	7443047.586	Western Hill	Trapping	05/11/2018	1
RC18WAW0008	669700.905	7443047.586	Western Hill	Scraping	05/11/2018	1
RC18WAW0009	669411.47	7443409.146	Western Hill	Trapping	01/05/2019	2
RC18WAW0009	669411.47	7443409.146	Western Hill	Scraping	01/05/2019	2
RC18WAW0011	669204.233	7443498.703	Western Hill	Trapping	05/11/2018	1
RC18WAW0011	669204.233	7443498.703	Western Hill	Scraping	05/11/2018	1
RC18WAW0011	669204.233	7443498.703	Western Hill	Trapping	01/05/2019	2
RC18WAW0011	669204.233	7443498.703	Western Hill	Scraping	01/05/2019	2
RC18WAW0014	668933.979	7443449.161	Western Hill	Trapping	05/11/2018	1
RC18WAW0025	668710.118	7443546.199	Western Hill	Trapping	01/05/2019	2
RC18WAW0025	668710.118	7443546.199	Western Hill	Scraping	01/05/2019	2
RC18WAW0026	668796.982	7443507.104	Western Hill	Trapping	05/11/2018	1
RC18WAW0026	668796.982	7443507.104	Western Hill	Scraping	05/11/2018	1
RC18WAW0029	668708.017	7443651.474	Western Hill	Trapping	05/11/2018	1
RC18WAW0029	668708.017	7443651.474	Western Hill	Scraping	05/11/2018	1
RC18WAW0031	668498.259	7443552.387	Western Hill	Trapping	05/11/2018	1
RC18WAW0031	668498.259	7443552.387	Western Hill	Scraping	05/11/2018	1
RC18WAW0033	669599.893	7443102.945	Western Hill	Trapping	05/11/2018	1
RC18WAW0033	669599.893	7443102.945	Western Hill	Scraping	05/11/2018	1
RC18WAW0039	669094.539	7443251.822	Western Hill	Trapping	01/05/2019	2
RC18WAW0039	669094.539	7443251.822	Western Hill	Scraping	01/05/2019	2
RC18WAW0042	669199.422	7443099.343	Western Hill	Trapping	01/05/2019	2
RC18WAW0042	669199.422	7443099.343	Western Hill	Hauling	01/05/2019	2
RC18WAW0042	669199.422	7443099.343	Western Hill	Scraping	01/05/2019	2
RC18WAW0049	668799.58	7442998.569	Western Hill	Trapping	05/11/2018	1
RC18WAW0049	668799.58	7442998.569	Western Hill	Scraping	05/11/2018	1
RC18WAW0051	666945.92	7442789.577	Western Hill	Trapping	05/11/2018	1
RC18WAW0051	666945.92	7442789.577	Western Hill	Scraping	05/11/2018	1
RC18WAW0051	666945.92	7442789.577	Western Hill	Trapping	30/04/2019	2
RC18WAW0051	666945.92	7442789.577	Western Hill	Scraping	30/04/2019	2
RC18WAW0054	666849.888	7442853.147	Western Hill	Scraping	05/11/2018	1
RC18WAW0054	666849.888	7442853.147	Western Hill	Trapping	30/04/2019	2
RC18WAW0054	666849.888	7442853.147	Western Hill	Scraping	30/04/2019	2
RC18WAW0057	666749.175	7443051.87	Western Hill	Trapping	05/11/2018	1
RC18WAW0057	666749.175	7443051.87	Western Hill	Scraping	05/11/2018	1
RC18WAW0060	666245.777	7443095.02	Western Hill	Trapping	05/11/2018	1
RC18WAW0060	666245.777	7443095.02	Western Hill	Scraping	05/11/2018	1
RC18WAW0060	666245.777	7443095.02	Western Hill	Trapping	30/04/2019	2
RC18WAW0060	666245.777	7443095.02	Western Hill	Scraping	30/04/2019	2
RC18WAW0062	666347.095	7443103.55	Western Hill	Trapping	30/04/2019	2
RC18WAW0062	666347.095	7443103.55	Western Hill	Scraping	30/04/2019	2

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RC18WAW0063	666454.549	7442998.796	Western Hill	Trapping	30/04/2019	2
RC18WAW0063	666454.549	7442998.796	Western Hill	Scraping	30/04/2019	2
RC18WAW0064	666349.757	7442951.324	Western Hill	Trapping	05/11/2018	1
RC18WAW0064	666349.757	7442951.324	Western Hill	Scraping	05/11/2018	1
RC18WAW0065	666254.476	7442899.074	Western Hill	Trapping	30/04/2019	2
RC18WAW0065	666254.476	7442899.074	Western Hill	Scraping	30/04/2019	2
RC18WAW0068	666449.275	7442799.538	Western Hill	Scraping	05/11/2018	1
RC18WAW0071	666527.472	7442708.716	Western Hill	Trapping	05/11/2018	1
RC18WAW0071	666527.472	7442708.716	Western Hill	Scraping	05/11/2018	1
RC18WAW0073	668998.493	7442599.934	Western Hill	Scraping	14/09/2018	1
RC18WAW0076	668598.803	7442946.482	Western Hill	Scraping	14/09/2018	1
RC18WAW0077	668394.628	7442894.075	Western Hill	Scraping	14/09/2018	1
RC18WAW0082	668398.568	7443402.097	Western Hill	Trapping	01/05/2019	2
RC18WAW0082	668398.568	7443402.097	Western Hill	Scraping	01/05/2019	2
RC18WAW0085	668503.017	7443294.121	Western Hill	Trapping	05/11/2018	1
RC18WAW0085	668503.017	7443294.121	Western Hill	Hauling	05/11/2018	1
RC18WAW0085	668503.017	7443294.121	Western Hill	Scraping	05/11/2018	1
RC18WAW0087	668599.121	7443410.391	Western Hill	Trapping	01/05/2019	2
RC18WAW0087	668599.121	7443410.391	Western Hill	Hauling	01/05/2019	2
RC18WAW0087	668599.121	7443410.391	Western Hill	Scraping	01/05/2019	2
RC18WAW0090	668785.69	7443352.346	Western Hill	Trapping	05/11/2018	1
RC18WAW0090	668785.69	7443352.346	Western Hill	Scraping	05/11/2018	1
RC18WAW0090	668785.69	7443352.346	Western Hill	Trapping	01/05/2019	2
RC18WAW0090	668785.69	7443352.346	Western Hill	Scraping	01/05/2019	2
RC18WAW0091	668199.967	7443600.078	Western Hill	Trapping	01/05/2019	2
RC18WAW0091	668199.967	7443600.078	Western Hill	Hauling	01/05/2019	2
RC18WAW0091	668199.967	7443600.078	Western Hill	Scraping	01/05/2019	2
RC18WAW0096	668918.549	7443230.699	Western Hill	Trapping	05/11/2018	1
RC18WAW0096	668918.549	7443230.699	Western Hill	Scraping	05/11/2018	1
RC18WAW0100	668800.435	7442699.556	Western Hill	Trapping	01/05/2019	2
RC18WAW0100	668800.435	7442699.556	Western Hill	Scraping	01/05/2019	2
RC18WAW0109	662401.755	7442645.684	Western Hill	Trapping	30/04/2019	2
RC18WAW0109	662401.755	7442645.684	Western Hill	Scraping	30/04/2019	2
RC18WAW0113	662849.76	7442799.241	Western Hill	Trapping	06/11/2018	1
RC18WAW0113	662849.76	7442799.241	Western Hill	Hauling	06/11/2018	1
RC18WAW0113	662849.76	7442799.241	Western Hill	Scraping	06/11/2018	1
RC18WAW0121	663057.441	7442407.809	Western Hill	Trapping	06/11/2018	1
RC18WAW0121	663057.441	7442407.809	Western Hill	Scraping	06/11/2018	1
RC18WAW0121	663057.441	7442407.809	Western Hill	Trapping	30/04/2019	2
RC18WAW0121	663057.441	7442407.809	Western Hill	Scraping	30/04/2019	2
RC18WAW0122	663351.991	7442354.42	Western Hill	Trapping	06/11/2018	1
RC18WAW0122	663351.991	7442354.42	Western Hill	Scraping	06/11/2018	1
RC18WAW0122	663351.991	7442354.42	Western Hill	Trapping	30/04/2019	2
RC18WAW0122	663351.991	7442354.42	Western Hill	Scraping	30/04/2019	2
RC18WAW0129	663549.61	7442250.941	Western Hill	Trapping	06/11/2018	1
RC18WAW0129	663549.61	7442250.941	Western Hill	Scraping	06/11/2018	1
RC18WAW0135	663650.868	7442397.536	Western Hill	Trapping	06/11/2018	1
RC18WAW0135	663650.868	7442397.536	Western Hill	Scraping	06/11/2018	1
RC18WAW0135	663650.868	7442397.536	Western Hill	Trapping	30/04/2019	2
RC18WAW0135	663650.868	7442397.536	Western Hill	Scraping	30/04/2019	2
RC18WAW0137	663851.597	7442345.109	Western Hill	Trapping	06/11/2018	1
RC18WAW0137	663851.597	7442345.109	Western Hill	Scraping	06/11/2018	1
RC18WAW0137	663851.597	7442345.109	Western Hill	Trapping	30/04/2019	2
RC18WAW0137	663851.597	7442345.109	Western Hill	Scraping	30/04/2019	2
RC18WAW0140	663857.486	7442101.215	Western Hill	Trapping	06/11/2018	1
RC18WAW0140	663857.486	7442101.215	Western Hill	Scraping	06/11/2018	1
RC18WAW0145	663750.293	7441898.919	Western Hill	Trapping	06/11/2018	1
RC18WAW0145	663750.293	7441898.919	Western Hill	Hauling	06/11/2018	1
RC18WAW0145	663750.293	7441898.919	Western Hill	Scraping	06/11/2018	1
RC18WAW0149	663652.534	7442099.275	Western Hill	Trapping	06/11/2018	1

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RC18WAW0152	663839.24	7442567.333	Western Hill	Trapping	06/11/2018	1
RC18WAW0153	663960.348	7442695.836	Western Hill	Trapping	06/11/2018	1
RC18WAW0153	663960.348	7442695.836	Western Hill	Trapping	06/11/2018	1
RC18WAW0153	663960.348	7442695.836	Western Hill	Scraping	06/11/2018	1
RC18WAW0153	663960.348	7442695.836	Western Hill	Scraping	06/11/2018	1
RC18WAW0158	664251.541	7442513.378	Western Hill	Trapping	06/11/2018	1
RC18WAW0180	664948.861	7442853.998	Western Hill	Trapping	30/04/2019	2
RC18WAW0180	664948.861	7442853.998	Western Hill	Scraping	30/04/2019	2
RC18WAW0200	664546.348	7442946.601	Western Hill	Hauling	08/05/2019	2
RC18WAW0200	664546.348	7442946.601	Western Hill	Scraping	08/05/2019	2
RC18WAW0201	664254.31	7441899.423	Western Hill	Trapping	06/11/2018	1
RC18WAW0201	664254.31	7441899.423	Western Hill	Scraping	06/11/2018	1
RC18WAW0208	664049.429	7442405.589	Western Hill	Scraping	06/11/2018	1
RC18WAW0249	664551.192	7443044.24	Western Hill	Trapping	30/04/2019	2
RC18WAW0249	664551.192	7443044.24	Western Hill	Scraping	30/04/2019	2
RC18WAW0252	666146.459	7442542.568	Western Hill	Scraping	05/11/2018	1
RC18WAW0254	666235.738	7442431.756	Western Hill	Scraping	05/11/2018	1
RC18WAW0263	665541.35	7442005.857	Western Hill	Trapping	30/04/2019	2
RC18WAW0263	665541.35	7442005.857	Western Hill	Scraping	30/04/2019	2
RC18WAW0268	665352.57	7441705.291	Western Hill	Hauling	06/11/2018	1
RC18WAW0268	665352.57	7441705.291	Western Hill	Scraping	06/11/2018	1
RC18WAW0300	665043.983	7441991.715	Western Hill	Trapping	30/04/2019	2
RC18WAW0300	665043.983	7441991.715	Western Hill	Hauling	30/04/2019	2
RC18WAW0300	665043.983	7441991.715	Western Hill	Scraping	30/04/2019	2
RC18WAX0001	687100.617	7431603.16	MTEE	Trapping	07/11/2018	1
RC18WAX0001	687100.617	7431603.16	MTEE	Scraping	07/11/2018	1
RC18WAX0001	687100.617	7431603.16	MTEE	Trapping	01/05/2019	2
RC18WAX0001	687100.617	7431603.16	MTEE	Scraping	01/05/2019	2
RC18WAX0002	686903.354	7431555.21	MTEE	Trapping	07/11/2018	1
RC18WAX0003	686697.868	7431600.935	MTEE	Trapping	07/11/2018	1
RC18WAX0003	686697.868	7431600.935	MTEE	Scraping	11/09/2018	1
RC18WAX0003	686697.868	7431600.935	MTEE	Trapping	02/05/2019	2
RC18WAX0003	686697.868	7431600.935	MTEE	Scraping	02/05/2019	2
RC18WAX0006	686503.617	7431806.254	MTEE	Trapping	07/11/2018	1
RC18WAX0006	686503.617	7431806.254	MTEE	Scraping	07/11/2018	1
RC18WAX0006	686503.617	7431806.254	MTEE	Trapping	02/05/2019	2
RC18WAX0006	686503.617	7431806.254	MTEE	Scraping	02/05/2019	2
RC18WAX0010	684065.588	7432210.731	MTEE	Trapping	07/11/2018	1
RC18WAX0010	684065.588	7432210.731	MTEE	Scraping	07/11/2018	1
RC18WAX0011	683601.03	7431951.369	MTEE	Trapping	07/11/2018	1
RC18WAX0011	683601.03	7431951.369	MTEE	Scraping	11/09/2018	1
RC18WAX0013	683609.019	7432109.084	MTEE	Trapping	02/05/2019	2
RC18WAX0013	683609.019	7432109.084	MTEE	Scraping	02/05/2019	2
RC18WAX0017	683701.004	7432310.183	MTEE	Trapping	07/11/2018	1
RC18WAX0017	683701.004	7432310.183	MTEE	Scraping	07/11/2018	1
RC18WAX0017	683701.004	7432310.183	MTEE	Trapping	02/05/2019	2
RC18WAX0017	683701.004	7432310.183	MTEE	Scraping	02/05/2019	2
RC18WAX0019	683401.98	7432105.641	MTEE	Trapping	09/11/2018	1
RC18WAX0019	683401.98	7432105.641	MTEE	Scraping	11/09/2018	1
RC18WAX0019	683401.98	7432105.641	MTEE	Trapping	02/05/2019	2
RC18WAX0019	683401.98	7432105.641	MTEE	Scraping	02/05/2019	2
RC18WAX0022	686900.155	7431702.392	MTEE	Scraping	07/11/2018	1
RC18WAX0023	686900.579	7432002.301	MTEE	Trapping	07/11/2018	1
RC18WAX0023	686900.579	7432002.301	MTEE	Scraping	07/11/2018	1
RC18WAX0023	686900.579	7432002.301	MTEE	Trapping	01/05/2019	2
RC18WAX0023	686900.579	7432002.301	MTEE	Scraping	01/05/2019	2
RC18WAX0026	683202.335	7431960.925	MTEE	Trapping	07/11/2018	1
RC18WAX0026	683202.335	7431960.925	MTEE	Scraping	07/11/2018	1
RC18WAX0026	683202.335	7431960.925	MTEE	Trapping	02/05/2019	2
RC18WAX0026	683202.335	7431960.925	MTEE	Scraping	02/05/2019	2

Hole ID	Easting	Northing	Sampling Area	Sampling Method	Date	Phase
RC18WAX0028	683202.702	7432150.921	MTEE	Trapping	02/05/2019	2
RC18WAX0031	682902.846	7432152.79	MTEE	Trapping	02/05/2019	2
RC18WAX0031	682902.846	7432152.79	MTEE	Scraping	02/05/2019	2
RC18WAX0034	686704.579	7432103.803	MTEE	Hauling	07/11/2018	1
RC18WAX0034	686704.579	7432103.803	MTEE	Scraping	07/11/2018	1
RC18WAX0036	686701.989	7432002.527	MTEE	Trapping	07/11/2018	1
RC18WAX0036	686701.989	7432002.527	MTEE	Hauling	07/11/2018	1
RC18WAX0036	686701.989	7432002.527	MTEE	Scraping	07/11/2018	1
RC18WAX0036	686701.989	7432002.527	MTEE	Trapping	01/05/2019	2
RC18WAX0036	686701.989	7432002.527	MTEE	Hauling	01/05/2019	2
RC18WAX0036	686701.989	7432002.527	MTEE	Scraping	01/05/2019	2
RC18WAX0038	686500.62	7432100.114	MTEE	Scraping	07/11/2018	1
RC18WAX0039	686901.514	7431811.724	MTEE	Trapping	07/11/2018	1
RC18WAX0039	686901.514	7431811.724	MTEE	Scraping	07/11/2018	1
RC18WAX0039	686901.514	7431811.724	MTEE	Trapping	01/05/2019	2
RC18WAX0039	686901.514	7431811.724	MTEE	Scraping	01/05/2019	2
RC18WAX0040	682903.716	7432451.08	MTEE	Trapping	07/11/2018	1
RC18WAX0040	682903.716	7432451.08	MTEE	Scraping	07/11/2018	1
RC18WAX0040	682903.716	7432451.08	MTEE	Trapping	02/05/2019	2
RC18WAX0040	682903.716	7432451.08	MTEE	Scraping	02/05/2019	2
RC18WAX0041	682802.602	7432152.395	MTEE	Trapping	07/11/2018	1
RC18WAX0041	682802.602	7432152.395	MTEE	Trapping	02/05/2019	2
RC18WAX0041	682802.602	7432152.395	MTEE	Scraping	02/05/2019	2
RC18WAX0042	686703.158	7431802.013	MTEE	Hauling	07/11/2018	1
RC18WAX0042	686703.158	7431802.013	MTEE	Scraping	07/11/2018	1
RC18WAX0045	686792.501	7431600.762	MTEE	Trapping	07/11/2018	1
RC18WAX0045	686792.501	7431600.762	MTEE	Scraping	11/09/2018	1
RC18WAX0045	686792.501	7431600.762	MTEE	Trapping	02/05/2019	2
RC18WAX0045	686792.501	7431600.762	MTEE	Scraping	02/05/2019	2
RC18WAX0050	682597.832	7432398.46	MTEE	Scraping	07/11/2018	1
RC18WAX0054	682501.291	7432452.954	MTEE	Scraping	07/11/2018	1
RC18WAX0055	682500.493	7432562.415	MTEE	Trapping	07/11/2018	1
RC18WAX0055	682500.493	7432562.415	MTEE	Scraping	12/09/2018	1
RC19WAX0001	693199.72	7432654.027	MTEE	Scraping	04/10/2020	4
RC19WAX0002	693000.415	7432199.328	MTEE	Scraping	04/10/2020	4
RC19WAX0003	692399.429	7432504.159	MTEE	Scraping	04/10/2020	4
RC19WAX0004	692401.795	7432099.939	MTEE	Scraping	04/10/2020	4
RC19WAX0006	692396.729	7431898.255	MTEE	Scraping	04/10/2020	4
RC19WAX0008	691998.963	7431898.696	MTEE	Scraping	04/10/2020	4
RC19WAX0009	691802.484	7431714.03	MTEE	Scraping	04/10/2020	4
RC19WAX0011	691798.215	7431899.651	MTEE	Scraping	04/10/2020	4
RC19WAX0012	691594.605	7432298.76	MTEE	Scraping	04/10/2020	4
RC19WAX0013	691797.726	7431397.3	MTEE	Scraping	04/10/2020	4
RC19WAX0014	691998.947	7431200.028	MTEE	Scraping	04/10/2020	4
RC19WAX0017	691992.282	7431614.498	MTEE	Scraping	04/10/2020	4
RC19WAX0018	692197.533	7431604.796	MTEE	Scraping	04/10/2020	4
RC19WAX0019	692206.334	7431735.706	MTEE	Scraping	04/10/2020	4
RC19WAX0021	691401.258	7431799.84	MTEE	Scraping	04/10/2020	4
RC19WAX0023	691595.95	7431555.226	MTEE	Scraping	04/10/2020	4
RC19WAX0025	691199.906	7430998.418	MTEE	Scraping	04/10/2020	4
RC19WAX0027	691192.851	7431407.626	MTEE	Scraping	05/10/2020	4
RC19WAX0028	691004.357	7431305.605	MTEE	Scraping	05/10/2020	4
RC19WAX0029	690801.3	7431047.805	MTEE	Scraping	05/10/2020	4
RC19WAX0031	690648.773	7431239.977	MTEE	Scraping	05/10/2020	4
RC19WAX0032	690797.243	7431267.118	MTEE	Scraping	05/10/2020	4
RC19WAX0034	691003.913	7430904.675	MTEE	Scraping	05/10/2020	4
RC19WAX0036	690802.384	7430647.099	MTEE	Scraping	05/10/2020	4
RC19WAX0037	690014.526	7430650.599	MTEE	Scraping	04/10/2020	4
RC19WAX0038	691203.393	7430609.561	MTEE	Scraping	04/10/2020	4
RC19WAX0039	691996.168	7430799.444	MTEE	Scraping	05/10/2020	4

Hole ID	Easting	Northing	Sampling Area	Sampling Method	Date	Phase
RC19WAX0041	692001.895	7430606.017	MTEE	Scraping	04/10/2020	4
RC19WAX0042	691398.618	7430816.77	MTEE	Scraping	05/10/2020	4
RC19WAX0043	691599.198	7430952.755	MTEE	Scraping	04/10/2020	4
RC19WAX0045	691400.872	7431199.372	MTEE	Scraping	04/10/2020	4
RC19WAX0047	691393.502	7431495.564	MTEE	Scraping	05/10/2020	4
RC19WAX0050	690599.655	7431495.781	MTEE	Scraping	05/10/2020	4
RC19WAX0052	690409.186	7431499.711	MTEE	Scraping	05/10/2020	4
RC19WAX0053	690200.263	7431494.148	MTEE	Scraping	05/10/2020	4
RC19WAX0055	691200.367	7431610.072	MTEE	Scraping	04/10/2020	4
RC19WAX0056	691001.765	7431851.07	MTEE	Scraping	05/10/2020	4
RC19WAX0057	691000.621	7431652.258	MTEE	Scraping	05/10/2020	4
RC19WAX0058	690804.633	7431599.805	MTEE	Scraping	05/10/2020	4
RC19WAX0060	688994.185	7432099.579	MTEE	Scraping	05/10/2020	4
RC19WAX0061	689806.114	7431598.69	MTEE	Scraping	05/10/2020	4
RC19WAX0062	689795.864	7431495.399	MTEE	Scraping	05/10/2020	4
RC19WAX0063	689809.141	7431399.479	MTEE	Scraping	05/10/2020	4
RC19WAX0064	689604.706	7431266.156	MTEE	Scraping	05/10/2020	4
RC19WAX0065	689594.421	7431365.941	MTEE	Scraping	05/10/2020	4
RC19WAX0066	688797.543	7432000.646	MTEE	Scraping	05/10/2020	4
RC19WAX0071	688397.108	7432102.199	MTEE	Scraping	05/10/2020	4
WA7RC0085	666043.6525	7443038.76	Western Hill	Trapping	05/11/2018	1
WA7RC0085	666043.6525	7443038.76	Western Hill	Scraping	05/11/2018	1
WA7RC0090	662668.2315	7441852.905	Western Hill	Trapping	06/11/2018	1
WA7RC0090	662668.2315	7441852.905	Western Hill	Hauling	06/11/2018	1
WA7RC0090	662668.2315	7441852.905	Western Hill	Scraping	06/11/2018	1
WA7RC0090	662668.2315	7441852.905	Western Hill	Trapping	30/04/2019	2
WA7RC0090	662668.2315	7441852.905	Western Hill	Scraping	30/04/2019	2
WA7RC0091	663506.6655	7441742.864	Western Hill	Scraping	06/11/2018	1
WAAWE0008	672380.494	7437864.939	CWB	Hauling	09/09/2018	1
WAAWE0008	672380.494	7437864.939	CWB	Hauling	08/05/2019	2
WAAWE0054	674610.453	7437158.644	CWB	Pumping	09/05/2019	2
WAFRC1716	692160.593	7434606.658	F North	Trapping	09/11/2018	1
WAFRC1716	692160.593	7434606.658	F North	Scraping	12/09/2018	1
WAFRC1716	692160.593	7434606.658	F North	Trapping	04/05/2019	2
WAFRC1716	692160.593	7434606.658	F North	Scraping	04/05/2019	2
WB033	672784.63	7437710.721	CWB	Pumping	09/05/2019	2
WB13WAPP016	650908.332	7429354.79	TCBF	Hauling	14/03/2019	2
WB13WAPP016	650908.332	7429354.79	TCBF	Hauling	07/05/2019	2
WB16WAW0001	664510.712	7439300.46	CALC	Hauling	18/03/2019	2
WB16WAW0001	664510.712	7439300.46	CALC	Hauling	09/05/2019	2
WB43	682891	7440845	CWB	Hauling	08/05/2019	2
WB51	678910.72	7438443.93	CWB	Hauling	09/09/2018	1
WB51	678910.72	7438443.93	CWB	Hauling	08/05/2019	2
WB52	680179.69	7438926.1	CWB	Hauling	09/09/2018	1
WB52	680179.69	7438926.1	CWB	Hauling	08/05/2019	2
WB60	677864.52	7436705.98	CWB	Hauling	09/09/2018	1
WB60	677864.52	7436705.98	CWB	Hauling	08/05/2019	2
WB61	675829.82	7438038.73	CWB	Hauling	09/09/2018	1
WB61	675829.82	7438038.73	CWB	Hauling	08/05/2019	2
WB63	684591.48	7439795.53	CWB	Hauling	08/05/2019	2
WOB01	651892.86	7433635.75	TCBF	Hauling	13/03/2019	2
WOB01	651892.86	7433635.75	TCBF	Hauling	07/05/2019	2
WOB03	648835.42	7433438.68	TCBF	Hauling	13/03/2019	2
WOB03	648835.42	7433438.68	TCBF	Hauling	07/05/2019	2
WOB05	650302.92	7430685.6	TCBF	Hauling	13/03/2019	2
WOB05	650302.92	7430685.6	TCBF	Hauling	07/05/2019	2
WOB07	649351.51	7430885.74	TCBF	Hauling	13/03/2019	2
WOB09	648817.11	7435472.77	TCBF	Hauling	13/03/2019	2
WOB09	648817.11	7435472.77	TCBF	Hauling	07/05/2019	2
WOB12	649279.77	7429070.56	TCBF	Hauling	14/03/2019	2

Hole ID	Easting	Northing	Sampling Area	Sampling Method	Date	Phase
WOB12	649279.77	7429070.56	TCBF	Hauling	07/05/2019	2
WOB13	646568.3	7426077.87	TCBF	Hauling	07/05/2019	2
WOB20	649279.28	7435834.11	TCBF	Hauling	13/03/2019	2
WOB20	649279.28	7435834.11	TCBF	Hauling	07/05/2019	2
WOB22	646299.45	7431171.94	TCBF	Hauling	13/03/2019	2
WOB22	646299.45	7431171.94	TCBF	Hauling	07/05/2019	2
WOB4	651924.41	7433914.74	TCBF	Hauling	14/03/2019	2
WOB4	651924.41	7433914.74	TCBF	Hauling	07/05/2019	2
WTP5	649791.93	7432707.73	TCBF	Hauling	13/03/2019	2
WTP5	649791.93	7432707.73	TCBF	Hauling	07/05/2019	2

Appendix B – Molecular systematics analysis report

This appendix has been provided separately
("WAN_Molecular Sequencing Report v.01.docx")

Appendix C – Database search results

Higher Taxon	Lowest ID	Site/Well	Latitude	Longitude	Source
Acari	*Neumania* sp. indet.	27.6 km E. of Coondewanna Hill	-23.133	119.051	WAM
Acari	Pezidae sp. indet.	N/A	N/A	N/A	NM
Amphipoda	Amphipoda sp. indet.	WB033	-23.161	118.688	ecologia (2005)
Amphipoda	Amphipoda sp. indet.	WB33	-23.161	118.688	Biota (2003)
Amphipoda	Amphipoda sp. indet.	WB41	-23.127	118.779	ecologia (2005)
Amphipoda	Amphipoda sp. indet.	WB41	-23.127	118.779	Biota (2003)
Amphipoda	Amphipoda sp. indet.	WB41	-23.127	118.779	Biota (2003)
Amphipoda	Amphipoda sp. indet.	WB51	-23.153	118.748	ecologia (2005)
Amphipoda	Amphipoda sp. indet.	WB51	-23.153	118.748	Biota (2003)
Amphipoda	Amphipoda sp. indet.	WB51	-23.153	118.748	Biota (2003)
Amphipoda	Amphipoda sp. indet.	WB51	-23.153	118.748	Biota (2003)
Amphipoda	Amphipoda sp. indet.	WB54	-23.159	118.689	ecologia (2005)
Amphipoda	Amphipoda sp. indet.	WB54	-23.159	118.689	Biota (2003)
Amphipoda	Amphipoda sp. indet.	WB54	-23.159	118.689	Biota (2003)
Amphipoda	Amphipoda sp. indet.	WB54	-23.159	118.689	Biota (2003)
Amphipoda	Amphipoda sp. indet.	WB56	-23.163	118.707	ecologia (2005)
Amphipoda	Amphipoda sp. indet.	WB58	-23.135	118.787	Biota (2003)
Amphipoda	Amphipoda sp. indet.	WOB01	-23.199	118.484	Biota (2003)
Amphipoda	Amphipoda sp. indet.	WOB05	-23.226	118.469	Biota (2003)
Amphipoda	Amphipoda sp. indet.	WOB22	-23.222	118.430	Biota (2003)
Amphipoda	Amphipoda sp. indet.	WOB9	-23.183	118.454	Biota (2003)
Amphipoda	*Kruptus* `sp. AR`	ANRRC0388	-23.324	118.779	Sub. Ecology (2012)
Amphipoda	*Kruptus* `sp. AR`	ANRRC0432	-23.328	118.762	Sub. Ecology (2012)
Amphipoda	*Kruptus* `sp. AR`	ANRRC0457	-23.326	118.776	Sub. Ecology (2012)
Amphipoda	*Kruptus* `sp. AR`	ANRRC0472	-23.439	118.730	Sub. Ecology (2012)
Amphipoda	*Kruptus* `sp. AR`	ANRRC0494	-23.410	118.758	Sub. Ecology (2012)
Amphipoda	*Kruptus* `sp. AR`	ANRRC0506	-23.327	118.738	Sub. Ecology (2012)
Amphipoda	*Kruptus* `sp. Helix-AMP035`	RC13WAD0287	-23.174	118.635	Biologic (2016a)
Amphipoda	*Kruptus* `sp. Helix-AMP035`	RC13WAD0287	-23.174	118.635	Biologic (2016a)
Amphipoda	*Kruptus* `sp. Helix-AMP035`	RC14WAD0346	-23.171	118.611	Biologic (2016a)
Amphipoda	*Kruptus* `sp. Helix-AMP035`	RC15WAC0387	-23.141	118.624	Biologic (2016a)
Amphipoda	*Kruptus* `sp. Helix-AMP035`	RC15WAC0387	-23.141	118.624	Biologic (2016a)
Amphipoda	*Kruptus* sp. indet.	ca. 113 km WNW of Newman	-23.175	118.625	WAM
Amphipoda	*Kruptus* sp. indet.	ca. 113 km WNW of Newman	-23.174	118.635	WAM
Amphipoda	*Kruptus* sp. indet.	ca. 113 km WNW of Newman	-23.174	118.635	WAM
Amphipoda	*Kruptus* sp. indet.	ca. 113 km WNW of Newman	-23.171	118.611	WAM
Amphipoda	*Kruptus* sp. indet.	ca. 113 km WNW of Newman	-23.141	118.624	WAM
Amphipoda	*Kruptus* sp. indet.	ca. 113 km WNW of Newman	-23.149	118.686	WAM
Amphipoda	*Kruptus* sp. indet.	ca. 113 km WNW of Newman	-23.141	118.624	WAM
Amphipoda	*Maarrka* `sp. Helix-AMP037`	RC12WAD0295	-23.163	118.609	Biologic (2016a)
Amphipoda	*Maarrka* sp. indet.	ca. 113 km WNW of Newman	-23.163	118.609	WAM
Amphipoda	Paramelitidae `sp. Helix-AMP036`	RC15WAC0276	-23.149	118.686	Biologic (2016a)
Amphipoda	Paramelitidae sp. B03	Boundary Ridge North, ca. 87 km SSE. Wittenoom	-23.019	118.724	WAM
Amphipoda	Paramelitidae sp. indet.	N/A	N/A	N/A	NM
Amphipoda	Paramelitidae sp. indet.	RC13WAD0297	-23.175	118.625	Biologic (2016a)
Amphipoda	*Pilbarus millsi*	N/A	N/A	N/A	NM
Arachnida	Arachnida `DNA05`	ca. 79.5 km NW. of Newman	-23.166	118.981	WAM
Arachnida	Arachnida `DNA08`	Wonmunna, ca 70 km WNW. of Newman	-23.121	119.054	WAM
Araneae	*Araneus* sp. indet.	N/A	N/A	N/A	ALA
Araneae	*Encoptarthria* sp. indet.	N/A	N/A	N/A	ALA
Araneae	Gnaphosidae `wonmunna`	Wonmunna, ca 75 km WNW. of Newman	-23.166	118.985	WAM
Araneae	Gnaphosidae `wonmunna`	Wonmunna, ca 75 km WNW. of Newman	-23.162	118.999	WAM
Araneae	Gnaphosidae sp. indet.	N/A	N/A	N/A	ALA
Araneae	Gnaphosidae sp. indet.	RC14WAD0350	-23.166	118.615	Biologic (2016a)
Araneae	Gnaphosidae sp. indet.	RC15WAG0290	-23.137	118.734	Biologic (2016a)
Araneae	Gnaphosidae sp. indet.	WA6RC0055	-23.199	118.720	Biota (2013)
Araneae	Oonopidae sp. indet.	ANRRC0468	-23.447	118.719	Sub. Ecology (2012)
Araneae	Oonopidae sp. indet.	N/A	N/A	N/A	ALA
Araneae	Oonopidae sp. indet.	RC15WAC0390	-23.137	118.623	Biologic (2016a)
Araneae	Oonopidae sp. indet.	RC15WAG0296	-23.134	118.732	Biologic (2016a)
Araneae	*Prethopalpus* `DNA01`	Wonmunna, ca 70 km WNW. of Newman	-23.143	119.000	WAM
Araneae	*Prethopalpus* `DNA01`	Wonmunna, ca 70 km WNW. of Newman	-23.124	119.066	WAM
Araneae	*Prethopalpus* `DNA01`	Wonmunna, ca 70 km WNW. of Newman	-23.143	119.003	WAM
Araneae	*Prethopalpus julianneae*	ca. 100 km NW. of Newman, MAC, bore SF0569R	-22.992	118.833	WAM
Araneae	*Prethopalpus maini*	ca. 100 km NW. of Newman, MAC, bore SF0260R	-22.996	118.819	WAM
Araneae	*Prethopalpus maini*	ca. 100 km NW. of Newman, MAC, bore SF0288R	-22.985	118.818	WAM
Araneae	*Prethopalpus maini*	ca. 100 km NW. of Newman, MAC, bore SF0383R	-22.985	118.854	WAM
Araneae	*Prethopalpus* sp. indet.	WAH017	-23.124	118.886	ecologia (2013)
Araneae	Theridiidae sp. indet.	31.8 km SE. of Mt Meharry, West Angelas	-23.123	118.859	WAM
Bathynellacea	*Atopobathynella* `sp. Helix-BAP027/ WA`	RC15WAC0384	-23.139	118.635	Biologic (2016a)
Bathynellacea	*Atopobathynella* `sp. Helix-BAP027/ WA`	RC15WAC0413	-23.142	118.655	Biologic (2016a)
Bathynellacea	*Atopobathynella* `sp. Helix-BAP027/ WA`	RC15WAC0416	-23.142	118.647	Biologic (2016a)
Bathynellacea	*Atopobathynella* `sp. Helix-BAP027/ WA`	RC15WAC0416	-23.142	118.647	Biologic (2016a)
Bathynellacea	*Atopobathynella* sp. indet.	ca. 113 km WNW of Newman	-23.139	118.635	WAM
Bathynellacea	*Atopobathynella* sp. indet.	ca. 113 km WNW of Newman	-23.142	118.655	WAM
Bathynellacea	*Atopobathynella* sp. indet.	ca. 113 km WNW of Newman	-23.142	118.647	WAM
Bathynellacea	Bathynellacea sp. indet.	WB51	-23.153	118.748	Biota (2003)
Bathynellacea	Bathynellacea sp. indet.	WB51	-23.153	118.748	Biota (2003)
Bathynellacea	Bathynellacea sp. indet.	WB58	-23.135	118.787	Biota (2003)
Bathynellacea	Bathynellacea sp. indet.	WOB12	-23.241	118.459	Biota (2003)
Bathynellacea	Bathynellidae `1614-01`	ca. 113 km WNW of Newman	-23.142	118.647	WAM
Bathynellacea	Bathynellidae `1614-01`	ca. 113 km WNW of Newman	-23.139	118.635	WAM
Bathynellacea	Bathynellidae `1614-01`	ca. 113 km WNW of Newman	-23.142	118.655	WAM
Bathynellacea	Bathynellidae `sp. Helix-BAB018`	RC15WAC0384	-23.139	118.635	Biologic (2016a)
Bathynellacea	Bathynellidae `sp. Helix-BAB018`	RC15WAC0413	-23.142	118.655	Biologic (2016a)
Bathynellacea	*Billibathynella* `sp. AR`	ANRRC0506	-23.327	118.738	Sub. Ecology (2012)
Bathynellacea	*Billibathynella* `sp. AR`	110 km WNW of Newman	-23.037	118.714	WAM

Higher Taxon	Lowest ID	Site/Well	Latitude	Longitude	Source
Bathynellacea	*Billibathynella* `sp. AR`	110 km WNW of Newman	-23.037	118.714	WAM
Bathynellacea	*Billibathynella* `sp. AR`	Area C: 110 km WNW of Newman	-23.038	118.745	WAM
Bathynellacea	*Billibathynella* `sp. AR`	Area C: 110 km WNW of Newman	-23.038	118.745	WAM
Bathynellacea	*Billibathynella* `sp. AR`	Area C: 110 km WNW of Newman	-23.037	118.727	WAM
Bathynellacea	*Billibathynella* `sp. AR`	Area C: 110 km WNW of Newman	-23.037	118.727	WAM
Bathynellacea	*Billibathynella* `sp. AR`	Area C: 110 km WNW of Newman	-23.037	118.727	WAM
Bathynellacea	*Billibathynella* `sp. AR`	Area C: 110 km WNW of Newman	-23.038	118.745	WAM
Bathynellacea	*Notobathynella* sp. indet.	N/A	N/A	N/A	NM
Bathynellacea	Parabathynellidae `won1`	ca 74 km heading 290.7° from Newman	-23.122	119.062	WAM
Blattodea	*Nocticola* `BLA004`	N/A	-23.194	118.973	WAM
Blattodea	*Nocticola* `Won1`	N/A	-23.123	119.050	WAM
Blattodea	*Nocticola* `Won1`	N/A	-23.123	119.050	WAM
Blattodea	*Nocticola* sp. indet.	ANRRC0468	-23.447	118.719	Sub. Ecology (2012)
Blattodea	*Nocticola* sp. indet.	ANRRC0635	-23.460	118.700	Sub. Ecology (2012)
Blattodea	*Nocticola* sp. indet.	ANRRC0660	-23.259	118.739	Sub. Ecology (2012)
Blattodea	*Nocticola* sp. indet.	N/A	N/A	N/A	ALA
Blattodea	*Nocticola* sp. indet.	WAH011	-23.127	118.870	ecologia (2013)
Blattodea	*Nocticola* sp. indet.	WAH048	-23.124	118.889	ecologia (2013)
Blattodea	*Nocticola* sp. indet.	WAH189	-23.122	118.864	ecologia (2013)
Blattodea	*Nocticola* sp. indet.	N/A	-23.447	118.714	WAM
Blattodea	*Nocticola* sp. indet.	N/A	-23.259	118.739	WAM
Blattodea	*Nocticola* sp. indet.	N/A	-23.447	118.714	WAM
Blattodea	*Nocticola* sp. indet.	N/A	-23.461	118.700	WAM
Blattodea	*Nocticola* sp. indet.	N/A	-23.447	118.714	WAM
Blattodea	*Nocticola* sp. indet.	N/A	-23.124	118.889	WAM
Blattodea	*Nocticola* sp. indet.	N/A	-23.122	118.864	WAM
Blattodea	*Nocticola* sp. indet.	N/A	-23.127	118.870	WAM
Blattodea	*Nocticola* sp. indet.	N/A	-23.122	118.864	WAM
Blattodea	*Nocticola* sp. indet.	N/A	-23.127	118.870	WAM
Blattodea	*Nocticola* sp. indet.	N/A	-22.977	118.818	WAM
Blattodea	*Nocticola* sp. indet.	N/A	-22.977	118.818	WAM
Blattodea	*Nocticola* sp. indet.	N/A	-22.977	118.818	WAM
Blattodea	Nocticolidae `sp. S3`	N/A	-23.036	118.774	WAM
Blattodea	Nocticolidae sp. indet.	ANRRC0468	-23.447	118.719	Sub. Ecology (2012)
Cephalostigmata	Cephalostigmata `DNA06`	Wonmunna, ca 70 km WNW. of Newman	-23.161	118.977	WAM
Cephalostigmata	Cephalostigmata `DNA06`	Wonmunna, ca 70 km WNW. of Newman	-23.161	118.979	WAM
Cephalostigmata	Cephalostigmata `DNA08`	ca. 79.5 km NW. of Newman	-23.164	118.977	WAM
Cephalostigmata	Scutigerellidae `sp. Helix-SYM027`	RC14WAF0072	-23.187	118.878	Biologic (2016b)
Cephalostigmata	Scutigerellidae `sp. Helix-SYM028`	RC15WAC0276	-23.149	118.686	Biologic (2016a)
Cephalostigmata	Scutigerellidae `sp. Helix-SYM029`	RC15WAC0197	-23.149	118.647	Biologic (2016a)
Coleoptera	*Anillini* sp. indet.	WAC332	-23.148	118.681	ecologia (2013)
Coleoptera	Carabidae sp. indet.	N/A	N/A	N/A	ALA
Coleoptera	Carabidae sp. indet.	N/A	-23.259	118.739	WAM
Coleoptera	Carabidae sp. indet.	N/A	-23.148	118.681	WAM
Coleoptera	Carabidae sp. indet.	N/A	-22.987	118.818	WAM
Coleoptera	Carabidae sp. indet.	N/A	-22.987	118.818	WAM
Coleoptera	Coleoptera sp. indet.	N/A	-23.259	118.739	WAM
Coleoptera	Coleoptera sp. indet.	N/A	-23.167	118.617	WAM
Coleoptera	*Hydrobiomorpha* sp. indet.	WAD329	-23.167	118.617	ecologia (2013)
Coleoptera	*Zuphium* `sp. AR`	ANRRC0660	-23.259	118.739	Sub. Ecology (2012)
Cyclopoida	Cyclopoida sp. indet.	ca 73.9 km heading 289.8° from Newman	-23.134	119.051	WAM
Cyclopoida	Cyclopoida sp. indet.	ca 73.9 km heading 289.8° from Newman	-23.134	119.051	WAM
Cyclopoida	Cyclopoida sp. indet.	ca 74 km heading 290.7° from Newman	-23.122	119.062	WAM
Cyclopoida	Cyclopoida sp. indet.	ca 77.5 km heading 287.6° from Newman	-23.148	118.997	WAM
Cyclopoida	Cyclopoida sp. indet.	ca. 113 km WNW of Newman	-23.142	118.655	WAM
Cyclopoida	Cyclopoida sp. indet.	ca. 113 km WNW of Newman	-23.139	118.635	WAM
Cyclopoida	Cyclopoida sp. indet.	ca. 113 km WNW of Newman	-23.142	118.655	WAM
Cyclopoida	Cyclopoida sp. indet.	ca. 113 km WNW of Newman	-23.142	118.655	WAM
Cyclopoida	Cyclopoida sp. indet.	ca. 113 km WNW of Newman	-23.142	118.647	WAM
Cyclopoida	Cyclopoida sp. indet.	RC15WAC0384	-23.139	118.635	Biologic (2016a)
Cyclopoida	Cyclopoida sp. indet.	RC15WAC0413	-23.142	118.655	Biologic (2016a)
Cyclopoida	Cyclopoida sp. indet.	RC15WAC0413	-23.142	118.655	Biologic (2016a)
Cyclopoida	Cyclopoida sp. indet.	Turee Creek East Branch (north)	-23.235	118.287	WAM
Cyclopoida	Cyclopoida sp. indet.	RC15WAC0413	-23.142	118.655	Biologic (2016a)
Cyclopoida	Cyclopoida sp. indet.	Turee Creek East Branch (north)	-23.235	118.287	WAM
Cyclopoida	Cyclopoida sp. indet.	Turee Creek East Branch (north)	-23.235	118.287	WAM
Cyclopoida	Cyclopoida sp. indet.	Turee Creek East Branch (south)	-23.325	118.317	WAM
Cyclopoida	Cyclopoida sp. indet.	WB51	-23.153	118.748	ecologia (2005)
Cyclopoida	Cyclopoida sp. indet.	WB54	-23.159	118.689	ecologia (2005)
Cyclopoida	Cyclopoida sp. indet.	WB56	-23.163	118.707	ecologia (2005)
Cyclopoida	Cyclopoida sp. indet.	WOB12	-23.241	118.459	ecologia (2005)
Cyclopoida	*Diacyclops humphreysi*	ANRRC0388	-23.324	118.779	Sub. Ecology (2012)
Cyclopoida	*Diacyclops humphreysi*	ANRRC0457	-23.326	118.776	Sub. Ecology (2012)
Cyclopoida	*Diacyclops humphreysi*	ANRRC0474	-23.432	118.735	Sub. Ecology (2012)
Cyclopoida	*Diacyclops humphreysi humphreysi*	N/A	N/A	N/A	NM
Cyclopoida	*Diacyclops sobeprolatus*	ANRRC0494	-23.410	118.758	Sub. Ecology (2012)
Cyclopoida	*Dussartcyclops* `sp. B10`	Coondewanna Flat, ca. 80 km NW. Newman	-23.008	118.812	WAM
Cyclopoida	*Metacyclops* `B01` (nr pilbaricus)	c.a. 113 km WNW of Newman	-23.142	118.655	WAM
Cyclopoida	*Metacyclops* `B01` (nr pilbaricus)	c.a. 113 km WNW of Newman	-23.142	118.655	WAM
Cyclopoida	*Metacyclops* `B01` (nr pilbaricus)	c.a. 113 km WNW of Newman	-23.142	118.655	WAM
Cyclopoida	*Metacyclops* `B01` (nr pilbaricus)	c.a. 113 km WNW of Newman	-23.142	118.655	WAM
Cyclopoida	*Metacyclops* `B01` (nr pilbaricus)	c.a. 113 km WNW of Newman	-23.142	118.655	WAM
Cyclopoida	*Metacyclops* `B01` (nr pilbaricus)	c.a. 113 km WNW of Newman	-23.142	118.655	WAM
Cyclopoida	*Metacyclops* `B01` (nr pilbaricus)	ca. 113 km WNW of Newman	-23.142	118.655	WAM
Cyclopoida	*Metacyclops* `B01` (nr pilbaricus)	ca. 113 km WNW of Newman	-23.142	118.655	WAM
Cyclopoida	*Metacyclops* `B01` (nr pilbaricus)	RC15WAC0413	-23.142	118.655	Biologic (2016a)
Cyclopoida	*Metacyclops* `B01` (nr pilbaricus)	RC15WAC0413	-23.142	118.655	Biologic (2016a)
Cyclopoida	*Metacyclops* `B01` (nr pilbaricus)	RC15WAC0413	-23.142	118.655	Biologic (2016a)
Cyclopoida	*Metacyclops* `B01` (nr pilbaricus)	RC15WAC0413	-23.142	118.655	Biologic (2016a)
Cyclopoida	*Microcyclops varicans*	c.a. 113 km WNW of Newman	-23.142	118.655	WAM
Cyclopoida	*Microcyclops varicans*	c.a. 113 km WNW of Newman	-23.142	118.647	WAM

Higher Taxon	Lowest ID	Site/Well	Latitude	Longitude	Source
Cyclopoida	*Microcyclops varicans*	c.a. 113 km WNW of Newman	-23.142	118.647	WAM
Cyclopoida	*Microcyclops varicans*	c.a. 113 km WNW of Newman	-23.142	118.647	WAM
Cyclopoida	*Microcyclops varicans*	c.a. 113 km WNW of Newman	-23.142	118.655	WAM
Cyclopoida	*Microcyclops varicans*	c.a. 113 km WNW of Newman	-23.142	118.655	WAM
Cyclopoida	*Microcyclops varicans*	c.a. 113 km WNW of Newman	-23.142	118.655	WAM
Cyclopoida	*Microcyclops varicans*	c.a. 113 km WNW of Newman	-23.142	118.655	WAM
Cyclopoida	*Microcyclops varicans*	c.a. 113 km WNW of Newman	-23.142	118.655	WAM
Cyclopoida	*Microcyclops varicans*	c.a. 113 km WNW of Newman	-23.142	118.655	WAM
Cyclopoida	*Microcyclops varicans*	c.a. 113 km WNW of Newman	-23.142	118.647	WAM
Cyclopoida	*Microcyclops varicans*	c.a. 113 km WNW of Newman	-23.142	118.647	WAM
Cyclopoida	*Microcyclops varicans*	c.a. 113 km WNW of Newman	-23.142	118.655	WAM
Cyclopoida	*Microcyclops varicans*	c.a. 113 km WNW of Newman	-23.142	118.655	WAM
Cyclopoida	*Microcyclops varicans*	c.a. 113 km WNW of Newman	-23.142	118.655	WAM
Cyclopoida	*Microcyclops varicans*	c.a. 113 km WNW of Newman	-23.142	118.647	WAM
Cyclopoida	*Microcyclops varicans*	ca. 113 km WNW of Newman	-23.142	118.647	WAM
Cyclopoida	*Microcyclops varicans*	ca. 113 km WNW of Newman	-23.142	118.655	WAM
Cyclopoida	*Microcyclops varicans*	ca. 113 km WNW of Newman	-23.142	118.655	WAM
Cyclopoida	*Microcyclops varicans*	ca. 113 km WNW of Newman	-23.142	118.655	WAM
Cyclopoida	*Microcyclops varicans*	ca. 113 km WNW of Newman	-23.142	118.655	WAM
Cyclopoida	*Microcyclops varicans*	ca. 113 km WNW of Newman	-23.142	118.647	WAM
Cyclopoida	*Microcyclops varicans*	RC15WAC0413	-23.142	118.655	Biologic (2016a)
Cyclopoida	*Microcyclops varicans*	RC15WAC0413	-23.142	118.655	Biologic (2016a)
Cyclopoida	*Microcyclops varicans*	RC15WAC0413	-23.142	118.655	Biologic (2016a)
Cyclopoida	*Microcyclops varicans*	RC15WAC0413	-23.142	118.655	Biologic (2016a)
Cyclopoida	*Microcyclops varicans*	RC15WAC0413	-23.142	118.655	Biologic (2016a)
Cyclopoida	*Microcyclops varicans*	RC15WAC0413	-23.142	118.655	Biologic (2016a)
Cyclopoida	*Microcyclops varicans*	RC15WAC0413	-23.142	118.655	Biologic (2016a)
Cyclopoida	*Microcyclops varicans*	RC15WAC0413	-23.142	118.655	Biologic (2016a)
Cyclopoida	*Microcyclops varicans*	RC15WAC0416	-23.142	118.647	Biologic (2016a)
Cyclopoida	*Microcyclops varicans*	RC15WAC0416	-23.142	118.647	Biologic (2016a)
Cyclopoida	*Microcyclops varicans*	RC15WAC0416	-23.142	118.647	Biologic (2016a)
Cyclopoida	*Microcyclops varicans*	RC15WAC0416	-23.142	118.647	Biologic (2016a)
Cyclopoida	*Microcyclops varicans*	RC15WAC0416	-23.142	118.647	Biologic (2016a)
Cyclopoida	*Microcyclops varicans*	RC15WAC0416	-23.142	118.647	Biologic (2016a)
Cyclopoida	*Microcyclops varicans*	RC15WAC0416	-23.142	118.647	Biologic (2016a)
Cyclopoida	*Microcyclops varicans*	RC15WAC0416	-23.142	118.647	Biologic (2016a)
Cyclopoida	*Thermocyclops* `sp. WA`	RC15WAC0413	-23.142	118.655	Biologic (2016a)
Cyclopoida	*Thermocyclops* `sp. WA`	RC15WAC0413	-23.142	118.655	Biologic (2016a)
Cyclopoida	*Thermocyclops* sp. indet.	c.a. 113 km WNW of Newman	-23.142	118.655	WAM
Cyclopoida	*Thermocyclops* sp. indet.	c.a. 113 km WNW of Newman	-23.142	118.655	WAM
Cyclopoida	*Thermocyclops* sp. indet.	RC15WAC0413	-23.142	118.655	Biologic (2016a)
Diplura	Diplura sp. indet.	RC15WAC0390	-23.137	118.623	Biologic (2016a)
Diplura	Diplura sp. indet.	WA7RC0060	-23.121	118.645	Biota (2013)
Diplura	Diplura sp. indet.	WA7RC0063	-23.113	118.654	Biota (2013)
Diplura	Japygidae `DPL002`	N/A	-23.063	118.745	WAM
Diplura	Japygidae `DPL005`	N/A	-23.063	118.635	WAM
Diplura	Japygidae `DPL011`	N/A	-23.005	118.924	WAM
Diplura	Japygidae `DPL011`	N/A	-23.004	118.912	WAM
Diplura	Japygidae sp. indet.	N/A	-22.937	118.791	WAM
Diplura	Parajapygidae `DPL023`	N/A	-22.999	118.848	WAM
Diplura	Projapygidae `Won3`	N/A	-23.165	119.001	WAM
Diplura	Projapygidae sp. indet.	RC15WAC0380	-23.142	118.676	Biologic (2016a)
Geophilida	Geophilida sp. indet.	WA9DR0207	-23.190	118.642	Biota (2013)
Haplotaxida	Enchytraeidae `sp. Helix-OLE030`	RC14WAF0066	-23.197	118.849	Biologic (2016b)
Haplotaxida	Enchytraeidae `sp. Helix-OLE030`	RD14WAF0003	-23.198	118.849	Biologic (2016b)
Haplotaxida	Enchytraeidae sp. indet.	RC14WAF0066	-23.197	118.849	Biologic (2016b)
Harpacticoida	*Australocamptus* `sp. B13`	ca. 113 km WNW of Newman	-23.139	118.635	WAM
Harpacticoida	*Australocamptus* `sp. B13`	ca. 113 km WNW of Newman	-23.142	118.647	WAM
Harpacticoida	*Australocamptus* `sp. B13`	ca. 113 km WNW of Newman	-23.142	118.655	WAM
Harpacticoida	*Australocamptus* `sp. B13`	ca. 113 km WNW of Newman	-23.142	118.655	WAM
Harpacticoida	*Australocamptus* `sp. B13`	ca. 113 km WNW of Newman	-23.139	118.635	WAM
Harpacticoida	*Australocamptus* `sp. B13`	ca. 113 km WNW of Newman	-23.142	118.647	WAM
Harpacticoida	*Australocamptus* `sp. B13`	ca. 113 km WNW of Newman	-23.139	118.635	WAM
Harpacticoida	*Australocamptus* `sp. B13`	RC15WAC0384	-23.139	118.635	Biologic (2016a)
Harpacticoida	*Australocamptus* `sp. B13`	RC15WAC0384	-23.139	118.635	Biologic (2016a)
Harpacticoida	*Australocamptus* `sp. B13`	RC15WAC0384	-23.139	118.635	Biologic (2016a)
Harpacticoida	*Australocamptus* `sp. B13`	RC15WAC0413	-23.142	118.655	Biologic (2016a)
Harpacticoida	*Australocamptus* `sp. B13`	RC15WAC0413	-23.142	118.655	Biologic (2016a)
Harpacticoida	*Australocamptus* `sp. B13`	RC15WAC0416	-23.142	118.647	Biologic (2016a)
Harpacticoida	*Australocamptus* `sp. B13`	RC15WAC0416	-23.142	118.647	Biologic (2016a)
Harpacticoida	Harpacticoida sp. indet.	WB54	-23.159	118.689	ecologia (2005)
Harpacticoida	Harpacticoida sp. indet.	WOB12	-23.241	118.459	ecologia (2005)
Harpacticoida	Harpacticoida sp. indet.	ca 73.9 km heading 289.8° from Newman	-23.134	119.051	WAM
Harpacticoida	Harpacticoida sp. indet.	ca 74 km heading 290.7° from Newman	-23.122	119.062	WAM
Harpacticoida	*Parastenocaris* sp. indet.	RC15WAC0416	-23.142	118.647	Biologic (2016a)
Harpacticoida	*Parastenocaris* sp. indet.	ca. 113 km WNW of Newman	-23.142	118.647	WAM
Hemiptera	Hemiptera sp. indet.	N/A	-22.996	118.943	WAM
Hemiptera	Meenoplidae `sp. B04`	N/A	-23.004	118.934	WAM
Hemiptera	Meenoplidae `sp. Helix-HEM003`	RC14WAD0217	-23.170	118.620	Biologic (2016a)
Hemiptera	Meenoplidae `sp. Helix-HEM003`	RC15WAC0377	-23.147	118.635	Biologic (2016a)
Hemiptera	Meenoplidae `Won1`	N/A	-23.166	118.981	WAM

