GABANINTHA VANADIUM PROJECT

EP Act s38 Referral: Supporting Information

Part B: Appendices

REV C

INTEGRATE SUSTAINABILITY PTY LTD

Appendices

APPENDIX B-6: Biologic Environmental Survey – Targeted Vertebrate Fauna and SRE Assessment

Gabanintha Vanadium Project

Targeted Vertebrate Fauna & SRE Assessment

Biologic Environmental Survey Pty Ltd

Technology Metals Australia Limited.

November 2018

GABANINTHA VANADIUM PROJECT
TARGETED VERTEBRATE FAUNA & SRE ASSESSMENT

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Final	C. van den Bergh	C. Knuckey	Belinda Bastow	22/11/2018

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EXECUTIVE SUMMARY

Technology Metals Australia Limited (TMAL) proposes to develop the Gabanintha Vanadium Project. TMAL is currently completing a pre-feasibility study into the Project and plan on progressing the Project further to obtain the necessary environmental approvals. To assist in the development of environmental impact assessment (EIA) documents, Integrate Sustainability Pty Ltd (ISPL), on behalf of TMAL, commissioned Biologic Environmental Survey Pty Ltd (Biologic) to complete a targeted vertebrate fauna and Short-Range Endemic (SRE) assessment of the Project. The Project includes two areas and associated access corridors which are 1,233 hectares in size. The field survey was completed from the 7th to the 12th of May 2018. An additional field trip (vertebrate fauna and SRE) was completed over a portion of the Study Area in 2017 for another client. The results from the 2017 surveys that occur on TMAL tenure have been included in this assessment, where relevant.

Vertebrate Fauna

The vertebrate fauna assemblage of the Study Area was assessed via a desktop assessment and targeted survey. The desktop assessment identified a total of 288 species of vertebrate fauna, which have previously been recorded and/ or have the potential to occur within the Study Area. This comprised 32 native mammals, nine non-native mammals, 182 native birds, two non-native birds, 55 reptiles and eight amphibians. Of the 288 species of vertebrate fauna identified as being previously recorded and/ or having the potential to occur, 33 species are of conservation significance, comprising five mammals, 26 birds and two reptiles.

A total of seven broad fauna habitat types were recorded and mapped across the Study Area. This comprised, in decreasing order of extent, Stony Plain, Chenopod Shrubland, Mulga Woodland, Rocky Outcrop, Minor Drainage Line, Drainage Area and Sandy Mulga. The Rocky Outcrop was deemed to be of relatively high local significance due to the potential to provide habitat for species of conservation significance i.e. potential denning and foraging habitat for the Long-tailed Dunnart. The Rocky Outcrop habitat also provides moderately suitable habitat for SRE invertebrate species. The Rocky Outcrop habitat is of low regional significance as rocky outcropping and similar habitat occurs sporadically throughout the Murchison bioregion. The remaining habitats were deemed to have a low significance as they either do not support species of conservation significance and/ or such species are not dependent on these habitats at the fine-scale. Furthermore, these habitats are widely distributed within the Study Area and within the region generally (McKenzie *et al.*, 2002).

A total of 70 vertebrate fauna species, comprising 14 mammal species, 46 bird species, nine reptile species, and one amphibian species were recorded from the Study Area during the current assessment. Two conservation significant vertebrate fauna species, the Long-tailed Dunnart and the Peregrine Falcon, were recorded from the Study Area in 2017 during previous work. Based on distribution, previous records and the habitats present, none of the 33 species of conservation significance were deemed highly likely or likely to occur. Four were deemed possible to occur, while 14 may rarely occur within the Study Area. The remaining 13 conservation significant taxa are unlikely (seven taxa) and

highly unlikely (six taxa) to occur within the Study Area due to current known distribution and habitat requirements.

SRE Invertebrates

The database searches identified 690 records. The total included 542 specimens of arachnids and myriapods, and 148 crustaceans. While most of these taxa represent epigean taxa, they are not filtered to exclude subterranean or aquatic taxa. Furthermore, the SRE status on these taxa cannot be determined from these results although they do provide insight of nearby collected specimens and the amount of sampling effort conducted in the vicinity of the Study Area.

From a review of the database searches only two specimens have been collected within 10 km of the Study Area. The taxa were a species of Araneomorph, a group which is not recognised as being prone to short-range endemism, and *Aname mainae*, a Mygalomorph spider which is considered widespread and not SRE.

The current assessment collected invertebrate samples from microhabitats in leaf litter, topsoil, under rocks, and woody debris at 13 of the 20 sampling sites. The sampling collected invertebrate specimens from 13 groups that are conducive to representing SRE species (i.e. from the family Olpiidae). The specimens are all from the Pseudoscorpions group. Of the invertebrate specimens collected, six represent two taxa that are Potential SRE. In 2017 Biologic collected a further five invertebrate fauna species from within the TMAL tenure that are Potential SRE (see Section 4.7). The five specimens were all pseudoscorpions from the Olpiidae family, while two other specimens from the Olpiidae family could not be identified to taxon (genera) level due to damage, and are considered to be Potential SRE.

The Potential SRE taxa were identified to *Austrohorus* sp. Indet., *Indolpium* sp. Indet., and Olpiidae sp. Indet. The invertebrate specimens are from one taxonomic group prone to short-range endemism (Pseudoscorpions, Olpiidae family) and are identified as representing Potential SRE taxa (Data Deficient). The data deficiency was due to the specimens not possessing the characteristics required for species level identification, and/or that the taxonomy of such groups is lacking in the Murchison region. Due to the limited taxonomic work for this family and the lack of regional data, it is difficult to definitively say that any of the species identified are locally or regionally significant.

All potential SRE specimens are currently regarded as ‘data deficient’, as they cannot be fully assessed for SRE status due to significant knowledge gaps at the taxonomic levels. At the current time, the regional genetic sequence data on these taxa is also insufficient to provide meaningful resolution of species boundaries; therefore, options for further investigation are limited.

Summary

In summary the Study Area was surveyed to an adequate scale with 70 vertebrate fauna species recorded and invertebrate specimens collected from 13 groups conducive to SRE status. A further six ‘Potential SRE’ have been recorded in the Study Area in 2017. The Study Area appears to represent common and widespread habitats which occur across the Murchison bioregion. The Rocky Outcrop habitat, although locally significant for providing habitat for conservation significant fauna, occurs sporadically in the region as either rocky outcrops, ridges or small ranges/ hills. As such, the majority

of the fauna occurring within the Study Area are likely to spread across the region. The assessment did identify two species of conservation significance, the Long-tailed Dunnart and the Peregrine Falcon. The Long-tailed Dunnart may be locally impacted by disturbances to the Rocky Outcrop habitat. The Peregrine Falcon is unlikely to rely solely on the Study Area for survival and is highly mobile. The Rocky Outcrop habitat may also possibly provide habitat for SRE invertebrates.

1 INTRODUCTION

1.1 Background

Technology Metals Australia Limited (TMAL) primary purpose is to identify exploration projects in Australia (and overseas) with the aim of discovering commercially significant mineral deposits. TMALs primary focus is on the Gabanintha Vanadium Project (the Project), with the aim to develop this Project to supply high-quality vanadium oxide ($V_2 0_5$) flake product to both the steel market and the emerging vanadium redox battery (VRB) market. TMAL is currently completing a pre-feasibility study into the Project and plan on progressing the Project further to obtain the necessary environmental approvals.

To assist in the development of environmental impact assessment (EIA) documents, Integrate Sustainability Pty Ltd (ISPL), on behalf of TMAL, commissioned Biologic Environmental Survey Pty Ltd (Biologic) to complete a targeted vertebrate fauna and SRE assessment of the Project. The Project is located approximately 36 kilometres (km) south-southeast of the town of Meekatharra, within the Murchison bioregion (according to the Interim Biogeographical Regionalisation of Australia, IBRA; Thackway & Cresswell, 1995) (Figure 1.1). The Project includes two regions (Northern and Southern) and associated access corridors (Figure 1.2, collectively hereafter referred to as the Study Area) and is 1,233.2 hectares (ha) in size:

- Northern Region (M51/883- pending) – 789.2 hectares (ha);
- Northern Access – 95.2 ha;
- Southern Region (M51/884 – pending) – 93.9 ha; and
- Southern Access – 254.9 ha.

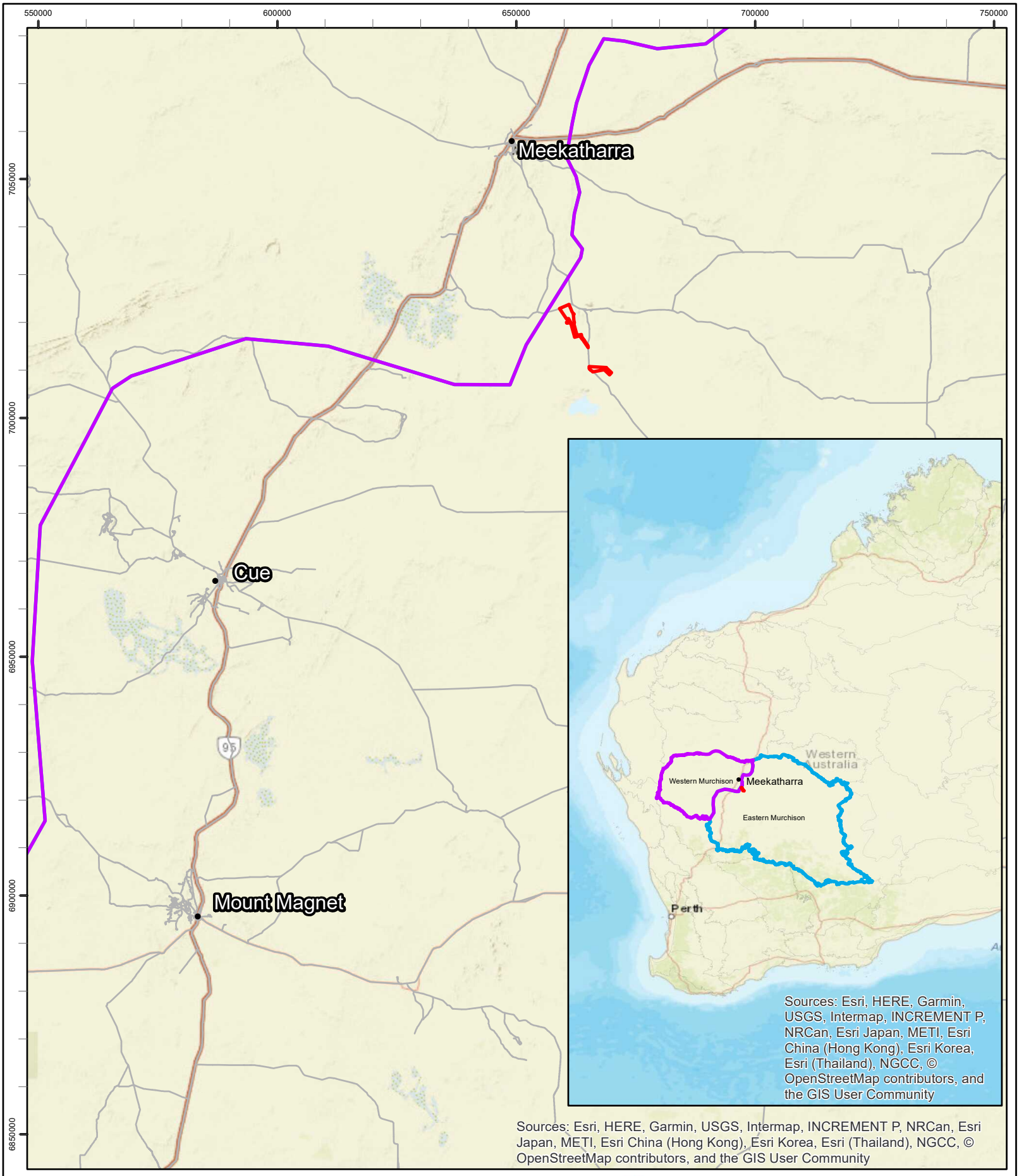
The Study Area occurs across numerous tenements, not all held by TMAL. The Study Area occurs in part or wholly within tenements E51/1510-I, P51/2944, P51/2943, P51/2942 and E51/1818. The Northern and Southern Regions partially or wholly occur within mining tenement M51/883 (pending) and M51/884 (pending) (Figure 1.2). The field survey for the current assessment was completed in May 2018, while additional survey work completed within the Study Area was completed in April and October 2017.

1.2 Objectives and Scope of Work

The overarching objective of this assessment (hereafter referred to as the survey) was to identify the environmental values of the Study Area and to determine if there are any conservation significant values that need to be considered during the design and future approval of the Project. The overarching objective was achieved via the following scope of works:

- A review of vertebrate fauna recorded (through current database searches and recent surveys) within Study Area and surrounding area;
- An assessment on the presence, or likely presence, of vertebrate fauna currently considered to be of conservation significance (under state and federal legislation);
- A review of SRE fauna recorded within the vicinity of the Study Area and broad habitats in the Study Area, to indicate whether SRE species are likely to occur;

- Conducting targeted sampling for vertebrate fauna of conservation significance and conduct targeted sampling for potential SRE species;
- The discussion of significant environmental values (and remaining environmental values) from a regional and local context; and
- The provision of advice and guidance related to the environmental approval process with respect to any significant values identified from the Study Area.



Legend

- Study Area
- Major Towns
- Roads

IBRA Subregions

- Eastern Murchison
- Western Murchison

biologic Environmental Survey

N

1:1,000,000

0 10 20 40 km

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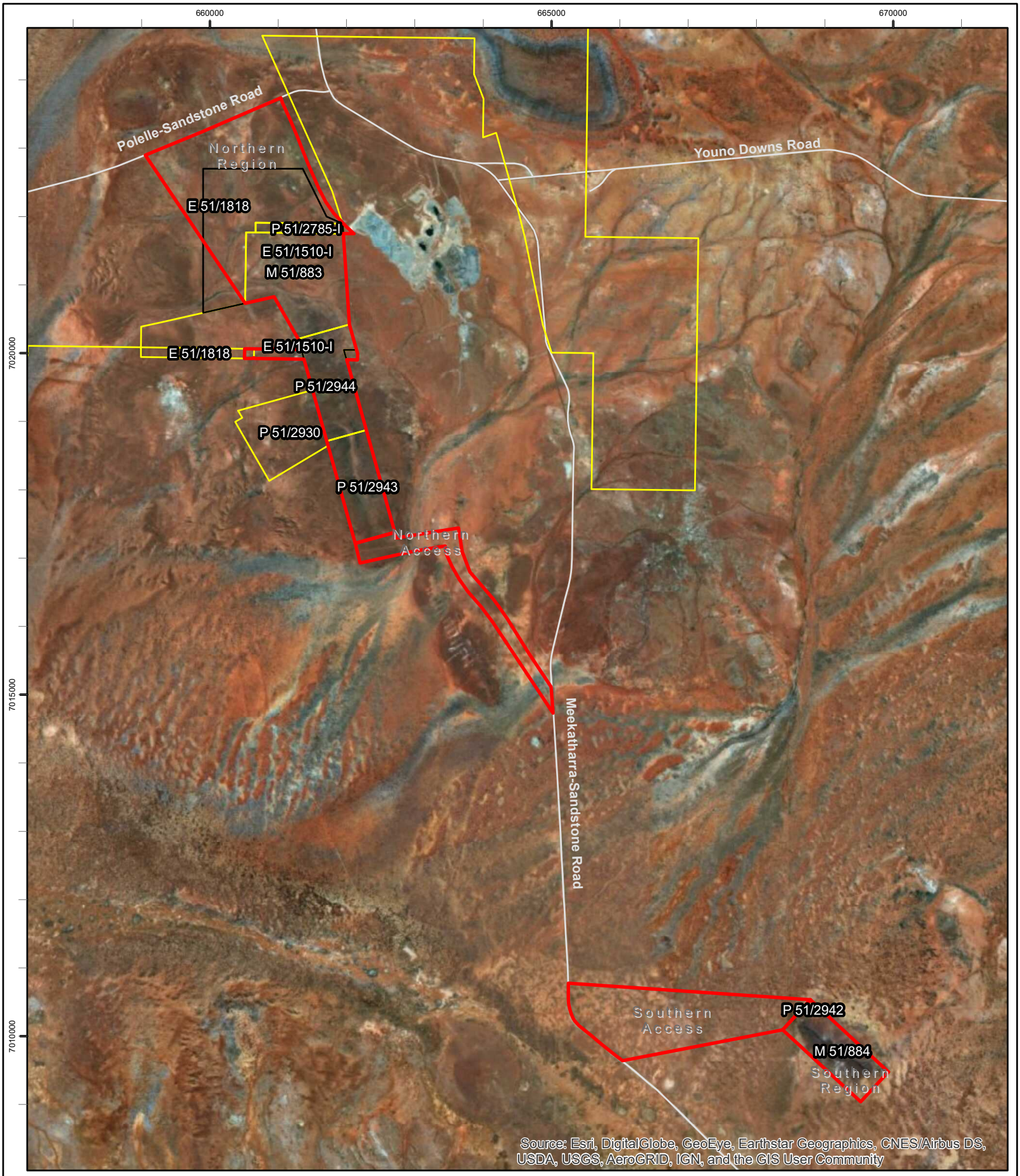
Gabanintha Vanadium Project

Figure 1.1: Regional location and IBRA subregion

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

Size A4. Created 05/09/2018



Legend

- StudyArea
- Roads

TMAL Tenure

- Live
- Pending

biologic Environmental Survey

N

1:70,000

0 0.5 1 2 km

Technology Metals Australian Limited

Gabanintha Vanadium Project

Figure 1.2: Gabanintha Study Area

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

Size A4. Created 20/11/2018

1.3 Background to Protection of Fauna

1.3.1 Conservation Significance

Within Western Australia, native fauna is protected under the *Wildlife Conservation Act 1950* (WC Act) and at a national level under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act). Any action that has the potential to impact on native fauna needs to be approved by relevant state and/or federal departments as dictated by the state *Environmental Protection Act 1986* (EP Act).

Some species of fauna that are determined to be at risk of extinction or decline are afforded extra protection under these Acts. For the purposes of this report, these species are deemed to be of conservation significance. A summary of applicable legislation and status codes is provided in Table 1.1 and additional information on status codes is provided in Appendix A. A number of migratory bird species are also prioritised for conservation under international agreements and therefore protected under the EPBC Act and WC Act as Migratory.

For some species, there is insufficient information to determine their status. These species are generally considered by the EPA and the Department of Biodiversity, Conservation and Attraction's (DBCA) as being of conservation interest for all development related approvals, and are listed on a 'Priority List' that is regularly reviewed and maintained by the DBCA (Table 1.1).

Table 1.1 Definitions and terms for fauna of conservation significance

Agreement, Act or List	Status Codes
Federal	
***Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act)** The Department of the Environment and Energy (DoEE) lists threatened fauna, which are determined by the Threatened Species Scientific Committee (TSSC) per criteria set out in the Act. The Act lists fauna that are considered to be of conservation significance under one of eight categories (listed under 'Status Codes').	• Extinct (Ex) • Extinct in the Wild (EW) • Critically Endangered (Cr) • Endangered (En) • Vulnerable (Vu) • Conservation Dependent (CD) • Migratory (Mi) • Marine (Ma)
State	
***Wildlife Conservation Act 1950* (WC Act)** At a state level, native fauna are protected under the *Wildlife Conservation Act 1950*. Species in need of conservation are given a ranking ranging from Critically Endangered to Vulnerable.	• Schedule 1 (Critically Endangered) (S1) • Schedule 2 (Endangered) (S2) • Schedule 3 (Vulnerable) (S3) • Schedule 4 (Extinct) (S4) • Schedule 5 (Migratory) (S5) • Schedule 6 (Conservation Dependent) (S6) • Schedule 7 (Other Specially Protected) (S7)
DBCA Priority List DBCA produces a list of Priority species that have not been assigned statutory protection under the *Wildlife Conservation Act 1950*. This system gives a ranking from Priority 1 to Priority 4.	• Priority 1 (Poorly-known species) (P1) • Priority 2 (Poorly-known species) (P2) • Priority 3 (Poorly-known species) (P3) • Priority 4 (Rare, Near Threatened, and other species in need of monitoring) (P4)

- The *Biodiversity Conservation Act 2016* was enacted in 2016, however only several parts of the new Act were proclaimed by the State Governor in the *Government Gazette*. Provisions that replace those existing under the WC Act (including threatened species listings and controls over the taking and keeping of native species) and their associated Regulations cannot be brought into effect until the necessary *Biodiversity Conservation Regulations* have been made.

1.3.2 Short-range Endemism

Endemism refers to the restriction of a species to a particular area, whether it is at the continental, national or local scale, the latter being commonly referred to as short-range endemism (Allen *et al.*, 2006; Harvey, 2002). Short-range endemism is influenced by several factors including life history, physiology, habitat requirements, dispersal capabilities, biotic and abiotic interactions and historical conditions which not only influence the distribution of a species, but also the tendency for differentiation and speciation (Ponder & Colgan, 2002).

In recent years a number of taxonomic groups of invertebrates have been highlighted as comprising a high proportion of species likely to be regarded as SREs (i.e. Harvey, 2002; terrestrial snails, Johnson *et al.*, 2004; Mygalomorph spiders, Main *et al.*, 2000; freshwater snails, Ponder & Colgan, 2002). This identification of restricted taxonomic groups has led to SRE invertebrate fauna being recognised as a potentially significant biodiversity issue, and that SRE fauna "may be at a greater risk of changes in conservation status as a result of habitat loss or other threatening processes" (EPA, 2016b).

Harvey (2002) proposed a range criterion for terrestrial short-range endemic (SRE) species at less than 10,000 km^2 (or 100 km x 100 km), which has been adopted by regulatory authorities in Western Australia (EPA, 2016b). SRE invertebrate species often share similar biological, behavioural and life history characteristics that influence their restricted distributions and limit their wider dispersal (Harvey, 2002). For example, burrowing taxa such as mygalomorph spiders and *Urodacus* scorpions may only leave their burrows (or a narrow home territory around the burrow) as juveniles dispersing from the maternal burrow, or when males search for a mate. In other cases, SRE taxa are dispersal-limited because of their slow pace of movement and cryptic habitats (such as isopods, millipedes and snails), while some specialised taxa can be limited by very specific habitat requirements, such as selenopid spiders within fractured rocky outcrops.

An increasingly large number of terrestrial invertebrates are discovered to exhibit short-range endemism in Western Australia. While protection for listed species (species of conservation significance) and/ or Threatened or Priority Ecological Communities is provided under state and federal legislation, the majority of SRE species and communities are not currently listed. This is due largely to incomplete taxonomic or ecological knowledge. As such, the assessment of conservation significance for SRE is guided primarily by expert advice provided by the Western Australian Museum (WAM) and other taxonomic experts.

1.3.3 SRE Status Categorisation

The SRE status categories used in this report broadly follows the WAM's revised categorisation for SRE invertebrates. This system is based upon the 10,000 km^2 range criterion proposed by Harvey (2002), and uses three broad categories to deal with varying levels of taxonomic certainty that may apply to any given taxon (Table 1.2).

Table 1.2: SRE categorisation used by WAM taxonomists

	Taxonomic Certainty	Taxonomic Uncertainty
Distribution < 10 000 km^2	Confirmed SRE • A known distribution of < 10,000 km^2. • The taxonomy is well known. • The group is well represented in collections and/ or via comprehensive sampling.	Potential SRE • Patchy sampling has resulted in 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 > 10 000 km^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.	

Under this system, “Potential SRE” status is the default categorisation for species within the typical SRE taxonomic groups, including mygalomorph spiders, selenopid spiders, land snails, pseudoscorpions, scorpions, and isopods, unless sufficient evidence exists to confirm widespread or confirmed SRE status.

Potential SRE status is sub-categorised by what is currently known about the species in question; *i.e.* whether there are B) habitat indicators, C) morphology indicators, D) molecular evidence, or E) a weight of general knowledge and experience with the group that suggests a reasonable likelihood that the species could be SRE. In terms of SRE likelihood, the more evidence that exists under sub categories 'B', 'C', 'D', and 'E', the greater the likelihood that further investigation would confirm that the species is an SRE.

However, the Potential SRE category 'A' - data deficient is unique; this category indicates that the current information is insufficient to adequately assess the SRE status of the species in question. In such cases, where the SRE status cannot be confirmed, a conservative approach would be unable to consider the SRE risk to be higher than average where:

A. the taxonomy of the genus (or family) requires significant review in order to make any statement on SRE status, and/or

B. the genus is not known to include any confirmed SRE species within the region (subject to the extent of prior sampling / taxonomic effort).

To avoid confusion with other Potential SRE species for which there is some certainty and/or some precedent for their SRE status, this report represents the WAM’s "Potential SRE - category 'A' - data

deficient" as "data deficient". The identifications from the taxonomists are presented within the broader context of the habitat assessments, desktop review, habitat connectivity, and other ecological information collected during the survey. This approach aims to provide a more holistic assessment of SRE likelihood at scales relevant to the project, as well as the standard SRE range criterion of <10,000 km^2 (Harvey 2002).

2 ENVIRONMENT

2.1 Biogeography

The Interim Biogeographic Regionalisation for Australia (IBRA) is a key tool for planning nature conservation in Australia and is used by all levels of government. IBRA regions are defined and mapped by the Department of the Environment and Energy (DoEE) and updated regularly. IBRA regions are defined based on commonalities in climate, vegetation, soils, geology and fauna. Currently 89 IBRA bioregions and 419 subregions are recognised, and maps are available on the DoEE website (http://www.environment.gov.au/land/nrs/science/ibra).

The Study Area lies within the Murchison IBRA bioregion and the Eastern Murchison subregion, close to the boundary with the Western Murchison subregion. The Eastern Murchison subregion represents the northern parts of the Yilgarn craton and is geologically characterised by internal drainage, areas of elevated red desert sandplains, salt lakes with paleo-drainages and plains of red-brown soils with breakaways (Cowan *et al.*, 2001). Vegetation in this broad subregion of nearly 7.9 million hectares, is dominated by Mulga (*Acacia aneura* and close relatives) woodlands, hummock (spinifex) grasslands (*Triodia* spp.), saltbush (*Atriplex* spp.) shrublands and Samphire (*Tecticornia* spp.) shrublands. The climate is arid with mostly winter rainfall of around 200 mm per annum (Cowan *et al.*, 2001).

2.2 Climate

The Study Area is located within the Eastern Murchison subregion of the Murchison bioregion (following Thackway & Cresswell, 1995) (Figure 1.1). The region features an arid climate, with rainfall occurring predominantly in winter of 200 mm per annum (Cowan *et al.*, 2001).

Long-term climatic data is not available for the Study Area itself, although is available from the Bureau of Meteorology (BoM) weather station at Meekatharra Airport (Station 7045), 35.24 km north of the Study Area, which provides an indication of climatic conditions experienced at the Study Area (Figure 2.1).

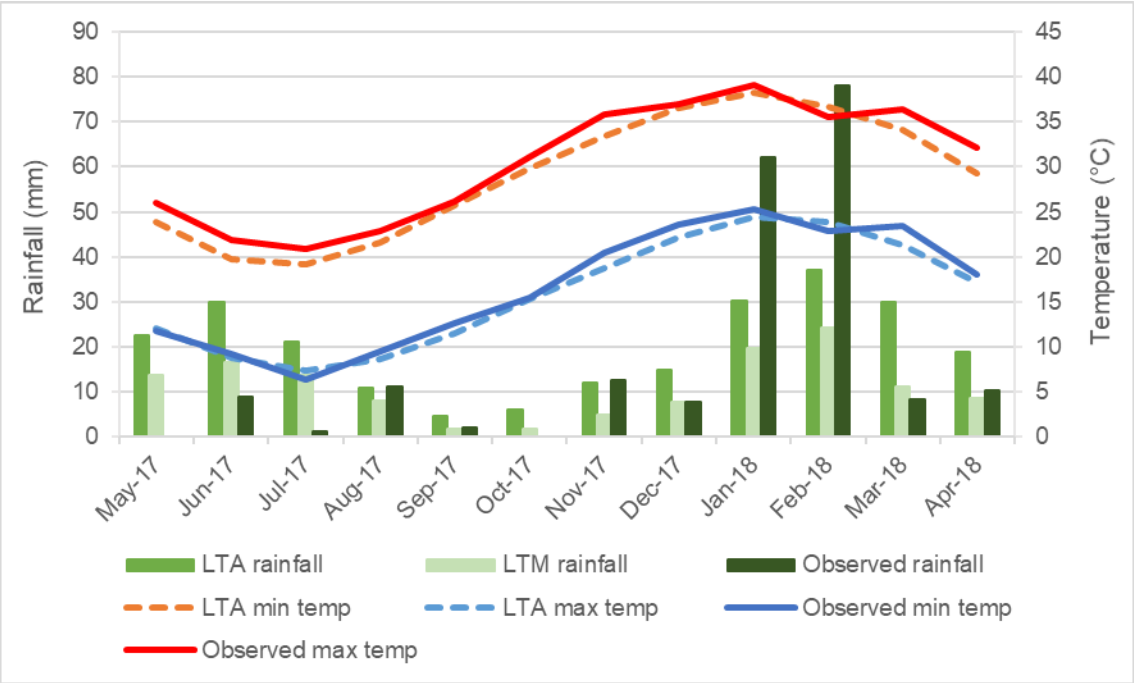


Figure 2.1: Climate data for Meekatharra Airport (BoM, 2018), comparing long-term average (LTA) monthly rainfall (mm) and temperatures (°C), Long-term median (LTM) rainfall (mm), observed average monthly rainfall (mm) and temperatures (°C).

2.3 Soils and Landforms

The Study Area is located within the Murchison Province and occurs in association with three soils zones; 272 Upper Murchison Zone, 273 Yalgoo Plains Zone, and Salinaland Plains Zone (Tille, 2006). The Atlas of Australian Soils (Northcote *et al.*, 1960-1968) was compiled by the Commonwealth Scientific and Industrial Research Organisation (CSIRO) in the 1960's to provide a consistent national description of Australia's soils. It comprises of a series of ten maps and associated explanatory notes and is published at a scale of 1:2,000,000 (with its original compilation at scales from 1:250,000 to 1:500,000). The landscape soil mapping across the Study Area indicates that two units occur, units BE2 and Mz23. The Southern Region and Southern Access occur within unit Mz23, while the Northern Region and the majority of the Northern Access occur within unit BE2. The remaining portion of the Northern Access occurs within unit Mz23.

Table 2.1: Soil landscape units mapped within the Study Area

Code	Description	Extent	
		Ha	%
BE2	Generally undulating terrain on granites with rocky granitic hills, bosses, and tors, some breakaways, and a surface stone mantle: chief soils seem to be shallow earthy loams (Um5.3) underlain by a red-brown hardpan. Associated are shallow (Uc5.21, Uc5.22) soils both underlain by a red-brown hardpan; some (Gn2.1) soils underlain by a red-brown hardpan; and shallow (Uc1.43) and (Um5.41) soils on the hills (no hardpan). The red-brown hardpan is often exposed in eroded sites, and elsewhere is present between 8 and 40 in.	873	71

Code	Description	Extent	
		Ha	%
Mz23	Extensive flat and gently sloping plains with a scatter of surface gravels, similar in topography to unit My5O: chief soils are shallow acid red earths (Gn2.11) and shallow earthy loams (Um5.3) often occurring in intimate micro-associations. Red-brown hardpan occasionally outcrops and is normally present within a depth of 1 m. As mapped, soils of units Oc47 and My5O may be included	360	29
Total		**1,233**	**100**

2.4 Geology

The Murchison Province occupies the north-western part of the Yilgarn Craton and is divided into six major crustal components; two greenstone sequences, the Luke Creek and the overlying Mount Farmer Groups (together forming the Murchison super group), and four granitoid suites (Watkins & Hickman, 1990).

The Study Area is located over units of the Meekatharra-Wydgee Greenstone Belt within the Archaean Yilgarn Craton. More specifically, it is located over the Archaean Gabanintha Gabbro (part of the Lady Anna Igneous Complex), one of several mafic / ultramafic intrusive complexes in the region (IIR, 2018).

The Study Area consists of two rocky ridges, located in the Northern and Southern Regions. The two ridges are located on the eastern limb of the synclinal Meekatharra Greenstone Belt, which consists of interlayered mafic and felsic-volcanoclastic units. The ridges represent cumulate magnetite bands within a layered gabbro sill, dipping steeply to the west, which contains layers of anorthosite as well as magnetite. The magnetite bands are coarsely crystalline and contain titanium and vanadium (John Barnett personal communication, 1 September 2018).

2.5 Land Systems

Work undertaken by a joint team from the (former) Department of Agriculture (now Department of Primary Industries and Regional Development) and the (former) Department of Lands Administration (now Department of Planning, Lands and Heritage) attempted to classify the pastoral areas of Western Australia (Curry *et al.*, 1994). The purpose of the surveys were to provide a comprehensive description and mapping of the biophysical resources of the pastoral areas, together with an evaluation of the pastoral potential and the condition of the soils and vegetation (Curry *et al.*, 1994).

The Study Area occurs close to the boundary of three rangeland surveys, Curry *et al.* (1994), Payne *et al.* (1998) and Mabbutt *et al.* (2010). Pollele Station occurs within Curry *et al.* (1994), Yarrabubba Station occurs within Payne *et al.* (1998) and Hillview Station occurs predominantly within Mabbutt *et al.* (2010).

The Study Area is located across eight land systems, as mapped by Curry *et al.* (1994) and Payne *et al.* (1998) (Figure 2.2; Table 2.2). The dominant land system is the Wiluna Land System, which covers 61% of the Study Area, while the Carnegie Land System covers 15% of the Study Area. The remaining

six land systems also represent less than 10% of the Study Area, with the Koonmarra Land System representing 2% of the Study Area as the smallest extent.

Table 2.2: Land Systems mapped within the Study Area and their extent

Land System	Description	Extent within the Study Area	
		ha	%
Carnegie	Salt lakes with fringing saline alluvial plains, kopi dunes and sandy banks, supporting halophytic shrublands and acacia tall shrublands.	186	15
Gabanintha	Greenstone ridges, hills and footslopes supporting sparse acacia and other mainly non-halophytic shrublands.	70	6
Koonmarra	Quartz-strewn stony plains and low rises with outcropping granite, gneiss and schist, supporting scattered mulga shrublands and other mainly non-saline shrubs.	22	2
Nallex	Gently undulating stony plains supporting *Acacia* tall shrublands and chenopod low shrublands.	36	3
Naluthanna	Rough hills, tor fields and slopes of gabbro above lower stony plains with gilgaied drainage floors supporting mixed acacia shrublands with sparse halophytes.	53	4
Violet	Gently undulating gravelly plains on greenstone, laterite and hardpan, with low stony rises and minor saline plains; supporting groved mulga and bowgada shrublands and occasionally chenopod shrublands.	39	3
Wiluna	Low greenstone hills with occasional lateritic breakaways and broad stony slopes, lower saline stony plains and broad drainage tracts; supporting sparse mulga and other acacia shrublands with patches of halophytic shrubs.	750	61
Yanganoo	Almost flat hardpan wash plains, with or without small wanderrie banks and weak groving; supporting mulga shrublands and wanderrie grasses on banks.	78	6
Total		1,233	100

NB: values have been rounded to the nearest whole number

Legend

- StudyArea
- **Land System**
- Belele System
- Carnegie System
- Challenge System
- Cunyu System
- Ero System
- Gabanintha System
- Jundee System
- Koonmarra System
- Millrose System
- Nallex System
- Naluthanna System
- Sherwood System
- Violet System
- Wiluna System
- Yagahong System
- Yanganoo System

biologic Environmental Survey

N

1:70,000

0 0.5 1 2 km

Technology Metals Australian Limited

Gabanintha Vanadium Project

Figure 2.2: Land System mapping across the Study Area

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

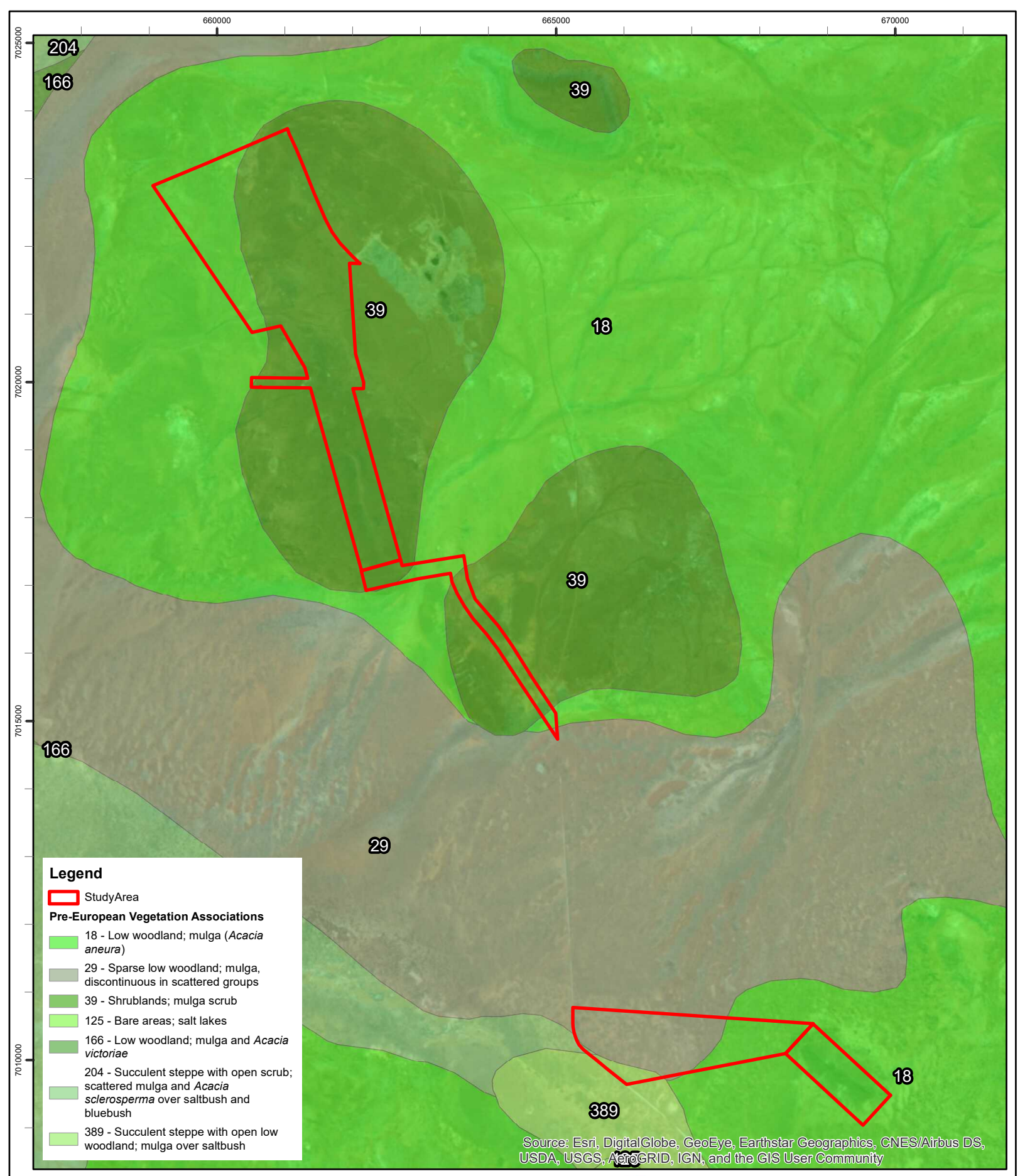
Size A4. Created 25/06/2018

2.6 Vegetation Association

The Study Area is located in the Austin Botanical District, which is a part of the Eremaean Province. It is predominantly mulga low woodlands (*Acacia aneura)* on plains, reduced to scrub on hills. Tree steppe of *Eucalyptus* spp. and *Triodia basedowii* occur on sand plains within the area (Beard, 1990). The vegetation associations of the Study area was mapped by Beard (1976), in which he classified the following five vegetation associations (Figure 2.3):

- 18: Low woodland; mulga (*Acacia aneura*);
- 29: Sparse low woodland; mulga, discontinuous in scattered groups;
- 39: Shrublands; mulga scrub;
- 204: Succulent steppe with open scrub; scattered mulga & *Acacia sclerosperma* over saltbush & bluebush; and
- 389: Succulent steppe with open low woodland; mulga over saltbush.

Shepherd *et al.* (2002) attempted to reinterpret and update the vegetation association mapping to reflect the National Vegetation Information System (NVIS) standards (ESCAVI, 2003). The update also accounts for extensive clearing since Beard (1976) mapping. Some of Beard's vegetation associations have been separated to remove mosaic vegetation associations; however, some mosaics still occur. The majority of the Study Area is located within the Wiluna System (99.8%), while a small portion is in the Upper Murchison System (0.2%), as reinterpreted by Shepherd *et al*. (2002) (Figure 2.3).



biologic Environmental Survey

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Gabanintha Vanadium Project

Figure 2.3: Vegetation Associations mapped across the Study Area

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

Size A4. Created 25/06/2018

3 METHODOLOGY

3.1 Compliance

The survey was carried out in a manner consistent with the Western Australian EPA, DBCA and the DoEE guidelines for the environmental surveying and reporting of fauna. The key documents that the current assessment had due regard for, include:

- EPA (2016a) Technical Guidance: Sampling Methods for Terrestrial Vertebrate Fauna;
- EPA (2016c) Technical Guidance: Terrestrial Fauna Surveys;
- EPA (2016b) Technical Guidance: Sampling of Short-range Endemic Invertebrate Fauna; and
- DPaW (2017) Interim guideline for preliminary surveys of night parrot (*Pezoporus occidentalis*) in Western Australia.

3.2 Desktop Assessment

3.2.1 Literature Review

A review of all publicly available literature relevant to the Study Area was undertaken to compile a list of vertebrate fauna species with the potential to occur with the Study Area. A total of seven assessments were reviewed, comprising three Level 2 surveys, one Level 2/ long-term research focussed survey, one Level 1/ Targeted survey, one Level 1 and one Reconnaissance survey (Table 3.1).

Table 3.1: Literature sources used for the review

Survey Title	Reference	Survey Type	Distance from Study Area (km)
Barrambie Vanadium Project Targeted Fauna Assessment	Outback Ecology (2009)	Level 1/ Targeted	~32 km SE
Weld Range Vertebrate Fauna Assessment	ecologia Environment (2009)	Level 2	~74 km W
Vertebrate Fauna Assessment Yeelirrie Project Baseline Report	Bamford Consulting Ecologists (2011)	Level 2	~115 km E
Rosslyn Hill Project Proposed Priority Expansion Areas Fauna Assessment	Bamford Consulting Ecologists (2017)	Level 2	~133 km SW
Windimurra Vanadium Threatened Fauna Assessment	Western Wildlife (2007)	Level1	~136 km SW
A biological survey of the Youanmi-Leonora Study Area	Dell and How (1992)	Level 2 (equivalent - long term scientific study)	~150 km S

3.2.2 Database Searches

Five fauna databases were searched (Table 3.2), three to obtain information on all species previously recorded (NatureMap, Birdlife Birdata and Atlas of Living Australia (ALA)), one to identify species of conservation significance previously recorded (DBCA Threatened Fauna Database), and one to identify species of conservation significance known or likely to occur within the region (Protected Matters

Database). An additional three databases (Western Australian Museum (WAM)) were searched to identify a list of all previously recorded invertebrates, including SRE species (Table 3.2).

Table 3.2: Details of database searches conducted

Provider	Reference	Database	Parameters
Department of Biodiversity, Conservation and Attractions (DBCA)	DBCA (2018a)	NatureMap. Accessed 20 June 2018	Circle of radius 40 km centred on the coordinates: 26°57'51.65"S, 118°39'0.18"E
Department of Biodiversity, Conservation and Attractions (DBCA)	DBCA (2018a)	Threatened Fauna Database. Received 27 April 2018	Circle of radius 40 km centred on the coordinates: 26°57'51.65"S, 118°39'0.18"E
BirdLife Australia	Birdlife Australia (2018)	Birdata Custom Bird Atlas. Received 22 June 2018	Circle of radius 100 km centred on the coordinates: 26°57'51.65"S, 118°39'0.18"E
Department of Environment and Energy (DoEE)	DoEE (2018)	Protected Matters Database Search Tool. Accessed 2 May 2018	Circle of radius 40 km centred on the coordinates: 26°57'51.65"S, 118°39'0.18"E
Atlas of Living Australia (ALA)	ALA (2018)	Species Occurrence Search Accessed 4 September 2018	Circle of radius 10 km centred on the coordinates: 26°57'51.65"S, 118°39'0.18"E
Western Australian Museum (WAM)	WAM (2018a)	Arachnid/ Myriapod Database Received 17 April 2018	Bounding Box (40,000km^2) using points: Northwest corner: -26.099359°, 117.628046° Southeast corner – -27.852695°, 119.678660°
Western Australian Museum (WAM)	WAM (2018c)	Crustacean Database Received 28 February 2018	Bounding Box (40,000km^2) using points: Northwest corner: -26.099359°, 117.628046° Southeast corner – -27.852695°, 119.678660°
Western Australian Museum (WAM)	WAM (2018d)	Mollusc Database Received 7 March 2018	Bounding Box (40,000km^2) using points: Northwest corner: -26.099359°, 117.628046° Southeast corner – -27.852695°, 119.678660°

3.3 Field Survey

The survey was undertaken between the 7th and the 12th of May 2018 by Mr Brad Maryan and Mr Clinton van den Bergh. In the six months prior to the survey (November 2017 to April 2018), Meekatharra Airport recorded 179 mm of rainfall. This was slightly above the long-term annual average rainfall for the same period (142.4 mm, BoM, 2018). The field survey was undertaken following a summer and autumn season of large fluctuations. The months of January and February 2018 received well above average rainfall (62 mm and 78 mm, respectively; Figure 2.1). The months of March and April received below average rainfall, while the day time maximum temperatures were over 2°C higher, on average (Figure 2.1). As a result of the low March and April rainfall, and the high maximum temperatures and perceived

high evaporation rates, the soil and surrounds was noted as being dry over the majority of the Study Area.

The climatic conditions during the field survey were adequate to complete the survey with minimal constraints and limitations (Table 3.3). No rain was recorded during the field survey.

Table 3.3: Climatic conditions during the field survey

Date	Min. temp (°C)	Max. temp (°C)	Rainfall (mm)	RH at 9 am (%)	RH at 3 pm (%)
7/05/2018	17.2	29.0	0.0	67	32
8/05/2018	16.6	31.8	0.0	28	16
9/05/2018	14.7	32.1	0.0	42	15
10/05/2018	18.7	32.3	0.0	38	16
11/05/2018	16.4	30.0	0.0	34	18
12/05/2018	16.3	30.1	0.0	30	16

RH: Relative Humidity

3.3.1 Survey Team and Licensing

The assessment was undertaken by a senior zoologist, Brad Maryan and a senior ecologist Clinton van den Bergh, whom both have extensive experience with fauna in the Murchison region. The survey was conducted under DBCA Regulation 17 license 08-002111-2 issued to Biologic.

3.3.2 Habitat Assessments and Mapping

Habitat assessments were undertaken at 45 locations across the Study Area (Table 3.4), including at every targeted search, song meter and motion camera location and 30 flora and vegetation relevé sites (which was undertaken concurrently) (Figure 3.1). Habitats in the Study Area were assessed using methodology and terminology modified from the Australian Soil and Land Survey Field Handbook (National Committee on Soil and Terrain, 2009). The characteristics recorded during the habitat assessments were:

- site information, photo and location.;
- landform: slope, relative inclination of slope, morphological type and landform type;
- vegetation: leaf litter %, twig litter %, wood litter, dead stags and hollow bearing trees, broad floristic formation, vegetation structure (tall, mid and low), and dominant species;
- land surface: micro relief, sheet erosion, rill erosion, gully erosion, gully depth, abundance and size of coarse fragments, rock outcropping, water bodies, comments on nests, burrows, roosts and diggings;
- soil: texture, colour;
- substrate: bare ground, rock size, rock type, rock outcropping; and
- disturbance: time since last fire, evidence of weeds, grazing, or human disturbances.

The condition of vegetation and fauna habitats in the Study Area were assessed based on the vegetation condition rating scale detailed in EPA (2016d). Vegetation condition is assessed on a rating scale ranging from Completely Degraded to Excellent (EPA, 2016d). The condition of the vegetation

and fauna habitats was obtained from the Reconnaissance Flora and Vegetation Survey of the Study Area (Biologic, *in prep.*), which was undertaken concurrently.

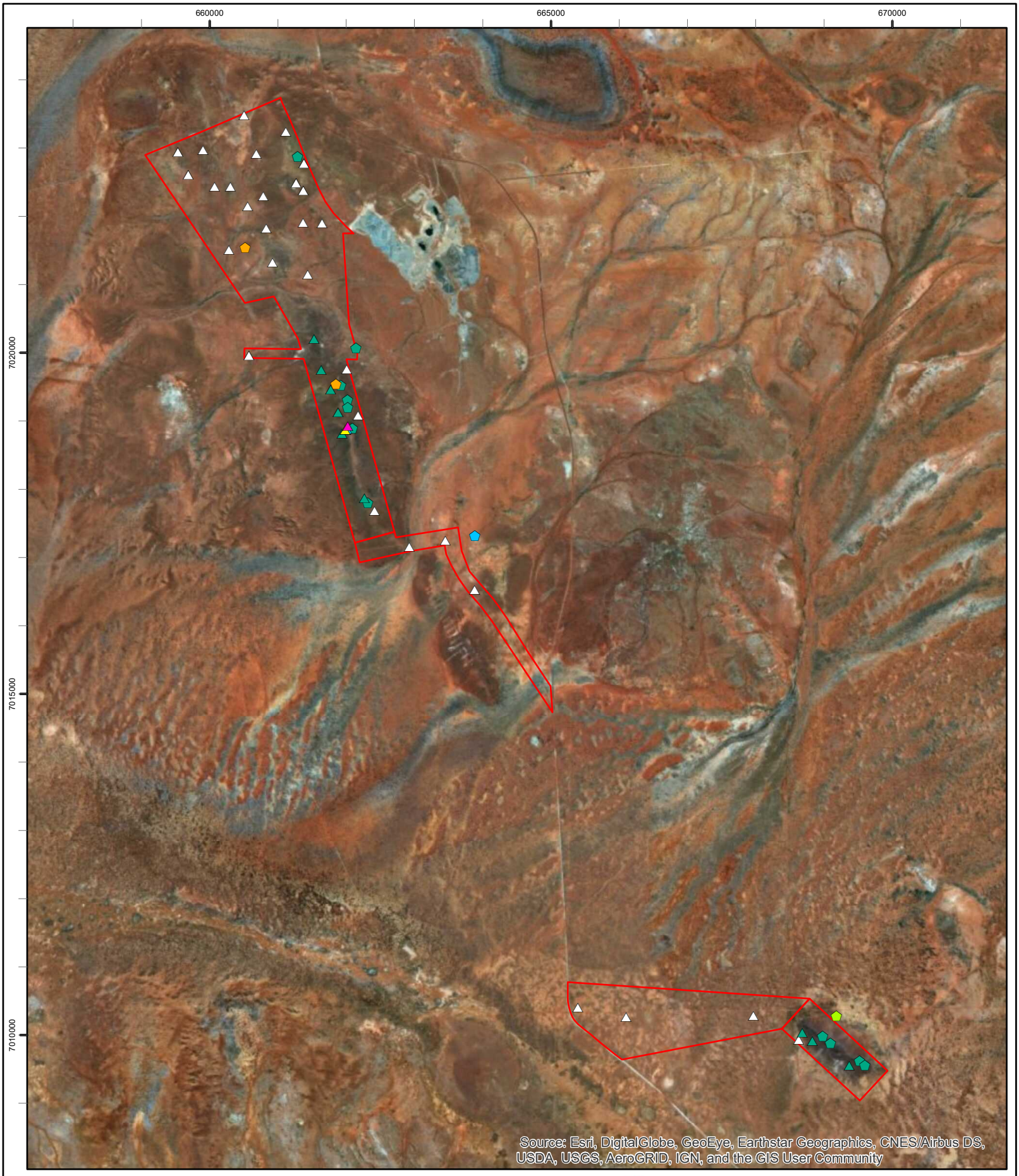
Fauna habitats were assessed for the likelihood that they may support conservation significant fauna. All major fauna habitats present within the Study Area were rated (High, Moderate or Low) per the criteria in Table 3.5.

In addition to the 45 locations assessed across the Study Area in May 2018, a further 13 habitat assessment sites, consisting of 11 motion camera locations, one SM2 unit location and one vertebrate fauna trapping transect, were sampled in 2017 (Table 3.4 and Figure 3.1). The data collected from these sites were utilised during the current assessment to further supplement the survey work completed in May 2018. The data collected from one active search and one spotlighting search (Figure 3.1) completed in 2017 within TMAL tenure was also included in the current assessment. The total number of vertebrate fauna sampling sites is 60 across 2017 and 2018 (Table 3.4 and Figure 3.1).

Table 3.4: Vertebrate fauna sampling sites

Site	Date	GDA94 Zone 50K		Habitat Assessment	Motion Camera	SM2/ SM4	Trap Line	Active Search
		Easting	Northing					
AS-02	Apr 2017	661985	7018875					✓
BSH-01	Oct 2017	669447	7009626	✓	✓			
BSH-02	Oct 2017	662065	7018942	✓	✓			
BSH-03	Oct 2017	662014	7018888	✓	✓			
BSH-04	Apr 2017	661848	7019533	✓	✓			
BSH-1.4	Oct 2017	661605	7020278	✓	✓			
BSH-4.2_A7.1	Apr 2017	668906	7009990	✓	✓			
BSH-8.3_3.1	Apr 2017	662339	7017948	✓	✓			
BSH-No #	Oct 2017	661709	7019822	✓	✓			
GAB01	May 2018	669019	7009880	✓	✓			
GAB02	May 2018	668905	7009987	✓	✓			
GAB03	May 2018	669448	7009622	✓	✓			
GAB04	May 2018	669524	7009557	✓	✓			
GAB05	May 2018	669183	7010279	✓		✓		
GAB06	May 2018	661845	7019523	✓	✓			
GAB07	May 2018	661850	7019540	✓	✓	✓		
GAB08	May 2018	661946	7019310	✓	✓			
GAB09	May 2018	661951	7019197	✓	✓			
GAB10	May 2018	662018	7018890	✓	✓			
GAB11	May 2018	662242	7017800	✓	✓			
GAB12	May 2018	662071	7020068	✓	✓			
GAB13	May 2018	660520	7021549		✓	✓		

Site	Date	GDA94 Zone 50K		Habitat Assessment	Motion Camera	SM2/ SM4	Trap Line	Active Search
		Easting	Northing					
GAB14	May 2018	661214	7022882	✓	✓			
GAB15	May 2018	663884	7017324	✓		✓		
MC-11.3	Apr 2017	668755	7010110	✓	✓			
MC-2.2-7.2	Apr 2017	661956	7019200	✓	✓			
MC-9.2	Apr 2017	662061	7018948	✓	✓			
SM2-BIO-2	Apr 2017	662009	7018880	✓		✓		
SS-03	Apr 2017	661986	7018874					✓
TR-02	Apr 2017	662025	7018925	✓			✓	
GABF01	May 2018	661116	7023242	✓				
GABF02	May 2018	659901	7022970	✓				
GABF03	May 2018	660302	7022433	✓				
GABF04	May 2018	660073	7022436	✓				
GABF05	May 2018	660830	7021828	✓				
GABF06	May 2018	660923	7021328	✓				
GABF07	May 2018	660280	7021513	✓				
GABF08	May 2018	661374	7022375	✓				
GABF09	May 2018	661266	7022487	✓				
GABF10	May 2018	661379	7022774	✓				
GABF11	May 2018	660685	7022915	✓				
GABF12	May 2018	660578	7019958	✓				
GABF13	May 2018	660786	7022294	✓				
GABF14	May 2018	660556	7022152	✓				
GABF15	May 2018	659533	7022941	✓				
GABF16	May 2018	659688	7022607	✓				
GABF17	May 2018	661368	7021909	✓				
GABF18	May 2018	661646	7021895	✓				
GABF19	May 2018	660504	7023483	✓				
GABF20	May 2018	661437	7021144	✓				
GABF46	May 2018	667966	7010288	✓				
GABF47	May 2018	668627	7009935	✓				
GABF48	May 2018	662005	7019763	✓				
GABF49	May 2018	662175	7019085	✓				
GABF50	May 2018	662415	7017685	✓				
GABF51	May 2018	665397	7010400	✓				
GABF52	May 2018	666100	7010268	✓				
GABF53	May 2018	663452	7017251	✓				
GABF54	May 2018	662925	7017158	✓				
GABF55	May 2018	663880	7016525	✓				



Legend

- StudyArea

2017 Sampling

- External Trapping Transect
- Motion Camera
- Song Meter - Ultrasonic
- Targeted Search

2018 Sampling

- Habitat Assessment (only)
- Motion Camera
- Song Meter - Acoustic
- Song Meter - Ultrasonic
- Song Meter - Ultrasonic & Motion Camera

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Figure 3.1: Vertebrate fauna suvey sampling locations

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

Size A4. Created 22/11/2018

Table 3.5: Fauna habitat significance assessment criteria

Score	Possible criteria (score results from any possible criterion being met)
High	Fauna listed as threatened on the EPBC Act or WC Act have been recorded within the habitat.
	Habitat is known to be suitable core habitat for EPBC Act listed species, and there are records of the species within 50 km. If survey work in the vicinity of the Study Area has been limited, then the species will be considered likely to be present, using a precautionary approach.
	Habitat is uncommon (regionally) and considered critical for DBCA listed Priority fauna. For example, if the habitat for a Priority species is limited in the region and the extent within the Study Area forms a large proportion of the known habitat, it would be scored 'high'.
	Habitat that only occurs in small, isolated geographic areas.
Moderate	Habitat is known to supports DBCA listed Priority fauna that do not occur in any of the other habitat types.
	Habitat that supports EPBC Act listed Migratory fauna. Habitat may be used by EPBC Act listed fauna but it is not their core habitat *(i.e.* may be used periodically/ seasonally or for dispersal).
	Habitat supports a particularly diverse and uncommon faunal assemblage. Habitat that occurs throughout region, and does not occur in small or isolated areas, is excluded.
Low	Habitat is widespread, common, and does not solely support any significant fauna.

3.3.3 Targeted Searches

Targeted searches were undertaken to identify the occurrence of fauna of conservation significance and important habitat features, such as breakaways. Targeted searches were conducted within the most prospective areas in terms of habitat features and habitats suitable for species of conservation significance. During the targeted searches, and while traversing the Study Area, the team recorded all vertebrate fauna species of conservation significance encountered, either from primary (i.e. direct observation) or secondary (e.g. burrows, scratching's, diggings and scats) evidence. Targeted searches were opportunistically undertaken throughout the Study Area, with approximately 24 personnel hours devoted to searches. In addition to the targeted searches completed during the current assessment, one active search, and one spotlighting search was completed in 2017. Approximately 6 personnel hours were devoted to the two targeted searches in 2017.

3.3.4 Ultrasonic Recordings – Bats

Overnight recordings of bat echolocation calls were undertaken using SM2BAT+ (SM2; Wildlife Acoustics, USA) fitted with an external, omnidirectional SMX-US ultrasonic microphone. The location of each SM2 unit was selected based on prospective bat foraging grounds, such as the artificial watering points. The unit was positioned to provide shelter from direct sun or rain, whilst retaining an

unobstructed 'line of sight' between the microphone and the likely bat flyway. Each SM2 was preconfigured to activate at astronomical sunset each day, and deactivate at astronomical sunrise the following morning. Jumper settings, audio settings, selectable filters and selectable triggers used to preconfigure each SM2 unit, and hence define the volume and frequency ranges sought, followed the manufacturer's recommendations for bat detection (Wildlife Acoustics, 2011).

SM2 units were deployed at three locations across the Study Area for a total of 12 recording nights (Figure 3.1). The data collected from an additional SM2 unit (one night of recording) deployed in 2017 was included in the current assessment. Bat calls were analysed by Robert Bullen of Bat Call WA.

3.3.5 Acoustic Recordings – Night Parrot

Overnight recordings using SM4 units were also undertaken for the Night Parrot. SM4 units were fitted with SMX-II acoustic microphones and set to record between 0-500 Hz each night. Units were deployed within halophytic shrublands (stands of samphire shrubs), which is similar to habitat confirmed to support populations elsewhere (Murphy *et al.*, 2017; Night Parrot Recovery Team, 2017) and in accordance with interim guidelines developed by DPaW (2017).

An SM4 unit targeting Night Parrots was deployed at one location in the Study Area for a total of four recording nights (Figure 3.1). The recordings were analysed manually by Robert Bullen of Bat Call WA using the software program Song Scope (Wildlife Acoustics, USA) and against reference calls provided by the Night Parrot Recovery Team (2017). The Study Area is not considered to support suitable habitat, and the halophytic shrubland in which the SM4 unit was established in occurred outside of the Study Area, and was only approximately 2 ha in size. In addition, cattle were observed trampling through the area. No large unburnt stands of hummock grasslands (*Triodia* spp.) are known to occur within 10 km of the Study Area. As such, the Study Area is unlikely to support Night Parrots.

3.3.6 Motion Cameras

Acorn and Bushnell Trophy Cam motion cameras were deployed to survey for species of conservation significance, specifically Long-tailed Dunnarts and migratory birds. Cameras were deployed at eight locations considered prospective for detecting Long-tailed Dunnarts, specifically rocky outcrops and magnetite outcropping (Figure 3.1). Two cameras were deployed at the two artificial watering points (man-made dams and windmills) located within and adjacent to the Study Area, to target migratory birds (and other highly mobile fauna species) (Figure 3.1). A further four motion cameras were deployed across the Study Area to capture any additional fauna species. Motion cameras were deployed at 14 locations for a total of 56 nights. The resulting footage was analysed manually by Biologic personnel.

Results from an additional eleven motion cameras deployed in 2017 were included in the current assessment (Figure 3.1). The eleven cameras were deployed across a total of 57 nights, ranging from 4 nights to 7 nights for an individual camera.

3.3.7 Opportunistic Vertebrate Fauna Records

Opportunistic records of vertebrate species encountered during the survey were documented. Birds were recorded on a presence/absence basis, determined by call identification, visual identification and/or tracks and traces.

3.3.8 Taxonomy and Nomenclature

The latest checklist of mammal, reptile and amphibian names published by the Western Australian Museum (WAM, 2018b) was used as a guide to the current taxonomy and nomenclature of these groups. For birds, the current checklist of Australian birds maintained by Birdlife Australia (based on Christidis & Boles, 2008) was used in conjunction with the WAM (2017) species list.

3.4 Assessment on Occurrence

Conservation significant fauna species recorded from the databases and previous reports were assessed for their likelihood to occur within the Study Area using the decision matrix below (Table 3.6).

Table 3.6: Species likelihood of occurrence decision matrix

Range categories:	Habitat Categories				
	Core habitat known to occur	Foraging habitat known to occur	Dispersal habitat known to occur	Potential dispersal habitat	No known habitat occurs
Species recorded <5 km	Highly Likely	Likely	Likely	Possible	Possible
Species recorded 5-10 km	Likely	Likely	Possible	Possible	Rarely
Species recorded 10-40 km	Likely	Possible	Possible	Rarely	Unlikely
Species recorded >40 km	Possible	Possible	Rarely	Rarely	Unlikely
Species rarely recorded in region	Possible	Rarely	Unlikely	Unlikely	Highly Unlikely

This decision matrix is only intended to be an indicative guide, and was applied with the following considerations:

- The range categories are subject to interpretation based on the known range of each species and its natural dispersal capabilities (for example, >50 km range may be a significant distance for a fossorial skink, but not a migratory bird);
- Both the range categories and the habitat categories can vary markedly for different types of fauna such as birds, reptiles, mammals, and amphibians, and fauna with different ecological niches within each of these groups;
- The degree of habitat specificity for each species is a major determining factor for each of the habitat categories, and this in turn is dependent on the current state of ecological knowledge of the species.
- The amount and location of previous sampling is a major factor influencing the applicability of the range categories, as well as the amount of effort that has been expended in (and the accessibility of) the area in question for sampling;

- The current state of taxonomy is another major factor for species that are poorly known taxonomically and thus difficult to identify accurately, as well as for any recent changes of classification and/or conservation category. Such taxonomic changes can affect the reliability of previous records within fauna databases, the conservation status of the newly defined species/ populations, and the assumptions regarding species ranges and habitat preferences; and
- The language used in each of the habitat and range categories may be useful for some taxa and not for others (for example, 'rarely' occurrences may be useful for describing birds or fauna which can traverse large distances, but in the case of fauna with more limited dispersal capabilities such as reptiles, there is no basis for 'rarely' occurrences. Such likelihoods may be more likely to represent range extensions.

3.5 SRE Invertebrate Fauna Methodology

Site Selection

Sites were chosen according to Technical Guidance – Sampling of Short Range Endemic invertebrate fauna (EPA, 2016b). Habitats considered suitable for SRE terrestrial invertebrates were targeted. To provide adequate geographical coverage and local context, several reference sites in less suitable habitat types were also assessed.

Sampling was completed in May 2018. Sampling during the current assessment occurred at 20 sites located across the Study Area, with an additional 10 sites sampled within TMAL tenure in 2017 (Table 3.7 and Figure 3.2).

Table 3.7: SRE Invertebrate fauna sampling sites

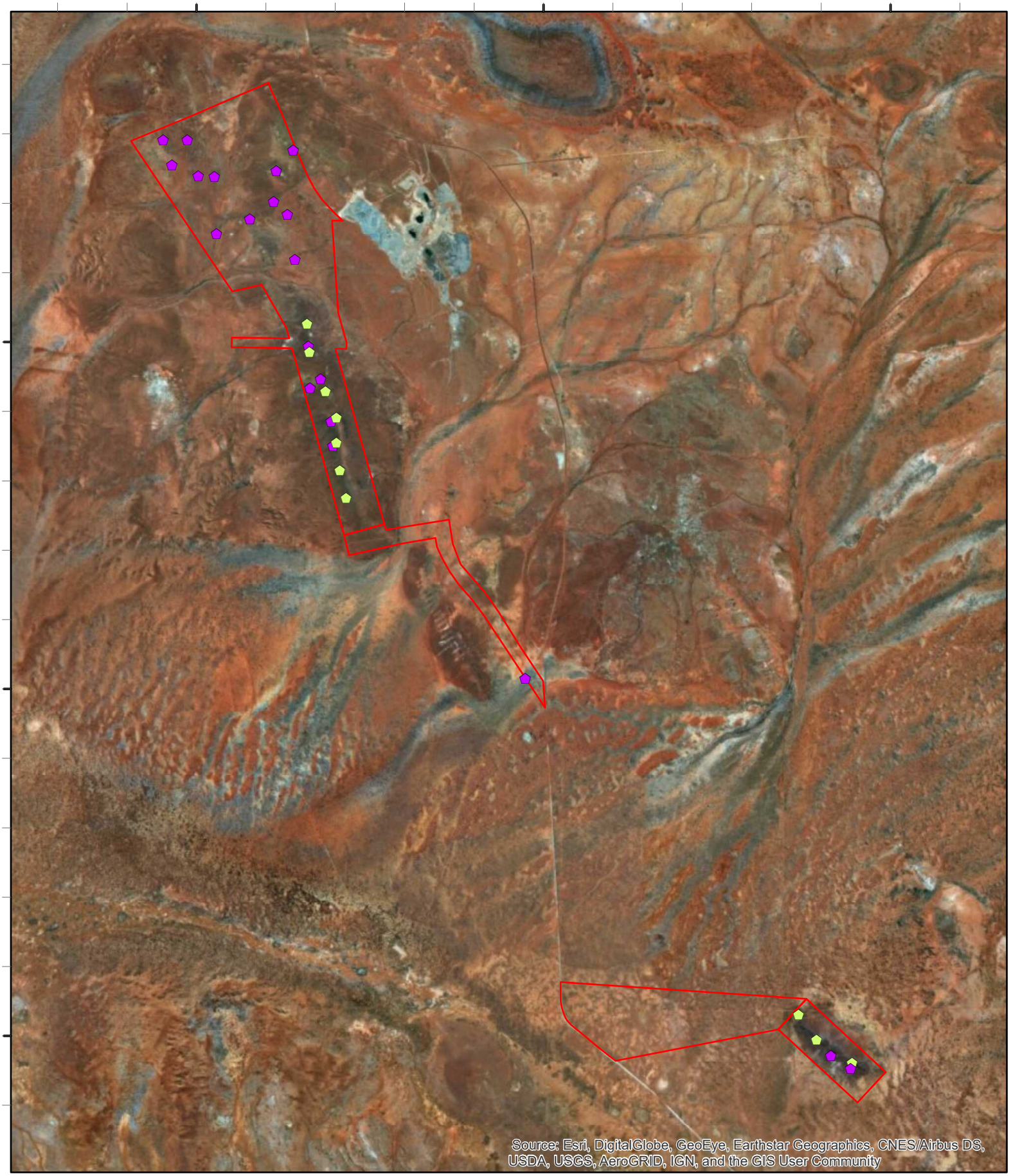
Site	Date	GDA94 Zone 50K	
		Easting	Northing
SRE-01	May 2018	659920	7022959
SRE-02	May 2018	660308	7022400
SRE-03	May 2018	660075	7022403
SRE-04	May 2018	660819	7021839
SRE-05	May 2018	660338	7021624
SRE-06	May 2018	661199	7022499
SRE-07	May 2018	661445	7022829
SRE-08	May 2018	661662	7019945
SRE-09	May 2018	661162	7022057
SRE-10	May 2018	661840	7019499
SRE-11	May 2018	661687	7019391
SRE-12	May 2018	661988	7018943
SRE-13	May 2018	662017	7018611
SRE-14	May 2018	664788	7015250
SRE-15	May 2018	669190	7009762
SRE-16	May 2018	669472	7009537

Site	Date	GDA94 Zone 50K	
		Easting	Northing
SRE-17	May 2018	659569	7022963
SRE-18	May 2018	659695	7022629
SRE-19	May 2018	661361	7021943
SRE-20	May 2018	661471	7021277
SRE-FO-01	Oct 2017	661595	7020278
SRE-FO-02	Oct 2017	661629	7019835
SRE-FO-03	Oct 2017	661862	7019278
SRE-FO-04	Oct 2017	662015	7018500
SRE-FO-05	Oct 2017	662066	7018167
SRE-FO-06	Apr 2017 & Oct 2017	662157	7017722
SRE-FO-07	Oct 2017	662018	7018943
SRE-FO-16	Oct 2017	668674	7010323
SRE-FO-17	Apr 2017 & Oct 2017	668933	7009987
SRE-FO-25	Oct 2017	669447	7009648

Active foraging

Active foraging was undertaken at each sampling site for approximately one (1) personnel hour and involved various techniques relevant to the following microhabitats:

- Under rocks, within cracks and crevices: suitably sized rocks were over turned, and rocky microhabitats were actively searched for rock dwelling species;
- Woody debris: larger logs and woody debris were investigated and over turned searching for detritivores;
- Vegetation and tree bark: significant vegetation (*e.g.* Mulga, and fig trees) were actively searched, including underneath sheets of bark; and
- Burrow searching: active searches were undertaken for mygalomorph spider and scorpion burrows within suitable habitats. Note: searches for burrows were undertaken during foraging time and also whilst walking through the Study Area, but time taken to excavate burrows was additional to foraging time.



Legend

- StudyArea

SRE Sampling Sites

- 2017
- 2018

biologic Environmental Survey

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Figure 3.2: SRE Invertebrate fauna suvey sampling locations

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

Size A4. Created 22/11/2018

Leaf litter searching

Leaf litter, humus and topsoil (to approximately 5 cm below surface) was placed in a sieve at the site and agitated to divide the sample into four grades (>7 mm, >3 mm, >1.4 mm, <1.4 mm). Each grade was thoroughly searched for target SRE species such as pseudoscorpions, millipedes, snails, and small scorpions. The maximum volume of litter in the sieve was approximately 4,808 cm^3, with a minimum of two sifts and up to five sifts were conducted at each site, providing sufficient leaf litter and humus was available.

Specimen preservation

All specimens were euthanised in 100% ethanol to preserve DNA for sequencing. The pseudoscorpion specimens collected were sent directly to Dr Erich Volschenk for identification prior to vouchering at the WAM. The isopods were sent to Dr Simon Judd for identification.