Higher Taxon	Lowest ID	Site/Well	Latitude	Longitude	Source
Hemiptera	Meenoplidae `Won2`	N/A	-23.162	119.001	WAM
Hemiptera	Meenoplidae `Won2`	N/A	-23.162	119.001	WAM
Hemiptera	Meenoplidae sp. indet.	ANRRC0388	-23.324	118.779	Sub. Ecology (2012)
Hemiptera	Meenoplidae sp. indet.	ANRRC0446	-23.301	118.818	Sub. Ecology (2012)
Hemiptera	Meenoplidae sp. indet.	ANRRC0457	-23.326	118.776	Sub. Ecology (2012)
Hemiptera	Meenoplidae sp. indet.	ANRRC0497	-23.447	118.715	Sub. Ecology (2012)
Hemiptera	Meenoplidae sp. indet.	ANRRC0635	-23.460	118.700	Sub. Ecology (2012)
Hemiptera	Meenoplidae sp. indet.	N/A	N/A	N/A	ALA
Hemiptera	Meenoplidae sp. indet.	WAG307	-23.142	118.730	ecologia (2013)
Hemiptera	Meenoplidae sp. indet.	WAH189	-23.122	118.864	ecologia (2013)
Hemiptera	Meenoplidae sp. indet.	N/A	-23.461	118.700	WAM
Hemiptera	Meenoplidae sp. indet.	N/A	-23.326	118.776	WAM
Hemiptera	Meenoplidae sp. indet.	N/A	-23.324	118.779	WAM
Hemiptera	Meenoplidae sp. indet.	N/A	-23.301	118.818	WAM
Hemiptera	Meenoplidae sp. indet.	N/A	-23.447	118.716	WAM
Hemiptera	Meenoplidae sp. indet.	N/A	-23.142	118.730	WAM
Hemiptera	Meenoplidae sp. indet.	N/A	-23.122	118.864	WAM
Isopoda	*Acanthodillo* `won1`	ca 79.5 km heading 285.5° from Newman	-23.165	118.979	WAM
Isopoda	*Acanthodillo* `won1`	ca 79.5 km heading 285.5° from Newman	-23.165	118.979	WAM
Isopoda	Armadillidae `sp. Helix-ISA049`	RC12WAD0295	-23.163	118.609	Biologic (2016a)
Isopoda	Armadillidae `sp. Helix-ISA049`	RC12WAD0295	-23.163	118.609	Biologic (2016a)
Isopoda	Armadillidae sp. B13	South Flank	-22.974	118.836	WAM
Isopoda	Armadillidae sp. B13	South Flank	-23.013	118.883	WAM
Isopoda	Armadillidae sp. B14	South Flank	-23.009	118.897	WAM
Isopoda	Armadillidae sp. B14	South Flank	-23.009	118.897	WAM
Isopoda	Armadillidae sp. B14	South Flank	-23.009	118.897	WAM
Isopoda	Armadillidae sp. B6	South Flank	-22.996	118.819	WAM
Isopoda	Armadillidae sp. B14	South Flank	-23.009	118.897	WAM
Isopoda	Armadillidae sp. B6	South Flank	-22.996	118.819	WAM
Isopoda	Armadillidae sp. indet.	ca. 113 km WNW of Newman	-23.163	118.609	WAM
Isopoda	*Armadillo* `sp. AR`	ANRRC0370	-23.337	118.754	Sub. Ecology (2012)
Isopoda	*Armadillo* `sp. AR`	ANRRC0478	-23.416	118.762	Sub. Ecology (2012)
Isopoda	*Buddelundia* `sp. 19`	ca. 71 km heading 291° from Newman	-23.125	119.067	WAM
Isopoda	*Buddelundia* sp. indet.	Wonmunna Mine Lease	-23.164	118.983	WAM
Isopoda	Isopoda sp. indet.	WA6RC0079	-23.199	118.724	Biota (2013)
Isopoda	Isopoda sp. indet.	WB51	-23.153	118.748	Biota (2003)
Isopoda	Philosciidae `sp. AR`	ANRRC0468	-23.447	118.719	Sub. Ecology (2012)
Isopoda	Philosciidae sp. B03	Sth Flank	-23.004	118.934	WAM
Isopoda	Philosciidae sp. B04	Sth Flank	-23.004	118.934	WAM
Isopoda	*Pseudodiploexochus* sp. indet.	WAH017	-23.124	118.886	ecologia (2013)
Isopoda	Troglarmadillo `DNA03`	Wonmunna Mine Lease	-23.161	118.977	WAM
Isopoda	Troglarmadillo `DNA03`	Wonmunna Mine Lease	-23.161	118.977	WAM
Isopoda	Troglarmadillo sp. indet.	ca 77.5 km heading 287.6° from Newman	-23.143	119.012	WAM
Maxillopoda	Maxillopoda sp. indet.	WB32	-23.161	118.688	Biota (2003)
Maxillopoda	Maxillopoda sp. indet.	WB40	-23.127	118.779	Biota (2003)
Maxillopoda	Maxillopoda sp. indet.	WB51	-23.153	118.748	Biota (2003)
Maxillopoda	Maxillopoda sp. indet.	WB51	-23.153	118.748	Biota (2003)
Maxillopoda	Maxillopoda sp. indet.	WB51	-23.153	118.748	Biota (2003)
Maxillopoda	Maxillopoda sp. indet.	WB54	-23.159	118.689	Biota (2003)
Oligochaeta	*Insulodrilus angela*	N/A	N/A	N/A	NM
Oligochaeta	Oligochaeta sp. indet.	WB32	-23.161	118.688	Biota (2003)
Oligochaeta	Oligochaeta sp. indet.	WB41	-23.127	118.779	ecologia (2005)
Oligochaeta	Oligochaeta sp. indet.	WB41	-23.127	118.779	Biota (2003)
Oligochaeta	Oligochaeta sp. indet.	WB41	-23.127	118.779	Biota (2003)
Oligochaeta	Oligochaeta sp. indet.	WB51	-23.153	118.748	ecologia (2005)
Oligochaeta	Oligochaeta sp. indet.	WB51	-23.153	118.748	Biota (2003)
Oligochaeta	Oligochaeta sp. indet.	WB54	-23.159	118.689	ecologia (2005)
Oligochaeta	Oligochaeta sp. indet.	WOB01	-23.199	118.484	ecologia (2005)
Oligochaeta	Oligochaeta sp. indet.	WOB05	-23.226	118.469	Biota (2003)
Oligochaeta	Phreodrilid with dissimilar ventral chaetae	N/A	N/A	N/A	NM
Oligochaeta	Phreodrilid with similar ventral chaetae	N/A	N/A	N/A	NM
Ostracoda	*Notacandona gratia*	RC15WAC0416	-23.142	118.647	Biologic (2016a)
Ostracoda	*Notacandona gratia*	ca. 113 km WNW of Newman	-23.142	118.647	WAM
Ostracoda	*Notacandona gratia*	RC15WAC0416	-23.142	118.647	Biologic (2016a)
Ostracoda	*Notacandona gratia*	ca. 113 km WNW of Newman	-23.142	118.647	WAM
Ostracoda	*Notacandona gratia*	ca. 113 km WNW of Newman	-23.142	118.647	WAM
Ostracoda	Ostracoda sp. indet.	ca 73.9 km heading 289.8° from Newman	-23.134	119.051	WAM
Ostracoda	Ostracoda sp. indet.	ca 73.9 km heading 289.8° from Newman	-23.134	119.051	WAM
Ostracoda	Ostracoda sp. indet.	ca 74 km heading 290.7° from Newman	-23.122	119.062	WAM
Ostracoda	Ostracoda sp. indet.	ca 77.5 km heading 287.6° from Newman	-23.148	118.997	WAM
Ostracoda	Ostracoda sp. indet.	Turee Creek East Branch (south)	-23.325	118.317	WAM
Ostracoda	Ostracoda sp. indet.	Turee Creek East Branch (south)	-23.325	118.317	WAM
Ostracoda	Ostracoda sp. indet.	Pastoral Bore	-23.209	118.378	Biota (2003)
Palpigradi	Palpigradi sp. indet.	RC14WAF0072	-23.187	118.878	Biologic (2016b)
Platyhelminthes	Platyhelminthes sp. indet.	WB41	-23.127	118.779	Biota (2003)
Platyhelminthes	Platyhelminthes sp. indet.	WB54	-23.159	118.689	Biota (2003)
Platyhelminthes	Turbellaria sp. indet.	RC15WAC0413	-23.142	118.655	Biologic (2016a)
Platyhelminthes	Turbellaria sp. indet.	RC15WAC0416	-23.142	118.647	Biologic (2016a)
Platyhelminthes	Turbellaria sp. indet.	WB54	-23.159	118.689	ecologia (2005)
Polychaeta	Aeolosomatidae sp. indet.	RC15WAC0276	-23.149	118.686	Biologic (2016a)
Polyxenida	Lophoproctidae sp. indet.	N/A	N/A	N/A	ALA
Polyxenida	Polyxenidae `DNA01`	ca. 79.5 km NW. of Newman	-23.162	118.985	WAM
Polyxenida	Polyxenidae sp. indet.	N/A	N/A	N/A	ALA
Pseudoscorpiones	*Beierolpium* `DNA01`	ca. 77 km NW. of Newman	-23.162	119.001	WAM
Pseudoscorpiones	*Beierolpium* sp. indet.	N/A	N/A	N/A	ALA
Pseudoscorpiones	Chthoniidae sp. indet.	ANRRC0388	-23.324	118.779	Sub. Ecology (2012)
Pseudoscorpiones	*Euryolpium* sp. indet.	N/A	N/A	N/A	ALA
Pseudoscorpiones	*Indohya* `PSE005`	South Flank, 100 km NW. of Newman	-22.985	118.818	WAM
Pseudoscorpiones	*Indolpium* sp. indet.	N/A	N/A	N/A	ALA
Pseudoscorpiones	*Indolpium* sp. indet.	N/A	N/A	N/A	NM
Pseudoscorpiones	*Indolpium* sp. indet.	WA6RC0055	-23.199	118.720	Biota (2013)

Higher Taxon	Lowest ID	Site/Well	Latitude	Longitude	Source
Pseudoscorpiones	*Indolpium* sp. indet.	WA7RC0058	-23.119	118.645	Biota (2013)
Pseudoscorpiones	*Indolpium* sp. indet.	West Angelas, 104.8 km W. of Newman	-23.199	118.720	WAM
Pseudoscorpiones	*Indolpium* sp. indet.	West Angelas, 114.4 km W. of Newman	-23.119	118.645	WAM
Pseudoscorpiones	*Lagynochthonius* `PSE039`	South Flank, ca. 103 km NW. of Newman	-22.975	118.830	WAM
Pseudoscorpiones	*Lagynochthonius* `PSE041`	Alligator Jaws, ca. 118 km WNW. of Newman	-23.063	118.635	WAM
Pseudoscorpiones	*Lagynochthonius* `PSE101`	ca. 104 km WNW. of Newman	-23.137	118.734	WAM
Pseudoscorpiones	*Lagynochthonius* `PSE101`	RC15WAG0290	-23.137	118.734	Biologic (2016a)
Pseudoscorpiones	*Lagynochthonius* sp. indet.	N/A	N/A	N/A	ALA
Pseudoscorpiones	*Lechytia* `wonmunna`	ca. 77 km heading 286° from Newman	-23.162	119.000	WAM
Pseudoscorpiones	*Lechytia* `wonmunna`	ca. 77 km heading 286° from Newman	-23.162	119.000	WAM
Pseudoscorpiones	*Lechytia* `wonmunna`	ca. 77 km heading 286° from Newman	-23.162	119.000	WAM
Pseudoscorpiones	*Lechytia* `wonmunna`	ca. 79.5 km heading 285.5° from Newman	-23.164	118.979	WAM
Pseudoscorpiones	*Lechytia* `wonmunna`	ca. 79.5 km heading 285.5° from Newman	-23.165	118.979	WAM
Pseudoscorpiones	*Lechytia* `wonmunna`	ca. 79.5 km heading 285.5° from Newman	-23.162	118.991	WAM
Pseudoscorpiones	*Lechytia* `wonmunna`	ca. 79.5 km heading 285.5° from Newman	-23.162	118.991	WAM
Pseudoscorpiones	*Lechytia* `wonmunna`	ca. 79.5 km heading 285.5° from Newman	-23.164	118.979	WAM
Pseudoscorpiones	*Lechytia* `wonmunna`	ca. 79.5 km heading 285.5° from Newman	-23.163	118.989	WAM
Pseudoscorpiones	*Lechytia* `wonmunna`	ca. 79.5 km heading 285.5° from Newman	-23.163	118.989	WAM
Pseudoscorpiones	*Lechytia* `wonmunna`	ca. 79.5 km heading 285.5° from Newman	-23.162	118.991	WAM
Pseudoscorpiones	*Lechytia* `wonmunna`	ca. 79.5 km heading 285.5° from Newman	-23.162	118.991	WAM
Pseudoscorpiones	*Lechytia* `wonmunna`	ca. 79.5 km heading 285.5° from Newman	-23.162	118.991	WAM
Pseudoscorpiones	*Lechytia* `wonmunna`	ca. 79.5 km heading 285.5° from Newman	-23.165	118.979	WAM
Pseudoscorpiones	*Lechytia* `wonmunna`	ca. 79.5 km heading 285.5° from Newman	-23.163	118.989	WAM
Pseudoscorpiones	*Lechytia* `wonmunna`	ca. 79.5 km heading 285.5° from Newman	-23.162	118.991	WAM
Pseudoscorpiones	*Linnaeolpium* `w1`	Wonmunna, ca 70 km WNW. of Newman	-23.165	118.985	WAM
Pseudoscorpiones	*Tyrannochthonius* `DNA05`	Wonmunna, ca 70 km WNW. of Newman	-23.120	119.054	WAM
Pseudoscorpiones	*Tyrannochthonius* `PSE102`	ca. 113 km WNW. of Newman	-23.142	118.647	WAM
Pseudoscorpiones	*Tyrannochthonius* `sp. WAM-PSE102`	RC15WAC0416	-23.142	118.647	Biologic (2016a)
Pseudoscorpiones	*Xenolpium* sp. indet.	N/A	N/A	N/A	ALA
Schizomida	*Draculoides* `SCH022`	South Flank, ca. 89 km WNW. of Newman	-23.001	118.930	WAM
Schizomida	*Draculoides* `SCH022`	South Flank, ca. 90 km WNW. of Newman	-23.004	118.918	WAM
Schizomida	*Draculoides* `SCH023`	South Flank MAC, ca. 80 km NW. of Newman	-22.983	118.856	WAM
Schizomida	*Draculoides* `SCH023`	South Flank, ca. 100 km WNW. of Newman	-22.985	118.854	WAM
Schizomida	*Draculoides* `SCH023`	South Flank, ca. 90 km SE. of Wittenoom	-22.983	118.842	WAM
Schizomida	*Draculoides* `SCH023`	South Flank, ca. 90 km SE. Wittenoom	-22.983	118.839	WAM
Schizomida	*Draculoides* `SCH023`	South Flank, ca. 92 km SE. of Wittenoom	-22.993	118.865	WAM
Schizomida	*Draculoides* `SCH023`	South Flank, ca. 93 km SE. of Wittenoom	-22.993	118.877	WAM
Schizomida	*Draculoides* `SCH023`	South Flank, ca. 94 km WNW. of Newman	-23.000	118.913	WAM
Schizomida	*Draculoides* `SCH023`	South Flank, ca. 94 km WNW. of Newman	-23.000	118.913	WAM
Schizomida	*Draculoides* `SCH051`	ca. 113 km WNW. of Newman	-23.166	118.615	WAM
Schizomida	*Draculoides* `sp. B16`	South Flank, ca. 93 km SE. of Wittenoom	-22.997	118.874	WAM
Schizomida	*Draculoides* `sp. B16`	South Flank, ca. 93 km SE. of Wittenoom	-23.005	118.866	WAM
Schizomida	*Draculoides* `sp. B16`	South Flank, ca. 93 km SE. of Wittenoom	-23.007	118.871	WAM
Schizomida	*Draculoides* `sp. B16`	South Flank, ca. 93 km SE. of Wittenoom	-23.005	118.866	WAM
Schizomida	*Draculoides* `sp. B16`	South Flank, ca. 93 km WNW. of Newman	-23.005	118.883	WAM
Schizomida	*Draculoides* `sp. B20`	South Flank, ca. 93 km WNW. of Newman	-22.995	118.924	WAM
Schizomida	*Draculoides* `sp. B32`	South Flank MAC, ca. 88 km SE. of Wittenoom	-22.974	118.830	WAM
Schizomida	*Draculoides* `sp. B55`	Packsaddle West, ca. 80 km NW. of Newman	-22.925	118.758	WAM
Schizomida	*Draculoides* `sp. WAM-SCH051`	RC14WAD0350	-23.166	118.615	Biologic (2016a)
Scolopendrida	*Cormocephalus* `sp. CHI003`	31.5 km SE. of Mt Meharry, Greater West Angelas	-23.123	118.859	WAM
Scolopendrida	*Cormocephalus* `sp. CHI003`	WAH192	-23.123	118.859	ecologia (2013)
Scolopendrida	Cryptopidae `sp. SER`	Angelo River, 120 km WSW. of Newman	-23.326	118.776	WAM
Scolopendrida	Cryptopidae `sp. SER`	ANRRC0457	-23.326	118.776	Sub. Ecology (2012)
Scolopendrida	*Cryptops* `DNA17`	ca. 77.5 km NW. of Newman	-23.145	119.002	WAM
Scolopendrida	*Cryptops* `sp. SV (=Cryptops sp. B06)`	Angelo River, 120 km WSW. of Newman	-23.427	118.731	WAM
Scolopendrida	*Cryptops* `sp. SV (=Cryptops sp. B06)`	ANRRC0555	-23.427	118.731	Sub. Ecology (2012)
Scolopendrida	*Cryptops* sp. indet.	RC14WAF0072	-23.187	118.878	Biologic (2016b)
Symphyla	Symphyla sp. indet.	ANRRC0468	-23.447	118.719	Sub. Ecology (2012)
Symphyla	Symphyla sp. indet.	ANRRC0635	-23.460	118.700	Sub. Ecology (2012)
Syncarida	nr *Billibathynella* `sp. B02`	Boundary Ridge North, ca. 87 km SSE. Wittenoom	-23.019	118.724	WAM
Tetramerocerata	*Allopauropus* `sp. B11`	Mudlark, ca. 100 km NW. of Newman	-22.949	118.803	WAM
Tetramerocerata	*Allopauropus* `sp. B11`	South Flank, ca. 90 km NW. of Newman	-22.999	118.930	WAM
Tetramerocerata	Pauropodidae `sp. B14`	South Flank, ca. 100 km NNW. of Newman	-23.010	118.866	WAM
Tetramerocerata	Pauropodidae `sp. B14`	South Flank, ca. 100 km NNW. of Newman	-22.997	118.924	WAM
Tetramerocerata	*Polypauropus* `sp. B01`	Mudlark, ca. 100 km NW. of Newman	-22.950	118.792	WAM
Thermosbaenacea	Thermosbaenacea sp. indet.	WB51	-23.153	118.748	Biota (2003)
Thermosbaenacea	Thermosbaenacea sp. indet.	WB54	-23.159	118.689	Biota (2003)
Tubificata	Enchytraeidae `sp. Helix-OLE026`	RC15WAC0380	-23.142	118.676	Biologic (2016a)
Tubificata	Enchytraeidae `sp. Helix-OLE026`	RC15WAC0387	-23.141	118.624	Biologic (2016a)
Tubificata	Enchytraeidae `sp. Helix-OLE028`	RC12WAD0189	-23.174	118.676	Biologic (2016a)
Tubificata	Enchytraeidae `sp. Helix-OLE029`	RC14WAD0350	-23.166	118.615	Biologic (2016a)
Tubificata	Enchytraeidae sp. indet.	RC14WAD0346	-23.171	118.611	Biologic (2016a)
Tubificata	Enchytraeidae sp. indet.	RC15WAC0387	-23.141	118.624	Biologic (2016a)
Tubificata	Enchytraeidae sp. indet.	RC15WAD0124	-23.172	118.655	Biologic (2016a)
Tubificata	Phreodrilidae `sp. Helix-OLP12`	RC14WAD0346	-23.171	118.611	Biologic (2016a)
Tubificata	*Pristina longiseta*	RC15WAC0384	-23.139	118.635	Biologic (2016a)
Tubificata	*Pristina longiseta*	RC15WAC0413	-23.142	118.655	Biologic (2016a)
Tubificata	Tubificata sp. indet.	RC15WAC0416	-23.142	118.647	Biologic (2016a)
Tubificida	Enchytraeidae sp. indet.	ANRRC0415	-23.326	118.695	Sub. Ecology (2012)
Tubificida	Enchytraeidae sp. indet.	ANRRC0468	-23.447	118.719	Sub. Ecology (2012)
Tubificida	Enchytraeidae sp. indet.	ANRRC0676	-23.265	118.732	Sub. Ecology (2012)
Tubificida	Phreodrilidae sp. indet.	ANRRC0388	-23.324	118.779	Sub. Ecology (2012)
Tubificida	Phreodrilidae sp. indet.	ANRRC0510	-23.326	118.731	Sub. Ecology (2012)
Turbellaria	Turbellaria sp. indet.	N/A	N/A	N/A	NM
Zygentoma	Ateluridae sp. indet.	N/A	-23.416	118.762	WAM
Zygentoma	Ateluridae sp. indet.	ANRRC0478	-23.416	118.762	Sub. Ecology (2012)
Zygentoma	Atelurinae sp. indet.	WAD358	-23.172	118.636	ecologia (2013)

Higher Taxon	Lowest ID	Site/Well	Latitude	Longitude	Source
Zygentoma	*Dodecastyla crypta*	N/A	-22.995	118.839	WAM
Zygentoma	*Dodecastyla crypta*	N/A	-22.995	118.839	WAM
Zygentoma	*Dodecastyla crypta*	N/A	-22.995	118.839	WAM
Zygentoma	*Dodecastyla crypta*	N/A	-23.001	118.942	WAM
Zygentoma	Nicoletiidae `Won1`	N/A	-23.160	119.004	WAM
Zygentoma	Nicoletiidae `Won2`	N/A	-23.145	119.002	WAM
Zygentoma	Nicoletiidae sp. indet.	N/A	-23.172	118.638	WAM
Zygentoma	Nicoletiidae sp. indet.	RC14WAD0350	-23.166	118.615	Biologic (2016a)
Zygentoma	*Trinemura* `sp. AR`	N/A	-23.270	118.733	WAM
Zygentoma	*Trinemura* `sp. AR`	ANRRC0669	-23.270	118.733	Sub. Ecology (2012)
Zygentoma	Zygentoma sp. indet.	WA9RC0152	-23.188	118.716	Biota (2013)

Appendix D – Database records not included in the assessment.

Taxonomy	Likely subterranean status	SRE status where known	Source
Phreodrilid with dissimilar ventral chaetae	Stygofauna	Defunct OTU	NM
Phreodrilid with similar ventral chaetae	Stygofauna	Defunct OTU	NM
Phreodrilidae sp. indet.	Stygofauna	Uncertain	SubEcol (2012)
Enchytraeidae sp. indet.	Stygofauna	Uncertain	SubEcol (2012), Biologic (2016a, b)
Tubificata sp. indet.	Stygofauna	Uncertain	Biologic (2016a)
Oligochaeta sp. indet.	Stygofauna	Uncertain	Biota (2003), ecologia (2005)
Ostracoda sp. indet.	Potential Stygofauna	Uncertain	WAM, Biota (2003)
Thermocyclops sp. indet.	Stygofauna	Uncertain	WAM, Biologic (2016a)
Cyclopoida sp. indet.	Potential Stygofauna	Uncertain	WAM, ecologia (2005), Biologic (2016a)
Harpacticoida sp. indet.	Potential Stygofauna	Uncertain	WAM, ecologia (2005)
Atopobathynella sp. indet.	Stygofauna	Potential SRE	WAM
Notobathynella sp. indet.	Stygofauna	Potential SRE	NM
Bathynellacea sp. indet.	Stygofauna	Uncertain	Biota (2003)
Kruptus sp. indet.	Stygofauna	Uncertain	WAM
Maarrka sp. indet.	Stygofauna	Uncertain	WAM
Paramelitidae sp. indet.	Stygofauna	Uncertain	NM, Biologic (2016a)
Amphipoda sp. indet.	Potential Stygofauna	Uncertain	Biota (2003), ecologia (2005)
Thermosbaenacea sp. indet. *	Potential Stygofauna	Uncertain	Biota (2003)
Troglarmadillo sp. indet.	Troglofauna	Uncertain	WAM
Armadillidae sp. indet.	Troglofauna	Uncertain	WAM
Isopoda sp. indet.	Potential Troglofauna	Uncertain	Biota (2003, 2013)
Buddelundia sp. indet.	Troglofauna	Uncertain	WAM
Cryptops sp. indet.	Troglofauna	Uncertain	Biologic (2016b)
Symphyla sp. indet.	Potential Troglofauna	Uncertain	SubEcol (2012)
Polyxenidae sp. indet.	Potential Troglofauna	Uncertain	ALA
Beierolpium sp. indet.	Troglofauna	Uncertain	ALA
Lagynochthonius sp. indet.	Troglofauna	Uncertain	ALA
Chthoniidae sp. indet.	Troglofauna	Uncertain	SubEcol (2012)
Encoptarthria sp. indet.	Troglofauna	Potential SRE	ALA
Prethopalpus sp. indet.	Troglofauna	Potential SRE	ecologia (2013)
Gnaphosidae sp. indet.	Potential Troglofauna	Potential SRE	ALA, Biota (2013), Biologic (2016a)
Oonopidae sp. indet.	Potential Troglofauna	Potential SRE	ALA, SubEcol (2012)
Nocticola sp. indet.	Troglofauna	Uncertain	ALA, ecologia (2013), SubEcol (2012)
Nocticolidae sp. indet.	Troglofauna	Uncertain	SubEcol (2012)
Carabidae sp. indet.	Troglofauna	Uncertain	ALA, WAM
Coleoptera sp. indet.	Potential Troglofauna	Uncertain	WAM
Meenoplidae sp. indet.	Troglofauna	Uncertain	ALA, WAM, SubEcol (2011), ecologia (2013)
Hemiptera sp. indet.	Potential Troglofauna	Uncertain	WAM
Atelurinae sp. indet.	Troglofauna	Uncertain	WAM, SubEcol (2012), ecologia (2013)
Nicoletiidae sp. indet.	Troglofauna	Uncertain	WAM, Biologic (2016a)
Zygentoma sp. indet.	Troglofauna	Uncertain	Biota (2013)
Japygidae sp. indet.	Troglofauna	Uncertain	WAM
Projapygidae sp. indet.	Troglofauna	Uncertain	Biologic (2016a)
Diplura sp. indet.	Potential Troglofauna	Uncertain	Biota (2013), Biologic (2016a)
Arachnida `DNA05`	Troglofauna	Potential SRE	WAM
Arachnida `DNA08`	Troglofauna	Potential SRE	WAM

Note: records may represent synonyms to other known species due to indeterminate and/ or outdated taxonomy. Highlighted records indicates taxa recorded within or near (<1.5 km) the Study Area. *Thermosbaenacea sp. indet. may have been the result of misidentified specimens.

Appendix E – Higher level troglofauna and stygofauna identifications (morphological) from the Study Area

Taxonomy	No. spms	Taxonomic certainty and comment	Sub-fauna status, SRE status	Sampling areas	No. sites
Palpigradi sp. indet.	4	Indeterminate higher-level taxon (order). DNA fail (2 specimens) and DNA not tested (2 specimens). May represent other Palpigradi sp. collected from the Study Area.	Potential Troglobite, Uncertain	Dep F, Dep H, MTEE	3
Pseudoscorpiones sp. indet.	1	Indeterminate higher-level taxon (order). DNA not tested.	Potential Troglofauna, Uncertain	Dep H	1
Theridiidae sp. indet.	3	Indeterminate higher-level taxon (genus level); may represent Theridiidae `sp. Biologic-ARAN010`, no DNA available.	Potential Troglofauna, Uncertain	MTEE	2
Araneae sp. indet.	2	Indeterminate higher-level taxon (order). DNA fail (1 specimen) and DNA not tested (2 specimens). May represent other Araneae sp. collected from the Study Area.	Potential Troglofauna, Uncertain	MTEE, W Hill	2
Lophoproctidae sp. indet.	1	Indeterminate higher-level taxon (family level); may represent Lophoproctidae `sp. Biologic-POLX002`, no DNA available.	Trogloxene/ Troglophile, Uncertain	Dep J	1
Polyxenida sp. indet.	9	Indeterminate higher-level taxon (order). DNA fail (1 specimen) and DNA not tested (8 specimens).	Potential Troglofauna, Uncertain	Dep F, MTEE, W Hill	4
Pauropoda sp. indet.	24	Indeterminate higher-level taxon (class). DNA fail (3 specimens) and DNA not tested (21 specimens).	Potential Troglofauna, Uncertain	Dep H, W Hill	4
Hanseniella sp. indet.	6	Indeterminate higher-level taxon (genus). DNA fail (4 specimens) and DNA not tested (2 specimens).	Potential Troglofauna, Uncertain	Dep F, Dep H, Dep J, MTEE	6
Parajapygidae sp. indet.	1	Indeterminate higher-level taxon (family). DNA fail.	Potential Troglobite, Uncertain	Dep J	1
Japygidae sp. indet.	2	Indeterminate higher-level taxon (family). DNA not tested.	Potential Troglobite, Uncertain	Dep J	1
Nocticola sp. indet.	59	Indeterminate higher-level taxon (genus). DNA fail (1 specimen) and DNA not tested (58 specimens).	Potential Troglobite, Uncertain	Dep H, Dep J, MTEE, W Hill	13
Meenoplidae sp. indet.	85	Indeterminate higher-level taxon (family). DNA fail (5 specimens) and DNA not tested (80 specimens).	Trogloxene/ Troglophile, Uncertain	Dep F, Dep J, MTEE, W Hill	15
Trinemura sp. indet	1	Indeterminate higher-level taxon (genus level). DNA fail.	Potential Troglobite, Uncertain	MTEE	1
Atelurinae sp. indet.	12	Indeterminate higher-level taxon (subfamily level). DNA fail (2 specimens) and DNA not tested (10 specimens).	Trogloxene/ Troglophile, Uncertain	Dep F, Dep H, Dep J, MTEE	8
Subnicoletiinae sp. indet.	2	Indeterminate higher-level taxon (subfamily level). DNA fail (1 specimen) and DNA not tested (1 specimen).	Potential Troglobite, Uncertain	MTEE, W Hill	2
Sciaridae sp. indet.	10	Indeterminate higher-level taxon (family). DNA fail (1 specimen) and DNA not tested (9 specimens).	Potential Troglofauna, Uncertain	W Hill	2
Pselaphinae sp. indet.	3	Indeterminate higher-level taxon (family). DNA not tested.	Potential Troglobite, Uncertain	MTEE	2
Coleoptera sp. indet.	2	Indeterminate higher-level taxon (order). DNA not tested.	Potential Troglobite, Uncertain	MTEE	1
Amphipoda sp. indet	48	Indeterminate higher-level taxon (order). DNA fail (2 specimens) and DNA not tested (46 specimens).	Potential Stygofauna, Uncertain	CWB	4
Paramelitidae sp. indet.	59	Indeterminate higher-level taxon (family). DNA fail (5 specimens) and DNA not tested (54 specimens).	Potential Stygobite, Uncertain	CWB, CALC	3
Parabathynellidae sp. indet.	1	Indeterminate higher-level taxon (family). DNA not tested.	Stygobite, Uncertain	CWB	1
Cyclopoida sp. indet.	32	Indeterminate higher-level taxon (order). DNA not tested.	Potential Stygofauna, Uncertain	CWB	3
Enchytraeidae sp. indet.	32	Indeterminate higher-level taxon (family). DNA fail (3 specimens) and DNA not tested (29 specimens).	Stygoxene/ Stygophile, Uncertain	CWB, Dep J, W Hill	9
Phreodrilidae sp. indet.	63	Indeterminate higher-level taxon (family). DNA fail (1 specimen) and DNA not tested (62 specimens).	Potential Stygobite, Uncertain	CWB, TCBF	7

Appendix F – Water physicochemistry

APPENDIX F: Water physicochemical measurements observed during the current survey

Deposit	Bore No.	Date	DTW (m)	Temp (°C)	EC (µS/cm)	Acidity (pH)	Redox (mV)	Turbidity	Appearance
CALC	MB16WAW0001	15/03/2019	40	28.7	1175	7.22	-70.5	3-6 cm	Fresh clean odour
CALC	MB16WAW0002	07/05/2019	37	28.8	1122	7.57	79.9	1-3 cm	Fresh clean odour
CALC	MB16WAW0002	19/03/2019	36	28.9	1180		641.8	1-3 cm	Fresh clean odour
CALC	MB16WAW0003	14/03/2019	27	28.1	1811	6.76	-36.8	>30 cm	Fresh clean odour
CALC	MB16WAW0004	14/03/2019	30	21.1	1112	6.96	-57.9	>30 cm	Fresh clean odour
CALC	MB16WAW0004	09/05/2019	30	28.1	1038	7.66	80.9	15-20 cm	Fresh clean odour
CALC	MB16WAW0006	14/03/2019	32	29.2	1186	6.99	-162.3	>30 cm	Fresh clean odour
CALC	MB16WAW0006	09/05/2019	32	28.3	1107	7.5	-59.3	>30 cm	Biological odour
CALC	MB16WAW0008	19/03/2019	33	28.9	1150	7.93	-85.6	1-3 cm	Fresh clean odour
CALC	MB16WAW0008	09/05/2019	33	28.5	1093	7.58	41.3	10-15 cm	Fresh clean odour
CALC	MB16WAW0009	19/03/2019	43	28.5	857		735.6	25-30 cm	Fresh clean odour
CALC	MB16WAW0009	07/05/2019	43	28.6	790	7.57	77.5	10-15 cm	Fresh clean odour
CALC	MB16WAW0012	19/03/2019	41	27.7	2109		649.2	15-20 cm	Fresh clean odour
CALC	MB16WAW0012	09/05/2019	41	28.1	1589	7.61	64.5	15-20 cm	Fresh clean odour
CALC	WB16WAW0001	18/03/2019	36	29.8	1896		584.5	>30 cm	Fresh clean odour
CALC	WB16WAW0001	09/05/2019	36	28.1	1746	8.06	65.1	20-25 cm	Fresh clean odour
CWB	WAAWE0008	09/09/2018	15	27	1460	7.44	10.5	>30 cm	Stale odour
CWB	WAAWE0008	08/05/2019	12	28.5	1409	8.07	58.9	>30 cm	Fresh clean odour
CWB	WB033	09/05/2019		24.7	1496	7.81	86.8	>30 cm	Fresh clean odour
CWB	WB43	08/05/2019	8	25.7	1768	8.14	-144.4	15-20 cm	Biological odour
CWB	WB51	09/09/2018	16	28	1922	7.06	-2.6	>30 cm	Fresh clean odour
CWB	WB51	08/05/2019	12	25.6	2287	7.56	53.9	25-30 cm	Fresh clean odour
CWB	WB52	09/09/2018	11	27.4	4642	6.7	12.7	>30 cm	Fresh clean odour
CWB	WB52	08/05/2019	11	24.5	4145	7.22	59.1	>30 cm	Fresh clean odour
CWB	WB60	09/09/2018	9	26.5	789	7.39	18.1	25-30 cm	Fresh clean odour
CWB	WB60	08/05/2019	9	26.6	776	7.86	-23	25-30 cm	Fresh clean odour
CWB	WB61	09/09/2018	11	28.4	27.19	6.92	-5.1	20-25 cm	Fresh clean odour
CWB	WB61	08/05/2019	11	26.6	2580	7.65	71.1	25-30 cm	Fresh clean odour
CWB	WB63	08/05/2019	7	23.4	250.8	7.08	-73.9	20-25 cm	Biological odour
F	RC17WAF0098	13/09/2018	68	26.4	775	7.2	-176.3	20-25 cm	Biological odour
H	RC14WAH0081	05/05/2019	47	27.5	799	7.68	100.9	<1 cm	Fresh clean odour
H	RC16WAH0095	05/05/2019		28.6	493.5	6.23	108.9	1-3 cm	Fresh clean odour
H	RC16WAH0103	05/05/2019	51	27.8	492.2	6.83	123.6	<1 cm	Fresh clean odour
J	RC18WAJ0004	10/09/2018	115	28.6	975	6.59	1.6	<1 cm	Fresh clean odour
J (South)	RC18ANG0004	02/08/2020	60	28.2	623	6.9	-62.9	6-10 cm	Fresh clean odour

Deposit	Bore No.	Date	DTW (m)	Temp (°C)	EC (µS/cm)	Acidity (pH)	Redox (mV)	Turbidity	Appearance
Regional	MB14WAE006	12/09/2018	127	27.3	855	8.47	78.4	20-25 cm	Stale odour
TCBF	WB13WAPP016	14/03/2019	32	29.5	790	7.1	-27.5	>30 cm	Fresh clean odour
TCBF	WB13WAPP016	07/05/2019	30	29.2	740	7.07	86.5	>30 cm	Fresh clean odour
TCBF	WOB01	13/03/2019	56	30.4	1180	5.05	79.8	>30 cm	Fresh clean odour
TCBF	WOB01	07/05/2019	56	29.1	1095	7.38	74.6	3-6 cm	Fresh clean odour
TCBF	WOB03	13/03/2019	47	30.3	962		708.8	>30 cm	Fresh clean odour
TCBF	WOB03	07/05/2019	45	29.1	864	7.76	99.9	20-25 cm	Fresh clean odour
TCBF	WOB05	13/03/2019	41	30.9	675		707.9	>30 cm	Fresh clean odour
TCBF	WOB05	07/05/2019	41	30.6	638	7.26	76.4	>30 cm	Fresh clean odour
TCBF	WOB07	13/03/2019		30.4	589		659.8	>30 cm	Fresh clean odour
TCBF	WOB09	13/03/2019	60	30.1	1175	6.86	10.5	>30 cm	Fresh clean odour
TCBF	WOB09	07/05/2019	60	28.1	1064	7.54	96.4	6-10 cm	Fresh clean odour
TCBF	WOB12	14/03/2019	38	29.7	409.5	6.72	-32.2	20-25 cm	Fresh clean odour
TCBF	WOB12	07/05/2019	38	29.3	368.4	6.91	65.6	25-30 cm	Fresh clean odour
TCBF	WOB13	07/05/2019	29	29.4	285.3	6.84	96.6	15-20 cm	Fresh clean odour
TCBF	WOB20	13/03/2019	70	29.3	969	5.64	46.6	15-20 cm	Fresh clean odour
TCBF	WOB22	13/03/2019	22	30.2	142.3	5.99	-69.2	>30 cm	Fresh clean odour
TCBF	WOB22	07/05/2019	22	29	132	7.23	-58.4	25-30 cm	Biological odour
TCBF	WOB4	14/03/2019	58	29.8	565		253.7	20-25 cm	Fresh clean odour
TCBF	WOB4	07/05/2019	55	30.1	551	7.41	71.4	6-10 cm	Fresh clean odour
TCBF	WTP5	13/03/2019	54	30.6	900	6.9	-81.7	25-30 cm	Fresh clean odour
TCBF	WTP5	07/05/2019	43	28.7	951	7.81	91.1	6-10 cm	Fresh clean odour
Western Hill	RC15WAW0044	30/04/2019	41	26.8	788	7.75	80.9	<1 cm	Fresh clean odour
Western Hill	RC17WAW0072	01/05/2019	78	26.4	1005	7.92	101.5	<1 cm	Fresh clean odour
Western Hill	RC18WAW0113	06/11/2018	46	29.2	3293	6.93	205.4	3-6 cm	Fresh clean odour
Western Hill	RC18WAW0145	06/11/2018	48	27.4	1536	7.12	179	10-15 cm	Mineral odour
Bores from which no water chemistry sample could be obtained									
J	GD17WAJ0001	06/10/2020							
F North	GR17WAF0014	12/09/2018							
F North	MB14WAF0001	12/09/2018							
H	RC14WAH0009	06/05/2019							
H	RC14WAH0030	06/05/2019							
H	RC14WAH0035	05/05/2019							
J	RC14WAJ0022	03/05/2019							
H	RC16WAH0095	05/05/2019							
J	RC16WAJ0030	03/05/2019							
J	RC16WAJ0030	06/10/2020							

Deposit	Bore No.	Date	DTW (m)	Temp (°C)	EC (µS/cm)	Acidity (pH)	Redox (mV)	Turbidity	Appearance
F North	RC17WAF0088	04/05/2019							
F North	RC17WAF0097	13/09/2018							
Western Hill	RC17WAW0116	05/11/2018							
Western Hill	RC17WAW0181	06/11/2018							
Western Hill	RC17WAW0181	30/04/2019							
J	RC18ANG0004	05/03/2020							
H	RC18WAH0576	06/05/2019							
J	RC18WAJ0001	08/11/2018							
J	RC18WAJ0004	04/05/2019							
J	RC18WAJ0028	08/09/2018							
J	RC18WAJ0034	08/09/2018							
J	RC18WAJ0038	03/05/2019							
Western Hill	RC18WAW0042	01/05/2019							
Western Hill	RC18WAW0085	05/11/2018							
Western Hill	RC18WAW0087	01/05/2019							
Western Hill	RC18WAW0091	01/05/2019							
Western Hill	RC18WAW0200	08/05/2019							
Western Hill	RC18WAW0268	06/11/2018							
Western Hill	RC18WAW0300	30/04/2019							
MTEE	RC18WAX0034	07/11/2018							
MTEE	RC18WAX0036	07/11/2018							
MTEE	RC18WAX0036	01/05/2019							
MTEE	RC18WAX0042	07/11/2018							
Western Hill	WA7RC0090	06/11/2018							
CWB	WAAWE0054	09/05/2019							
CWB	WB033	09/05/2019							
TCB	WOB07	13/03/2019							
TCB	WOB20	07/05/2019							

Appendix G – Subterranean fauna records from current survey

Full Name	Order	Family	Genus	Specimens	Site	Method	Date	Classification	Genes Sequenced
Araneae `sp. Biologic-ARAN008`	Araneae	indet.	indet.	1	RC18WAF0061	Scraping	04/05/2019	Morpho & DNA	COI
Araneae `sp. Biologic-ARAN009`	Araneae	indet.	indet.	1	RC18WAJ0009	Scraping	03/05/2019	Morpho & DNA	COI
Araneae `sp. Biologic-ARAN009`	Araneae	indet.	indet.	1	RC18WAJ0009	Scraping	08/11/2018	Morpho & DNA	COI
Araneae `sp. Biologic-ARAN017`	Araneae	indet.	indet.	1	RC19WAX0052	Scraping	05/10/2020	Morpho & DNA	COI
Araneae `sp. Biologic-ARAN017`	Araneae	indet.	indet.	1	RC19WAX0052	Scraping	05/10/2020	Morpho & DNA	COI
Araneae `sp. Biologic-ARAN030`	Araneae	indet.	indet.	1	RC18WAW0122	Scraping	30/04/2019	Morpho & DNA	COI
Araneae sp. indet.	Araneae	indet.	indet.	1	RC18WAW0122	Scraping	30/04/2019	Morphologic	failed
Oonopidae `sp. Biologic-ARAN011`	Araneae	Oonopidae	indet.	1	RC18WAJ0020	Scraping	02/05/2019	Morpho & DNA	COI
Oonopidae `sp. Biologic-ARAN011`	Araneae	Oonopidae	indet.	1	RC16WAJ0007	Scraping	03/05/2019	Morpho & DNA	COI
Oonopidae `sp. Biologic-ARAN018`	Araneae	Oonopidae	indet.	1	RC19WAX0039	Scraping	05/10/2020	Morpho & DNA	COI
Prethopalpus `sp. Biologic-ARAN012`	Araneae	Oonopidae	*Prethopalpus*	1	RC16WAH0095	Scraping	05/05/2019	Morpho & DNA	COI
Prethopalpus `sp. Biologic-ARAN013`	Araneae	Oonopidae	*Prethopalpus*	1	DD16WAJ0001	Scraping	08/11/2018	Morpho & DNA	COI
Theridiidae `sp. Biologic-ARAN010`	Araneae	Theridiidae	indet.	1	RC17WAJ0080	Scraping	08/11/2018	Morpho & DNA	COI
Theridiidae `sp. Biologic-ARAN010`	Araneae	Theridiidae	indet.	1	RC18WAH0273	Scraping	05/05/2019	Morpho & DNA	COI
Theridiidae `sp. Biologic-ARAN010`	Araneae	Theridiidae	indet.	1	RC14ANR0006	Scraping	02/05/2019	Morpho & DNA	COI
Theridiidae `sp. Biologic-ARAN010`	Araneae	Theridiidae	indet.	1	RC16WAJ0007	Scraping	03/05/2019	Morpho & DNA	COI
Theridiidae `sp. Biologic-ARAN010`	Araneae	Theridiidae	indet.	1	RC16WAJ0007	Scraping	03/05/2019	Morpho & DNA	COI
Theridiidae `sp. Biologic-ARAN010`	Araneae	Theridiidae	indet.	1	RC16WAH0060	Scraping	05/05/2019	Morpho & DNA	COI
Theridiidae `sp. Biologic-ARAN010`	Araneae	Theridiidae	indet.	1	RC17WAH0007	Scraping	06/05/2019	Morpho & DNA	COI
Theridiidae `sp. Biologic-ARAN010`	Araneae	Theridiidae	indet.	1	RC17WAJ0083	Scraping	08/11/2018	Morpho & DNA	COI
Theridiidae `sp. Biologic-ARAN010`	Araneae	Theridiidae	indet.	1	RC17WAJ0080	Scraping	08/11/2018	Morpho & DNA	COI
Theridiidae `sp. Biologic-ARAN010`	Araneae	Theridiidae	indet.	1	RC19WAX0039	Scraping	05/10/2020	Morpho & DNA	COI
Theridiidae `sp. Biologic-ARAN010`	Araneae	Theridiidae	indet.	1	RC19WAX0045	Scraping	04/10/2020	Morpho & DNA	COI
Theridiidae sp. indet.	Araneae	Theridiidae	indet.	1	RC19WAX0039	Scraping	05/10/2020	Morphologic	
Theridiidae sp. indet.	Araneae	Theridiidae	indet.	2	RC19WAX0045	Scraping	04/10/2020	Morphologic	
Nocticola `sp. Biologic-BLAT014`	Blattodea	Nocticolidae	*Nocticola*	1	RC16WAJ0007	Trapping	03/05/2019	Morpho & DNA	COI
Nocticola `sp. Biologic-BLAT014`	Blattodea	Nocticolidae	*Nocticola*	1	RC17WAJ0074	Trapping	03/05/2019	Morpho & DNA	COI
Nocticola `sp. Biologic-BLAT014`	Blattodea	Nocticolidae	*Nocticola*	1	RC18WAW0121	Scraping	30/04/2019	Morpho & DNA	COI
Nocticola `sp. Biologic-BLAT014`	Blattodea	Nocticolidae	*Nocticola*	1	RC14ANR0025	Scraping	03/05/2019	Morpho & DNA	COI
Nocticola `sp. Biologic-BLAT014`	Blattodea	Nocticolidae	*Nocticola*	1	RC18WAX0026	Scraping	07/11/2018	Morpho & DNA	COI
Nocticola `sp. Biologic-BLAT014`	Blattodea	Nocticolidae	*Nocticola*	1	RC17WAJ0013	Trapping	03/05/2019	Morpho & DNA	COI
Nocticola `sp. Biologic-BLAT014`	Blattodea	Nocticolidae	*Nocticola*	1	RC18WAX0041	Scraping	02/05/2019	Morpho & DNA	COI
Nocticola `sp. Biologic-BLAT014`	Blattodea	Nocticolidae	*Nocticola*	1	RC18WAF0079	Trapping	04/05/2019	Morpho & DNA	COI
Nocticola `sp. Biologic-BLAT014`	Blattodea	Nocticolidae	*Nocticola*	1	RC18WAX0045	Scraping	02/05/2019	Morpho & DNA	COI
Nocticola `sp. Biologic-BLAT014`	Blattodea	Nocticolidae	*Nocticola*	1	RC19WAX0037	Scraping	04/10/2020	Morpho & DNA	COI
Nocticola `sp. Biologic-BLAT014`	Blattodea	Nocticolidae	*Nocticola*	1	RC19WAX0039	Scraping	05/10/2020	Morpho & DNA	COI
Nocticola `sp. Biologic-BLAT014`	Blattodea	Nocticolidae	*Nocticola*	1	RC19WAX0041	Scraping	04/10/2020	Morpho & DNA	COI
Nocticola `sp. Biologic-BLAT014`	Blattodea	Nocticolidae	*Nocticola*	1	RC19WAX0042	Scraping	05/10/2020	Morpho & DNA	COI
Nocticola `sp. Biologic-BLAT014`	Blattodea	Nocticolidae	*Nocticola*	1	RC19WAX0047	Scraping	05/10/2020	Morpho & DNA	COI
Nocticola `sp. Biologic-BLAT014`	Blattodea	Nocticolidae	*Nocticola*	1	RC19WAX0063	Scraping	05/10/2020	Morpho & DNA	COI
Nocticola `sp. Biologic-BLAT014`	Blattodea	Nocticolidae	*Nocticola*	1	RC17ANR0022	Scraping	09/03/2020	Morpho & DNA	COI
Nocticola `sp. Biologic-BLAT014`	Blattodea	Nocticolidae	*Nocticola*	1	RC17ANR0022	Trapping	27/06/2020	Morpho & DNA	COI
Nocticola `sp. Biologic-BLAT015`	Blattodea	Nocticolidae	*Nocticola*	1	RC18WAH0117	Scraping	06/05/2019	Morpho & DNA	COI
Nocticola quartermainei	Blattodea	Nocticolidae	*Nocticola*	1	RC15WAW0023	Trapping	30/04/2019	Morpho & DNA	COI
Nocticola quartermainei	Blattodea	Nocticolidae	*Nocticola*	1	RC14WAH0039	Trapping	05/05/2019	Morpho & DNA	COI
Nocticola quartermainei	Blattodea	Nocticolidae	*Nocticola*	1	RC14WAH0047	Scraping	05/05/2019	Morpho & DNA	COI
Nocticola sp. indet.	Blattodea	Nocticolidae	*Nocticola*	1	RC18WAW0122	Scraping	30/04/2019	Morphologic	failed
Nocticola sp. indet.	Blattodea	Nocticolidae	*Nocticola*	1	RC18WAX0026	Trapping	07/11/2018	Morphologic	
Nocticola sp. indet.	Blattodea	Nocticolidae	*Nocticola*	1	RC17WAJ0013	Trapping	03/05/2019	Morphologic	
Nocticola sp. indet.	Blattodea	Nocticolidae	*Nocticola*	1	RC18WAW0121	Scraping	30/04/2019	Morphologic	
Nocticola sp. indet.	Blattodea	Nocticolidae	*Nocticola*	6	RC14WAH0047	Scraping	05/05/2019	Morphologic	
Nocticola sp. indet.	Blattodea	Nocticolidae	*Nocticola*	13	RC14WAH0047	Trapping	05/05/2019	Morphologic	
Nocticola sp. indet.	Blattodea	Nocticolidae	*Nocticola*	1	RC18WAH0586	Scraping	05/05/2019	Morphologic	
Nocticola sp. indet.	Blattodea	Nocticolidae	*Nocticola*	1	RC14ANR0025	Trapping	03/05/2019	Morphologic	
Nocticola sp. indet.	Blattodea	Nocticolidae	*Nocticola*	1	RC17WAJ0074	Scraping	03/05/2019	Morphologic	
Nocticola sp. indet.	Blattodea	Nocticolidae	*Nocticola*	8	RC14ANR0025	Scraping	03/05/2019	Morphologic	
Nocticola sp. indet.	Blattodea	Nocticolidae	*Nocticola*	3	RC16WAJ0007	Scraping	03/05/2019	Morphologic	
Nocticola sp. indet.	Blattodea	Nocticolidae	*Nocticola*	3	RC19WAX0037	Scraping	04/10/2020	Morphologic	
Nocticola sp. indet.	Blattodea	Nocticolidae	*Nocticola*	1	RC19WAX0039	Scraping	05/10/2020	Morphologic	
Nocticola sp. indet.	Blattodea	Nocticolidae	*Nocticola*	5	RC19WAX0042	Scraping	05/10/2020	Morphologic	
Nocticola sp. indet.	Blattodea	Nocticolidae	*Nocticola*	4	RC17ANR0022	Scraping	09/03/2020	Morphologic	
Nocticola sp. indet.	Blattodea	Nocticolidae	*Nocticola*	1	RC17ANR0022	Trapping	27/06/2020	Morphologic	
Nocticola sp. indet.	Blattodea	Nocticolidae	*Nocticola*	8	RC17ANR0022	Trapping	6//10/2020	Morphologic	
Hanseniella `sp. Biologic-SYMP010`	Cephalostigmata	Scutigerellidae	*Hanseniella*	1	RC16WAJ0030	Scraping	03/05/2019	Morpho & DNA	COI
Hanseniella `sp. Biologic-SYMP010`	Cephalostigmata	Scutigerellidae	*Hanseniella*	1	RC18WAJ0042	Scraping	08/11/2018	Morpho & DNA	COI
Hanseniella `sp. Biologic-SYMP017`	Cephalostigmata	Scutigerellidae	*Hanseniella*	1	RC19WAX0019	Scraping	04/10/2020	Morpho & DNA	COI
Hanseniella `sp. Biologic-SYMP018`	Cephalostigmata	Scutigerellidae	*Hanseniella*	1	RC19WAX0025	Scraping	04/10/2020	Morpho & DNA	COI
Hanseniella sp. indet.	Cephalostigmata	Scutigerellidae	*Hanseniella*	1	WAFRC1716	Scraping	04/05/2019	Morphologic	failed
Hanseniella sp. indet.	Cephalostigmata	Scutigerellidae	*Hanseniella*	1	RC14ANR0025	Scraping	03/05/2019	Morphologic	failed
Hanseniella sp. indet.	Cephalostigmata	Scutigerellidae	*Hanseniella*	1	RC17WAH0011	Scraping	05/05/2019	Morphologic	failed
Hanseniella sp. indet.	Cephalostigmata	Scutigerellidae	*Hanseniella*	1	RC14WAH0035	Scraping	05/05/2019	Morphologic	failed
Hanseniella sp. indet.	Cephalostigmata	Scutigerellidae	*Hanseniella*	1	RC19WAX0019	Scraping	04/10/2020	Morphologic	
Hanseniella sp. indet.	Cephalostigmata	Scutigerellidae	*Hanseniella*	1	RC18ANG0004	Scraping	05/03/2020	Morphologic	
Scolopendrellidae `sp. Biologic-SYMP012`	Cephalostigmata	Scolopendrellidae	indet.	1	RC17WAW0236	Trapping	30/04/2019	Morpho & DNA	COI
Scutigerellidae `sp. Biologic-SYMP011`	Cephalostigmata	Scutigerellidae	indet.	1	RC14WAH0039	Scraping	05/05/2019	Morpho & DNA	COI
Scutigerellidae `sp. Biologic-SYMP011`	Cephalostigmata	Scutigerellidae	*Hanseniella*	1	RC17WAF0088	Scraping	04/05/2019	Morpho & DNA	COI