SRE Invertebrate Habitat Assessments

The habitat assessments were aimed at determining the significance of each site as Potential SRE habitat, and hence the likelihood that each site may contain SRE fauna. The habitat assessment was based on three major factors influencing the significance of habitats for SRE species; isolation, protection and habitat complexity, as briefly outlined below and illustrated in Figure 3.3.

Isolation: based on the level of connectivity between sites, which share similar habitat characteristics. Isolation is the most important factor when it comes to the level of risk, as any fauna with limited dispersal characteristics, regardless of the habitat preference, will likely be, at least, an isolated population. Examples include islands and mountaintops; in the Pilbara, peaks like Mt Meharry have been shown to harbour significant SRE species (Durrant, 2011).

Protection: this primarily covers protection from exposure. With respect to the Pilbara region however, protection from disturbance is also very important for the long-term viability of SRE habitats and communities, i.e. protection from fire, flood and invasive species.

Protection is provided at two levels; the site level where the structural composition of the site (aspect, slope etc.) can provide protection from exposure and disturbance by providing physical barriers (e.g. gorges and gullies); and the habitat level where certain microhabitat characteristics, associated with habitat complexity, provide more direct protection, particularly from exposure (i.e. leaf litter, rocky substrates, canopy cover and soil depth).

Habitat complexity: this factor drives species richness and often abundance at a site, i.e. the more complex a site is, the more species and individuals it is likely to contain. This is particularly important, as a number of SRE groups are predators; therefore, the richness and abundance of prey species are critical to their survival.

Complexity, with respect to SREs, is based around a number of microhabitat types:

- Leaf litter: both depth and structural variation;
- Rocky substrates: loose rocks and crevices;

- Vegetation variation: flora richness and structural variation; and
- Soil: depth and structural variation.

Likewise, the complexity of the habitat is important to detritivore SRE taxa, such as isopods, millipedes and some snails, which rely upon decaying leaf litter, woody debris and organic matter for survival. Examples in the Pilbara include deep gullies and gorges, where many of these areas contain most of the above microhabitat types, and therefore tend to be the richest areas.

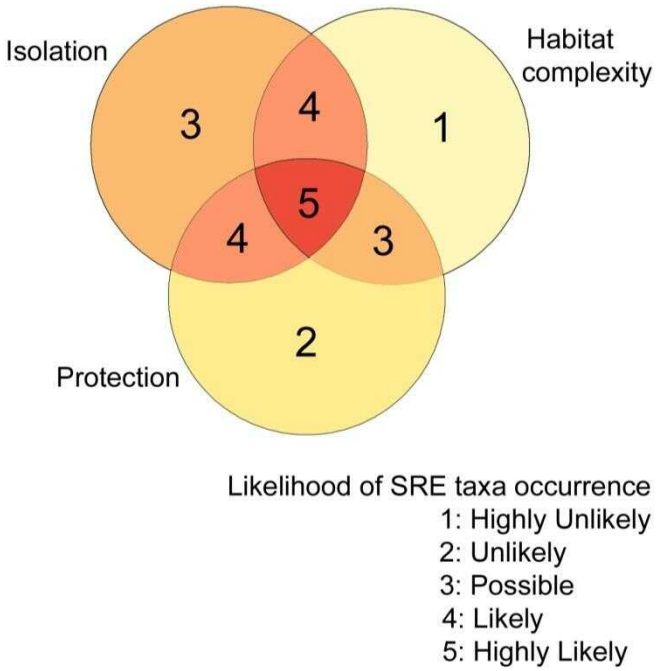


Figure 3.3: Factors influencing the suitability of habitats for SRE invertebrate fauna

3.6 Potential Limitation and Constraints

The EPA (2016c) outlines several potential limitations to fauna surveys. These aspects are assessed and discussed in Table 3.8 below.

Table 3.8: Survey limitations and constraints

Potential limitation or constraint	Constraint	Applicability to this survey
Experience of personnel.	No	The field personnel involved in the survey each have more than 10 years of fauna survey experience in the Murchison bioregion.
Scope (faunal groups sampled and whether any constraints affect this)	No	The scope was a Level 1 survey and SRE assessment and was conducted within that framework. No nocturnal work was undertaken by the field personnel; this reduced the ability for opportunistic detection of nocturnally active species.

Potential limitation or constraint	Constraint	Applicability to this survey
Proportion of fauna identified	No	All observed fauna were identified at the point of observation. All recorded bat calls were successfully identified. Invertebrate specimens collected from the field were sorted in-house prior to sending them to the taxonomic experts.
Sources of information (recent or historic) and availability of contextual information	No	A moderate amount of survey work has been undertaken in the wider local area and the surrounding region, and the majority of these previous survey results were available for review. Biologic (2018) have also completed a two-phase Level 2 vertebrate fauna and SRE survey within the immediate area, which partially overlaps the Study Area. Only information collected from within TMAL tenure is utilised within this current assessment.
Proportion of the task achieved	No	A targeted vertebrate fauna survey and SRE assessment of the Study Area was completed and related to the results of surveys in the broader area.
Disturbances (e.g. fire or flood)	No	Conditions experienced during the survey were ideal for recording conservation significant species targeted.
Intensity of survey	No	A targeted vertebrate fauna survey and SRE assessment was identified by the client as the requirement for this survey.
Completeness of survey	No	The survey was adequately completed to meet the requirements of a targeted survey and SRE assessment.
Resources (e.g. degree of expertise available)	No	All resources required to complete the survey were available.
Remoteness or access issues	No	The majority of the Study Area was accessible either by vehicle or on foot, thus the sampling techniques used during this survey were unconstrained by accessibility or remoteness.

4 RESULTS AND DISCUSSION

4.1 Desktop Assessment

4.1.1 Vertebrate Fauna

The literature review and database searches identified a total of 288 species of vertebrate fauna, which have previously been recorded and/ or have the potential to occur within the Study Area. This comprised 32 native mammals, nine non-native mammals, 182 native birds, two non-native birds, 55 reptiles and eight amphibians (Appendix B). Note that some of these species are unlikely to occur in the Study Area as the database searches were undertaken over a larger area than the Study Area itself, therefore containing habitats that do not necessarily occur within the Study Area. Additionally, many species tend to be patchily distributed even where appropriate habitats are present, and many species of birds can occur as regular migrants, occasional visitors or vagrants.

Of the 288 species of vertebrate fauna identified as being previously recorded and/ or having the potential to occur, 33 species are of conservation significance, comprising five mammals, 26 birds and two reptiles (Table 4.1). Two of these species have previously been recorded from TMAL tenure within the Study Area; the Long-tailed Dunnart and Peregrine Falcon (Biologic, 2018).

Table 4.1: Species of conservation significance identified and their conservation status

Common Name	Scientific Name	Current Conservation Status	
		EPBC Act	WC Act
Mammals			
Bilby	*Macrotis lagotis*	Vu	S3
Black-flanked Rock-wallaby	*Petrogale lateralis lateralis*	Vu	S3
Greater Long-eared Bat	*Nyctophilus major tor*		P3
Brush-tailed mulgara	*Dasycercus blythi*		P4
Long-tailed dunnart	*Sminthopsis longicaudata*		P4
Birds			
Curlew sandpiper	*Calidris ferruginea*	Cr/Mi	S3/S5
Night parrot	*Pezoporus occidentalis*	En	S1
Malleefowl	*Leipoa ocellata*	Vu	S3
Princess parrot	*Polytelis alexandrae*	Vu	P4
Grey falcon	*Falco hypoleucos*		S3
Common greenshank	*Tringa nebularia*	Mi	S5
Fork-tailed swift	*Apus pacificus*	Mi	S5
Glossy ibis	*Plegadis falcinellus*	Mi	S5
Red-necked stint	*Calidris ruficollis*	Mi	S5
Marsh Sandpiper	*Tringa stagnatilis*	Mi	S5
Oriental pratincole	*Glareola maldivarum*	Mi	S5

Common Name	Scientific Name	Current Conservation Status	
		EPBC Act	WC Act
Sharp-tailed sandpiper	*Calidris acuminata*	Mi	S5
White-winged black tern	*Chlidonias leucopterus*	Mi	S5
Wood sandpiper	*Tringa glareola*	Mi	S5
Grey wagtail	*Motacilla cinerea*	Mi	S5
Yellow wagtail	*Motacilla flava*	Mi	S5
Common sandpiper	*Actitis hypoleucos*	Mi	S5
Pectoral sandpiper	*Calidris melanotos*	Mi	S5
Oriental plover	*Charadrius veredus*	Mi	S5
Caspian tern	*Hydroprogne caspia*	Mi	S5
Gull-billed tern	*Gelochelidon nilotica*	Mi	S5
Peregrine falcon	*Falco peregrinus*		S7
Blue-billed duck	*Oxyura australis*		P4
Striated grasswren (sandplain)	*Amytornis striatus striatus*		P4
Western grasswren	*Amytornis textilis textilis*		P4
Hooded plover	*Thinornis rubricolis*		P4
Reptiles			
Gilled Slender Blue-Tongue	*Cyclodomorphus branchialis*		S3
West coast mulga sider	*Lerista eupoda*		P1

4.1.2 Short-range Endemic Invertebrates

The database searches identified 690 records (Appendix C). The total included 542 specimens of arachnids and myriapods, and 148 crustaceans. While most of these taxa represent epigean taxa, they are not filtered to exclude subterranean or aquatic taxa. Furthermore, the SRE status on these taxa cannot be determined from these results although they do provide insight of nearby collected specimens and the amount of sampling effort conducted in the vicinity of the Study Area.

From the database search only two specimens have been collected within 10 km of the Study Area. The taxa were a species of Araneomorph, a group which is not recognised as being prone to short-range endemism, and *Aname mainae*, a Mygalomorph spider which is considered widespread and not SRE. Both specimens were opportunistic collections. The remaining records were recorded >20km outside the Study Area, thus unlikely to occur in the Study Area, and if present, unlikely to represent an SRE species.

The lack of records obtained within the immediate vicinity of the Study Area demonstrates the lack of sampling effort conducted in the area, which reduces the regional context available and our ability to assess the significance of SRE taxa recorded.

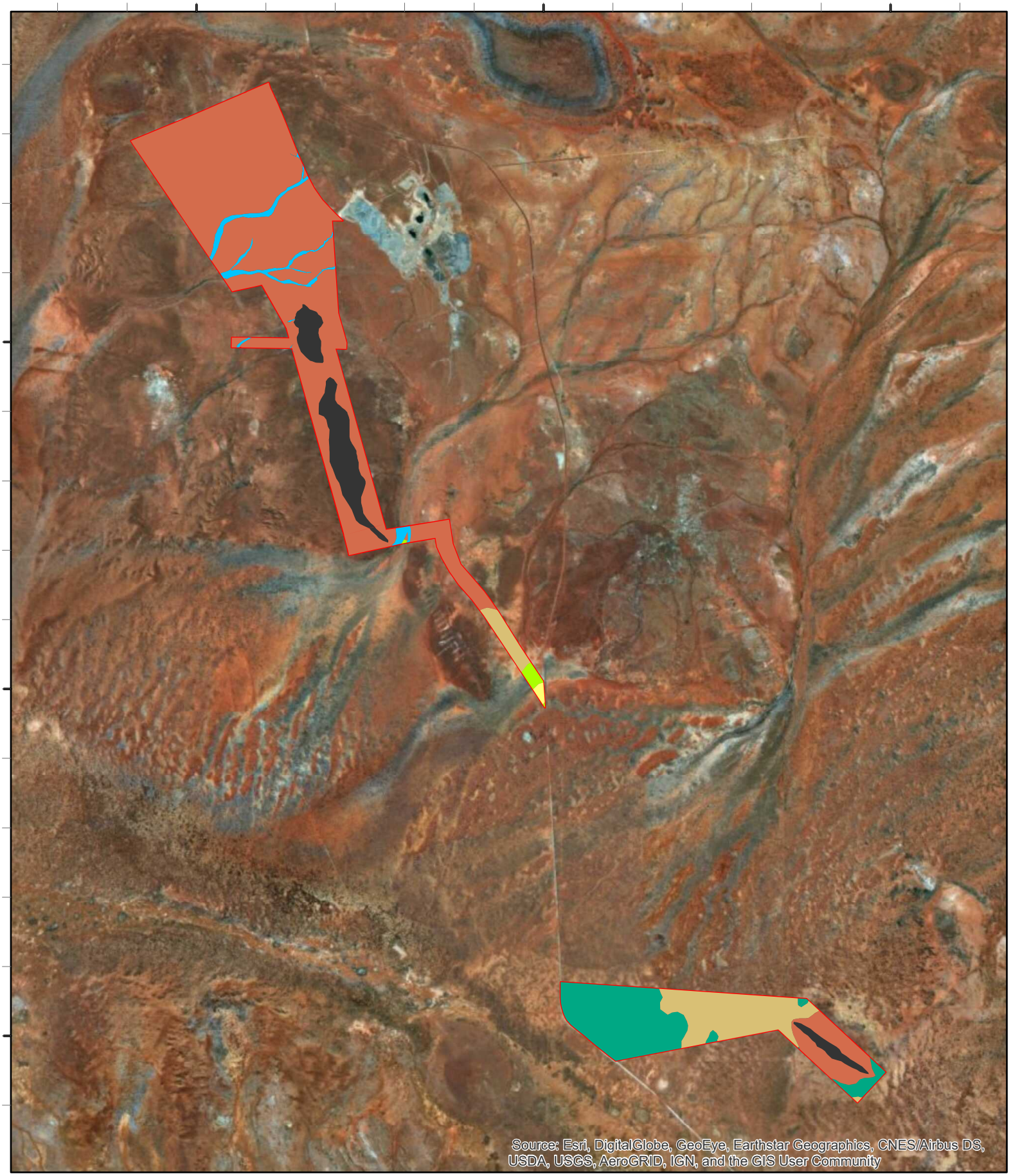
4.2 Fauna Habitats

A total of seven broad fauna habitat types were recorded and mapped across the Study Area. This comprised, in decreasing order of extent, Stony Plain, Chenopod Shrubland, Mulga Woodland, Rocky Outcrop, Minor Drainage Line, Drainage Area and Sandy Mulga (Figure 4.1). Descriptions of the distinguishing characteristics and the occurrence inside and outside of the Study Area for each of these habitat types are presented in Table 4.2, and the data from on-site habitat assessments are presented in Appendix E.

The Rocky Outcrop was deemed to be of relatively high local significance due to the potential to provide habitat for species of conservation significance, providing potential denning and foraging habitat for the Long-tailed Dunnart. The Rocky Outcrop habitat also provides highly suited habitat for SRE invertebrate species. The Rocky Outcrop is limited in the local extent, with occurrences located sporadically throughout the local region. Extents of Rocky Outcrop occur approximately 0.5 km to 3.5 km to the west and east of the Study Area. The Rocky Outcrop was deemed to be of Low regional significance. Rocky outcrops, ridges, ranges and small hills occur throughout the Murchison bioregion. For example, Weld Range consists of numerous rocky outcrops and ridges and is more extensive in size than the rocky outcrops in the Study Area. Weld Range is located approximately 80 km to the west of the Study Area.

The remaining habitats were deemed to have a Low significance as they either do not support species of conservation significance and/ or such species are not dependent on these habitats at the broad-scale. Furthermore, these habitats are widely distributed within the Study Area and within the region generally (McKenzie *et al.*, 2002).

The condition of habitats within the Study Area ranged from Degraded to Excellent. The largest disturbance was caused by pastoralism and grazing by cattle (*Bos taurus*), mine exploration drilling (a large portion of the Study Area has been exposed to ongoing exploration activities) and clearing of road/ access tracks (Appendix E). The occurrence of weeds, particularly members of the Cucurbit family (**Citrullus colocynthis* and **Cucumis myriocarpus*) was apparent in low densities across the Study Area.



Legend

- StudyArea
- **Fauna Habitats**
- Chenopod Shrubland
- Drainage Area
- Minor Drainage Line
- Mulga Woodland
- Rocky Outcrop
- Sandy Mulga
- Stony Plain

biologic Environmental Survey

N

1:70,000

0 0.5 1 2 km

Technology Metals Australian Limited

Gabanintha Vanadium Project

Figure 4.1: Fauna habitats occurring within the Study Area

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

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Table 4.2: Fauna habitat descriptions

Habitat	Distinguishing habitat characteristics	Extent of the habitat	Photo
Mulga Woodland **136.5 ha** **11%** **Vertebrate Fauna Significance: Low** **SRE Suitability: Low**	This habitat comprises woodlands in which Mulga (*Acacia aneura* and close relatives) is dominant, either as the principal *Acacia* species or mixed with others. It consists of broad groves on alluvial, sometimes stony, soils. The density varies from thick groves to open woodlands, often greater than 3 metres in height. The Mulga woodlands typically contained very little understorey with occasional *Eremophila* and *Acacia* spp. shrubs. The habitat comprises a moderate-high amount of leaf litter and woody debris.	The Mulga Woodland is the most common and widespread habitat type occurring within the Study Area. Its distribution extends from the north-west to the south-east through the central portion of the Study Area. This habitat type is a common and widespread habitat of the Murchison region and of the Australian arid-zone generally. Mulga itself is believed to occupy ~20% of the continent and is keystone group for many ecosystems (Maslin & Reid, 2009).	
Stony Plain **789.2 ha** **64%** **Vertebrate Fauna Significance: Low** **SRE Suitability: Low**	The Stony Plain comprised low-lying open plains. The habitat is defined by the stony substrate that extends through its distribution, and the lack of continuous vegetation. The vegetation varied throughout the extent but was dominated by scattered Mulga and Gidgee (*Acacia pruinocarpa*) over-storey, with a mid-storey comprising *Eremophila* and *Ptilotus* spp.	The Stony Plain habitat is concentrated in the northern and southern portion of the Study Area. It represents a transition from the rocky outcrops occurring within and outside the Study Area, to the alluvial plains and drainage areas. The Stony Plain is a common habitat both within the Study Area and in the wider regions throughout the region.	

Habitat	Distinguishing habitat characteristics	Extent of the habitat	Photo
Sandy Mulga **2.9 ha** **<1%** **Vertebrate Fauna Significance: Low** **SRE Suitability: Moderate**	The Sandy Mulga habitat comprised areas where Mulga Woodlands occur on sandy soils. They differ from Mulga Woodland habitat due to a sandier substrate and often support a unique composition of fauna due to the ability for species to burrow in the sandy soil. Vegetation is dominated by an overstorey of Mulga with various scattered shrubs and a tussock grassland dominated by *Eragrostis eriopoda*. Small hollows, leaf litter and woody debris are components of this habitat.	The Sandy Mulga woodlands are solely located in the central portion of the Study Area, surrounded by the Drainage Area and Mulga Woodland habitat types. The condition throughout the Sandy Mulga is generally Very Good with instances of overgrazing and weed infestation. The habitat type is moderately common in the region, although far less than Mulga Woodlands (Cowan *et al.*, 2001).	
Minor Drainage Line **33.1 ha** **3%** **Vertebrate Fauna Significance: Low** **SRE Suitability: Low**	Minor Drainage Lines comprise drainage systems that are dominated by dense stands of Mulga and other *Acacia* spp. over sandy creek beds. The vegetation adjacent to the main channel or channels is denser, taller and more diverse than adjacent terrain. The microhabitats within are similar to surrounding Mulga Woodlands but with a high density of vegetation, leaf litter, woody debris and often sandier alluvial soils.	The Minor Drainage Lines comprise the most common drainage features within the Study Area and region. All instances of the habitat were located in the eastern margins of the Study Area, providing drainage into the Study Area from the north-east. The habitat is common throughout the region but comprises small percentage of the landscape. The habitat is common through the arid-zone occurring wherever Mulga is dominant.	
Rocky Outcrop **102.6 ha** **8%** **Vertebrate Fauna Significance: High** **SRE Suitability: Moderate**	The Rocky outcrops comprises cumulate magnetite outcropping in the Study Area. Vegetation comprised tall scattered Mulga and Gidgee over scattered shrubs of *Acacia* and *Eremophila* spp. The substrate existed as skeletal red soils with exposed bedrock. The primary feature of the habitat is the abundance of rocky, cracks and crevices.	The Rocky Outcrop habitat type was a restricted habitat within the Study Area, occurring in two separate locations. In the north, a small, low-thin ridge running north to south; and in the south-east a lower-thin ridge running east-west. This habitat type is relatively uncommon in the region and for that reason is an important component of the area.	

Habitat	Distinguishing habitat characteristics	Extent of the habitat	Photo
Chenopod Shrubland **162.4 ha** **13%** **Vertebrate Fauna Significance: Low** **SRE Suitability: Moderate**	This habitat is characterised by low-lying chenopod shrubs, such as saltbush (*Atriplex* spp.) and samphire (*Tecticornia* spp.) over heavy alluvial soils in low-lying areas. The vegetation is homogenous and lacking diversity in composition and structure, with an apparent lack of an upper storey. The habitat is often devoid of significant woody debris and leaf-litter.	This habitat is restricted to the southern portion of the Study Area, closer to the Quinns Lake and surrounded by other low-lying habitats such as the Claypans and Wetlands. The habitat is widespread through the region, co-occurring in low-lying areas, particularly in the vicinity of salt lakes which are scattered through the region. The faunal assemblage occurring in this habitat comprises numerous specialists and species unique to this habitat.	
Drainage Area **6.5 ha** **1%** **Vertebrate Fauna Significance: Low** **SRE Suitability: Moderate**	Densely vegetated plains occurring on low-lying alluvial plains. The vegetation differed from that of Mulga Woodlands by the dominance of other *Acacia* spp., such as *A. tetragonophylla* and *A. craspedocarpa*, and by the abundance of small ephemerals grasses and herbs. The habitat comprises a moderate-high amount of leaf litter and woody debris.	The Drainage Areas were distributed throughout the Study Area, feeding from and to the Minor Drainage Lines within the Study Area – acting as a transition from the Mulga Woodlands and the Minor Drainage Lines. They, alike their neighbouring habitats are common in the Study Area as well as within the region generally.	

4.3 Fauna Habitat Features

One artificial waterbody (Plate 4.1) was recorded within the Study Area during the survey, while an additional artificial waterbody was located outside of the Study Area, approximately 200 m to the east. The waterbodies are artificial and represent man-made dams and associated windmills, to provide a water source for grazing cattle (*Bos taurus*). A motion sensor camera and two SM2 units were established at the waterbodies to identify fauna usage. The motion sensor camera did not identify any conservation significant fauna utilising the waterbody. Common native fauna was identified from the motion camera, including Red Kangaroo's (*Osphranter rufus*) and numerous birds. The motion camera also recorded the presence of Wild Dogs (*Canis lupis*) and Cows (*Bos taurus*). The presence of microbats were also identified at the two artificial waterbodies, however the five microbats (*Austronomus australis, Chalinolobus gouldii, Nyctophilus geoffroyi, Scotorepens balstoni* and *Vespadelus finlaysoni*) are considered to be common and are not conservation listed. The waterbodies would be utilised for foraging and as a source of freshwater.

Plate 4.1: Waterbody recorded within the Study Area

4.4 Habitats of Significance

4.4.1 Vertebrate Fauna

The Rocky Outcrop was deemed to be of relatively high significance due to the potential to provide habitat for species of conservation significance, providing potential denning and foraging habitat for the Long-tailed Dunnart. The artificial waterbodies may provide isolated foraging sources for migratory birds, however this is considered to be limited. Migratory birds are highly unlikely to rely on the artificial waterbodies for their survival due to the small size of the dams and the degraded condition of the vegetation (unable to provide suitable cover and roosting).

The remaining habitats were deemed to have a Low significance, as they either do not support species of conservation significance, and/ or such species are not dependent on these habitats at the broad-scale. Furthermore, these habitats are widely distributed within the Study Area and within the region generally (McKenzie *et al.*, 2002).

4.4.2 SRE Invertebrates

The majority of the fauna habitats occurring within the Study Area were assessed as having a Low to Low/Moderate suitability for supporting SRE invertebrate species due to the fact they provide little protection and complexity, and that the majority of these habitats are widespread and continuous throughout the landscape – thus promoting dispersal from invertebrates that occupy such niches. This was the case for the Mulga Woodlands, Stony Plain and Minor Drainage Line.

Drainage Area, Chenopod Shrubland, Sandy Mulga and Rocky Outcrop were all deemed to have Moderate suitability for SRE invertebrate fauna. The Sandy Mulga and Drainage Areas provide some microhabitat complexity, including deeper soils, leaf litter and woody debris and are somewhat restricted. The Chenopod Shrublands were assessed as Moderately suitable due to restricted connectivity between similar habitats and such habitats are known to contain unique and restricted terrestrial invertebrate species generally. The Rocky Outcrops were assessed as Moderately suitable habitat for SRE invertebrates due to the moderate degree of complexity and protection in the form of rocky cracks, crevices, soil pockets and leaf litter accumulations. While protection offered by this habitat was seemingly higher relative to other habitats within the Study Area, it was significantly less than other, much larger, rocky habitats within the region (Banded Ironstone Formation ranges such as Weld Range and Jack Hills), which are known to support short-range endemism (ecologia Environment, 2010, 2011). For example, no area at either outcrop was protected from the sun (e.g. no southern facing slopes), making the habitats distinctively dry. The two instances of this habitat within the Study Area occurred as isolated features within the Study Area; however, in both instances, the rocky outcropping was restricted in extent and likely too small to support localised endemism.

4.5 Fauna Recorded

4.5.1 Vertebrate Fauna

A total of 70 vertebrate fauna species, comprising 14 mammal species, 46 bird species, nine reptile species, and one amphibian species were recorded from the Study Area during the current survey (Appendix D). The 70 vertebrate fauna species recorded from the Study Area have previously been recorded from the region, based on the desktop assessment.

In comparison with the results from other previous surveys located near the Study Area, the fauna assemblage recorded (70 species) is considered to be moderate, and is similar to the assemblage recorded by Outback Ecology (2009, 58 fauna species), and greater than the assemblage recorded by Western Wildlife (2007, 25 fauna species) (Table 4.3). The remaining surveys (Bamford Consulting Ecologists, 2011, 2017; Dell & How, 1992; ecologia Environment, 2009) recorded two to three times more fauna species, however these surveys were multi-season Level 2 vertebrate fauna trapping surveys (Table 4.3).

The desktop assessment identified 33 vertebrate fauna species of conservation significance (Table 4.3). The 33 species included five mammals, 26 birds (mostly comprised of migratory waders) and two reptiles (Table 4.3).

Table 4.3 shows that the total species richness for all surveys located near the Study Area and from database searches within a 40 km radius. This total species richness currently stands at 288 species, with 41 species of mammals (including nine introduced mammals), 184 species of birds (including two introduced birds), 55 species of reptiles, and eight amphibians were recorded among the fauna (Appendix B).

Table 4.3: Summary of fauna species recorded or reported from database searches within the vicinity of the Study Area.

Source	Mammals	Birds	Reptiles	Amphibians	Total species
Barrambie Vanadium Project Targeted Fauna Assessment (Outback Ecology 2009)	12	38	8	0	58
Sinosteel Midwest Corporation Pty Ltd Weld Range Vertebrate Fauna Assessment (ecologia, 2009)	23	80	42	1	146
Vertebrate Fauna Assessment Yeelirrie Project Baseline Report (Bamford Consulting Ecologists, 2011)	25	82	49	4	160
Rosslyn Hill Project Proposed Priority Expansion Areas Fauna Assessment (Bamford Consulting Ecologists, 2017)	17	57	31	5	110
Windimurra Vanadium Threatened Fauna Assessment (Western Wildlife, 2007)	3	22	0	0	25
A biological survey of the Youanmi-Leonora Study Area (Dell and How, 1992)	22	78	43	3	146
Current Survey - Gabanintha	**14**	**46**	**9**	**1**	**70**
DPaW Naturemap database	4	27	17	2	50
DoE Protected Matters database	0	12	0	0	12
DBCA Threatened fauna	3	16	1	0	20
Birdlife	0	171	0	0	171
Total species *	**41**	**184**	**55**	**8**	**288**
Conservation significant species*	**5**	**26**	**2**	**0**	**33**

*Table includes all surveys intercepting/ adjoining the Study Area, and database searches with a 40 km radius.

4.5.2 SRE Invertebrate Fauna

The current assessment collected invertebrate samples from microhabitats in leaf litter, topsoil, under rocks, and woody debris at 13 of the 20 sampling sites. The sampling collected invertebrate specimens from 13 groups that are conducive to representing SRE species (i.e. from the family Olpiidae) (Table 4.4). The specimens are all from the Pseudoscorpions group. Of the invertebrate specimens collected, six represent two taxa that are Potential SRE (Table 4.4 and Section 4.7). In 2017 Biologic collected a further five invertebrate fauna species from within the TMAL tenure that are Potential SRE (see Section 4.7). The five specimens were all pseudoscorpions from the Olpiidae family.

Several other invertebrate specimens were collected from the Study Area during the current assessment (Table 4.4). These species were either identified by the expert taxonomist (E. Volschenk) or sorted in Biologic's laboratory and reviewed by in-house invertebrate zoologists. The specimens reviewed in-house were deemed to be common taxa, that are widespread, and are members of families that do not display short-range endemism. The specimen sent to the expert taxonomist were identified as being widespread pseudoscorpions (Table 4.4).

Table 4.4: Invertebrate fauna specimens collected from the Study Area

Site	GDA94 MGA Zone 50		Habitat type	Method	Group	Family	Taxon	No. of Specimens	SRE Comment
	Easting	Northing							
SRE-04	660819	7021828	Medium Drainage Line	litter sifting	Pseudoscorpion	Olpiidae	*Austrohorus* sp.	1M	Potential
SRE-04	660819	7021828	Medium Drainage Line	litter sifting	Pseudoscorpion	Olpiidae	*Euryolpium* sp.	1M	Widespread
SRE-04	660819	7021828	Medium Drainage Line	litter sifting	Pseudoscorpion	Olpiidae	Olpiidae sp.	1J (tritonymph)	Either *Indolpium* or *Euryolpium*. The specimen is in bad condition and chelicerae (containing diagnostic features) are damaged
SRE-04	660819	7021828	Medium Drainage Line	litter sifting	Pseudoscorpion	Olpiidae	*Beierolpium* '8/3'	F	Widespread
SRE-04	660819	7021828	Medium Drainage Line	litter sifting	Pseudoscorpion	Olpiidae	*Beierolpium* '8/3'	F	Widespread
SRE-06	661199	7022517	Hillslope	litter sifting	Pseudoscorpion	Olpiidae	*Euryolpium* sp.	1M	Widespread
SRE-10	661839	7019516	Boulders/ Rockpiles	litter sifting	Pseudoscorpion	Olpiidae	*Indolpium* sp.	1J (Tritonymph)	Potential
SRE-13	662016	7018561	Hillslope	litter sifting	Pseudoscorpion	Olpiidae	*Beierolpium* '8/3'	1F	Widespread
SRE-13	662016	7018561	Hillslope	litter sifting	Pseudoscorpion	Olpiidae	*Indolpium* sp.	1J (Tritonymph)	Potential
SRE-16	669473	7009575	Ironstone Outcrops	litter sifting	Pseudoscorpion	Olpiidae	*Beierolpium* '8/3'	1M, 1J (tritonymph?)	Widespread

Site	GDA94 MGA Zone 50		Habitat type	Method	Group	Family	Taxon	No. of Specimens	SRE Comment
	Easting	Northing							
SRE-16	669473	7009575	Ironstone Outcrops	litter sifting	Pseudoscorpion	Olpiidae	*Indolpium* sp.	1J (Tritonymph)	Potential
SRE-20	661471	7021236	Minor Drainage Line	litter sifting	Pseudoscorpion	Olpiidae	*Beierolpium* '8/4'	1F	Widespread
SRE-20	661471	7021236	Minor Drainage Line	litter sifting	Pseudoscorpion	Olpiidae	*Austrohorus* sp.	1M 1F	Potential

4.6 Fauna of Conservation Significance

4.6.1 Vertebrate Fauna

A total of 33 species of conservation significance have the potential to occur within the Study Area, based on the results of the desktop assessment (Section 3.2), comprising five mammals, 26 birds and two reptiles (Table 4.3 and Table 4.5). Two of these species have previously been recorded within the Study Area, the Long-tailed Dunnart and Peregrine Falcon (Biologic, 2018) (Table 4.5), while the current assessment (May 2018 field survey) did not record any conservation significant fauna species. Based on distribution, previous records and the habitats present, no species were deemed highly likely or likely to occur, four were deemed possible to occur, 14 may rarely occur, seven are unlikely to occur and six are highly unlikely to occur (Table 4.5). Species, confirmed, or with the possibility to occur are detailed below (Sections 4.6.2 and 4.6.3).