Full Name	Order	Family	Genus	Speci-mens	Site	Method	Date	Classification	Genes Sequenced
Symphylella `sp. Biologic-SYMP019`	Cephalostigmata	Scolopendrellidae	*Symphylella*	1	RC16WAJ0030	Scraping	06/10/2020	Morpho & DNA	COI
Coleoptera `sp. Biologic-COLE007`	Coleoptera	indet.	indet.	1	RC19WAX0061	Scraping	05/10/2020	Morpho & DNA	COI
Coleoptera sp. indet.	Coleoptera	indet.	indet.	2	RC19WAX0061	Scraping	05/10/2020	Morphologic	
Pselaphinae `sp. Biologic-COLE006`	Coleoptera	Staphylinidae	indet.	1	RC19WAX0037	Scraping	04/10/2020	Morpho & DNA	COI
Pselaphinae `sp. Biologic-COLE006`	Coleoptera	Staphylinidae	indet.	1	RC19WAX0039	Scraping	05/10/2020	Morpho & DNA	COI
Pselaphinae `sp. Biologic-COLE008`	Coleoptera	Staphylinidae	indet.	1	RC19WAX0061	Scraping	05/10/2020	Morpho & DNA	COI
Pselaphinae sp. indet.	Coleoptera	Staphylinidae	indet.	2	RC19WAX0037	Scraping	04/10/2020	Morphologic	
Pselaphinae sp. indet.	Coleoptera	Staphylinidae	indet.	1	RC19WAX0061	Scraping	05/10/2020	Morphologic	
Japygidae `sp. Biologic-DIPL017`	Diplura	Japygidae	indet.	1	RC18WAF0058	Scraping	04/05/2019	Morpho & DNA	COI
Japygidae `sp. Biologic-DIPL017`	Diplura	Japygidae	indet.	1	RC18WAJ0037	Scraping	03/05/2019	Morpho & DNA	COI
Japygidae `sp. Biologic-DIPL017`	Diplura	Japygidae	indet.	1	RC17WAJ0146	Scraping	05/03/2020	Morpho & DNA	COI
Japygidae sp. indet.	Diplura	Japygidae	indet.	2	RC18WAJ0037	Scraping	03/05/2019	Morphologic	
Parajapigydae `sp. Biologic-DIPL016`	Diplura	Parajapygidae	indet.	1	RC18WAH0132	Scraping	06/05/2019	Morpho & DNA	COI
Parajapygidae sp. indet.	Diplura	Parajapygidae	indet.	1	RC18WAJ0025	Scraping	08/11/2018	Morphologic	failed
Sciaridae `sp. Biologic-DIPT001`	Diptera	Sciaridae	indet.	1	RC16WAJ0030	Trapping	03/05/2019	Morpho & DNA	COI
Sciaridae `sp. Biologic-DIPT001`	Diptera	Sciaridae	indet.	1	RC18WAW0065	Trapping	30/04/2019	Morpho & DNA	COI
Sciaridae sp. indet.	Diptera	Sciaridae	indet.	1	RC15WAW0023	Trapping	30/04/2019	Morphologic	failed
Sciaridae sp. indet.	Diptera	Sciaridae	indet.	9	RC15WAW0023	Trapping	30/04/2019	Morphologic	
Meenoplidae `sp. Biologic-HEMI001`	Hemiptera	Meenoplidae	indet.	1	RC18WAJ0029	Scraping	08/11/2018	Morpho & DNA	COI
Meenoplidae `sp. Biologic-HEMI002`	Hemiptera	Meenoplidae	indet.	1	RC17WAH0003	Scraping	06/05/2019	Morpho & DNA	COI
Meenoplidae `sp. Biologic-HEMI006`	Hemiptera	Meenoplidae	indet.	1	RC13ANR0083	Scraping	03/05/2019	Morpho & DNA	COI
Meenoplidae `sp. Biologic-HEMI006`	Hemiptera	Meenoplidae	indet.	1	RC13ANR0083	Scraping	03/05/2019	Morpho & DNA	COI
Meenoplidae `sp. Biologic-HEMI010`	Hemiptera	Meenoplidae	indet.	1	WA7RC0090	Scraping	06/11/2018	Morpho & DNA	COI
Meenoplidae sp. indet.	Hemiptera	Meenoplidae	indet.	1	RC18WAX0050	Scraping	07/11/2018	Morphologic	failed
Meenoplidae sp. indet.	Hemiptera	Meenoplidae	indet.	1	RC18WAX0026	Scraping	07/11/2018	Morphologic	failed
Meenoplidae sp. indet.	Hemiptera	Meenoplidae	indet.	1	RC18WAJ0029	Scraping	08/11/2018	Morphologic	
Meenoplidae sp. indet.	Hemiptera	Meenoplidae	indet.	2	WAFRC1716	Scraping	04/05/2019	Morphologic	
Meenoplidae sp. indet.	Hemiptera	Meenoplidae	indet.	4	RC16WAJ0007	Scraping	03/05/2019	Morphologic	
Meenoplidae sp. indet.	Hemiptera	Meenoplidae	indet.	10	RC14ANR0025	Scraping	03/05/2019	Morphologic	
Meenoplidae sp. indet.	Hemiptera	Meenoplidae	indet.	1	WA7RC0090	Scraping	30/04/2019	Morphologic	
Meenoplidae sp. indet.	Hemiptera	Meenoplidae	indet.	1	RC18WAX0050	Scraping	07/11/2018	Morphologic	
Meenoplidae sp. indet.	Hemiptera	Meenoplidae	indet.	1	RC18WAJ0029	Scraping	08/11/2018	Morphologic	
Meenoplidae sp. indet.	Hemiptera	Meenoplidae	indet.	1	WA7RC0090	Scraping	06/11/2018	Morphologic	
Meenoplidae sp. indet.	Hemiptera	Meenoplidae	indet.	15	RC14ANR0006	Scraping	02/05/2019	Morphologic	
Meenoplidae sp. indet.	Hemiptera	Meenoplidae	indet.	14	RC16WAJ0030	Scraping	06/10/2020	Morphologic	
Meenoplidae sp. indet.	Hemiptera	Meenoplidae	indet.	3	RC19WAX0008	Scraping	04/10/2020	Morphologic	
Meenoplidae sp. indet.	Hemiptera	Meenoplidae	indet.	5	RC19WAX0018	Scraping	04/10/2020	Morphologic	
Meenoplidae sp. indet.	Hemiptera	Meenoplidae	indet.	15	RC19WAX0025	Scraping	04/10/2020	Morphologic	
Meenoplidae sp. indet.	Hemiptera	Meenoplidae	indet.	1	RC19WAX0036	Scraping	05/10/2020	Morphologic	
Meenoplidae sp. indet.	Hemiptera	Meenoplidae	indet.	3	RC17ANR0022	Scraping	04/08/2020	Morphologic	
Meenoplidae sp. indet.	Hemiptera	Meenoplidae	indet.	6	RC17WAJ0074	Scraping	03/05/2019	Morphologic	
Oliarus `sp. WAM-CIXO001`	Hemiptera	Cixiidae	*Oliarus*	1	RC19WAX0008	Scraping	04/10/2020	Morpho & DNA	COI
Phaconeura `sp. Biologic-HEMI003`	Hemiptera	Meenoplidae	*Phaconeura*	1	RC18WAF0061	Scraping	04/05/2019	Morpho & DNA	COI
Phaconeura `sp. Biologic-HEMI003`	Hemiptera	Meenoplidae	*Phaconeura*	1	RC18WAH0273	Scraping	05/05/2019	Morpho & DNA	COI
Phaconeura `sp. Biologic-HEMI003`	Hemiptera	Meenoplidae	*Phaconeura*	1	RC16WAJ0007	Scraping	03/05/2019	Morpho & DNA	COI
Phaconeura `sp. Biologic-HEMI003`	Hemiptera	Meenoplidae	*Phaconeura*	1	RC18WAF0079	Scraping	04/05/2019	Morpho & DNA	COI
Phaconeura `sp. Biologic-HEMI003`	Hemiptera	Meenoplidae	*Phaconeura*	1	RC18WAJ0032	Scraping	08/09/2018	Morpho & DNA	COI
Phaconeura `sp. Biologic-HEMI003`	Hemiptera	Meenoplidae	*Phaconeura*	1	RC19WAX0018	Scraping	04/10/2020	Morpho & DNA	COI
Phaconeura `sp. Biologic-HEMI003`	Hemiptera	Meenoplidae	*Phaconeura*	1	RC19WAX0025	Scraping	04/10/2020	Morpho & DNA	COI
Phaconeura `sp. Biologic-HEMI003`	Hemiptera	Meenoplidae	*Phaconeura*	1	RC19WAX0036	Scraping	05/10/2020	Morpho & DNA	COI
Phaconeura `sp. Biologic-HEMI003`	Hemiptera	Meenoplidae	*Phaconeura*	1	RC19WAX0063	Scraping	05/10/2020	Morpho & DNA	COI
Phaconeura `sp. WAM-PHAC001`	Hemiptera	Meenoplidae	*Phaconeura*	1	RC18WAW0085	Scraping	05/11/2018	Morpho & DNA	COI
Phaconeura `sp. WAM-PHAC001`	Hemiptera	Meenoplidae	*Phaconeura*	1	RC16WAJ0030	Scraping	06/10/2020	Morpho & DNA	COI
Phaconeura `sp. WAM-PHAC001`	Hemiptera	Meenoplidae	*Phaconeura*	1	RC19WAX0047	Scraping	05/10/2020	Morpho & DNA	COI
Philosciidae `sp. Biologic ISOP015`	Isopoda	Philosciidae	indet.	1	RC19WAX0039	Scraping	05/10/2020	Morpho & DNA	COI
Philosciidae `sp. WAF`	Isopoda	Philosciidae	indet.	1	RC18WAF0052	Trapping	04/05/2019	Morphologic	failed
Philosciidae `sp. WAF`	Isopoda	Philosciidae	indet.	1	RC18WAF0052	Trapping	04/05/2019	Morphologic	failed
Pseudodiploexochus `sp. WAH`	Isopoda	Armadillidae	*Pseudodiplo-exochus*	1	RC14WAH0035	Scraping	05/05/2019	Morphologic	failed
Palpigradi `sp. Biologic-PALP015`	Palpigradi	indet.	indet.	1	RC18WAJ0037	Scraping	03/05/2019	Morpho & DNA	COI
Palpigradi `sp. Biologic-PALP016`	Palpigradi	indet.	indet.	1	RC17WAW0222	Scraping	30/04/2019	Morpho & DNA	COI
Palpigradi `sp. Biologic-PALP017`	Palpigradi	indet.	indet.	1	RC16WAH0065	Scraping	05/05/2019	Morpho & DNA	COI
Palpigradi `sp. Biologic-PALP018`	Palpigradi	indet.	indet.	1	RC17WAF0068	Scraping	04/05/2019	Morpho & DNA	COI
Palpigradi `sp. Biologic-PALP018`	Palpigradi	indet.	indet.	1	RC17WAF0068	Scraping	04/05/2019	Morpho & DNA	COI
Palpigradi `sp. Biologic-PALP018`	Palpigradi	indet.	indet.	1	RC18WAF0050	Scraping	04/05/2019	Morpho & DNA	COI
Palpigradi `sp. Biologic-PALP018`	Palpigradi	indet.	indet.	1	RC16WAX0016	Scraping	07/11/2018	Morpho & DNA	COI
Palpigradi `sp. Biologic-PALP018`	Palpigradi	indet.	indet.	1	RC17WAF0088	Scraping	04/05/2019	Morpho & DNA	COI
Palpigradi `sp. Biologic-PALP019`	Palpigradi	indet.	indet.	1	RC18WAX0006	Scraping	07/11/2018	Morpho & DNA	COI
Palpigradi `sp. Biologic-PALP020`	Palpigradi	indet.	indet.	1	RC16WAH0081	Scraping	05/05/2019	Morpho & DNA	COI
Palpigradi `sp. Biologic-PALP021`	Palpigradi	indet.	indet.	1	RC17WAJ0083	Scraping	08/11/2018	Morpho & DNA	COI
Palpigradi sp. indet.	Palpigradi	indet.	indet.	1	RC18WAF0061	Scraping	04/05/2019	Morphologic	failed
Palpigradi sp. indet.	Palpigradi	indet.	indet.	1	RC18WAX0041	Scraping	02/05/2019	Morphologic	failed
Palpigradi sp. indet.	Palpigradi	indet.	indet.	2	RC16WAH0065	Scraping	05/05/2019	Morphologic	
Decapauropus `sp. WAM-PAUD002`	Pauropoda	Pauropodidae	*Decapauropus*	1	WA7RC0091	Scraping	06/11/2018	Morpho & DNA	COI
Pauropoda `sp. Biologic-PAUR014`	Pauropoda	indet.	indet.	1	RC18WAW0135	Scraping	06/11/2018	Morpho & DNA	COI
Pauropoda `sp. Biologic-PAUR015`	Pauropoda	indet.	indet.	1	RC17WAJ0057	Scraping	03/05/2019	Morpho & DNA	COI
Pauropoda `sp. Biologic-PAUR015`	Pauropoda	indet.	indet.	1	RC17WAF0055	Scraping	02/05/2019	Morpho & DNA	COI
Pauropoda `sp. Biologic-PAUR016`	Pauropoda	indet.	indet.	1	RC17WAW0072	Scraping	01/05/2019	Morpho & DNA	COI

Full Name	Order	Family	Genus	Speci-mens	Site	Method	Date	Classification	Genes Sequenced
Pauropoda `sp. Biologic-PAUR017`	Pauropoda	indet.	indet.	1	RC17WAH0007	Scraping	06/05/2019	Morpho & DNA	COI
Pauropoda `sp. Biologic-PAUR018`	Pauropoda	indet.	indet.	1	RC18WAW0025	Scraping	01/05/2019	Morpho & DNA	COI
Pauropoda `sp. Biologic-PAUR019`	Pauropoda	indet.	indet.	1	WAFRC1716	Scraping	04/05/2019	Morpho & DNA	COI
Pauropoda `sp. Biologic-PAUR020`	Pauropoda	indet.	indet.	1	RC18WAW0135	Scraping	06/11/2018	Morpho & DNA	COI
Pauropoda `sp. Biologic-PAUR027`	Pauropoda	indet.	indet.	1	RC19WAX0006	Scraping	04/10/2020	Morpho & DNA	COI
Pauropoda sp. indet.	Pauropoda	indet.	indet.	1	RC18WAW0129	Scraping	06/11/2018	Morphologic	failed
Pauropoda sp. indet.	Pauropoda	indet.	indet.	1	RC18WAW0137	Scraping	30/04/2019	Morphologic	failed
Pauropoda sp. indet.	Pauropoda	indet.	indet.	1	RC17WAF0055	Scraping	02/05/2019	Morphologic	failed
Pauropoda sp. indet.	Pauropoda	indet.	indet.	1	RC18WAW0135	Scraping	06/11/2018	Morphologic	
Pauropoda sp. indet.	Pauropoda	indet.	indet.	1	RC18WAW0135	Scraping	06/11/2018	Morphologic	
Pauropoda sp. indet.	Pauropoda	indet.	indet.	8	RC18WAW0135	Scraping	30/04/2019	Morphologic	
Pauropoda sp. indet.	Pauropoda	indet.	indet.	11	RC17WAF0055	Scraping	02/05/2019	Morphologic	
Lophoproctidae `sp. Biologic-POLX002`	Polyxenida	Lophoproctidae	indet.	1	RC17WAF0147	Trapping	04/05/2019	Morpho & DNA	COI
Lophoproctidae `sp. Biologic-POLX002`	Polyxenida	Lophoproctidae	indet.	1	RC18WAX0001	Trapping	07/11/2018	Morpho & DNA	COI
Lophoproctidae `sp. Biologic-POLX002`	Polyxenida	Lophoproctidae	indet.	1	RC14WAJ0013	Trapping	27/06/2020	Morpho & DNA	COI
Lophoproctidae `sp. Biologic-POLX003`	Polyxenida	Lophoproctidae	indet.	1	RC18WAW0129	Scraping	06/11/2018	Morpho & DNA	COI
Lophoproctidae `sp. Biologic-POLX003`	Polyxenida	Lophoproctidae	indet.	1	RC18WAW0135	Trapping	06/11/2018	Morpho & DNA	COI
Lophoproctidae `sp. Biologic-POLX003`	Polyxenida	Lophoproctidae	indet.	1	RC14ANR0025	Scraping	03/05/2019	Morpho & DNA	COI
Lophoproctidae `sp. Biologic-POLX003`	Polyxenida	Lophoproctidae	indet.	1	RC18WAW0011	Scraping	01/05/2019	Morpho & DNA	COI
Lophoproctidae `sp. Biologic-POLX005`	Polyxenida	Lophoproctidae	indet.	1	WAFRC1716	Scraping	04/05/2019	Morpho & DNA	COI
Lophoproctidae `sp. Biologic-POLX005`	Polyxenida	Lophoproctidae	indet.	1	RC17WAJ0122	Scraping	03/05/2019	Morpho & DNA	COI
Lophoproctidae sp. indet.	Polyxenida	Lophoproctidae	indet.	1	RC14WAJ0013	Trapping	27/06/2020	Morphologic	
Polyxenida sp. indet.	Polyxenida	indet.	indet.	1	RC18WAX0001	Trapping	07/11/2018	Morphologic	
Polyxenida sp. indet.	Polyxenida	indet.	indet.	1	RC17WAF0147	Trapping	04/05/2019	Morphologic	
Polyxenida sp. indet.	Polyxenida	indet.	indet.	1	RC18WAX0001	Scraping	07/11/2018	Morphologic	
Polyxenida sp. indet.	Polyxenida	indet.	indet.	1	RC18WAX0001	Scraping	07/11/2018	Morphologic	
Polyxenida sp. indet.	Polyxenida	indet.	indet.	1	RC18WAX0001	Scraping	07/11/2018	Morphologic	
Polyxenida sp. indet.	Polyxenida	indet.	indet.	1	RC18WAX0001	Trapping	07/11/2018	Morphologic	
Polyxenida sp. indet.	Polyxenida	indet.	indet.	1	RC18WAX0045	Scraping	07/11/2018	Morphologic	
Polyxenida sp. indet.	Polyxenida	indet.	indet.	1	RC18WAW0129	Scraping	06/11/2018	Morphologic	
Polyxenida sp. indet.	Polyxenida	indet.	indet.	1	RC18WAX0001	Scraping	07/11/2018	Morphologic	
Chthoniidae `sp. Biologic-PSEU029`	Pseudoscorpiones	Chthoniidae	indet.	1	RC19WAX0032	Scraping	05/10/2020	Morpho & DNA	COI
Indohya `sp. Biologic-PSEU016`	Pseudoscorpiones	Hyidae	*Indohya*	1	RC17WAH0007	Scraping	06/05/2019	Morpho & DNA	COI
Indolpium `sp. Biologic-PSEU017`	Pseudoscorpiones	Olpiidae	*Indolpium*	1	RC16WAX0005	Scraping	02/05/2019	Morpho & DNA	COI
Tyrannochthonius `sp. Biologic-PSEU010`	Pseudoscorpiones	Chthoniidae	*Tyrannochthonius*	1	RC18WAJ0024	Scraping	03/05/2019	Morpho & DNA	COI
Tyrannochthonius `sp. Biologic-PSEU010`	Pseudoscorpiones	Chthoniidae	*Tyrannochthonius*	1	RC18WAJ0037	Scraping	03/05/2019	Morpho & DNA	COI
Tyrannochthonius `sp. Biologic-PSEU011`	Pseudoscorpiones	Chthoniidae	*Tyrannochthonius*	1	RC16WAX0016	Scraping	07/11/2018	Morpho & DNA	COI
Tyrannochthonius `sp. Biologic-PSEU011`	Pseudoscorpiones	Chthoniidae	*Tyrannochthonius*	1	RC16WAX0007	Scraping	02/05/2019	Morpho & DNA	COI
Tyrannochthonius `sp. Biologic-PSEU012`	Pseudoscorpiones	Chthoniidae	*Tyrannochthonius*	1	RC14ANR0006	Scraping	02/05/2019	Morpho & DNA	COI
Tyrannochthonius `sp. Biologic-PSEU012`	Pseudoscorpiones	Chthoniidae	*Tyrannochthonius*	1	RC18WAX0019	Scraping	02/05/2019	Morpho & DNA	COI
Tyrannochthonius `sp. Biologic-PSEU013`	Pseudoscorpiones	Chthoniidae	*Tyrannochthonius*	1	RC18WAH0409	Scraping	06/05/2019	Morpho & DNA	COI
Tyrannochthonius `sp. Biologic-PSEU014`	Pseudoscorpiones	Chthoniidae	*Tyrannochthonius*	1	RC17WAH0008	Scraping	05/05/2019	Morpho & DNA	COI
Tyrannochthonius `sp. Biologic-PSEU014`	Pseudoscorpiones	Chthoniidae	*Tyrannochthonius*	1	RC17WAH0008	Scraping	05/05/2019	Morpho & DNA	COI
Tyrannochthonius `sp. Biologic-PSEU014`	Pseudoscorpiones	Chthoniidae	*Tyrannochthonius*	1	RC18WAH0586	Scraping	05/05/2019	Morpho & DNA	COI
Tyrannochthonius `sp. Biologic-PSEU015`	Pseudoscorpiones	Chthoniidae	*Tyrannochthonius*	1	RC18WAW0065	Scraping	30/04/2019	Morpho & DNA	COI
Cryptops `sp.  Biologic-CHIL008`	Scolopendrida	Cryptopidae	Cryptops	1	RC17WAJ0165	Scraping	04/05/2019	Morpho & DNA	COI
Cryptops `sp. WAWH`	Scolopendrida	Cryptopidae	Cryptops	1	RC18WAW0201	Scraping	06/11/2018	Morphologic	failed
Speleostrophus `sp. Biologic-DPLO001`	Spirobolida	Trigoniulidae	*Speleostrophus*	1	RC18WAJ0038	Trapping	03/05/2019	Morpho & DNA	COI
Phreodrilidae sp. indet.	Tubificida	Phreodrilidae	indet.	1	RC17ANR0022	Scraping	09/03/2020	Morphologic	
Atelurinae `sp. Biologic-ZYGE012`	Zygentoma	Nicoletiidae	indet.	1	RC18WAW0122	Scraping	06/11/2018	Morpho & DNA	COI
Atelurinae `sp. Biologic-ZYGE012`	Zygentoma	Nicoletiidae	indet.	1	RC18WAW0122	Scraping	06/11/2018	Morpho & DNA	COI
Atelurinae `sp. Biologic-ZYGE014`	Zygentoma	Nicoletiidae	indet.	1	RC16WAJ0007	Scraping	03/05/2019	Morpho & DNA	12S
Atelurinae `sp. Biologic-ZYGE014`	Zygentoma	Nicoletiidae	indet.	1	RC17WAJ0074	Scraping	03/05/2019	Morpho & DNA	12S
Atelurinae `sp. Biologic-ZYGE014`	Zygentoma	Nicoletiidae	indet.	1	RC18WAX0026	Scraping	07/11/2018	Morpho & DNA	12S
Atelurinae sp. indet.	Zygentoma	Nicoletiidae	indet.	1	WAFRC1716	Scraping	09/11/2018	Morphologic	failed
Atelurinae sp. indet.	Zygentoma	Nicoletiidae	indet.	1	RC14WAH0081	Scraping	05/05/2019	Morphologic	failed
Atelurinae sp. indet.	Zygentoma	Nicoletiidae	indet.	1	RC16WAJ0007	Scraping	03/05/2019	Morphologic	
Atelurinae sp. indet.	Zygentoma	Nicoletiidae	indet.	1	RC17WAJ0074	Scraping	03/05/2019	Morphologic	
Atelurinae sp. indet.	Zygentoma	Nicoletiidae	indet.	3	RC18WAF0061	Scraping	04/05/2019	Morphologic	
Atelurinae sp. indet.	Zygentoma	Nicoletiidae	indet.	1	RC18WAX0026	Scraping	07/11/2018	Morphologic	
Atelurinae sp. indet.	Zygentoma	Nicoletiidae	indet.	1	RC18WAJ0020	Scraping	02/05/2019	Morphologic	
Atelurinae sp. indet.	Zygentoma	Nicoletiidae	indet.	1	RC16WAJ0002	Scraping	03/05/2019	Morphologic	
Atelurinae sp. indet.	Zygentoma	Nicoletiidae	indet.	2	RC18WAX0026	Scraping	02/05/2019	Morphologic	
Dodecastyla `sp. Biologic-ZYGE011`	Zygentoma	Nicoletiidae	*Dodecastyla*	1	RC18WAF0061	Scraping	04/05/2019	Morpho & DNA	COI
Dodecastyla `sp. Biologic-ZYGE011`	Zygentoma	Nicoletiidae	*Dodecastyla*	1	RC18WAX0026	Scraping	07/11/2018	Morpho & DNA	COI
Dodecastyla `sp. Biologic-ZYGE011`	Zygentoma	Nicoletiidae	*Dodecastyla*	1	RC16WAJ0002	Scraping	03/05/2019	Morpho & DNA	COI
Subnicoletiinae sp. indet.	Zygentoma	Nicoletiidae	indet.	1	RC18WAX0041	Scraping	02/05/2019	Morphologic	failed

Full Name	Order	Family	Genus	Speci-mens	Site	Method	Date	Classification	Genes Sequenced
Subnicoletiinae sp. indet.	Zygentoma	Nicoletiidae	indet.	1	RC18WAW0122	Scraping	30/04/2019	Morphologic	
Trinemura `sp. Biologic-ZYGE013`	Zygentoma	Nicoletiidae	*Trinemura*	1	RC18WAW0122	Scraping	06/11/2018	Morpho & DNA	COI
Trinemura `sp. Biologic-ZYGE017`	Zygentoma	Nicoletiidae	*Trinemura*	1	RC19WAX0037	Scraping	04/10/2020	Morpho & DNA	COI
Trinemura sp. indet.	Zygentoma	Nicoletiidae	*Trinemura*	1	RC19WAX0006	Scraping	04/10/2020	Morphologic	failed
Amphipoda sp. indet	Amphipoda	indet.	indet.	1	WB43	Hauling	08/05/2019	Morphologic	failed
Amphipoda sp. indet	Amphipoda	indet.	indet.	1	WAAWE0054	Hauling	09/05/2019	Morphologic	failed
Amphipoda sp. indet	Amphipoda	indet.	indet.	45	WB51	Hauling	09/09/2018	Morphologic	
Amphipoda sp. indet	Amphipoda	indet.	indet.	1	WB43	Hauling	08/05/2019	Morphologic	
Kruptus `sp. Helix-AMP035`	Amphipoda	Paramelitidae	*Kruptus*	1	RC18WAW0300	Scraping	30/04/2019	Morpho & DNA	COI
Kruptus? `sp. Biologic-AMPH016`	Amphipoda	Paramelitidae	*Kruptus?*	1	WB13WAPP016	Hauling	14/03/2019	Morpho & DNA	COI
Maarrka `sp. Helix-AMP037`	Amphipoda	Paramelitidae	*Maarrka*	1	MB16WAW0003	Hauling	14/03/2019	Morpho & DNA	COI
Paramelitidae `sp. Biologic-AMPH017`	Amphipoda	Paramelitidae	indet.	1	WB51	Hauling	09/09/2018	Morpho & DNA	COI
Paramelitidae `sp. Biologic-AMPH017`	Amphipoda	Paramelitidae	indet.	1	WB51	Hauling	09/09/2018	Morpho & DNA	COI
Paramelitidae `sp. Biologic-AMPH017`	Amphipoda	Paramelitidae	indet.	1	WB51	Hauling	09/09/2018	Morpho & DNA	COI
Paramelitidae `sp. Biologic-AMPH017`	Amphipoda	Paramelitidae	indet.	1	WB43	Hauling	08/05/2019	Morpho & DNA	COI
Paramelitidae `sp. Biologic-AMPH017`	Amphipoda	Paramelitidae	indet.	1	WB43	Hauling	08/05/2019	Morpho & DNA	COI
Paramelitidae `sp. Biologic-AMPH017`	Amphipoda	Paramelitidae	indet.	1	WB51	Hauling	09/09/2018	Morpho & DNA	COI
Paramelitidae `sp. Biologic-AMPH017`	Amphipoda	Paramelitidae	indet.	1	WB43	Hauling	08/05/2019	Morpho & DNA	COI
Paramelitidae `sp. Biologic-AMPH018`	Amphipoda	Paramelitidae	indet.	1	MB16WAW0003	Hauling	14/03/2019	Morpho & DNA	COI
Paramelitidae `sp. Biologic-AMPH018`	Amphipoda	Paramelitidae	indet.	1	MB16WAW0008	Hauling	09/05/2019	Morpho & DNA	COI
Paramelitidae `sp. Helix-AMP036`	Amphipoda	Paramelitidae	indet.	1	MB16WAW0008	Hauling	09/05/2019	Morpho & DNA	COI
Paramelitidae `sp. Helix-AMP036`	Amphipoda	Paramelitidae	indet.	1	MB16WAW0009	Hauling	19/03/2019	Morpho & DNA	COI
Paramelitidae `sp. Helix-AMP036`	Amphipoda	Paramelitidae	indet.	1	MB16WAW0009	Hauling	19/03/2019	Morpho & DNA	COI
Paramelitidae `sp. Helix-AMP036`	Amphipoda	Paramelitidae	indet.	1	MB16WAW0009	Hauling	19/03/2019	Morpho & DNA	COI
Paramelitidae sp. indet.	Amphipoda	Paramelitidae	indet.	1	MB16WAW0009	Hauling	19/03/2019	Morphologic	failed
Paramelitidae sp. indet.	Amphipoda	Paramelitidae	indet.	1	WB51	Hauling	09/09/2018	Morphologic	failed
Paramelitidae sp. indet.	Amphipoda	Paramelitidae	indet.	50	WB51	Hauling	09/09/2018	Morphologic	
Paramelitidae sp. indet.	Amphipoda	Paramelitidae	indet.	6	MB16WAW0009	Hauling	19/03/2019	Morphologic	
Paramelitidae sp. indet.	Amphipoda	Paramelitidae	indet.	1	MB16WAW0003	Hauling	14/03/2019	Morphologic	
Atopobathynella `sp. Biologic-PBAT008`	Bathynellacea	Parabathynellidae	*Atopobathynella*	1	RC18WAJ0042	Scraping	08/11/2018	Morpho & DNA	COI
Billibathynella `sp. Biologic-PBAT007`	Bathynellacea	Parabathynellidae	*Billibathynella*	1	WB51	Hauling	09/09/2018	Morpho & DNA	COI
Billibathynella `sp. Biologic-PBAT007`	Bathynellacea	Parabathynellidae	*Billibathynella*	1	WB51	Hauling	08/05/2019	Morpho & DNA	COI
Parabathynellidae sp. indet.	Bathynellacea	Parabathynellidae	indet.	1	WB51	Hauling	08/05/2019	Morphologic	
Cyclopoida sp. indet.	Cyclopoida	indet.	indet.	1	WB51	Hauling	09/09/2018	Morphologic	
Cyclopoida sp. indet.	Cyclopoida	indet.	indet.	21	WB43	Hauling	08/05/2019	Morphologic	
Cyclopoida sp. indet.	Cyclopoida	indet.	indet.	10	WB51	Hauling	09/09/2018	Morphologic	
Diacyclops humphreysi	Cyclopoida	Cyclopidae	*Diacyclops*	1	WB51	Hauling	09/09/2018	Morphologic	
Diacyclops humphreysi	Cyclopoida	Cyclopidae	*Diacyclops*	1	WB51	Hauling	09/09/2018	Morphologic	
Diacyclops humphreysi	Cyclopoida	Cyclopidae	*Diacyclops*	1	WB51	Hauling	09/09/2018	Morphologic	
Diacyclops humphreysi	Cyclopoida	Cyclopidae	*Diacyclops*	1	WB51	Hauling	09/09/2018	Morphologic	
Diacyclops humphreysi	Cyclopoida	Cyclopidae	*Diacyclops*	50	WB51	Hauling	09/09/2018	Morphologic	
Parastenocaris `sp. cf. *jane*`	Harpacticoida	Parastenocarididae	*Parastenocaris*	1	WB51	Hauling	09/09/2018	Morphologic	
Pygolabis `sp. WAN`	Isopoda	Tainisopidae	*Pygolabis*	1	MB16WAW0006	Hauling	14/03/2019	Morphologic	failed
Pygolabis `sp. WAN`	Isopoda	Tainisopidae	*Pygolabis*	1	MB16WAW0012	Hauling	19/03/2019	Morphologic	failed
Pygolabis `sp. WAN`	Isopoda	Tainisopidae	*Pygolabis*	1	MB16WAW0006	Hauling	14/03/2019	Morphologic	failed
Pygolabis `sp. WAN`	Isopoda	Tainisopidae	*Pygolabis*	1	MB16WAW0012	Hauling	19/03/2019	Morphologic	
Candonidae? `sp. WAN`	Podocopida	Candonidae?	indet.	2	MB16WAW0003	Hauling	14/03/2019	Morphologic	
Enchytraeidae `sp. Biologic-OLIG006`	Tubificida	Enchytraeidae	indet.	1	RC14WAH0009	Hauling	06/05/2019	Morpho & DNA	COI
Enchytraeidae `sp. Biologic-OLIG007`	Tubificida	Enchytraeidae	indet.	1	RC16WAJ0028	Scraping	03/05/2019	Morpho & DNA	COI
Enchytraeidae `sp. Biologic-OLIG006`	Tubificida	Enchytraeidae	indet.	1	RC14WAH0009	Hauling	06/05/2019	Morpho & DNA	COI
Enchytraeidae `sp. Biologic-OLIG007`	Tubificida	Enchytraeidae	indet.	1	RC16WAJ0028	Scraping	03/05/2019	Morpho & DNA	COI
Enchytraeidae `sp. Biologic-OLIG008`	Tubificida	Enchytraeidae	indet.	1	RC17WAW0072	Hauling	01/05/2019	Morpho & DNA	COI
Enchytraeidae `sp. Biologic-OLIG008`	Tubificida	Enchytraeidae	indet.	1	RC18WAW0180	Trapping	30/04/2019	Morpho & DNA	COI
Enchytraeidae `sp. E11`	Tubificida	Enchytraeidae	indet.	1	RC17WAF0160	Scraping	09/11/2018	Morpho & DNA	COI
Enchytraeidae `sp. E6`	Tubificida	Enchytraeidae	indet.	1	RC16WAJ0019	Trapping	04/05/2019	Morpho & DNA	COI
Enchytraeidae sp. indet.	Tubificida	Enchytraeidae	indet.	1	WB51	Hauling	09/09/2018	Morphologic	failed
Enchytraeidae sp. indet.	Tubificida	Enchytraeidae	indet.	1	WB51	Hauling	09/09/2018	Morphologic	failed
Enchytraeidae sp. indet.	Tubificida	Enchytraeidae	indet.	1	WB51	Hauling	09/09/2018	Morphologic	failed
Enchytraeidae sp. indet.	Tubificida	Enchytraeidae	indet.	10	WB51	Hauling	09/09/2018	Morphologic	
Enchytraeidae sp. indet.	Tubificida	Enchytraeidae	indet.	14	RC16WAJ0019	Trapping	04/05/2019	Morphologic	
Enchytraeidae sp. indet.	Tubificida	Enchytraeidae	indet.	1	RC16WAJ0028	Scraping	03/05/2019	Morphologic	
Enchytraeidae sp. indet.	Tubificida	Enchytraeidae	indet.	1	RC17WAW0072	Hauling	01/05/2019	Morphologic	
Enchytraeidae sp. indet.	Tubificida	Enchytraeidae	indet.	2	RC18WAW0180	Trapping	30/04/2019	Morphologic	
Enchytraeidae sp. indet.	Tubificida	Enchytraeidae	indet.	1	WB51	Hauling	08/05/2019	Morphologic	
Phreodrilidae `sp. Biologic-OLIG010`	Tubificida	Phreodrilidae	indet.	1	WOB12	Hauling	07/05/2019	Morpho & DNA	COI
Phreodrilidae `sp. P1`	Tubificida	Phreodrilidae	indet.	1	WB51	Hauling	09/09/2018	Morpho & DNA	COI
Phreodrilidae `sp. P1`	Tubificida	Phreodrilidae	indet.	1	WB51	Hauling	09/09/2018	Morpho & DNA	COI
Phreodrilidae `sp. P1`	Tubificida	Phreodrilidae	indet.	1	WB51	Hauling	09/09/2018	Morpho & DNA	COI
Phreodrilidae `sp. P12`	Tubificida	Phreodrilidae	indet.	1	WOB01	Hauling	13/03/2019	Morpho & DNA	COI
Phreodrilidae `sp. P12`	Tubificida	Phreodrilidae	indet.	1	WOB01	Hauling	13/03/2019	Morpho & DNA	COI
Phreodrilidae `sp. P12`	Tubificida	Phreodrilidae	indet.	1	WB43	Hauling	08/05/2019	Morpho & DNA	COI
Phreodrilidae sp. indet.	Tubificida	Phreodrilidae	indet.	1	WB61	Hauling	09/09/2018	Morphologic	failed
Phreodrilidae sp. indet.	Tubificida	Phreodrilidae	indet.	26	WOB01	Hauling	13/03/2019	Morphologic	
Phreodrilidae sp. indet.	Tubificida	Phreodrilidae	indet.	28	WB51	Hauling	09/09/2018	Morphologic	

Full Name	Order	Family	Genus	Speci-mens	Site	Method	Date	Classification	Genes Sequenced
Phreodrilidae sp. indet.	Tubificida	Phreodrilidae	indet.	4	WB43	Hauling	08/05/2019	Morphologic	
Phreodrilidae sp. indet.	Tubificida	Phreodrilidae	indet.	1	WOB01	Hauling	13/03/2019	Morphologic	
Phreodrilidae sp. indet.	Tubificida	Phreodrilidae	indet.	1	WOB01	Hauling	13/03/2019	Morphologic	
Phreodrilidae sp. indet.	Tubificida	Phreodrilidae	indet.	2	WOB01	Hauling	07/05/2019	Morphologic	

Appendix H – Regulation 17 licence

This appendix has been provided separately
("WAN_Reg17_Licence_08-002749-1.pdf")

Appendix I – Shared species tables

Troglofauna taxa recorded only from a single deposit area, *vs.* taxa recorded from multiple deposit areas, and taxa recorded externally

Troglofauna taxa	Western Hill	Dep H	Dep FN	MTEE	Dep J	External match	Occurrence pattern
Araneae `sp. Biologic-ARAN008`			1				Single deposit area
Araneae `sp. Biologic-ARAN009`					1		Single deposit area
Araneae `sp. Biologic-ARAN017`				1			Single deposit area
Araneae `sp. Biologic-ARAN030`	1						Single deposit area
Atelurinae `sp. Biologic-ZYGE012`	1						Single deposit area
Chthoniidae `sp. Biologic-PSEU029`				1			Single deposit area
Coleoptera `sp. Biologic-COLE007`				1			Single deposit area
Cryptops `sp. WAWH`	1						Single deposit area
Hanseniella `sp. Biologic-SYMP017`				1			Single deposit area
Hanseniella `sp. Biologic-SYMP018`				1			Single deposit area
Indohya `sp. Biologic-PSEU016`		1					Single deposit area
Nocticola `sp. Biologic-BLAT015`		1					Single deposit area
Oonopidae `sp. Biologic-ARAN011`					1		Single deposit area
Palpigradi `sp. Biologic-PALP015`					1		Single deposit area
Palpigradi `sp. Biologic-PALP016`	1						Single deposit area
Palpigradi `sp. Biologic-PALP017`		1					Single deposit area
Palpigradi `sp. Biologic-PALP019`				1			Single deposit area
Palpigradi `sp. Biologic-PALP020`		1					Single deposit area
Palpigradi `sp. Biologic-PALP021`					1		Single deposit area
Parajapygidae `sp. Biologic-DIPL016`		1					Single deposit area
Pauropoda `sp. Biologic-PAUR014`	1						Single deposit area
Pauropoda `sp. Biologic-PAUR017`		1					Single deposit area
Pauropoda `sp. Biologic-PAUR018`	1						Single deposit area
Pauropoda `sp. Biologic-PAUR019`			1				Single deposit area
Pauropoda `sp. Biologic-PAUR020`	1						Single deposit area
Pauropoda `sp. Biologic-PAUR027`				1			Single deposit area
Philosciidae `sp. Biologic ISOP015`				1			Single deposit area
Philosciidae `sp. WAF `			1				Single deposit area
Prethopalpus `sp. Biologic-ARAN012`		1					Single deposit area
Prethopalpus `sp. Biologic-ARAN013`					1		Single deposit area
Pselaphinae `sp. Biologic-COLE006`				1			Single deposit area
Pseudodiploexochus `sp. WAH`		1					Single deposit area
Scolopendrellidae `sp. Biologic-SYMP012`	1						Single deposit area
Trinemura `sp. Biologic-ZYGE013`	1						Single deposit area
Trinemura `sp. Biologic-ZYGE017`				1			Single deposit area
Tyrannochthonius `sp. Biologic-PSEU010`					1		Single deposit area
Tyrannochthonius `sp. Biologic-PSEU011`				1			Single deposit area
Tyrannochthonius `sp. Biologic-PSEU013`		1					Single deposit area
Tyrannochthonius `sp. Biologic-PSEU014`		1					Single deposit area
Tyrannochthonius `sp. Biologic-PSEU015`	1						Single deposit area
Atelurinae `sp. Biologic-ZYGE014`				1	1		Two deposit areas (local)
Palpigradi `sp. Biologic-PALP018`			1	1			Two deposit areas (local)
Pauropoda `sp. Biologic-PAUR015`			1		1		Two deposit areas (local)
Scutigerellidae `sp. Biologic-SYMP011`		1	1				Two deposit areas (local)
Tyrannochthonius `sp. Biologic-PSEU012`				1	1		Two deposit areas (local)
Cryptops `sp. Biologic-CHIL008`					1	1	One deposit area, external match
Decapauropus `sp. WAM-PAUD002`	1					1	One deposit area, external match
Hanseniella `sp. Biologic-SYMP010`					1	1	One deposit area, external match
Indolpium `sp. Biologic-PSEU017`				1		1	One deposit area, external match
Meenoplidae `sp. Biologic-HEMI001`					1	1	One deposit area, external match
Meenoplidae `sp. Biologic-HEMI002`		1				1	One deposit area, external match
Meenoplidae `sp. Biologic-HEMI006`					1	1	One deposit area, external match
Meenoplidae `sp. Biologic-HEMI010`	1					1	One deposit area, external match
Oliarus `sp. WAM-CIXO001`				1		1	One deposit area, external match
Oonopidae `sp. Biologic-ARAN018`				1		1	One deposit area, external match
Pauropoda `sp. Biologic-PAUR016`	1					1	One deposit area, external match
Pselaphinae `sp. Biologic-COLE008`				1		1	One deposit area, external match
Speleostrophus `sp. Biologic-DPLO001`					1	1	One deposit area, external match
Symphylella `sp. Biologic-SYMP019`					1	1	One deposit area, external match
Dodecastyla `sp. Biologic-ZYGE011`			1	1	1	1	Many deposit areas, external match
Japygidae `sp. Biologic-DIPL017`			1		1	1	Many deposit areas, external match
Lophoproctidae `sp. Biologic-POLX002`			1	1	1	1	Many deposit areas, external match
Lophoproctidae `sp. Biologic-POLX003`	1				1	1	Many deposit areas, external match
Lophoproctidae `sp. Biologic-POLX005`			1		1	1	Many deposit areas, external match
Nocticola `sp. Biologic-BLAT014`	1		1	1	1	1	Many deposit areas, external match
Nocticola quartermainei	1	1				1	Many deposit areas, external match
Phaconeura `sp. Biologic-HEMI003`		1	1	1	1	1	Many deposit areas, external match
Phaconeura `sp. WAM-PHAC001`	1			1	1	1	Many deposit areas, external match
Sciaridae `sp. Biologic-DIPT001`	1				1	1	Many deposit areas, external match
Theridiidae `sp. Biologic-ARAN010`		1		1	1	1	Many deposit areas, external match
Total species	**18**	**15**	**12**	**24**	**25**	**25**	**70 species total**
Total species unique to deposit area	**10**	**10**	**3**	**11**	**6**		**40 species unique to 1 deposit area**
Total shared species (internal)	**5**	**4**	**9**	**9**	**13**		**16 species shared between deposits**
Total shared species (internal/ external)	**8**	**5**	**9**	**13**	**19**		**25 species with external matches**

Stygofauna taxa recorded only from a single deposit area, *vs.* taxa recorded from multiple deposit areas, and taxa recorded externally

Stygofauna taxa	Western Hill	Dep H	Dep J	Dep FN	CALC/ SYNC	CWB	TCBF	External match	Occurrence pattern
Billibathynella `sp. Biologic-PBAT007`						1			Single deposit area
Candonidae `sp. WAN`					1				Single deposit area
Kruptus? `sp. Biologic-AMPH016`							1		Single deposit area
Maarrka `sp. Helix-AMP037`					1				Single deposit area
Paramelitidae `sp. Biologic-AMPH017`						1			Single deposit area
Paramelitidae `sp. Biologic-AMPH018`					1				Single deposit area
Paramelitidae `sp. Helix-AMP036`					1				Single deposit area
Parastenocaris cf. *jane*						1			Single deposit area
Phreodrilidae `sp. Biologic-OLIG010`							1		Single deposit area
Phreodrilidae `sp. P1`						1			Single deposit area
Pygolabis `sp. WAN`					1				Single deposit area
Kruptus `sp. Helix-AMP035`	1				1				Two deposit areas (local)
Phreodrilidae `sp. P12`						1	1	1	Many deposit areas, external match
Atopobathynella `sp. Biologic-PBAT008`			1					1	One deposit area, external match
Diacyclops humphreysi						1		1	One deposit area, external match
Enchytraeidae `sp. Biologic-OLIG006`		1						1	One deposit area, external match
Enchytraeidae `sp. Biologic-OLIG007`			1					1	One deposit area, external match
Enchytraeidae `sp. Biologic-OLIG008`	1							1	One deposit area, external match
Enchytraeidae `sp. E11`				1				1	One deposit area, external match
Enchytraeidae `sp. E6`			1					1	One deposit area, external match
Total species	**2**	**1**	**3**	**1**	**6**	**6**	**3**	**8**	**20 species total**
Total species unique to deposit area	**-**	**-**	**-**	**-**	**5**	**4**	**2**		**11 species unique to 1 deposit area**
Total shares species (internal)	**1**	**-**	**-**	**-**	**1**	**1**	**1**		**2 species shared between deposits**
Total shared species (internal/ external)	**1**	**1**	**3**	**1**	**-**	**2**	**1**		**7 species with external matches**

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F.3: West Angelas Revised Proposal Environmental Impact Assessment of Subterranean Fauna







West Angelas Revised Proposal:

Environmental Impact Assessment of Subterranean Fauna

Biologic Environmental Survey

Report to Rio Tinto Iron Ore

December 2022



WEST ANGELAS REVISED PROPOSAL
ENVIRONMENTAL IMPACT ASSESSMENT OF SUBTERRANEAN FAUNA

DOCUMENT STATUS				
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GLOSSARY

AWT	Above Water Table
BC Act	*Western Australian Biodiversity Conservation Act 2016*
BoM	Bureau of Meteorology
BrIF	Brockman Iron Formation
BWT	Below Water Table
DBCA	Department Biodiversity, Conservation and Attractions
DFN	F North Deposit
DH	Deposit H
DJ	Deposit J reference area
EPA	Western Australian Environmental Protection Authority
EP Act	*Environmental Protection Act 1986*
EPBC Act	*Environment Protection and Biodiversity Conservation Act 1999*
GoWA	Government of Western Australia
MAR	Managed Aquifer Recharge
MMIF	Marra Mamba Iron Formation
MTEE	Mount Ella East Deposit
OTU	Operational Taxonomic Unit
PEC	Priority Ecological Community
SRE	Short-range Endemism
TEC	Threatened Ecological Community
WAM	Western Australian Museum
West Angelas Region	The area occupied by proposed Development Envelope and existing mining operations (proposed and all previous Development Envelopes)
WH	Western Hill Deposit

EXECUTIVE SUMMARY

Rio Tinto Iron Ore Pty Ltd proposes to construct and develop new above water table (AWT) and below water table (BWT) deposits at the West Angelas Iron Ore Project, extending the existing operations as part of the West Angelas Revised Proposal (the Proposal, EPA Assessment 2290). Additional activities for the Proposal include but are not limited to dewatering and surplus water management, mineral waste management, and placement of associated infrastructure and support facilities. The Development Envelope of the Proposal covers 36,779 hectares and is located approximately 100 km north-west of Newman in the Pilbara region of Western Australia.

This report provides an assessment of the potential proposed impacts and combined impacts to subterranean fauna (troglofauna and stygofauna) from the implementation of the Proposal. Assessment of cumulative (third party) impacts was not included as there are no third-party mining projects within the immediate vicinity of the Development Envelope likely to impact subterranean fauna values.

The direct impacts included in this assessment were removal of subterranean fauna habitats through mining, temporary or permanent loss of stygofauna habitat due to mine dewatering, and associated losses of subterranean fauna populations or assemblages. The indirect impacts included in the assessment consisted of the potential reduction of habitat quality beneath waste and stockpile landforms. Combined direct impacts were quantified and assessed in relation to the existing approved Rio Tinto operations at West Angelas, comprising mining operations at Deposits A, B, C, D, E, F and G approved under Ministerial Statements 1113, 1015, 0970 and 0514.

Results from 16 subterranean fauna surveys undertaken between 1998 and 2020 resulted in 903 troglofauna samples and 141 stygofauna samples from the Development Envelope and surrounds. Four extensive subterranean fauna surveys since 2012 form the primary basis for the assessment, all of which met relevant EPA Guidelines and were broadly comparable with contemporary sampling practices, survey effort and taxonomic effort.

A total of 165 troglofauna individuals representing 77 taxa and 490 stygofauna individuals representing 23 taxa have been recorded from the Development Envelope and surrounds. Substantial taxonomic effort, including molecular systematics analysis has been undertaken to reduce the uncertainties of species-level identifications and distributions throughout and beyond the Development Envelope.

A three-dimensional (3D) model was created from detailed geological and hydrogeological information, geophysics and structural geology information, and subterranean fauna sampling to assess the extent and connectivity of prospective above water table (AWT) and below water table (BWT) subterranean habitats. For each scenario where the model predicted changes to habitat thickness, connectivity and extent, the volume of habitat remaining in-situ was quantified in relation to any predicted loss. A determination of the suitability of the remaining habitat to support specific species was made through comparing the distribution patterns of subterranean fauna with the remaining post-impact habitat.

Troglofauna

Troglofauna values identified from the Development Envelope comprised 42 species/taxa and corresponding suitable habitats AWT as modelled. The magnitude of direct impacts to troglofauna

habitat values resulting from the Proposal was assessed as Low. This was based on the predicted retention of approximately 98% (8.97 billion cubic metres) of suitable habitat, with no significant reduction in the extent, thickness and connectivity of troglofauna habitat. The remaining habitat is expected to continue to support the troglofauna assemblages present, and no known troglofauna values are expected to be significantly impacted from the direct impacts of the Proposal. The magnitude of direct impacts to troglofauna species values resulting from the Proposal was assessed as Low to Medium. No troglofauna taxa or habitat values are expected to be lost following the implementation of the Proposal.

Indirect impacts are not expected to compromise the ecological integrity of the AWT habitats that remain intact after impacts, or to increase the level of impact to any troglofauna values (species or habitats). Indirect impacts are predicted to affect only 3% of the 2D area of the suitable habitat AWT that remains intact following direct impacts (from both the Proposal and combined impacts).

The magnitude of combined impacts to troglofauna habitat values (including proposed and previous direct impacts from existing operations) was assessed as Low. This was based on the predicted retention of approximately 88% of the suitable habitat (approximately 8.11 billion cubic metres of habitat rated as Medium to High suitability) throughout the Development Envelope. The remaining habitat is expected to retain its overall value and suitability and should continue to support the troglofauna assemblages present. The magnitude of combined impacts to troglofauna species values was assessed as Low to Medium. None of the known troglofauna values are expected to be lost from the combined effects of the Proposal and existing operations.

Stygofauna

Important stygofauna values identified from the Development Envelope comprised 12 species/taxa and corresponding suitable habitats BWT as modelled. The magnitude of direct impacts to stygofauna values resulting from the Proposal was assessed as Low. This was based on the predicted retention of approximately 86% (0.87 billion cubic metres) of suitable habitat BWT as modelled within the Western Hill orebody aquifer and Deposit H. The remaining habitat was rated as High to Medium suitability for stygofauna taxa and its extent, thickness and connectivity is expected to continue to support the known stygofauna assemblages present.

The magnitude of combined impacts to known stygofauna values from the Proposal and existing operations was assessed as Low. This was based on the predicted retention of 83% (12.46 billion cubic metres) of suitable BWT habitat throughout the Development Envelope and adjacent synclinal valley aquifer under the combined impact scenario. The habitats predicted to remain intact under the combined scenario are extensive and well-connected,Figure 4.14 and are expected to continue to support stygofauna. None of the known stygofauna values are expected to be significantly impacted from the combined impacts of the Proposal and existing operations.

The ecological integrity of the BWT habitats that remain after mining is not expected to be compromised by indirect impacts, nor do indirect impacts increase the level of impact to any stygofauna value (species or habitat). Indirect impacts are predicted to affect only 7% of the 2D area of the suitable habitat BWT that remains intact following direct combined impacts.

It is expected that the EPA's factor objective for subterranean fauna will be met in relation to species, populations and assemblages for both troglofauna and stygofauna values. The biological diversity and ecological integrity of the known subterranean fauna values within the Development Envelope are likely to be maintained following the implementation of the Proposal (and existing operations). No subterranean fauna species or habitat values are expected to be lost following the implementation of the Proposal (and existing operations).

1. INTRODUCTION

Rio Tinto Iron Ore Pty Ltd (Rio Tinto) owns and operates the West Angelas Iron Ore Project (The Project). Current and previous mining operations within the West Angelas Region comprise operations at Deposits A, B, C, D, E, F and G approved under Ministerial Statements 1113, 1015, 0970 and 0514. Rio Tinto is evaluating the potential to extend the life of the West Angelas mine through development of additional deposits via the West Angelas Revised Proposal (the Proposal, EPA Assessment 2290). The Proposal is located approximately 100 km north-west of Newman in the Pilbara region of Western Australia (Figure 1.1), which is internationally recognised as an area of globally important subterranean fauna evolution and divergence.

Current operations at the West Angelas Region comprise:

- Mining Deposits A and B (Ministerial Statement 0514, approved in June 1999)
    - AWT and BWT mining
    - Establishment of the Turee Creek B Borefield for water supply
- Mining Deposits A, B, and E (Ministerial Statement 0970, approved in June 2014)
    - AWT and BWT mining
    - Additional water supply from the Turee Creek B Borefield
- Mining Deposit A West and Deposit F (Ministerial Statement 1015, approved in August 2015)
    - AWT and BWT mining
    - Additional water supply from the Turee Creek B Borefield
- Mining Deposits C, D and G (Ministerial Statement 1113, approved in September 2019)
    - AWT and BWT pits at Deposit C, D (AWT only at Deposit G)
    - Backfilling of BWT pits to prevent the formation of permanent pit lakes
    - Discharge of surplus dewatering water to local ephemeral tributary of Turee Creek if required
    - Managed Aquifer Recharge (MAR) within the synclinal aquifer west of Deposits C and D, approved under MS1113 (Condition 6-1).

The Proposal comprises both above water table (AWT) and below water table (BWT) mining (and construction of associated infrastructure) within the 36,779 hectares (ha) Development Envelope. The potential impacts to subterranean fauna (animals that live underground) from the Proposal are either direct via the removal of habitats (i.e. pit construction, groundwater drawdown), or indirect via the reduction of the quality of remaining habitats (i.e. waste and infrastructure areas, habitat desiccation, noise and vibration from blasting). Biologic Environmental Survey Pty Ltd (Biologic) was commissioned to undertake a subterranean fauna environmental impact assessment (EIA) to provide detailed information for the West Angelas Environment Review Document.

This report considers the potential impacts of the Proposal on the ecological integrity of subterranean fauna habitat values, as well as the potential impacts to the biodiversity values of troglofauna and stygofauna species known to occur within the West Angelas Region (including the proposed Development Envelope, existing operations areas, and immediate surrounds). The impacts to subterranean fauna habitat values were assessed via three-dimensional (3D) modelling of subterranean fauna habitats, which allowed for the detailed quantification of the extent, thickness and connectivity of

prospective subterranean habitats pre-mining and post-mining (2022b). The impacts to subterranean species values were assessed via consolidating all subterranean fauna sampling results from within the Development Envelope and surrounds to date (16 surveys, undertaken between 1998 to 2020) and assessing the known species distributions in relation to proposed direct and indirect impact areas for each subterranean fauna taxon occurring within the Development Envelope and immediate surrounds.

1.1 Subterranean fauna overview

Subterranean fauna are animals that live underground in habitats such as caves, cavities and aquifers. The Pilbara and Yilgarn regions are recognised as globally significant 'hot-spots' for subterranean fauna biodiversity and endemism (EPA, 2016a). Estimates of species richness for the subterranean fauna of WA range from nearly 3,000 taxa in the Pilbara alone (Halse, 2018) to over 4,000 in Western Australia (Guzik *et al.*, 2010). Except for three fish species and a blind snake, all known species of subterranean fauna in Western Australia are invertebrates such as arachnids (e.g. spiders, scorpions), crustacea (e.g. crabs, woodlice, shrimp), insects and myriapods (e.g. centipedes, millipedes) (Aplin, 1998; Larson *et al.*, 2013; Moore, 2019).

Aquatic species that inhabit subterranean habitats such as groundwater are known as stygofauna, while terrestrial (or air-breathing) species inhabiting subterranean habitats such as caves and cavities are termed troglofauna. Both stygofauna and troglofauna can be classified into three ecological categories (stygoxenes/stygophiles/stygobites and trogloxenes/troglophiles/troglobites) according to the degree of adaptation to subterranean environments. Stygobites and troglobites are considered obligate or true subterranean fauna, as no part of their life cycle is spent above ground. They are completely adapted to and dependent upon underground environments and are considered more susceptible to the impacts of proposed developments. Stygobites and troglobites are the focus of EPA guidance for consideration during EIA. Stygoxenes/philes and trogloxenes/philes may inhabit both surface and subterranean habitats and tend to be able to disperse more widely beyond areas of relevance for subterranean fauna EIA.

1.2 Sections of the Proposal (Development Envelope)

Rio Tinto (EPA Assessment 2290) provides a detailed description of the Proposal, which involves clearing of an additional 5,350 ha of native vegetation (in addition to the 12,205 ha currently authorised under Ministerial Statement 1113) within a Development Envelope of 36,779 ha.

For the purposes of this assessment, the Development Envelope has been conceptually split into four EIA sections according to deposit areas (Figure 1.2) as follows:

- **Western Hill** – Proposed AWT pits. (minor abstraction for supply)
- **Deposit H** – Proposed AWT and BWT pits
- **Deposit F-North** – Proposed predominantly AWT pits, minor percentage BWT
- **Mt Ella East** – Proposed AWT pits.

Deposit J reference area (Figure 1.2) represents a sampling area for the baseline survey (Biologic, 2022a) which will not be subject to any direct impacts from the Proposal.

660000 670000 680000 690000 700000

7450000 7440000 7430000

Karijini National Park

Turee Creek East Branch

Western Hill

Great Northern Hwy

Deposit H

Deposit F North

West Angelas

Mt Ella East

Deposit J

Port Hedland

Karratha

Newman

Legend

- West Angelas Beyond 2020 Development Envelope
- Current Operations Development Envelope
- Existing Pit
- Proposed Pit
- Karijini National Park
- West Angelas
- State Road
- Rail
- Major Surface Hydrology

IBRA Region

- Pilbara

IBRA Subregion

- Chichester
- Fortescue
- Hamersley
- Roebourne

N

biologic Environmental Survey

Scale: 1:125,000

0 2 4 6 Km

Coordinate System: GDA 1994 MGA Zone 50
Projection: Transverse Mercator
Datum: GDA 1994 Created 23/08/2022

Port Hedland
Karratha
Marble Bar
Pannawonica
Tom Price
Paraburdoo
Newman

RIO TINTO IRON ORE

West Angelas Environmental Impact Assessment of Subterranean Fauna

Figure 1.1: Regional location of the Development Envelope, including existing operations

660000 670000 680000 690000

7440000

7430000

Western Hill

Deposit H

Deposit F North

Mt Ella East

Deposit J

Legend

- West Angelas Beyond 2020 Development Envelope
- Current Operations Development Envelope
- EIA Section Boundary
- Existing Pit
- Proposed Infrastructure
- Proposed Pit
- Proposed Topsoil Stockpile
- Proposed Waste Dump
- Main Access Track

Surface Hydrology

- Minor
- Major

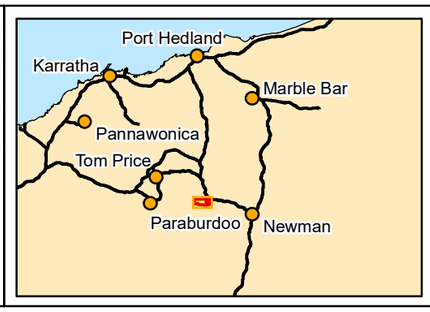
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biologic Environmental Survey

Scale: 1:100,000

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Coordinate System: GDA 1994 MGA Zone 50
Projection: Transverse Mercator
Datum: GDA 1994 Created 23/08/2022



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West Angelas Environmental Impact Assessment of Subterranean Fauna

Figure 1.2: Development Envelope, EIA sections and existing and proposed operations

1.3 Supporting documents and studies

The technical reports used to prepare this subterranean fauna impact assessment are shown in Figure 1.3 and include:

- West Angelas Subterranean Fauna Survey Report (Biologic, 2022a); the most recent survey report, which contains a summary of all subterranean fauna sampling surveys and results from West Angelas to date.
- DNA Analysis Report and regional comparisons of subterranean taxa from the Development Envelope (Appendix B to Biologic, 2022a).
- West Angelas 3D Subterranean Habitat Modelling and Assessment (Biologic, 2022b); the memo report containing the methodology of all habitat assessment and modelling of relevance to the EIA.
- Memorandum: Subterranean Fauna Habitat Assessment and Modelling; a peer reviewed document submitted to EPA in June 2021, detailing the methodology and background of the 3D habitat modelling techniques for subterranean fauna (Biologic, 2021b).

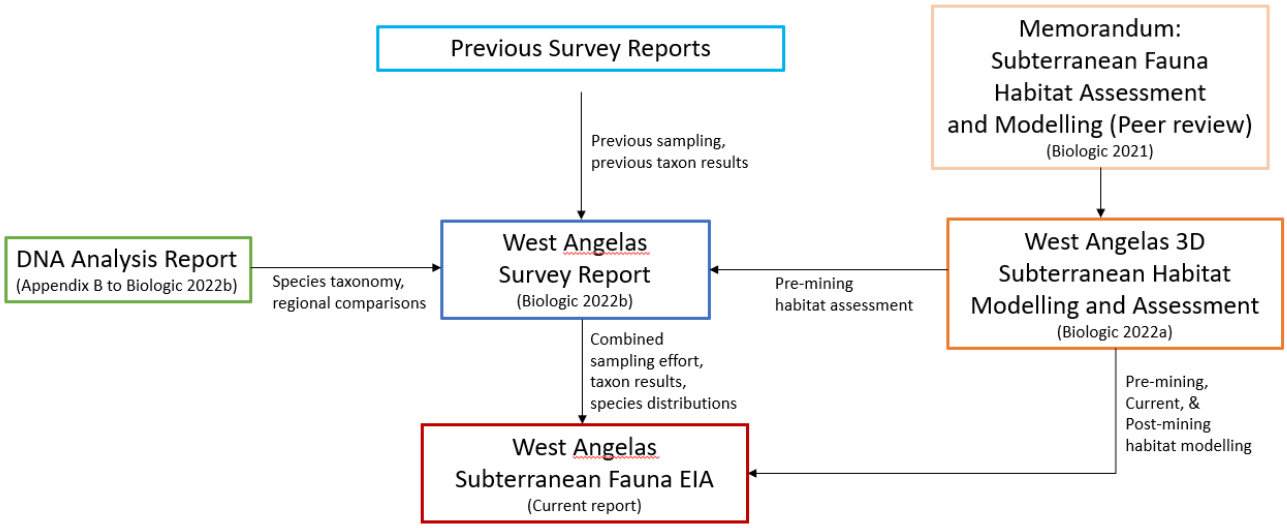


Figure 1.3: Integration of reports relevant to EIA of subterranean fauna

Sixteen subterranean fauna surveys have been conducted across varying parts of the Development Envelope and immediate surrounds to date. These reports are listed in Table 1-1 and have been summarised in Biologic (2022a). In addition, a 3D habitat assessment and modelling report for the West Angelas Region was developed in 2021/2022. A total of 903 troglofauna samples (by trapping and scraping) and 141 stygofauna samples (via net-hauling) have been collected from the West Angelas Region to date (Figure 1.4).

Table 1-1: Summary of previous subterranean fauna reports within and immediately surrounding the Development Envelope

Survey/Investigation	Study area, type and timing
Subterranean fauna surveys	
Ecologia (1998) West Angelas Iron Ore Project Stygofauna Assessment Survey	**Study area:** Dep. A, B, C, Central Water Bores (CWB), Turee Creek Borefield (TCBF) **Type:** Baseline stygofauna sampling – net hauling, baited traps – 44 bores (44 successfully sampled) **Timing:** October 1998
Ecologia (2002) West Angelas Iron Ore Project Stygofauna Assessment Survey	**Study area:** Dep. A, B, CWB, TCBF **Type:** Stygofauna monitoring survey – net hauling – 20 bores (12 successfully sampled) **Timing:** 20 March to 22 March 2002
Biota (2003) West Angelas Stygofauna Survey	**Study area:** Dep. A, B, CWB, TCBF **Type:** Stygofauna sampling – net hauling – 30 bores (24 successfully sampled) **Timing:** 28 November to 1 December 2002
Biota (2004c) West Angelas Expansion Deposits E/F Subterranean Fauna Survey	**Study area:** Dep. E, F **Type:** Stygofauna – net hauling – 28 bores (20 successfully sampled) **Timing:** 5 December and 6 December 2003
Ecologia (2005) West Angelas Stygofauna Monitoring Programme Report	**Study area:** Dep. A, B, CWB, TCBF **Type:** Stygofauna – net hauling – 16 bores (14 successfully sampled) **Timing:** 28 to 30 January 2005
Biota (2008a) West Angelas and Deposit A Stygofauna Survey	**Study area:** Dep. A **Type:** Stygofauna – net hauling – 19 bores (13 successfully sampled) **Timing:** 4 to 5 March 2008
Biota (2008b) West Angelas Operations Stygofauna Compliance Review	**Study area:** Dep. A, B, CWB **Type:** Desktop compliance review **Timing:** 2008
Biota (2012) West Angelas Stygofauna Survey 2012	**Study area:** Dep. A, TCBF **Type:** Stygofauna – net hauling – 12 bores (12 bores successfully sampled) **Timing:** 9 to 11 July 2012
Ecologia (2013) Greater West Angelas Subterranean Fauna Assessment	**Study area:** Dep. C, D, G, F, H **Type:** Single phase subterranean fauna survey (troglofauna and stygofauna) Stygofauna (4 accessible bores in Deposit F) and Troglofauna – net hauling, scraping, trapping – 91 bores (38 successfully sampled for troglofauna and 4 successfully sampled for stygofauna) **Timing:** 9 July to 5 October 2012
Biota (2013) Rio Tinto Iron Ore Regional Troglofauna Sampling & Biota (2014) Rio Tinto Regional Troglobitic Fauna Study Integration Report	**Study area:** Dep. Western Hill, Mt Ella East, beyond Study Area **Type:** Troglofauna – trapping and scraping – 25 bores at Western Hill Deposit and 28 bores at Mt Ella East **Timing:** 28 January to 13 October 2010
Ecologia (2015) West Angelas Deposit B Stygofauna Assessment	**Study area:** Dep. B **Type:** Single phase stygofauna assessment– net hauling – 8 bores (7 successfully sampled in the Central anticline area to the south of Deposit B) **Timing:** 6 to 8 October 2015
Eco Logical (2015) West Angelas Subterranean Fauna Assessment – Report Excerpt	**Study area:** Dep. A West, Dep. F **Type:** Desktop report prepared as an excerpt from the Greater West Angelas Subterranean Fauna Assessment (Ecologia 2013) **Timing:** n/a

Survey/Investigation	Study area, type and timing
Subterranean fauna surveys	
Biologic (2016b) West Angelas Deposits C, D & G Subterranean Fauna Survey 2016	**Study area:** Dep. C, D, G **Type:** Stygofauna and Troglofauna — (92 bores (92 successfully sampled) over two field trips; 43 troglofauna traps, 71 troglofauna scrapes, 29 stygofauna net hauls) **Timing:** 15 to 23 March 2016 and 10 to 12 May 2016
Biologic (2016a) West Angelas Deposit F Stygofauna Monitoring 2016	**Study area:** Dep. F **Type:** Stygofauna - net hauling – 28 bores (9 successfully sampled) **Timing:** 15 to 23 March 2016 and 10 to 12 May 2016
Biologic (2022a) West Angelas: Subterranean fauna survey	**Study area:** Dep H, J, F North, Western Hill & Mt Ella East **Type:** Two season Level 2 Subterranean Fauna Survey: Stygofauna and Troglofauna – trapping, net hauling, scrapes – 331 bores (278 successfully sampled) **Timing (8 sampling episodes):** 6 to 14 September 2018 4 to 9 November 2018 11-18 March 2019 29 March to 10 May 2019 4 to 12 March 2020 24 to 30 June 2020 30 July to 7 August 2020 30 Sept to 7 October 2020
Biologic (2022c) Habitat Assessment and Modelling Report	**Study area:** Greater West Angelas area (comprised 36,779 ha) **Type**: Desktop assessment and integration of: 2D surface geology for suitable habitat 3D habitat modelling from drill hole information AWT and BWT. **Timing**: 2021 to 2022

Surveys shaded in green sampled within the four sections of the proposed Development Envelope and therefore contributed most of the subterranean species information considered in this assessment.

The most recent survey undertaken by Biologic (2022a) focused on the Development Envelope and consisted of 278 bores and holes sampled over two phases (this included reference bores not shown here). Biologic (2022a) provides full details of the sampling and taxonomic effort underpinning the impact assessment. Figure 1.4 shows the spatial layout of all subterranean fauna sampling sites to date throughout the Development Envelope. Sampling adequacy in relation to EPA guidance is discussed in section 3.4.

664000

676000

688000

7440000

7428000

Western Hill

Deposit H

Deposit F North

Mt Ella East

Deposit J

Legend

- West Angelas Beyond 2020 Development Envelope
- Current Operations Development Envelope
- EIA Section Boundary
- Existing Pit
- Proposed Pit
- Main Access Track

Surface Hydrology

- Minor
- Major

Previous sampling

- Stygofauna (141)
- Troglofauna (903)

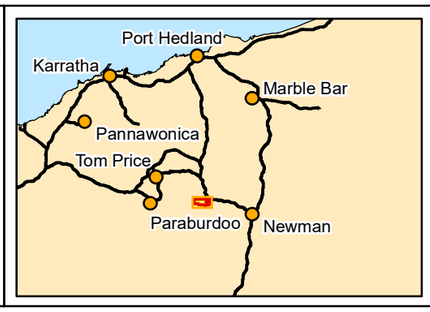
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Datum: GDA 1994 Created 24/08/2022



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Figure 1.4: Subterranean fauna sampling locations in the Beyond 2020 Development Envelope and vicinity

2. EIA FRAMEWORK

2.1 Regulatory framework

As per Environmental Protection Authority guidelines (EPA, 2016a), stygobites and troglobites are the primary focus of this EIA, as both can have very restricted geographic ranges due to inherent constraints on the extent and connectivity of their underground habitats. The highly restricted ranges and high specialisation to underground habitats can make obligate subterranean fauna vulnerable to extinction from anthropogenic impacts such as mining.

Subterranean fauna species are protected under State and Federal legislation:

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

Currently, 25 subterranean fauna species have been identified as a threatened or priority species in the Pilbara and are recognised as conservation-significant species by the Minister for Environment (Appendix A, Table A-1; DBCA, 2021).

Subterranean fauna assemblages may also be significant, with some formally recognised in Threatened Ecological Community (TEC) and Priority Ecological Communities (PECs) listings. One subterranean fauna community has been listed as a TEC in the Pilbara region, and eight communities have been listed as PECs (Appendix A, Table A-2, DBCA, 2021).

The developing state of taxonomy for most subterranean fauna groups means that most species and assemblages detected during survey work are not listed as conservation-significant. Because of this knowledge gap, the consideration of range-restricted subterranean fauna is important, including noting that potentially new species may occur only within restricted habitats, and also have a higher potential of being a Short-Range Endemic (SRE) species (Eberhard *et al.*, 2009; Harvey, 2002).

In Western Australia, the EPA provides guidance on how to consider subterranean fauna during an environmental impact assessment in their *Environmental Factor Guideline – Subterranean Fauna*. The EPA's environmental objective for subterranean fauna is to "protect subterranean fauna so that biological diversity and ecological integrity are maintained" (EPA, 2016a, 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, 2016a, p. 2). Following the EPA Guidelines (EPA, 2016a), this assessment considers potential impacts of the Proposal on the ecological integrity of subterranean fauna values by assessing impacts to high value subterranean fauna habitats and potentially range-restricted species. Concurrently, the potential impacts of the Proposal on the biodiversity of subterranean fauna are assessed by considering impacts to troglofauna and stygofauna species (or species-level taxa known as operational taxonomic units or OTUs) known to occur within the Development Envelope and immediate surrounds.

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

- EPA (2021c) Technical Guidance – Subterranean Fauna Surveys for Environmental Impact Assessment
- EPA (2016a) Environmental Factor Guideline Subterranean Fauna
- EPA (2021b) Statement of Environmental Principles, Factors, Objectives and Aims of EIA .

2.2 Potential impacts to subterranean fauna values

This assessment considered the following three categories of potential impacts (direct, indirect, and combined) following EPA (2016) Environmental Factor Guideline for subterranean fauna. Assessment of cumulative (third party) impacts was not included as there are no third-party mining projects within the immediate vicinity of the Development Envelope likely to impact subterranean fauna values.

2.2.1 Direct impacts assessed

Direct impacts are described by EPA (2016) as including:

> "... the removal of habitat, drawdown of groundwater, inundation, and water quality changes. The main threats include excavation of geologies known to support subterranean fauna; groundwater extraction for process or domestic purposes; dewatering for below water table excavation, and groundwater reinjection of waste or excess water." (EPA 2016).

Direct impacts for troglofauna occur with the removal of AWT habitat in mining pits. Direct impacts for stygofauna occur during the construction of BWT mining pits and in areas that are subjected to altered groundwater levels through pit dewatering, water supply abstraction, and potential evaporative losses from pit lakes following closure. Direct impacts are the focus of this impact assessment as these have been quantified using 3D habitat modelling.

2.2.2 Indirect impacts

Indirect impacts are described by EPA (2016) as including:

> "Indirect impacts include changes to hydrology, siltation, void collapse, alteration to nutrient balance and contamination. The main threats include changed surface topography due to compaction or creation of hard surfaces resulting in altered groundwater flow paths, increased runoff, and reduced infiltration and aquifer recharge; clearing of surface vegetation leading to sedimentation and changed nutrient inputs; potential leaks or leaching including tailings and waste water resulting in alterations to groundwater chemistry and quality, and introduction of toxins or radiation; and salinisation due to intrusion of saline water into freshwater aquifers and leaching from pit voids." (EPA 2016).

Indirect impacts occur when proposed actions reduce the quality of subterranean fauna habitat (or degrade the habitat), rather than removing or reducing the quantity of habitat. Indirect impacts are typically more subtle or gradational and may be expressed at varying distances from the source of impact or the activity; therefore, they are more complex to predict and assess.

Suitable habitat for subterranean fauna may be indirectly impacted by:

- Changes to surface inputs of water, nutrients and oxygen.

  This assessment considers the areas of proposed waste dumps and stockpiles as the major areas of indirect impact, particularly in relation to impacts on troglofauna habitats (AWT). Structures placed over suitable subterranean fauna habitat reduce the infiltration of water and associated nutrients from the surface and increase the risk of cavity-fill from clays and fine sediments. The potential for this type of indirect impact may be higher where suitable subterranean habitat occurs as a thin layer close to surface and is therefore more susceptible to land-surface changes. The risks of impacts in the development footprint beyond waste dumps (i.e. areas of vegetation clearing, infrastructure and roads) are likely to be highly localised and less significant. The risk of inundation to troglofauna habitat (AWT) from changed hydrological flows is expected to be effectively managed by Rio Tinto's internal policies and processes.

- Changes to the structure or presence of underground voids.

  The risk of compaction, vibration and shock to subterranean habitats in the dominant geological setting of the Development Envelope (banded iron formations) is unlikely to extend more than a few metres beyond proposed pits and excavation areas (EPA, 2012) or from infrastructure and waste/stockpile areas at the surface. Based on the comparatively vast extent of suitable habitat throughout the Development Envelope, these risks are likely to be minimal.

- Desiccation of subterranean habitat.

  The risk of desiccation to AWT habitat from groundwater drawdown and surface cover changes is difficult to assess or model on available information. Troglofauna require a near-saturated humid atmosphere within their subterranean cavities, and it is likely that both surface infiltration and groundwater may have an influence on the humidity of the suitable habitat. The assessment considered the pre-mining watertable depth and the area of habitat covered by proposed waste dump and stockpiles in relation to potential desiccation risks. Nevertheless, the significance of these risks to troglofauna habitat is difficult to determine due to a lack of experimental data.

- Fragmentation of previously connected or contiguous habitat by mining or groundwater drawdown.

  The risks of habitat fragmentation (or decreased connectivity) to subterranean species and assemblages are assessed on a case-by-case basis for each impact scenario as described in section 2.3. Some subterranean species are naturally more dispersal-limited than others, and many subterranean habitats may be subject to natural barriers formed by dykes and sills or less permeable geologies. Therefore, the assessment considered habitat factors alongside ecological characteristics and known species ranges to determine the likelihood of indirect impacts of fragmentation.

- Contamination from spills, leaching, and environmental incidents.

  The risk of contamination to subterranean habitat from spills, leachates and environmental incidents is expected to be effectively managed by current spill and incident management practices, and appropriate engineering controls around chemical storage and use areas. The risk of acid rock drainage on troglofauna habitats is considered low, as it is expected to be effectively managed by Rio Tinto's internal policies and processes.

- Re-injection of excess water into potential subterranean fauna habitat.

  Rio Tinto has outlined a Managed Aquifer Recharge (MAR) strategy (Rio Tinto, 2019) to be implemented to mitigate the propagation of groundwater drawdown from the existing and approved operations into Karijini National Park (Ministerial Statement 1113). The risk of inundation to troglofauna habitat (AWT) from MAR is considered low. This area features extensive detrital layers AWT, and the MAR is not expected to have any impact on water levels in the peripheral geological habitats of the Brockman Iron Formation and Marra Mamba Iron Formation. The MAR is not expected to result in significant mounding of water levels above pre-impact water levels, therefore the impact on troglofauna habitats should be negligible.

In conclusion, the main quantifiable indirect impacts likely to affect the subterranean fauna include changes to the inflow of water and nutrients from the soil surface through the development of waste dumps or stockpiles. Other indirect impacts listed above cannot be quantified and will not be formally assessed in this EIA.

2.2.3 Combined impacts

As the Proposal is a significant amendment to an existing proposal (EPA Assessment Number: 2132, MS1113), as per the Environmental Impact Assessment (Part IV Divisions 1 and 2) Administrative Procedures 2021 (EPA, 2021a), the combined existing and proposed impacts have been assessed.

For the purposes of this assessment, combined impacts have been defined as the combination of the 'existing and approved' direct impacts (as per section 2.2.1) of Rio Tinto mining operations within the West Angelas Region (comprising operations at Deposits A, B, C, D, E, F and G approved under Ministerial Statements 1113, 1015, 0970 and 0514) with the 'proposed' direct impacts (pits for troglofauna, and pits and groundwater drawdown for stygofauna) from the Proposal Development Envelope. Direct impacts are the focus of the combined impact assessment as these can be readily quantified using 3D habitat modelling.

2.2.4 Cumulative impacts (third-party operations)

Cumulative environmental impacts are described by EPA (2021) as:

> "… the successive, incremental and interactive impacts on the environment of a proposal with one or more past, present and reasonably foreseeable future activities."

Cumulative impacts comprise the combination of the 'existing and approved' direct impacts with the 'proposed' direct impacts from the current Proposal, as well as third-party impacts. Potential third-party operations in the wider regional area surrounding the Development Envelope include Mining Area C (BHP), South Flank (BHP) and Hope Downs (Rio Tinto).

However, these operations occupy areas within different catchments and geological settings, which are distinct and separate from the habitats of the Development Envelope and surrounding West Angelas Region. Although some widespread subterranean fauna species are known to occur at West Angelas, the overall assemblages recorded within each of the Development Envelope sections were found to be largely distinct from each other and from assemblages detected further afield in the sub-regional area (Biologic 2022). Therefore, given the third-party operational areas are located many kilometres beyond the West Angelas Region in different geological and hydrogeological settings, it is unlikely that cumulative impacts from these third-party operations would be a factor in the current assessment. As a result, no cumulative impacts on subterranean fauna values from third-party operations are anticipated in this assessment.

2.3 Impact scenarios

The assessment of impacts from implementation of the Proposal on subterranean habitat values and subterranean species values considered the following scenarios:

- Pre-impact

The 'pre-impact' scenario was used as a baseline reference for the impact assessment and models the AWT/BWT habitat prior to any mining or groundwater drawdown impacts within the Development Envelope.

- Post-impact: current scenario

The 'current' scenario consisted of the habitat remaining AWT and BWT following existing and approved Rio Tinto operations within the Development Envelope (pits and drawdown from Deposits A, B, C, D, E, F and G approved under Ministerial Statements 1113, 1015, 0970 and 0514). Volumetric calculations of direct impacts under the current scenario were not considered herein as these impacts have already been assessed and approved.

- Post-impact: proposed scenario

The 'proposed' scenario relates to habitat remaining AWT and BWT following direct impacts arising from the Proposal (West Angelas Revised Proposal, EPA Assessment 2290) at the end of Life of Mine (LOM) in 2050. It should be noted that the proposed scenario AWT was modelled separately to any impacts under the 'current' scenario.

- Post-impact: combined scenarios

Troglofauna (above water table):

Combined impacts on troglofauna habitat AWT included a combination of direct impacts from the current or approved Rio Tinto mining operations within the Development Envelope (refer 'current' scenario) as well as proposed mining operations associated with the Proposal (refer 'proposed' scenario) at the end of Life of Mine (2050).

Combined impacts at a Deposit scale were only relevant at Deposit F North and Mt Ella East. No combined impacts were modelled for Deposit H or Western Hill orebodies as they do not have current

impacts, and therefore combined impacts and volumes are regarded as the same as proposed impacts for those deposits.

Stygofauna (below water table):

Combined impacts on stygofauna habitat BWT have been modelled using a combination of direct impacts from current or approved Rio Tinto mining operations within the West Angelas Region (refer 'current' scenario), as well as the proposed mining operations and groundwater drawdown associated with the Proposal (refer 'proposed' scenario), at end of Life of Mine (2050).

Another combined scenario was modelled to assess the volume of habitat predicted to remain intact under the MAR strategy (approved under Ministerial Statement 1113). This scenario used MAR water levels as modelled by IGS (2021). This scenario was applied only to the synclinal valley BWT habitat as this is the focal area of the MAR strategy, and no other aquifer units are expected to be subject to change.

2.4 Subterranean fauna habitat modelling

Three-dimensional (3D) modelling of subterranean habitats has been developed throughout the Development Envelope and wider West Angelas Region to facilitate quantitative impact assessment under multiple scenarios as described above in section 2.3 and Biologic (2022b). 3D modelling provides a step-change in the density of data available for subterranean fauna habitat assessment, and the resulting confidence in predictions regarding:

- the extent, thickness, and connectivity of subterranean habitats
- the potential occurrence of species throughout habitats or landscapes
- the quantitative assessment of impacts, across proposed, current and cumulative impact scenarios
- the proportion of suitable habitat remaining intact after impacts, which is directly related to conservation outcomes for subterranean fauna.

The 3D modelling of prospective subterranean habitats was based on lithology information from drill-hole logging data and bore logs, alongside diamond drill cores, hydrogeological information, geophysical information and structural information. 3D modelling focused upon the most likely geological and hydrogeological strata where suitable cavities, fractures and porous zones that provide habitat for subterranean fauna occur. Data sources were independently validated, integrated and cross-checked against subterranean fauna records from sampling throughout the Development Envelope and West Angelas Region. Further details of the habitat modelling methodology are available in Biologic (2022b), based upon Rio Tinto and Biologic's peer reviewed 3D habitat modelling framework described in Biologic (2021b).

Two types of models were used for the modelling of the subterranean fauna habitats from the Proposal, a vein model and a stratigraphic model. Both models were executed within specific and conservative lateral and vertical boundaries, as described in Biologic (2022a).

Vein modelling

Vein modelling was applied in areas which have been intensively drilled for exploration throughout the Proposal, particularly in areas near existing and proposed pits and in the upper part of the geological strata nearer to the surface. A very high density of drill logging information from 28,350 drill holes (23,606 drill holes were used in AWT modelling, and 6,819 drill holes were used in BWT modelling) was used to model subterranean fauna habitats within the Development Envelope, with geological information recorded from over 2.1 million metres of drilling. This high-density information facilitated detailed modelling of zones (or 'veins') of high, medium and low habitat suitability within the rock, based primarily on stratigraphy and ranked on the recorded occurrence and frequency of cavities, porosity, fracturing and weathering zones (Table 2-1). Once classified, suitable habitat for troglofauna (AWT) or stygofauna (BWT) was grouped into Zone A and Zone B for later interpretations and volumetric calculations. Zone A is defined by the High and Medium classifications from Table 2-1. Zone B is the inferred classification which is included in the suitable BWT habitat volumetric calculations. Habitat units classified as Low suitability were not considered to be potential subterranean fauna habitat and are not included in the volumetric calculations and other outputs from the model.

Table 2-1: Habitat suitability categories used in the 3D habitat model (vein model)

Habitat suitability category	Description
High	• Geological units known to frequently support subterranean fauna (AWT/BWT) including rich assemblages or • Records observation of subterranean habitat features such as fractures, pore spaces, cavities or unconsolidated material.
Medium	• Geological units known to support subterranean fauna (AWT/BWT) in some circumstances (such as fractured or weathered rock habitats) or • Geological units known to support subterranean fauna less frequently, less consistently, or to support less diverse assemblages based on previous experience in similar geological contexts or • Fractures, pore spaces, cavities and secondary weathering features are recorded as less well-developed, less frequently occurring, or not specifically recorded but known to occur within this unit.
Low	• Geological units that rarely support subterranean fauna or lack the physical characteristics required to support subterranean fauna (i.e. insufficient void spaces or porosity) or • Known barriers to hydrogeological/geological habitat connectivity such as clays, shales, dolerite dykes and sills.
Inferred	• Units that lack sufficient information or context to classify as above – lacking geology/hydrogeology logging and/or stratigraphic information.

Stratigraphic modelling

A stratigraphic model was used throughout the regional synclinal valley aquifer to include the western extent of the aquifer beyond the Development Envelope boundary in Karijini National Park. Extrapolation of habitat 'veins' could not be undertaken with confidence throughout the western extent of this aquifer due to low drilling density, and so the modelling was undertaken based on stratigraphy. Broad stratigraphic units were coded into 'Potential habitat' or 'Low potential habitat' categories based on geological or hydrogeological characteristics described in (Biologic, 2022b).

2.5 Assessment of subterranean habitat values

Direct and combined direct impacts on subterranean fauna habitat values AWT and BWT were quantitatively assessed via 3D modelling. Indirect impacts from the Proposal were calculated by a 2D area assessment of proposed waste dumps/stockpiles against the habitat remaining outside of all impacts under the combined impact scenario (representing the maximum 'worst case' scenario).

Assessment of direct and combined impacts to habitat values was based on the modelled volumetric loss (in thousand cubic metres) of suitable AWT and BWT habitat, as a proportion of the pre-impact habitat volume. Impacts to habitat values within each section of the Development Envelope were allocated an overall impact ranking of High, Medium or Low using the following proportional habitat loss thresholds:

- **High impact** – Loss of pre-mining habitat volume >50% (i.e. retention of habitat <50%). Serious overall changes to habitat extent, thickness and connectivity. The long-term viability and persistence of the habitat is at risk; the habitat values are at risk of being lost. Where the residual impact is High, it is unlikely that the EPA's environmental objectives would be able to be met in relation to the Proposal.
- **Medium impact** – Loss of pre-mining habitat volume 25–50% (i.e. retention of habitat 50–75%). Moderate changes to habitat extent, thickness and connectivity. The long-term viability or persistence of the habitat is not at risk; the habitat values may be subject to change but are unlikely to be lost. Where the residual impact is Medium, it is likely that the EPA's environmental objectives would be able to be met in relation to the Proposal.
- **Low impact** – Loss of pre-mining habitat volume <25% (i.e. retention of habitat >75%). Minimal change to habitat extent, thickness and connectivity. The long-term viability or persistence of the habitat values is unlikely to be significantly changed. Where the residual impact is Low, the EPA's environmental objectives are met in relation to the Proposal.

Figure 2.1 provides a simplified overview of the data sources and modelling/assessment process for subterranean fauna habitat values.

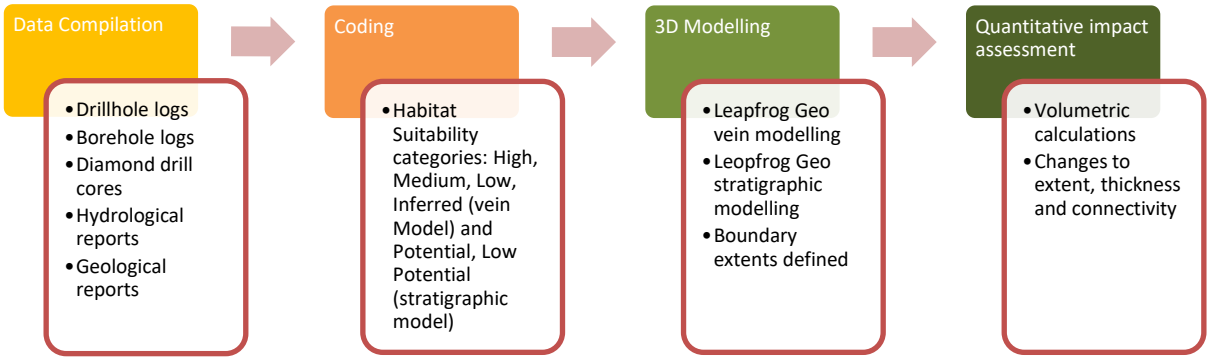


Figure 2.1: Overview of the EIA process for subterranean fauna habitat values

The above thresholds for habitat loss for each impact rank were based on the best available information on subterranean fauna habitats (3D modelling) and species (survey information). The assessment acknowledges a lack of experimental data or established precedent throughout the Pilbara region with

regards to a threshold of habitat loss or a reduction that causes a significant decline in long-term persistence of subterranean fauna species or assemblages. The ability to model subterranean fauna habitats in 3D and quantify impacts is relatively new, and the current or previous EPA guidelines do not specify volumetric threshold impacts to habitats. The 3D modelling used a range of measures to ensure conservative estimation and limits to extrapolation of the extent of habitat (refer sections 2.3 and 2.4).

Several factors create further challenges for determining appropriate impact thresholds. Sampling limitations from the available bores and holes during survey, and taxonomic constraints on historical records, may have resulted in species occurrence being underrepresented. Where habitats are well connected, it is reasonable to assume a wider potential area of occupancy for most species throughout the local extent of modelled habitat. Subterranean surveys frequently discover new species, but limited information exists about their potential habitat requirements, ecological characteristics and environmental tolerances. The thresholds of habitat loss for the impact rankings (High, Medium, or Low) were therefore determined broadly at an assemblage level within the context of these knowledge limitations.

2.6 Assessment of subterranean fauna species values

This assessment consolidated all subterranean fauna sampling results throughout the West Angelas Region (16 surveys, undertaken between 1998 and 2020).

The species assessment focused on taxa recorded only from the West Angelas Region. As such, widespread or putatively widespread taxa (known trogloxenes and troglophiles or stygoxenes and stygophiles) were excluded from the assessment. The known distribution of each taxon was then assessed in relation to the direct impacts, with consideration given to ecological factors and habitat factors influencing its potential wider occurrence throughout the modelled habitat, within the limits of available information.

As stated in section 2.5 above, there are a number of challenges for determining appropriate impact thresholds for subterranean species and habitats, related to uncertainties and information gaps. For the purposes of assessing impacts to species values, the key factors were the known and likely occurrence of the species in relation to direct or combined impacts (as described in section 2.2) and its potential area of occupancy within the local extent of habitat as modelled (described above in section 2.5). Each troglofauna or stygofauna taxon was assessed and allocated an impact ranking of High, Medium, or Low as follows:

- **High impact** – Proposed impacts are likely to affect the long-term viability or persistence of the species; the species is at risk of being lost. Where the residual impact to a species is High, it is unlikely that the EPA's environmental objectives would be able to be met in relation to the Proposal.
- **Medium impact** – Proposed impacts are moderate and unlikely to seriously affect the long-term viability or persistence of the species; the species is not at risk of being lost. Where the residual impact to a species is Medium, it is likely that the EPA's environmental objectives would be able to be met in relation to the Proposal.

- **Low impact** – Proposed impacts are unlikely to change the long-term viability or persistence of the values. The EPA's environmental objectives are met in relation to the species values in question.

Figure 2.2 provides a simplified overview of the process applied to assess impacts from the Proposal on subterranean fauna species values.

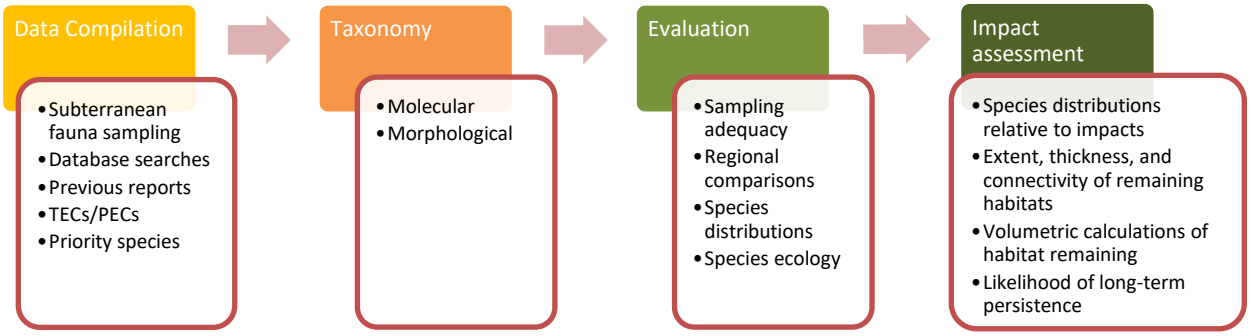


Figure 2.2: Overview of the EIA process for subterranean fauna species values

2.7 Overall assessment of impacts

The overall assessment considered impacts to habitat and species values in combination to provide a single, overall assessment of the significance of impacts to troglofauna and stygofauna values throughout the Development Envelope (Figure 2.3). The overall assessment focussed on values and impacts at the Development Envelope scale and within the broader regional context. It also outlined which types of impacts, to which values, in what areas factored most highly into the overall impact rank.

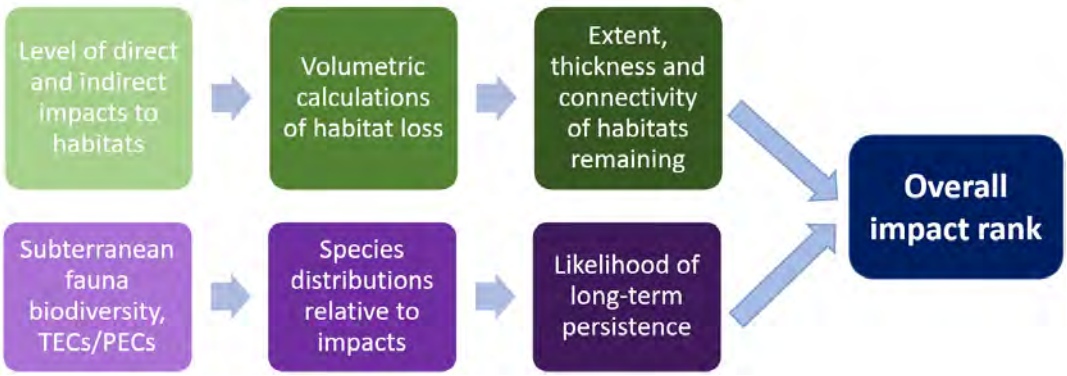


Figure 2.3: Assessment process for overall impact ranking

3. EXISTING ENVIRONMENT

3.1 Overview

The West Angelas Revised Proposal is located in the Pilbara region of Western Australia, which encompasses a portion of the ancient continental Western Australian Shield comprising pre-Cambrian, Proterozoic and Archaean rocks. The Pilbara Craton dates back to the Archaean and includes some of the oldest rocks in the world, formed 2,500 million years ago. It is overlain by Proterozoic rocks deposited in the Hamersley and Bangemall Basins. The Hamersley Group is the most relevant to the Project. It contains several large units of alternating iron-rich and silica-rich layers called banded iron formation (BIF) that is mined for iron ore.

The West Angelas Region encompasses the Wonmunna Anticline. This Anticline dominates the topography of the Development Envelope and consists of a low, east-west striking, rounded range extending from the west corner of the Envelope to the eastern parts (splitting into a northern and a southern limb in Deposit J reference area) (Figure 3.1). The Marra Mamba Iron Formation (MMIF) presents in the outcropping hinge of the anticline and overlies the Fortescue Group basement formation. The centre of the Anticline (the Wittenoom Formation) has been eroded to form a low and mostly flat central plateau (detritals).

The most common geologies that provide subterranean fauna habitat within the West Angelas Region are the Brockman Iron Formation (BrIF) and MMIF (Figure 3.1). Several mineralised orebodies within the MMIF exist along the outer flank of the Anticline at West Angelas, comprising Deposits A, B, C, D, E, F and G. Proposed Deposits H and F North are also within the MMIF, while the proposed Western Hill and Mt Ella East deposits are formed within BrIF ridges that rise on the opposite sides of the synclinal valley that surrounds the Wonmunna Anticline.

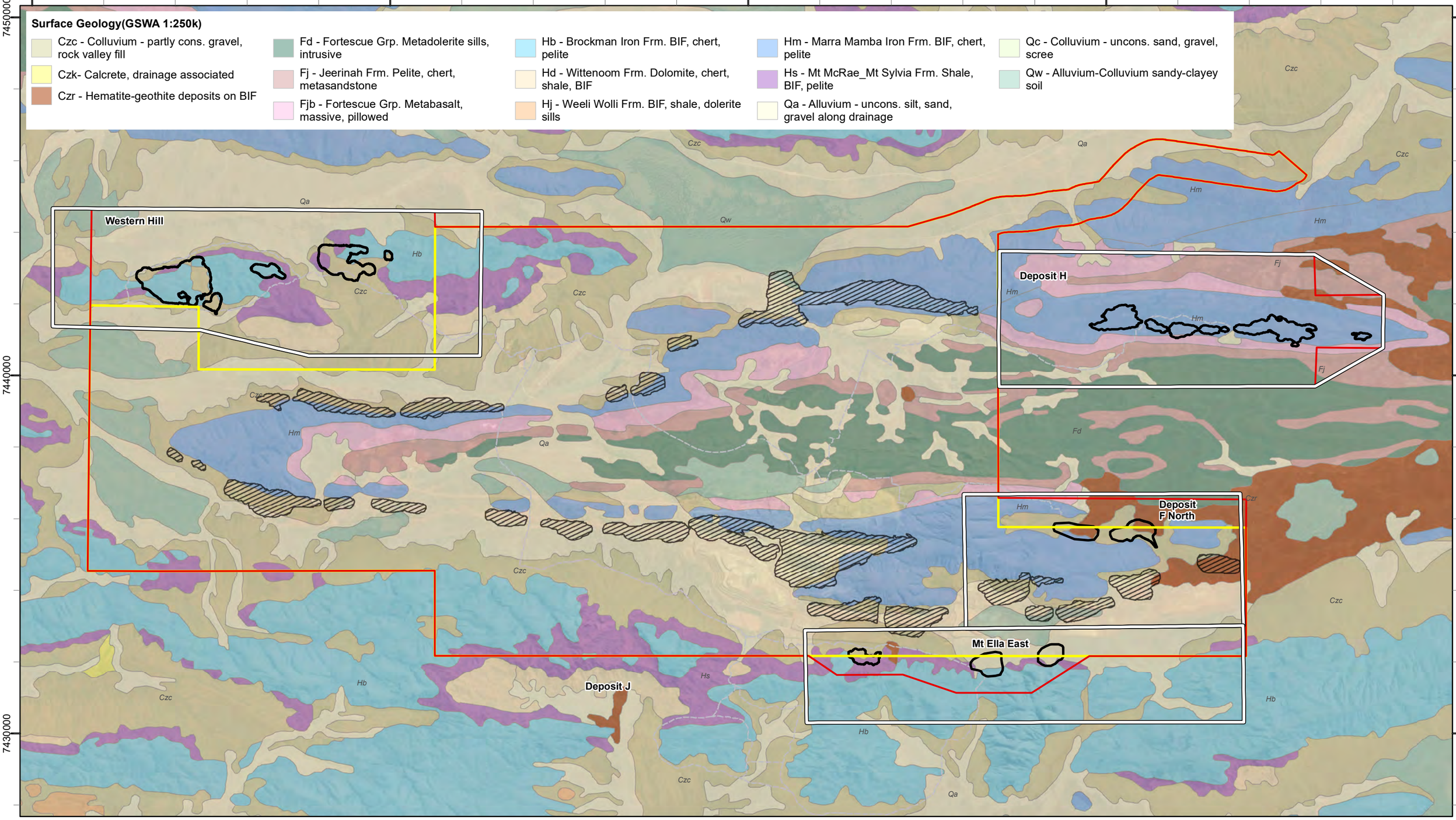
There are no subterranean fauna TECs or PECs known to occur within or surrounding the Development Envelope, and no threatened or priority subterranean fauna species have been recorded to date from the Development Envelope or immediate surrounds.

660000 670000 680000 690000

7450000 7440000 7430000

Surface Geology(GSWA 1:250k)

- Czc - Colluvium - partly cons. gravel, rock valley fill
- Czk- Calcrete, drainage associated
- Czr - Hematite-geothite deposits on BIF
- Fd - Fortescue Grp. Metadolerite sills, intrusive
- Fj - Jeerinah Frm. Pelite, chert, metasandstone
- Fjb - Fortescue Grp. Metabasalt, massive, pillowed
- Hb - Brockman Iron Frm. BIF, chert, pelite
- Hd - Wittenoom Frm. Dolomite, chert, shale, BIF
- Hj - Weeli Wolli Frm. BIF, shale, dolerite sills
- Hm - Marra Mamba Iron Frm. BIF, chert, pelite
- Hs - Mt McRae_Mt Sylvia Frm. Shale, BIF, pelite
- Qa - Alluvium - uncons. silt, sand, gravel along drainage
- Qc - Colluvium - uncons. sand, gravel, scree
- Qw - Alluvium-Colluvium sandy-clayey soil



Legend

- West Angelas Beyond 2020 Development Envelope
- Current Operations Development Envelope
- EIA Section Boundary
- Main Access Track
- Existing Pit
- Proposed Pit

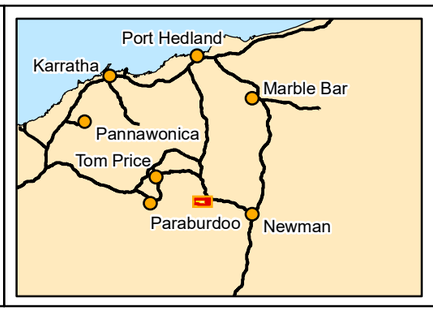
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biologic Environmental Survey

Scale: 1:100,000

0 2 4 6 Km

Coordinate System: GDA 1994 MGA Zone 50
Projection: Transverse Mercator
Datum: GDA 1994 Created 24/08/2022



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West Angelas Environmental Impact Assessment of Subterranean Fauna

Figure 3.1: Geology of the West Angelas 2020 Proposal Area

3.2 Abiotic environment

The geological and hydrogeological setting of the West Angelas Region is dominated by the BrIF and MMIF as well as the weathered Wittenoom Dolomite Formation in the synclinal valley. The main geological/hydrogeological formations relevant in providing habitat for subterranean fauna include:

- Brockman Iron Formation and Marra Mamba Iron Formation
    - Highly suitable subterranean fauna habitats (AWT and BWT) are prevalent in weathered and fractured Dales Gorge and Joffre Members of the BrIF, Mt Newman Member of the MMIF, and pisolitic duricrust/hardcap on the flanks of the ranges. Other members of the BrIF and MMIF also provide similar habitat values where suitably weathered and fractured.
- The synclinal valley features suitable habitats (AWT/BWT) within:
    - unconsolidated and porous alluvial/ colluvial detritals
    - secondarily weathered deposits of calcrete and pisolitic channel iron deposits (CID) occurring in patches throughout the valley detritals
    - weathered and fractured Wittenoom Dolomite Formation occurring throughout the valley (typically below the detritals and BWT).

3.2.1 Geological environment

The Marra Mamba Iron Formation present in the outcropping hinge of the anticline forms prospective habitat for subterranean fauna in the weathered and fractured banded iron rocks above and below the water table (Figure 3.1). The Marra Mamba Formation overlies the Fortescue Group basement (predominantly Jeerinah Formation basalts), which is exposed and eroded in the centre of the anticline. The Jeerinah Formation basalts tend to be low permeability to fresh/massive rock at depth (*i.e.* typically poor subterranean fauna habitat) but may be overlain by superficial detritals which can provide some habitat for subterranean fauna (particularly where BWT).

Moving outward north and south from the outer limbs of the anticline is a deep synclinal valley occupied by Wittenoom Dolomite overlain by deep detrital sequences (alluvium and colluvium) (Figure 3.1). Within these deep detritals, historical groundwater processes have precipitated large calcrete deposits that are fractured and weathered, providing suitable habitats for subterranean fauna above and below the water table. The karstic/weathered Wittenoom Dolomite forms a regional aquifer, providing suitable habitat for stygofauna that extends to greater depths throughout the synclinal valley than the overlying detritals.

At the periphery of the synclinal valley, the Wittenoom Formation gives way to the Mt McRae Shales, which are mainly impervious except for minor permeability where they are deeply faulted/fractured and are therefore generally unlikely to support sufficient pore spaces for subterranean fauna.

Geological structures such as dykes, faults and folds occur relatively frequently throughout the Development Envelope. These structures can influence local habitat connectivity, with dykes potentially providing impervious barriers, and faults and folds increasing habitat occurrence by promoting fractures and weathering. Geological structures are thought to only affect potential habitats within the bedrock, as suitable habitats within detrital deposits are formed after (and typically occur above) structures within the bedrock. Habitat connectivity may also be affected where less permeable geological units occur,

such as detrital clays, Mt McRae Shales, Fortescue Group basalts, and fresh rock members of the Brockman, Marra Mamba and Wittenoom Formations at depth.

A generalised stratigraphy of the major geological units is shown in Figure 3.2, Figure 3.3 and Table 3-1 with notes relating to subterranean fauna habitat suitability, based on local sampling results and regional knowledge. The four sections of the Development Envelope occur in different areas of the syncline, each having a unique combination of geological, hydrological and topographical factors that have contributed to the size, extent and complexity of habitat available for subterranean fauna above and below the water table (refer Biologic 2022b for full details).

Table 3-1: Generalised stratigraphy of major geological units occurring within the Development Envelope

Age	Unit		Description	Typical suitability for subterranean fauna
Cainozoic	Detrital layers (alluvium/colluvium)		Superficial deposits occupying lower flanks, valleys, drainage lines. Secondary calcrete, silcrete and CID common.	Medium to high – particularly in secondary deposits, well sampled throughout the Pilbara
	Channel Iron Deposits (CID)		Secondarily weathered deposits of Robe Pisolite, mainly along drainage lines or in valley detritals.	High – well sampled throughout the Pilbara
Paleozoic	Wyloo Group		Sandstone, mudstone, conglomerate, banded iron formation (BIF) and chert.	Medium to low – poorly sampled
	Turee Creek Group (Kungarra Formation)		Fine-grained sandstone, siltstone and mudstone.	Unknown/uncertain.
Various	Dolerite Dykes		Dolerite dykes intrude the bedrock (following fault planes) throughout the Development Envelope. Most strike NW to SE.	Low – mainly impervious, potential barriers
	Hamersley Group			
Proterozoic	Boolgeeda Formation		BIF, jaspilite, siltstone and shale.	Low – poorly sampled, typically low permeability.
	Woongarra Formation		Rhyolite lavas, pyroclastic rocks, and BIF	
	Weeli Wolli Formation		Jaspilitic BIF, shale and siltstone.	
	Brockman Iron Formation (HB)	Yandicoogina Shale	Interbedded chert, shale and BIF	Medium to low – poorly sampled
		Joffre Member	BIF with shale bands	Medium to high – particularly mineralised/ hydrated, well sampled Low within impervious shale bands (e.g. J3 unit)
		Whaleback Shale	Interbedded chert and shale bands, minor BIF.	Medium to low – moderately sampled
		Dales Gorge	Interbedded BIF and shale bands	Medium to high – particularly mineralised/hydrated, well sampled
	Mount McRae Shale Formation		Shale and interbedded BIF	Low – mainly impervious, potential barrier, well sampled
	Mount Silvia Formation		BIF, chert and shale	Mostly low – poorly sampled, typically low permeability.
	Wittenoom Formation (HD)	Bee Gorge Member	Calcareous dolomite, chert, volcaniclastics and BIF.	Medium to high – particularly fractured/weathered, moderately sampled
		Paraburdoo Member	Dolomite with minor chert.	Medium to high – particularly fractured/weathered/karstic, well sampled

Age	Unit		Description	Typical suitability for subterranean fauna
		West Angela Member	Manganese rich shale, BIF, dolomite and chert.	Mostly low – poorly sampled, typically low permeability.
	Marra Mamba Iron Formation (HM)	Mount Newman Member	BIF with thin shale bands	Medium to high – particularly mineralised/hydrated, well sampled
		McLeod Member	BIF, chert and carbonate, with interbedded shale.	Medium to high – particularly if mineralised/fractured, moderately sampled
		Nammuldi Member	Cherty BIF interbedded with thin shales.	Medium to low – poorly sampled, typically lower permeability.
	Fortescue Group			
Lower Proterozoic	Jeerinah Formation		Basaltic flows interbedded with shale, chert, BIF, mudstone, quartzite and dolomite.	Mostly low – poorly sampled, typically low permeability.
	Bunjinah, Pyradie, and Boongal Formations		Metabasaltic flows and breccia.	Unknown/uncertain.
	Hardey Formation		Sedimentary pelite, metasandstone and conglomerate.	

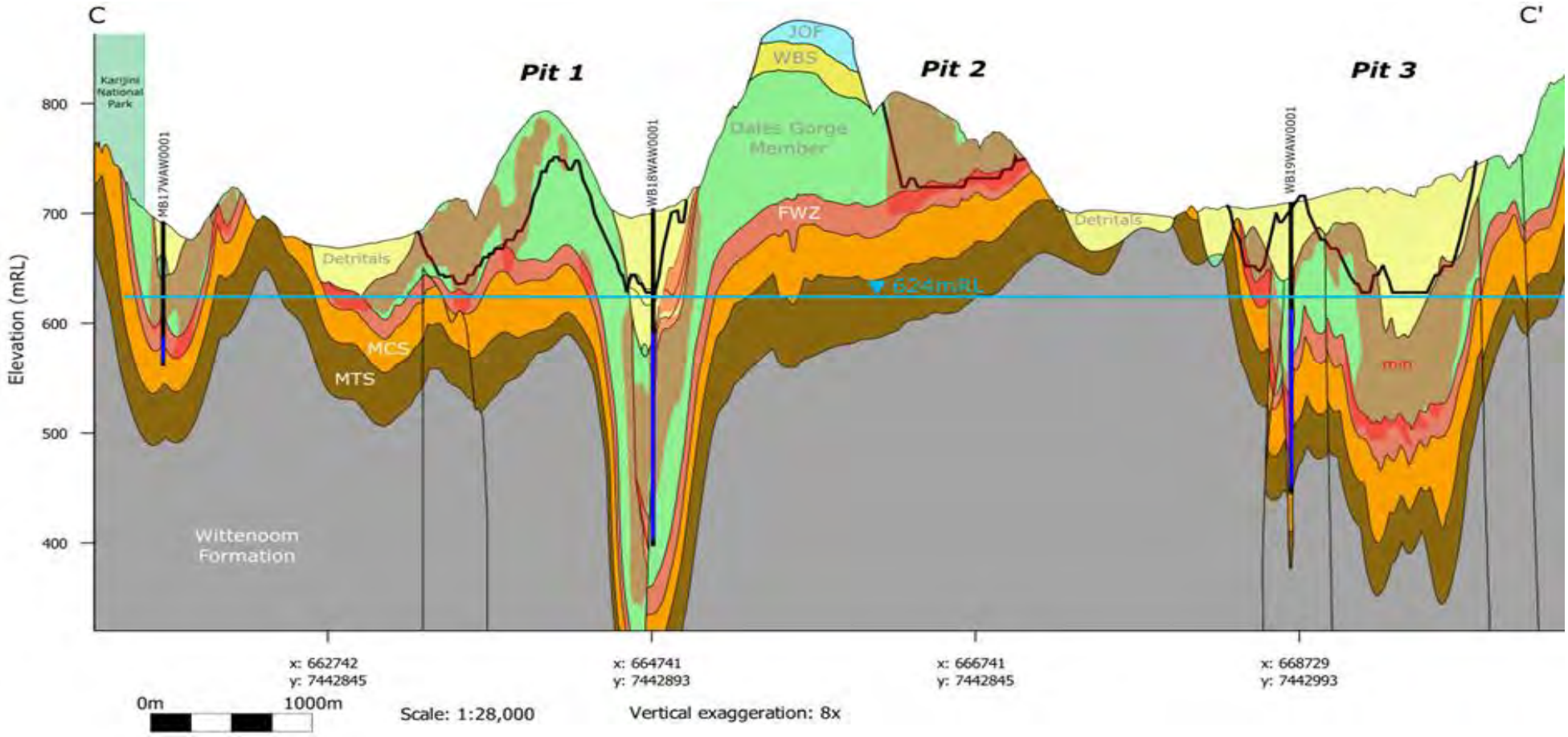


Figure 3.2: West-east long-section through Western Hill showing the generalised stratigraphy of West Angelas Region. Provided by RTIO.

Abbreviations: MTS = Mount Sylvia Formation; MCS = Mount McRae Shale; and JOF (Joffre), WBS (Whaleback Shale), and FWZ (Footwall Zone) members of the Brockman Iron Formation

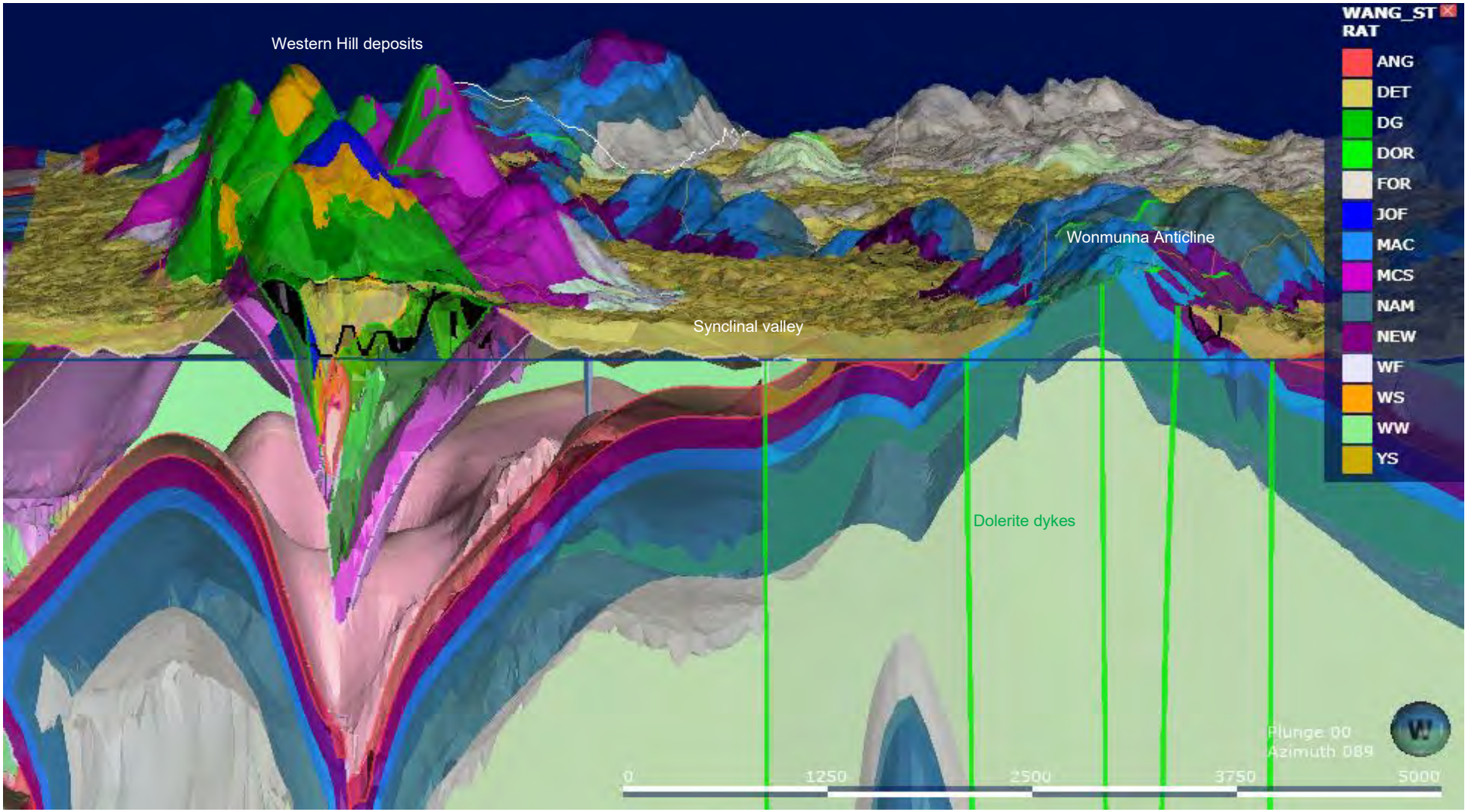


Figure 3.3: North-south section (facing east) through Western Hill and Wonmunna Anticline showing the generalised stratigraphy and structures (Leapfrog model 2022, vertical exaggeration x5).

3.2.2 Hydrogeological environment

Groundwater in the various sections of the West Angelas Region occurs in fractured, weathered and karstic basement rocks (particularly the MMIF, Wittenoom Dolomite and BrIF) and the Cainozoic detrital deposits (colluvium/alluvium) lying atop them. Groundwater is recharged directly from rainfall into local aquifers, and indirectly through the detritals via stream runoff and sheetwash.

Three major types of aquifers occur in the West Angelas Region:

- large, unconstrained 'regional' aquifers as occurs in the synclinal valley surrounding the central anticline
- mineralised bedrock aquifers within the Marra Mamba Iron Formation and Brockman Iron Formation (which range in size and depth and are variably connected or separate from other adjacent groundwater systems)
- locally constrained aquifers deep within bedrock, isolated by faulting or folding and the surrounding impervious rock layers.

Each section of the Development Envelope features a different aquifer type occurring in a slightly different hydrogeological catchment. Two aquifer types occur at Western Hill, with groundwater hosted in a small, mineralised BrIF orebody aquifer beneath Western Hill, as well as in the thick detritals and Wittenoom Formation of the regional synclinal valley aquifer (Figure 3.9). These two aquifer settings are conceptually separated by the low-permeability Mt McRae Shales, although major faulting in this area may provide a limited degree of connectivity between these two aquifers (Rio Tinto, 2021). In contrast, the surrounding synclinal aquifer is extensive and deep, highly porous/karstic, and well-connected throughout its extent within and beyond the Development Envelope (Figure 3.10).