Table 4.5: Conservation significant species likelihood assessment

Species	Conservation Status		Preferred Broad Habitats Within Region	Habitat Within Study Area	Within Current Known Distribution	Distance to Nearest Record – Year	Recorded Within Study Area	Likelihood of Occurrence
	EPBC Act	WC Act						
Mammals								
Greater Bilby *(Macrotis lagotis)*	Vu	S3	Variety of habitats including spinifex hummock grassland and Acacia shrubland, on soft soils (Burrows *et al.*, 2012). In the Pilbara often associated with major drainage line sandy terraces (How *et al.*, 1991).	Highly Unlikely	No (regionally extinct)	~95 km (SW) – date unknown (DBCA, 2018a)	No	Highly Unlikely
Black-flanked Rock-wallaby (*Petrogale lateralis lateralis*)	Vu	S3	More recently confined to granite outcrops and breakaways (van Dyck & Strahan, 2008). Recorded from rocky outcrops with caves and rock piles associated with the Barr Smith Range by Bamford Consulting Ecologists (2011)	Unlikely	No	~115 km E – 2011 (Bamford Consulting Ecologists, 2011)	No	Highly Unlikely
Long-tailed Dunnart *(Sminthopsis longicaudata)*	-	P4	Typically occurs on plateaus near breakaways and scree slopes, and on rugged boulder-strewn scree slopes (Gibson & McKenzie, 2012). Once considered rare but now shown to be relatively common and widespread in rocky habitats (Burbidge *et al.*, 2008).	Confirmed	Yes	~40 km (N) – 1981 (DBCA, 2018a)	Yes	Confirmed
Brush-tailed Mulgara *(Dasycercus blythi)*	-	P4	Prefers spinifex *Triodia* spp. grasslands on sand plains and the swales between low dunes (Pavey *et al.*, 2012; Woolley, 2006). Mature spinifex hummocks appear to be important for protection from introduced predators (Körtner *et al.*, 2007).	Possible	No	~90 km (E) – 2013 (DBCA, 2018a)	No	Possible
Greater Long-eared Bat (*Nyctophilus major tor*)		P3	Believed to roost in the sheathing layers of rock on weathered granite outcrops (Woinarski *et al.*, 2014). Will forage over numerous habitats (Woinarski *et al.*, 2014).	Possible (foraging only)	Yes	~100 km (E) – 2011 (Bamford Consulting Ecologists, 2011)	No	Possible

Species	Conservation Status		Preferred Broad Habitats Within Region	Habitat Within Study Area	Within Current Known Distribution	Distance to Nearest Record – Year	Recorded Within Study Area	Likelihood of Occurrence
	EPBC Act	WC Act						
Birds								
Curlew Sandpiper *(Calidris ferruginea)*	Cr/Mi	S3/S5	Inhabits intertidal mudflats in sheltered coastal areas (i.e. estuaries, bays, inlets and lagoons) (Geering *et al.*, 2007). This rare species generally roosts on bare dry shingle, shell or sand beaches, sandspits and islets in or around coastal or near-coastal lagoons and other wetlands (Geering *et al.*, 2007).	Possible	Yes	~32 km (W) – 1980 ~48 km (NW) – 1980 (DBCA, 2018a)	No	Rarely
Night Parrot *(Pezoporus occidentalis)*	En	S1	The Night Parrot prefers sandy/stony plain habitat with old-growth spinifex (*Triodia*) for roosting and nesting in conjunction with native grasses and herbs for foraging (DPaW, 2017).	Possible (foraging only)	Yes	~143 km (SW) - 1854 (DBCA, 2018a)	No	Unlikely
Malleefowl (*Leipoa ocellata*)	Vu	S3	Inhabits semi-arid shrublands and low woodlands dominated by mallee eucalypts and/or acacias with sandy loam soils (Benshemesh, 2007).	Possible	Yes	~27 km (SW) – 1981 ~50 km (E) – 1996 (DBCA, 2018a)	No	Possible
Princess Parrot (*Polytelis alexandrae*)	Vu	P4	It is restricted to the arid zone of Western Australia, the Northern Territory and South Australia. The Princess Parrot inhabits sand dunes and sand flats. It occurs in open savanna woodlands and shrublands that usually consist of scattered stands of *Eucalyptus*, *Casuarina* or *Allocasuarina* trees; an understorey of shrubs such as *Acacia*, *Eremophila*, *Grevillea*, *Hakea* and *Senna*; and a ground cover dominated by *Triodia* species. It also frequents *Eucalyptus* or *Allocasuarina* trees in riverine or littoral areas.	Highly Unlikely	No	~127 km (SE) – 1915 ~200 km (E) - 1964 (DBCA, 2018a)	No	Highly Unlikely
Grey Falcon (*Falco hypoleucos*)	-	S3	Timbered lowlands, particularly Acacia shrubland and along inland drainage systems. Also frequent spinifex and tussock grassland (Burbidge *et al.*, 2010; Olsen & Olsen, 1986)	Possible	No	~40 km (W) – 2003 (DBCA, 2018a)	No	Possible

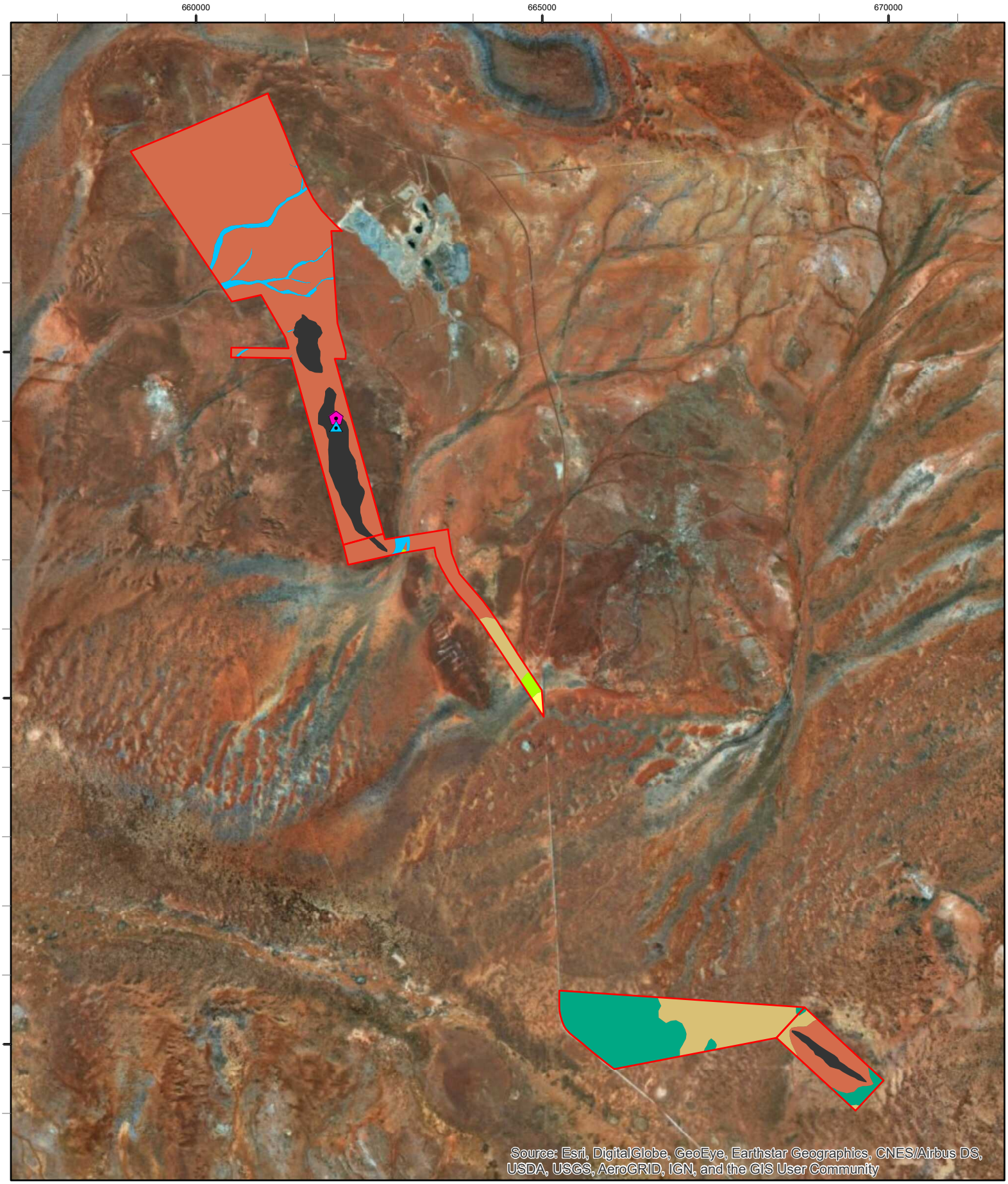
Species	Conservation Status		Preferred Broad Habitats Within Region	Habitat Within Study Area	Within Current Known Distribution	Distance to Nearest Record – Year	Recorded Within Study Area	Likelihood of Occurrence
	EPBC Act	WC Act						
Common Sandpiper (*Actitis hypoleucos*)	Mi	S5	Estuaries and deltas of streams, as well as banks farther upstream; around lakes, pools, billabongs, reservoirs, dams and claypans (Johnstone & Storr, 1998a).	Temporary Only	No	~68 km (SW) – 2001, 2005, 2015 (DBCA, 2018a)	No	Rarely
Fork-tailed Swift (*Apus pacificus*)	Mi	S5	Inhabits dry/open habitats, inclusive of riparian woodlands and tea-tree swamps, low scrub, heathland or saltmarsh, as well as treeless grassland and sandplains covered with spinifex, open farmland and inland and coastal sand-dunes (Johnstone & Storr, 1998a).	Likely	No	~15 km (W) – 1980 (DBCA, 2018a)	No	Rarely
Grey Wagtail (*Motacilla cinerea*)	Mi	S5	A rare vagrant to Western Australia where it has been recorded within various habitats with open waterbodies (Johnstone & Storr, 2004).	Temporary Only	No	~1,196 km (NE) - 2013 (DBCA, 2018a)	No	Highly Unlikely
Yellow Wagtail (*Motacilla flava)*	Mi	S5	An uncommon but regular visitor to the Pilbara region (Johnstone *et al.*, 2013). Occupies a range of damp or wet habitats with low vegetation, although favours edges of fresh water, especially sewage ponds (Oakwood, 2000)	Temporary Only	No	~1, 070 km (NE) – 1981, 2002, 2003 (DBCA, 2018a)	No	Highly Unlikely
Oriental Pratincole (*Glareola maldivarum*)	Mi	S5	Prefers open plains, floodplains or short grasslands, often with extensive bare areas. They often occur near terrestrial wetlands (such as billabongs, lakes or creeks), and artificial wetlands (such as reservoirs, saltworks and sewage farms) (Johnstone & Storr, 1998a).	Likely	No	~55 km (S) – 1980 (DBCA, 2018a)	No	Unlikely
Oriental Plover (*Charadrius veredus*)	Mi	S5	A variety of habitats, including coastal habitats, such as estuarine mudflats and sandbanks, on sandy or rocky ocean beaches as well as open inland environments such as, semi-arid or arid grasslands, where the grass is short and sparse (Johnstone & Storr, 2004).	Possible	No	~167 km (NE) - 1978 (DBCA, 2018a)	No	Unlikely

Species	Conservation Status		Preferred Broad Habitats Within Region	Habitat Within Study Area	Within Current Known Distribution	Distance to Nearest Record – Year	Recorded Within Study Area	Likelihood of Occurrence
	EPBC Act	WC Act						
Pectoral Sandpiper (*Calidris melanotos*)	Mi	S5	Coastal lagoons, estuaries, bays, swamps, lakes, inundated grasslands, saltmarshes, river pools, creeks, floodplains and artificial wetlands (Johnstone & Storr, 2004; Johnstone *et al.*, 2013). It prefers wetlands with open fringing mudflats and low, emergent or fringing vegetation (Geering *et al.*, 2007).	Temporary Only	No	~33 km (W) - 2013 (DBCA, 2018a)	No	Rarely
Sharp-tailed Sandpiper (*Calidris acuminata)*	Mi	S5	Favours flooded samphire flats and grasslands, mangrove creeks mudflats, beaches, river pools, saltwork ponds, sewage ponds and freshwater soaks (Johnstone *et al.*, 2013).	Temporary Only	Yes	~32 km (W) – 1980 ~48 km (NW) – 1980 (DBCA, 2018a)	No	Rarely
Red-necked Stint (*Calidris ruficollis*)	Mi	S5	Lives in permanent or ephemeral wetlands of varying salinity, and also regularly at sewage farms and saltworks. They are recorded less often at reservoirs, waterholes, soaks, bore-drain swamps and flooded inland lakes. In Western Australia they prefer freshwater to marine environments. The species usually forages in shallow water at the edge of wetlands and roost or loaf on tidal mudflats, near low saltmarsh, and around inland swamps (Johnstone & Storr, 1998a).	Temporary Only	Yes	~65 km (SW) – 2003, 2005 (DBCA, 2018a)	No	Rarely
Common Greenshank *(Tringa nebularia)*	Mi	S5	Species occurs as a non-breeding summer migrant, which occurs throughout the region. Occurs mainly in Tidal mudflats, mangrove creeks, flooded samphire flats, beaches, river pools, and saltwork and sewage ponds (Johnstone *et al.*, 2013).	Temporary Only	Yes	~32 km (W) – 1980 ~65 km (SW) – 2009 (DBCA, 2018a)	No	Rarely

Species	Conservation Status		Preferred Broad Habitats Within Region	Habitat Within Study Area	Within Current Known Distribution	Distance to Nearest Record – Year	Recorded Within Study Area	Likelihood of Occurrence
	EPBC Act	WC Act						
Marsh Sandpiper (*Tringa stagnatilis*)	Mi	S5	Lives in permanent or ephemeral wetlands of varying salinity, and also regularly at sewage farms and saltworks. They are recorded less often at reservoirs, waterholes, soaks, bore-drain swamps and flooded inland lakes. In Western Australia they prefer freshwater to marine environments. The species usually forages in shallow water at the edge of wetlands and roost or loaf on tidal mudflats, near low saltmarsh, and around inland swamps (Johnstone & Storr, 1998a).	Temporary Only	Yes	~65 km (SW) – 2013, 2004, 1999 (DBCA, 2018a)	No	Rarely
Wood Sandpiper (*Tringa glareola)*	Mi	S5	Species occurs as a non-breeding summer migrant, which occurs throughout the region. Occurs mainly in river pools, sewage ponds, flooded claypans, freshwater lagoons and bore overflows (Johnstone *et al.*, 2013).	Temporary Only	Yes	~38 km (N) – 2013 ~65 km (SW) – 2003 (DBCA, 2018a)	No	Rarely
Gull-billed Tern (*Gelochelidon nilotica*)	Mi	S5	Shallow sheltered seas close to land, estuaries, tidal creeks; and inundated samphire flats, flooded salt lakes, claypans and watercourses in the interior (Johnstone & Storr, 1998d).	Temporary Only	Yes	~22 km (NWW) – 1999 ~26km (W) - 2000 ~34 km (SE) – 2001 ~68 km (SW) – 1999, 2000, 2011, 2012, 2015, (Birdlife Australia, 2018; DBCA, 2018a)	No	Rarely
Caspian Tern (*Hydroprogne caspia*)	MI	S5	Mainly sheltered seas, estuaries and tidal creeks; occasionally near-coastal salt lakes (including saltwork ponds) and brackish pools in lower courses of rivers; rarely fresh water (Johnstone & Storr, 1998a).	Temporary Only	Yes	~67 km (SW) – 1999, 2013 (Birdlife Australia, 2018; DBCA, 2018a)	No	Rarely

Species	Conservation Status		Preferred Broad Habitats Within Region	Habitat Within Study Area	Within Current Known Distribution	Distance to Nearest Record – Year	Recorded Within Study Area	Likelihood of Occurrence
	EPBC Act	WC Act						
White-winged Black Tern (*Chlidonias leucopteris*)	Mi		Mainly estuaries and sheltered seas in the north, mainly freshwater swamps and lakes in the south; also samphire and short-grass flats, saltlakes, saltwork and sewage ponds (Johnstone & Storr, 1998a).	Temporary Only	Yes	~68 km (SW) – 1999, 2015 (Birdlife Australia, 2018; DBCA, 2018a)	No	Rarely
Glossy Ibis *(Plegadis falcinellus)*	-	S5	Freshwater wetlands, irrigated areas, margins of dams, floodplains, brackish and saline wetlands, tidal mudflats, pastures, lawns and public gardens (Johnstone *et al.*, 2013).	Temporary Only	Yes	~65 km (SW) – 2005, 2004, 1999 (DBCA, 2018a)	No	Rarely
Peregrine Falcon *(Falco peregrinus)*	-	S7	In arid areas, it is most often encountered along cliffs above rivers, ranges and wooded watercourses where it hunts birds (Johnstone & Storr, 1998a). It typically nests on rocky ledges occurring on tall, vertical cliff faces between 25 m and 50 m high (Olsen *et al.*, 2004; Olsen & Olsen, 1989).	Highly Likely (foraging only) Breeding (Unlikely)	Yes	~27 km (W) – 2000 ~65 km (N) - 2013 (DBCA, 2018a)	Yes	Confirmed
Blue-billed Duck (*Oxyura australis*)	-	P4	Mainly deep freshwater swamps and lakes; occasionally salt lakes and estuaries freshened by flood waters (Johnstone & Storr, 1998c).	Possible	No	~80 km (SW) – 2000 (DBCA, 2018a)	No	Rarely
Striated Grasswren (Sandplain) (*Amytornis striatus striatus*)	-	P4	It typically occurs in the arid interior, within tall, dense *Triodia* spp. hummock grasslands (Garnett & Crowley, 2000a).	Highly Unlikely	No	~80 km (NE) – 1983 (DBCA, 2018a)	No	Unlikely
Western Grasswren (*Amytornis textilis textilis*)	-	P4	Now, open shrubland (mostly low *Acacia* spp., especially with *Triodia* spp.), recumbent *Acacia* shrublands with *Ptilotus obovatus*. Previously in dense *Acacia* scrub, and bluebush of arid areas (Johnstone & Storr, 1998a).	Possible	No	~85 km (SW) – 1899 (DBCA, 2018a)	No	Highly Unlikely

Species	Conservation Status		Preferred Broad Habitats Within Region	Habitat Within Study Area	Within Current Known Distribution	Distance to Nearest Record – Year	Recorded Within Study Area	Likelihood of Occurrence
	EPBC Act	WC Act						
Hooded Plover *(Thinornis rubricolis*)	-	P4	Margins and shallows of salt lakes, sandy and sea-weedy beaches and estuaries and also damns (Johnstone & Storr, 1998a).	Possible	No	~70 km (SW) – 2015 ~95 km (SW) – 2000 (Birdlife Australia, 2018)	No	Unlikely
Reptiles								
Gilled Slender Blue-Tongue (*Cyclodomorphus branchialis*)	-	S3	A ground-dwelling lizard of largely crepuscular and nocturnal habit, sheltering by day in porcupine grass, leaf-litter and under fallen timber (Cogger, 2014).	Unlikely	No	~150 km (S) – 2005 (DBCA, 2018a)	No	Unlikely
West Coast Slider *(Lerista eupoda)*	-	P1	Open Mulga areas on red loams and sandy loam soils (Cogger, 2014). A record exists approximately 5 km from the area (Ray Lloyd, *pers. comm.*)	Possible	No	~25 km (W) – 2014, 2011, 2009 (DBCA, 2018a)	No	Possible



Legend

- StudyArea
- **Fauna Habitats**
  - Chenopod Shrubland
  - Drainage Area
  - Minor Drainage Line
  - Mulga Woodland
  - Rocky Outcrop
  - Sandy Mulga
  - Stony Plain
- **Fauna of Conservation Significance**
  - Long-tailed Dunnart
  - Peregrine Falcon

biologic Environmental Survey

N

1:70,000

0 0.5 1 2 km

Technology Metals Australian Limited

Gabanintha Vanadium Project

Figure 4.2: Fauna of conservation significance recorded in the Study Area

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

Size A4. Created 25/06/2018

4.6.2 Species Confirmed within Study Area

Long-tailed Dunnart (*Sminthopsis longicaudata*)

The Long-tailed Dunnart is listed as Priority 4 by DBCA. Little is known of the life history of the species, but available evidence suggests that this widely scattered species is restricted to rugged, rocky areas and, once located, is present in reasonable numbers (Gibson & McKenzie, 2009). The species is believed to be a rock dwelling specialist, inhabiting rugged rocky landscapes that support a low open woodland or shrubland of *Acacia* spp. (especially Mulga) with an understorey of spinifex hummocks, and (occasionally) also perennial grasses and cassias (van Dyck & Strahan, 2008).

The species was previously known from few records (van Dyck & Strahan, 2008), but is now being caught more regularly around ranges in the Murchison (M. Cowan, DBCA Ecologist, *pers. comm.*). Records of the species are scarcely scattered throughout its distribution, which extends from the northern Pilbara south-west to Morawa, and east into the Gibson Desert. A separate population is also located near Alice Springs (ALA, 2018). The nearest record of the species to the Study Area is located 40 km to the north at Meekatharra, taken from 1981 (DBCA, 2018a).

One individual of the species was captured in 2017 within the TMAL tenure. The capture was recorded within the Rocky Outcrop habitat. This habitat type is likely to be the only suited habitat for the species within the Study Area.

Peregrine Falcon (*Falco peregrinus*)

The Peregrine Falcon is listed as Schedule 7 “other specially protected fauna” under the WC Act. In arid areas it is most often encountered along cliffs above rivers, ranges and wooded watercourses where it hunts birds (Johnstone & Storr, 1998a). It typically nests on rocky ledges occurring on tall, vertical cliff faces, and also occasionally within tall trees occurring along Major Drainage Lines (Olsen & Olsen, 1989). This species is also known for nesting on radio-towers and other human built structures.

The Peregrine Falcon is a wide-ranging bird of prey that occurs throughout Australia. The nearest records of the species are located ~27 km west of the Study Area from 2000 (DBCA, 2018a), at Lake Annean, and two records near Meekatharra, ~65 km north of the Study Area from 2013 (DBCA, 2018a).

The Peregrine falcon was opportunistically recorded from the Northern Region area, within TMAL tenure, in 2017. The record was from the Rocky Outcrop fauna habitat type. No habitats within the Study Area are likely to provide breeding habitat for the species. The mine pits of the abandoned Gabanintha mine (0.5 km west of the Study Area) or the ridges of Mt Yagahong (~3 km west of the Study Area), may provide potential breeding habitat for the species. If the species is resident to the Study Area, it is likely that individual/s will forage in the Study Area regularly. All habitats within the Study Area provide potential foraging habitat for the species.

4.6.3 May Possibly Occur

Brush-tailed Mulgara (*Dasycercus blythi*)

The Mulgara is listed as Priority 4 under the WC Act and Vulnerable under the EPBC Act (under its old name of *Dasycercus cristicauda* which no longer is attributed to this species). The Brush-tailed Mulgara was formerly known simply as the Mulgara and because of taxonomic changes, has seen a change of species from *cristicauda* to *blythi*. This species is found in sand ridge habitat, Triodia sand plain and gibber plain, a recently recorded habitat for the species (Pavey *et al.*, 2012).

In Western Australia the species is distributed in the Pilbara and Western Desserts, with few records in the Murchison region (DBCA, 2018a). The Study Area is slightly west of the species current known distribution. The nearest records of the species are located ~90 km north-east of the Study Area from 2013 (DBCA, 2018a). No distinctive burrows were located during the current assessment, though it was impossible to cover the entire area on foot. There was an absence of the red sandy loams preferred by this species, and it is considered to have a low likelihood of occurring based on distributional records and partially suited habitats in the form of the Sandy Mulga and Stony Plain.

Malleefowl (*Leipoa ocellata*)

The Malleefowl is listed as Vulnerable by the IUCN, under the EPBC act and Schedule 3 'Vulnerable' under the WC Act. Once common and widespread across semi-arid southern Australia, Malleefowl have declined severely in the last century, with a 20% decrease in abundance and 50% decrease in area of occupancy (Benshemesh, 2005; Garnett & Crowley, 2000b). Malleefowl prefer habitat consisting of thickets of mallee, mulga or other dense litter-forming shrublands, as well as dry forest dominated by other eucalypt and *Acacia* spp. (Benshemesh, 2005; Johnstone & Storr, 1998b). They require sandy substrate with leaf litter to build their nesting mounds (Frith, 1976) and, hence, the highest breeding densities appear to occur in vegetation that is at least 40 years post fire (Benshemesh, 1990, 1992; Woinarski, 1989). They rarely breed in vegetation that has been burnt within the last 15 years (Crowley *et al.*, 1969; Tarr, 1965).

The nearest two records of the species are located approximately 27 km south-west of the Study Area from 1981 (DBCA, 2018a). The next three closest records are located ~50 km east from 1996 (DBCA, 2018a). The most recent record of the region is from 2010 (DBCA, 2018a) and located 88 km north-east of the Study Area.

The species was not recorded within the Study Area during the survey. Personal contact with the owner of Polelle Station (Jim Lacy) via email (16/3/15) revealed that there have been no contemporary sightings of mounds or birds on that lease, and thus this species is considered unlikely to be present. The lack of records in the area suggests that the species does not occur,

or if present, that is occurs in very low densities. The Sandy Mulga and Drainage Area habitats provide the most suitable habitat for the species.

Grey Falcon (*Falco hypoleucos*)

This rare bird of prey is listed as Vulnerable (Schedule 3) under the WC Act. Storr (1985) describes the species as a rare visitor to the region. Garnett *et al.* (2011) note that it favours treeless areas as well as timbered lowland plains, particularly acacia shrublands in areas with tree-lined water-courses. This species breeds in the nests of other bird species in tall trees along watercourses (Garnett *et al.*, 2011), and is thought to be threatened by ongoing pastoral activities, which may limit recruitment and provision of nest trees (Garnett *et al.*, 2011)

The species core distribution is in the northern half of Western Australia, through the Gascoyne, Lake Carnegie and Warburton regions. South of this, such as the region of the Study Area, the species is a casual visitor only. The nearest record of the species was taken approximately 40 km west of the Study Area in 2003 (DBCA, 2018a).

It is unlikely that individuals of the species would be resident in the Study Area, although individuals may potentially occur following suitable conditions. If present, all habitats within the Study Area may provide foraging habitats for the species.

Greater Long-eared Bat (*Nyctophilus major tor*)

The Greater Long-eared Bat is listed as Priority 3 by DBCA. The species is distributed through the transitional zone between the southwest and arid interior of Western Australia (DBCA, 2018b; Parnaby, 2009). Taxonomy of the genus is poorly known, and echolocation calls are difficult to differentiate between species, potentially explaining the lack of records for the species (DBCA, 2018b; Parnaby, 2009). The species is thought to roost in the sheathing plates of granite outcrops that are scattered throughout the region (Woinarski *et al.*, 2014).

The nearest record of the species is located approximately 100 km east of the Study Area by Bamford Consulting Ecologists (2011). The Rocky Outcrop habitat provides marginal roosting habitat for the species and therefore it is unlikely that the species will roost within the Study Area. There is however suitable roosting habitat in the vicinity outside of the Study Area and it is possible that the species occurs in the broader regional area. Foraging requirements of the species are unknown although unlikely to be specific.

West Coast Slider (*Lerista eupoda*)

This fossorial skink is listed as Priority 1 by DBCA, reflecting a poor state of knowledge for the species. Little is known on its ecology, although it is often recorded in deep leaf-litter accumulations of deep red loams and sandy loams (Cogger, 2014), usually in shrublands dominated by Mulga and other *Acacia* spp. The species is only known from 22 records in the Meekatharra-Cue area (DBCA, 2018a), most of which are associated with Lake Annean and the area around Cue – mostly sand plains fringing salt lakes. The nearest record of the species is located approximately 5 km from the Study Area (Ray Lloyd *pers. comm.*).

The Mulga Woodland and Sandy Mulga habitats may provide sporadic suitable habitat within the Study Area; however it was not recorded during the current assessment. The remaining fauna habitats mapped in the Study Area do not provide suitable habitat for the species (deep leaf-litter accumulations of loamy soils).

4.6.4 Species Which May Rarely Occur in the Study Area

Fork-tailed Swift (*Apus pacificus*)

The Fork-tailed Swift is listed as Schedule 5 'Migratory' listed species under the WC Act and Migratory protected under the EPBC Act. It is a migratory species that breeds in northeast and east Asia, wintering in Australia and southern New Guinea (Johnstone & Storr, 1998a). It is a rare visitor and a largely aerial species not common to any particular terrestrial habitat. The nearest record of the species is located ~15 km west of the Study Area from 1980 (DBCA, 2018a). All habitats within the Study Area provide suitable habitat for the species although individuals would not be restricted or dependent on these.

Blue-billed Duck (*Oxyura australis*)

The Blue-billed Duck is listed as Priority 4 by DBCA. It is widespread in southern Australia and is a rare visitor to the arid zone. The species typically inhabits the deeper freshwater swamps and lakes, occasionally salt lakes and estuaries freshened by flood waters. In Western Australia the species typical distribution comprises the south-west, north to Dongara and east to Esperance, and no more than 200 km from the coast (Johnstone & Storr, 1998c). Any further north or east the species is considered a vagrant. The nearest record of the species is located ~80 km south-west of the Study Area from Nallan Lake in 2000 (DBCA, 2018a). The lack of additional records demonstrates the rarity of the species within the region. Individuals of the species may occur at any seasonal waterbodies (and the pastoral dams) located in close proximity to the Study Area during periods of inundation.

Red-necked Stint, Sharp-tailed Sandpiper, Curlew Sandpiper, Common Sandpiper, Common Greenshank, Pectoral Sandpiper, Marsh Sandpiper and Wood Sandpiper

The Red-necked Stint, Sharp-tailed Sandpiper, Curlew Sandpiper, Common Sandpiper, Common Greenshank, Pectoral Sandpiper, Marsh Sandpiper and Wood Sandpiper are all migratory shorebirds protected under international convention. They have all been recorded within 100 km of the Study Area, mostly from Lake Annean and Lake Nallan (DBCA, 2018a). These shorebirds utilise Australia's wetland areas during their non-breeding season. These species may occasionally visit Quinns Lake to the south of the Study Area during periods of inundation, although they would not be reliant on this habitat. The pastoral dams and waterbodies may be sporadically utilised as short stop-overs.

Glossy Ibis, White-winged Black Tern, Gull-billed Tern and Caspian Tern

The Glossy Ibis, White-winged Black Tern, Gull-billed Tern and Caspian Tern would all be rare migrants that would visit any large seasonally inundated lakes, including the large seasonally

inundated lakes near the Study Area (Lake Annean, Nallan Lake and Lake Austin). As a result, the Glossy Ibis, White-winged Black Tern, Gull-billed Tern and Caspian Tern may occasionally fly over the Study Area. The Glossy Ibis has been recorded (DBCA, 2018a) on numerous occasions at Nallan. Quinns Lake, to the south of the Study Area, would provide suitable habitat when inundated.

4.7 SRE Invertebrate Fauna

Of the specimens sorted and sent for further identifications by taxonomic experts, three taxa from one family (Olpiidae) of invertebrates have been identified as being Potential SRE species (Data Deficient) (Table 4.6; Figure 4.3) owing to the poor state of taxonomy for the specimens collected and the lack of regional data. This limits the current assessment somewhat; however, the SRE fauna habitat assessments provide some local context with respect to the Study Area.

While further molecular investigations could be undertaken, the regional genetic sequence data on these taxa is also insufficient to provide meaningful resolution of species boundaries.

The current survey recorded the following taxa regarded as Potential SRE (Data Deficient):

Pseudoscorpions

- *Austrohorus* sp. Indet.;
- *Indolpium* sp. Indet; and
- Olpiidae sp. Indet.

4.7.1 Pseudoscorpions

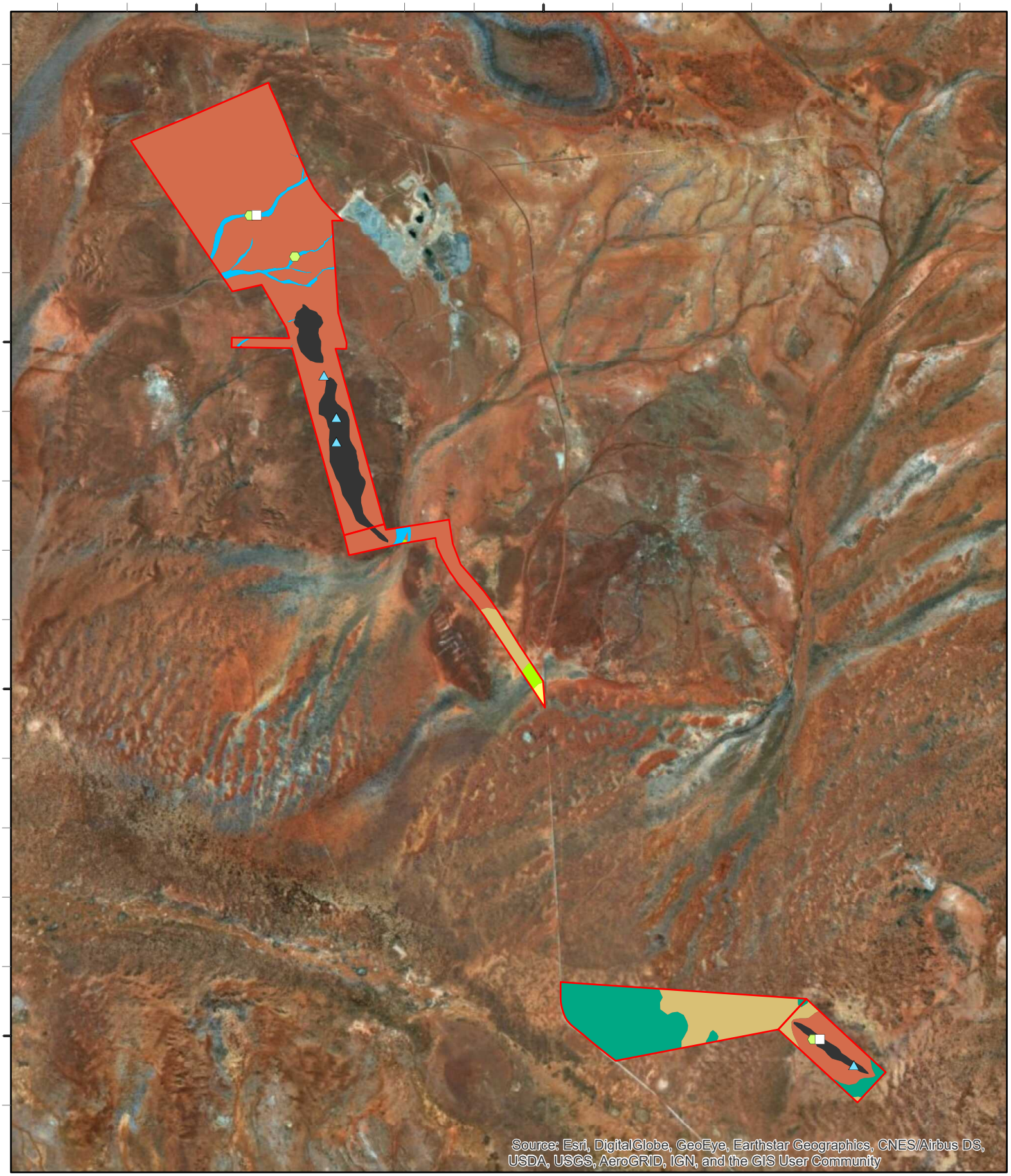
Olpiidae sp. indet

Olpiidae was the most commonly recorded pseudoscorpion family from the surveys, with nine collected, including widespread taxa. Two of the specimens collected (one in 2017 and one in 2018) could not be identified past family, to genus level, as the specimens were damaged. The specimens may represent unique species, or taxon (genera) that was collected elsewhere in the Study Area, including taxa regarded as Potential SRE (such as *Austrohorus* sp. Indet. and *Indolpium* sp. Indet.), and taxa considered Widespread (*Beierolpium* sp. Indet.) although further work would be required to determine this. The specimens were collected from the Rocky Outcrop habitat in the Southern Region of the Study Area and the Minor Drainage Line habitat in the Northern Region. Taxa belonging to this family, but further identified to genus, were also collected from this habitat.

The taxonomy of the Olpiidae is poorly known, and as a result all species from this family are classified under WAM category ‘A’ (Data Deficient) until further taxonomic resolution has been developed.

Table 4.6: SRE target taxa detected within the Study Area.

Higher taxon	Family	Morphospecies	SRE Status	Chenopod Shrubland	Drainage Area	Minor Drainage Line	Mulga Woodland	Rocky Outcrop	Sandy Mulga	Stony Plain	Total	Extent Outside Study Area
Pseudoscorpiones												
	Olpiidae	*Austrohorus* sp. `Indet.`	Potential SRE (Data Deficient)			2		4			6	Unknown
	Olpiidae	*Indolpium* sp. `Indet.`	Potential SRE (Data Deficient)					3		1	4	Unknown
	Olpiidae	Olpiidae sp. `Indet.`	Potential SRE (Data Deficient)			1		1			2	Unknown



Legend

- Study Area
- **Fauna Habitats**
  - Chenopod Shrubland
  - Drainage Area
  - Minor Drainage Line
  - Mulga Woodland
  - Rocky Outcrop
  - Sandy Mulga
  - Stony Plain
- **Potential SRE Invertebrates**
  - *Austrohorus* sp. Indet.
  - *Indolpium* sp. Indet.
  - Olpiidae sp. Indet.

biologic Environmental Survey

N

1:70,000

0 0.5 1 2 km

Technology Metals Australian Limited

Gabanintha Vanadium Project

Figure 4.3: Potential SRE invertebrates recorded in the Study Area

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

Size A4. Created 22/11/2018

Indolpium sp. indet.

Four specimens were identified as *Indolpium* sp. indet. and were collected from four locations, within the Rocky Outcrop and Stony Plain habitats via leaf/soil sieving.

The taxonomy of the Olpiidae (the family to which this taxon belongs to) is poorly known, and as a result all unidentifiable specimens from this family are classified under WAM category 'A' (Data Deficient) until further taxonomic resolution has been developed.

Austrohorus sp. indet.

This taxon was represented by six specimens from three locations within the Study Area (Figure 4.3), obtained via leaf and soil sieving and rock searching within Minor Drainage Line and Rocky Outcrop habitats. It is not possible to determine whether these specimens all represent the same species but personal communication from the identifying taxonomist (E. Volschenk pers. comm.) suggests they all look similar; however, molecular work would be required to confirm this.

The taxonomy of the Olpiidae (the family to which this taxon belongs to) is poorly known, and as a result all unidentifiable specimens from this family are classified under WAM category 'A' (Data Deficient) until further taxonomic resolution has been developed.

5 CONCLUSION

5.1 Vertebrate Fauna

A total 70 fauna species, comprising 14 mammal species (including four non-native mammals), 46 bird species, nine reptile species and one amphibian species were recorded from the Study Area. The number of vertebrate fauna recorded from the Study Area is consistent with the surveys completed in the region, and in consideration of the survey intensity (targeted survey). The fauna assemblage recorded from the Study Area is typical of the region in which the Study Area occurs.

A total of seven broad fauna habitat types were recorded and mapped across the Study Area. This comprised, in decreasing order of extent, Stony Plain, Chenopod Shrubland, Mulga Woodland, Rocky Outcrop, Minor Drainage Line, Drainage Area and Sandy Mulga. The Rocky Outcrop habitat type should be considered of relative high local significance, due to the ability to provide habitat for the conservation listed Long-tailed Dunnart, which was recorded in the area in 2017. The Rocky Outcrop habitat is restricted in the local region, with limited occurrences. Additional occurrences of Rocky Outcrop occur between 0.5 km and 3.5 km to the east and west of the Study Area. The Rocky Outcrop habitat is deemed to be of low regional significance. Rocky outcropping, ridges, ranges and small rocky hills occur sporadically throughout the Murchison bioregion. The remaining habitat types are considered to provide habitat of low significance. These habitat types are widespread in the region and no conservation significant fauna species would wholly rely on the habitat for their survival.