The aquifer at Deposit H features a deep, porous, mineralised bedrock aquifer that is constrained within a deep fold of the MMIF by the low-permeability Nammuldi Member and Fortescue Group geologies on all sides. The aquifer at Deposit H is a closed system that is supported by local infiltration and is interpreted to be disconnected from other nearby aquifer systems (Section 6.1, Biologic, 2022b).

Rio Tinto has outlined a Managed Aquifer Recharge (MAR) strategy (Rio Tinto, 2019) to be implemented to mitigate the propagation of groundwater drawdown from the existing operations into Karijini National Park (approved under Ministerial Statement 1113). The MAR is expected to maintain pre-impact groundwater levels in the synclinal valley aquifer to the west of the Development Envelope, as well as supporting the groundwater environmental values of Karijini National Park.

3.3 Subterranean Fauna Values

3.3.1 Troglofauna values

Troglofauna habitat values

3D habitat modelling showed that suitable AWT habitats for troglofauna occur widely throughout all four sections of the Development Envelope, hosted within a variety of geological settings (Figure 3.4, Figure 3.5 to Figure 3.8). The BrIF and MMIF host the majority of suitable habitat, as supergene weathering processes associated with mineralisation have created highly suitable fractured and

weathered rock habitats in these geologies. Suitable troglofauna habitats also extend along the flanks of the BrIF and MMIF ranges, hosted by hematite-goethite-martite hardcap (pisolitic duricrust). The valley between the BrIF and MMIF ranges provides further troglofauna habitats within karstic calcrete deposits and weathered Wittenoom Dolomite Formation.

Unconsolidated alluvial and colluvial layers in the valley, adjacent drainage lines and flanking the main ranges host further suitable AWT habitats for troglofauna where sufficient pore spaces occur. These habitats can be vertically constrained by near-surface groundwater tables and, if adjacent to drainage lines, may be subject to periodic inundation. Nevertheless, even shallow detrital deposits <5 m to groundwater are known to provide highly suitable AWT habitats for troglofauna.

The AWT habitats obtained from the 3D model represent a conservative estimate of suitable AWT habitats occurring at West Angelas, as the 3D habitat model was delimited at a 300 m distance surrounding each drill hole and any modelled AWT habitats outside of that high-confidence boundary were excluded. As such, the valley between the BrIF and MMIF ranges is mostly outside of the habitat modelling boundary due to lack of drill holes in this area but is expected to provide further prospective troglofauna habitats.

The key troglofauna habitat values within each of the four sections of the Development Envelope are briefly described below (for more details, see Biologic, 2022b)

Western Hill

At Western Hill, the 3D modelling shows extensive, continuous and thick troglofauna habitats associated with the tall hills and ridges of the BrIF range which strikes from west to east (Figure 3.5, Figure 4.2A, Figure 4.3A). Geologically, these hills comprise intensively folded and fractured Dales Gorge, Whaleback Shale and Joffre Members of BrIF. Where exposed to weathering and intense fracturing from faults and deformation, such units are well-known to provide suitable habitats for troglofauna. The Turee Creek East valley to the immediate south of the BrIF range at Western Hill hosts relatively thick AWT habitats comprised of colluvial detritals, calcrete and weathered Wittenoom Dolomite Formation (Figure 3.5, Figure 4.2A, Figure 4.3A). AWT habitats within this valley are expected to connect to troglofauna habitats in the MMIF range further south (Figure 3.5, Figure 4.2A, Figure 4.3A). However, due to the low density of drill holes in this area, prospective AWT habitats in the valley between the BrIF and MMIF ranges could not be modelled to their full extent. The detrital habitats AWT are continuous along the valley and are locally contiguous with the bedded ironstone habitats formed in BrIF (Figure 3.5) within the hills and mountains.

Several dykes occur at Western Hill and strike the BrIF range from the north-west to the south-east (Figure 3.4). AWT habitat connectivity is most likely not interrupted by these dykes as it is expected that the intense deformation and weathering will have affected these structures as well. Furthermore, habitat connectivity is expected to be maintained via detrital layers occurring above these geological structures, both in the valley as well as in several areas along the BrIF range.

The 3D modelling of AWT habitats in the Western Hill area is supported by 106.1 km of logging data from 1,569 drillholes, evaluation of diamond drill cores, geophysical data, and a recently revised

stratigraphic model. Owing to this high density of data, there is a very high level of confidence in the modelling of high and medium suitability 'veins' AWT throughout the Western Hill section.

Deposit H

At Deposit H, 3D modelling shows extensive, continuous and moderately thick troglofauna habitats along a west to east striking range (Figure 3.6, Figure 4.5 (A) and Figure 4.6 (A). The range is primarily comprised of the Newman Member of the MMIF, which is known to commonly host highly suitable AWT habitats due to its high porosity. The central part of the range also comprises the West Angelas Member of the Wittenoom Formation, which also hosts suitable troglofauna habitats where weathered.

The MMIF range is surrounded by Fortescue Group geologies which are characterised by low permeability and are unlikely to host AWT habitats suitable for troglofauna. No regional dolerite dykes or significant fault structures are known to occur at Deposit H and therefore the troglofauna habitats are expected to be continuous along the MMIF range and surrounding valleys (Figure 3.4).

The 3D modelling of AWT habitats at Deposit H is supported by 61.8 km of logging data from 1,565 drillholes, evaluation of diamond drill cores, geophysical data and a recently revised stratigraphic model. Owing to this high density of data, there is a high level of confidence in the modelling of high and medium suitability 'veins' AWT throughout the Deposit H section.

Deposit F North

At Deposit F North, the 3D modelling shows extensive, continuous and variably thick troglofauna habitats associated with the hills of the MMIF range which strikes from west to east (Figure 3.7, Figure 4.9A and Figure 4.10A). The MMIF hills are relatively low-lying in the northern section of Deposit F North (at the location of the proposed pits), and provide thin to moderately thick AWT habitats in this area (Figure 3.7, Figure 4.9A and Figure 4.10A). AWT habitats are thicker in the southern section of the Deposit (at the location of the existing pits) where the MMIF hills are taller. The hills are primarily comprised of the weathered and fractured Newman Member of the MMIF as well as the West Angelas Member of the Wittenoom Formation, which are both known to host suitable troglofauna habitats due to their high permeability.

One regional dyke is known to occur at Deposit F North, which runs between the proposed pits in a north-west to south-east direction. Nevertheless, the connectivity of troglofauna habitat is expected to be maintained in this area via detrital layers occurring above this geological structure.

The 3D modelling of AWT habitats at Deposit F North is supported by 202.6 km of logging data from 2861 drillholes, evaluation of diamond drill cores, geophysical data, and a recently revised stratigraphic model. Owing to this high density of data, there is a very high level of confidence in the modelling of high and medium suitability 'veins' AWT throughout the Deposit F North section.

Mt Ella East

At Mt Ella East, the 3D modelling shows extensive, continuous and thick troglofauna habitats associated with the hills and ridges of the BrIF range which is particularly tall in this area (Figure 3.8). The range comprises deeply weathered Dales Gorge, Whaleback Shale and Joffre Members of

Brockman Iron Formation (as observed at Western Hill), which are known to provide highly suitable habitats for troglofauna where exposed to weathering and faulting/fracturing.

Thin to moderately thick AWT habitats occur in the valley immediately north of the BrIF range, hosted by colluvial detritals, calcrete and weathered Wittenoom Dolomite Formation. These eventually connect to AWT habitats hosted in MMIF range further north (Figure 3.8).

Very few dykes are known to occur at Mt Ella East. One regional dyke trends east-west through the peak of the BrIF range, but it is expected that the intense weathering has also affected this structure and it is not expected to restrict broad-scale AWT habitat connectivity in this area.

The 3D modelling of AWT habitats at Mt Ella East is supported by 50.6 km of logging data from 675 drillholes, evaluation of diamond drill cores, geophysical data, and a recently revised stratigraphic model. While the quantity is lower than other deposit sections, there is a reasonable level of confidence in the modelling of high and medium suitability ‘veins’ AWT throughout the Mt Ella East section due to the consistent spacing of the drilling, which averages 200 m over the entire deposit area.

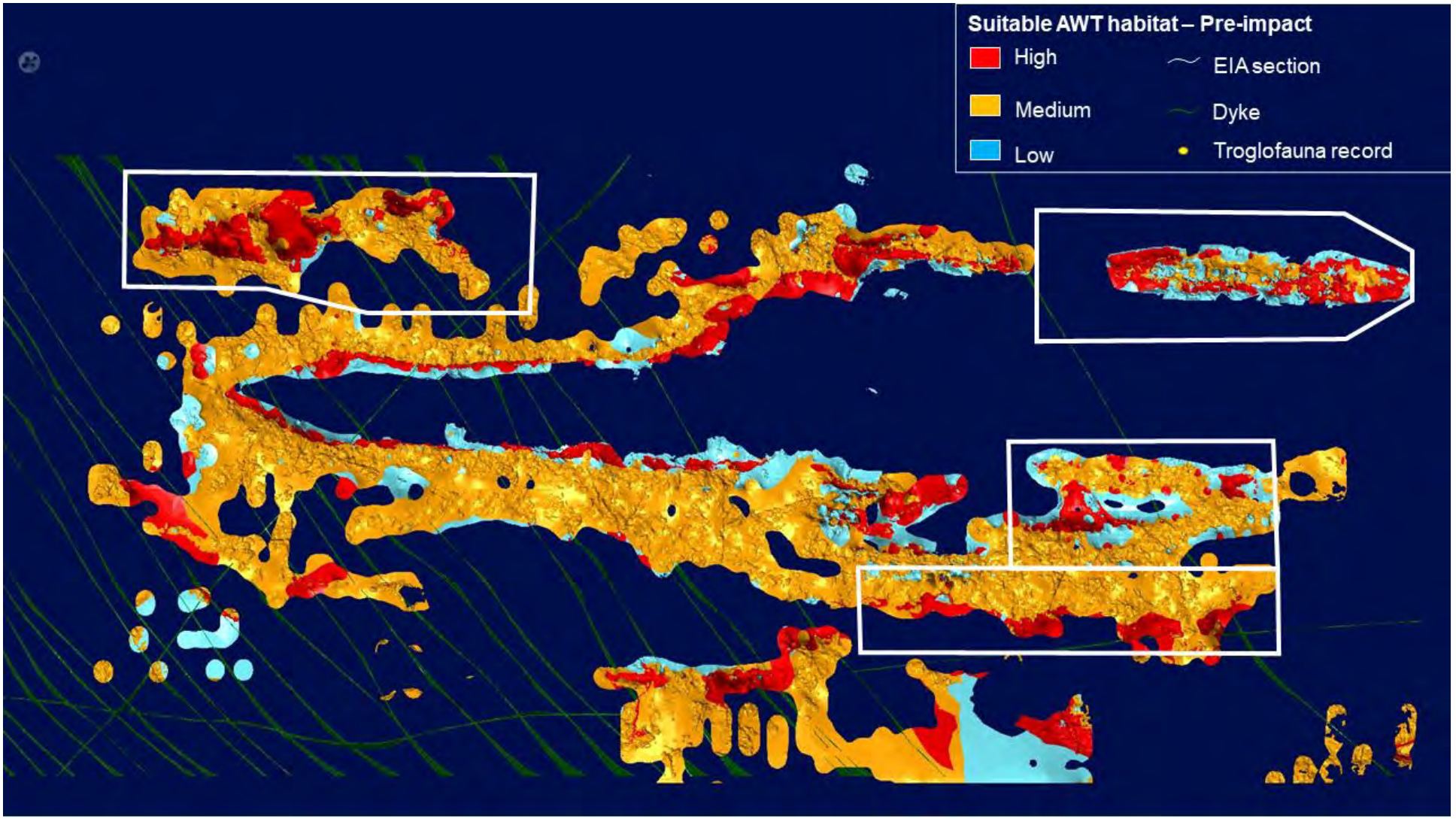


Figure 3.4: Extent of suitable habitat AWT throughout the West Angelas Region – Overview

664000

668000

7444000

7442000

Arachnida

- Araneae `sp. Biologic-ARAN030`
- Palpigradi `sp. Biologic-PALP016`
- Tyrannochthonius `sp. Biologic-PSEU015`

Chilopoda

- Cryptops `sp. WAWH`

Insecta

- Atelurinae `sp. Biologic-ZYGE012`
- Meenoplidae `sp. Biologic-HEMI010`
- Nocticola `sp. Biologic-BLAT014`
- Sciaridae `sp. Biologic-DIPT001`
- Trinemura `sp. Biologic-ZYGE013`

Pauropoda

- Pauropoda `sp. Biologic-PAUR014`
- Pauropoda `sp. Biologic-PAUR016`
- Pauropoda `sp. Biologic-PAUR018`
- Pauropoda `sp. Biologic-PAUR020`

Symphyla

- Scolopendrellidae `sp. Biologic-SYMP012`

Legend

- West Angelas Beyond 2020 Development Envelope
- Current Operations Development Envelope
- EIA Section Boundary
- Main Access Track
- Proposed Pit
- Proposed Waste/ Infrastructure
- Troglofauna Sampling Site
- 3D Modelling Boundary (Vein Model)

Habitat Thickness – Pre-impact

m AWT

High : 281

Low : 1

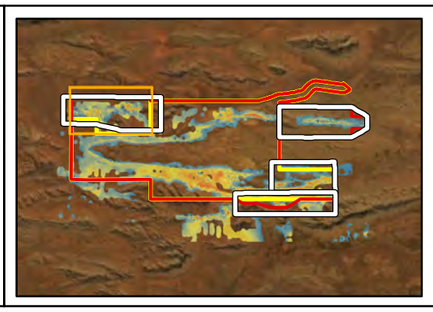
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biologic Environmental Survey

Scale: 1:25,000

0 0.5 1 1.5 Km

Coordinate System: GDA 1994 MGA Zone 50
Projection: Transverse Mercator
Datum: GDA 1994 Created 24/08/2022



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Figure 3.5: Troglofauna records and thickness of suitable habitat at Western Hill

692000

696000

7442000

7440000

Arachnida

- Indohya `sp. Biologic-PSEU016`
- Palpigradi `sp. Biologic-PALP017`
- Palpigradi `sp. Biologic-PALP020`
- Prethopalpus `sp. Biologic-ARAN012`
- Theridiidae `sp. Biologic-ARAN010`
- Tyrannochthonius `sp. Biologic-PSEU013`
- Tyrannochthonius `sp. Biologic-PSEU014`

Entognatha

- Parajapigydae `sp. Biologic-DIPL016`

Insecta

- Nocticola `sp. Biologic-BLAT015`
- Phaconeura `sp. Biologic-HEMI003`

Pauropoda

- Pauropoda `sp. Biologic-PAUR017`
- Pseudodiploexochus `sp. WAH`

Symphyla

- Scutigerellidae `sp. Biologic-SYMP011`

Legend

- West Angelas Beyond 2020 Development Envelope
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- 3D Modelling Boundary (Vein Model)

Habitat Thickness – Pre-impact

m AWT

High : 281

Low : 1

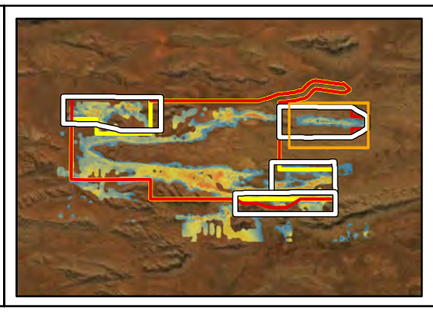
N

biologic Environmental Survey

Scale: 1:24,000

0 0.5 1 Km

Coordinate System: GDA 1994 MGA Zone 50
Projection: Transverse Mercator
Datum: GDA 1994 Created 24/08/2022



RIO TINTO IRON ORE

West Angelas Environmental Impact Assessment of Subterranean Fauna

Figure 3.6: Troglofauna records and thickness of suitable habitat at Deposit H

688000

692000

7436000

7434000

Arachnida

- Araneae `sp. Biologic-ARAN008`
- Palpigradi `sp. Biologic-PALP018`

Entognatha

- Japygidae `sp. Biologic-DIPL017`

Insecta

- Dodecastyla `sp. Biologic-ZYGE011`
- Nocticola `sp. Biologic-BLAT014`
- Phaconeura `sp. Biologic-HEMI003`

Pauropoda

- Pauropoda `sp. Biologic-PAUR019`

Symphyla

- Scutigerellidae `sp. Biologic-SYMP011`
- Symphyla, Scutigerellidae `sp. Helix-SYM027`

Legend

- West Angelas Beyond 2020 Development Envelope
- Current Operations Development Envelope
- EIA Section Boundary
- Existing Pit
- Proposed Pit
- Proposed Waste/ Infrastructure
- Troglofauna Sampling Site
- 3D Modelling Boundary (Vein Model)

Habitat Thickness – Pre-impact

m AWT

High : 281

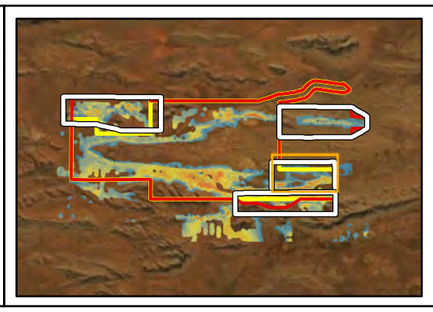
Low : 1

N

Scale: 1:20,000

0 0.5 1 Km

Coordinate System: GDA 1994 MGA Zone 50
Projection: Transverse Mercator
Datum: GDA 1994 Created 24/08/2022



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West Angelas Environmental Impact Assessment of Subterranean Fauna

Figure 3.7: Troglofauna records and thickness of suitable habitat at Deposit F North

682000 684000 686000 688000 690000 692000

7434000 7432000 7430000

Arachnida

- Indolpium `sp. Biologic-PSEU017`
- Oonopidae `sp. Biologic-ARAN018`
- Palpigradi `sp. Biologic-PALP018`
- Palpigradi `sp. Biologic-PALP019`
- Theridiidae `sp. Biologic-ARAN010`
- Tyrannochthonius `sp. Biologic-PSEU011`
- Tyrannochthonius `sp. Biologic-PSEU012`

Insecta

- Atelurinae `sp. Biologic-ZYGE014`
- Dodecastyla `sp. Biologic-ZYGE011`
- Nocticola `sp. Biologic-BLAT014`
- Phaconeura `sp. Biologic-HEMI003`
- Trinemura `sp. Biologic-ZYGE017`

Malacostraca

- Philosciidae `sp. Biologic ISOP015`

Symphyla

- Hanseniella `sp. Biologic-SYMP018`

Legend

- West Angelas Beyond 2020 Development Envelope
- Current Operations Development Envelope
- EIA Section Boundary
- Existing Pit
- Proposed Pit
- Proposed Waste/ Infrastructure
- Troglofauna Sampling Site
- 3D Modelling Boundary (Vein Model)

Habitat Thickness – Pre-impact

m AWT

High : 281

Low : 1

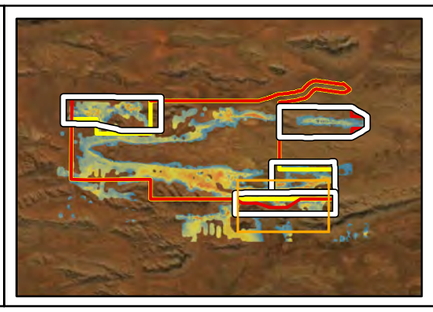
N

biologic Environmental Survey

Scale: 1:27,700

0 0.5 1 1.5 Km

Coordinate System: GDA 1994 MGA Zone 50
Projection: Transverse Mercator
Datum: GDA 1994 Created 24/08/2022



RIO TINTO IRON ORE

West Angelas Environmental Impact Assessment of Subterranean Fauna

Figure 3.8: Troglofauna records and thickness of suitable habitat at Mt Ella East

Troglofauna species values

A total of 165 troglofauna specimens representing 77 troglofauna taxa (species or operational taxonomic units) were recorded within the West Angelas Region. Full details of all troglofauna taxa recorded and the associated survey data are provided in Biologic (2022a).

Not all of the troglofauna taxa sampled to date are relevant to this EIA, and 35 troglofauna taxa recorded from surveys to date were excluded from consideration in this assessment (and are not listed in tables or figures) for the following reasons:

- Twenty-five taxa were recorded only from areas outside of direct and potential indirect impact areas.
- Eight taxa were found to be widespread regionally (linear ranges >100 km), or were highly likely to occur regionally with external genetic matches at linear ranges >50 km (Biologic, 2022a).
- Two taxa were recorded only from existing operational areas subject to previous environmental approvals.

In addition to these 35 excluded troglofauna taxa, 29 indeterminate troglofauna records that could not be resolved to species-level were also excluded from this assessment. For the most part, these indeterminate records were residual specimens left over from sub-sampling for molecular analysis, and/or were damaged and juvenile specimens unfit for further taxonomic work. Although it is not possible to eliminate the possibility that undetected species may occur within the excluded material, all efforts were made to undertake morphological identifications and genetic sub-sampling as far as practicable to reduce the chance of this occurring (Biologic, 2022a).

Troglofauna included in this assessment

Forty-two (42) troglofauna taxa (species and species-level OTUs) recorded throughout the Development Envelope and surrounds are considered key troglofaunal values and included in the EIA (Table 3-2). These taxa are currently known only from the four Development Envelope sections and immediate surrounds, based on a review of available regional specimen databases and DNA sequence libraries (Biologic, 2022a). The 42 troglofauna taxa represent 12 orders: Araneae, Blattodea, Symphyla, Diplura, Diptera, Hemiptera, Isopoda, Palpigradi, Pauropoda, Pseudoscorpiones, Scolopendrida and Zygentoma. None of these troglofauna taxa nor the troglofauna communities are listed or recognised as conservation priorities under state or federal legislation (Biologic, 2022a).

Table 3-2 lists the 42 troglofauna taxa included in the assessment, alongside distribution information relative to direct (pits) and indirect (waste/infrastructure) impact areas. A breakdown of the species assessed within each section of the Development Envelope is presented below, and their locations are shown on Figures 3.4 to Figure 3.8. It should be noted that a number of singletons recorded only from outside of the impact areas have been included within the assessment. These taxa have been included as it is likely that the distribution of these taxa is more widespread (potentially within the proposed impact areas) than is currently documented; however, sampling to date has not fully characterised the potential population distribution.

Table 3-2: Troglofauna taxa included in the assessment from each of the four sections of the Development Envelope (Western Hill, Dep H, Dep F North and Mt Ella East)

Taxonomy	Subterranean status & SRE status	Section of the DE	Locations	Known local/regional linear range	Direct impact	Indirect impact	Outside of impact areas
Arachnida							
Araneae							
Araneae `sp. Biologic-ARAN008`	Troglobite, Potential SRE	DFN	Singleton	-			✓
Araneae `sp. Biologic-ARAN030`	Troglobite, Potential SRE	WH	Singleton		✓		
Oonopidae `sp. Biologic-ARAN018`	Potential Troglobite, Potential SRE	MTEE	Single site, external match	7.6 km			✓
Prethopalpus `sp. Biologic-ARAN012`	Troglobite, Potential SRE	DH	Singleton	-		✓	
Theridiidae `sp. Biologic-ARAN010`	Troglophile/xene, Uncertain SRE	DH, MTEE	Locally widespread, external match	13.8 km/17.6 km	✓	✓	✓
Palpigradi							
Palpigradi `sp. Biologic-PALP016`	Troglobite, Potential SRE	WH	Singleton	-	✓		
Palpigradi `sp. Biologic-PALP017`	Troglobite, Potential SRE	DH	Singleton	-	✓		
Palpigradi `sp. Biologic-PALP018`	Potential Troglobite, Potential SRE	DFN, MTEE	Multiple local sites	8.7 km	✓		✓
Palpigradi `sp. Biologic-PALP019`	Troglobite, Potential SRE	MTEE	Singleton	-	✓		
Palpigradi `sp. Biologic-PALP020`	Troglobite, Potential SRE	DH	Singleton	-	✓		
Pseudoscorpiones							
Indohya `sp. Biologic-PSEU016`	Troglobite	DH	Singleton	-		✓	
Indolpium `sp. Biologic-PSEU017`	Troglophile/xene, Uncertain SRE	MTEE	Locally widespread, external match	23.2 km			✓
Tyrannochthonius `sp. Biologic-PSEU011`	Troglobite, Potential SRE	MTEE	Multiple local sites	0.3 km	✓		✓
Tyrannochthonius `sp. Biologic-PSEU012`	Troglobite, Potential SRE	MTEE	Multiple local sites	3.5 km	✓		✓
Tyrannochthonius `sp. Biologic-PSEU013`	Troglobite, Potential SRE	DH	Singleton	-	✓		
Tyrannochthonius `sp. Biologic-PSEU014`	Troglobite, Potential SRE	DH	Multiple local sites	0.7 km		✓	✓
Tyrannochthonius `sp. Biologic-PSEU015`	Troglobite, Potential SRE	WH	Singleton	-	✓		
Myriapoda							
Scolopendrida							
Cryptops `sp. WAWH`	Uncertain troglobite/trogloxene. Uncertain SRE	WH	Singleton	-			✓
Pauropoda							
Pauropoda `sp. Biologic-PAUR014`	Potential troglophile/xene Uncertain SRE	WH	Singleton	-	✓		

Taxonomy	Subterranean status & SRE status	Section of the DE	Locations	Known local/regional linear range	Direct impact	Indirect impact	Outside of impact areas
Pauropoda `sp. Biologic-PAUR016`	Potential troglophile/xene Potential SRE	WH	Locally widespread, external match	37.2 km			✓
Pauropoda `sp. Biologic-PAUR017`	Potential troglophile/xene Uncertain SRE	DH	Singleton	-		✓	
Pauropoda `sp. Biologic-PAUR018`	Potential troglophile/xene Uncertain SRE	WH	Singleton	-	✓		
Pauropoda `sp. Biologic-PAUR019`	Potential troglophile/xene Uncertain SRE	DFN	Singleton	-			✓
Pauropoda `sp. Biologic-PAUR020`	Potential troglophile/xene Uncertain SRE	WH	Singleton	-	✓		
Symphyla							
Hanseniella `sp. Biologic-SYMP018`	Uncertain troglobite/trogloxene. Uncertain SRE	MTEE	Singleton	-			✓
Scutigerellidae `sp. Biologic-SYMP011`	Potential troglophile/xene Potential SRE	DFN, DH	Multiple sites, locally widespread	24.1 km	✓		✓
Scolopendrellidae `sp. Biologic-SYMP012`	Uncertain troglobite/trogloxene. Potential SRE	WH	Singleton	-	✓		
Scutigerellidae sp. `Helix-SYM027` *	Uncertain troglobite/trogloxene. Uncertain SRE	DFN	Singleton	-		✓	✓
Entognatha							
Diplura							
Parajapigydae `sp. Biologic-DIPL016`	Uncertain troglobite/trogloxene. Uncertain SRE	DH	Singleton	-			✓
Japygidae `sp. Biologic-DIPL017`	Potential troglophile/xene Potential SRE	DFN	Locally widespread, external match	29.4 km	✓		✓
Insecta							
Blattodea							
Nocticola `sp. Biologic-BLAT014`	Potential troglophile/xene Uncertain SRE	WH, DFN MTEE	Locally widespread, external match	50.9 km	✓		✓
Nocticola `sp. Biologic-BLAT015`	Potential troglophile/xene Uncertain SRE	DH	Singleton	-	✓		
Diptera							
Sciaridae `sp. Biologic-DIPT001`	Potential troglophile/xene Uncertain SRE	WH	Singleton, external match	38.4 km	✓		✓
Hemiptera							
Meenoplidae `sp. Biologic-HEMI010`	Potential troglophile/xene Uncertain SRE	WH	Singleton, external match	28.4 km			✓
Phaconeura `sp. Biologic-HEMI003`	Potential troglophile/xene Uncertain SRE	DH, DFN	Singleton, external match	67 km	✓		✓

Taxonomy	Subterranean status & SRE status	Section of the DE	Locations	Known local/regional linear range	Direct impact	Indirect impact	Outside of impact areas
Zygentoma							
Dodecastyla `sp. Biologic-ZYGE011`	Troglophile/xene. Uncertain SRE	DFN, MTEE	Locally widespread, external match	9.1 km/27.9 km	✓		✓
Atelurinae `sp. Biologic-ZYGE012`	Troglophile/xene. Uncertain SRE	WH	Single site	-	✓		
Atelurinae `sp. Biologic-ZYGE014`	Troglophile/xene. Uncertain SRE	MTEE	Multiple local sites	4.0 km	✓		✓
Trinemura `sp. Biologic-ZYGE013`	Potential Troglobite. Uncertain SRE	WH	Singleton	-	✓		
Trinemura `sp. Biologic-ZYGE017`	Potential Troglobite. Uncertain SRE	MTEE	Singleton	-			✓
Crustacea							
Isopoda							
Philosciidae `sp. Biologic ISOP015`	Potential troglophile/xene. Uncertain SRE	MTEE	Singleton	-			✓
Pseudodiploexochus `sp. WAH`	Potential troglobite. Potential SRE.	DH	Multiple local sites	0.8 km	✓		✓

Western Hill

Fourteen troglofauna taxa recorded from the Western Hill Deposit were included in the assessment, from a total of 17 taxa from 183 samples (Table 3-4, Figure 3.5, section 3.4). Three widely occurring taxa were excluded according to the framework outlined above. The 14 included taxa represented the following groups: Araneae (1 taxon), Blattodea (1), Diptera (1), Hemiptera (1), Palpigradi (1), Pseudoscorpiones (1), Pauropoda (4), Zygentoma (2), Symphyla (1) and Scolopendrida (1) (Table 3-2).

The majority of these taxa (10 taxa) were collected from a single site only, and were often singletons from within pits, while the remainder were locally widespread (linear ranges varying from 28.4 km to 50.9 km). The most widely collected species was *Nocticola* `sp. Biologic-BLAT014`, which matched genetic sequences collected externally at nearby Rio Tinto sites (linear range 50.9 km) (Table 3-2).

Deposit H

Thirteen troglofauna taxa recorded from Deposit H were included in the assessment, from a total of 14 taxa from 81 samples (Table 3-4) (Biologic, 2022a). The widely occurring taxon *Phaconeura* `sp. Biologic-HEMI002` was excluded (linear range 67.4, also occurring at Paraburdoo). The 13 included taxa represented the following groups: Araneae (2 taxa), Blattodea (1), Palpigradi (2), Pseudoscorpiones (3), Hemiptera (1), Pauropoda (1), Symphyla (1), Diplura (1) and Isopoda (1) (Figure 3.6, Table 3-2).

The majority of these taxa (8) were collected from a single site only, often singletons. Two taxa (*Tyrannochthonius* `sp. Biologic-PSEU014` and *Pseudodiploexochus* `sp. WAH`) were recorded from multiple local sites and had linear ranges of less than one kilometre. Three locally widespread taxa, *Phaconeura* `sp. Biologic-HEMI003`, Theridiidae `sp. Biologic-ARAN010` and Scutigerellidae `sp. Biologic-SYMP011`, were recorded in other sections of the Development Envelope, with linear ranges of 67 km, 17.6 km and 24.1 km, respectively (Table 3-2).

Deposit F North

Nine troglofauna taxa recorded from Deposit F North were included in the assessment, from a total of 13 taxa collected from 106 samples (Table 3-4) (Biologic, 2022a). Two widely occurring taxa and two taxa found only outside of the impact areas were excluded from the assessment. The nine included taxa represented the following groups: Araneae (1 taxon), Palpigradi (1), Blattodea (1), Hemiptera (2), Pauropoda (1), Diplura (1), Zygentoma (1) and Symphyla (1) (Figure 3.7, Table 3-2).

The majority of these taxa were collected from multiple Deposits and are locally widespread (linear ranges between 27.8 km to 50.9 km) or locally restricted (local linear ranges from 8.7 km to 9.1 km) within the West Angelas Region. Araneae `sp. Biologic-ARAN008` and Pauropoda `sp. Biologic-PAUR019` were only recorded at a single site within Deposit F North (Table 3-2).

Mt Ella East

Fourteen troglofauna taxa recorded from the Mt Ella East Deposit were included in the assessment from a total of 24 taxa collected from 157 samples (Table 3-4) (Biologic, 2022a). Of the 10 excluded taxa, three were widespread and 7 occurred outside all areas of impact. The 14 included taxa represented the following groups: Araneae (2 taxa), Palpigradi (2), Blattodea (1), Hemiptera (1), Pseudoscorpiones (3), Zygentoma (3), Symphyla (1) and Isopoda (1) (Table 3-2, Figure 3.8).

Of the 14 taxa recorded from the Mt Ella Deposit, four were also recorded in other sections of the Development Envelope. Of the remaining 10 taxa, four were recorded as singletons, while six were locally widespread (linear ranges varying from 7.6 km to 50.9 km) with external matches at nearby Rio Tinto Sites (Table 3-2).

3.3.2 Stygofauna values

Stygofauna habitat values

The 3D habitat modelling showed that suitable BWT habitats for stygofauna (to be assessed as being impacted) occur in three sections, comprising Western Hill (orebody aquifer), the synclinal valley aquifer and Deposit H. No significant aquifer or BWT habitat has been modelled at Mt Ella East and Deposit F North, and therefore these two areas are not expected to host significant stygofauna values.

BWT habitats within the Proposal are hosted by a variety of geological settings, with each section of the Development Envelope featuring a different type of aquifer and occurring in a slightly different hydrogeological setting. Suitable BWT habitats for stygofauna within the Development Envelope and surrounds are present in the fractured/weathered and karstic basement rocks of the MMIF and the BrIF, which form the hills and ranges that intersect the Development Envelope. These mineralised bedrock aquifers range in size and depth and are variably connected or separated from other adjacent groundwater systems.

Suitable habitats for stygofauna also occur within karstic and weathered Wittenoom Dolomite in the valleys. The Wittenoom Dolomite forms a large, unconstrained ‘regional’ aquifer in the valley surrounding the central anticline at the Proposal, providing a continuous network of BWT habitat throughout the synclinal valley.

Suitable habitats for stygofauna also occur within the Cainozoic detrital deposits (colluvium/alluvium) lying atop of the MMIF, BrIF and Wittenoom Dolomite basement rocks. The detrital deposits in the synclinal valley are particularly deep, and historical groundwater processes have precipitated large calcrete deposits that are fractured and weathered, which provide highly suitable habitats for stygofauna in this area.

The Development Envelope also hosts locally constrained aquifers that lie deep within the bedrock and are isolated by faulting/folding and surrounding impervious rock layers. These aquifers are not expected to be suitable for stygofauna due to their isolation and low influx of nutrients and oxygen due to low permeability of surrounding rock.

Geological structures such as dykes, faults and folds occur relatively frequently throughout the Development Envelope. These structures can influence local habitat connectivity, with dykes potentially providing impervious barriers, and faults/folds increasing habitat occurrence by promoting fractures and weathering. Geological structures are thought to only affect potential habitats within the bedrock, as suitable habitats within detrital deposits are formed after (and typically occur above) structures within the bedrock. Habitat connectivity may also be affected where less permeable geological units occur, such as detrital clays, Mt McRae Shales, Fortescue Group basalts, and fresh rock members of the Brockman, Marra Mamba, and Wittenoom Formations at depth.

The important stygofauna habitat values within each of the four sections of the Development Envelope are briefly described below (for more details, see Biologic, 2022b).

Western Hill and synclinal valley

At Western Hill, suitable BWT habitats for stygofauna are found within two different hydrogeological settings. There is a mineralised bedrock aquifer, formed within the Brockman Iron Formation (Dales Gorge Member), which forms suitable stygofauna habitat at depth below the location of the orebodies and proposed pits (Figure 3.9) (Rio Tinto 2020a). The BrIF has undergone supergene weathering and has been intensively faulted and fractured in this area, creating highly porous/fractured groundwater habitat. 3D modelling shows that BWT habitats within this mineralised bedrock aquifer are moderately extensive, continuous, and variably thick.

A regional synclinal aquifer occurs in the valley to the south of the Western Hill orebodies and mineralised bedrock aquifer (Figure 3.10). The regional aquifer is comprised of deep colluvial detritals, calcrete, and highly karstic/porous Wittenoom Dolomite Formation which collectively provide an extensive, highly porous/weathered aquifer (Rio Tinto 2020a). The synclinal valley aquifer extends around the northern and southern limb of the Wonmunna anticline (including Deposits C and D) and extends west of the Development Envelope boundary within Karijini National Park, and to the north of Western Hill (Figure 3.10).

The Western Hill orebody aquifer and synclinal valley aquifer are separated from each other via Mt McRae Shales which are characterised by low permeability and form a functional barrier between the two groundwater systems. Limited habitat connectivity may exist between the two aquifers where the Mt McRae Shales have been deeply faulted/ fractured to the south of Western Hill, but throughflow remains limited and localised (Rio Tinto 2020a).

Several dykes occur at Western Hill and strike the BrIF range and synclinal valley from the north-west to the south-east (Figure 5.2A, Figure 5.5A, Figure 5.6A). BWT habitat connectivity is most likely not interrupted by these dykes as it is expected that the intense deformation and weathering will have affected these structures as well. Furthermore, habitat connectivity is expected to be maintained via deep detrital and calcrete layers occurring above these geological structures, particularly in the synclinal valley.

Limited water quality information was recorded at the time of subterranean fauna sampling, particularly at Western Hill owing to the depth of groundwater below surface. However, in the synclinal aquifer (calcrete bores) Biologic (2022) recorded fresh to brackish groundwater (EC 790–2109 µS/cm), circum-neutral to slightly alkaline pH (6.7–8), and dissolved oxygen concentrations of 1.3–5.6 mg/L (17–71% saturation) from 10 bores where depth to water was between 27–43 mbgl. This data suggests broadly suitable conditions for stygofauna occurrence, based on published tolerances (Hancock *et al*. 2005; Hose *et al.* 2015; Malard and Hervent 1999).

The 3D modelling of BWT habitats in the Western Hill area is supported by 97.4 km of logging data from 2,422 drillholes, of which 476 holes and 24 km of drilling was within the BrIF orebody section of the Development Envelope. This density of data provides a high level of confidence in the modelling of high and medium suitability 'veins' BWT throughout the Western Hill orebody aquifer. However, there are limitations on the modelling in the Western Hill regional area (areas beyond the Western Hill orebodies). This is mostly due to lack of drilling outside of the Development Envelope, especially in Karijini National Park. Nevertheless, a stratigraphic model was created to better capture the stygofauna habitats in this area.

Deposit H

At Deposit H, suitable stygofauna habitats occur within a deep, porous, mineralised bedrock aquifer which is primarily hosted within the Marra Mamba Iron Formation (Mt Newman Member) and West Angela Shales of the Wittenoom Formation (Rio Tinto 2020b). Deposit H runs from west to east, offset to the east of the northern limb of the Wonmunna Anticline (Figure 3.11, Figure 5.8A, Figure 5.9A). The MMIF has been deeply fractured and folded, creating deep, highly porous/ fractured aquifer. At the centre of the MMIF lies a long, narrow centre of fractured West Angelas Shales which is overlain by detritals. Together these geological units provide a large and deep groundwater habitat at Deposit H (Figure 3.11, Figure 5.8A, Figure 5.9A).

The Deposit H aquifer is surrounded by the low permeability Nammuldi Member of the MMIF and Fortescue Group geologies on all sides which constrain the aquifer. Interpretations from geophysical data suggest elevated (perched) groundwater levels in these low permeability units surrounding Deposit H, but recharge and discharge investigations suggested limited connection if any to the orebody aquifer (Rio Tinto 2020b). Water levels throughout Deposit H remain relatively flat, and outflow from the orebody aquifer is interpreted to be minimal, through superficial alluvials in eroded gullies to the north of the deposit (Rio Tinto 2020b) (Figure 3.11, Figure 5.8A, Figure 5.9A). Consequently, the groundwater habitat at Deposit H is considered restricted to the mineralised bedrock aquifer and is not connected to any other aquifer units.

Water quality information was recorded from three sites at the time of subterranean fauna sampling; Biologic (2022) recorded fresh/ low salinity groundwater (EC 492 µS/cm – 799 µS/cm), circum-neutral pH (6.2-7.6), and dissolved oxygen ranging between 3.8 mg/L – 6.2 mg/L (49% - 76% saturation) where depth to water was between 47-83 mbgl. Rio Tinto (2020b) recorded similar conditions; fresh groundwater (EC 690 µS/cm – 762 µS/cm), circum-neutral pH (6.76-7.42), and dissolved oxygen at 103% saturation from a water bore slotted between 54-95 mbgl. This

data suggests broadly suitable conditions for stygofauna occurrence, based on published tolerances (Hancock *et al.* 2005; Hose *et al.* 2015; Malard and Hervent 1999).

The 3D modelling of BWT habitats at Deposit H is supported by 13.9 km of logging data from 580 drillholes, evaluation of diamond cores, geophysical data, and a recently revised stratigraphic/deposit model. This density of data provides a moderate level of confidence in the lateral extent of modelled of high and medium suitability 'veins'; however, the depth extent and continuity BWT is less well represented due to the shallow depth of most of the drilling. The BWT habitats obtained from the 3D model represent a conservative estimate of suitable BWT habitats occurring at Deposit H, as the 3D habitat model was capped at 150 m metres below ground level. However, drill hole and bore data show high to medium porosity at depths of up to 200 mbgl. Therefore, it is probable that suitable habitat extends beyond the vertical modelling boundary.

Deposit F North

No significant aquifer or BWT habitat suitable for stygofauna has been modelled to occur within the west to east striking Marra Mamba Iron Formation at Deposit F North, nor does a regional aquifer exist within the Fortescue group geologies to the north of the deposit.

At Deposit F North, groundwater occurs as small, locally constrained patch in the mineralised Mt Newman Member of the Marra Mamba Formation. Groundwater is located deep below the surface at ~716 mRL (~78 m below ground), interpreted from exploration hole geophysics and validated with water levels from two 2017 exploration grade holes converted into monitoring bores. The water table is approximately 46 m higher than in Deposit F to the south, which suggests a disconnect between these orebodies. The patch of groundwater at Deposit F North is functionally disconnected from other groundwater systems as it is surrounded by low permeability unmineralized MacLeod and Nammuldi Members of the Marra Mamba Iron Formation on all sides. The aquifer is not expected to be suitable for stygofauna due to its isolation from the surrounding impermeable rock and consequent low influx of nutrients and oxygen.

Several dolerite dykes have been identified at Deposit F North, but it has not been established if these cause any compartmentalisation of groundwater.

Biologic (2022) recorded groundwater conditions at one bore at Deposit F north where depth to water was approx. 68 mbgl; observing fresh groundwater (EC 775 uS/cm), circum-neutral pH (7.2), and dissolved oxygen 3.7 mg/L (47% saturation). Despite the moderate dissolved oxygen levels, which could be attributed to bailer sampling from the top of the water column, the sample was noted to have a sulphurous/ biological odour and strong negative redox values (-176.3 mV) (Biologic 2022). It is considered likely that the groundwater conditions at this site would become increasingly anoxic with depth BWT.

Mt Ella East

No significant aquifer or BWT habitat suitable for stygofauna has been modelled to occur within the Brockman Iron Formation at Mt Ella East. The groundwater table in the synclinal valley to the

north of the deposit is very deep (>100 m below surface). No stygofauna have been recorded from sampling at Mt Ella East. Generally habitat at such depths are considered unsuitable for stygofauna due to low input of nutrients and oxygen from the surface above (Hose *et al.*, 2015). With consideration to the available habitat and lack of records to date, this area is not expected to provide significant stygofauna habitat values.

660000 664000 668000 672000

7444000 7440000 7436000

Habitat Thickness (m)

Zone A

- 1 - 30
- 31 - 60
- 61 - 90
- 91 - 120

Habitat Thickness (m)

Zone B

- 1 - 30
- 31 - 60
- 61 - 90
- 91 - 120

Legend

- West Angelas Beyond 2020 Development Envelope
- Current Operations Development Envelope
- EIA Section Boundary
- Existing Pit
- Proposed Pit
- Proposed Waste/ Infrastructure
- Stygofauna Sampling Site
- 3D Modelling Boundary (Vein Model)

Amphipoda

- Kruptus `sp. Helix-AMP035`

Haplotaxida

- Enchytraeidae `sp. Biologic-OLIG008`

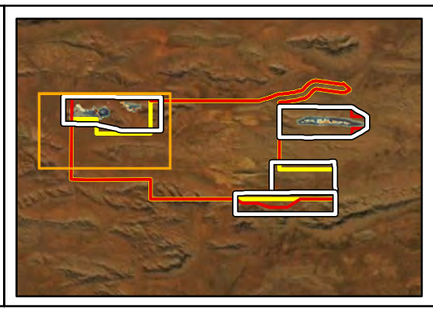
N

biologic Environmental Survey

Scale: 1:40,000

0 1 2 Km

Coordinate System: GDA 1994 MGA Zone 50
Projection: Transverse Mercator
Datum: GDA 1994 Created 24/08/2022



RIO TINTO IRON ORE

West Angelas Environmental Impact Assessment of Subterranean Fauna

Figure 3.9: Stygofauna assessed at Western Hill and suitable habitat (orebody aquifer)

660000

670000

7445000

7440000

7435000

Karijini National Park

Habitat Thickness (m)

Potential suitable habitat

- 1 - 30
- 31 - 60
- 61 - 90
- 91 - 120

Habitat Thickness (m)

Inferred habitat

- 1 - 30
- 31 - 60
- 61 - 90
- 91 - 120

Amphipoda

- Maarrka `sp. Helix-AMP037`
- Paramelitidae `sp. Biologic-AMPH018`
- Paramelitidae `sp. Helix-AMP036`

Bathynellacea

- Atopobathynella `sp. Helix-BAP027_WA`
- Bathynellidae `sp. Helix-BAB018`

Haplotaxida

- Enchytraeidae `sp. Helix-OLE028`
- Enchytraeidae `sp. Helix-OLE029`

Harpacticoida

- Australocamptus `sp. B13`

Isopoda

- Pygolabis `sp. WAN`

Podocopida

- Candonidae `sp. WAN`

Legend

- West Angelas Beyond 2020 Development Envelope
- Current Operations Development Envelope
- Karijini National Park
- Existing Pit
- Proposed Pit
- Proposed Waste/ Infrastructure
- Stygofauna Sampling Site
- Western Hill (Regional Synclinal Aquifer) Modelling Boundary

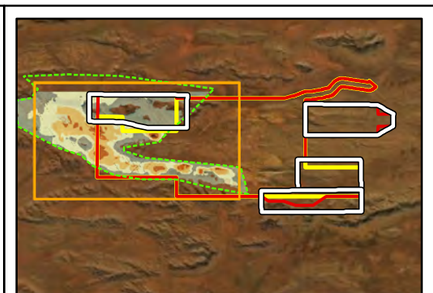
N

biologic Environmental Survey

Scale: 1:62,500

0 1 2 3 Km

Coordinate System: GDA 1994 MGA Zone 50
Projection: Transverse Mercator
Datum: GDA 1994 Created 24/08/2022



RIO TINTO IRON ORE

West Angelas Environmental Impact Assessment of Subterranean Fauna

Figure 3.10: Stygofauna assessed at Western Hill and suitable habitat (regional synclinal aquifer)

692000

696000

7442000

7440000

Habitat Thickness (m) Zone A	Habitat Thickness (m) Zone B
1 - 30	1 - 30
31 - 60	31 - 60
61 - 90	61 - 90
91 - 120	91 - 120

Legend

- West Angelas Beyond 2020 Development Envelope
- Current Operations Development Envelope
- EIA Section Boundary
- Proposed Pit
- Proposed Waste/ Infrastructure
- Stygofauna Sampling Site
- 3D Modelling Boundary (3D Habitat Model)

N

biologic Environmental Survey

Scale: 1:24,000

0 0.5 1 Km

Coordinate System: GDA 1994 MGA Zone 50
Projection: Transverse Mercator
Datum: GDA 1994 Created 16/12/2022



RIO TINTO IRON ORE

West Angelas Environmental Impact Assessment of Subterranean Fauna

Figure 3.11: Stygofauna assessed at Deposit H and suitable habitat

Stygofauna species values

A total of 490 stygofauna specimens representing 23 stygofauna taxa (species or operational taxonomic units) were recorded within the West Angelas Region. The number of stygofauna taxa recorded at West Angelas is relatively low compared to other areas in the wider region (e.g. Paraburdoo (Biologic, 2019), Greater Brockman (Bennelongia, 2013; Biologic, 2018, 2022c) Ethel Gorge (Bennelongia, 2013), Mining Area C (Bennelongia, 2014; Biota, 2004b), Solomon (Subterranean Ecology, 2011), Weeli Wolli, and Mesa A and Mesa H (Biota, 2004a, 2019). Such regional areas are known to have larger, more complex, and more highly suitable hydrogeological habitats, and would be expected to support richer stygofauna assemblages overall.

Nevertheless, the stygofauna results from West Angelas are also likely to be affected by sampling effort constraints related to the availability of bores and drillholes intercepting groundwater at the time of survey (Biologic, 2022a). Legacy issues from historical surveys prevented the inclusion of some species records, due to unresolved identifications and a lack of genetic sequencing (Biologic, 2022a). While the overall survey effort for stygofauna met EPA (2016) guidance expectations, given the occurrence of different aquifers and habitat units in different sections of the Development Envelope, the sampling effort at each individual section was somewhat more limited (Biologic, 2022a). Full details of all stygofauna taxa recorded and associated survey data are provided in Biologic (2022a).

Not all of the stygofauna taxa sampled to date are relevant to this EIA, and eleven (11) stygofauna taxa recorded from surveys to date have been excluded from consideration in this assessment (and are not listed in tables or figures) for the following reasons:

- Seven taxa were recorded only from areas that will not experience any impacts from mining pits and/or groundwater drawdown;
- One taxon was recorded from an already approved area; and
- Three taxa were found to be widespread regionally (linear ranges >100 km).

In addition to these 11 excluded stygofauna taxa, six indeterminate records that could not be resolved to species-level were also excluded from the assessment. For the most part, these indeterminate records represent residual specimens left over from sub-sampling for molecular analysis, and/ or damaged and juvenile specimens unfit for further taxonomic work. Although it is not possible to eliminate the possibility that undetected species may occur within the excluded material, all efforts were made to undertake morphological identifications and genetic sub-sampling as far as practicable to reduce the chance of this occurring (Biologic, 2022a).

Stygofauna included in this assessment

Twelve (12) stygofauna taxa (species and species-level OTU's) recorded throughout the Development Envelope are included in this EIA (Table 3-3). These taxa are currently known only from current records within the West Angelas Region, based on a review of available regional specimen databases and DNA sequence libraries (Biologic, 2022a). The 12 stygofauna taxa represent six orders comprising Amphipoda (4 taxa), Bathynellacea (Syncarida) (2), Harpacticoida

(1), Podocopida (Ostracoda) (1 taxon), Tubificida (Oligochaeta) (3), and Isopoda (1). Of these, one stygofauna species is exclusively known from a direct impact area (Western Hill orebody aquifer), and one species is known from both the Western Hill orebody aquifer as well as the synclinal valley. The remaining ten taxa were recorded within the synclinal aquifer to the south of Western Hill and have been included in the combined impact assessment.

None of these stygofauna taxa, nor the stygofauna communities, are currently listed or recognised as conservation priorities under state or federal legislation (Biologic, 2022a).

Table 3-3 lists the 12 stygofauna taxa included in the direct and combined impact assessment, alongside distribution information relative to impact areas (pits and groundwater drawdown impacts). It should be noted that none of the stygofauna taxa included in the EIA were recorded at Deposits H, F North and Mt Ella East. A breakdown of the species assessed within the Western Hill and synclinal aquifer is presented below, and their recorded locations are shown on Figure 3.9 to Figure 3.11.

Table 3-3: Stygofauna taxa included in the assessment. Blue text denotes taxa recorded within combined impacts (Western Hill/synclinal aquifer).

Taxonomy	Subterranean status & SRE status	Section of the DE	Locations	Known linear range	Direct impact	Combined Impact	Outside of impact areas
OLIGOCHAETA							
Tubificida							
Enchytraeidae `sp. Biologic-OLIG008`	Amphibious, unlikely SRE	WH	Amphibious, locally widespread beyond Development Envelope, external genetic matches	21 km	✓		✓
Enchytraeidae `sp. Helix-OLE028`	Amphibious, unlikely SRE	SYNC	Singleton within synclinal aquifer. Habitat extends beyond Development Envelope	-		✓	
Enchytraeidae `sp. Helix-OLE029`	Amphibious, unlikely SRE	SYNC	Singleton within synclinal aquifer. Habitat extends beyond Development Envelope	-		✓	
OSTRACODA							
Podocopida							
Candonidae `sp. WAN`	Stygobite, Uncertain SRE	SYNC	Single site within synclinal aquifer. Habitat extends beyond Development Envelope	-		✓	
MAXILLOPODA							
Copepoda							
Harpacticoida							
Australocamptus `sp. B13`	Stygobite, Potential SRE	SYNC	Localised range within synclinal aquifer. Habitat extends beyond Development Envelope	2.1 km		✓	
MALACOSTRACA							
Syncarida							
Bathynellacea							
Atopobathynella `sp. Helix-BAP027_WA`	Stygobite, Potential SRE	SYNC	Localised range within synclinal aquifer. Habitat extends beyond Development Envelope	2.1 km		✓	
Bathynellidae `sp. Helix-BAB018`	Stygobite, Potential SRE	SYNC	Localised range within synclinal aquifer. Habitat extends beyond Development Envelope	2.1 km		✓	
Amphipoda							
Kruptus `sp. Helix-AMP035`	Stygobite, Potential SRE	WH/SYNC	Localised range within synclinal aquifer. Habitat extends beyond Development Envelope	6.2 km	✓		
Maarrka `sp. Helix-AMP037`	Stygobite, Potential SRE	SYNC	Localised range within synclinal aquifer. Habitat extends beyond Development Envelope	2.4 km		✓	
Paramelitidae `sp. Biologic-AMPH018`	Stygobite, Potential SRE	SYNC	Localised range within synclinal aquifer. Habitat extends beyond Development Envelope	1.1 km		✓	
Paramelitidae `sp. Helix-AMP036`	Stygobite, Potential SRE	SYNC	Occurs widely within synclinal aquifer. Habitat extends beyond Development Envelope	8.9 km		✓	
Isopoda							
Pygolabis `sp. WAN`	Stygobite, Potential SRE	SYNC	Localised range within synclinal aquifer. Habitat extends beyond Development Envelope	1.1 km		✓	

Western Hill and synclinal aquifer

A moderately diverse stygofauna assemblage was recorded at Western Hill and the nearby synclinal aquifer (12 taxa). Sampling within Western Hill (orebody aquifer) was limited by available bores/ holes intercepting groundwater (15 samples), however sampling in the nearby calcrete within the synclinal valley provided additional context for the stygofauna assemblage occurring to the south of the proposed pits at Western Hill (38 samples). Only two (2) stygofauna taxa were recorded from the immediate vicinity of the proposed pits at Western Hill, while ten (10) stygofauna taxa were recorded from the area immediately south within the extent of groundwater drawdown associated with the synclinal aquifer (combined impacts).

The amphipod *Kruptus* `sp. Helix-AMP035` was recorded from the Western Hill orebody aquifer as well as from several sites within the synclinal aquifer to the south of the Western Hill section. Stygal amphipods in the Pilbara are known to include restricted SREs as well as locally and regionally widespread species, often co-occurring within the same hydrogeological habitats. The occurrence of this taxon across two separate aquifer types indicates that this species may occur more widely as currently known (within the wider local area).

The oligochaete Enchytraeidae `sp. Biologic-OLIG008` was recorded from two sites within the Western Hill orebody aquifer. Oligochaetes are stygophile/xenes (i.e. taxa that can also live within surface waters) and are frequently known to be widespread (Table 3-3). Enchytraeidae are regularly detected from troglofauna traps, as they can move through water films within air-filled subterranean cavities as well as groundwater. There is significant uncertainty over what represents a species in this family, which currently has no taxonomic framework beyond family level in Australia (A. Pinder pers. comm. 2021). Therefore, it is considered likely that this oligochaete taxon occurs more widely, at least within the wider local area.

The remaining ten taxa from Western Hill were recorded exclusively from within the synclinal valley, outside of direct impact areas. Of these, three taxa were stygal amphipods (*Maarrka* `sp. Helix-AMP037`, Paramelitidae `sp. Biologic-AMPH018` and Paramelitidae `sp. Helix-AMP036`) which are known to include both restricted SREs as well as locally and regionally widespread species in the Pilbara. Therefore, there may be a chance that some of these species could occur more widely, despite available regional comparisons showing them being recorded only within the West Angelas Region to date.

The two stygobitic syncarids (*Atopobathynella* `sp. Helix-BAP027_WA` and Bathynellidae `sp. Helix-BAB018`) recorded from the synclinal valley belong to a group (Syncarida) where the majority of members are known to have very limited dispersal abilities and show high rates of species turnover over geographical distance and different hydrogeological habitats (Abrams *et al.*, 2012; Matthews *et al.*, 2020; Perina *et al.*, 2018, 2019a; Perina *et al.*, 2019b). It is therefore not expected that these taxa should occur considerably more widely beyond the habitats of the synclinal aquifer.

In addition to the oligochaete recorded from the Western Hill orebody aquifer (see above), two further oligochaete taxa (Enchytraeidae `sp. Helix-OLE028` and Enchytraeidae `sp. Helix-OLE029`) were recorded from the synclinal valley. Following the same rationale described above in relation to Enchytraeidae `sp. Biologic-OLIG008`, it is considered likely that these oligochaete taxa occur more widely, at least within the wider local area.

The remaining three taxa recorded from the synclinal valley included one ostracod (Candonidae `sp. WAN`), one harpacticoid (*Australocamptus* `sp. B13) and one isopod (*Pygolabis* `sp. WAN`).

Candonidae `sp. WAN` is a stygobite recorded from a single site within the combined groundwater drawdown zone. There was a low taxonomic certainty over the individuals collected at the time of the survey and DNA was not available to enable regional comparisons, therefore this taxon is treated as unique only as a precaution. Candonid ostracods (like amphipods) are known to contain species with a wide range of different distributions from SRE fauna to catchment-wide and regionally widespread species. This putative taxon's SRE status is uncertain, and there is a chance that this taxon could occur more widely than recorded to date.

The harpacticoid *Australocamptus* `sp. B13` was recorded from multiple sites over a small spatial area (2.1 km) within the synclinal aquifer. Harpacticoid copepods (alongside cyclopoid copepods) are some of the more vagile and widespread stygofauna taxa regionally, and the likelihood of range-restricted copepod species from the Pilbara is generally considered low. Therefore, there is a reasonable likelihood that this taxon occurs more widely, at least within the wider local area.

The isopod *Pygolabis* `sp. WAN` was recorded from two sites over a small spatial area (1.1 km) within the synclinal aquifer. There was a low taxonomic certainty over the individuals collected at the time of the survey, and the attempted DNA analysis failed, therefore no regional comparisons were possible. The taxon is putatively treated as unique as a precaution. Stygobitic isopods are known to have varying distribution ranges in the Pilbara, with both locally and regionally widespread taxa and more restricted species known to occur. Most *Pygolabis* known from the Pilbara are known to have widespread distributions at present.

Despite the occurrence of dolerite dykes in the bedrock synclinal aquifer, stygofauna taxa were found to occur throughout the sampled extent of the aquifer. This suggests that the dykes do not form barriers to stygofauna species movement or compartmentalisation of the synclinal aquifer under current conditions (for example, connectivity may be maintained throughout saturated detritals and calcrete atop the bedrock).

3.4 Subterranean Fauna sampling effort

A total of 1044 subterranean fauna samples comprising 903 troglofauna and 141 stygofauna samples, were obtained from within the four sections of the Development Envelope and immediate surrounds (including Deposit J reference area) (Table 3-4). The majority of the subterranean fauna sampling surveys associated with the Development Envelope were designed and undertaken between 2018-2020 under the draft Technical Guidance – Sampling methods for Subterranean

Fauna (EPA, 2016b). Therefore, sampling rates and number of phases of survey reflect the 2016 guidance.

Table 3-4: Number of troglofauna and stygofauna samples for each section of the Development Envelope (and surrounds) and sampling method

	Western Hill orebody	Western Hill synclinal aquifer	Deposit H	Deposit F North	Mt Ella East	All other areas (o	Total
Traps retrieved	100	131	49	63	53	107	**503**
Scrapes	83	54	32	43	104	84	**400**
Net hauls	15	38	7	29	4	48	**141**
Troglofauna total	183	185	81	106	157	191	**903**
Stygofauna total	15	38	7	29	4	48	**141**
Total sampling, all surveys	**198**	**223**	**88**	**135**	**161**	**239**	**1044**

Includes sampling from all previous surveys within the West Angelas Region (refer Table 1.1)

Sampling throughout the Development Envelope was designed to maximise spatial coverage relative to potential habitat units (AWT/ BWT) and potential impact areas where known at the time of survey. Nevertheless, the final sampling layout and intensity was limited by the availability of suitable bore/ holes at the time of survey, particularly those which intercepted the groundwater table (for BWT sampling).

Troglofauna sampling was performed over two phases in alignment with the EPA guidance that was available at the time of survey (EPA 2016). The troglofauna sampling effort met and exceeded EPA minimum guidelines in all four sections of the Development Envelope, with a good spatial coverage across the geological habitats and impact areas. Troglofauna sampling was undertaken within and outside of the impact areas to an extent that would be appropriate to indicate whether species located within the impact areas are likely to occur outside the impact areas according to EPA Guidance (EPA, 2021).

Table 3-5: Troglofauna and stygofauna sampling for each Development Envelope section and pit impact area

Pit impact area	Western Hill orebody	Western Hill synclinal aquifer	Deposit H	Deposit F North	Mt Ella East	All other areas	Total
Troglofauna							
Inside proposed pit	124	-	41	12	60	-	**237**
Existing operations area	-	90	-	25	-	35	**150**
Outside pit boundaries	59	95	40	69	97	156	**516**
Troglofauna total	**183**	**185**	**81**	**106**	**157**	**191**	**903**
Stygofauna							
Inside proposed pit	10	-	3	3	4	-	**20**
Existing operations area	-	12	-	18	-	19	**49**
Outside pit boundaries	5	26	4	8	-	29	**72**
Stygofauna total	**15**	**38**	**7**	**29**	**4**	**48**	**141**

The stygofauna sampling within the sections of the Development Envelope was constrained by the numbers of bores/ drill holes intercepting the water table. The number of water bores available at the time of sampling was relatively low in areas where the groundwater table was relatively deep below surface (e.g. Western Hill orebody aquifer), and at areas such as Deposit F North and

Mt Ella East, where no significant groundwater aquifer was recorded (Biologic, 2022a). Stygofauna sampling at Western Hill was complemented by additional sampling in a similar nearby groundwater habitat within the synclinal valley. Additional stygofauna sampling was also undertaken at reference areas in the central anticline (Central Water Bores) and at Deposit J reference area to supplement stygofauna sampling of the other sections of the Development Envelope and to provide an opportunity to determine the species distributions in the wider local context. In general, the stygofauna assemblages were unique, with little species overlap between the borefield reference areas and each of the Development Envelope sections.

At Mt Ella East and Deposit F North, no significant aquifer or BWT habitat has been predicted to occur by the 3D model, and therefore these two areas are not expected to hold significant stygofauna habitat values and further stygofauna sampling is not expected to reveal a significant stygofauna species assemblage. At Western Hill, where groundwater extraction is proposed, sufficient samples were collected inside and outside the direct impact areas. Sampling at Deposit H was limited by the lack of accessible bores and drill holes intercepting water at the time of survey. However, while the sampling for stygofauna at Deposit H (seven samples, Table 3-4) was less than the minimum recommendations for areas likely to have significant stygofauna values, the assemblage at Deposit H was found to be depauperate, containing only oligochaete worms. A more intensive sampling effort at Deposit H would be expected to provide greater confidence in the stygofauna results from this area; however, even the current sampling would have been expected to result in richer stygofauna results, if a significant stygofauna assemblage was present.

A substantial taxonomic effort (including molecular genetics) was undertaken to validate species-level identifications and assess regional distributions of subterranean fauna (Biologic 2022b). A high proportion of troglofauna and stygofauna records were sub-sampled for genetic analyses, resulting in 132 successful sequences from 213 troglofauna records (approximately 62% of the troglofauna records), and 32 successful sequences from 73 stygofauna species records (approx. 44% of the total stygofauna records). The remaining indeterminate records that could not be resolved to species-level represent mostly residual specimens left over from sub-sampling for molecular analysis, and/ or damaged and juvenile specimens unfit for further taxonomic work. They are unlikely to represent new taxa not already considered in this assessment.

The West Angelas Region consists of a series of deposits within a larger geological formation, which has its own distinct geological and hydrogeological context. Sampling to date has indicated that troglofauna found throughout the Development Envelope are generally specific to a section of the Development Envelope and rarely widespread beyond the West Angelas Region. Subterranean fauna data available from projects surrounding the Development Envelope, such as Mining Area C, Hope Downs, and other regional locations (Biologic, 2022a) has been incorporated within this assessment, where information was available. Many taxa/ morphospecies recorded from previous surveys could not be compared to OTUs from the current survey due to the specimens or DNA being unavailable, and/ or due to updated taxonomic frameworks between the

previous and current surveys; therefore, some synonyms or data artefacts could remain unresolved in the combined (historical and current) species lists.

4. ASSESSMENT OF IMPACTS TO TROGLOFAUNA

Impacts to troglofauna habitat and species values were assessed following the framework detailed in section 2.

4.1 Direct impacts from the Proposal

4.1.1 Impacts to troglofauna habitat values per section of the Development Envelope

Western Hill

The impact of the proposed mining activities on the troglofauna habitat values at Western Hill is considered Low, because:

- The proposed mining activities result in a reduction of approximately 17% of the pre-impact volume of suitable AWT habitat (based on conservative assessment of high and medium suitability combined) (Appendix B, Table B-1).
- Approximately 83% of the pre-impact volume of suitable habitat AWT is expected to be retained (Figure 4.1).
- The 3D modelling showed a considerable reduction in habitat thickness in the proposed pit areas, but a reasonable thickness of high to medium suitability habitat remains intact AWT after proposed mining operations within each of the proposed pits (between 5 m and 100 m thick in patches) (compare A and B of Figure 4.2 and Figure 4.3).
- The overall extent and connectivity of the AWT habitats outside of the proposed pit areas is maintained (compare A and B of Figure 4.2 and Figure 4.3).

The volume, extent, thickness, and connectivity of suitable habitat remaining at Western Hill is expected to continue to support the troglofauna species and assemblages recorded (Figure 4.1, Figure 4.2 and Figure 4.3).

The extent of prospective suitable habitat at Western Hill is likely to be underrepresented due to the narrowness of the conservative modelling boundary (300 m surrounding each drill hole) between the two largest pits, as well as to the south and east of Western Hill (Figure 4.1, Figure 4.2 and Figure 4.3). An absence of wider drilling in prospective geologies in these areas (including BrIF, Wittenoom Dolomite, and alluvial/ colluvial detritals) is a limiting factor for the current modelling extent (see section 7). Consequently, potential wider subterranean fauna habitats beyond the modelling boundary at Western Hill are excluded from the current assessment, yet the overall impacts from the proposed pits are nonetheless low.

In this context, the direct impacts to troglofauna habitat values at Western Hill are considered Low and overall ecological integrity is expected to be maintained.

Deposit H

The impact of the proposed mining activities on the troglofauna habitat values at Deposit H is considered Low, because:

- The proposed mining activities result in a minor reduction of suitable habitat, approximately 13% of the pre-impact volume (based on conservative assessment of high and medium suitability combined) (Appendix B, Table B-1).
- Approximately 87% of the pre-mining suitable habitat AWT is expected to be retained (Figure 4.4).
- Modelling shows negligible change in habitat thickness, extent, or connectivity throughout Deposit H (compare A and B of Figure 4.5 and Figure 4.6).
- Extensive areas of prospective AWT habitat are expected to remain unaffected throughout the Deposit H area, beyond and below the proposed pits (Figure 4.4).
- The current 3D modelling boundary (constrained by 300 m distance from drill holes) is smaller than the mapped extent of highly prospective MMIF geology, therefore there may be additional suitable habitat for troglofauna outside the modelled area.

In this context, the direct impacts to troglofauna habitat values at Deposit H are expected to be Low and overall ecological integrity is expected to be maintained.

Deposit F North

The impact of the proposed mining activities on the troglofauna habitat values at Deposit F North is considered Low, because:

- The proposed mining activities result in a negligible reduction of suitable habitat, approximately 3% of the pre-impact volume (based on conservative assessment of high and medium suitability combined) (Appendix B, Table B-1).
- Approximately 97% of the pre-mining suitable habitat AWT is expected to be retained (Figure 4.7).
- The modelling shows a moderate change in habitat thickness, extent, and connectivity throughout Deposit F North (compare A and B of Figure 4.9 and Figure 4.10).
- The current 3D modelling boundary (constrained by 300 m distance from drill holes, and the shallow depth of drilling across the deposit) is considerably narrower than the mapped extent of highly prospective MMIF geology at Deposit F North. It is expected that the additional suitable habitat may exist at depths beyond the current drilling, and outside the modelled area within the wider mapped extent of MMIF geology.

In this context, the direct impacts to troglofauna habitat values at Deposit F North are expected to be Low and overall ecological integrity is expected to be maintained under the proposed scenario.

Mt Ella East

The impact of the proposed mining activities on the troglofauna habitat values at Mt Ella East is considered Low, because:

- The proposed mining activities result in a negligible reduction of approximately 2% of the pre-impact volume of suitable AWT habitat (based on conservative assessment of high and medium suitability combined) (Appendix B, Table B-1).
- Approximately 98% of the pre-impact volume of suitable habitat AWT is expected to be retained (Figure 4.11).
- Modelling shows a moderate change in habitat thickness, extent, and connectivity throughout the Mt Ella East Deposits (compare A and B of Figure 4.12 and Figure 4.13).
- The current 3D modelling boundary (constrained by 300 m distance from drill holes) is smaller than the mapped extent of highly prospective BrIF geology (AWT), therefore, there may be additional suitable habitat for troglofauna outside the modelled area.

In this context, the direct impacts to troglofauna habitat values at Mt Ella East are expected to be Low and overall ecological integrity is expected to be maintained under the proposed scenario.

4.1.2 Impacts to troglofauna species values per section of the Development Envelope

Western Hill

The direct impacts of the Proposal on the 14 troglofauna species values recorded at Western Hill are considered Medium for six taxa, and low for eight taxa, as summarised in Table 4-1. Habitat suitability categories used in habitat modelling are outlined in section 2.2 (Table 2-1).

Table 4-1: Summary of direct impact rank and rationale for troglofauna taxa at Western Hill

Taxon	Likelihood that taxon is restricted to impacts	Magnitude of impact within linear range	Suitability of habitat remaining	Direct impact rank
Arachnida				
Araneae				
Araneae sp. `Biologic ARAN030`	Possible, based on taxonomy/ ecology and known occurrence	Moderate. Suitable, well-connected habitat remains intact	Medium, >30m thick	**Med**
Blattodea				
Nocticola `sp. Biologic-BLAT014`	Occurs inside and outside of direct impacts	Low. Extensive habitat remains intact.	High to Medium, throughout Dev Env.	**Low**
Palpigradi				
Palpigradi `sp. Biologic-PALP016`	Possible, based on taxonomy/ ecology and known occurrence	Moderate. Suitable, well-connected habitat remains intact	Medium, >30m thick	**Med**
Pseudoscorpiones				
Tyrannochthonius `sp. Biologic-PSEU015`	Unlikely, occurs on edge of pit	Low. Extensive habitat remains intact	High to Medium, >70m thick	**Low**
Insecta				
Zygentoma				
Atelurinae `sp. Biologic-ZYGE012`	Unlikely, trogloxene	Low to moderate. Suitable, well-connected habitat remains intact	Medium to high, >30m thick	**Low**

Taxon	Likelihood that taxon is restricted to impacts	Magnitude of impact within linear range	Suitability of habitat remaining	Direct impact rank
Trinemura `sp. Biologic-ZYGE013`	Possible, based on taxonomy/ ecology and known occurrence	Moderate. Suitable, well-connected habitat remains intact	Medium, >30m thick	Med
Hemiptera				
Meenoplidae `sp. Biologic-HEMI010`	Occurs inside and outside of direct impacts	Low. Extensive habitat remains intact.	High to Medium, throughout Dev Env.	Low
Myriapoda				
Scolopendrida				
Cryptops `sp. WAWH`	Occurs outside impacts	Low. Extensive habitat remains intact.	High to Medium, throughout Dev Env.	Low
Pauropoda				
Pauropoda `sp. Biologic-PAUR014`	Unlikely, based on taxonomy/ ecology and occurrence	Moderate. Suitable, well-connected habitat remains intact	Medium, >30m thick	Med
Pauropoda `sp. Biologic-PAUR016`	Occurs outside impacts	Negligible.	Unchanged.	Low
Pauropoda `sp. Biologic-PAUR018`	Unlikely, based on taxonomy/ ecology and occurrence	Low. Extensive habitat remains intact.	High to medium, >70m thick	Low
Pauropoda `sp. Biologic-PAUR020`	Unlikely, based on taxonomy/ ecology and occurrence	Moderate. Suitable, well-connected habitat remains intact	Medium, >30m thick	Med
Symphyla				
Scolopendrellidae `sp. Biologic-SYMP012`	Possible, based on taxonomy/ ecology and known occurrence	Moderate. Suitable, well-connected habitat remains intact	Medium, >30m thick	Med
Diptera				
Sciaridae `sp. Biologic-DIPT001`	Occurs inside and outside of direct impacts	Low. Extensive habitat remains intact.	High to medium, throughout Dev Env.	Low

The six Medium impact troglofauna taxa (Araneae sp. `Biologic ARAN030`, Palpigradi `sp. Biologic-PALP016`, *Trinemura* `sp. Biologic-ZYGE013`, Pauropoda `sp. Biologic-PAUR014`, Pauropoda `sp. Biologic-PAUR020`, and Scolopendrellidae `sp. Biologic-SYMP012`) were all collected from a single site or single individual inside proposed pits at Western Hill. Of these, the two arachnids (Araneae sp. `Biologic ARAN030` and Palpigradi `sp. Biologic-PALP016`) belong to groups that typically have restricted ranges when troglobitic, while the other four taxa belong to groups for which range restricted taxa may occur.

Well-connected high to medium suitability habitat is modelled throughout the Western Hill area with no obvious barriers to fauna movement or dispersal. Moderately to very thick (30 m to 70 m) well-connected, extensive AWT habitats are expected to remain intact at the location of each of these records, and/or in the immediate vicinity (i.e., within 50–100 m from each record) (Figure 4.1).

Where troglofauna taxa were only recorded from a single site, it is reasonable to assume that the current sampling has detected only a part of their area of occupancy within the wider local extent of suitable habitat. Given the lack of habitat barriers, it is reasonable to infer that singleton

troglofauna could potentially occur more widely in the immediate local vicinity beyond their single record location. Therefore, the suitable AWT habitat remaining intact beneath the proposed pits and surrounding the recorded locations of these taxa is expected to continue to support these taxa following impacts.

The direct impacts of the Proposal are considered low for the remaining eight troglofauna taxa recorded from Western Hill considering the following.

- *Cryptops* `sp. WAWH`;
    - singleton collected outside the boundaries of proposed pits at Western Hill;
    - most of its potential habitat is expected to remain unimpacted.
- Atelurinae `sp. Biologic-ZYGE012`, Pauropoda `sp. Biologic-PAUR018`, and *Tyrannochthonius* `sp. Biologic-PSEU015;
    - singletons collected just inside the boundaries of proposed pits at Western Hill.
    - minimal direct impacts (records located close to edge of pits);
    - Thick (up to 100 m), well-connected, and extensive suitable troglofauna habitats will remain intact beneath all record locations and more widely throughout the surrounding area (Figure 4.1).
- *Nocticola* `sp. Biologic-BLAT014` (51 km), Pauropoda `sp. Biologic-PAUR016` (37 km), Meenoplidae `sp. Biologic-HEMI010` (28 km) and Sciaridae `sp. Biologic-DIPT001` (38 km);
    - Locally widespread taxa (likely trogloxenic) recorded throughout the West Angelas Region and/or wider sub-regional area (current linear ranges shown in brackets above).

Deposit H

The direct impacts of the Proposal on troglofauna species are considered Low for 12 taxa, and Medium for one taxon (Palpigradi `sp. Biologic-PALP017`), as summarised in Table 4-2.

Table 4-2: Summary of direct impact rank and rationale for troglofauna taxa at Deposit H

Taxon	Likelihood of species restricted to impact area	Magnitude of direct impact within LR	Suitability of habitat remaining after impact	Direct impact rank
Arachnida				
Araneae				
Prethopalpus `sp. Biologic-ARAN012`	Occurs outside direct impacts	Low. Extensive habitat remains intact	Unlikely to change, localised indirect impact	**Low**
Theridiidae `sp. Biologic-ARAN010`	Occurs outside direct impacts, locally widespread	Low. Extensive habitat remains intact	High to Medium th/out Dev Env	**Low**
Palpigradi				
Palpigradi `sp. Biologic-PALP017`	Possible, based on taxonomy/ ecology and occurrence	Moderate. Suitable, well-connected habitat remains intact	Medium, >25m thick	**Med**

Taxon	Likelihood of species restricted to impact area	Magnitude of direct impact within LR	Suitability of habitat remaining after impact	Direct impact rank
Palpigradi `sp. Biologic-PALP020`	Occurs outside direct impacts	Low. Extensive habitat remains intact	High to medium outside pit	**Low**
Pseudoscorpiones				
Indohya `sp. Biologic-PSEU016`	Occurs outside direct impacts	Low. Extensive habitat remains intact	Unlikely to change, localised indirect impact	**Low**
Tyrannochthonius `sp. Biologic-PSEU013`	Unlikely, based on occurrence on edge of pit	Low. Extensive, habitat remains intact	High to Medium, >45m thick	**Low**
Tyrannochthonius `sp. Biologic-PSEU014`	Occurs outside direct impacts	Low. Extensive habitat remains intact	Unlikely to change, localised indirect impact	**Low**
Crustacea				
Isopoda				
Pseudodiploexochus `sp. WAH`	Occurs outside impacts	Negligible	Unchanged	**Low**
Entognatha				
Diplura				
Parajapigydae `sp. Biologic-DIPL016`	Occurs outside impacts	Negligible	Unchanged	**Low**
Insecta				
Blattodea				
Nocticola `sp. Biologic-BLAT015`	Unlikely, typically widespread	Moderate. Suitable, well-connected habitat remains intact	High to Medium, >35m thick	**Low**
Hemiptera				
Phaconeura `sp. Biologic-HEMI003`	Occurs inside/ outside impacts	Low. Extensive habitat remains intact	High to Medium th/out Dev Env	**Low**
Myriapoda				
Pauropoda				
Pauropoda `sp. Biologic-PAUR017`	Occurs outside direct impacts	Low. Extensive habitat remains intact	Unlikely to change, localised indirect impact	**Low**
Symphyla				
Scutigerellidae `sp. Biologic-SYMP011`	Occurs inside/ outside impacts	Low. Extensive habitat remains intact	High to Medium th/out Dev Env	**Low**

The direct impacts of the Proposal at Deposit H are considered Medium for Palpigradi `sp. Biologic-PALP017 (Table 4-2). Troglobitic palpigrades typically have narrowly restricted ranges within single geological formations, although one species recorded from the Development Envelope is known from Deposits F North and Mt Ella East over approximately 9 km (Table 3-2).

Surrounding the recorded location of Palpigradi `sp. Biologic-PALP017 (i.e. within 50–100 m), suitable troglofauna habitats are expected remain moderately thick (>25 m) and well-connected following the proposed impacts (Figure 4.4). Although this taxon was only detected from a single site, it is reasonable to assume that the moderately thick suitable habitat surrounding its location and extending beyond impacts will remain for this species to persist following direct impacts.

Table 4-2 and Figure 4.4 show that 11 of the 12 taxa ranked as 'Low impact' are known to occur beyond the direct impact areas at Deposit H, including:

- *Indohya* `sp. Biologic-PSEU016`
- Palpigradi `sp. Biologic-PALP020`
- *Prethopalpus* `sp. Biologic-ARAN012`
- Theridiidae `sp. Biologic-ARAN010`
- *Tyrannochthonius* `sp. Biologic-PSEU013`
- *Tyrannochthonius* `sp. Biologic-PSEU014`
- *Pseudodiploexochus* `sp. WAH`
- Parajapigydae `sp. Biologic-DIPL016`
- *Phaconeura `sp. Biologic-HEMI003`*
- *Nocticola* `sp. Biologic-BLAT015`; and
- Scutigerellidae `sp. Biologic-SYMP011`.

Three of these taxa were known to be locally widespread (Theridiidae `sp. Biologic-ARAN010`, *Phaconeura* `sp. Biologic-HEMI003` and Scutigerellidae `sp. Biologic-SYMP011`), with linear ranges from approximately 17 km to 67 km (Table 3-2). One further taxon, *Nocticola* `sp. Biologic-BLAT015`, is considered highly likely to occur more widely than its current records and is predicted to occur throughout the connected habitats at Deposit H as a minimum. Recent genetic studies at West Angelas and other regional areas have shown that almost all *Nocticola* cockroaches tend to range between locally and regionally widespread (Biologic, 2021a, 2022a; Trotter *et al.*, 2017).

Four of the 'Low ranked' taxa (*Indohya* `sp. Biologic-PSEU016, *Prethopalpus* `sp. Biologic-ARAN012`, *Tyrannochthonius* `sp. Biologic-PSEU014`, and Parajapigydae `sp. Biologic-DIPL016`) were recorded within indirect impact areas (waste dumps and stockpiles) and are discussed further below in section 4.2.

Deposit F North

The direct impacts of the Proposal on troglofauna species are considered Low for all eight (8) troglofauna taxa recorded at Deposit F North, as summarised in Table 4-3.

Table 4-3: Summary of direct impact rank and rationale for troglofauna taxa at Deposit F North

Taxon	Likelihood of species restricted to impact area	Magnitude of direct impact within LR	Suitability of habitat remaining after impact	Direct impact rank
Arachnida				
Araneae				
Araneae `sp. Biologic-ARAN008`	Occurs outside impacts	Negligible	Unchanged	**Low**
Palpigradi				
Palpigradi `sp. Biologic-PALP018`	Occurs inside/ outside impacts	Low. Extensive habitat remains intact	High to Medium th/out Dev Env	**Low**

Taxon	Likelihood of species restricted to impact area	Magnitude of direct impact within LR	Suitability of habitat remaining after impact	Direct impact rank
Insecta				
Zygentoma				
Dodecastyla `sp. Biologic-ZYGE011`	Occurs inside/ outside impacts	Low. Extensive habitat remains intact	High to Medium th/out Dev Env	**Low**
Blattodea				
Nocticola `sp. Biologic-BLAT014`	Occurs inside/ outside impacts	Low. Extensive habitat remains intact	High to Medium th/out Dev Env	**Low**
Hemiptera				
Phaconeura `sp. Biologic-HEMI003`	Occurs inside/ outside impacts	Low. Extensive habitat remains intact	High to Medium th/out Dev Env	**Low**
Entognatha				
Diplura				
Japygidae `sp. Biologic-DIPL017`	Occurs inside/ outside impacts	Low. Extensive habitat remains intact	High to Medium th/out Dev Env	**Low**
Myriapoda				
Pauropoda				
Pauropoda `sp. Biologic-PAUR019`	Occurs outside impacts	Negligible	Unchanged	**Low**
Symphyla				
Scutigerellidae `sp. Biologic-SYMP011`	Occurs inside/ outside impacts	Low. Extensive habitat remains intact	High to Medium th/out Dev Env	**Low**
Scutigerellidae sp. `Helix SYM027` *	Occurs outside direct impacts	Low. Extensive habitat remains intact	Unlikely to change, localised indirect impact	**Low**

Table 4-3 and Figure 4.7 show that none of the taxa known to occur at Deposit F North are restricted to the impact areas. Six of the eight taxa were known to be locally widespread with linear ranges from approximately 9 to 67 km (Palpigradi `sp. Biologic-PALP018`, *Dodecastyla* `sp. Biologic-ZYGE011`, Japygidae `sp. Biologic-DIPL017`, *Nocticola* `sp. Biologic-BLAT014`, *Phaconeura* `sp. Biologic-HEMI003` and Scutigerellidae `sp. Biologic-SYMP011`) (Table 3-2).

The two remaining low impact taxa (Araneae `sp. Biologic-ARAN008` and Pauropoda `sp. Biologic-PAUR019`) were recorded as singletons outside direct and within indirect impacts, respectively. Scutigerellidae sp. `Helix SYM027` was recorded only within a topsoil stockpile area and is discussed below in section 4.2.

Based on the known occurrence of these taxa and the volume and extent of habitat remaining, the direct impacts of the Proposal to troglofauna are expected to be Low at Deposit F North.

Mt Ella East

The direct impacts of the Proposal on troglofauna species are considered Low for all 14 taxa, as summarised in Table 4-4.

Table 4-4: Summary of direct impact rank and rationale for troglofauna taxa at Mt Ella East

Taxon	Likelihood of species restricted to impact area	Magnitude of direct impact within LR	Suitability of habitat remaining after impact	Direct impact rank
Arachnida				
Araneae				
Oonopidae `sp. Biologic-ARAN018`	Occurs outside impacts	Negligible	Unchanged	**Low**
Theridiidae `sp. Biologic-ARAN010`	Occurs outside impacts	Negligible	Unchanged	**Low**
Pseudoscorpiones				
Indolpium `sp. Biologic-PSEU017`	Occurs outside impacts	Negligible	Unchanged	**Low**
Tyrannochthonius `sp. Biologic-PSEU011`	Occurs inside/ outside impacts	Low. Extensive habitat remains intact	High to Medium, >70m thickness	**Low**
Tyrannochthonius `sp. Biologic-PSEU012`	Occurs inside/ outside impacts	Low. Extensive habitat remains intact	High to Medium th/out Dev Env	**Low**
Palpigradi				
Palpigradi `sp. Biologic-PALP018`	Occurs inside/ outside impacts	Low. Extensive habitat remains intact	High to Medium th/out Dev Env	**Low**
Palpigradi `sp. Biologic-PALP019`	Possible, based on taxonomy/ ecology and occurrence	Low. Extensive habitat remains intact	High to Medium, >50m thickness	**Low**
Crustacea				
Isopoda				
Philosciidae `sp. Biologic ISOP015`	Occurs outside impacts	Negligible	Unchanged	**Low**
Insecta				
Blattodea				
Nocticola `sp. Biologic-BLAT014`	Occurs outside impacts	Low to negligible	High to Medium th/out Dev Env	**Low**
Hemiptera				
Phaconeura `sp. Biologic-HEMI003`	Occurs inside/ outside impacts	Low. Extensive habitat remains intact	High to Medium th/out Dev Env	**Low**
Zygentoma				
Atelurinae `sp. Biologic-ZYGE014`	Occurs inside/ outside impacts	Low. Extensive habitat remains intact	High to Medium th/out Dev Env	**Low**
Dodecastyla `sp. Biologic-ZYGE011`	Occurs inside/ outside impacts	Low. Extensive habitat remains intact	High to Medium th/out Dev Env	**Low**
Trinemura `sp. Biologic-ZYGE017`	Occurs outside impacts	Negligible	Unchanged	**Low**
Myriapoda				
Symphyla				
Hanseniella `sp. Biologic-SYMP018`	Occurs outside impacts	Negligible	Unchanged	**Low**

The direct impacts of the Proposal are considered low for the 14 troglofauna taxa recorded at Mt Ella East according to the following:

- *Tyrannochthonius* `sp. Biologic-PSEU011` was recorded both inside and outside direct impact areas;
- Five taxa occur beyond direct impact areas beyond proposed impacts (*Indolpium* `sp. Biologic-PSEU017`, *Nocticola* `sp. Biologic-BLAT014`, Oonopidae `sp. Biologic-ARAN018`, *Phaconeura* `sp. Biologic-HEMI003` and Theridiidae `sp. Biologic-ARAN010`).
- Four taxa (Atelurinae `sp. Biologic-ZYGE014`, *Dodecastyla* `sp. Biologic-ZYGE011`, Palpigradi `sp. Biologic-PALP018`, and *Tyrannochthonius* `sp. Biologic-PSEU012`) occur in direct impact areas however also have a wider distribution (27.8 km to 3.5 km) occurring beyond the proposed impacts.
- Four taxa (Philosciidae `sp. Biologic ISOP015`, Palpigradi `sp. Biologic-PALP019`, *Trinemura* `sp. Biologic-ZYGE017` and *Hanseniella* `sp. Biologic-SYMP018`) were recorded as singletons from outside direct impact areas.

664000

668000

7444000

7442000

Arachnida

- Araneae `sp. Biologic-ARAN030`
- Palpigradi `sp. Biologic-PALP016`
- Tyrannochthonius `sp. Biologic-PSEU015`

Chilopoda

- Cryptops `sp. WAWH`

Insecta

- Atelurinae `sp. Biologic-ZYGE012`
- Meenoplidae `sp. Biologic-HEMI010`
- Nocticola `sp. Biologic-BLAT014`
- Sciaridae `sp. Biologic-DIPT001`
- Trinemura `sp. Biologic-ZYGE013`

Pauropoda

- Pauropoda `sp. Biologic-PAUR014`
- Pauropoda `sp. Biologic-PAUR016`
- Pauropoda `sp. Biologic-PAUR018`
- Pauropoda `sp. Biologic-PAUR020`

Symphyla

- Scolopendrellidae `sp. Biologic-SYMP012`

Legend

- West Angelas Beyond 2020 Development Envelope
- Current Operations Development Envelope
- EIA Section Boundary
- Main Access Track
- Proposed Pit
- Proposed Waste/ Infrastructure
- Troglofauna Sampling Site
- 3D Modelling Boundary (Vein Model)

Habitat Thickness – Pre-impact

m AWT

High : 281

Low : 1

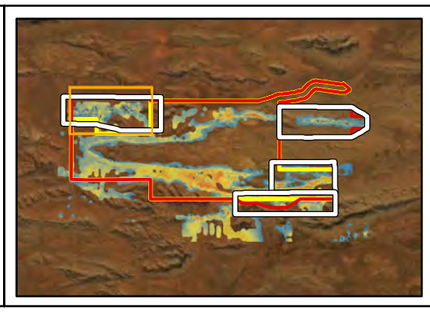
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Scale: 1:25,000

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Coordinate System: GDA 1994 MGA Zone 50
Projection: Transverse Mercator
Datum: GDA 1994 Created 24/08/2022



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Figure 4.1: Troglofauna assessed at Western Hill and suitable habitats after mining (proposed scenario)

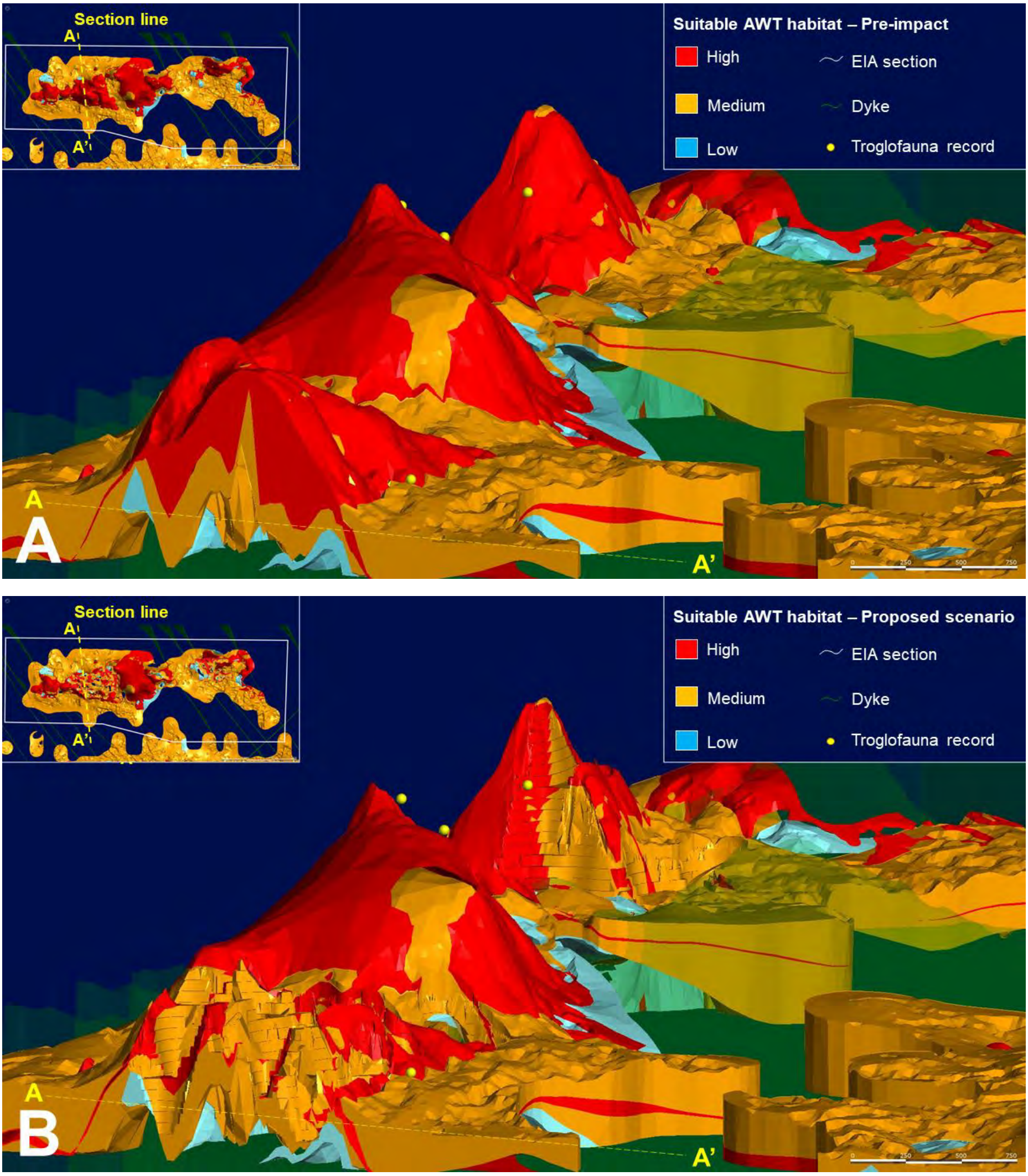


Figure 4.2: Cross-section of the 3D subterranean habitat model showing AWT habitats (A) pre-impact and (B) post-impact (proposed) at Western Hill.*Vertical scale exaggerated x5*

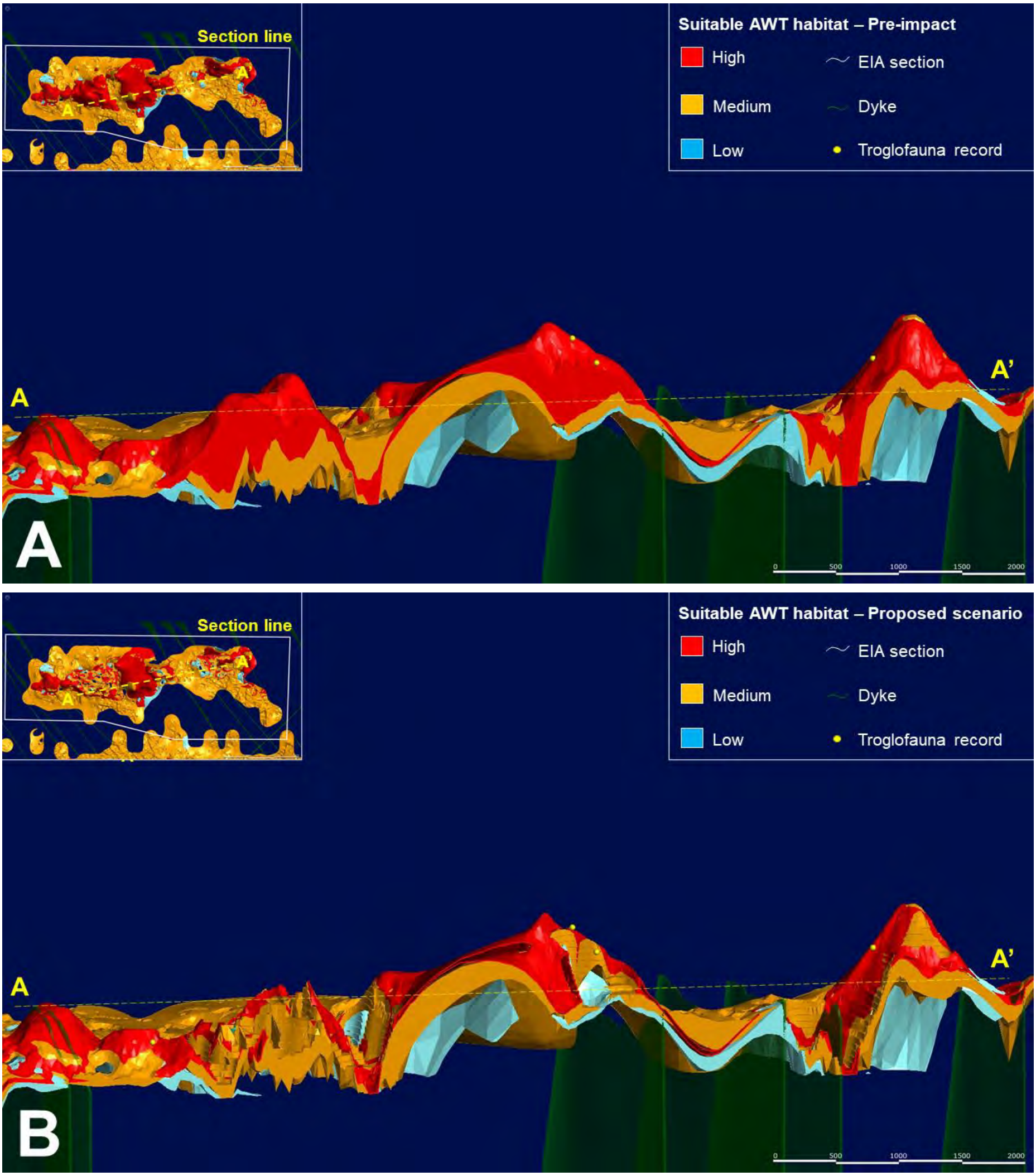


Figure 4.3: Long-section of the 3D subterranean habitat model showing AWT habitats (A) pre-impact and (B) post-impact (proposed) at Western Hill. *Vertical scale exaggerated x5*

692000

696000

7442000

7440000

Arachnida

- Indohya `sp. Biologic-PSEU016`
- Palpigradi `sp. Biologic-PALP017`
- Palpigradi `sp. Biologic-PALP020`
- Prethopalpus `sp. Biologic-ARAN012`
- Theridiidae `sp. Biologic-ARAN010`
- Tyrannochthonius `sp. Biologic-PSEU013`
- Tyrannochthonius `sp. Biologic-PSEU014`

Entognatha

- Parajapigydae `sp. Biologic-DIPL016`

Insecta

- Nocticola `sp. Biologic-BLAT015`
- Phaconeura `sp. Biologic-HEMI003`

Pauropoda

- Pauropoda `sp. Biologic-PAUR017`
- Pseudodiploexochus `sp. WAH`

Symphyla

- Scutigerellidae `sp. Biologic-SYMP011`

Legend

- West Angelas Beyond 2020 Development Envelope
- Current Operations Development Envelope
- EIA Section Boundary
- Main Access Track
- Proposed Pit
- Proposed Waste/ Infrastructure
- Troglofauna Sampling Site
- 3D Modelling Boundary (Vein Model)

Habitat Thickness – Pre-impact

m AWT

High : 281

Low : 1

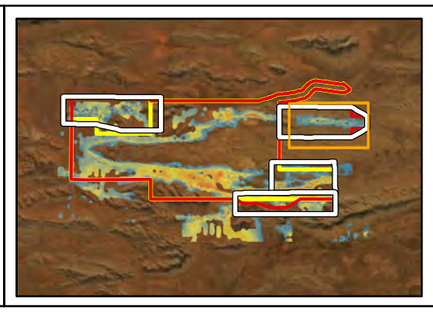
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Scale: 1:24,000

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Coordinate System: GDA 1994 MGA Zone 50
Projection: Transverse Mercator
Datum: GDA 1994 Created 24/08/2022



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Figure 4.4: Troglofauna assessed at Deposit H and suitable habitats after mining (proposed scenario)

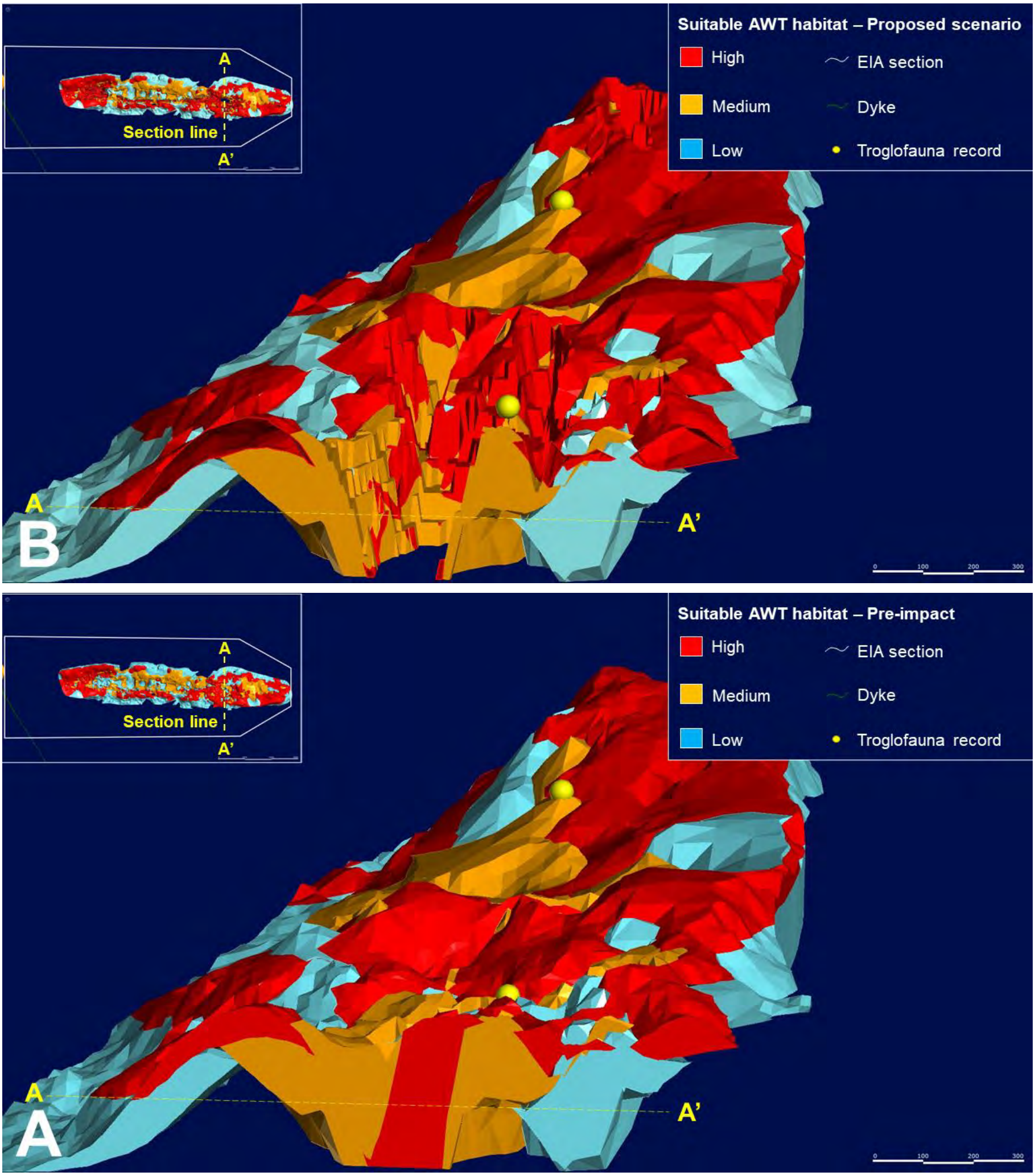


Figure 4.5: Cross-section of the 3D subterranean habitat model showing AWT habitats (A) pre-impact and (B) post-impact (proposed) at Deposit H. *Vertical scale exaggerated x5*

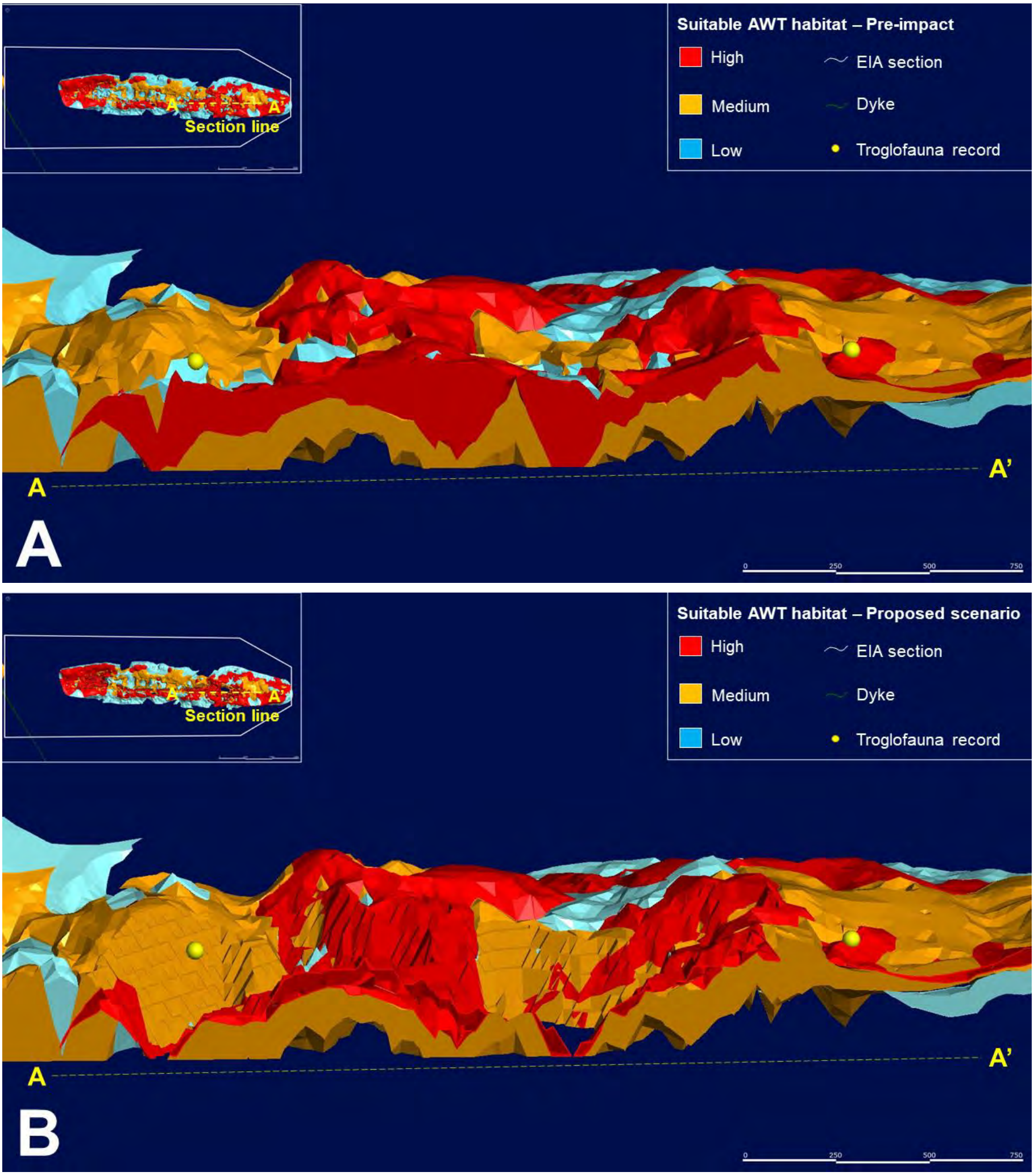


Figure 4.6: Long-section of the 3D subterranean habitat model showing AWT habitats (A) pre-impact and (B) post-impact (proposed) at Deposit H. *Vertical scale exaggerated x5*

688000

692000

7436000

7434000

Arachnida

- Araneae `sp. Biologic-ARAN008`
- Palpigradi `sp. Biologic-PALP018`

Entognatha

- Japygidae `sp. Biologic-DIPL017`

Insecta

- Dodecastyla `sp. Biologic-ZYGE011`
- Nocticola `sp. Biologic-BLAT014`
- Phaconeura `sp. Biologic-HEMI003`

Pauropoda

- Pauropoda `sp. Biologic-PAUR019`

Symphyla

- Scutigerellidae `sp. Biologic-SYMP011`
- Symphyla, Scutigerellidae `sp. Helix-SYM027`

Legend

- West Angelas Beyond 2020 Development Envelope
- Current Operations Development Envelope
- EIA Section Boundary
- Existing Pit
- Proposed Pit
- Proposed Waste/ Infrastructure
- Troglofauna Sampling Site
- 3D Modelling Boundary (Vein Model)

Habitat Thickness – Pre-impact

m AWT

High : 281

Low : 1

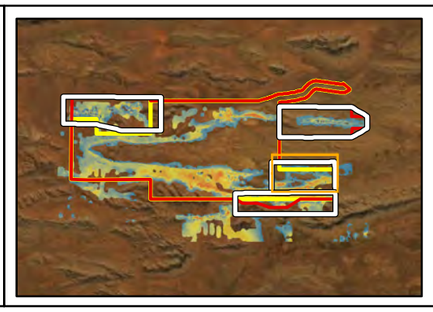
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biologic Environmental Survey

Scale: 1:20,000

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Coordinate System: GDA 1994 MGA Zone 50
Projection: Transverse Mercator
Datum: GDA 1994 Created 24/08/2022



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Figure 4.7: Troglofauna assessed at Deposit F North and suitable habitats after mining (proposed scenario)

688000

692000

7436000

7434000

Arachnida

- Araneae `sp. Biologic-ARAN008`
- Palpigradi `sp. Biologic-PALP018`

Entognatha

- Japygidae `sp. Biologic-DIPL017`

Insecta

- Dodecastyla `sp. Biologic-ZYGE011`
- Nocticola `sp. Biologic-BLAT014`
- Phaconeura `sp. Biologic-HEMI003`

Pauropoda

- Pauropoda `sp. Biologic-PAUR019`

Symphyla

- Scutigerellidae `sp. Biologic-SYMP011`
- Symphyla, Scutigerellidae `sp. Helix-SYM027`

Legend

- West Angelas Beyond 2020 Development Envelope
- Current Operations Development Envelope
- EIA Section Boundary
- Existing Pit
- Proposed Pit
- Proposed Waste/ Infrastructure
- Troglofauna Sampling Site
- 3D Modelling Boundary (Vein Model)

Habitat Thickness – Pre-impact

m AWT

High : 281

Low :

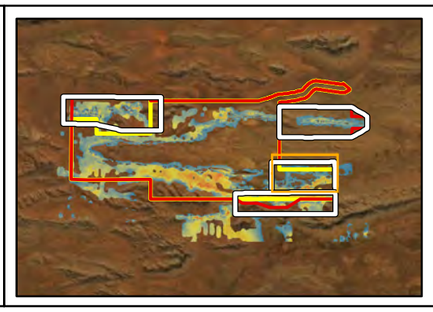
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Scale: 1:20,000

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Coordinate System: GDA 1994 MGA Zone 50
Projection: Transverse Mercator
Datum: GDA 1994 Created 24/08/2022



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West Angelas Environmental Impact Assessment of Subterranean Fauna

Figure 4.8: Troglofauna assessed at Deposit F North and suitable habitats after mining (combined scenario)

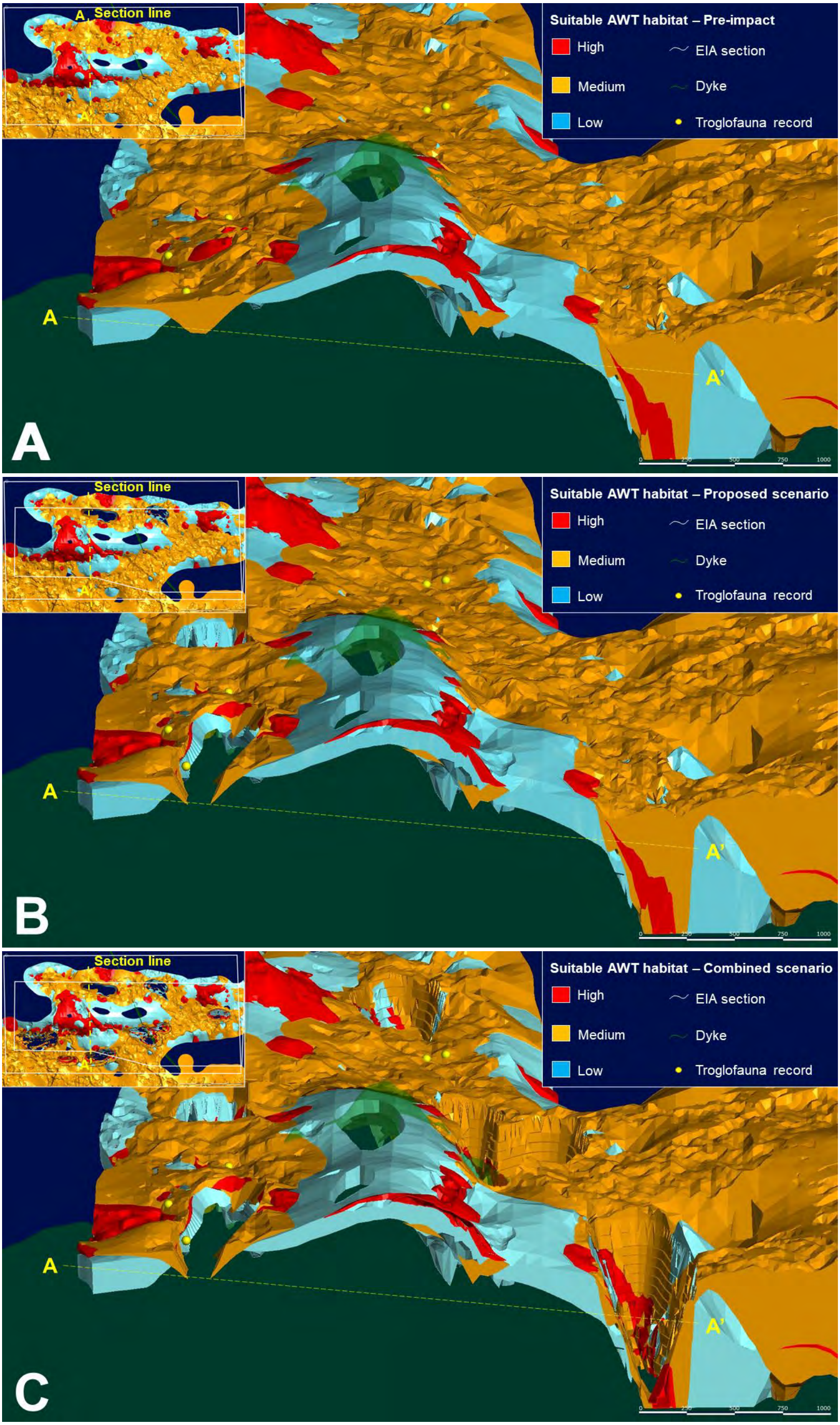


Figure 4.9: Cross-section of the 3D subterranean habitat model showing AWT habitats (A) pre-impact, (B) post-impact (proposed) and (C) post-impact (combined) at Deposit F North. *Vertical scale exaggerated x5*