One artificial waterbody (a pastoral dam and windmill) provides accessible freshwater for all, or part, of the year. As a result, fauna activity, native and non-native, is high, with numerous species recorded via motion camera and ultrasonic recorders. No conservation significant fauna was recorded to be utilising the artificial waterbody at the time of the field survey. The waterbody is unlikely to wholly support, and be of significant importance, to the survival of any conservation listed fauna species.

A total of 33 species of conservation significance were recorded during the desktop assessment, comprising five mammals, 26 birds and two reptiles. Of these, two were recorded within the Study Area, the Long-tailed Dunnart and the Peregrine Falcon. Four additional species were assessed as possible to occur in the Study Area and a further 14 species were assessed as rarely occurring within the Study Area.

One Long-tailed Dunnart individual was recorded in 2017 from within TMAL tenure. The individual was trapped from the Rocky Outcrops habitat in the Northern Region area. It is likely that the Long-tailed Dunnart is restricted to the Rocky Outcrops habitat and would likely be impacted by any disturbance to this habitat type. The low number of records for this species in the region suggests the Study Area may be of local importance, although the low number of records in the Study Area may suggest that the species only occurs in low densities. The Peregrine Falcon was recorded in the northern section of the Study Area in October 2017. While no breeding habitat is likely to occur in the Study Area, it is possible that species nests close-by, and thus frequent the Study Area for foraging.

The four additional species assessed as possibly occurring in the Study Area were: Brush-tailed Mulgara, West-coast Slider, Malleefowl and Grey Falcon. Given that none of these species have been recorded in the Study Area, despite the search effort, it is more than likely that if the species are present it is likely to

be on a transient basis only. If resident individuals occur, they are likely to occur in very low densities. The 14 species assessed as rarely occurring within the Study Area, comprised migratory birds and waterbirds that only occur in the region sporadically (usually after heavy rainfall). As such, none of these species are likely to be reliant on the Study Area, particularly given that most have been recorded at better suited wetlands in the local region (i.e. Lake Annean, Lake Nallan).

5.2 SRE Invertebrates

Of the seven habitats recorded in the Study Area, the majority were assessed as being unlikely to support SRE invertebrate species – due to the fact that they lack protection, complexity and are generally widespread, common and continuous. The Drainage Area, Chenopod Shrubland, Sandy Mulga and Rocky Outcrop were all deemed to possibly contain SRE invertebrates.

Invertebrate specimens were collected from 13 groups that are conducive to representing SRE taxa within the Study Area during the current assessment. Eight of the invertebrate specimens collected were from one taxonomic group prone to short-range endemism, pseudoscorpions (two taxa and one identified to family, Olpiidae) and are identified as representing Potential SRE taxa (Data Deficient). An additional four invertebrate specimens collected in 2017 from the family Olpiidae also represent Potential SRE taxa (Data Deficient). The data deficiency was due to the specimens not possessing the characteristics required for species level identification, and/or that the taxonomy of such groups is lacking in the Murchison region.

In the absence of more conclusive taxonomic results, the species' habitats provide an insight into the likelihood that the taxa collected are restricted to the Study Area. All Potential SRE specimens were recorded within the Rocky Outcrops, Minor Drainage Line and Stony Plain habitat types. The latter two (Minor Drainage Line and Stony Plain habitat) are regarded as having Low suitability for supporting short-range endemism due to a lack of suitable microhabitats and are widespread and well connected beyond the Study Area. The Rocky Outcrops habitat is regarded as Moderately suitable for SRE invertebrate fauna and while this particular occurrence of this habitat appears restricted to the Study Area, it is a common habitat type in the local area and it is highly unlikely any species recorded here would be unable to disperse to other local rocky habitats during favourable conditions.

5.3 Summary

In summary, the Study Area was surveyed to an adequate scale with 70 vertebrate fauna species recorded and 13 invertebrate specimens collected. The number of invertebrate specimens collected does not include the specimens collected by Biologic (2018) within TMAL tenure. The Study Area appears to represent common and widespread habitats, which occur across the Murchison bioregion. As such, the majority of the fauna occurring within the Study Area are likely to spread across the region. The assessment did identify one species of conservation significance, the Long-tailed Dunnart, which may be impacted by disturbances to the Rocky Outcrop habitat. The Rocky Outcrop habitat is also regarded as Moderately suitable for SRE invertebrate fauna but it is highly unlikely that any species would be restricted to this habitat within the Study Area.

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APPENDICES

Appendix A: Conservation listings

International Union for Conservation of Nature

Category	Definition
Extinct (Ex)	A taxon is Extinct when there is no reasonable doubt that the last individual has died. A taxon is presumed Extinct when exhaustive surveys in known and/or expected habitat, at appropriate times (diurnal, seasonal, annual), throughout its historic range have failed to record an individual. Surveys should be over a time frame appropriate to the taxon's life cycle and life form.
Extinct in the Wild (Ex)	A taxon is Extinct in the Wild when it is known only to survive in cultivation, in captivity or as a naturalized population (or populations) well outside the past range. A taxon is presumed Extinct in the Wild when exhaustive surveys in known and/or expected habitat, at appropriate times (diurnal, seasonal, annual), throughout its historic range have failed to record an individual. Surveys should be over a time frame appropriate to the taxon's life cycle and life form.
Critically Endangered (Cr)	A taxon is Critically Endangered when the best available evidence indicates that it meets any of the criteria A to E for Critically Endangered (see Section V), and it is therefore considered to be facing an extremely high risk of extinction in the wild.
Endangered (En)	A taxon is Endangered when the best available evidence indicates that it meets any of the criteria A to E for Endangered (see Section V), and it is therefore considered to be facing a very high risk of extinction in the wild.
Vulnerable (Vu)	A taxon is Vulnerable when the best available evidence indicates that it meets any of the criteria A to E for Vulnerable (see Section V), and it is therefore considered to be facing a high risk of extinction in the wild.
Near Threatened (NT)	A taxon is Near Threatened when it has been evaluated against the criteria but does not qualify for Critically Endangered, Endangered or Vulnerable now, but is close to qualifying for or is likely to qualify for a threatened category in the near future
Data Deficient (DD)	A taxon is Data Deficient when there is inadequate information to make a direct, or indirect, assessment of its risk of extinction based on its distribution and/or population status. A taxon in this category may be well studied, and its biology well known, but appropriate data on abundance and/or distribution are lacking. Data Deficient is therefore not a category of threat. Listing of taxa in this category indicates that more information is required and acknowledges the possibility that future research will show that threatened classification is appropriate. It is important to make positive use of whatever data are available. In many cases, great care should be exercised in choosing between DD and a threatened status. If the range of a taxon is suspected to be relatively circumscribed, and a considerable period of time has elapsed since the last record of the taxon, threatened status may well be justified.

Environment Protection and Biodiversity Conservation Act 1999

Category	Definition
Extinct (Ex)	Taxa not definitely located in the wild during the past 50 years.
Extinct in the Wild (EW)	Taxa known to survive only in captivity.
Critically Endangered (Cr)	Taxa facing an extremely high-risk of extinction in the wild in the immediate future.
Endangered (En)	Taxa facing a very high risk of extinction in the wild in the near future.
Vulnerable (Vu)	Taxa facing a high risk of extinction in the wild in the medium-term future.
Migratory (Mi)	Consists of species listed under the following International Conventions: Japan-Australia Migratory Bird Agreement (JAMBA); China-Australia Migratory Bird Agreement (CAMBA); Convention on the Conservation of Migratory Species of Wild animals (Bonn Convention)

Wildlife Conservation Act 1950

Category	Definition
Schedule 1 (S1)	Rare or likely to become extinct, as critically endangered fauna.
Schedule 2 (S2)	Rare or likely to become extinct, as endangered fauna.
Schedule 3 (S3)	Rare or likely to become extinct, as vulnerable fauna.
Schedule 4 (S4)	Being fauna that is presumed to be extinct.
Schedule 5 (S5)	Birds that are subject to international agreements relating to the protection of migratory birds.
Schedule 6 (S6)	Special conservation need being species dependent on ongoing conservation intervention.
Schedule 7 (S7)	In need of special protection, otherwise than for the reasons pertaining to Schedule 1 through to Schedule 6 Fauna.

Department of Biodiversity, Conservation and Attractions Priority Definitions

Category	Definition
Priority 1 (P1)	Taxa with few, poorly known populations on threatened lands.
Priority 2 (P2)	Taxa with few, poorly known populations on conservation lands; or taxa with several, poorly known populations not on conservation lands.
Priority 3 (P3)	Taxa with several, poorly known populations, some on conservation lands.
Priority 4 (P4)	Taxa in need of monitoring. Taxa which are considered to have been adequately surveyed, or for which sufficient knowledge is available, and which are considered not currently threatened or in need of special protection, but could be if present circumstances change.

Appendix B: Vertebrate Fauna Identified in the Desktop Assessment

Mammals

Genus and Species	Common Name	Conservation Status				NatureMap	Protected Matters	DBCA Threatened Fauna	Bamford Consulting Ecologists (2011)	Outback Ecology (2009)	Western Wildlife (2007)	Dell & How (1992)	Ecologia (2009)	Bamford Consulting Ecologists (2017)	Current Survey
		EPBC	WCA	DEC	IUCN										
BOVIDAE															
Bos taurus	*European Cattle									●		●	●		●
Capra hircus	*Goat									●	●	●	●		
Ovis aries	*Sheep									●		●			
CAMELIDAE															
Camelus dromedarius	*Camel								●	●					
CANIDAE															
Canis dingo	Dingo								●	●			●		●
Vulpes vulpes	*Red Fox								●	●		●	●	●	
DASYURIDAE															
Antechinomys laniger	Kultarr					●						●	●		
Dasycercus blythi	Brush-tailed Mulgara			P4				●	●						
Ningaui ridei	Wongai Ningaui								●			●		●	
Pseudantechinus woolleyae	Woolley's Pseudantechinus								●				●		●
Sminthopsis crassicaudata	Fat-tailed Dunnart											●			
Sminthopsis dolichura	Little Long-tailed Dunnart											●	●	●	
Sminthopsis hirtipes	Hairy-footed Dunnart								●			●			
Sminthopsis longicaudata	Long-tailed Dunnart			P4				●					●	●	
Sminthopsis macroura	Stripe-faced Dunnart								●			●	●	●	?

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		EPBC	WCA	DEC	IUCN										
Sminthopsis ooldea	Ooldea Dunnart								•						
EMBALLONURIDAE															
Saccolaimus flaviventris	Yellow-bellied Sheathtail-bat								•					•	
Taphozous hilli	Hill's Sheathtail-bat												•	•	
EQUIDAE															
Equus asinus	*Donkey									•					
FELIDAE															
Felis catus	*Cat								•	•			•	•	
LEPORIDAE															
Oryctolagus cuniculus	*Rabbit								•	•	•	•	•		•
MACROPODIDAE															
Osphranter robustus	Euro								•	•	•	•	•	•	•
Osphranter rufus	Red Kangaroo					•			•	•		•	•	•	•
Petrogale lateralis lateralis	Black-flanked Rock-wallaby	EN	S2		VU				•						
MOLOSSIDAE															
Austronomus australis	White-striped Freetail-bat								•				•	•	•
Ozimops lumsdenae	Northern Free-tailed Bat														
Ozimops petersi	Inland Free-tailed Bat								•						
Mormopterus planiceps	Southern Freetail-bat				LC							•			
MURIDAE															
Mus musculus	*House Mouse											•	•	•	

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		EPBC	WCA	DEC	IUCN										
Notomys alexis	Spinifex Hopping-mouse								•				•		
Notomys mitchellii	Mitchell's Hopping-mouse											•		•	
Pseudomys hermannsburgensis	Sandy Inland Mouse											•	•	•	
TACHYGLOSSIDAE															
Tachyglossus aculeatus	Short-beaked Echidna								•	•		•	•	•	•
THYLACOMYIDAE															
Macrotis lagotis	Bilby	VU	S3		VU			•							
VESPERTILIONIDAE															
Chalinolobus gouldii	Gould's Wattled Bat								•			•	•	•	•
Nyctophilus geoffroyi	Lesser Long-eared Bat					•			•			•	•		•
Nyctophilus major tor	Greater Long-eared Bat			P3					•						
Scotorepens balstoni	Inland Broad-nosed Bat								•			•	•		•
Vespadelus baverstocki	Inland Forest Bat								•						
Vespadelus finlaysoni	Finlayson's Cave Bat					•			•				•	•	•
Vespadelus regulus	Southern Forest Bat											•			

Birds

Genus and Species	Common Name	Conservation Status				NatureMap	Protected Matters	DBCA Threatened Fauna	Birdlife	Bamford Consulting Ecologists (2011)	Outback Ecology (2009)	Western Wildlife (2007)	Dell & How (1992)	Ecologia (2009)	Bamford Consulting Ecologists (2017)	Current Survey
		EPBC	WCA	DEC	IUCN											
ACANTHIZIDAE																
Acanthiza apicalis	Inland Thornbill								●	●			●	●		
Acanthiza chrysorrhoa	Yellow-rumped Thornbill								●	●		●	●	●	●	
Acanthiza iredalei	Slender-billed Thornbill								●					●		
Acanthiza robustirostris	Slaty-backed Thornbill								●	●			●	●	●	
Acanthiza uropygialis	Chestnut-rumped Thornbill								●	●	●	●	●	●	●	
Aphelocephala leucopsis	Southern Whiteface								●	●			●	●	●	
Aphelocephala nigricincta	Banded Whiteface					●			●							
Calamanthus campestris	Rufous Fieldwren								●				●			
Gerygone fusca	Western Gerygone					●			●	●			●	●	●	
Pyrrholaemus brunneus	Redthroat								●	●	●		●	●	●	
Smicrornis brevirostris	Weebill								●	●			●	●	●	
ACCIPITRIDAE																
Accipiter cirrocephalus	Collared Sparrowhawk								●	●			●	●	●	
Accipiter fasciatus	Brown Goshawk	MA							●					●		
Aquila audax	Wedge-tailed Eagle								●	●	●		●	●	●	●
Circus approximans	Swamp Harrier	MA			LC				●							
Circus assimilis	Spotted Harrier								●	●						
Elanus axillaris	Black-shouldered Kite								●							

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		EPBC	WCA	DEC	IUCN											
Haliastur sphenurus	Whistling Kite	MA							●	●				●	●	
Hamirostra melanosternon	Black-breasted Buzzard								●					●	●	
Hieraaetus morphnoides	Little Eagle								●	●	●		●			
Milvus migrans	Black Kite								●		●					
AEGOTHELIDAE																
Aegotheles cristatus	Australian Owlet-nightjar								●	●			●	●	●	
ALCEDINIDAE																
Todiramphus pyrrhopygius	Red-backed Kingfisher								●	●			●			●
Todiramphus sanctus	Sacred Kingfisher	MA							●						●	
ANATIDAE																
Anas castanea	Chestnut Teal								●							
Anas gracilis	Grey Teal					●			●						●	
Anas rhynchotis	Australasian Shoveler								●							
Anas superciliosa	Pacific Black Duck								●							
Aythya australis	Hardhead								●							
Biziura lobata	Musk Duck								●							
Chenonetta jubata	Australian Wood Duck								●							
Cygnus atratus	Black Swan					●			●							
Malacorhynchus membranaceus	Pink-eared Duck								●							
Oxyura australis	Blue-billed Duck			P4	NT			●	●							
Stictonetta naevosa	Freckled Duck								●							
Tadorna tadornoides	Australian Shelduck								●	●						

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		EPBC	WCA	DEC	IUCN											
ANHINGIDAE																
Anhinga novaehollandiae	Australiasian Darter								●							
APODIDAE																
Apus pacificus	Fork-tailed Swift	MG	S5				Likely	●								
ARDEIDAE																
Ardea modesta	Eastern Great Egret								●							
Ardea novaehollandiae	White-faced Heron								●				●			
Ardea pacifica	White-necked Heron								●				●		●	
ARTAMIDAE																
Artamus cinereus	Black-faced Woodswallow					●			●	●	●	●	●	●	●	●
Artamus cyanopterus	Dusky Woodswallow								●							
Artamus minor	Little Woodswallow								●					●		
Artamus personatus	Masked Woodswallow								●	●	●		●	●		
BURHINIDAE																
Burhinus grallarius	Bush Stone-curlew								●	●				●	●	
CACATUIDAE																
Cacatua leadbeateri	Major Mitchell's Cockatoo												●			
Cacatua roseicapilla	Galah								●	●	●		●	●	●	●
Cacatua sanguinea	Little Corella								●		●				●	
Nymphicus hollandicus	Cockatiel								●	●			●	●		●
CAMPEPHAGIDAE																

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		EPBC	WCA	DEC	IUCN											
Coracina maxima	Ground Cuckoo-shrike								●	●			●	●	●	
Coracina novaehollandiae	Black-faced Cuckoo-shrike	MA				●			●	●	●	●	●	●	●	●
Lalage tricolor	White-winged Triller								●	●			●	●	●	●
CAPRIMULGIDAE																
Eurostopodus argus	Spotted Nightjar	MA							●	●			●	●	●	
CHARADRIIDAE																
Charadrius melanops	Black-fronted Dotterel								●		●					
Charadrius ruficapillus	Red-capped Plover	MA							●							
Charadrius veredus	Oriental Plover	MA/MG	S5				May									
Erythrogonys cinctus	Red-kneed Dotterel					●			●							
Peltohyas australis	Inland Dotterel					●			●							
Thinornis rubricollis	Hooded Plover	MA	P4		VU				●							
Vanellus tricolor	Banded Lapwing								●	●						
CLIMACTERIDAE																
Climacteris affinis	White-browed Treecreeper								●				●			
COLUMBIDAE																
Columba livia	*Domestic Pigeon								●							
Geopelia cuneata	Diamond Dove								●					●		●
Geopelia striata	Peaceful Dove								●							
Geophaps plumifera	Spinifex Pigeon								●							
Ocyphaps lophotes	Crested Pigeon					●			●	●	●	●	●	●	●	●

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		EPBC	WCA	DEC	IUCN											
Phaps chalcoptera	Common Bronzewing								●	●		●	●	●	●	●
Streptopelia senegalensis	*Laughing Turtle-Dove								●							
CORVIDAE																
Corvus bennetti	Little Crow								●	●	●	●	●	●		●
Corvus coronoides	Australian Raven								●				●			
Corvus orru	Torresian Crow								●	●	●		●	●	●	
CRACTICIDAE																
Cracticus nigrogularis	Pied Butcherbird								●	●	●	●	●	●		●
Cracticus tibicen	Australian Magpie					●			●	●	●		●	●	●	●
Cracticus torquatus	Grey Butcherbird								●	●	●	●	●	●	●	
Strepera versicolor	Grey Currawong									●			●		●	
CUCULIDAE																
Cacomantis pallidus	Pallid Cuckoo	MA				●			●	●			●	●		
Chrysococcyx basalis	Horsfield's Bronze Cuckoo	MA							●	●	●		●	●		
Chrysococcyx osculans	Black-eared Cuckoo	MA							●					●	●	
DICAEIDAE																
Dicaeum hirundinaceum	Mistletoebird								●	●			●	●	●	
DROMAIIDAE																
Dromaius novaehollandiae	Emu								●	●	●		●	●		
ESTRILDIDAE																
Taeniopygia guttata	Zebra Finch					●			●	●	●		●	●	●	●

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		EPBC	WCA	DEC	IUCN											
FALCONIDAE																
Falco berigora	Brown Falcon								●	●	●		●	●	●	●
Falco cenchroides	Australian Kestrel	MA							●	●	●		●	●		●
Falco hypoleucos	Grey Falcon		S3		VU			●	●							
Falco longipennis	Australian Hobby								●	●	●		●	●		●
Falco peregrinus	Peregrine Falcon		S7					●	●	●				●	●	
Falco subniger	Black Falcon								●							
GLAREOLIDAE																
Glareola maldivarum	Oriental Pratincole	MG/MA	S5					●								
HIRUNDINIDAE																
Cheramoeca leucosternus	White-backed Swallow								●	●		●	●	●		
Hirundo neoxena	Welcome Swallow	MA							●	●	●			●	●	
Petrochelidon ariel	Fairy Martin								●	●			●	●		
Petrochelidon nigricans	Tree Martin								●	●		●			●	
LARIDAE																
Larus novaehollandiae	Silver Gull	MA				●			●							
Hydroprogne caspia	Caspian Tern	MG	S5						●							
Sterna hybrida	Whiskered Tern					●			●							
Chlidonias leucopterus	White-winged Black Tern	MG	S5					●	●							
Gelochelidon nilotica	Gull-billed Tern	MG	S5						●							
LOCUSTELLIDAE																

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		EPBC	WCA	DEC	IUCN											
Megalurus cruralis	Brown Songlark								●				●			
Megalurus mathewsi	Rufous Songlark								●					●		
MALURIDAE																
Amytornis striatus striatus	Striated Grasswren			P4				●								
Amytornis textilis textilis	Thick-billed Grass-wren (western ssp.)			P4				●								
Malurus lamberti	Variegated Fairy-wren								●	●	●		●	●	●	●
Malurus leucopterus	White-winged Fairy-wren								●	●			●	●		
Malurus splendens	Splendid Fairy-wren								●	●		●	●	●	●	
MEGAPODIIDAE																
Leipoa ocellata	Malleefowl	VU	S3		VU	●	Likely	●		●						
Acanthagenys rufogularis	Spiny-cheeked Honeyeater								●	●	●	●	●	●	●	●
Certhionyx variegatus	Pied Honeyeater								●				●			
Epthianura albifrons	White-fronted Chat								●							
Epthianura aurifrons	Orange Chat								●					●		
Epthianura tricolor	Crimson Chat					●			●	●			●	●		
Gavicalis virescens	Singing Honeyeater								●	●	●	●	●	●	●	●
Lacustroica whitei	Grey Honeyeater								●					●		
Lichmera indistincta	Brown Honeyeater								●	●	●					
Manorina flavigula	Yellow-throated Miner					●			●	●	●	●	●	●	●	●
Ptilotula keartlandi	Grey-headed Honeyeater								●							
Ptilotula penicillatus	White-plumed Honeyeater								●	●	●			●	●	●

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		EPBC	WCA	DEC	IUCN											
Ptilotula plumulus	Grey-fronted Honeyeater								•				•			
Purnella albifrons	White-fronted Honeyeater								•	•			•			
Sugomel niger	Black Honeyeater								•							
MEROPIDAE																
Merops ornatus	Rainbow Bee-eater								•	•			•		•	
MONARCHIDAE																
Grallina cyanoleuca	Magpie-lark	MA							•	•	•	•	•	•	•	•
MOTACILLIDAE																
Anthus australis	Australian Pipit								•	•	•		•	•		•
Motacilla cinerea	Grey Wagtail	MG	S5				May									
Motacilla flava	Yellow Wagtail	MG	S5				May									
NEOSITTIDAE																
Daphoenositta chrysoptera	Varied Sittella								•	•			•			
OTIDIDAE																
Ardeotis australis	Australian Bustard								•	•	•		•			
OREOICIDAE																
Oreoica gutturalis	Crested Bellbird					•			•	•		•	•	•	•	•
PACHYCEPHALIDAE																
Colluricincla harmonica	Grey Shrike-thrush								•	•		•	•	•	•	•
Pachycephala rufiventris	Rufous Whistler								•	•		•	•	•	•	•
PARDALOTIDAE																

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		EPBC	WCA	DEC	IUCN											
Pardalotus rubricatus	Red-browed Pardalote								●							
Pardalotus striatus	Striated Pardalote								●	●			●	●	●	
PELECANIDAE																
Pelecanus conspicillatus	Australian Pelican	MA							●							
PETROICIDAE																
Melanodryas cucullata	Hooded Robin								●	●			●	●		●
Microeca fascinans	Jacky Winter								●	●			●			
Petroica goodenovii	Red-capped Robin								●	●			●	●	●	●
PHAETHONTIDAE																
Phalacrocorax carbo	Great Cormorant								●							
Phalacrocorax melanoleucos	Little Pied Cormorant								●							
Phalacrocorax sulcirostris	Little Black Cormorant								●							
PHASIANIDAE																
Coturnix pectoralis	Stubble Quail	MA							●							
Coturnix ypsilophora	Brown Quail								●							
PODARGIDAE																
Podargus strigoides	Tawny Frogmouth					●			●	●			●	●	●	●
PODICIPEDIDAE																
Podiceps cristatus	Great Crested Grebe								●							
Poliocephalus poliocephalus	Hoary-headed Grebe					●			●							
Tachybaptus novaehollandiae	Australasian Grebe								●							

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		EPBC	WCA	DEC	IUCN											
POMATOSTOMIDAE																
Pomatostomus superciliosus	White-browed Babbler								●	●	●	●	●	●		
Pomatostomus temporalis	Grey-crowned Babbler					●			●	●				●	●	●
PSITTACIDAE																
Melopsittacus undulatus	Budgerigar					●			●	●			●	●		●
Neophema bourkii	Bourke's Parrot					●			●				●	●		●
Neophema elegans	Elegant Parrot								●	●				●		
Pezoporus occidentalis	Night Parrot	EN	S1		EN		May									
Platycercus varius	Mulga Parrot								●	●	●		●	●	●	●
Platycercus zonarius	Australian Ringneck					●			●	●	●	●	●	●	●	●
Polytelis alexandrae	Princess Parrot	VU		P4	NT		May									
PSOPHODIDAE																
Cinclosoma marginatum	Western Quail-thrush														●	
Psophodes occidentalis	Western Wedgebill								●		●		●			
Cinclosoma castaneothorax	Chestnut-breasted Quail-thrush								●	●				●		●
PTILINORHYNCHIDAE																
Ptilonorhynchus maculatus guttatus	Western Bowerbird								●	●			●	●		●
RALLIDAE																
Fulica atra	Eurasian Coot								●							
Porzana fluminea	Australian Spotted Crake								●							
Tribonyx ventralis	Black-tailed Native-hen								●						●	

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		EPBC	WCA	DEC	IUCN											
RECURVIROSTRIDAE																
Cladorhynchus leucocephalus	Banded Stilt					●			●							
Himantopus himantopus	Black-winged Stilt	MA				●			●							
Recurvirostra novaehollandiae	Red-necked Avocet	MA				●			●							
RHIPIDURIDAE																
Rhipidura albiscapa	Grey Fantail								●	●				●		
Rhipidura leucophrys	Willie Wagtail								●	●	●	●	●	●	●	●
SCOLOPACIDAE																
Calidris acuminata	Sharp-tailed Sandpiper	MG	S5				May	●	●							
Calidris ferruginea	Curlew Sandpiper	CR/MG	S3/5		NT		Likely	●	●							
Calidris melanotos	Pectoral Sandpiper	MG	S5				May		●							
Calidris ruficollis	Red-necked Stint	MG	S5		NT			●	●							
Tringa glareola	Wood Sandpaper	MG	S5					●	●							
Tringa hypoleucos	Common Sandpiper	MG	S5				May		●							
Tringa nebularia	Common Greenshank	MG	S5				May	●	●							
Tringa stagnatilis	Marsh Sandpiper	MG	S5					●	●							
STRIGIDAE																
Ninox boobook	Boobook Owl								●	●			●	●	●	
Ninox connivens	Barking Owl								●							
THRESKIORNITHIDAE																
Platalea flavipes	Yellow-billed Spoonbill								●					●		

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		EPBC	WCA	DEC	IUCN											
Platalea regia	Royal Spoonbill								•							
Plegadis falcinellus	Glossy Ibis	MG	S5					•	•							
Threskiornis molucca	Australian White Ibis	MA							•							
Threskiornis spinicollis	Straw-necked Ibis	MA							•							
TURNICIDAE																
Turnix velox	Little Button-quail								•					•		
TYTONIDAE																
Tyto alba	Barn Owl								•							
ZOSTEROPIDAE																
Zosterops lateralis	Silvereye	MA							•							

Reptiles

Genus and Species	Common Name	Conservation Status				NatureMap	Protected Matters	DBCA Threatened Fauna	Bamford Consulting Ecologists (2011)	Outback Ecology (2009)	Western Wildlife (2007)	Dell & How (1992)	Ecologia (2009)	Bamford Consulting Ecologists (2017)	Current Survey
		EPBC	WCA	DEC	IUCN										
AGAMIDAE															
Ctenophorus caudicinctus	Ring-tailed Dragon					•			•				•	•	•
Ctenophorus isolepis	Military Dragon								•						
Ctenophorus nuchalis	Central Netted Dragon					•			•			•	•	•	
Ctenophorus reticulatus	Western Netted Dragon					•						•	•	•	•
Ctenophorus salinarum	Salt Pan Dragon					•						•			
Ctenophorus scutulatus									•			•	•	•	
Diporiphora amphiboluroides												•	•		
Gowidon longirostris	Long-nosed Dragon												•	•	
Moloch horridus	Thorny Devil								•			•	•		
Pogona minor									•			•	•	•	
Tympanocryptis cephalus	Coastal Pebble-mimic dragons				DD							•	•		
CARPHODACTYLIDAE															
Nephrurus vertebralis									•			•	•		
Nephrurus wheeleri												•		•	
CHELUIDAE															

Genus and Species	Common Name	Conservation Status				NatureMap	Protected Matters	DBCA Threatened Fauna	Bamford Consulting Ecologists (2011)	Outback Ecology (2009)	Western Wildlife (2007)	Dell & How (1992)	Ecologia (2009)	Bamford Consulting Ecologists (2017)	Current Survey
		EPBC	WCA	DEC	IUCN										
Chelodina steindachneri	Flat-shelled Turtle												•		
DIPLODACTYLIDAE															
Diplodactylus conspicillatus	Variable Fat-tailed Gecko								•						
Diplodactylus granariensis									•			•			
Diplodactylus pulcher									•			•	•	•	
Lucasium squarrosum												•	•		
Oedura fimbria	Western Marbled Velvet Gecko												•		
Rhynchoedura ornata	Western Beaked Gecko								•			•		•	
Strophurus assimilis	Goldfields Spiny-tailed Gecko											•			
Strophurus elderi									•			•			
Strophurus strophurus									•			•			
Strophurus wellingtonae						•			•				•	•	
ELAPIDAE															
Brachyurophis approximans													•		
Brachyurophis semifasciatus												•			
Demansia psammophis	Yellow-faced Whipsnake													•	
Furina ornata	Moon Snake												•		

Genus and Species	Common Name	Conservation Status				NatureMap	Protected Matters	DBCA Threatened Fauna	Bamford Consulting Ecologists (2011)	Outback Ecology (2009)	Western Wildlife (2007)	Dell & How (1992)	Ecologia (2009)	Bamford Consulting Ecologists (2017)	Current Survey
		EPBC	WCA	DEC	IUCN										
Parasuta monachus													•		
Pseudechis butleri	Spotted Mulga Snake												•		
Pseudonaja modesta	Ringed Brown Snake								•				•		
Pseudonaja nuchalis	Gwardar; Northern Brown Snake				DD				•						
Simoselaps bertholdi	Jan's Banded Snake					•			•			•	•	•	
Suta fasciata	Rosen's Snake												•		
GEKKONIDAE															
Gehyra punctata													•		
Gehyra variegata						•			•	•		•	•	•	•
Heteronotia binoei	Bynoe's Gecko					•			•	•		•	•	•	•
PYGOPODIDAE															
Delma australis													•		
Delma butleri									•			•			
Delma nasuta									•						
Lialis burtonis									•			•		•	
Pygopus nigriceps									•			•	•	•	
SCINCIDAE															

Genus and Species	Common Name	Conservation Status				NatureMap	Protected Matters	DBCA Threatened Fauna	Bamford Consulting Ecologists (2011)	Outback Ecology (2009)	Western Wildlife (2007)	Dell & How (1992)	Ecologia (2009)	Bamford Consulting Ecologists (2017)	Current Survey
		EPBC	WCA	DEC	IUCN										
Cryptoblepharus buchananii									●					●	
Cryptoblepharus plagiocephalus									●	●		●	●		
Ctenotus ariadnae									●						
Ctenotus atlas												●			
Ctenotus grandis									●						
Ctenotus hanloni									●						
Ctenotus helenae									●			●			
Ctenotus leonhardii						●			●			●	●	●	
Ctenotus pantherinus	Leopard Ctenotus								●						
Ctenotus schomburgkii									●			●	●	●	
Ctenotus severus													●		
Ctenotus uber													●	●	
Egernia depressa	Southern Pygmy Spiny-tailed Skink					●			●			●	●	●	
Eremiascincus richardsonii	Broad-banded Sand Swimmer					●			●			●	●	●	
Lerista bipes						●									
Lerista desertorum									●	●				●	
Lerista eupoda				P1		●		●					●		

Genus and Species	Common Name	Conservation Status				NatureMap	Protected Matters	DBCA Threatened Fauna	Bamford Consulting Ecologists (2011)	Outback Ecology (2009)	Western Wildlife (2007)	Dell & How (1992)	Ecologia (2009)	Bamford Consulting Ecologists (2017)	Current Survey
		EPBC	WCA	DEC	IUCN										
Lerista gerrardii												•			
Lerista nichollsi													•		
Lerista timida						•			•	•		•		•	•
Liopholis inornata									•	•		•			
Liopholis striata	Night Skink								•						
Menetia greyii						•			•	•		•	•	•	•
Morethia butleri									•			•			
Tiliqua multifasciata	Central Blue-tongue								•						
Tiliqua occipitalis	Western Bluetongue								•			•			
TYPHLOPIDAE															
Anilios bicolor									•						
Anilios bituberculatus												•			
Anilios hamatus									•			•	•	?	
Anilios waitii														•	
VARANIDAE															
Varanus caudolineatus						•			•			•	•	•	
Varanus eremius	Pygmy Desert Monitor								•						

Genus and Species	Common Name	Conservation Status				NatureMap	Protected Matters	DBCA Threatened Fauna	Bamford Consulting Ecologists (2011)	Outback Ecology (2009)	Western Wildlife (2007)	Dell & How (1992)	Ecologia (2009)	Bamford Consulting Ecologists (2017)	Current Survey
		EPBC	WCA	DEC	IUCN										
Varanus giganteus	Perentie								•				•		
Varanus gouldii	Sand Monitor								•	•		•			
Varanus panoptes	Yellow-spotted Monitor					•			•			•	•	•	
Varanus tristis	Racehorse Monitor											•	•	•	

Amphibians

Genus and Species	Common Name	Conservation Status				NatureMap	Protected Matters	DBCA Threatened Fauna	Bamford Consulting Ecologists (2011)	Outback Ecology (2009)	Western Wildlife (2007)	Dell & How (1992)	Ecologia (2009)	Bamford Consulting Ecologists (2017)	Current Survey
		EPBC	WCA	DBCA	IUCN										
HYLIDAE															
Cyclorana maini	Sheep Frog					●			●					●	
Cyclorana occidentalis	Western Water-holding Frog					●			●					●	
Litoria rubella	Little Red Tree Frog								●				●	●	
LIMNODYNASTIDAE															
Neobatrachus sudellae	Desert Trilling Frog											●		●	
Neobatrachus sutor	Shoemaker Frog											●			
Neobatrachus wilsmorei	Plonking Frog											●			
Platyplectrum spenceri	Centralian Burrowing Frog													●	
MYOBATRACHIDAE															
Pseudophryne occidentalis	Western Toadlet								●						

Appendix C: SRE Database Search Records

														GDA94 MGA Zone 50							
Phylum	Subphylum	Class	Order	Suborder	Infraorder	Superfamily	Family	Subfamily	Tribe	Genus	Subgenus	Species	Reliability	Easting	Northing	Collection Method	Male	Female	Juvenile	Specimen	Sampling Year
Arthropoda	Chelicerata	Arachnida	Araneae	Opisthothelae	Mygalomorphae		Actinopodidae			Missulena			3	701251	6980549	by hand	0	0	0	1	1932
Arthropoda	Chelicerata	Arachnida	Araneae	Opisthothelae	Mygalomorphae		Actinopodidae			Missulena			3	649378	7058842	by hand	0	0	0	1	1936
Arthropoda	Chelicerata	Arachnida	Araneae	Opisthothelae	Mygalomorphae		Actinopodidae			Missulena			3	701251	6980549	by hand	0	0	0	1	1932
Arthropoda	Chelicerata	Arachnida	Pseudoscorpiones	Iocheirata	Panctenata	Cheliferoidea	Chernetidae	Goniochernetinae		Conicochernes		`PSE024`	2	626031	7023023	hand collecting	0	0	0	9	2004
Arthropoda	Chelicerata	Arachnida	Pseudoscorpiones	Iocheirata	Panctenata	Cheliferoidea	Chernetidae	Chernetinae		Haplochernes			2	632427	7025793		1	4	1	6	1982
Arthropoda	Chelicerata	Arachnida	Pseudoscorpiones	Iocheirata	Panctenata	Cheliferoidea	Chernetidae	Chernetinae		Haplochernes			2	632427	7025793		1	1	0	2	1982
Arthropoda	Chelicerata	Arachnida	Pseudoscorpiones	Iocheirata	Panctenata	Garypoidea	Garypidae			Synsphyronus			2	626031	7023023		0	0	0	1	2004
Arthropoda	Chelicerata	Arachnida	Araneae	Opisthothelae	Mygalomorphae		Idiopidae	Arbanitinae	Aganippini	Gaius		villosus	1	672615	7058548	by hand	1	0	0	1	1938
Arthropoda	Chelicerata	Arachnida	Araneae	Opisthothelae	Mygalomorphae		Idiopidae	Arbanitinae	Aganippini	Idiosoma	`Aganippe`	occidentalis	1	649356	7056992	by hand	1	0	0	1	1985
Arthropoda	Chelicerata	Arachnida	Araneae	Opisthothelae	Mygalomorphae		Nemesiidae	Anaminae		Aname		mainae	1	661966	7005138	by hand	0	1	0	1	1978
Arthropoda	Chelicerata	Arachnida	Pseudoscorpiones	Iocheirata	Panctenata	Garypoidea	Olpiidae	Olpiinae		Austrohorus		`sp. indet. (female)`	2	618673	6993837	wet pitfall trap	0	1	0	1	2011/ 2012
Arthropoda	Chelicerata	Arachnida	Scorpiones			Scorpionoidea	Urodacidae			Urodacus		armatus	0	649378	7058842	by hand	1	0	0	1	1936
Arthropoda	Chelicerata	Arachnida	Scorpiones			Scorpionoidea	Urodacidae			Urodacus		armatus	0	649378	7058842	by hand	0	1	0	1	1936
Arthropoda	Chelicerata	Arachnida	Scorpiones			Scorpionoidea	Urodacidae			Urodacus		armatus	3	634086	7025776	by hand	1	0	0	1	1925
Arthropoda	Chelicerata	Arachnida	Scorpiones			Scorpionoidea	Urodacidae			Urodacus		armatus	3	634086	7025776	by hand	1	0	0	1	1925
Arthropoda	Chelicerata	Arachnida	Scorpiones			Scorpionoidea	Urodacidae			Urodacus		hoplurus	1	649378	7058842	by hand	0	0	0	1	1929
Arthropoda	Chelicerata	Arachnida	Scorpiones			Scorpionoidea	Urodacidae			Urodacus		hoplurus	1	649378	7058842	by hand	1	0	0	1	1968
Arthropoda	Chelicerata	Arachnida	Scorpiones			Scorpionoidea	Urodacidae			Urodacus		hoplurus	1	649378	7058842	by hand	1	0	0	1	1968
Arthropoda	Chelicerata	Arachnida	Scorpiones			Scorpionoidea	Urodacidae			Urodacus		hoplurus	1	649378	7058842	by hand	1	0	0	1	1968
Arthropoda	Chelicerata	Arachnida	Scorpiones			Scorpionoidea	Urodacidae			Urodacus		hoplurus	1	649378	7058842	by hand	1	0	0	1	1968
Arthropoda	Chelicerata	Arachnida	Scorpiones			Scorpionoidea	Urodacidae			Urodacus		hoplurus	1	649378	7058842	by hand	1	0	0	1	1968
Arthropoda	Chelicerata	Arachnida	Scorpiones			Scorpionoidea	Urodacidae			Urodacus		hoplurus	1	649378	7058842	by hand	0	1	0	1	1929
Arthropoda	Chelicerata	Arachnida	Scorpiones			Scorpionoidea	Urodacidae			Urodacus		hoplurus	1	634086	7025776	by hand	0	0	0	1	1925
Arthropoda	Chelicerata	Arachnida	Scorpiones			Scorpionoidea	Urodacidae			Urodacus		hoplurus	1	634086	7025776	by hand	0	1	0	1	1925
Arthropoda	Chelicerata	Arachnida	Scorpiones			Scorpionoidea	Urodacidae			Urodacus		hoplurus	1	649378	7058842	by hand	0	0	0	1	1929
Arthropoda	Chelicerata	Arachnida	Scorpiones			Scorpionoidea	Urodacidae			Urodacus			1	633229	7025563	by hand	0	0	0	1	1937
Arthropoda	Chelicerata	Arachnida	Scorpiones			Scorpionoidea	Urodacidae			Urodacus			3	649378	7058842	by hand	0	0	0	1	2015

Appendix D: Fauna Recorded During the Current Survey

Species	Scientific Name	Current Conservation Status	
		EPBC Act	WC Act
Mammals			
White-striped Free-tailed Bat	*Austronomus australis*		
Cow	**Bos taurus*		
Wild Dog	**Canis lupis*		
Goat (old scat record)	**Capra hircus*		
Gould's Wattled Bat	*Chalinolobus gouldii*		
Lesser Long-eared Bat	*Nyctophilus geoffroyi*		
Rabbit	**Oryctolagus cuniculus*		
Euro	*Osphranter robustus*		
Red Kangaroo	*Osphranter rufus*		
Woolley's Pseudantechinus	*Pseudantechinus woolleyae*		
Inland Broad-nosed Bat	*Scotorepens balstoni*		
Likely only - Stripe-faced Dunnart	*Sminthopsis macroura*		
Short-beaked Echidna	*Tachyglossus aculeatus*		
Finlayson's Cave-bat	*Vespadelus finlaysoni*		
Birds			
Spiny-cheeked Honeyeater	*Acanthagenys rufogularis*		
Inland Thornbill	*Acanthiza apicalis*		
Yellow-rumped Thornbill	*Acanthiza chrysorrhoa*		
Chestnut-rumped Thornbill	*Acanthiza uropygialis*		
Brown Goshawk	*Accipiter fasciatus*		
Australian Owlet-nightjar	*Aegotheles cristatus*		
Australian Pipit	*Anthus novaeseelandiae*		
Wedge-tailed Eagle	*Aquila audax*		
Black-faced Woodswallow	*Artamus cinereus*		
Masked Woodswallow	*Artamus personatus*		
Australian Ringneck	*Barnardius zonarius*		
Western Bowerbird	*Chlamydera guttata*		
Western Chestnut Quail-thrush	*Cinclosoma clarum*		
Grey Shrike-thrush	*Colluricincla harmonica*		
Black-faced Cuckoo-shrike	*Coracina novaehollandiae*		
Little Crow	*Corvus bennetti*		
Pied Butcherbird	*Cracticus nigrogularis*		
Australian Magpie	*Cracticus tibicen*		
Varied Sittella	*Daphoenositta chrysoptera*		
Galah	*Eolophus roseicapilla*		

Species	Scientific Name	Current Conservation Status	
		EPBC Act	WC Act
Brown Falcon	*Falco berigora*		
Nankeen Kestrel	*Falco cenchroides*		
Australian Hobby	*Falco longipennis*		
Singing Honeyeater	*Gavicalis virescens*		
Diamond Dove	*Geopelia cuneata*		
Western Gerygone	*Gerygone fusca*		
Magpie-lark	*Grallina cyanoleuca*		
White-winged Triller	*Lalage tricolor*		
Variegated Fairy-wren	*Malurus lamberti*		
Yellow-throated Miner	*Manorina flavigula*		
Hooded Robin	*Melanodryas cucullata*		
Budgerigar	*Melopsittacus undulatus*		
Bourke's Parrot	*Neopsephotus bourkii*		
Cockatiel	*Nymphicus hollandicus*		
Crested Pigeon	*Ocyphaps lophotes*		
Crested Bellbird	*Oreoica gutturalis*		
Rufous Whistler	*Pachycephala rufiventris*		
Red-capped Robin	*Petroica goodenovii*		
Common Bronzewing	*Phaps chalcoptera*		
Tawny Frogmouth	*Podargus strigoides*		
Grey-crowned Babbler	*Pomatostomus temporalis*		
Mulga Parrot	*Psephotellus varius*		
White-plumed Honeyeater	*Ptilotula penicillata*		
Willie Wagtail	*Rhipidura leucophrys*		
Zebra Finch	*Taeniopygia guttata*		
Red-backed Kingfisher	*Todiramphus pyrrhopygius*		
Reptiles			
Pygmy Python	*Antaresia perthensis*		
Western Ring-tailed Dragon	*Ctenophorus caudicinctus*		
Western Netted Dragon	*Ctenophorus reticulatus*		
A Gecko	*Gehyra variegata*		
Bynoe's Gecko	*Heteronotia bynoei*		
A Skink	*Lerista timida*		
A Skink	*Menetia greyii*		
Jan's Banded Snake	*Simoselaps bertholdi*		
Western Shield Spiny-tailed Gecko	*Strophurus wellingtonae*		

Species	Scientific Name	Current Conservation Status	
		EPBC Act	WC Act
Amphibians			
Desert Tree Frog	*Litoria rubella*		

Appendix E: Fauna Habitat Assessments

Site ID	GDA94 MGA Zone 50		Start Date	End Date	Habitat Type	Landform	Aspect	Slope	Soil Type	Soil Availability	Outcrop Amount	Outcrop Type	Rock Size	Veg. Litter	Wood. Debris	Dominant Veg.	Rocky Cracks/ Crevices	Burrowing Suitability	hollows < 10cm	hollows > 10cm	Water Presence	Habitat Condition	Disturbances	Last Fire
	Easting	Northing																						
Gab 01	669023	7009875	5/08/2018	5/12/2018	Ironstone Outcrops	Ironstone Outcrops	South/ West	Moderate	Loamy Sand	Scarce	Major Outcropping	Magnetite										Very Good		
Gab 02	668906	7009988	5/08/2018	5/12/2018	Ironstone Outcrops	Ironstone Outcrops	South/ West	Moderate	Loamy Sand	Scarce	Moderate Outcropping	Magnetite										Very Good	Rabbits, Cattle Grazing, Mining Exploration	Old (6+ yr)
Gab 03	669447	7009648	5/08/2018	5/12/2018	Ironstone Outcrops	Ironstone Outcrops	North/ West	Moderate	Loamy Sand	Scarce	Moderate Outcropping	Magnetite										Very Good	Rabbits	Old (6+ yr)
Gab 04	669525	7009536	5/08/2018	5/12/2018	Ironstone Outcrops	Ironstone Outcrops	North/ West	Moderate	Loamy Sand	Scarce	Moderate Outcropping	Magnetite										Very Good	Rabbits, Mining Exploration	Old (6+ yr)
Gab 05	669188	7010316	5/08/2018	5/12/2018	Stony Plain	Stony Plain	Flat	Flat	Sandy Clay Loam	Evenly Spread	Negligible					Tecticornia						Very Good	Cattle Grazing, Mining Exploration, Road/ Access Track	Old (6+ yr)
Gab 06	661844	7019499	5/08/2018	5/12/2018	Ironstone Outcrops	Ironstone Outcrops	West	Moderate	Loamy Sand	Few Small Patches	Major Outcropping	Magnetite				Acacia Shrubland,Mulga Woodland	High	Low	Scarce	None	None	Very Good	Mining Exploration, Road/ Access Track	Old (6+ yr)
Gab 07	661854	7019499	5/08/2018	5/12/2018	Ironstone Outcrops	Ironstone Outcrops	North/ East	Moderate	Loamy Sand	None Discernible	Major Outcropping	Magnetite	Boulders (>61cm)	Few Small Patches	Few Large Patches	Acacia Shrubland,Mulga Woodland	Very High	Low	Scarce	None	None	Very Good	Mining Exploration, Road/ Access Track	Old (6+ yr)
Gab 08	661950	7019276	5/08/2018	5/12/2018	Ironstone Outcrops	Ironstone Outcrops	East	Moderate	Loamy Sand	Scarce	Major Outcropping	Magnetite				Mulga Woodland						Very Good	Mining Exploration, Road/ Access Track	Old (6+ yr)
Gab 09	661949	7019166	5/08/2018	5/12/2018	Ironstone Outcrops	Ironstone Outcrops	South/ West	Moderate	Loamy Sand	Scarce	Moderate Outcropping	Magnetite				Mulga Woodland						Very Good	Mining Exploration, Road/ Access Track	Old (6+ yr)
Gab 10	662014	7018832	5/08/2018	5/12/2018	Breakaway/ Cliff	Breakaway	North	Low	Sandy Loam	Few Small Patches	Minor Outcropping	Granite				Acacia Shrubland						Very Good	Mining Exploration, Road/ Access Track	Old (6+ yr)

Site ID	GDA94 MGA Zone 50		Start Date	End Date	Habitat Type	Landform	Aspect	Slope	Soil Type	Soil Availability	Outcrop Amount	Outcrop Type	Rock Size	Veg. Litter	Wood. Debris	Dominant Veg.	Rocky Cracks/ Crevices	Burrowing Suitability	hollows < 10cm	hollows > 10cm	Water Presence	Habitat Condition	Disturbances	Last Fire
	Easting	Northing																						
Gab 11	662239	7017832	5/08/2018	5/12/2018	Stony Plain	Stony Plain	South	Low	Loamy Sand	Evenly Spread	Negligible					Mulga Woodland	Nil	Moderate	None	None	None	Good	Mining Exploration, Road/ Access Track	Old (6+ yr)
Gab 12	662069	7020050	5/08/2018	5/12/2018	Waterhole	Claypan	Flat	Flat	Clayey Sand	Evenly Spread	Negligible					Acacia Shrubland	Nil	Moderate	None	None	Prone to Pooling	Degraded	Cattle Grazing, Road/ Access Track	Old (6+ yr)
Gab 13	660519	7021511	5/08/2018	5/12/2018	Artificial Wetlands		Flat	Flat	Clayey Sand	Evenly Spread	Negligible					Acacia Shrubland						Degraded	Cattle Grazing, Dam	Old (6+ yr)
Gab 14	661211	7022832	5/08/2018	5/12/2018	Stony Plain	Stony Plain	South/ West	Low	Clay Loam	Few Large Patches	Negligible					Mulga Woodland						Very Good	Road/ Access Track, Historic Clearing	Old (6+ yr)
Gab 15	663881	7017368	5/08/2018	5/12/2018	Artificial Wetlands	windmill and dam	Flat	Flat	Sandy Clay Loam	Evenly Spread	Negligible					Mulga Woodland	Nil	Low	Scarce	None	Permanent	Good	Cattle Grazing, Windmill and Dam	Old (6+ yr)

APPENDIX B-7: Biologic Environmental Survey – Subterranean Fauna Preliminary Report (Phase 1)

Gabanintha Vanadium Project

Subterranean Fauna Survey

Preliminary Report (Phase 1)

Technology Metals Australia Pty Ltd

19 November 2018

Gabanintha Vanadium Project

Subterranean Fauna Survey (Phase 1)

DOCUMENT STATUS				
Version No.	Author	Review / Approved for Issue	Approved for Issue to	
			Name	Date
1	S. Callan	B. Durrant	B. Bastow (Integrate Sustainability)	17/10/2018
2	S. Callan	B. Durrant	B. Bastow	19/11/2018
Final				

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In preparing this report we have made certain assumptions. We have assumed that all information and documents provided to us by the Client or as a result of a specific request or enquiry were complete, accurate and up-to-date. Where we have obtained information from a government register or database, we have assumed that the information is accurate. Where an assumption has been made, we have not made any independent investigations with respect to the matters the subject of that assumption. We are not aware of any reason why any of the assumptions are incorrect.

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EXECUTIVE SUMMARY

Technology Metals Australia Pty Ltd (TMAL) commissioned Biologic Environmental Survey (Biologic) to undertake a baseline two-season subterranean fauna survey for the Gabanintha Vanadium Project (the Project) within two pending mining tenements (M 51/883, M 51/884), collectively referred to as the Study Area. The Study Area covers approximately 13,241 hectares (ha) and is located approximately 40 kilometres (km) south-east of Meekatharra in the Murchison region of Western Australia. The subterranean fauna survey will be used to inform future environmental approvals for the Project.

This report comprises a desktop assessment, methods and preliminary results for the first phase of subterranean fauna sampling at the Study Area (June to August 2018). At the time of writing, taxonomic identifications and regional comparisons required to assess wider distributions of specimens collected from the Study Area were unavailable.

A desktop assessment found that the Study Area occurs within a well-studied region (Murchison/ Yilgarn) that is known for very high subterranean fauna diversity, and endemicity associated with karstic calcrete deposits in palaeodrainage channels and isolated greenstone ranges. The southern M51/884 tenement occurs within the buffer area for the Nowthanna calcrete groundwater assemblage, which is recognised by DBCA as a Priority 1 Priority Ecological Community (PEC). A published regional desktop assessment, and recent unpublished sampling by Biologic undertaken within the local area has indicated that a diverse range of stygofauna and troglofauna species are known to be present in nearby calcrete deposits and greenstone ridges; including dytiscid diving beetles, copepods, ostracods, isopods, syncarids, chilopods, pauropods, Symphyla, and Zygentoma.

Habitat assessment of drill cores throughout the northern M51/883 tenement revealed indications of prospective subterranean habitats within coarse, unconsolidated gravel layers, well-developed, water-stained fractures, core loss and observed cavities, and evidence of vugs/ secondary weathering. Mapping of local geology and regolith revealed that these habitats are likely to be associated with the main magnetite ridge, including greenstone sub-crop and outcrop, ferruginous duricrust, laterite and sub-crop, magnetite rubble/ outcrop, and magnetite colluvium/ sheet wash.

A total of 150 subterranean fauna samples were collected from 72 exploration drill holes and bores during the first phase of survey, comprising 51 stygofauna and 99 troglofauna samples. Sampling methods included stygofauna net-hauling and pumping, plus troglofauna trapping and scraping. Both the methods and the survey effort undertaken to date aligned with current EPA guidelines for assessment of subterranean fauna. The key findings of the first phase of survey are as follows:

STYGOFAUNA

- Five taxonomic groups were detected within the Study Area and surrounds (Cyclopoida, Harpacticoida, Oligochaeta, Ostracoda, and Syncarida);
- Of these, the Syncarida were detected mostly within the two proposed mining tenements to date (only a single specimen has been recorded in the reference areas to date);

- Syncarids are relatively well-sampled throughout the region and there may be a reasonable basis for regional comparisons by further genetic or morphological work; and
- Oligochaetes, ostracods, and copepods were found within the two proposed mining tenements and throughout the reference areas, which should facilitate investigations of their wider local occurrence by further genetic or morphological work.

TROGLOFAUNA

- Five higher taxonomic groups have been detected within the Study Area and surrounds (Chilopoda, Diplura, Isopoda, Pauropoda, Zygentoma);
- Of these, the Chilopoda, Isopoda, and Zygentoma were detected only within the two proposed mining tenements to date; and
- Each of these taxa is represented by previous records in the region and there may be potential for regional comparisons by further genetic or morphological work.

The current findings are based on preliminary sampling data and parataxonomic information only and will be subject to change following:

- The second round of survey, which will be required to meet EPA guidelines for assessment of subterranean fauna;
- Further refinement of taxonomic identifications to species-level, which will also provide a basis for assessing wider local and regional occurrence of species; and
- Receipt of more detailed information regarding the likely extent and magnitude of potential impacts to geological and hydrogeological habitats from the proposed mine.

1 INTRODUCTION

1.1 Background

Technology Metals Australia Limited (TMAL) primary purpose is to identify exploration projects in Australia (and overseas) with the aim of discovering commercially significant mineral deposits. TMAL's primary focus is on the Gabanintha Vanadium Project (the Project), with the aim to develop this Project to supply high-quality vanadium oxide (V205) flake product to both the steel market and the emerging vanadium redox battery (VRB) market. TMAL is currently completing a pre-feasibility study into the Project and plan on progressing the Project further to obtain the necessary environmental approvals.

To assist in the development of environmental impact assessment (EIA) documents, Integrate Sustainability Pty Ltd (ISPL), on behalf of TMAL, commissioned Biologic Environmental Survey Pty Ltd (Biologic) to complete a Level 2, two-phase subterranean fauna survey of the Project.

The Project is located approximately 36 kilometres (km) south-southeast of the town of Meekatharra, in the Murchison region of Western Australia (Figure 1.1). The Project includes two regions and associated access corridors (Figure 1.2, collectively hereafter referred to as the Study Area) and is 1,233.2 hectares (ha) in size:

- Northern Region (M51/883- pending) – 789.2 hectares (ha);
- Northern Access – 95.2 ha;
- Southern Region (M51/884 – pending) – 93.9 ha; and
- Southern Access – 254.9 ha.

The Study Area occurs across numerous tenements, not all held by TMAL. The Study Area occurs in part or wholly within tenements E51/1510-I, P51/2944, P51/2943, P51/2942 and E51/1818 (pending). The Northern and Southern Regions partially or wholly occur within mining tenement M51/883 (pending) and M51/884 (pending) (Figure 1.2).

1.2 Objectives

The subterranean fauna survey will be used to inform future environmental approvals for the Project. This report comprises methods and preliminary results of the first season of subterranean fauna sampling at the Project, conducted from 20 – 25 June 2018 (Trip 1) and 6 – 10 August 2018 (Trip 2).

The overarching objective of the subterranean fauna assessment (hereafter referred to as the Survey) was to identify the environmental values of the Study Area and to determine if there are any conservation significant values that need to be considered during the design and future approval of the Project. The overarching objective was achieved via the following scope of works:

- The completion of a desktop assessment, including the review of previous subterranean fauna surveys and government/ non-government databases;
- The completion of a Level 2 Survey (formerly referred to as a Baseline survey) across the Study Area and relevant local/ regional context areas;
- A review of the results of the Level 2 Survey to determine if there are any significant environmental values within the Study Area;

- A discussion of significant environmental values from a regional and local context; and
- The provision of advice and guidance related to the environmental approval process, with respect to any significant subterranean fauna values identified from the Study Area.

At the time of writing the current report, detailed taxonomic identifications and regional comparisons required to assess the significance of environmental values within the local/ regional context were unavailable.

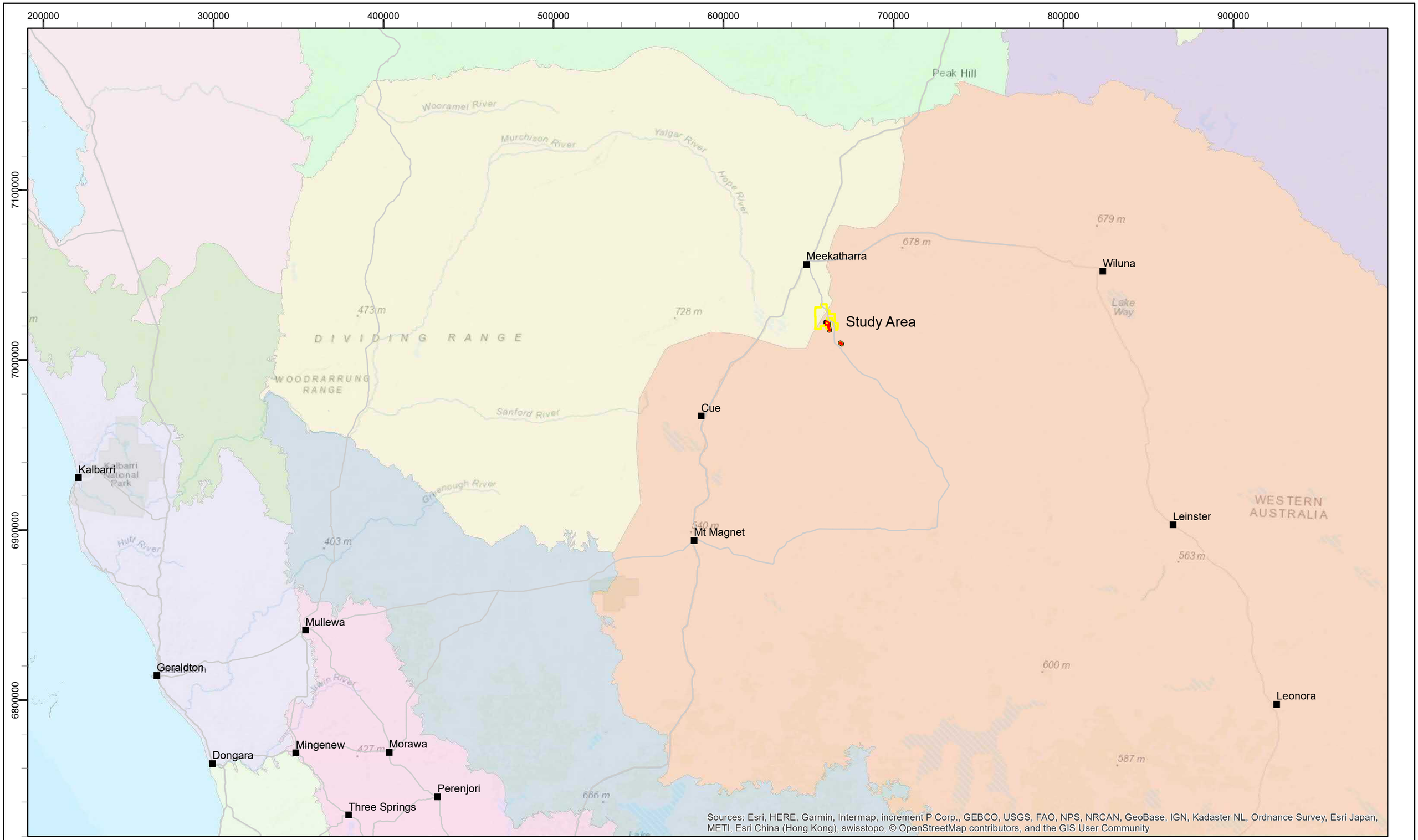
1.3 Legislation and Guidance

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

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

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

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



Legend

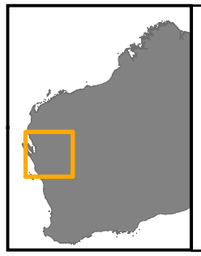
- Major towns
- Major roads
- Study Area

Gabanintha Tenure

- LIVE
- PENDING

IBRA Subregion

- Augustus
- Carnegie
- Eastern Murchison
- Edel
- Geraldton Hills
- Lesueur Sandplain
- Merredin
- Tallering
- Trainor
- Western Murchison
- Wooramel



biologic Environmental Survey

N

1:2,000,000

0 30 60 120 km

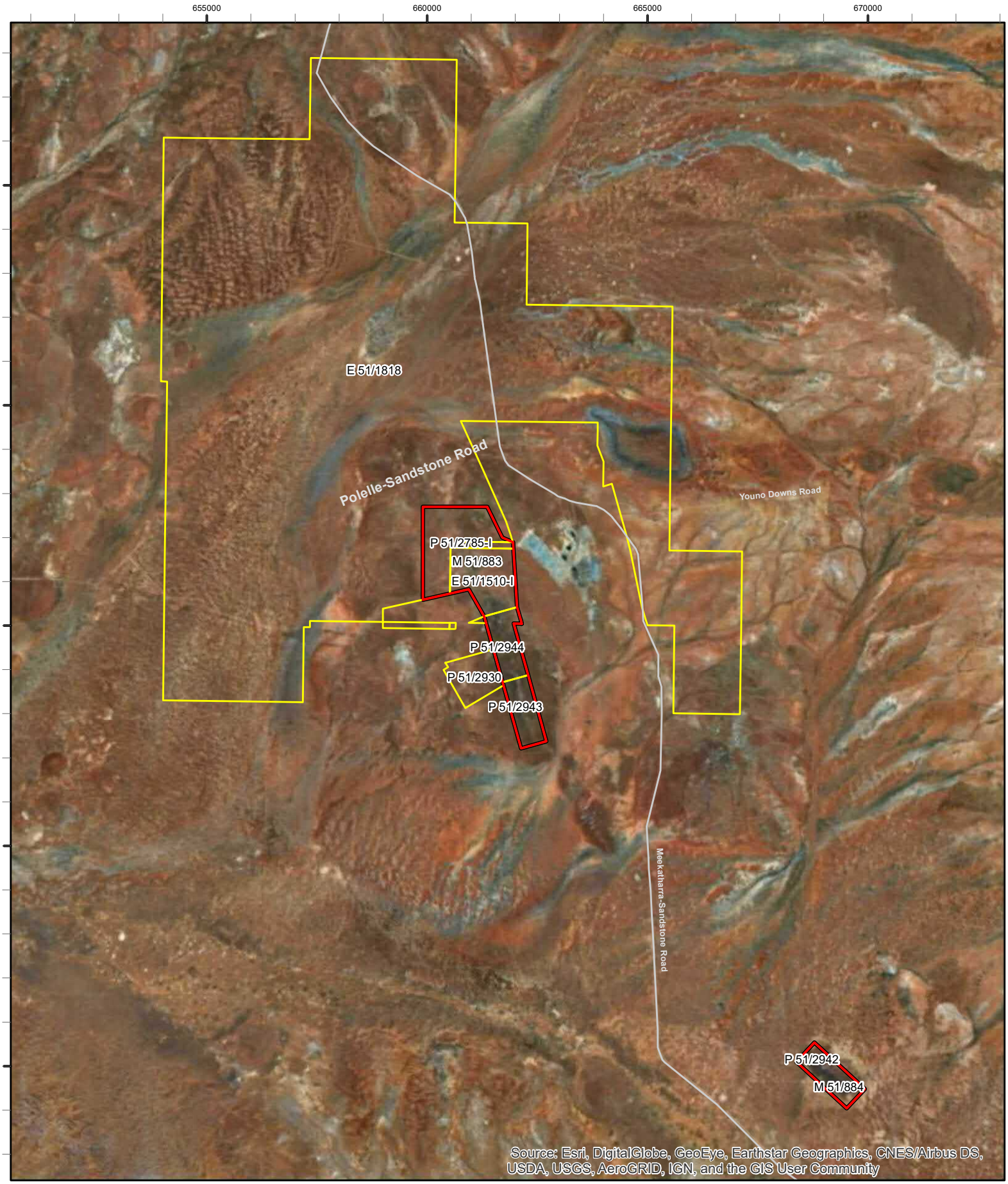
Technology Metals Australia Ltd

Gabanintha Vanadium Project

Fig. 1.1: Regional location and IBRA subregions

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

Size A3. Created 19/11/2018



Legend

Major roads **Gabanintha Tenure**

Study Area LIVE

PENDING

biologic Environmental Survey

N

1:110,000

0 0.75 1.5 3 km

Technology Metals Australia Ltd

Gabanintha Vanadium Project

Fig. 1.2: Gabanintha Study Area

Coordinate System: GDA 1994 MGA Zone 50

Projection: Transverse Mercator

Datum: GDA 1994

Size A4. Created 19/11/2018

1.4 Subterranean Fauna

Subterranean fauna are animals that live underground. In Western Australia, subterranean fauna are mainly invertebrates such as crustaceans, insects, arachnids, myriapods, worms, and snails, but a small number of vertebrate taxa such as fish and reptiles have also been found (Humphreys 1999; EPA 2016a). Subterranean fauna are grouped into two major ecological categories:

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

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

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

1.5 SRE Status Categorisation

The SRE status categories used in this report broadly follows the WA Museum's (WAM) revised categorisation for SRE invertebrates. This system is based upon the 10,000 km^2 range criterion proposed by Harvey (2002) and uses three broad categories to deal with varying levels of taxonomic certainty that may apply to any given taxon (Table 1.1).

Table 1.1: SRE categorisation used by WAM taxonomists

	Taxonomic Certainty	Taxonomic Uncertainty
Distribution < 10 000 km^2	**Confirmed SRE** • A known distribution of < 10,000 km^2. • The taxonomy is well known. • The group is well represented in collections and/ or via comprehensive sampling.	**Potential SRE** • Patchy sampling has resulted in 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 > 10 000 km^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.	

Under this system, the “Potential SRE” status is the default categorisation for obligate subterranean fauna, unless sufficient evidence exists to confirm a “Widespread” or “Confirmed SRE” status.

The Potential SRE status is sub-categorised by what is currently known about the species in question; *i.e.* whether there are B) habitat indicators, C) morphology indicators, D) molecular evidence, or E) a weight of knowledge and experience with the group that suggests a reasonable likelihood that the species could be SRE. In terms of SRE likelihood, the more evidence that exists under sub categories 'B', 'C', 'D', and 'E', the greater the likelihood that further investigation would confirm that the species is an SRE.

However, the Potential SRE 'A – data deficient’ category indicates that current information is insufficient to adequately assess the SRE status of the species in question. In such cases, where the SRE status cannot be confirmed, a conservative approach would be unable to consider the SRE risk to be higher than average where:

A. the taxonomy of the genus (or family) requires significant review in order to make any statement on SRE status,

B. the genus is not known to include any confirmed SRE species within the region (subject to the extent of prior sampling / taxonomic effort), and/or

C. there is some uncertainty as to whether the taxon is likely to be obligate subterranean fauna.

The results from the taxonomists are also presented within the broader context of the habitat assessments, desktop review, habitat connectivity, and other ecological information collected during the survey. This approach aims to provide a more holistic assessment of SRE likelihood at scales relevant to the likely impacts of the project, as well as the standard range criterion of <10,000 km^2 (Harvey 2002).

2 ENVIRONMENT

2.1 Climate

The Study Area is located within the Eastern Murchison subregion of the Murchison bioregion (following Thackway & Cresswell, 1995) (Figure 1.1). The region features an arid climate, with rainfall occurring predominantly in winter, averaging approximately 200 mm per annum with high year to year variability (Cowan et al., 2001).

Long-term climatic data is not available for the Study Area itself, although is available from the Bureau of Meteorology (BoM) weather station at Meekatharra Airport (Station 7045). The airport is located 35 km north of the Study Area, which provides an indication of climatic conditions experienced at the Study Area (Figure 2.1).

Figure 2.1 shows that the winter rainfall period coinciding with the subterranean fauna survey delivered almost exactly average rainfall (approx. 32 mm), with the heaviest falls in June. Previously, there had also been significantly above average summer rainfall in January and February (140 mm) as a result of tropical storms; therefore, climatic factors were considered potentially ideal for maximising subterranean fauna activity during the Phase 1 survey results (following Hyde et al. 2018).

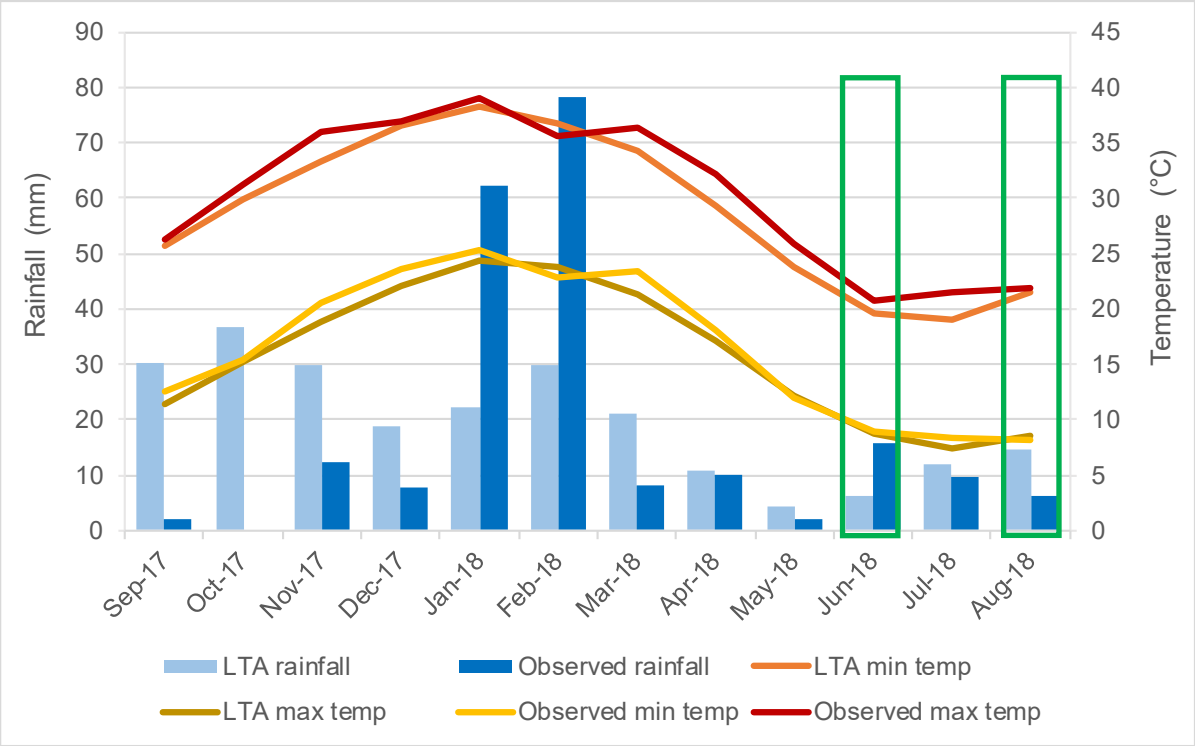


Figure 2.1: Climate data for Meekatharra Airport (BoM, 2018), comparing long-term average (LTA) monthly rainfall (mm) and temperatures (°C), Long-term median (LTM) rainfall (mm), observed average monthly rainfall (mm) and temperatures (°C). Survey timing indicated by green boxes.