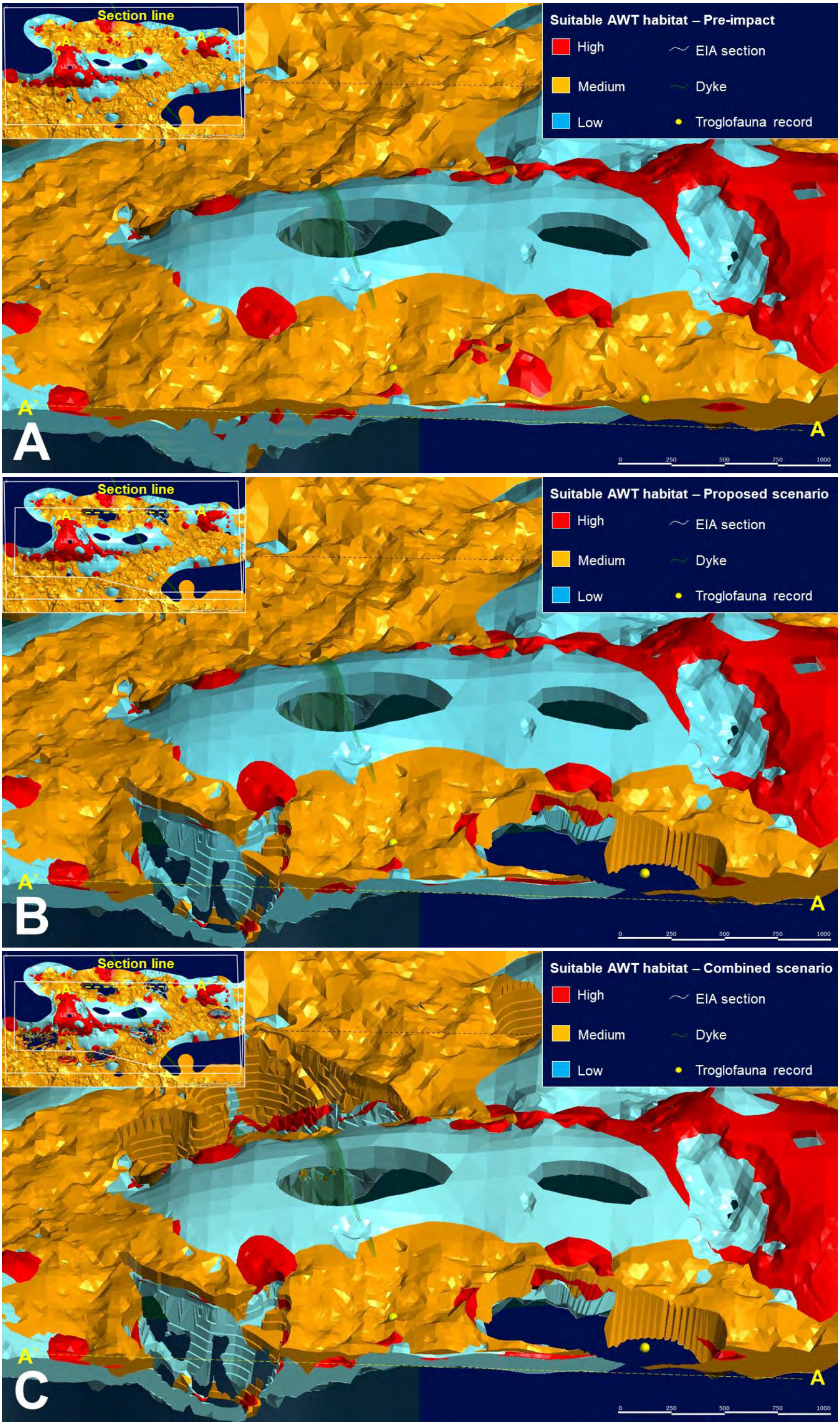


Figure 4.10: Long-section of the 3D subterranean habitat model showing AWT habitats (A) pre-impact, (B) post-impact (proposed) and (C) post-impact (cumulative) at Deposit F North. *Vertical scale exaggerated x5*

682000 684000 686000 688000 690000 692000

7434000 7432000 7430000

Arachnida

- Indolpium `sp. Biologic-PSEU017`
- Oonopidae `sp. Biologic-ARAN018`
- Palpigradi `sp. Biologic-PALP018`
- Palpigradi `sp. Biologic-PALP019`
- Theridiidae `sp. Biologic-ARAN010`
- Tyrannochthonius `sp. Biologic-PSEU011`
- Tyrannochthonius `sp. Biologic-PSEU012`

Insecta

- Atelurinae `sp. Biologic-ZYGE014`
- Dodecastyla `sp. Biologic-ZYGE011`
- Nocticola `sp. Biologic-BLAT014`
- Phaconeura `sp. Biologic-HEMI003`
- Trinemura `sp. Biologic-ZYGE017`

Malacostraca

- Philosciidae `sp. Biologic ISOP015`

Symphyla

- Hanseniella `sp. Biologic-SYMP018`

Legend

- West Angelas Beyond 2020 Development Envelope
- Current Operations Development Envelope
- EIA Section Boundary
- Existing Pit
- Proposed Pit
- Proposed Waste/ Infrastructure
- Troglofauna Sampling Site
- 3D Modelling Boundary (Vein Model)

Habitat Thickness – Pre-impact

m AWT

High : 281

Low : 1

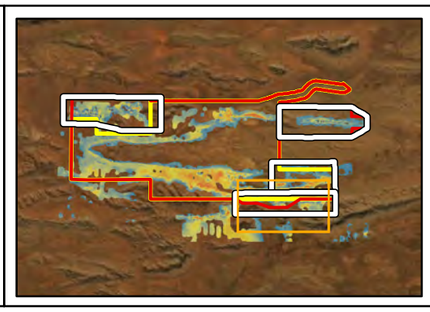
N

biologic Environmental Survey

Scale: 1:27,700

0 0.5 1 1.5 Km

Coordinate System: GDA 1994 MGA Zone 50
Projection: Transverse Mercator
Datum: GDA 1994 Created 24/08/2022



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West Angelas Environmental Impact Assessment of Subterranean Fauna

Figure 4.11: Troglofauna assessed at Mt Ella East and suitable habitats after mining (proposed scenario)

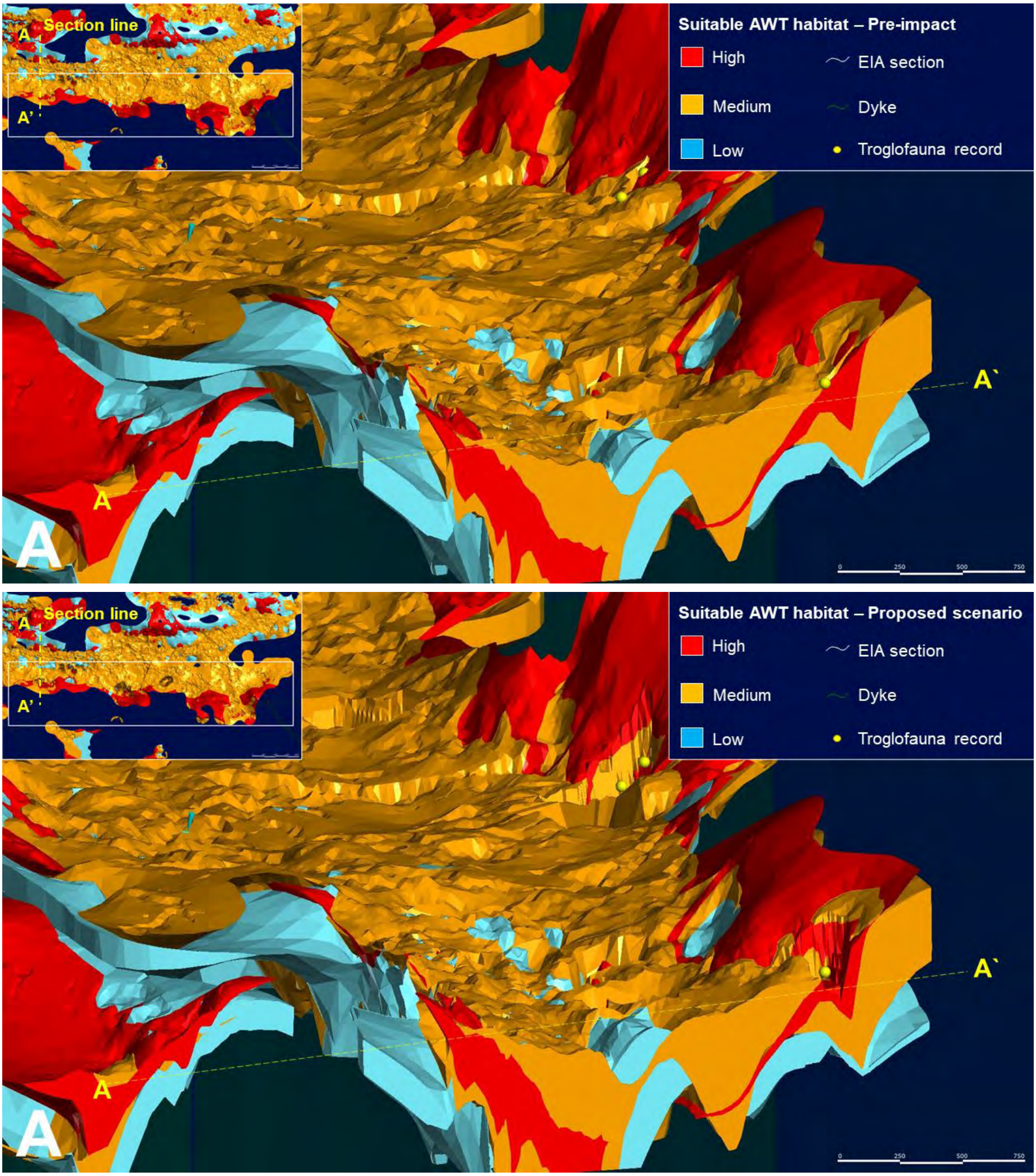


Figure 4.12: Cross-section of the 3D subterranean habitat model showing AWT habitats (A) pre-impact and (B) post-impact (proposed) at Mt Ella East. *Vertical scale exaggerated x5*

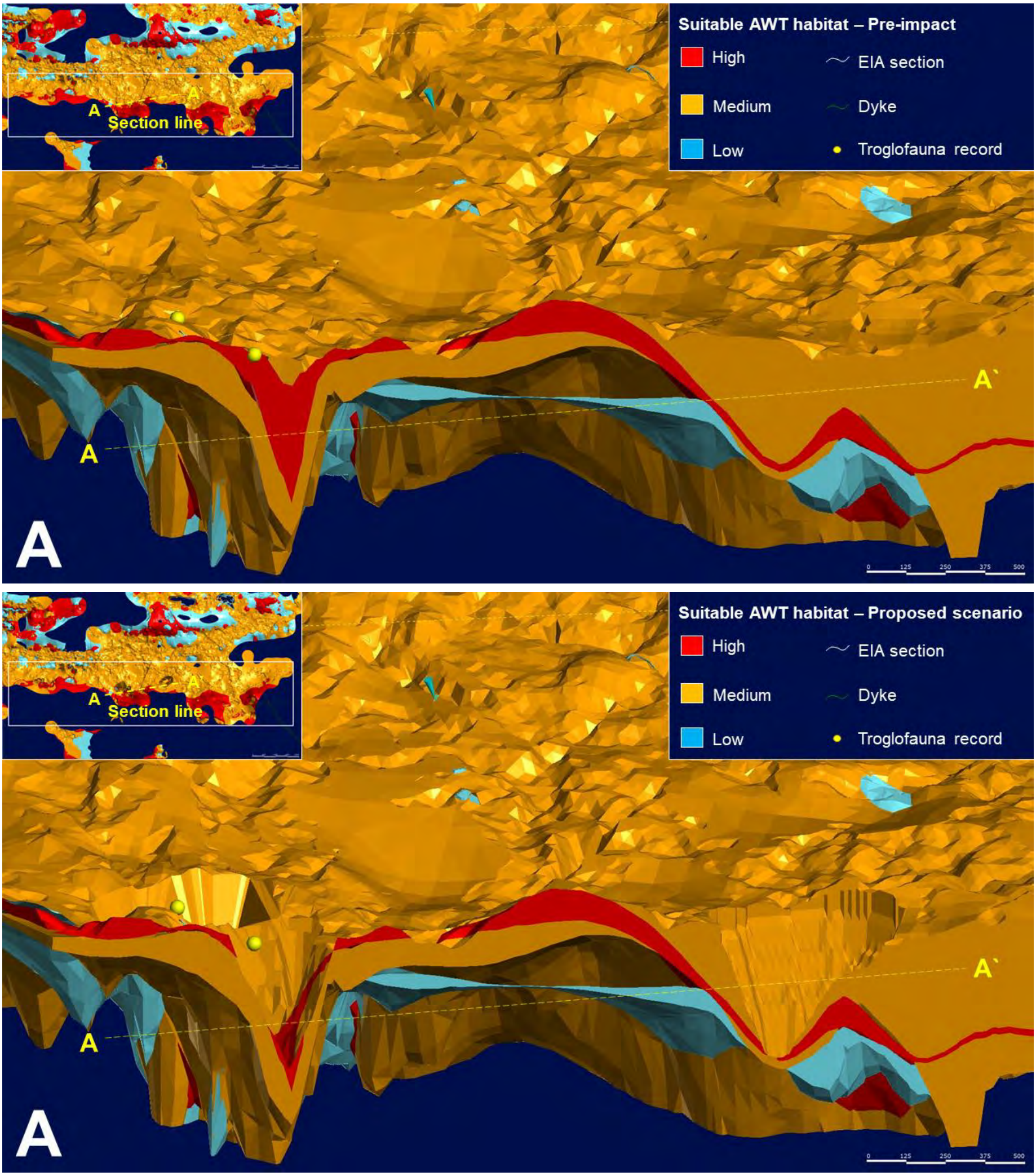


Figure 4.13: Long-section of the 3D subterranean habitat model showing AWT habitats (A) pre-impact and (B) post-impact (proposed) at Mt Ella East *Vertical scale exaggerated x*

4.1.3 Overall summary of direct impacts to troglofauna values

Throughout the Development Envelope, the direct impacts of the Proposal to troglofauna habitat and species values are not predicted to be significant overall. The 3D modelling showed that direct impacts only affect approximately 2% of the overall habitat modelled within the four Development Envelope sections, and predicted habitat loss does not exceed 17% of the habitat modelled in any section of the Development Envelope (Table 4-5). The habitats predicted to remain intact under the proposed scenario are extensive, reasonably thick, and well-connected (compare A and B of Figure 4.14Figure 4.14) and are expected to continue to support troglofauna.

Table 4-5: Overall summary of the proportions of troglofauna habitat directly impacted by the Proposal (proposed scenario) based on 3D modelling of habitat loss

Development Envelope Section	Pre-mining 3D habitat volume (m^3, '000)	Proposed scenario 3D habitat loss		Change to AWT habitat extent, thickness, connectivity	Overall impact to troglofauna habitat values
		m^3 ('000)	%		
Western Hill	845,580	144,310	17%	Minor	Low
Deposit H	189,173	24,801	13%	Minor	Low
Deposit F North	727,330	19,760	3%	Negligible	Low
Mt Ella East	1,163,720	27,390	2%	Negligible	Low
Remaining West Angelas	6,258,877	0	0%	None	None
Total Development Envelope	**9,184,680**	**216,261**	**2%**	**Minor**	**Low**

The Low overall impacts to habitat values, and the retention of the majority of suitable habitat as modelled under the proposed scenario is a key moderating factor for the significance of impacts to troglofauna species values.

From a total of 42 troglofauna taxa in the assessment, impacts to 7 troglofauna taxa known only from direct impact areas were ranked as Medium, while 35 troglofauna taxa (species known to occur or highly likely to occur beyond direct impacts) were ranked as Low impact (Table 4-6).

Sufficient suitable habitats AWT are expected to be retained in all areas relevant to the occurrence or range of all known troglofauna species. No troglofauna species were ranked as High impact, and no values are expected to be lost as a direct impact from the implementation of the Proposal.

Table 4-6: Number of troglofauna taxa within each impact rank under the proposed scenario

Development Envelope Section	High Ranked Taxa	Medium Ranked Taxa	Low Ranked Taxa
Western Hill	-	6	8
Deposit H	-	1	12
Deposit F North	-	-	8
Mt Ella East	-	-	14
Total Development Envelope	**0**	**7**	**35^**

^ Some low-risk taxa were recorded in multiple Development Envelope areas.

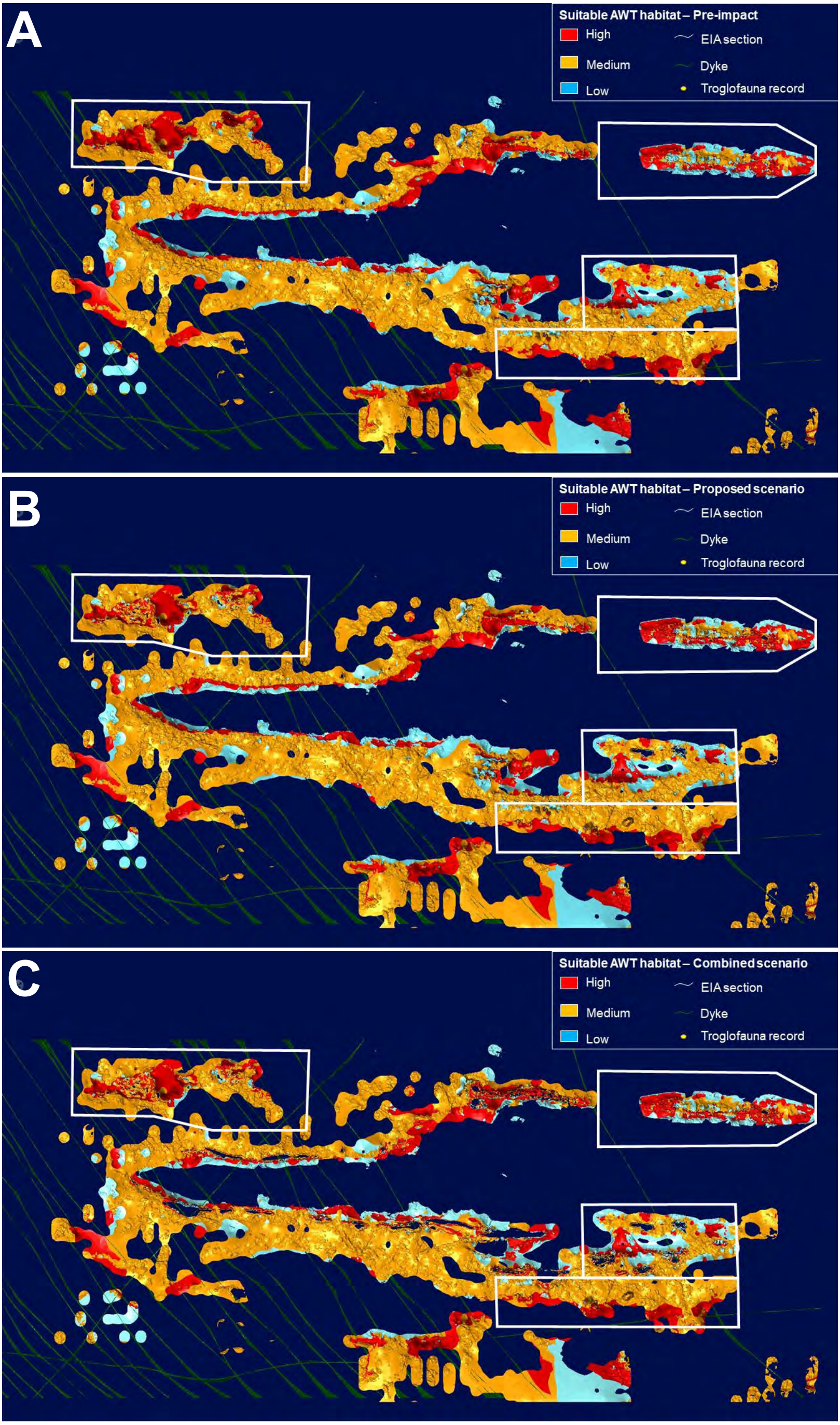


Figure 4.14: Overview of the 3D habitat model showing AWT habitats remaining in the (A) pre-impact, (B) proposed and (C), combined scenario

4.2 Indirect impacts

Indirect impacts to troglofauna values are considered Low in all four sections of the Development Envelope (Table 4-7). The two-dimensional spatial assessment of the proposed waste dumps and stockpile areas against the modelled extent of AWT habitat remaining in the worst-case (combined scenario) showed that only a minor proportion (approximately 3%) of the suitable habitat remaining intact despite combined impacts would potentially be subject to indirect impacts (Table 4-7).

In the context of the conservative modelling boundaries (section 2.4) and the subtle and gradational nature of indirect impacts (section 2.2.2), the finding that only 3% of the area of suitable habitat AWT is predicted to occur within indirect impact areas shows that indirect impacts from the Proposal are unlikely to be to be significant. Consequently, indirect impacts from waste dumps and stockpiles are not expected to increase the impact ranking of any troglofauna habitat or species values within the Development Envelope.

Table 4-7: Overall summary of the proportions of troglofauna habitat remaining under the worst-case (combined scenario) indirectly impacted by the Proposal, based on 2D area assessment

Development Envelope Section	Minimum area of 2D habitat outside impacts (combined scenario) (ha)	Area of habitat within proposed indirect impacts (waste, stockpiles)		Overall indirect impact to troglofauna habitat
		ha	% *	
Western Hill	2,030	248	12%	Low
Deposit H	899	131	15%	Low
Deposit F North	1,627	79	5%	Low
Mt Ella East	1,860	93	5%	Low
Remaining West Angelas	13,679	37	<1%	Negligible
Total Development Envelope	**20,095**	**588**	**3%**	**Low**

*percentage of the 2D habitat area remaining in the worst-case (combined) scenario that is occupied by proposed waste dumps and stockpiles

A total of six troglofauna taxa were recorded within indirect impact areas (waste dumps/ stockpiles) comprising five taxa at Deposit H (*Prethopalpus* `sp. Biologic-ARAN012`, Theridiidae `sp. Biologic-ARAN010`, *Indohya* `sp. Biologic-PSEU016`, *Tyrannochthonius* `sp. Biologic-PSEU014`, and Pauropoda `sp. Biologic-PAUR017`), and one taxon at Deposit F North (Scutigerellidae sp. `Helix-SYM027`). For the reasons detailed above, the indirect impacts to these taxa are considered Low.

4.3 Combined direct impacts

The overall combined impacts of current/ approved and proposed mining activities on troglofauna habitat and species values within the Development Envelope are considered Low. The 3D modelling predicted that combined direct impacts only affect approximately 12% of suitable habitat within the Development Envelope, and predicted habitat loss does not exceed 22% in any particular section (Table 4-8).

The habitats predicted to remain intact under the combined scenario are extensive, reasonably thick, and well-connected (compare A and C of Figure 4.14Figure 4.14) and are expected to continue to support troglofauna.

Table 4-8: Overall summary of the proportions of troglofauna habitat impacted by combined direct impacts (current and proposed) within the Development Envelope.

Development Envelope Section	Pre-mining 3D habitat volume (m^3, '000)	Combined scenario 3D habitat loss		Change to AWT habitat extent, thickness, connectivity	Overall impact to troglofauna habitat values
		m^3 ('000)	%		
Western Hill	845,580	144,310	17%	Minor	Low
Deposit H	189,173	24,801	13%	Minor	Low
Deposit F North	727,330	156,283	22%	Minor	Low
Mt Ella East	1,163,720	38,660	3%	Negligible	Low
Remaining West Angelas	6,258,877	712,586	11%	Not assessed	Not assessed
Total Development Envelope	**9,184,680**	**1,076,640**	**12%**	**Minor**	**Low**

Combined impacts are only present in the vicinity of existing operations at Deposit F North and, to a negligible degree, at Mt Ella East. There are no combined impacts from existing operations at Western Hill and Deposit H. Therefore, the assessment findings and outcomes are expected to be unchanged from the proposed (direct impacts) scenario in these two sections of the Development Envelope.

At Mt Ella East, combined impacts to troglofauna habitats and species are negligible, as modelling predicts a negligible (1%) additional loss of AWT habitat compared to the proposed scenario. Approximately 97% of the pre-impact volume of suitable AWT habitat is predicted to be retained following combined impacts. Therefore, the assessment findings and outcomes are expected to be unchanged from the proposed (direct impacts) scenario at Mt Ella East.

At Deposit F North, combined impacts to troglofauna habitat values are considered Low, because:

- the proposed mining activities result in a relatively small reduction of suitable habitat, approximately 22% of the pre-impact volume (based on conservative assessment of high and medium suitability combined) (Table 4-8). Approximately 78% of the pre-mining suitable habitat AWT is expected to be retained (Figure 4.8).
- Modelling shows a moderate change in habitat thickness, extent, and connectivity throughout Deposit F North (compare B and C of Figure 4.9 and Figure 4.10). The overall extent and connectivity of AWT habitats outside of the current and proposed pit areas is maintained.
- The current 3D modelling boundary (constrained by 300 m distance from drill holes, and the shallow depth of drilling across the deposit) is considerably narrower than the mapped extent of highly prospective MMIF geology at Deposit F North. It is expected that the additional suitable habitat may exist at depths beyond the current drilling, and outside the modelled area within the wider mapped extent of MMIF geology.

Consideration of current mining operations at Deposit F North did not alter the impact rankings of troglofauna taxa compared to the direct impact scenario (as detailed in section 4.1.2, Table 4-9) as:

- The predicted habitat loss under the combined scenario is considered Low (Table 4-8);
- The majority of troglofauna taxa occur in the northern part of the Deposit (F North), whereas all existing/approved pits are located in the southern part of Deposit F (Figure 4.8); and
- The majority of the troglofauna taxa recorded at Deposit F North are locally or regionally widespread, therefore combined impacts within their known linear ranges are low (overall 88% modelled suitable habitat retained throughout the Development Envelope).

Table 4-9: Number of troglofauna taxa within each impact rank under the combined scenario

Development Envelope Section	High Ranked Taxa	Medium Ranked Taxa	Low Ranked Taxa
Western Hill	-	6	8
Deposit H	-	1	12
Deposit F North	-	-	8
Mt Ella East	-	-	14
Total Development Envelope	**0**	**7**	**35^**

^ Some low-risk taxa were recorded in multiple Development Envelope sections.

4.4 Cumulative direct impacts

As outlined in section 2.2.4, it is unlikely that the impacts of any third-party operations in the wider regional area surrounding the West Angelas Region would affect troglofauna habitats or species values relevant to the Proposal. As a result, no cumulative impacts to troglofauna values are anticipated for the current assessment.

5. ASSESSMENT OF IMPACTS TO STYGOFAUNA

Impacts to stygofauna habitat and species values were assessed following the framework detailed in section 2.

5.1 Direct impacts from the Proposal

5.1.1 Impacts to stygofauna habitat values per section of the Development Envelope

Western Hill

The direct impacts of the Proposal on stygofauna habitats at Western Hill are considered Low, because:

- The proposed mining and groundwater drawdown (for supply) results in reduction of approximately 1% of the pre-impact volume of suitable habitat BWT as modelled within the section boundary (orebody aquifer) (Table 5-2).
- The proposed impacts at Western Hill are unlikely to have a significant impact on the overall thickness, extent or connectivity of BWT habitat in the orebody aquifer (compare A and B of Figure 5.2)
- The groundwater drawdown radial extent from the dewatering at Western Hill is mostly contained to the vicinity of the proposed pits and beneath the range itself, due to the low permeability of the Mt McRae Shales acting as a barrier (Figure 5.1, Rio Tinto, 2020).
- Groundwater drawdown extending, to the south, beyond the proposed pits at Western Hill is estimated to be less than 0.5 m, representing a negligible change in groundwater levels, within the range of the natural variability of the aquifer (Rio Tinto, 2020).

In this context, the direct impacts to stygofauna habitat values at Western Hill and the surrounding synclinal aquifer are expected to be Low, and the ecological integrity of the wider synclinal aquifer should not be significantly affected by the proposed direct impacts.

Deposit H

The direct impacts of the Proposal on stygofauna habitats at Deposit H are considered Low, because:

- The proposed mining and groundwater drawdown results in reduction of approximately 23% of the pre-impact volume of suitable habitat BWT as modelled within the section boundary (Table 5-2).
- Approximately 77% of the pre-impact volume of suitable habitat BWT is expected to be retained (Appendix B, Table B-2).
- The 3D modelling shows a minor reduction in habitat thickness, but the extent and connectivity of the BWT habitat remains unchanged (compare A and B of Figure 5.8 and Figure 5.9).

- The aquifer at Deposit H is hosted within the porous/ weathered/ fractured MMIF which is deeply folded and restricted in all directions by the low permeability Fortescue Group geologies. This has formed a 'bath-tub' type aquifer: a closed system that is not connected to other regional aquifers in the Development Envelope.
- The extent of suitably porous rock BWT at Deposit H is very deep within the MMIF (>200 m) due to intense folding and deep fractures within the Mt Newman Member. An indicative system basement of 150 m has been applied for conservative volumetric calculations, but drill hole data shows high to medium porosity as deep as 200 m in some areas at Deposit H.

Sampling at the Deposit H aquifer did not record any obligate stygofauna species (stygobites). The amount of BWT sampling was limited by the number of bores and drill holes intercepting the water table available at the time of survey, but the amount of sampling undertaken would have been sufficient to detect a richer stygofauna assemblage if present. In the context of the available information and acknowledged sampling constraints, it is unlikely that the Deposit H aquifer supports a rich stygofauna assemblage or represents a high value habitat for stygofauna. Nevertheless, assuming that undetected stygofauna taxa could occur at Deposit H, the reduction of 23% and retention of 77% of the suitable habitat BWT would still constitute a Low-level impact to any stygofauna values.

In this context, the overall impacts of the Proposal on BWT habitat values at Deposit H are Low. The ecological integrity of the suitable habitat BWT is expected to be maintained.

Deposit F North

The proposed mining at Deposit F North does not intersect a significant groundwater habitat. Hydrogeological studies showed that the western proposed pit is entirely AWT, and the eastern pit only hosts a small, locally constrained patch of groundwater. This small pocket of water is located deep below the surface at ~716 mRL (~78 m below ground), as interpreted from exploration hole geophysics and validated with water levels from two 2017 exploration grade holes converted into monitoring bores. The patch of groundwater at Deposit F North is of low porosity and is functionally disconnected from other groundwater systems as it is surrounded by low permeability unmineralized MacLeod and Nammuldi Members of the Marra Mamba Iron Formation and dolerite dykes on all sides

No stygobitic fauna were collected at Deposit F North from samples accessing groundwater within the proposed eastern pit. Given the considerable depth from surface, constrained extent and low porosity, it is unlikely that this small aquifer provides a suitable habitat for stygofauna. As this aquifer is unlikely to form a suitable habitat for stygofauna, the direct impacts from the Proposal to stygofauna habitat values at F North will be negligible.

Mt Ella East

The proposed mining at Mt Ella East is entirely AWT and does not intersect any groundwater habitat. The Mt Ella East pits are situated on the north facing flanks of Mt Ella, and the nearest

groundwater table occurs at depths approximately 120 mbgl in the valley to the north, between the proposed Mt Ella East pits and the current operations at Deposit E.

No stygofauna were collected by net hauling or scraping at Mt Ella East, and most of the holes and bores were dry to depths of 100 mbgl or beyond. Given the depth to groundwater and the lack of stygofauna from sampling, this area is not expected to provide suitable habitat for stygofauna.

As the proposed mining at Mt Ella East will not intersect groundwater or require any groundwater abstraction from bores in the area, the direct impacts from the Proposal to stygofauna habitat values will be negligible.

5.1.2 Impacts to stygofauna species values per section of the Development Envelope

Western Hill

The direct impacts of the Proposal on stygofauna species at Western Hill are considered Low for one stygofauna species exclusively known from Western Hill orebody aquifer (Enchytraeidae `sp. Biologic-OLIG008`) and one species known from both the Western Hill orebody aquifer as well as the synclinal valley (*Kruptus* `sp. Helix-AMP035`) (Table 5-1). The remaining ten stygofauna taxa from Western Hill occur exclusively within the synclinal aquifer to the south of the orebody aquifer. Groundwater drawdown modelling (Rio Tinto 2021) shows that the propagation of groundwater drawdown from the Western Hill orebody aquifer to the synclinal valley is expected to be negligible (less than 0.5 m) under the proposed scenario. The groundwater drawdown from the Western Hill orebody aquifer is expected to be limited by the low permeability Mt McRae Shales except where affected by major faulting/fracturing, which accounts for the limited propagation southwards into the synclinal valley (Rio Tinto 2021). The level of groundwater drawdown predicted to propagate beyond the Mt McRae Shales is expected to be within the natural variability of groundwater table fluctuations (0.5 m following Rio Tinto 2021) and is consequently considered to have a negligible impact on stygofauna values.

Table 5-1: Summary of direct impact rank and rationale for stygofauna taxa recorded within the groundwater impact area at Western Hill (proposed scenario) (refer Figure 5.1)

Taxon	Likelihood of occurring beyond direct impacts	Magnitude of direct impacts	Suitability of habitat remaining	Direct impact rank
Amphipoda				
Kruptus `sp. Helix-AMP035`	Confirmed. Occurs throughout synclinal aquifer south of Western Hill.	Minor. 2m drawdown at record. Habitat remains approx. 60m thick.	Unlikely to change. BWT habitat approx. 60m	**Low**
Haplotaxida				
Enchytraeidae `sp. Biologic-OLIG008`	Highly likely - amphibious, not limited to groundwater. Most enchytraeids regionally widespread.	Negligible. Moist subterranean habitats extensive beyond impacts	Unlikely to change habitat suitability	**Low**

The oligochaete worm Enchytraeidae `sp. Biologic-OLIG008` belongs to an amphibious group that is typically widespread and can occur within moist air-filled subterranean cavities, therefore is less

susceptible to drawdown impacts. Enchytraeids are typically found to be locally or regionally widespread, and other similar taxa from the Development Envelope had linear ranges up to 53 km. Therefore, this taxon is unlikely to be restricted to impact areas.

The amphipod *Kruptus* `sp. Helix-AMP035` was recorded from Western Hill orebody aquifer where there will be minimal drawdown, as well as several other sites within the synclinal valley beyond the propagation of the groundwater drawdown from the Proposal. It is at low risk of impact under the proposed scenario due to its wider known range beyond the proposed drawdown from the Western Hill pits.

Deposit H

As mentioned previously, sampling in the Deposit H aquifer did not record any stygobitic fauna species; only two regionally widespread, amphibious enchytraeid worms were recorded (Figure 5.7; Biologic, 2022a), and these species are unlikely to be impacted and are therefore not included in this assessment (section 3.3). Sampling effort was constrained by the availability of bores/ drill holes intercepting groundwater at the time of survey, however, would likely have detected a richer stygofauna assemblage if present.

In the context the available information and acknowledged sampling constraints, it is unlikely that the Deposit H aquifer supports a rich stygofauna assemblage. Nevertheless, assuming undetected stygofauna taxa could occur at Deposit H, the reduction of 23% and retention of 77% of the suitable habitat BWT would still constitute a Low-level impact to any stygofauna taxa present.

In this context, the direct impacts of the Proposal on stygofauna species values at Deposit H are negligible, and the Proposal does not pose a risk to stygofauna values known from this area.

Deposit F North

No true stygofauna were collected by net hauling or scraping at Deposit F North, although two regionally widespread enchytraeid worms were recorded (Biologic, 2022a). As both enchytraeid taxa recorded from this area are regionally widespread (known linear ranges >100 km), and enchytraeid worms are not obligate stygofauna species, these taxa are unlikely to be impacted and are not included in the assessment.

Deposit F North does not provide significant habitat for stygofauna, as groundwater occurs within a small, locally-restricted patch deep below the surfaces and is disconnected from other local aquifers. Groundwater drawdown at Deposit F North will be confined within this small, localised patch due to surrounding low permeability geologies.

In this context, the direct impacts of the Proposal on stygofauna species values at Deposit F North are negligible.

Mt Ella East

No stygofauna have been recorded at Mt Ella East, and the nearest groundwater table occurs at considerable depth below surface. Mt Ella East is not expected to provide significant stygofauna habitat, and no stygofauna species values are known to occur.

As the proposed mining at Mt Ella East will not intersect groundwater or require any abstraction from bores in the area, the direct impacts from the Proposal to stygofauna species values will be negligible.

5.1.3 Overall summary of direct impacts to stygofauna values

The overall magnitude of the direct impacts from the Proposal to stygofauna habitat and species values throughout the Development Envelope is predicted to be Low. The 3D habitat modelling BWT showed that the direct impacts from the Proposal only affect approximately 14% of the modelled stygofauna habitats within the West Angelas Region, and this does not exceed 23% of the habitat modelled in any particular section (Appendix B, Table 5-2). The habitats predicted to remain intact under the proposed scenario are extensive, relatively thick, and expected to continue to support stygofauna.

The predicted stygofauna habitat loss is considered to represent a conservative quantified estimate, as BWT modelling was delimited to a 300 m distance surrounding each drill hole, and to an indicative conceptual basement of 150 m below the topographic surface. In areas such as the synclinal aquifer surrounding Western Hill, additional BWT habitats are likely to occur beyond the modelling and beyond the Development Envelope boundaries. In other areas of the Development Envelope, suitably porous hydrogeological habitats are inferred to occur at depth within Zone B (to an indicative system basement of 150 mbgl), well beyond the depth of groundwater drawdown impacts (Biologic, 2022a).

Table 5-2: Overall summary of the proportions of stygofauna habitat (combined high, medium and inferred suitability) directly impacted by the Proposal based on 3D modelling of habitat loss

Development Envelope Section	Pre-mining 3D habitat volume (m^3, '000)	Proposed scenario 3D habitat loss		Change to BWT habitat extent, thickness, connectivity	Overall impact to stygofauna habitat values
		m^3 ('000)	%		
Western Hill Deposit (orebody aquifer)*	**409,281** *Zone A: 54,171* *Zone B: 355,110*	**5,707** *Zone A: 1,987* *Zone B: 3,720*	1%	Negligible	Low
Deposit H	**598,930** *Zone A: 39,820* *Zone B: 559,110*	**135,828** *Zone A: 17,828* *Zone B: 118,000*	**23%**	Minor	Low
Deposit F North^	NA	NA	NA	NA	Negligible
Mt Ella East^	NA	NA	NA	NA	Negligible
Total (excluding synclinal valley)	**1,008,211**	**141,535**	**14%**	**Minor**	**Low**

*Groundwater drawdown propagation into Western Hill synclinal valley is negligible (<0.5 m GWDD) and within natural variability of groundwater table fluctuations and therefore, the synclinal valley was excluded from the direct impact assessment.

^no significant stygofauna habitat values occur at Deposit F North and Mt Ella East. Mt Ella East is not proposed for BWT mining and proposed groundwater drawdown at Deposit F North is not expected to affect stygofauna habitat values as it is unsuitable for stygofauna and disconnected from other groundwater systems.

From a total of 12 stygofauna taxa in the assessment, only two taxa recorded from the Western Hill orebody aquifer are at risk from direct impacts from the Proposal. Impacts to these two taxa were ranked as Low (Table 5-3). The remaining 10 stygofauna taxa in the assessment are exclusively known from the synclinal valley which will receive negligible direct impacts from groundwater drawdown from the Proposal.

Sufficient suitable habitats BWT are expected to be retained in all areas relevant to the occurrence or range of all known stygofauna species. No stygofauna species was ranked as High impact, and no species values are expected to be lost as a direct impact from the implementation of the Proposal.

Table 5-3: Number of stygofauna taxa within each impact rank under the proposed scenario

Dev Envelope Section	High Ranked Taxa	Medium Ranked Taxa	Low Ranked Taxa
Western Hill	-	-	2
Deposit H	-	-	-
Deposit F North	-	-	-
Mt Ella East	-	-	-
Total Development Envelope	**0**	**0**	**2**

5.2 Indirect impacts

Indirect impacts to stygofauna values are considered Low or Negligible in all four sections of the Development Envelope (Table 5-4). The degree of indirect impact from surface landform changes such as waste dumps and stockpiles to groundwater habitat occurring at variable depths below surface is not easily quantified. Nevertheless, the 2D spatial assessment of indirect impact areas against the modelled extent of BWT habitat remaining intact (under the proposed scenario) showed that only a minor proportion (approximately 7%) of the remaining suitable habitat (Zone A and Zone B) would be subject to indirect impacts (Table 5-4). No stygofauna taxa were recorded within indirect impact areas (waste dump/ stockpile).

Given the subtle and gradational nature of indirect impacts from land surface changes (section 2.2.2), and the management of risks associated with surface hydrology changes, spills and contamination, acid rock drainage, and environmental incidents via procedural controls, the indirect impacts from the Proposal are unlikely to be significant to BWT habitats. Consequently, indirect impacts are not expected to increase the impact ranking of any stygofauna habitat or species value within the Development Envelope.

Table 5-4: Overall summary of the proportions of stygofauna habitat remaining under the worst-case (proposed scenario) indirectly impacted by the Proposal based on 2D area assessment

Development Envelope Section	Minimum area of 2D habitat remaining intact (proposed scenario) (ha)	Area of habitat within proposed indirect impacts (waste, stockpiles)		Overall impact to stygofauna habitat values
		ha	% *	
Western Hill (orebody aquifer)	851	0	0%	Negligible
Deposit H	755	120	16%	Low
Deposit F North^	NA	NA	NA	Negligible
Mt Ella East^	NA	NA	NA	Negligible
Total Development Envelope	**1605**	**120**	**7%**	**Low**

*percentage of the 2D BWT habitat area remaining in the proposed scenario that is occupied by proposed waste dumps and stockpiles. ^no significant stygofauna habitat modelled at Deposit F North and Mt Ella East.

5.3 Combined direct impacts

The overall combined impacts of current/ approved and proposed mining activities on stygofauna habitat and species values within the Development Envelope are considered Low. The 3D modelling predicted that combined direct impacts only affect approximately 17% of suitable habitat within the Development Envelope, and predicted habitat loss does not exceed 23% in any particular section of the Development Envelope (Table 5-5).

The habitats predicted to remain intact under the combined scenario are extensive, reasonably thick, and well-connectedFigure 4.14 and are expected to continue to support stygofauna.

Table 5-5: Overall summary of the proportions of stygofauna habitat impacted by combined direct impacts (current and proposed) without MAR in the synclinal Valley

Development Envelope Section	Pre-mining 3D habitat volume (m^3, '000)	Combined scenario 3D habitat loss		Change to BWT habitat extent, thickness, connectivity	Overall impact to stygofauna habitat values
		m^3 ('000)	%		
Vein model					
Western Hill (orebody aquifer	**409,281** *Zone A: 54,171* *Zone B: 355.110*	**7,796** *Zone A: 2,286* *Zone B: 5,510*	<1%	Negligible	Low
Deposit H	**598,930** *Zone A: 39,820* *Zone B: 559,110*	**135,828** *Zone A: 17,828* *Zone B: 118,000*	23%	Minor	Low
Stratigraphic model					
Western Hill Synclinal Valley without MAR	**13,996,583** *Zone A: 2,465,385* *Zone B: 11,531,198*	**2,396,269** *Zone A: 499,288* *Zone B: 1,896,981*	17%	Minor	Low
Total	**15,004,794**	**2,539,893**	**17%**	**Minor**	**Low**

Implementation of the MAR (as per Ministerial statement 1113) is predicted to reduce the combined impacts on stygofauna habitats. Following implementation of the MAR, habitat modelling predicts the retention of 97% of suitable habitat as modelled under the combined scenario (Table 5-6). Table 5.6 shows that the combined impact scenario with MAR is predicted to result in an approximate 3% BWT habitat loss throughout the synclinal valley regional aquifer, while in the combined scenario without MAR, the predicted habitat loss BWT is approximately 17% (Table 5-5).

Table 5-6: Overall summary of the proportions of stygofauna habitat impacted by combined direct impacts (current and proposed) with MAR in the Synclinal Valley

Development Envelope Section	Pre-mining 3D habitat volume (m^3, '000)	Combined scenario 3D habitat loss with MAR in the Synclinal Valley		Change to BWT habitat extent, thickness, connectivity	Overall impact to stygofauna habitat values
		m^3 ('000)	%		
Vein model					
Western Hill (orebody aquifer	**409,281** *Zone A: 54,171* *Zone B: 355.110*	**7,796** *Zone A: 2,286* *Zone B: 5,510*	<1%	Negligible	Low
Deposit H	**598,930** *Zone A: 39,820* *Zone B: 559,110*	**135,828** *Zone A: 17,828* *Zone B: 118,000*	23%	Minor	Low
Stratigraphic model					
Western Hill Synclinal Valley with MAR	**13,996,583** *Zone A: 2,465,385* *Zone B: 11,531,198*	**265,201** *Zone A: -27,425* *Zone B: 292,626*	2%	Minor	Low
Total	**15,004,794**	**408,825**	**3%**	**Minor**	**Low**

Impacts to all 12 stygofauna in the assessment are predicted to be Low under the combined scenario (Table 5-7). There are no additional impacts from existing operations predicted at Deposit H and Western Hill orebody aquifer, and therefore the assessment findings and outcomes are unchanged from the proposed (direct impacts) scenario in these two areas. Combined impacts from existing and proposed operations are solely expected to occur in the synclinal valley regional aquifer south of Western Hill. Key moderating factors for the significance of impacts to stygofauna species values were the Low overall impacts to stygofauna habitat values and the retention of the majority of suitable habitat as modelled under the combined scenario, with and without the implementation of the MAR.

Table 5-7: Numbers of stygofauna taxa within each impact rank under the combined impact scenario

Development Envelope Section	High impact	Medium impact	Low impact
Western Hill	-	-	2
Synclinal Valley			11
Deposit H	-	-	-
Deposit F North	-	-	-
Mt Ella East	-	-	-
Total	**0**	**0**	**12^**

^ One low-risk taxon was recorded in multiple sections of the Development Envelope.

The proposed groundwater drawdown for supply at Western Hill is expected to only extend minimally beyond the immediate vicinity of the proposed pits, due to the presence of low permeability Mount McRae Shales. Based on available drawdown modelling, 0.5 m of drawdown at Western Hill is predicted to propagate southward into the synclinal aquifer south of Western Hill. This level of drawdown is within the natural range of variability of the aquifer and is unlikely to cause a serious impact. Consequently, the combined groundwater drawdown impacts at Western Hill are unlikely to significantly increase the impacts of the current operations on the synclinal aquifer habitat.

The MAR strategy (as per Ministerial statement 1113) is proposed to be located immediately west of the anticline between Deposits C and D and is designed to maintain pre-impact groundwater levels to the west of West Angelas in Karijini National Park. Separate impact scenarios have been modelled against the synclinal aquifer BWT habitat model, as described in section 2.4.

The records of several stygofauna species throughout widely different areas of the synclinal aquifer (Figure 5.3 and Figure 5.4) suggests no apparent barriers to dispersal or hydrogeological compartmentalisation of the habitat. Despite the lack of available bores for sampling in Karijini National Park, it is likely that the same stygofauna assemblage identified within the Development Envelope in the eastern part of the synclinal aquifer is likely to occur more widely in the western part of the synclinal aquifer occurring within Karijini National Park.

Table 5-8: Summary of combined impact rank and rationale for stygofauna taxa recorded within the combined impact area at Western Hill and the synclinal aquifer

Taxon	Likelihood of occurring beyond direct impacts	Magnitude of direct impacts	Suitability of habitat remaining	Direct impact rank
Amphipoda				
Kruptus `sp. Helix-AMP035`	Likely to occur more widely than recorded throughout the synclinal aquifer.	Minor drawdown at Western Hill (2m). Minor drawdown in synclinal valley without MAR (7m-12m), negligible with MAR.	Unlikely to change. Suitable habitat remains >60m thick at WH, >30m thick in synclinal valley	**Low**
Maarrka `sp. Helix-AMP037` Paramelitidae `sp. Biologic-AMPH018` Paramelitidae `sp. Helix-AMP036`	Likely to occur more widely than recorded throughout the synclinal aquifer.	Minor drawdown in synclinal valley without MAR (7m-12m). Negligible GWDD/ change in thickness with MAR.	Unlikely to change. Suitable habitat remains >30m thick without MAR.	**Low**
Syncarida				
Atopobathynella `sp. Helix-BAP027_WA` Bathynellidae `sp. Helix-BAB018`	Likely to occur more widely than recorded throughout the synclinal aquifer.	Minor drawdown in synclinal valley without MAR (6m-7m). Negligible GWDD/ change in thickness with MAR.	Unlikely to change. Suitable habitat remains >30m thick without MAR.	**Low**
Harpacticoida				
Australocamptus `sp. B13`	Likely to occur more widely than recorded throughout the synclinal aquifer.	Minor drawdown in synclinal valley without MAR (6m-7m). Negligible GWDD/ change in thickness with MAR.	Unlikely to change. Suitable habitat remains >30m thick without MAR.	**Low**
Ostracoda				
Candonidae `sp. WAN`	Likely to occur more widely than recorded throughout the synclinal aquifer.	Minor drawdown in synclinal valley without MAR (7m-12m). Negligible GWDD/ change in thickness with MAR.	Unlikely to change. Suitable habitat remains >30m thick without MAR.	**Low**
Isopoda				
Pygolabis `sp. WAN`	Likely to occur more widely than recorded throughout the synclinal aquifer.	Minor drawdown in synclinal valley without MAR (7m-12m). Negligible GWDD/ change in thickness with MAR.	Unlikely to change. Suitable habitat remains >30m thick without MAR.	**Low**

Taxon	Likelihood of occurring beyond direct impacts	Magnitude of direct impacts	Suitability of habitat remaining	Direct impact rank
Oligochaeta				
Enchytraeidae `sp. Biologic-OLIG008`	Highly likely – amphibious. Most enchytraeids regionally widespread.	Negligible. Not restricted to groundwater - moist subterranean habitats extensive beyond impacts	Unlikely to change habitat suitability	**Low**
Enchytraeidae `sp. Helix-OLE028` Enchytraeidae `sp. Helix-OLE029`	Highly likely – amphibious. Most enchytraeids regionally widespread.	Negligible. Not restricted to groundwater - moist subterranean habitats extensive beyond impacts	Unlikely to change habitat suitability	**Low**

5.4 Cumulative direct impacts

As outlined in section 2.2.4, it is unlikely that any known third-party operations in the surrounding regional area would have a material impact on the stygofauna habitat or species values within the Development Envelope. As a result, no cumulative impacts to stygofauna values are anticipated for the current assessment.

660000 664000 668000 672000

7444000 7440000 7436000

Habitat Thickness (m)

Zone A
- 1 - 30
- 31 - 60
- 61 - 90
- 91 - 120

Habitat Thickness (m)

Zone B
- 1 - 30
- 31 - 60
- 61 - 90
- 91 - 120

Proposed groundwater drawdown

Metres below pre-impact water level
- 0 - 2
- 2 - 5
- 5 - 8
- 8 - 12
- 12 - 16

Legend

- West Angelas Beyond 2020 Development Envelope
- Current Operations Development Envelope
- EIA Section Boundary
- Existing Pit
- Proposed Pit
- Proposed Waste/ Infrastructure
- Stygofauna Sampling Site
- 3D Modelling Boundary (Vein Model)

Amphipoda
- Kruptus `sp. Helix-AMP035`

Haplotaxida
- Enchytraeidae `sp. Biologic-OLIG008`

N

biologic Environmental Survey

Scale: 1:40,000

0 1 2 Km

Coordinate System: GDA 1994 MGA Zone 50
Projection: Transverse Mercator
Datum: GDA 1994 Created 13/09/2022



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West Angelas Environmental Impact Assessment of Subterranean Fauna

Figure 5.1: Stygofauna assessed at Western Hill (orebody aquifer) and suitable habitat after groundwater drawdown (proposed)

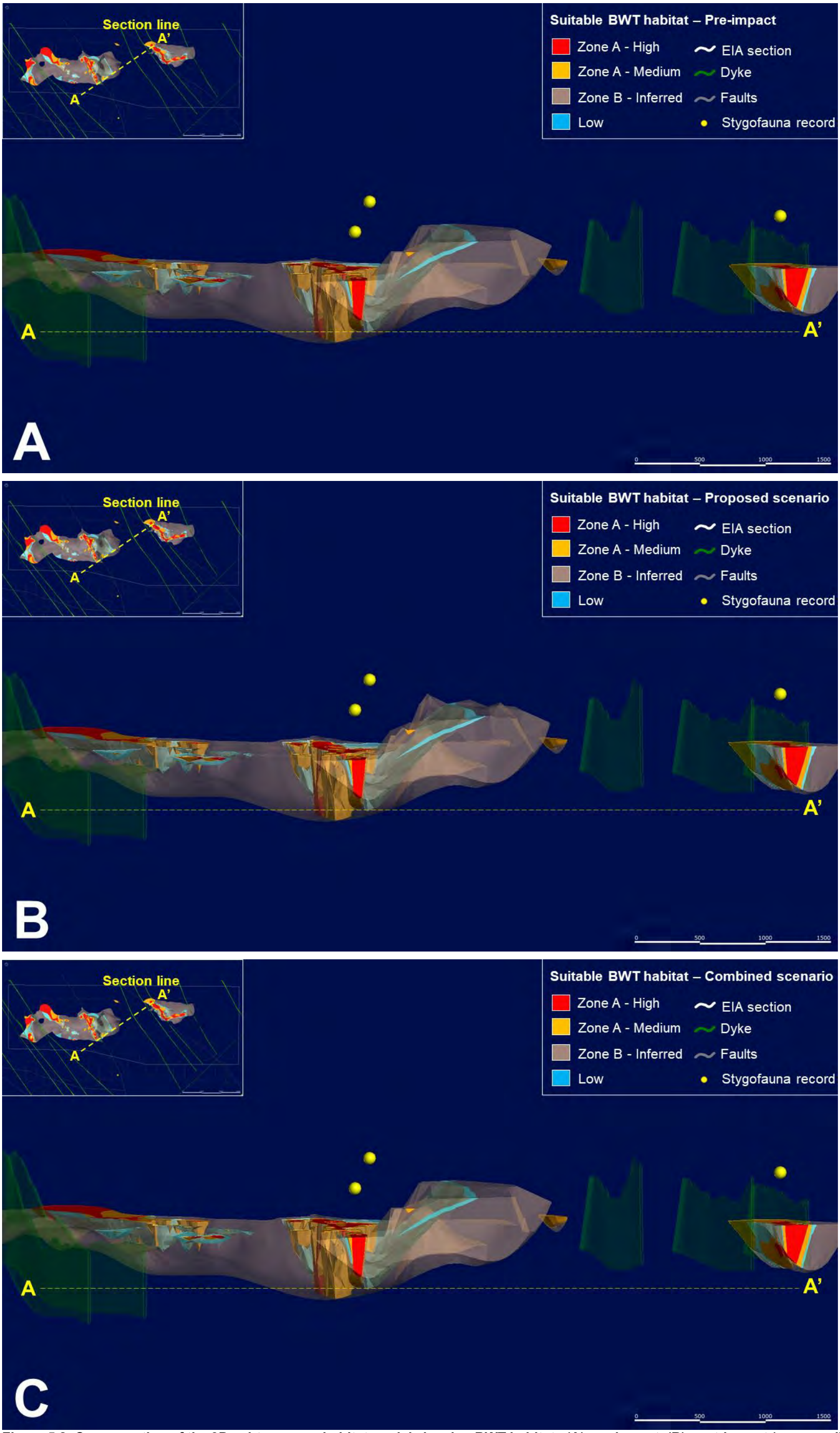


Figure 5.2: Cross-section of the 3D subterranean habitat model showing BWT habitats (A) pre-impact, (B) post-impact (proposed), and (C) post-impact (combined) at Western Hill orebody aquifer. *Vertical scale exaggerated*

660000

670000

7445000

7440000

7435000

Karijini National Park

Habitat Thickness (m)

Potential suitable habitat

- 1 - 30
- 31 - 60
- 61 - 90
- 91 - 120

Habitat Thickness (m)

Inferred habitat

- 1 - 30
- 31 - 60
- 61 - 90
- 91 - 120

Combined groundwater drawdown without MAR

Metres below pre-impact water level

- 0 - 2
- 2 - 5
- 5 - 8
- 8 - 12
- 12 - 16

Amphipoda

- Kruptus `sp. Helix-AMP035`
- Maarrka `sp. Helix-AMP037`
- Paramelitidae `sp. Biologic-AMPH018`
- Paramelitidae `sp. Helix-AMP036`

Bathynellacea

- Atopobathynella `sp. Helix-BAP027_WA`
- Bathynellidae `sp. Helix-BAB018`

Haplotaxida

- Enchytraeidae `sp. Biologic-OLIG008`
- Enchytraeidae `sp. Helix-OLE028`
- Enchytraeidae `sp. Helix-OLE029`

Harpacticoida

- Australocamptus `sp. B13`

Isopoda

- Pygolabis `sp. WAN`

Podocopida

- Candonidae `sp. WAN`

Legend

- West Angelas Beyond 2020 Development Envelope
- Current Operations Development Envelope
- Karijini National Park
- Existing Pit
- Proposed Pit
- Proposed Waste/ Infrastructure
- Stygofauna Sampling Site
- Western Hill (Regional Synclinal Aquifer) Modelling Boundary

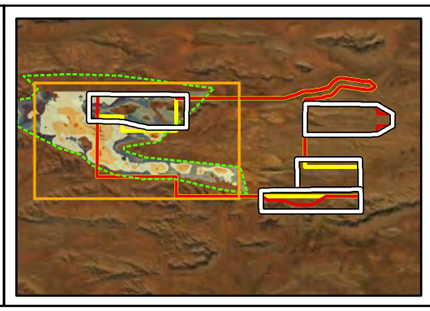
N

biologic Environmental Survey

Scale: 1:62,500

0 1 2 3 Km

Coordinate System: GDA 1994 MGA Zone 50
Projection: Transverse Mercator
Datum: GDA 1994 Created 13/09/2022



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West Angelas Environmental Impact Assessment of Subterranean Fauna

Figure 5.3: Stygofauna assessed at Western Hill (regional synclinal aquifer) and suitable habitat after groundwater drawdown (combined)

660000

670000

7445000

7440000

7435000

Karijini National Park

Habitat Thickness (m)

Potential suitable habitat

- 1 - 30
- 31 - 60
- 61 - 90
- 91 - 120

Habitat Thickness (m)

Inferred habitat

- 1 - 30
- 31 - 60
- 61 - 90
- 91 - 120

Modelled groundwater levels under MAR scenario

mAHD

- 623 - 623.5
- 623 - 624
- 624 - 624.5
- 624 - 625

Amphipoda

- Kruptus `sp. Helix-AMP035`
- Maarrka `sp. Helix-AMP037`
- Paramelitidae `sp. Biologic-AMPH018`
- Paramelitidae `sp. Helix-AMP036`

Bathynellacea

- Atopobathynella `sp. Helix-BAP027_WA`
- Bathynellidae `sp. Helix-BAB018`

Haplotaxida

- Enchytraeidae `sp. Biologic-OLIG008`
- Enchytraeidae `sp. Helix-OLE028`
- Enchytraeidae `sp. Helix-OLE029`

Harpacticoida

- Australocamptus `sp. B13`

Isopoda

- Pygolabis `sp. WAN`

Podocopida

- Candonidae `sp. WAN`

Legend

- West Angelas Beyond 2020 Development Envelope
- Current Operations Development Envelope
- Karijini National Park
- Existing Pit
- Proposed Pit
- Proposed Waste/ Infrastructure
- Stygofauna Sampling Site
- Indicative MAR Bore
- Western Hill (Regional Synclinal Aquifer) Modelling Boundary

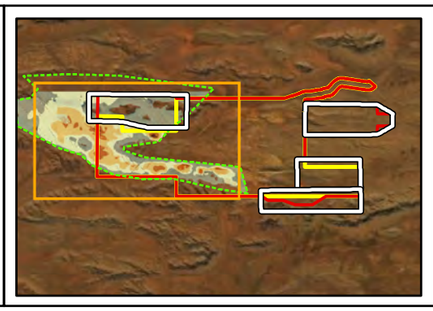
N

biologic Environmental Survey

Scale: 1:62,500

0 1 2 3 Km

Coordinate System: GDA 1994 MGA Zone 50
Projection: Transverse Mercator
Datum: GDA 1994 Created 13/09/2022



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West Angelas Environmental Impact Assessment of Subterranean Fauna

Figure 5.4: Stygofauna assessed at Western Hill (regional synclinal aquifer) and suitable habitat after groundwater drawdown (combined with MAR)

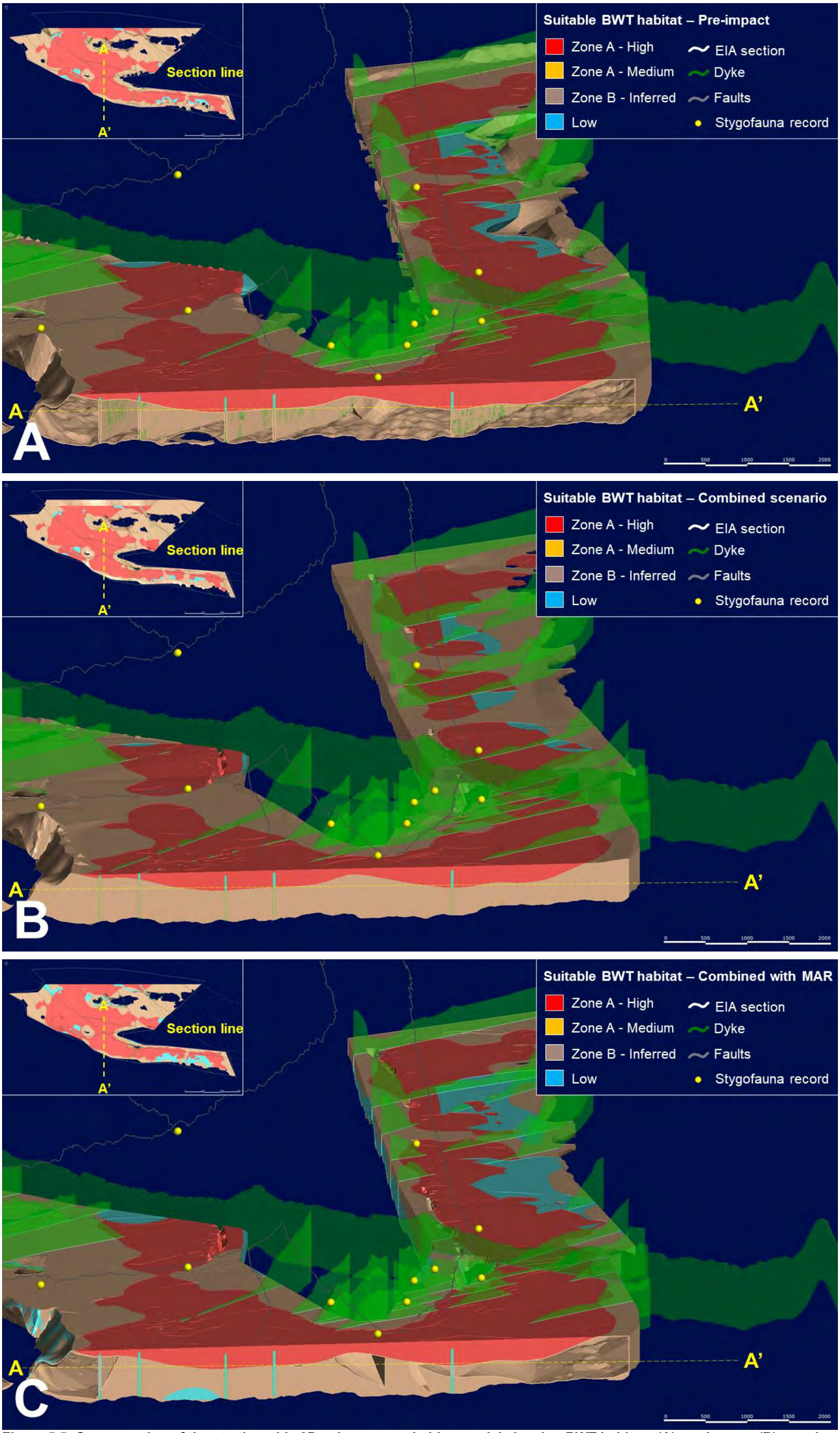


Figure 5.5: Cross-section of the stratigraphic 3D subterranean habitat model showing BWT habitats (A) pre-impact, (B) post-impact (combined), and (C) post-impact (combined with MAR) at Western Hill synclinal valley. *Vertical scale exaggerated x5*

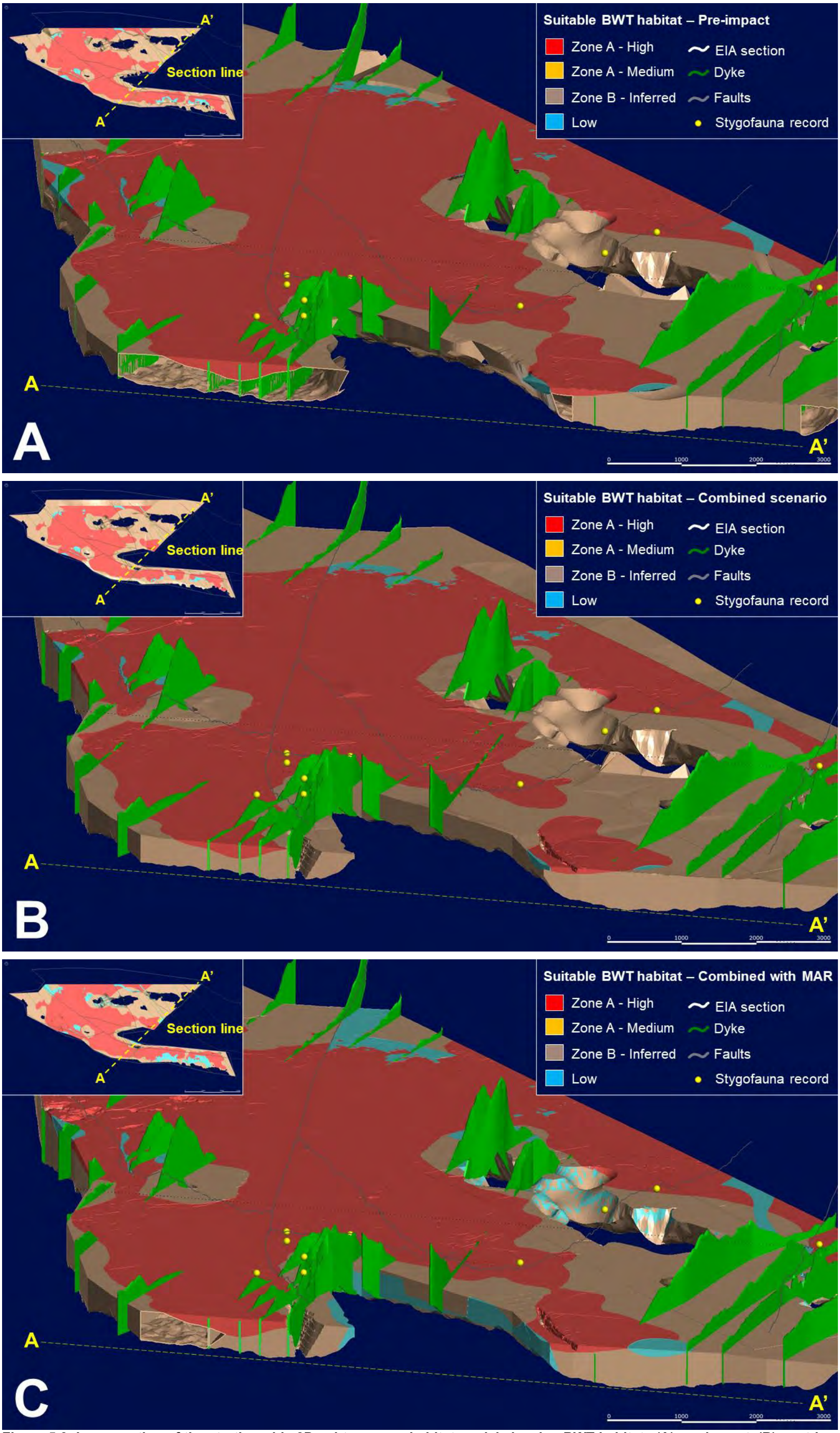


Figure 5.6: Long-section of the stratigraphic 3D subterranean habitat model showing BWT habitats (A) pre-impact, (B) post-impact (combined), and (C) post-impact (combined with MAR) at Western Hill synclinal valley. *Vertical scale exaggerated x*

692000

696000

7442000

7440000

Habitat Thickness (m)

Zone A

- 1 - 30
- 31 - 60
- 61 - 90
- 91 - 120

Habitat Thickness (m)

Zone B

- 1 - 30
- 31 - 60
- 61 - 90
- 91 - 120

Proposed groundwater drawdown

Metres below pre-impact water level

- 0 - 13
- 13 - 20
- 20 - 27
- 27 - 33
- 33 - 42

Legend

- West Angelas Beyond 2020 Development Envelope
- Current Operations Development Envelope
- EIA Section Boundary
- Proposed Pit
- Proposed Waste/ Infrastructure
- Stygofauna Sampling Site
- 3D Modelling Boundary (3D Habitat Model)

N

biologic Environmental Survey

Scale: 1:24,000

0 0.5 1 Km

Coordinate System: GDA 1994 MGA Zone 50
Projection: Transverse Mercator
Datum: GDA 1994 Created 13/09/2022



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West Angelas Environmental Impact Assessment of Subterranean Fauna

Figure 5.8: Stygofauna assessed at Deposit H and suitable habitat after groundwater drawdown (proposed)

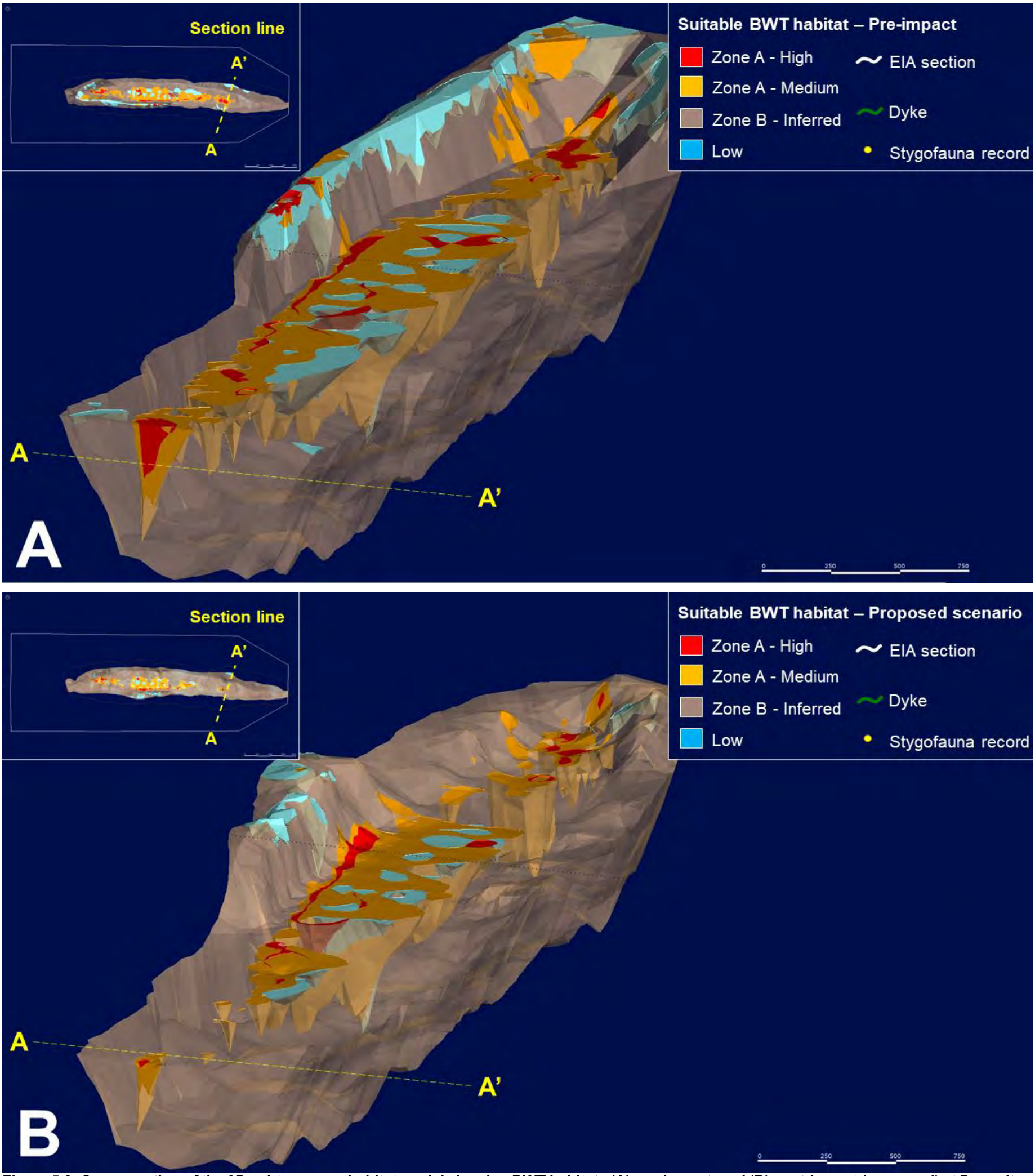


Figure 5.8: Cross-section of the 3D subterranean habitat model showing BWT habitats (A) pre-impact, and (B) post-impact (proposed) at Deposit H. *Vertical scale exaggerated*

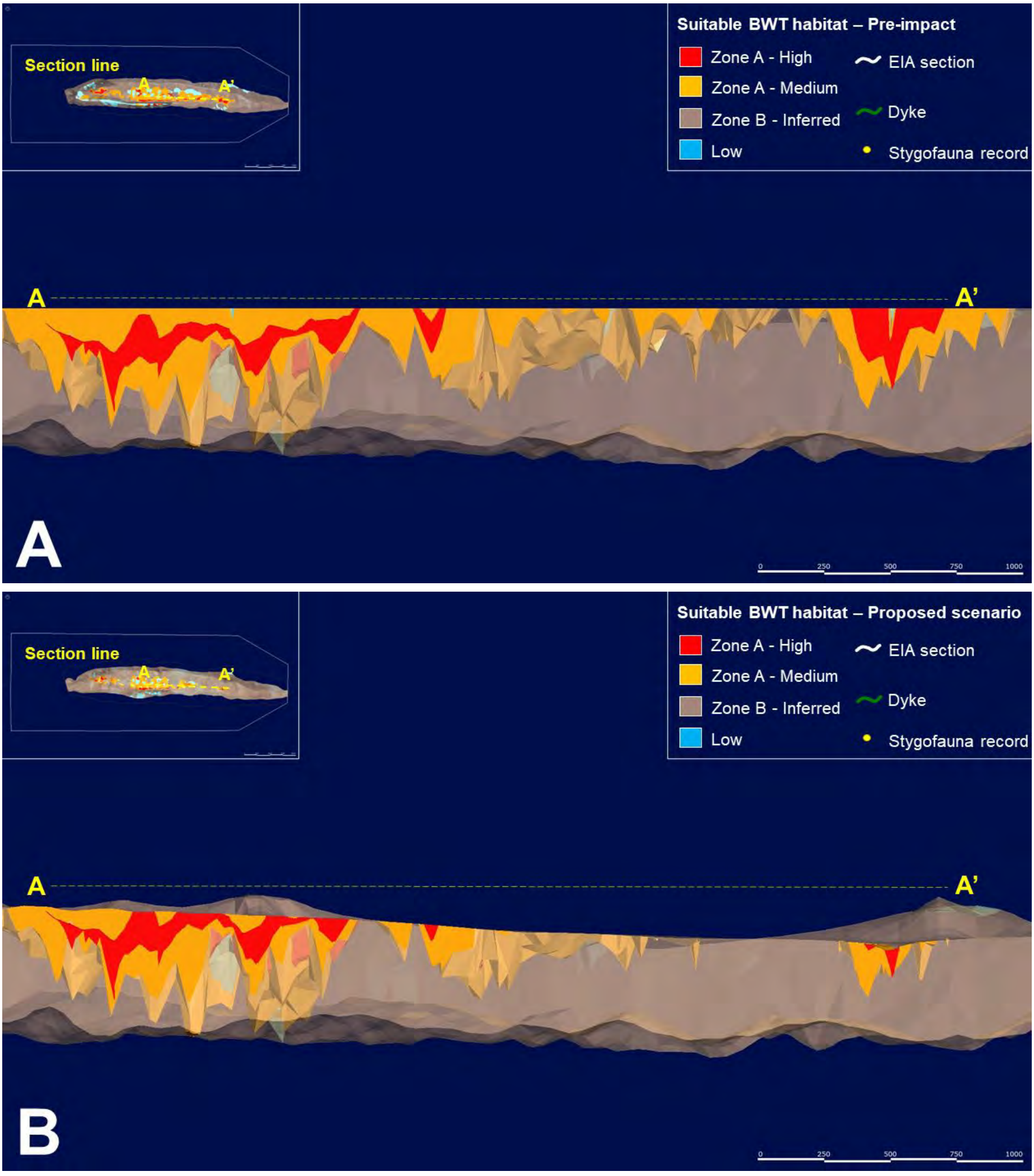


Figure 5.9: Long-section of the 3D subterranean habitat model showing BWT habitats (A) pre-impact, and (B) post-impact (proposed) at Deposit H. *Vertical scale exaggerated x5*

6. KEY FINDINGS AND OUTCOMES

6.1 Troglofauna

The West Angelas Region hosts extensive suitable AWT geological habitats that support diverse troglofauna assemblages throughout each section of the Development Envelope. The extent, thickness and connectivity of the habitats AWT were represented with high confidence by 3D modelling, owing to the high density of drilling data and geological information throughout the Development Envelope. Repeated sampling effort combined with comprehensive taxonomic effort including genetic analyses, has resulted in high confidence in the identification of important troglofauna species and habitat values throughout the Development Envelope, and in the modelling and quantification of predicted impacts.

The implementation of the Proposal will result in a small reduction of AWT habitat, with the maximum predicted loss (following combined impacts) predicted to be approximately 12% of the suitable habitat modelled. Approximately 88% of the suitable AWT habitat (8.1 billion cubic meters) is predicted to be retained following implementation of the Proposal. The remaining AWT habitat is extensive beyond impacts, of medium to high suitability, and well-connected throughout the landscape. Large areas of potentially suitable, contiguous geological habitats are also likely to occur beyond the modelling boundaries, based on available geological mapping.

Key troglofauna values comprised 42 unique troglofauna taxa and the corresponding suitable habitats modelled throughout the Development Envelope and the wider West Angelas Region. The direct and combined impacts from the Proposal are predicted to be Low to Medium for all 42 troglofauna taxa, and Low for all corresponding suitable AWT habitats. No troglofauna values (species or suitable habitats) are expected to be lost following implementation of the Proposal.

Indirect impacts are not expected to compromise the ecological integrity of the AWT habitats remaining intact after impacts, or to increase the level of impact to any troglofauna values (species or habitats). Indirect impacts are predicted to affect only 3% of the 2D area of the suitable habitat AWT remaining intact following direct impacts (from both the Proposal and combined impacts).

The Proposal is expected to meet the EPA objectives for troglofauna species, populations and assemblages, and the biological diversity and ecological integrity of the known troglofauna values are expected to be maintained.

6.2 Stygofauna

Suitable BWT habitats for stygofauna were identified in three sections of the Development Envelope, comprising Western Hill (orebody aquifer), the regional synclinal aquifer surrounding Western Hill, and Deposit H. No significant aquifer or BWT habitat was found to occur at Mt Ella East and Deposit F North, and therefore these two areas are not expected to support stygofauna habitat values. Habitat modelling BWT relied upon a variety of high and lower density drilling information, hydrogeological survey information, and interpretations of hydrostratigraphic trends

(particularly the regional synclinal aquifer) to model BWT habitats and quantitatively assess impact scenarios to the best of available information. Within the constraints of available sampling sites, and limitations to historic taxonomy, the sampling and taxonomic effort were appropriate to identify the key stygofauna values occurring throughout the Development Envelope, and to assess the predicted impacts within an appropriate local/ regional context.

Overall impact rankings were developed for the 12 stygofauna taxa recorded within the West Angelas Region and their habitats. Impacts to all 12 stygofauna taxa were ranked as Low under both the proposed and combined impact scenarios. None of the impacts to stygofauna species present were ranked as 'High' or 'Medium', and no values are expected to be lost from the implementation of the Proposal.

All 12 stygofauna taxa were recorded from areas where suitable habitats were modelled to remain intact following the direct and combined impacts of groundwater drawdown. The 3D modelling showed that the remaining BWT habitat will be suitable, extensive, and well-connected, and therefore able to continue to support stygofauna values.

The existing commitment to Managed Aquifer Recharge (as outlined in Ministerial Statement 1113) in the synclinal aquifer is expected to maintain groundwater levels west of the Development Envelope, and result in greater habitat retention BWT than the combined scenario without MAR. Nevertheless, the combined impact scenario without MAR is predicted to result in the retention of approximately 83% of the suitable habitat BWT throughout the synclinal aquifer, which would still constitute a Low-level impact to the known stygofauna values. With the implementation of the MAR as per Ministerial Statement 1113, the predicted impact to suitable habitat BWT throughout the synclinal aquifer is negligible.

Indirect impacts are not expected to compromise the ecological integrity of the BWT habitats remaining intact after impacts, or to increase the level of impact to any stygofauna values (species or habitats). Indirect impacts are predicted to affect only 7% of the 2D area of the suitable habitat BWT remaining intact following direct combined impacts.

The Proposal on its own and also when combined with the existing approved operations is expected to meet the Environmental Protection Authority's objective for subterranean fauna in relation to stygofauna values. Stygofauna species, populations, assemblages and key habitats are expected to be retained, and overall biological diversity and ecological integrity are expected to be maintained.

7. LIMITATIONS

Subterranean fauna taxonomy and ecology is an emerging field, which provides challenges for the interpretation of results and species distributions, particularly when combining new and old records from historical sampling. Many subterranean species (particularly troglofauna) are rare and difficult to detect throughout their range or habitat extent. Subterranean fauna inhabit cryptic habitats that are sampled only via bores/ drill holes developed in targeted locations for mineral exploration. As a result, surveys often reveal only part of the diversity and/or abundance the fauna present, often featuring low detection rates and high numbers of rare species. This assessment of impacts is based upon the best available information under the following constraints:

- Suitability of holes and bores – throughout the Development Envelope the subterranean fauna sampling was limited to locations of suitable drill holes and bores which varied between sections of the Development Envelope. The availability of holes that intercept the water table was relatively low across all deposits, limiting the number of stygofauna samples within the Development Envelope. Best efforts were made to enhance stygofauna sampling by repeated bore/ hole sampling where groundwater was intercepted and additional sampling in similar nearby groundwater habitats.
- Habitat Assessment – the 3D habitat modelling was limited to the area within and immediately surrounding the locations of bores and drill holes (within 300 m of each drill hole). Potentially suitable habitat may occur beyond the extent of modelling; however extrapolation was limited to this extent to ensure conservative estimation. While the modelling in the prospective sections of the Development Envelope was based on dense drilling information, fine-scale variability in the suitability or connectivity of habitat (e.g. variability in sediment texture and pore spaces within detrital units, and the 3D shape and connectivity of fracture zones/ subterranean cavities in bedrock) are beyond the resolution of the modelling.
- Impact Frameworks – The assessment acknowledges a lack of experimental data or established regional precedent in regard to impact thresholds for subterranean fauna species or habitats. 3D modelling and quantification of impacts is relatively new, and current or previous EPA guidelines do not specify impact thresholds. The sampling and habitat assessment limitations stated above create knowledge gaps and challenges for setting specific thresholds based on data. The habitat loss thresholds for the impact rankings (High, Medium, or Low) were therefore determined broadly at an assemblage level within the context of these limitations to knowledge.

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9. APPENDICES

Appendix A – Conservation significant subterranean fauna values of the Pilbara region

Table A-1: Conservation significant subterranean fauna in the Pilbara (DBCA, 2021)

Scientific name	Common name	Conservation Status	Type of fauna	Region
Threatened subterranean fauna				
Bogidomma australis	Barrow Island Bogidomma	Vulnerable	Amphipod	Pilbara (Barrow Island)
Draculoides bramstokeri	Barrow Island Draculoides	Vulnerable	Schizomid	Pilbara (Barrow Island)
Draculoides mesozeirus	Middle Robe Draculoides	Vulnerable	Schizomid	Pilbara
Liagoceradocus subthalassicus	Barrow Island Liagoceradocus	Vulnerable	Amphipod	Pilbara (Barrow Island)
Milyeringa justitia	Barrow Cave Gudgeon	Vulnerable	Fish	Pilbara (Barrow Island)
Milyeringa veritas	Blind Gudgeon	Vulnerable	Fish	Cape Range & Pilbara (Barrow Island)
Nedsia fragilis	/	Vulnerable	Amphipod	Pilbara (Barrow Island)
Nedsia humphreysi	/	Vulnerable	Amphipod	Pilbara (Barrow Island)
Nedsia hurlberti	/	Vulnerable	Amphipod	Pilbara (Barrow Island)
Nedsia macrosculptili	/	Vulnerable	Amphipod	Pilbara (Barrow Island)
Nedsia sculptilis	/	Vulnerable	Amphipod	Pilbara (Barrow Island)
Nedsia straskraba	/	Vulnerable	Amphipod	Pilbara (Barrow Island)
Nedsia urifimbriata	/	Vulnerable	Amphipod	Pilbara (Barrow Island)
Ophisternon candidum	Blind Cave Eel	Vulnerable	Fish	Cape Range & Pilbara (Barrow Island)
Paradraculoides anachoretus	Mesa A Paradraculoides	Vulnerable	Schizomid	Pilbara
Paradraculoides bythius	Mesa B/C Paradraculoides	Vulnerable	Schizomid	Pilbara
Paradraculoides gnophicola	Mesa G Paradraculoides	Vulnerable	Schizomid	Pilbara
Paradraculoides kryptus	Mesa K Paradraculoides	Vulnerable	Schizomid	Pilbara
Speleostrophus nesiotes	Barrow Island Millipede	Vulnerable	Millipede	Pilbara (Barrow Island)
Priority subterranean species				
Ideoblothrus linnaei	Linnaeus' Pseudoscorpion (Mesa A)	Priority 1	Pseudoscorpion	Pilbara
Ideoblothrus sp. 'Mesa A' (WAM T81374)	Ideoblothrus Pseudoscorpion (Mesa A)	Priority 1	Pseudoscorpion	Pilbara
Lagynochthonius asema	Mesa A Lagynochthonius Pseudoscorpion	Priority 1	Pseudoscorpion	Pilbara
Nedsia chevronia	Chevron's Freshwater Amphipod	Priority 2	Amphipod	Pilbara (Barrow Island)
Stygiocaris stylifera	Spear-beaked Cave Shrimp	Priority 4	Decapod	Cape Range & Pilbara (Barrow Island)
Tyrannochthonius sp. 'Mesa A' (WAM T81480)	Tyrannochthonius Pseudoscorpion (Mesa A)	Priority 1	Pseudoscorpion	Pilbara

Table A-2: Priority and Threatened Ecological Communities relevant to subterranean fauna in the Pilbara (DBCA, 2021)

Community Name	Description
Threatened Ecological Community (TEC)	
Ethel Gorge	Ethel Gorge aquifer stygobiont community
Priority Ecological Communities (PEC)	
Weeli Wolli Spring community	Weeli Wolli Spring's riparian woodland and forest associations are unusual as a consequence of composition of the understorey. The sedge and herbfield communities that fringe many of the pools and associated water bodies along the main channels of Weeli Wolli Creek have not been recorded from any other wetland site in the Pilbara. The spring and creekline are also noted for their relatively high diversity of stygofauna and this is probably attributed to the large-scale calcrete and alluvial aquifer system associated with the creek.
Barrow Island subterranean fauna	Barrow Island stygofauna and troglofauna.
Subterranean invertebrate communities of mesas in the Robe Valley region	A series of isolated mesas occur in the Robe Valley in the state's Pilbara Region. The mesas are remnants of old valley infill deposits of the palaeo Robe River. The troglobitic faunal communities occur in an extremely specialised habitat and appear to require the particular structure and hydrogeology associated with mesas to provide a suitable humid habitat. Short range endemism is common in the fauna. The habitat is the humidified pisolitic strata
Subterranean invertebrate community of pisolitic hills in the Pilbara	A series of isolated low undulating hills occur in the state's Pilbara region. The troglofauna are being identified as having very short-range distributions.
Mingah Springs calcrete groundwater assemblage type on Gascoyne palaeodrainage on Mingah Spring Station	Unique assemblages of invertebrates have been identified in the groundwater calcretes.
Stygofaunal community of the Bungaroo Aquifer	A unique assemblage of aquatic subterranean fauna including eels, snails and other stygofauna.
Invertebrate assemblages (Nyeetberry Pool type)	Permanent River Pool in the Pilbara (groundwater fed). Blind isopod collected from this site.
Stygofaunal communities of the Western Fortescue Plains freshwater aquifer	A unique assemblage of subterranean invertebrate fauna.

Appendix B – Volumetric calculations for habitat loss and retention

Table B-1: Summary of volumetric calculations for troglofauna habitat loss and retention for each EIA section and impact scenario

EIA Section	Volume (m^3) ('000)				% of total		
	Premining	Current	Proposed	Combined	Current	Proposed	Combined
Western Hill							
Suitable Habitat Retained	845,580	845,580	701,270	701,270	100	82.9	82.9
Loss of Suitable Habitat	0	0	144,310	144,310	0.0	17.1	17.1
DEP H							
Suitable Habitat Retained	189,173	189,173	164,372	164,372	100.0	86.9	86.9
Loss of Suitable Habitat	0	0	24,801	24,801	0.0	13.1	13.1
MTEE							
Suitable Habitat Retained	1,163,720	1,152,454	1,136,330	1,125,060	99.0	97.6	96.7
Loss of Suitable Habitat	0	11,266	27,390	38,660	1.0	2.4	3.3
DEP F North							
Suitable Habitat Retained	727,330	590,812	707,570	571,047	81.2	97.3	78.5
Loss of Suitable Habitat	0	136,518	19,760	156,283	18.8	2.7	21.5
Remaining West Angelas							
Suitable Habitat Retained	6,258,877	5,546,231	6,258,818	5,546,181	88.6	100	88.6
Loss of Suitable Habitat	0	712,646	0	712,586	11.4	0	11.4
Total retained	**9,184,680**	**8,324,250**	**8,968,360**	**8,107,930**	**90.6**	**97.6**	**88.3**
Total Loss	**0**	**860,430**	**216,261**	**1,076,640**	**9.4**	**2.4**	**11.7**

Note: All habitat volumes comprise both high and medium suitability habitat.

Table B-2: Summary of volumetric calculations for stygofauna habitat loss and retention for each EIA section and impact scenario

a) Vein model

EIA section	Volume (m3) ('000)				% of total		
	Pre-impact	Current	Proposed	Combined	Current	Proposed*	Combined
Western Hill orebody deposit							
Suitable Habitat Retained^	409,281	407,192	403,574	401,485	99.5	98.6	98.1
Loss of Suitable Habitat^	0	2,089	5,707	7,796	0.5	1.4	1.9
Deposit H							
Suitable Habitat Retained^	598,930	598,930	463,102	463,102	100	77.3	77.3
Loss of Suitable Habitat^	0	0	135,828	135,828	0	22.7	22.7

b) Stratigraphic model

EIA section	Volume (m3) ('000)				% of total		
	Pre-impact	Proposed	Combined	Combined MAR	Proposed	Combined	Combined MAR
Western Hill Synclinal Valley							
Suitable Habitat Retained*	13,996,582	13,657,038	11,600,313	13,731,382	97.6	82.9	98.1
Loss of Suitable Habitat*	0	339,554	2,396,269	265,201	2.4	17.1	1.9

^comprises Zone A and Zone B habitat

*comprises potential suitable habitat and inferred habitat.

APPENDIX G: OFFSET

G.1: Impact Reconciliation Procedure

Impact Reconciliation Procedure (Offsets)

Robe River Iron Co. Pty. Ltd.

West Angelas Revised Proposal

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November 2023

RTIO-0980794

Robe River Mining Co. Pty. Ltd.
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RioTinto

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This Impact Reconciliation Procedure has been prepared by Rio Tinto's Iron Ore group (Rio Tinto), on behalf of Robe River Mining Co. Pty. Ltd. (the Proponent), specifically for the West Angelas Iron Ore Revised Proposal. Neither the report nor its contents may be referred to without the express approval of Rio Tinto, unless the report has been released for referral and assessment of proposals.

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1 THE PROPOSAL AND CONDITION REQUIREMENTS

1.1 The Proposal

This West Angelas Significant Amendment Impact Reconciliation Procedure (IRP) has been prepared in accordance with the Western Australian (WA) Department of Water and Environmental Regulation's (DWER) requirements relating to offset reconciliation for the West Angelas Significant Amendment (the Proposal). The Proposal is currently subject to assessment under Part IV of the *Environmental Protection Act* 1986 (EP Act) Assessment Number 2290, and the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) Assessment 2021/8923, as an accredited assessment.

This IRP addresses both State and Commonwealth offset requirements. Rio Tinto on behalf of Robe River Mining Co. Pty. Ltd (the Proponent) intends to seek the Department of Climate Change, Energy, the Environment and Water's (DCCEEW) approval to utilise the WA Pilbara Environmental Offset Fund (PEOF), as the nominated 'Conservation Offset Fund', to meet EPBC Act Decision Notice offset requirements.

Once approved, this IRP will supersede the Impact Reconciliation Procedure for Ministerial Statement 1113 and EPBC Act Decision Notice 2018/8299 (RTIO-HSE-0354022), approved August 2022.

1.2 Ministerial Statement and Commonwealth approval condition requirements

Conditions from Ministerial Statement XXXX (State) and Decision Notice 2021/8923 (Commonwealth) relevant to offsets for the Proposal are included in Table A 1 and Table A 2 respectively of Appendix 1.

2 PROCEDURE

The methodology for determining the baseline and offset contributions to deliver an outcome that aligns with DWER's IRPs and Impact Reconciliation Reports (IRRs) is detailed below. Content of both IRPs and IRRs is outlined in Section 3.2.

2.1 Identification of the Environmental Values Requiring Offsets

Ministerial Statement XXXX and Decision Notice 2021/8923 include conditions that require the Proponent to offset the significant residual impact of the Proposal including clearing of 'good to excellent' condition native vegetation, and riparian vegetation and high significance/critical and supporting habitat for conservation significant (MNES) fauna species, in the Hamersley IBRA subregion.

Ministerial Statement XXXX and Decision Notice 2021/8923 specify the biodiversity values listed in Table 1 below and associated offset rates.

Table 1: Environmental Values Requiring Offsets for the Proposal

Biodiversity Value		**Offset Rate ($/ha)[1] (excl. GST)**
State (WA) Ministerial Statement XXXX (Placeholder values subject to offset conditions)		
Cond #	[condition]	$TBC
EPBC Decision Notice 2021/8923		
TBC	[TBC]	$TBC

[1] Base rate provided in Ministerial Statement XXXX and EPBC Decision Notice 2021/8923, to be adjusted annually in accordance with the percentage change in the Perth Consumer Price Index (CPI) applicable that year.

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2.1.1 Vegetation Condition

To support approval processes for the Proposal, baseline flora and vegetation surveys were conducted, identifying native vegetation types and condition in the proposed Development Envelope. Details of the surveys, including the time they were undertaken, are provided in Appendix 6. The 'CondDate' attribute in the data standard reflects the date that the vegetation survey occurred. Where vegetation surveys occurred over a period of time, the most recent date has been used.

At the time of the surveys botanists recorded the condition of the vegetation based on Trudgen's (1991) Vegetation Condition Index[2]. This data was then digitised and logged in the Rio Tinto (the Company) central GIS system. Note that all clearing conducted (at the time of the IRP submission) prior to the Proposal's approval has been assigned a vegetation condition of 'Cleared' in the offset exempt footprints and 'Completely Degraded' in vegetation condition data, and has been removed from environmentally significant value areas data. A reconciliation of offset exempt clearing conducted between submission of the IRP and commencement of the Proposal will be documented in the first IRR, as per Section 4.

Where fire has occurred, the vegetation condition was extrapolated from surrounding unburnt vegetation assuming that the area will regenerate over time.

2.1.2 Footprint Attribution

Aerial ortho or satellite imagery encompassing the proposed Development Envelope is taken as close to the Proposal's approval time as practicable and aligning with the Proponent's existing flyover schedules. Where required, ground survey and truthing practices may also be used to supplement the imagery.

Cleared areas are identified and digitised according to an internal data standard using the Company's GIS package. The 'CondDate' attribute in the data standard reflects the end of the reporting period as the vegetation was cleared up to the date of commencement of action under the current Ministerial Statement (MS) or, if a prior MS was superseded during the report period, the date the prior MS was superseded.

Whilst IRRs are required to be submitted biennially (refer to Table 4 for timing), footprints for each environmental value will be created annually.

Ministerial Statement

Using the Company's Approvals Request Coordination System (ARCS), a clearing mechanism, amongst other metadata fields in the data standard, is assigned to each digitised cleared polygon based on the purpose, location and time of the land clearing.

This clearing mechanism is then used to determine offset exempt areas, including areas cleared under:

- A previous MS, for areas not subjected to offset;
- A current MS where the previously approved clearing limits have not yet been exhausted, or where offsets are not applicable;
- An alternative clearing mechanism such as a Native Vegetation Clearing Permit (NVCP), *Bush Fires Act 1954*, *Land Administration Act 1997* or activities prescribed as clearing under Regulation 5 of the *Environmental Protection (Clearing of Native Vegetation) Regulations 2004*;
- Clearing not conducted by the Proponent e.g. pastoral station owners, government departments or other proponents;
- EPBC Act approval; since the EPBC Act Decision Notice approval offset rate is equal to or higher than the MS offset rate, disturbance within the EPBC Act approval areas will be captured in the EPBC Act offset payable layer and will then be exempt from additional payments under the MS to avoid duplication of payments.

Where a clearing limit has not yet been exhausted from a previously approved or superseded MS, clearing is attributed to the current MS and is identified as 'offset exempt' (i.e. to utilise the full complement of the approved clearing limit, however avoid attributing clearing to a superseded MS). This clearing is only assigned over a vegetation condition consistent with the previous MS (i.e. significant areas are avoided) and where activities are within the scope of the previous MS. Note that until the previously approved clearing limit is exhausted, this baseline layer will continue to change – refer to Section 4 for details of how such changes will be managed.

[2] Trudgen, M.E. (1991) *Vegetation Condition Scale. In: National Trust (WA) 1993 Urban Bushland Policy*. National Trust of Australia (WA). Wildflower Society of Western Australia (Inc.) and the Tree Society (Inc.), Perth, Western Australia.

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Where a Rio Tinto company has overlapping MS Development Envelopes, the ARCS system is used to identify which clearing mechanism to attribute the clearing polygons based on the purpose, location and timing of the clearing.

Clearing conducted under an overlapping MS, where a Rio Tinto company is the proponent, will be supplied as a separate layer (indicated as offset exempt for current MS) in order to provide assurance that all clearing has been accounted for within the Proposal Development Envelope. Note that the area will also be included in the overlapping MS/EPBC Act approval IRP/IRR when required.

Clearing conducted by a Rio Tinto company attributed to an NVCP that is not prescribed in a MS condition or to another approval mechanism such as an exemption, will be included as a totalised NVCP or Other clearing mechanism layer, respectively. Where a MS prescribes NVCPs which contribute to the total proposal clearing allocation (offset applicable or exempt), these MS-prescribed NVCPs shall be provided in a separate consolidated layer. Clearing suspected to have been performed by proponents other than Rio Tinto, with overlapping Development Envelopes will be attributed in the 'Other clearing' mechanism layer by review of internal records and the apparent purpose and location of the clearing. Data sharing agreements may also be utilised where present and ground survey and truthing practices implemented if required; however, the Proponent cannot confirm the clearing mechanism applied by a third party. Where possible, information will be added within the notes section of the data standard attribute table detailing the suspected cause of the impact. Refer to Section 3.2 for an outline of report content.

EPBC Act Decision Notice

All clearing conducted by the Proponent within the defined offset applicable areas and within the scope of the Proposed Action that occurred from commencement of the Action is offset applicable for the purposes of the EPBC Act approval. Exemptions related to clearing mechanisms applied at the Western Australian level do not apply to the EPBC Act approval, except for clearing not conducted by the Proponent.

2.2 Method to determine impacts

2.2.1 Footprint attribution

Aerial ortho or satellite imagery encompassing the proposed Development Envelope is taken as close to the end of the reporting period as practicable and aligning with the Company's existing flyover schedules. Where available, ground survey and truthing practices will also be used to supplement the imagery.

Although IRRs are submitted biennially (refer to Table 4 for timing), footprints for each environmental value will be created annually.

The previous annual footprint, or baseline footprint if first reporting year, will be overlaid on the report period image to identify new clearing and rehabilitation activities and/or changes in ground condition and land use. These areas will then be digitised and attributed in a similar process to that outlined in Section 2.1.2 above, in the Company's GIS package, to the Company's relevant data standards.

2.2.2 Offset contribution determination

Once the cleared footprint has been updated and finalised, data from the Company's internal data standard is consolidated and translated into the required DWER data standards.

For MS: Footprints attributed to the current MS are overlaid against baseline layers for vegetation condition, type and areas of significant environment value that have been identified as requiring offset. The offset contribution is determined where the footprint and offset applicable areas intersect.

For EPBC Act Decision Notice: Footprints attributed to the EPBC Act approval, after impacts commenced, will incur offset requirements (footprints prior to impacts commencing under the EPBC Act approval will be attributed to a MS or other clearing mechanism).

For areas that are offset applicable under both the State and Commonwealth approvals, the offset will be paid once only, at the highest applicable rate (i.e. no overlap between MS and EPBC Act approval offset payable layers) (Refer to Table 2 and Table 3).

Data and supporting spatial files will be submitted biennially in the IRR's, refer to Section 3.2 and Table 4 for details of IRR content and reporting period and frequency of the IRR's.

Where a previous and current MS (for the same Proposal) both have offset conditions over a common overlapping area, offset applicable clearing under both MS's will be subject to the requirements and rates of the newest MS, unless otherwise specified.

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The increase in the amount to be paid per hectare cleared in respect of the year in which clearing occurred will be calculated by application of the Perth Consumer Price Index (CPI) and paid as specified in the approval conditions.

Following the determination of offset liability, the Company will source the appropriate funds annually, aligning with internal accounting processes. Following submission and approval of IRRs (biennial), DWER will issue an invoice, which the Company will pay by transferring the required funds into the prescribed fund. The Company will submit evidence of each payment made to the prescribed fund to DCCEEW within 10 business days of the date of making the payment.

To meet the requirements of the EPBC Act Offsets Policy, an initial contribution of 10% of the total calculated offset contribution for MNES values is required to be paid into the PEOF prior to the commencement of ground disturbance associated with the Action. Payment will be made within one (1) month of receipt of the DWER invoice (see Table 2 for estimated contribution calculations). Since the initial payment is made prior to ground disturbance commencing, this amount will be subtracted from the subsequent offsets payable prior to CPI adjustments being applied, with CPI then applied only to any remaining amount owing for that period.

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Table 2: EP Act Offset - estimated contribution calculation into the PEOF

EP Act Environmental Value to be Offset	Amount of Area to be offset in ha(s)	Protected Matter Value Rating Category	Environmental Value Justification	IBRA Subregion	Estimated Offset Rate ($/ha) [3]	Total to be Offset
Good – Excellent condition native vegetation	4,922	Good – Excellent condition native vegetation	Clearing of good to excellent condition native vegetation	Hamersley	$890	$4,380,580*
Regionally significant vegetation	2	*West Angelas Cracking-Clays* Priority Ecological Community (Priority 1)	Clearing of Priority Ecological Community	Hamersley	$1,780	$3,560
High local significance vegetation	35	Riparian vegetation	Clearing of high value riparian vegetation	Hamersley	$1,780	$53,400 (5 ha overlies critical habitat and has been attributed to Cth offset)
Total amount for the Proposal into the PEOF (State Requirement)						**$4,437,540**
Actual amount for the Proposal into the PEOF based on higher rate (State Requirement)						**$56,960**

*Offset at lower rate and not counted in total offset for Proposal calculation

[3] Estimated offset rates calculated on the 2021/22 financial year (excluding GST) published PEOF rates. Real value of contributions will be maintained through indexation to the Perth Consumer Price Index (CPI), with the first adjustment to be applied to the first contribution

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Table 3: EPBC Act Offset – estimated contribution calculation into the PEOF

EPBC Act Protected Matter to be Offset	Amount of Area to be offset in ha(s)	Protected Matter Value Rating Category	Environmental Value Justification	IBRA Subregion	Estimated Offset Rate Documented ($/ha) [3]	Total to be Offset
Critical (high significance) habitat (roosting and breeding)	3,857	*Critical* habitat (breeding, denning, roosting, foraging and shelter) for MNES species: Northern Quoll, Pilbara Olive Python and Ghost Bat (including Pilbara Leaf-nosed Bat supporting habitat)	Clearing of critical habitat (breeding, denning and roosting [high significance] habitat) comprising: • Gorge/Gully; and • Hillcrest/Hillslope	Hamersley	$3,306	$12,751,242
Supporting habitat (moderate significance) (foraging and dispersal)	79	*Supporting* habitat (foraging and dispersal) for: • Northern Quoll and Pilbara Olive Python – within 1 km of records • Ghost Bat – 12 km from records • Pilbara Leaf-nosed Bat Category 4 roosts	Clearing of supporting habitat (foraging and dispersal habitat) comprising: • Drainage Line • Category 4 Pilbara Leaf-nosed bat roosts	Hamersley	$1,653	$119,667 (6.6 ha of riparian and has been attributed under the EP Act)
Supporting habitat (moderate significance) (foraging and dispersal)	2,181	*Supporting* habitat (foraging and dispersal) for: • Ghost Bat – 12 km from records	Clearing of supporting habitat (foraging and dispersal habitat) comprising: • Cracking Clay; • Mixed Acacia Woodland; and • Footslopes and Plains	Hamersley	$1,653	$3,563,207 (2 ha of cracking clay and 23.4 ha of riparian and has been attributed under the EP Act)
Total amount for the Proposal into the PEOF (EPBC Requirement)						**$16,432,473**
Initial estimated contribution into the PEOF (Commonwealth requirement, 10% of the overall EPBC Act offset contribution)						**$1,643,247**

*Total offset contribution is **$16,489,433** calculated using highest rates for each element as noted in 'Total to be Offset' column, 'good to excellent' condition vegetation is offset at a lower rate and is not included in this total (grey shading).

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3 REPORTING

3.1 Frequency and timing

The reporting schedule for IRR submission for the first three periods is outlined below in Table 4. It will be extrapolated and implemented until the end of the period of effect of the approval or as otherwise agreed to by DWER and the Australian Government Minister for the Environment.

Table 4: Proposed reporting period and frequency of the Impact Reconciliation Reports

Biennial period	Action	Timing
	Ministerial Statement issued	DD Month Year
	EPBC Decision Notice issued	DD Month Year
	Proposal implementation commenced	[Year 1]
	Initial EPBC Act payment	Prior to the commencement of ground disturbance associated with the Action
	Submit evidence of initial payment to the DCCEEW	Within 10 business days of receipt of payment
Period 1	First biennial reporting period	From the commencement of the Action to 31 December [Year 2]
	Aerial survey/ground-truthing	As close to 31 December as practicable
	IRR submission	30 April [Year 3], or as otherwise agreed with DWER and DCCEEW
	Submit evidence of payment into PEOF account to the DCCEEW	Within 10 business days of receipt of payment
Period 2	Second biennial reporting period	1 January [Year 3] – 31 December [Year 4]
	IRR submission	30 April [Year 5], or as otherwise agreed with DWER and DCCEEW
	Submit evidence of payment into PEOF account to the DCCEEW	Within 10 business days of receipt of payment
Period 3	Third biennial reporting period	1 January [Year 5] – 31 December [Year 6]
	IRR submission	30 April [Year 7], or as otherwise agreed with DWER and DCCEEW
	Submit evidence of payment into PEOF account to the DCCEEW	Within 10 business days of receipt of payment
Final Period	Final reporting period	1 January [Year X] – 31 December [Year X]
	Final IRR submission	30 April of Year after final reporting period, or as otherwise agreed with DWER and DCCEEW
	Submit evidence of payment into PEOF account to the DCCEEW	Within 10 business days of receipt of payment

3.2 Content

Commercially sensitive information within spatial data and aerial imagery in both Baseline and IRR's will be considered when completing required metadata and licensing statements (provided separately).

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3.2.1 Baseline

The Baseline package will contain three components:

1. IRP – this document.
2. Aerial imagery clipped to the proposed Development Envelope boundary and taken as close to the commencement of the approval as practicable, with an index providing date of capture for each image compiling the full composite.
3. Spatial data to support the above procedure. At a minimum, spatial data will meet the following:
    - be topographically accurate and georeferenced;
    - use GDA2020 (datum) co-ordinate system and projected into the appropriate Map Grid of Australia zone (ie 50);
    - include closed polygons and clipped to the relevant approval boundaries (any topology errors rectified);
    - be supplied in ESRI geodatabase format or shapefile;
    - be aligned with and attributed according to DWER's GIS Data Standards;
    - polygons of similar 'purpose' shall not overlap (ie. clearing polygons shall not overlap, vegetation type polygons shall not overlap, vegetation condition polygons shall not overlap, and exemption polygons shall not overlap);
    - all clearing data will be supplied to two decimal places in attributable tables.

    Spatial data and layers shall include:

    - Spatial boundaries including:
        - Development Envelopes *(Current and overlapping Proponent MSs only, previous MSs not to be included)*;
        - Areas of Significance *(Environment Matters specified in MS and EPBC Act Decision Notice, prescribed in offset conditions) with areas already cleared at the time of IRP submission removed;*
    - Vegetation condition and type (1 consolidated polygon per condition and type), by IBRA region;
    - Offset exempt areas. Exemptions may include clearing associated with:
        - previous MS (1 consolidated polygon per MS) *(where areas are not subject to offsets),* by IBRA region*;*
        - overlapping MS where the proponent is a Rio Tinto company (1 consolidated polygon per MS), by IBRA region;
        - MS-prescribed NVCPs (1 consolidated polygon) *(where MS prescribes NVCPs which contribute to the total Proposal clearing allocation),* by IBRA region;
        - other NVCP (1 consolidated polygon), all clearing attributed to NVCPs within the Proposal's Development Envelope, not prescribed by the MS, by IBRA region;
        - other clearing mechanism (1 consolidated polygon, by IBRA region) – may include:
            - Clearing authorised under an alternative approval mechanism (eg. *Bush Fires Act 1954*, *Land Administration Act 1997*, Prescribed clearing under Regulation 5 of the *Environmental Protection (Clearing of Native Vegetation) Regulations 2004*). Note NVCP has been separated;
            - Clearing conducted prior to clearing legislation commencement;
            - Clearing not completed by the Proponent (where possible, information will be added within the notes section of the attribution table detailing the suspected cause of the impact).
        - Note: Exemptions related to clearing mechanisms applied at the Western Australian level do not apply to the EPBC Act approval, except for clearing not conducted by the Proponent.
    - Maps to support the above-mentioned spatial data.

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3.2.2 Impact Reconciliation Reports

IRR's will contain three components:

1. A biennial report specifying the annual area cleared (in hectares), and base and CPI adjusted rates for each offset applicable requirement outlined in the MS and EPBC Act approval as well as estimates of projected clearing for subsequent biennial periods. The report structure and content will be in accordance with an internal template which will be reviewed biennially to ensure alignment and consistency with DWER issued templates and guidance material. A final IRR will be submitted in the year after the final reporting period that includes the offset attributable clearing footprint that has occurred over the life of the approval.
2. Aerial imagery clipped to the relevant approval boundaries and taken as close to the end of the annual reporting periods as practicable, with an index providing date of capture of each image compiling the full composite.
3. Spatial data to support the above report. Both IRR and Baseline spatial data shall be used to inform the overall requirement for offsets for the action. At a minimum, spatial data will meet the following:
    - be topographically accurate and georeferenced;
    - use GDA2020 (datum) co-ordinate system and projected into the appropriate Map Grid of Australia zone (ie. 50);
    - include closed polygons and clipped to the relevant approval boundaries (any topology errors rectified);
    - be supplied in ESRI geodatabase format or shapefile;
    - be aligned with and attributed according to DWER's GIS Data Standards;
    - polygons of similar 'purpose' shall not overlap (ie. clearing polygons shall not overlap, vegetation type polygons shall not overlap, vegetation condition polygons shall not overlap, and exemption polygons shall not overlap);
    - all clearing data will be supplied to two decimal places in the attribute tables.

    Spatial data and layers for both the MS and EPBC Act approval shall include:

    - Clearing activity:
        - all clearing undertaken for each calendar year of each biennial reporting period (1 polygon per year, per mechanism, per IBRA region);
        - offset payable clearing undertaken for each calendar year of each biennial reporting period (1 polygon per year, per rate, per mechanism);
        - updates to offset exempt areas (1 polygon for each previously submitted layer indicating changes).
    - Maps to support the above-mentioned spatial data.
    - Updated spatial layers if a change is required (refer to Section 4).

4 MANAGEMENT OF CHANGE

The Proponent recognises that due to the timing of new submissions, approval complexity and continued process and technology improvements, changes to submitted data may be required. For the below listed known changes, the Proponent will supply any updated data and support spatial files in the next IRR submission. Note that only the changed information will be provided, rather than the re-supply of the entire layer:

- offset exempt areas acknowledging that clearing will continue to occur between submission of baseline as part of pre-approval conditions (where required) and Proposal approval; and
- updated exempt areas as a result of continued clearing or until the previously approved offset-exempt clearing allocation has been exhausted.

For unforeseen changes, the Proponent will conduct an assessment of materiality and will initiate discussions with DWER and DCCEEW to determine an appropriate resolution strategy.

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5 APPENDICES

Appendix 1: PLACEHOLDER Proposed offset conditions that may apply to the Proposal

Table A 1 – EP Act Ministerial Statement XXX offset conditions that apply to the Proposal. PLACEHOLDER [placeholder until conditions are drafted. The values and associated rates are proposed to be offset in line with Table 1]

Condition Number	Condition Requirement
TBC	

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Table A 1 – EPBC Act Decision Notice XXX offset conditions that apply to the Proposed Action: PLACEHOLDER [placeholder until conditions are drafted. The values and associated rates are proposed to be offset in line with Table 1]

Condition Number	Condition Requirement
TBC	

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Appendix 2
Proposal Overview

Drawn: A.D.
Plan: RTIO-0985797v1
Date: March 2023

Proj: GDA 1994 MGA Zone 50
Scale: 1:120,000 @A3
GIS.Team@riotinto.com

660,000
670,000
680,000
690,000
7,450,000
7,440,000
7,430,000

Karijini National Park

Great Northern Highway

Western Hill
Deposit C
Deposit D
Deposit G
Deposit B
Deposit H
Deposit A West
Deposit A
Deposit E
Deposit F
Deposit F North
Mt Ella East

Legend

- Revised Development Envelope
- Conceptual Footprint

Proposed Conceptual Layout

- Pit
- Waste Landform

Approved Conceptual Layout

- Pit
- Waste Landform

- National Park
- Rio Tinto Railway
- Highway

N

0 1 2 3 4 5
Kilometres

Map units in metres

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660,000
670,000
680,000
690,000
7,450,000
7,440,000
7,430,000

Karijini National Park

Great Northern Highway

Western Hill

Deposit H

Deposit B

Deposit G

Turee Creek East Branch

Deposit C

Deposit D

Deposit A West

Deposit A

Deposit E

Deposit F North

Deposit F

Mt Ella East

Spearhole Creek

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Appendix 3
Proposal Baseline Vegetation

Drawn: A.D.
Plan: RTIO-0985798v1
Date: March 2023

Proj: GDA 1994 MGA Zone 50
Scale: 1:120,000 @A3
GIS.Team@riotinto.com

Legend

- Revised Development Envelope
- Extension Area

Proposed Conceptual Layout

- Pit
- Waste Landform

Approved Conceptual Layout

- Pit
- Waste Dump

Vegetation Condition

- Excellent
- Very Good
- Good
- Poor
- Completely Degraded

- National Park
- Rio Tinto Railway
- Highway
- Major Creek

N

0 1 2 3 4 5
Kilometres

Map units in metres

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Appendix 4: Proposal Offset Areas

[Placeholder]

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Appendix 5: Proposal Baseline Footprint

[Placeholder]

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Appendix 6: Vegetation Condition Mapping References

Report References
• Biologic, 2022. Deposit G Targeted Flora and Vegetation Survey • Biologic, 2022. Deposit H Infrastructure Reconnaissance Flora and Vegetation Survey • Biologic, 2022. Mt Ella East and Deposit J Detailed Flora and Vegetation Survey • Biologic, 2022. West Angelas Development Envelope Vegetation Condition Assessment • Biologic, 2022. West Angelas Development Envelope Vegetation Significance Assessment • Rio Tinto, 2022. Metadata_Statement Vegetation Condition Mapping for West Angelas • Biologic, 2021. West Angelas Development Envelope Consolidated Vegetation Mapping • Biota, 2020. West Angelas Beyond 2020 Detailed Flora and Vegetation Survey phases 1 and 2

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