2.2 Landforms

The Study Area consists of two rocky ridges, located in the northern and southern tenements. The two ridges are located on the eastern limb of the synclinal Meekatharra Greenstone Belt, which consists of interlayered mafic and felsic-volcanoclastic units. The ridges represent cumulate magnetite bands within a layered gabbro sill, dipping steeply to the west, which contains layers of anorthosite as well as magnetite. The area surrounding the two ridges is mostly flat, comprising broad palaeodrainage valleys and plains offering little topographic relief.

2.3 Geology and regolith

The Study Area is located over units of the Meekatharra-Wydgee Greenstone Belt within the Archaean Yilgarn Craton (Figure 2.2). More specifically, it is located over the Archaean Gabanintha Gabbro (part of the Lady Anna Igneous Complex), one of several mafic / ultramafic intrusive complexes in the region (IIR, 2018). The Gabanintha Formation, which dominates the local geology, is comprised of intermediate, mafic, ultramafic, extrusive and volcaniclastic rocks such as schist, gabbro/ leucogabbro, dolerite, and basalt. The target vanadium resource is hosted within mafic magnetite deposits, which appear to be interlayered with saprolite and clays, amongst other mafic/ ultramafic rocks such as dolerite, gabbro, leucogabbro, and komatiite. Figure 2.3 shows a typical cross section of the target magnetite units in the resource area.

A complex regolith profile lies atop the basement geologies within the M 51/883 tenement, comprised mainly of colluvium and sheetwash of the magnetite unit (which also outcrops atop the ridges) in the southern part of the tenement, while alluvial detritals, sheetwash overbank deposit and gabbro outcrop/ sub-crop are more common in the northern part. Based on regional knowledge of the types of regolith layers mapped in Figure 2.4, the following units may possibly provide habitat for subterranean fauna where sufficient cavities, porosity, secondary weathering, or fracture zones may occur at sufficient depth from the surface:

- Ferruginous duricrust developed on gabbro;
- Gabbro sub-crop and outcrop;
- Greenstone sub-crop and outcrop; and
- Magnetite rubble and outcrop.

600000 610000 620000 630000 640000 650000 660000 670000 680000 690000 700000 710000

7050000 7040000 7030000 7020000 7010000 7000000 6990000

Meekatharra
Meekatharra

f2a
f2c
b2c
d2a
g2
Czv
g2b
b2a
s2a
g2d
g2c
Y1
b2
s2
d2

499 m
620 m
569 m
554 m
613 m
584 m
605 m
539 m
569 m
542 m

Great Northern Hwy

Reedy

Sources: Esri, HERE, Garmin, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), swisstopo, © OpenStreetMap contributors, and the GIS User Community

Legend

- Major towns
- Major roads
- Study Area

Gabanintha Tenure

- LIVE
- PENDING

Geological description

- Acid volcanic rocks
- Alluvial and lacustrine valley-fill deposits; in places saline or calcreted
- Basic and ultrabasic volcanic rocks
- Dolerite, gabbro, and ultrabasic intrusions
- Granite
- Sandstone. dolomite. siltstone. shale
- Sedimentary rocks

N

1:300,000

0 4.5 9 18 km

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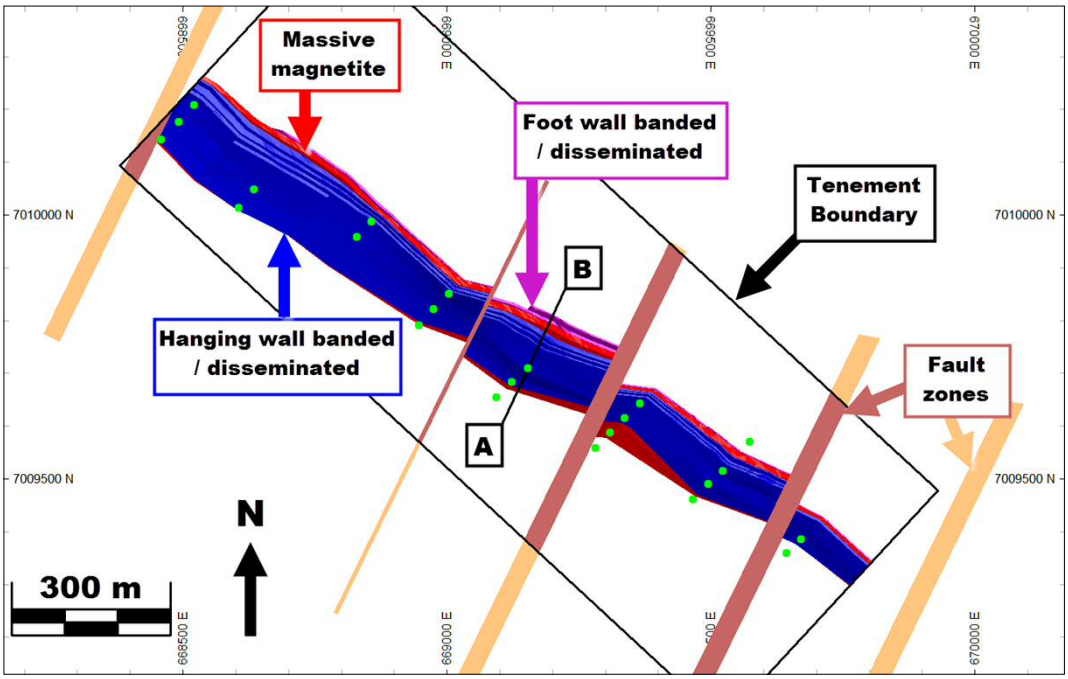
Gabanintha Vanadium Project

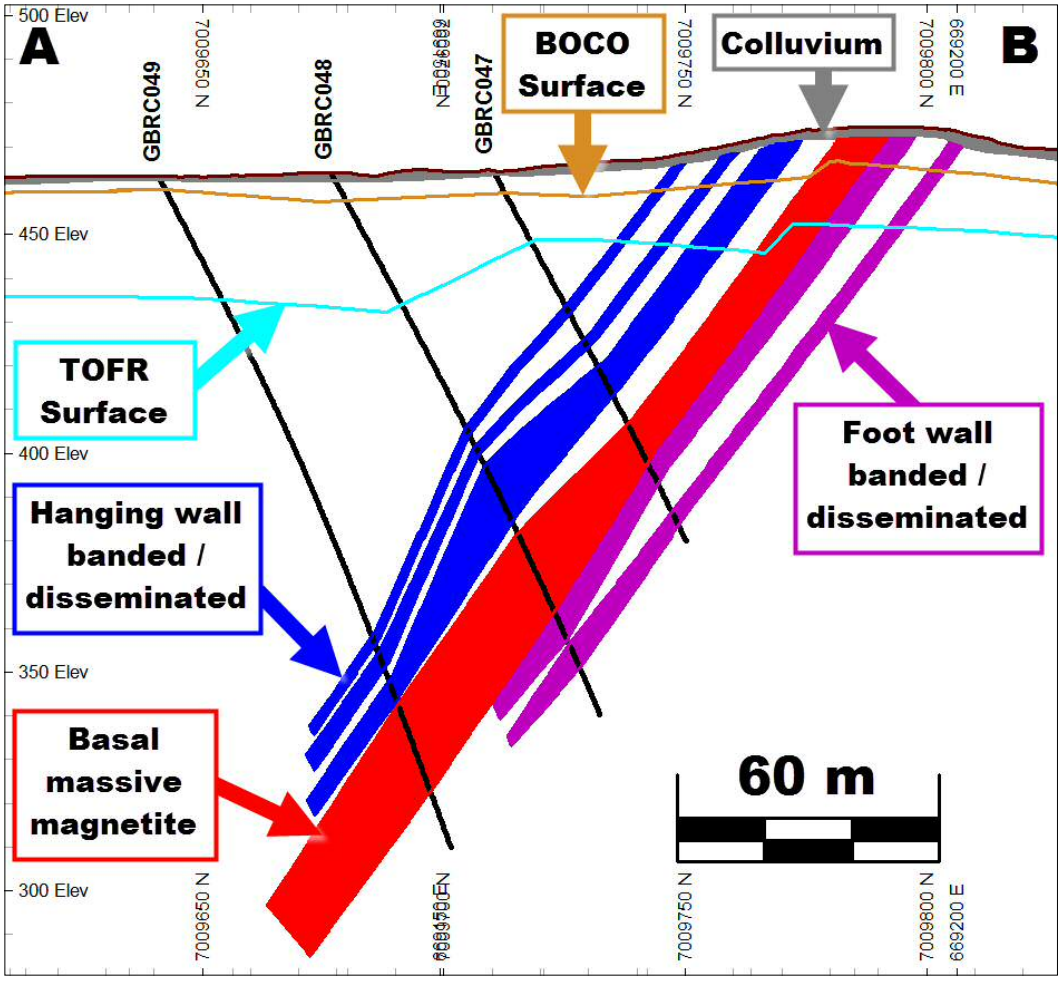
Fig. 2.2: Geology of the Study Area and surrounds (GSWA 1:250,000)

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

Size A3. Created 19/11/2018



(A)



(B)

Figure 2.3: Aerial view (A) and schematic cross section (B) of the Gabanintha mineralized deposit (Figures provided by CSA Global 2017).

653000 654000 655000 656000 657000 658000 659000 660000 661000 662000 663000 664000

7023000 7022000 7021000 7020000 7019000 7018000 7017000

Nannine-Polelle Rd

Young Downs Rd

E 51/1818

P 51/2785-I

M 51/883

E 51/1510-I

P 51/2944

P 51/2930

P 51/2943

471 m

465 m

476 m

488 m

518 m

Legend

- Study Area

Gabanintha Tenure

- LIVE
- PENDING

Geological description (GSWA 250k)

- Acid volcanic rocks
- Basic and ultrabasic volcanic rocks
- Granite
- Sedimentary rocks

Regolith description

- Active drainage with alluvial deposits
- Anthropological. Waste rock and mining landform.
- Cherts, BIF, sediments
- Colluvium and sheetwash of magnetite
- Colluvium. Cobble lags, thin soil, sub-outcrop.
- Felsic and granite subcrop and outcrop
- Ferruginous duricrust developed on gabbro
- Gabbro subcrop and outcrop
- Greenstone subcrop and outcrop
- Laterite and subcrop
- Lateritised gravel and colluvium
- Magnetite rubble and outcrop
- Rubble and talus
- Sheetwash and overbank deposits
- Sheetwash of magnetite debris

biologic Environmental Survey

N

1:32,000

0 0.5 1 2 km

Technology Metals Australia Ltd

Gabanintha Vanadium Project

Fig. 2.4: Regolith of the M 51/883 tenure and surrounds

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

Size A3. Created 19/11/2018

2.4 Hydrology and hydrogeology

The major drainage system of the area is the Lake Quinn drainage, which is characterised by a Salt Lake and a palaeodrainage channel that occurs almost directly south of the Study Area (Davis 2016) (Figure 2.5). Hydrogeological studies suggest that the major groundwater sources in the area comprise:

- Unconsolidated surficial alluvium (i.e. shallow sand aquifers beneath river systems);
- Calcrete and buried sand aquifers surrounding Lake Quinn;
- Geological contact zones between the major granite and greenstone rocks (or other minor geological boundaries, plus intrusives); and
- Major faults and shears within the greenstone belt (Davis 2016).

Based on regional knowledge of subterranean fauna habitats, calcrete deposits in the palaeodrainage valleys are expected to provide the primary hydrogeological habitat for diverse and abundant stygofauna assemblages in the sub-regional area (including around Lake Quinn). Fault and fracture zones within the greenstone rocks may also provide some habitat for subterranean fauna, as may transitional calcrete-clays (where sufficiently vuggy), and unconsolidated alluvium or colluvium (such as buried alluvial gravel lenses). From current information the extent to which these potential habitat units may occur in the Study Area is unclear, apart from calcrete, which is mapped further to the south and west of the Study Area in the Lake Quinn palaeodrainage (Figure 2.5).

600000 610000 620000 630000 640000 650000 660000 670000 680000 690000 700000 710000

7050000 7040000 7030000 7020000 7010000 7000000 6990000 6980000

Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

Legend

- Local Drainage
- Study Area

Gabanintha Tenure

- LIVE
- PENDING

Hydrogeological units (1:500,000)

- Dolerite, gabbro and ultrabasic intrusions
- Granitoid
- Limestone, calcrete
- Metamorphic rocks
- Surficial sediments
- Volcanic and sedimentary rocks in greenstone belts, undifferentiated

biologic Environmental Survey

N

1:300,000

0 4.5 9 18 km

Technology Metals Australia Ltd

Gabanintha Vanadium Project

Fig. 2.5: Hydrogeology and drainage of the Study Area and surrounds

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

Size A3. Created 19/11/2018

3 METHODS

3.1 Survey Timing

To date, a single phase (wet season) of subterranean fauna sampling has been undertaken in accordance with EPA guidelines for subterranean fauna assessments (EPA 2016a, 2016b). The first phase of sampling was undertaken in June - August as follows:

- Trip 1, 20 – 25 June 2018 (trap deployment and scrape / haul / pump sampling); and
- Trip 2, 6 – 10 August 2018 (trap retrieval and additional scrape / haul / pump sampling).

3.2 Site Selection and Survey Effort

Locations of 72 bores and drill holes sampled during the first phase of survey are shown in Figure 3.1 and listed in Appendix 1. The number and location of sampling holes was determined in consultation with TMAL based upon:

- The location of suitably constructed, accessible drill holes and bores;
- Ensuring good spatial spread throughout the Study Area and surrounds, particularly in relation to areas inside and outside of the likely mining impacts;
- The extent of prospective geological and hydrogeological habitat units;

During the first phase of survey, a total of 150 subterranean fauna samples were collected, comprising 51 stygofauna samples collected by net-hauling (48 samples) and pumping (3 samples), plus 99 troglofauna samples collected by scraping (59 samples) and trapping (40 samples) (Table 3.1). Unfortunately, nine trap samples were compromised, with two lost in-situ and seven affected by the hole plugs being removed, or traps being hauled out and left on the surface by an unknown third party.

Table 3.1: Subterranean fauna sample effort at the Study Area

	Troglofauna		Stygofauna		
No. Samples	**Scraping**	**Trapping**	**Hauling**	**Pumping**	**Total Samples**
Trip 1	39		37	2	79
Trip 2	20	40	21	1	38
TOTAL	59	40	48	3	150

645000 650000 655000 660000 665000 670000

7025000 7020000 7015000 7010000

Legend

- Study Area

Gabanintha Tenure

- LIVE
- PENDING
- Stygofauna hauling/ pumping
- Troglofauna scraping
- Troglofauna trapping

Hole type (inset)

- Diamond core
- RC drilled

Marsh Bore

Creek bore unk1

Hillview RC / Bore

Hill view well windmill

Alston Bore Windmill

Gabunk2steel

Gabunk2PVC

GBRC031 GBRC033 GBRC029 GRC087 GBRC028 GBRC104 GBRC101 GBRC081 GBRC091 GBRC038 GBRC043 GBRC098 GBRC071 GBRC009 GBRC002 GBRC094 GBRC095 GBRC083 GBRC017

Inset

GBRC067 GBRC065 GBRC060 GBRC057 GBRC063 GBRC053 GBRC047 GBRC055 GBRC052

P 51/2785-I

E 51/1818

E 51/1510-I

GBDD001 GBDD002 GBDD003

M 51/883

P 51/2944

GBDD004 GBDD006 GBDD007 GBDD008

P 51/2930

P 51/2943

GBDD010 GBDD011 GBDD012 GBDD013

Esri, HERE, Garmin, © OpenStreetMap contributors, and the GIS user community

Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

biologic Environmental Survey

N

1:75,000

0 1 2 4 km

Technology Metals Australia Ltd

Gabanintha Vanadium Project

Fig. 3.1: Locations of sampling to date and habitat assessment (diamond core holes)

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

Size A3. Created 19/11/2018

3.3 Sampling Methods

The sampling methods used were consistent with EAG #12 (EPA 2016a) and Guidance Statement #54A (EPA 2016b). The field work was undertaken by Dean Main, Syngeon Rodman and Fabian Rudin, while laboratory sorting and initial parataxonomy was undertaken by Dean Main, Syngeon Rodman, Fabian Rudin and Nihara Gunawardene.

3.3.1 Water physicochemistry

Prior to stygofauna sampling, a groundwater sample was collected using a 1 m plastic cylindrical bailer, for the purposes of physicochemical measurements. The bailer was lowered down the hole until reaching groundwater, and a water sample was collected at a depth of 2 m below the water surface. As such, the results were not indicative of water characteristics throughout the entire bore (or aquifer), but rather provide a general indication of near surface conditions. Water physicochemical measurements during pumping were made using a sample collected from the pump outflow, which may have affected readings due to turbulence. As such, readings were taken at the beginning and near the end of the pumping period at each depth to account for variability. Groundwater physicochemical data (including EC, pH, TDS, Redox, and Dissolved O_2) was measured using a multi-parameter water meter. Bore/ drill hole angle and construction, as well as blockages in some cases, inhibited the collection of groundwater physicochemical readings.

3.3.2 Stygofauna net hauling

Stygofauna were sampled by standard net hauling methods, using a plankton net of a diameter to suit each bore or drill hole (in most cases 30-90 mm). Each haul sample comprised a total of six hauls from the bottom of the hole to the top, with three hauls using a 150 µm mesh and three hauls using a 50 µm mesh. The base of the net was fitted with a lead weight and a sample receptacle with a base mesh of 50 µm. To stir up sediments, the net was raised and lowered at the bottom of the hole prior to retrieval and hauled at an even pace through the water column to maximise filtration of the water.

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

3.3.3 Troglofauna trapping

Trapping utilises custom made cylindrical PVC traps (approximately 50 mm x 300 mm) baited with decaying leaf litter (dead spinifex / acacia) and sterilised with boiling water prior to a 2-week composting period. Traps were lowered via a nylon cord to a suitable depth and left in operation six to eight weeks, before being collected and transported back to the laboratory in Perth, whereupon fauna were extracted from the bait using Tulgren funnels.

3.3.4 Troglofauna scraping

Scraping was undertaken at 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 drill hole. The net was lowered and raised through the full length of the hole at least three (3) times for holes where no water was present, with each haul being emptied into a sample bucket as per net hauling. Where the water table was intercepted, a combined net haul / scrape sample was taken using the scraping attachment. This comprised six (6) hauls throughout the full length of the hole from top to bottom, sampling both the air filled and below water subterranean habitats. The contents of the sample were elutriated, processed, and stored in 100 % ethanol as per net hauling. This technique can frequently result in stygofauna by-catch where scraping nets are lowered below the water table to collect any invertebrates that may have fallen past the net.

3.3.5 Sorting and taxonomy

Sorting and parataxonomy were undertaken in-house using dissecting microscopes. The personnel involved were suitably trained and experienced in both sorting and parataxonomy of subterranean fauna.

Parataxonomy of the specimens utilised published literature and taxonomic keys where available. Each morphospecies from each sample was assigned a separate vial and labelled with a specimen tracking code. Taxonomic groups were examined in as much detail as possible using in-house expertise, before sending a reference collection to specialist taxonomists for detailed taxonomic advice. Species comparisons and alignments were performed using regional specimens collected beyond the Study Area throughout the wider sub-regional area. Specialist identifications were undertaken by taxonomists with more than 50 years' combined experience with subterranean fauna in Western Australia.

3.3.6 Habitat assessment

Subterranean ecosystems are typically dependent upon inputs of nutrients and oxygen from the surface (Hahn 2009), which are transported into subterranean ecosystems by water infiltration (Howarth 1983; Humphreys 2006). Important features that can influence the suitability of habitats for subterranean fauna include the geomorphology and porosity of the target geological habitat and overlying strata, the depth from the surface of the target layer/s, and the presence of cavities or tree roots that can provide conduits for water and nutrients (Hahn and Fuchs 2006; Strayer 1994).

Local subterranean habitats were assessed via diamond drill core photographs at 17 holes drilled throughout the Study Area (Figure 3.1), cross-referenced with drilling logs and lithology codes. Drill cores were inspected for any dissolution channels, holes, or pore spaces, pre-existing fractures (i.e. large cracks that showed staining from water entry, and therefore were not a result of drilling), coarse gravel layers, or areas of significant core loss, which might indicate a subterranean cavity. The data was also inspected for key lithologies which, when sufficiently weathered or porous, are known to provide habitat for subterranean fauna in the region, such as calcrete, dolomite, quaternary alluvium/ colluvium, banded-iron formations, ferruginous pisolite/ laterite, and duricrust.

4 RESULTS

4.1 Regional subterranean fauna values

The Study Area occurs in the Murchison/ Yilgarn region, which is a known centre of subterranean fauna biodiversity and species endemicity (Humphreys 2008, EPA 2016a). The high degree of diversity and endemicity of the region's subterranean fauna is associated with the fragmented occurrence of their primary habitats, comprising a multitude of karstic calcrete deposits within the palaeodrainage channels and isolated greenstone ranges.

Many of the stygofauna species recorded in the region have been found to be endemic to single, isolated calcrete deposits, particularly in the case of dytiscid diving beetles (Bradford 2010, Watts and Humphreys 2004, 2006, 2008; Cooper *et al*. 2002; Leys *et al*. 2003), amphipods (King et al. 2012, Bradford et al. 2009), isopods (Javidkar 2014, Cooper *et al*. 2008), syncarids (Guzik *et al*. 2008, Cho 2005), and harpacticoid copepods (Karanovic and Cooper 2011a, 2011b, 2012). This pattern of locally-restricted species is known as the 'calcrete island' hypothesis; *i.e.* each calcrete aquifer is thought to be equivalent to a subterranean 'island', containing its own suite of restricted, endemic species (Cooper et al. 2007, 2008; Humphreys 2001, 2008; Guzik et al. 2011).

Despite this, some recent studies have shown that neighbouring calcrete aquifers can be functionally connected by other suitable layers (such as unconsolidated alluvium, fractured rocks, and vuggy 'transitional calcrete') (Outback Ecology 2012). In such cases, some stygofauna species may be shared between different calcretes within the same palaeochannel (Outback Ecology 2012; Subterranean Ecology 2011). In addition to this, there are several stygofauna taxa (particularly cyclopoid copepods) that are known to occur widely throughout the region (De Laurentiis et al. 2001), therefore not all species adhere to the 'calcrete island' biogeographic distribution model.

Iron–bearing greenstone formations are also known to host a number of subterranean fauna species, particularly troglofauna rather than stygofauna (Bennelongia 2012, 2014), as these tend to occur in the upper parts of the landscape, while calcretes form the primary habitat in the palaeochannel valleys.

4.2 Desktop Assessment

A review of available government and non-government subterranean fauna databases was conducted within search co-ordinates -26.278267, 117.640552 (north west); -27.635114, 119.800831 (south east), representing an approximate 100 km buffer surrounding the Project. Databases searched included WA Museum Arachnology/ Myriapodology, Crustacea, Mollusca, Entomology, as well as DBCA NatureMap, and unpublished data held by Biologic. The level of subterranean fauna identifications differed considerably between these various databases; therefore, in order to provide regional context to the current higher-level identifications, the data was mapped at order-level (Figure 4.1), as summarised in Table 4.1.

Legend

- Major towns
- Major roads
- Regional calcrete (indicative)
- Study Area

Gabanintha Tenure

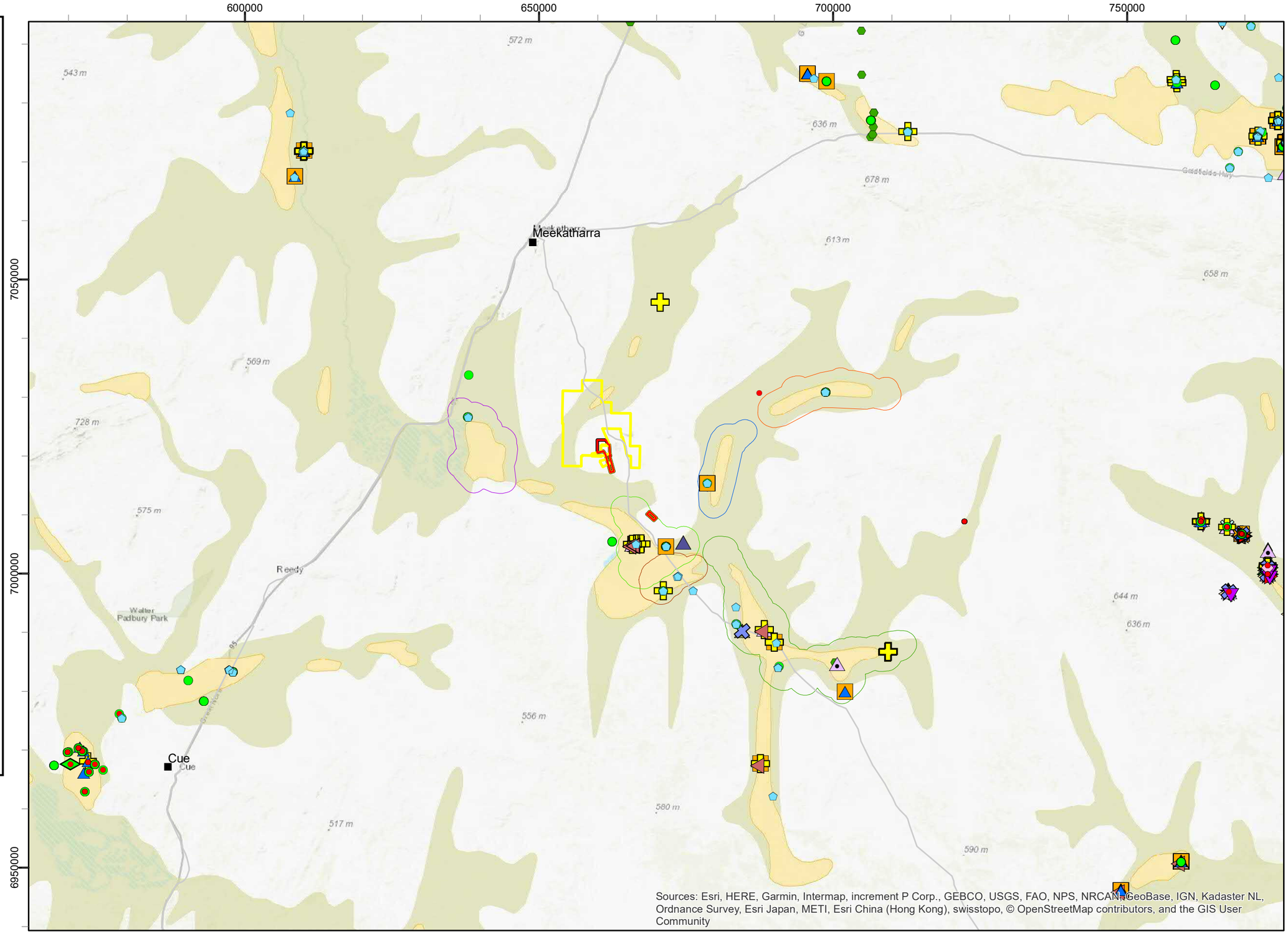
- LIVE
- PENDING
- Regional palaeodrainage (indicative)

Subterranean P1 PEC boundary

- Hillview Calcrete
- Murchison Calcrete
- Nowthanna Calcrete
- Polelle Calcrete
- Yarrabubba East Calcrete
- Yarrabubba West Calcrete

Subterranean Status, Order

- Stygofauna, Amphipoda
- Stygofauna, Bathynellacea
- Stygofauna, Coleoptera
- Stygofauna, Conchostraca
- Stygofauna, Copepoda
- Stygofauna, Cyclopoida
- Stygofauna, Harpacticoida
- Stygofauna, Isopoda
- Stygofauna, Oligochaeta
- Stygofauna, Podocopida
- Troglofauna, Chilopoda
- Troglofauna, Diplura
- Troglofauna, Isopoda
- Troglofauna, Pseudoscorpiones



Sources: Esri, HERE, Garmin, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), swisstopo, © OpenStreetMap contributors, and the GIS User Community

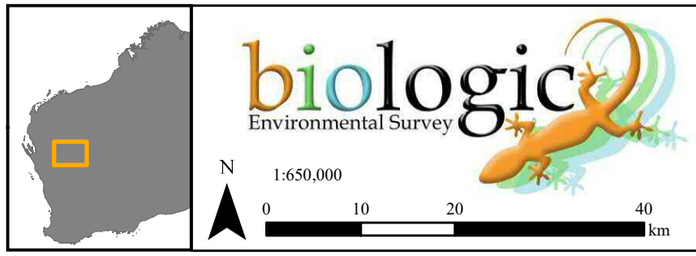


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Fig. 4.1: Locations of sub-regional subterranean fauna records and local PEC boundaries

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

Size A3. Created 19/11/2018

Table 4.1: Number of records of each taxonomic order from database searches

Stygofauna orders	Record count	Troglofauna orders	Record count
Amphipoda	49	Acari	1
Bathynellacea	45	Araneae	2
Coleoptera	57	Chilopoda	1
Conchostraca	1	Diplura	6
Copepoda	20	Geophilida	8
Cyclopoida	198	Hemiptera	8
Harpacticoida	115	Isopoda	21
Isopoda	9	Palpigradi	3
Oligochaeta	7	Pauropoda	7
Podocopida	59	Polyxenida	1
Tubificida	32	Pseudoscorpiones	5
Stygofauna total	**592**	Scolopendrida	3
		Symphyla	8
		Zygentoma	2
Grand Total	**668**	**Troglofauna total**	**76**

The southern M51/884 tenement occurs within the buffer area for the Nowthanna calcrete groundwater assemblage, which is a Priority 1 Priority Ecological Community (PEC) (DPaW 2016) (Figure 4.1). This PEC is directly associated with the stygofauna communities known to occur in calcrete deposits around Lake Quinn. A regional desktop assessment for the Yeelirrie project (based on 2010 WAM unpublished stygofauna data) indicated that up to 12 stygofauna species were known from the calcretes associated with Lake Quinn palaeodrainage, including dytiscid diving beetles, copepods, ostracods, isopods and syncarids (Subterranean Ecology, 2011).

Recent sampling conducted by Biologic in 2017 (unpublished data) has detected diverse stygofauna and troglofauna assemblages from regional bores and drill holes in the immediate local area surrounding the Study Area. Numbers of stygofauna identified to date comprise Bathynellidae (2 taxa), Parabathynellidae (2 taxa), Cyclopoida (6 taxa), Harpacticoida (9 taxa), Isopoda (2 taxa), Ostracoda (1 taxon), Dytiscidae (2 taxa), and Oligochaetes (indeterminate taxa). Numbers of troglofauna identified to date comprise Isopoda (4 taxa), Chilopoda (2 taxa), Pauropoda (1 taxon), Symphyla (4 taxa), and Zygentoma (2 taxa) (Biologic unpublished data).

The desktop assessment revealed the presence of abundant and diverse stygofauna and troglofauna assemblages in nearby regional areas surrounding the Study Area. Based on the known regional patterns of high diversity and endemicity, and the occurrence of Priority 1 PEC boundaries within and nearby the proposed mining tenements, it was considered likely that a two-season level two survey for stygofauna and troglofauna would be required to meet current regulatory guidelines for assessment of subterranean fauna values in relation to the Project.

4.3 Habitat Assessment

Drill cores from within the M 51/883 tenement showed several potentially suitable subterranean habitats, indicted by coarse unconsolidated gravel/ grit layers, well-developed fractures, core loss, and vugs/ small cavities in weathered rock. Table 4.1 shows the lithologies and cores where these types of geomorphological features were identified in core photos, and Figures 4.2-4.4 show some example drill cores from these holes.

Table 4.2: Drill core photos showing features which could indicate subterranean fauna habitat.

Hole ID	Coarse gravel (unconsolidated)	Pisolite	Fractures	Cavities (weathering)	Cavities (noted)	Core loss (noted)
GBDD001	Y		Y			
GBDD002	Y		Y			
GBDD003			Y			
GBDD004	Y	Y	Y			Y
GBDD005			Y			Y
GBDD006			Y			
GBDD007	Y		Y			Y
GBDD008	Y		Y	Y		Y
GBDD009	Y		Y			Y
GBDD010	Y		Y			Y
GBDD011	Y					Y
GBDD012	Y	Y	Y	Y	Y	Y
GBDD013	Y				Y	Y

Note: Locations of diamond drill holes previously shown in Figure 3.1

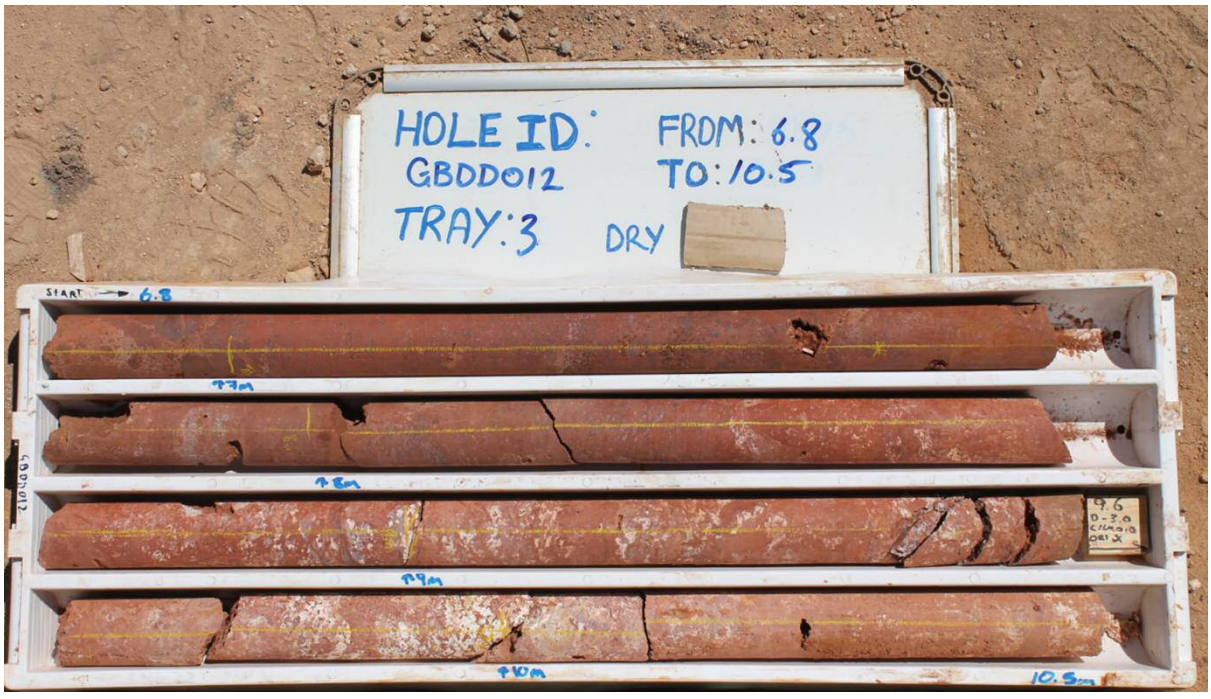

Figure 4.2: Core from GBDD012 showing pores/ cavities from secondary weathering

Figure 4.3: Core from GBDD008 showing stained fracture zones at depth

Figure 4.4: Core from GBDD004 showing unconsolidated gravel and pisolite

Cross comparison of the locations of drill cores (Figure 3.1) and geology/ regolith mapping (Figure 2.4) indicates that these potentially suitable subterranean habitats are found mainly within or beneath the colluvium of the main magnetite ridge, including greenstone sub-crop and outcrop, ferruginous duricrust, laterite and sub-crop, and magnetite rubble/ outcrop.

4.4 Preliminary Fauna Results

The survey to date (single phase) has collected a total of 597 subterranean fauna specimens from the Study Area and surrounds (Figure 4.5, Table 4.2). Stygofauna accounted for approximately 99% of subterranean fauna specimens; with 586 recorded specimens compared to 11 troglofauna specimens.

To date the specimens collected from the survey have been classified into five orders each for both stygofauna and troglofauna, with three orders yet to be confirmed as stygofauna or troglofauna (Table 4.2). At the time of writing, specimens had not yet been identified to species level, although morphological identifications are currently in progress with relevant specialist taxonomists.

Table 4.3: Subterranean fauna recorded the Study Area and surrounds (preliminary order level identifications only at time of writing).

Sampling area	M 51/883								M 51/884				Nth	South		East		West		
	GABUNK2PVC	GBRC006	GBRC018	GBRC020	GBRC021	GBRC071	GBRC084	GBRC104	GBRC052	GBRC059	GBRC063	GBRC067	Creek bore unk1	Kelly's bore	Woral well	GABUNK09	Hill view well windmill	McDonald well	Polelle bore windmill	Total specimens
Stygofauna																				
Cyclopoida	1										1	1			5	2		4		**14**
Harpacticoida																200				**200**
Oligochaeta				22	15								16		1	10		4	100	**168**
Ostracoda											1			1	40			8	100	**150**
Syncarida	5					1	1	1	1	1	15	23					1			**49**
Troglofauna																				
Chilopoda				2																**2**
Diplura																1				**1**
Isopoda		2	2																	**4**
Pauropoda																1				**1**
Zygentoma		2																		**2**
Uncertain																				
Nematoda																3	1			**4**
Acari																			1	**1**
Araneae			1																	**1**
Total taxonomic groups	**2**	**2**	**2**	**2**	**1**	**1**	**1**	**1**	**1**	**1**	**3**	**2**	**1**	**1**	**3**	**6**	**2**	**3**	**3**	**597**

Of the stygofauna detected to date, the syncarids were found almost entirely within the two mining tenements (M 51/883 and M 51/884), with only one specimen found in reference areas to the east. This group is well represented in previous sampling throughout the wider region, which should provide a good basis for local or sub-regional comparisons by further morphological or genetic work following the receipt of species level identifications.

Oligochaetes were also detected in reasonable numbers within the M 51/883 tenement as well as in many of the reference sites in all directions, which should provide a good basis for wider local-area comparisons by genetic, if not morphological taxonomy.

Similarly, the few cyclopoid, copepods and ostracods detected within the two mining tenements to date should be able to be compared with local, if not pre-existing regional specimens, to investigate their wider occurrence beyond the tenement areas.

Of the troglofauna, far fewer specimens have been detected to date, and the capacity to undertake local and regional comparisons is more limited for some groups. The capacity to undertake further morphological or genetic work to inform species occurrence outside of the mining tenements will be reassessed following the receipt of species level identifications.

Owing to the preliminary nature of the taxonomic identifications to date, there are some specimens listed as ‘uncertain’ in Table 4.2 which are yet to be confirmed as subterranean fauna. More information regarding subterranean status and SRE status of individual species/ morphospecies will be provided when taxonomic identifications are updated.

Legend

- Regional calcrete (indicative)
- Regional palaeodrainage (indicative)
- Study Area

Gabanintha Tenure

- LIVE
- PENDING

Subterranean P1 PEC boundary

- Nowthanna Calcrete
- Polelle Calcrete

Status, Preliminary ID

- Stygo, Cyclopoida
- Stygo, Harpacticoida
- Stygo, Oligochaeta
- Stygo, Ostracoda
- Stygo, Parabathynellidae
- Stygo, Syncarida
- Trog, Chilopoda
- Trog, Diplura
- Trog, Isopoda
- Trog, Pauropoda
- Trog, Zygentoma
- Uncertain, Acari
- Uncertain, Araneae
- Uncertain, Nematoda

645000 650000 655000 660000 665000 670000

7025000 7020000 7015000 7010000

E 51/1818
E 51/1510-I
M 51/883
P 51/2944
P 51/2930
P 51/2943
P 51/2785-I
M 51/884
P 51/2942
Inset
Young Downs Rd
Meekatharra-Sandstone Rd
515 m
504 m
480 m
605 m
547 m
506 m

Sources: Esri, HERE, Garmin, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), swisstopo, © OpenStreetMap contributors, and the GIS User Community

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biologic Environmental Survey

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Fig. 4.5: Subterranean fauna recorded to date (preliminary identifications only)

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

Size A3. Created 19/11/2018

4.5 Groundwater Physicochemistry

Groundwater physicochemical measurements taken during the survey provide an indication of the potential extent and connectivity of the major hydrogeological habitats sampled during the survey. Figure 4.6 shows mean (and standard deviation as error bars) temperature, pH, EC (as a proxy for salinity), ORP (redox potential) and DO (dissolved oxygen), for all bores within the M51/883 (northern) and M51/884 (southern) tenements, and nearby reference sites to the north, south, east and west. The interpretation of these data is somewhat affected by the unequal sample sizes between each area, with M51/883 and M51/884 having 28 and 13 sites respectively, whereas reference areas north, south, east and west had only 4, 2, 2, and 3 sites respectively.

Figure 4.6a showed little variability in average groundwater temperatures across all sites, except for reference sites to the west, which were slightly cooler on average. This could potentially indicate a different aquifer, although the sample size in the western area was low (3 sites) and the mean temperature data may have been skewed by an open well/ windmill site.

The pH readings (Figure 4.6b, showing the full pH range represented as error bars) showed that the groundwater of the northern tenement (M51/883) and the northern and western reference sites were most similar in terms of acidity, while the groundwater of the southern tenement (M51/884) was more similar in pH to the southern and eastern reference sites. Despite the differences in sample sizes, these results indicate considerable differences in groundwater acidity between the overall northern and overall southern sites. Nevertheless, the differences between individual bores were generally within a pH range regarded as tolerable for stygofauna (excluding a few high outliers beyond pH 8 in the northern areas).

The EC measurements (Figure 4.6c) showed that the southern tenement (M51/884) and reference sites were considerably more saline than all other sites, which ranged from fresh to slightly brackish. This is likely attributed to the proximity of these southern sites to the central palaeochannel calcrete and its associated playa at Lake Quinn, which would be expected to drive a groundwater salinity gradient, with highest values being closer to the playa, at greater depths from the surface. Yilgarn calcrete aquifers are known to be salinity stratified, with a fresher lens of groundwater often perched atop a saltier lens, separated by a halocline. This is thought to be a major driver of groundwater niche partitioning and species diversity/ richness (Humphreys 2001, Humphreys et al. 2009). Hypersaline groundwater (average EC >30,000 uS/cm) is not unusual for Yilgarn calcretes, or prohibitive for rich assemblages, which are known to occur up to approximately double the salinity of sea water (EC 60,000 uS/cm) (Humphreys et al. 2009, Outback Ecology 2012).

Redox (ORP) and DO measurements (Figure 4.6d and e) are typically more variable between sites due to individual bore conditions than pH or EC but can provide a useful indication of groundwater conditions that are highly relevant to stygofauna occurrence. All areas surveyed showed positive ORP and groundwater with sufficient dissolved oxygen for stygofauna (> 1ppm). Both tenement areas and the eastern reference area were lower in dissolved oxygen on average than the northern, southern, and western reference areas, although the results of the latter may have been affected by comparatively low sample sizes.

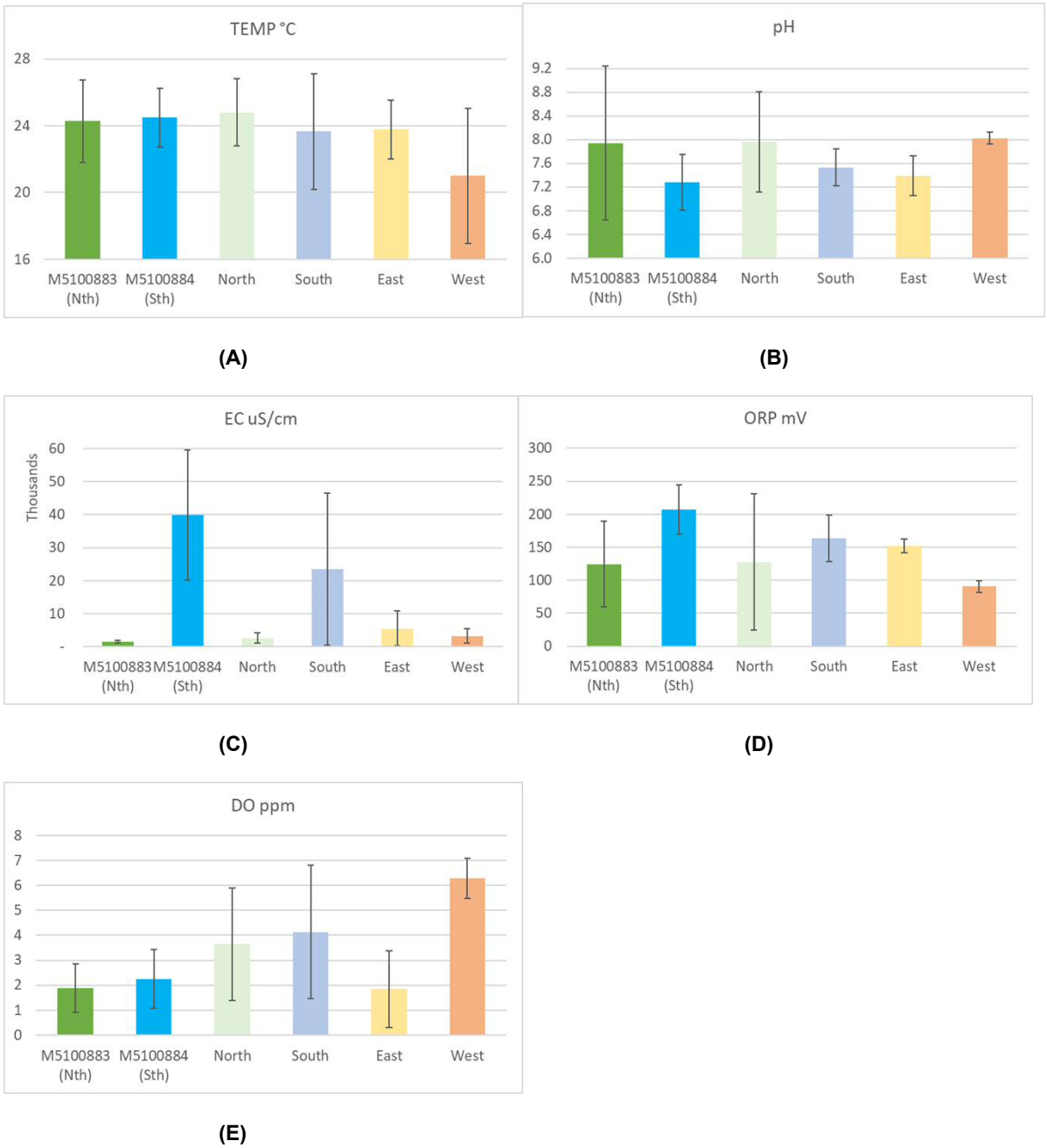

Figure 4.6: Groundwater physicochemical measurements recorded during sampling in the M51/883 and M51/884 tenements and reference sites to the north, south, east and west. Mean values shown as bars, standard deviations as error bars.

5 KEY FINDINGS TO DATE

The preliminary findings and risks to subterranean fauna discussed below are based on sampling data and taxonomic information (currently unresolved), regional knowledge of subterranean fauna, and habitat information available at the time of writing. No information regarding the potential extent or magnitude of impacts to subterranean fauna or habitats from the proposed mining was available at the time of writing. These key findings will be subject to change following the second round of survey work, which will include the refinement of specimen identifications and taxonomic/ ecological information including regional comparisons, and the receipt of additional impact information from client (including direct and indirect impacts areas).

The key findings of the first phase of survey are as follows:

STYGOFAUNA

- Specimens representing five higher taxonomic groups have been detected within the Study Area and surrounds (Cyclopoida, Harpacticoida, Oligochaeta, Ostracoda, and Syncarida). Of these, the Syncarida were detected mostly within the two proposed mining tenements to date (only a single specimen from 49 recorded in reference areas).
- Syncarids are well sampled throughout the region and there may be a reasonable basis for regional comparisons by further genetic or morphological work.
- Oligochaetes, ostracods, and copepods were found within the two proposed mining tenements and throughout the reference areas, which should provide a good opportunity for investigating their wider local occurrence.
- More detailed species-level taxonomic information is required, alongside information regarding the extent and magnitude of likely impacts to hydrogeological habitats, to assess potential risks to stygofauna from mining.

TROGLOFAUNA

- Specimens representing five higher taxonomic groups have been detected within the Study Area and surrounds (Chilopoda, Diplura, Isopoda, Pauropoda, Zygentoma). Of these, the Chilopoda, Isopoda, and Zygentoma were detected only within the two proposed mining tenements to date.
- Each of these taxa is represented by multiple previous records in the region and there may be potential for regional comparisons by further genetic or morphological work.
- More detailed species-level taxonomic information is required, alongside information regarding the extent and magnitude of likely impacts to specific geological habitats in order to assess potential risks from mining.

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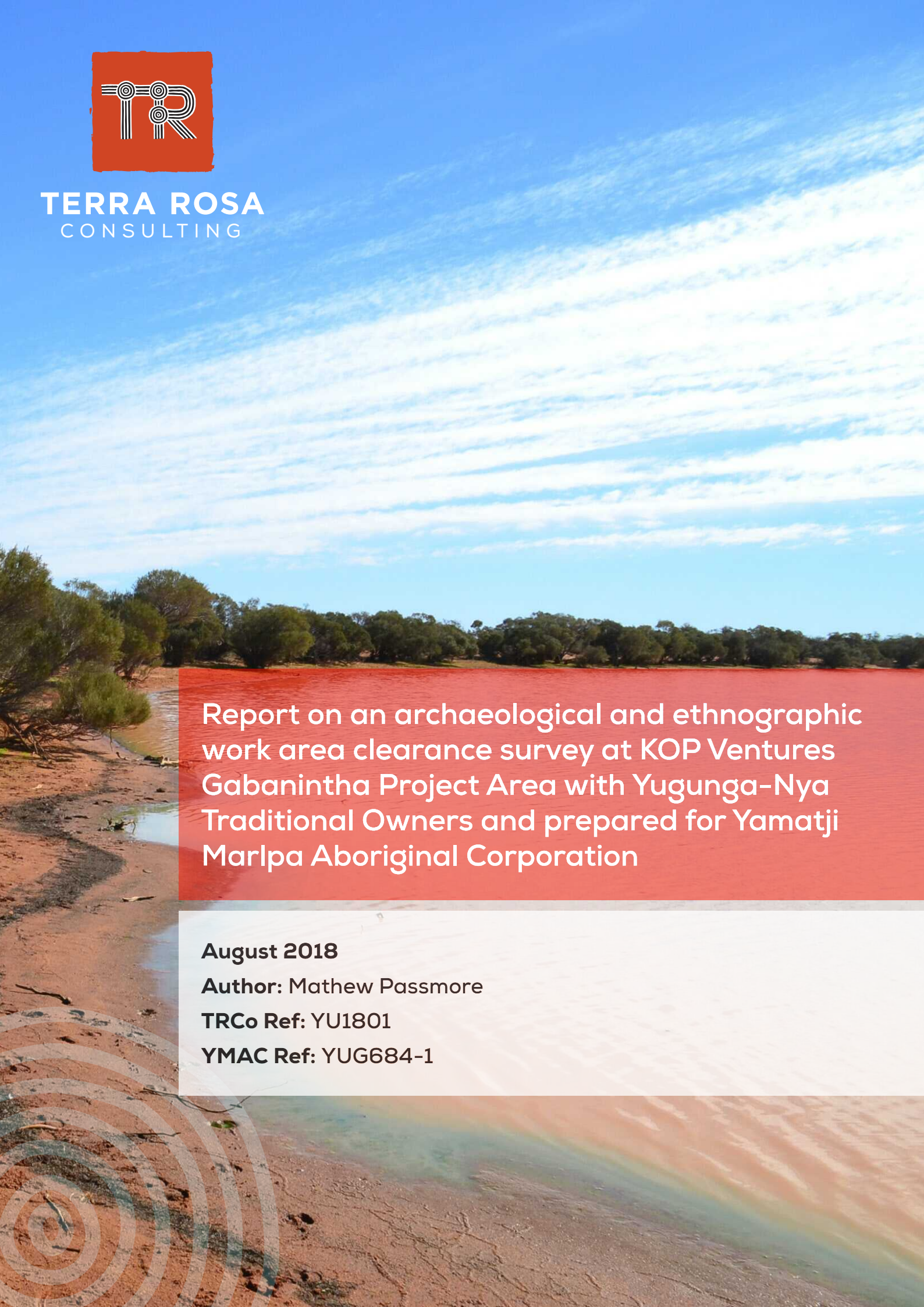
APPENDIX 1 – Subterranean Fauna Sampling Sites

Survey Area	Bore_Hole ID	Latitude	Longitude	Zone	Easting	Northing
M51/883	GABUNK2PVC	-26.92575463	118.6293888	50	661779.1	7020746.206
	GABUNK2steel	-26.92570945	118.6293425	50	661774.6	7020751.271
	GBDD013	-26.95411552	118.6375574	50	662549.6	7017593.767
	GBRC002	-26.95054462	118.634865	50	662287.4	7017992.83
	GBRC006	-26.9541749	118.6366579	50	662460.2	7017588.345
	GBRC008	-26.9469059	118.6337469	50	662181.6	7018397.382
	GBRC009	-26.94693551	118.6333017	50	662137.4	7018394.672
	GBRC012	-26.94333317	118.632285	50	662041.6	7018795.062
	GBRC014	-26.93968023	118.6308493	50	661904.2	7019201.593
	GBRC017	-26.93608929	118.6293832	50	661763.8	7019601.291
	GBRC018	-26.93608335	118.6300462	50	661829.6	7019601.1
	GBRC020	-26.93278252	118.6272044	50	661552.2	7019970.416
	GBRC021	-26.93230778	118.6279876	50	661630.6	7020022.009
	GBRC022	-26.92889127	118.6271739	50	661554.7	7020401.546
	GBRC028	-26.92528074	118.6241367	50	661258.2	7020805.414
	GBRC029	-26.92161048	118.6214694	50	660998.6	7021215.418
	GBRC031	-26.91999471	118.6214979	50	661003.7	7021394.385
	GBRC032	-26.91991869	118.6228681	50	661139.9	7021401.061
	GBRC033	-26.91971421	118.6231948	50	661172.6	7021423.298
	GBRC038	-26.94145807	118.6305019	50	661867.2	7019005.08
	GBRC039	-26.94056006	118.6316336	50	661980.9	7019103.116
	GBRC043	-26.94239667	118.6326013	50	662074.3	7018898.407
	GBRC070	-26.95047162	118.6338365	50	662185.4	7018002.239
	GBRC071	-26.94869628	118.6344609	50	662249.9	7018198.118
	GBRC076	-26.93786168	118.6308277	50	661904.7	7019403.088
	GBRC080	-26.93611324	118.6288151	50	661707.4	7019599.364
	GBRC081	-26.93432803	118.6280751	50	661636.4	7019798.085
	GBRC082	-26.93429142	118.6276108	50	661590.4	7019802.735
	GBRC083	-26.93044153	118.6276415	50	661598.9	7020229.204
	GBRC084	-26.9304744	118.627127	50	661547.8	7020226.22
	GBRC085	-26.92708825	118.625632	50	661404.1	7020603.262
	GBRC087	-26.92395285	118.6237851	50	661225.2	7020952.971
	GBRC091	-26.93879428	118.629969	50	661818.1	7019300.869
	GBRC092	-26.95237567	118.6357281	50	662370.5	7017788.869
	GBRC094	-26.95232496	118.6343597	50	662234.7	7017796.244
	GBRC095	-26.95317647	118.6359196	50	662388.3	7017699.906
	GBRC096	-26.95319215	118.63692	50	662487.6	7017696.882
	GBRC098	-26.94505665	118.6333689	50	662146.7	7018602.736
	GBRC101	-26.92977949	118.6264005	50	661476.6	7020304.133
	GBRC104	-26.9280073	118.6253454	50	661374.4	7020501.811
	GBRC105	-26.92614534	118.6249835	50	661341.1	7020708.549
M51/884	GBRC047	-27.02444454	118.7052106	50	669161	7009713.312
	GBRC051	-27.0264308	118.7085866	50	669492.9	7009488.721
	GBRC052	-27.02667293	118.7083301	50	669467.1	7009462.241
	GBRC053	-27.02568383	118.7094066	50	669575.4	7009570.374
	GBRC054	-27.0273399	118.7103981	50	669671.3	7009385.566
	GBRC055	-27.02759343	118.710122	50	669643.5	7009357.85
	GBRC057	-27.02531473	118.7070104	50	669338.2	7009614.488
	GBRC058	-27.0255677	118.7067465	50	669311.7	7009586.816
	GBRC059	-27.02581697	118.7064963	50	669286.5	7009559.536
	GBRC060	-27.02319339	118.7036382	50	669006.8	7009854.034
	GBRC061	-27.0235561	118.7032814	50	668970.9	7009814.329

	GBRC063	-27.02204507	118.7021852	50	668864.4	7009983.202
	GBRC064	-27.0222881	118.7018712	50	668832.9	7009956.698
	GBRC065	-27.02152521	118.6999048	50	668638.9	7010043.85
	GBRC067	-27.02004125	118.6987419	50	668525.7	7010209.81
	GBRC068	-27.020338	118.6984271	50	668494	7010177.355
North	Creek bore unk1	-26.91033272	118.5456749	50	653486.9	7022559.005
	GB16	-26.8873443	118.5753575	50	656466.6	7025069.372
	GB17	-26.8917817	118.57532	50	656456.7	7024577.832
	Marsh Bore	-26.88187873	118.5961416	50	658538.8	7025649.016
South	Kelly's bore	-27.0590332	118.7610424	50	674647.1	7005805.046
	Woral well	-27.06884371	118.7316999	50	671721.6	7004758.507
East	GABUNK09	-27.0196443	118.6571638	50	664400.8	7010308.691
	Hill view well windmill	-26.93341863	118.7040672	50	669183.6	7019799.415
	Hillview RC / Bore	-26.93341947	118.7040068	50	669177.6	7019799.403
	Hillunk1	-26.93278483	118.7048055	50	669257.9	7019868.644
	Alston Bore Windmill	-26.99212967	118.6867346	50	667375.7	7013318.066
West	GABUNK20	-26.9084582	118.6133139	50	660207.2	7022682.835
	GABUNK25	-26.9281796	118.6050527	50	659359	7020508.456
	McDonnald well	-26.9749066	118.5750728	50	656317.5	7015369.311
	Polelle bore windmill	-26.9325954	118.5714769	50	656018.8	7020061.128
Total sites	72					

APPENDIX B-8: Terra Rosa - An Archaeological and Ethnographic Heritage Survey for the purposes of exploration drilling was completed E51/1510-I, P51/2944, and P51/2943



TERRA ROSA
CONSULTING

Report on an archaeological and ethnographic work area clearance survey at KOP Ventures Gabanintha Project Area with Yugunga-Nya Traditional Owners and prepared for Yamatji Marlpa Aboriginal Corporation

August 2018

Author: Mathew Passmore

TRCo Ref: YU1801

YMAC Ref: YUG684-1

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0.1	26/07/2018	Draft document created	S. Keiller
0.2	01/8/2018	Recommendations added, draft reviewed	M. Passmore
0.3	02/08/2018	Draft report released to YMAC for review	C. Blight
1.0	07/08/2018	Final report released to YMAC	M. Tehnas
1.1	17/08/2018	Updates to final report	D. Lafrentz

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Coordinate capture

The author advises that all coordinates quoted in this document were initially obtained with a Garmin hand held GPS and an Apple iPad, using the GDA datum. All grid references are projected in MGA Zone 50, unless otherwise stated. Dependent on external conditions, these units afford an optimal spatial accuracy of ± 5 m.

Heritage project participants and contacts

The contact details of the heritage project stakeholders are provided below. The authors would like to thank everyone that participated in the heritage survey and assisted in organising the fieldwork.

The heritage survey was conducted in the 17 and 18 July 2018 (inclusive of travel days).

Heritage service provider	**Terra Rosa Consulting**
Address	12/20 Sustainable Avenue, Bibra Lake, Western Australia 6163
Field work participants	Mathew Passmore Grant Preller
Report authors	Mathew Passmore
Editor	Damien Lafrentz
Executive sign-off	Scott Chisholm
Traditional Owners	**Yugunga-Nya Traditional Owners**
Address	c/o Yamatji Marlpa Aboriginal Corporation Level 2, 16 St George's Terrace. Perth WA 6000
Contact	Lawrence Hillary (YMAC)
Field work participants	Bill Shay Trevor Shay Leroy Shay Justin Gentle Shane Riley Irwin Boddington
Proponent	**The KOP Ventures Pty Ltd**
Address	c/o McMahon Mining Title Services, PO BOX 592, Maylands, WA, 6931
Contact	Ian Prentice

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Acronyms and definitions

The following terms and acronyms are utilised throughout the report. Definitions are provided below for reference.

Term / Abbreviation	Definition
ACMC	Aboriginal Cultural Materials Committee
AHIS	Aboriginal Heritage Inquiry System
CCNTS	Cross Country Native Title Services
DPLH	Department of Planning, Lands and Heritage
GIS	Geographic information system
GPS	Global positioning system
Heritage object	An object to which the Act applies under s6
Isolated artefacts	Cultural material with insufficient density to constitute a site.
MGA	Map grid of Australia
NNTT	National Native Title Tribunal
Other Heritage Place	Other heritage places are places catalogued by the DPLH but not included on the Register of Aboriginal Sites for one of the following reasons: 1. Information about the OHP has been lodged with the DPLH but is pending assessment by the ACMC (status L – lodged; also see definition for 'potential site', below); or 2. The ACMC assessed the OHP and considered it not to meet the evaluation criteria for inclusion on the Register of Sites (i.e. not a registered Aboriginal site) (status S – stored / not a site).
Registered Aboriginal site	A site which has been determined as meeting criteria under section 5 of the *Aboriginal Heritage Act 1972 (WA),* and has been registered by the Registrar of Aboriginal Sites (DPLH status R - registered).
Site	Any place which may meet the criteria of an Aboriginal site under s5 of the *Aboriginal Heritage Act 1972 (WA).*
Terra Rosa	Terra Rosa Consulting
Traditional Owners	Yugunga-Nya native title claimants (WC1999/046)
The Act	*Aboriginal Heritage Act 1972 (WA)*
YMAC	Yamatji Marlpa Aboriginal Corporation

1 Heritage project overview

KOP Ventures Pty Ltd (KOP) plan to utilise land within the Yugunga-Nya native title claim (WC1999/046) for the purpose of an exploration drilling program. The project areas are contained within exploration licences E51/1510-I, P51/2944, P51/2943 and P51/2942 (see maps 1, 2, and 3).

Yamatji Marlpa Aboriginal Corporation (YMAC) on behalf of the Yugunga-Nya Traditional Owners, engaged Terra Rosa Consulting (Terra Rosa) to conduct an archaeological and ethnographic work program clearance heritage survey of proposed exploratory drilling areas at the Gabanintha Project area, in accordance with a heritage survey request submitted by KOP prior to the commencement of the survey.

The objective of work program clearance surveys is to establish the existence of any archaeological and ethnographic heritage places within the project area, to deviate any areas of the proposed work program that are likely to impact heritage places, and to address any heritage concerns arising from discussions with the Yugunga-Nya Traditional Owners Traditional Owners present.

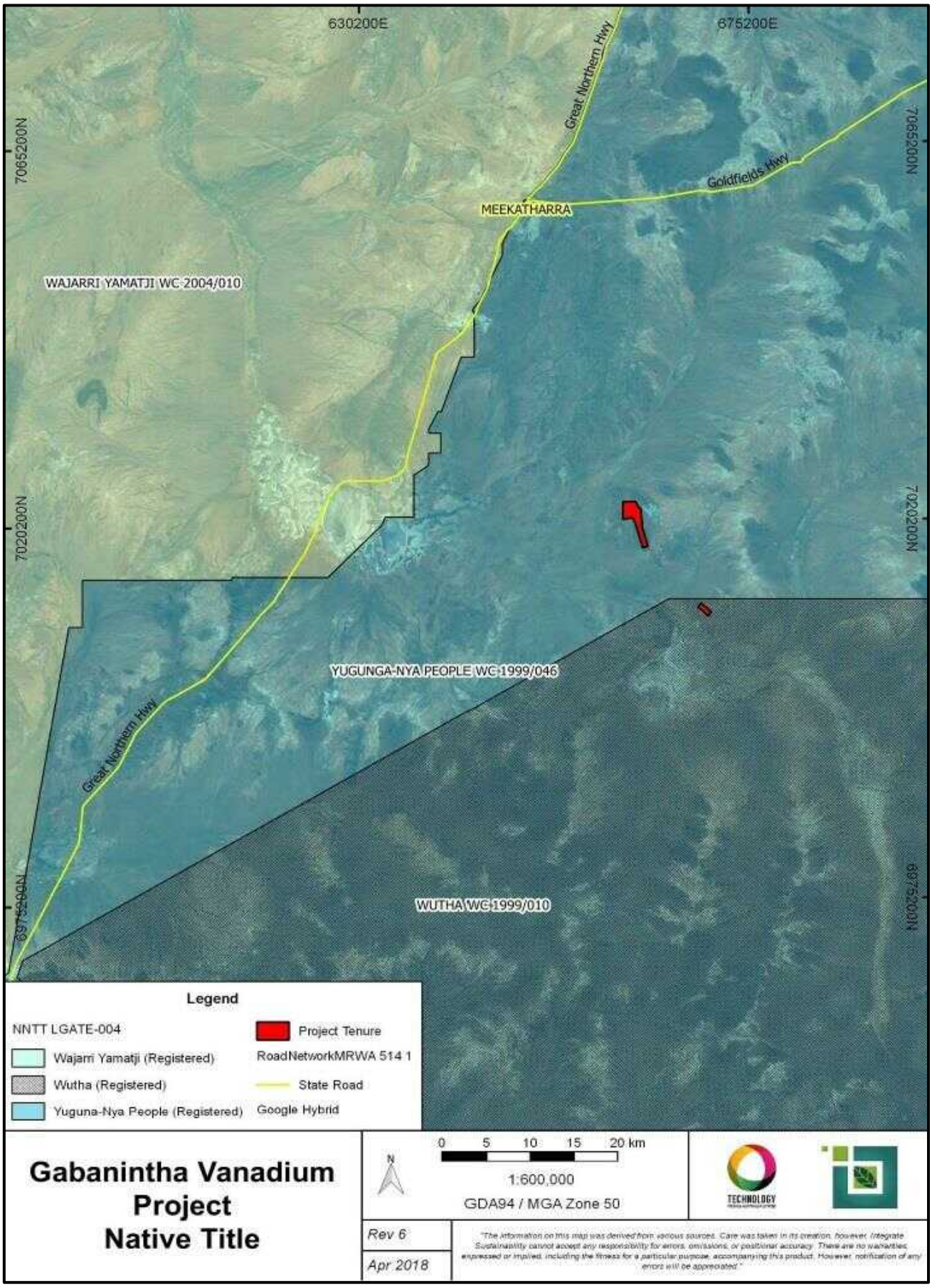
1.1 Qualifications to scope

To most efficiently survey the drill hole locations, the survey team conducted block surveys rather than targeted surveying of the individual drill holes. This provided KOP with additional cleared areas in which they could create access tracks for the drill program. These block areas have been provided in the spatial data and are shown in results maps 4, 5, and 6.

Additionally, following the commencement of the heritage survey, KOP requested that six drill holes be added to the scope of works. These drill holes were also surveyed as part of the block clearance.

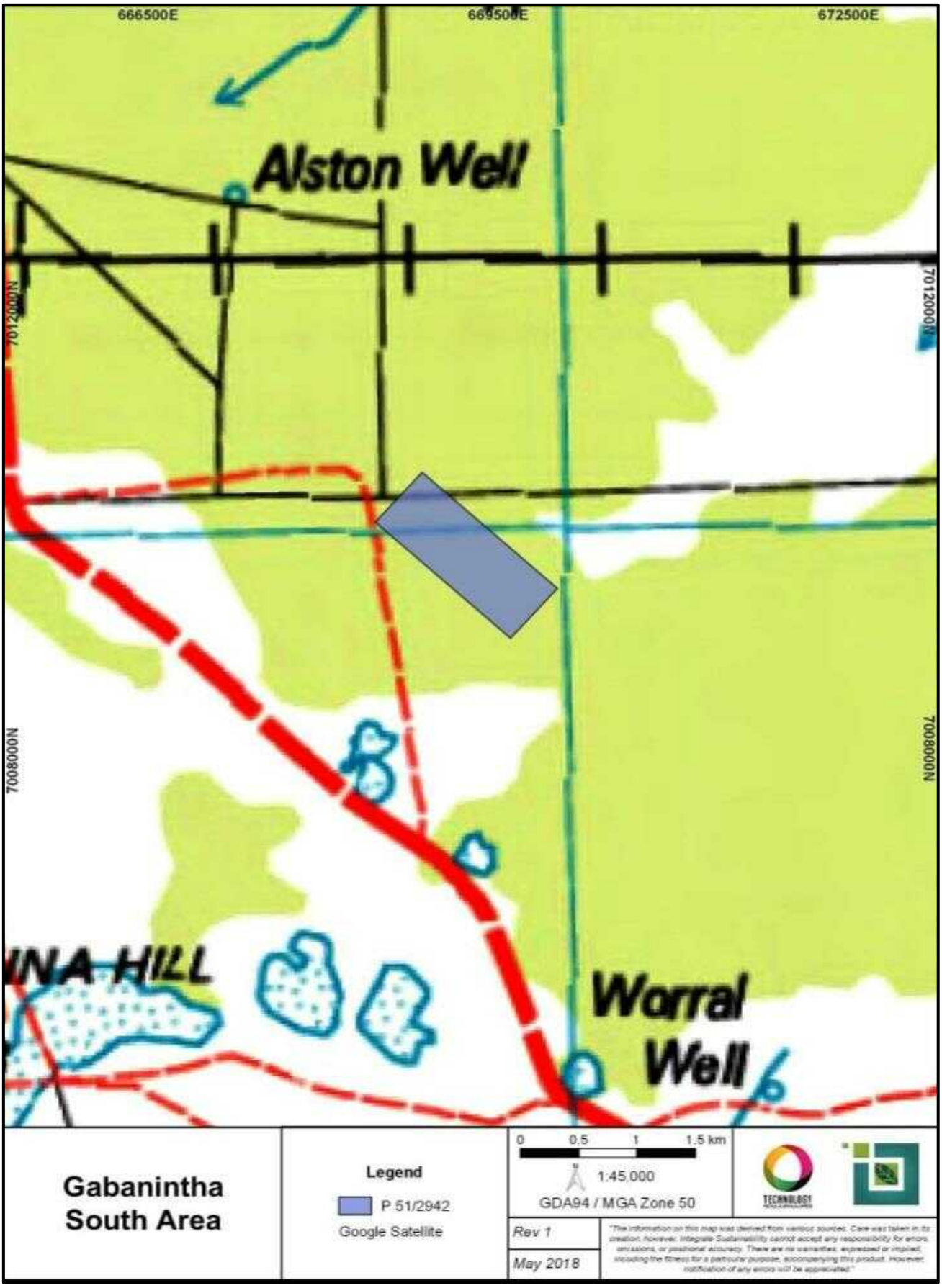
Plate 1: The survey team

Map 1: Proposed Gabanintha Project heritage survey areas



Map 2: Gabanintha North heritage survey area

Map 3: Gabanintha South heritage survey area



2 Heritage assessment method

The archaeological and ethnographic heritage survey was conducted to a work area clearance standard. The objective of a work area clearance assessment is to establish the existence of any archaeological and ethnographic values within the project areas, to establish avoidance boundaries around sites likely to be impacted by the proposed works, and to address any heritage concerns arising from discussions with the Traditional Owners present.

2.1 Desktop assessment procedure

Prior to field work, a preliminary desktop assessment was undertaken to provide an overview of heritage research undertaken to date within the area. Desktop research focused on the identification of any registered Aboriginal sites, OHPs and surveys within the area, which need to be considered in the heritage approval process for the project.

Desktop research for heritage values relies largely on the Register of Sites maintained by the Department of Planning, Lands and Heritage (DPLH), which provides an indication as to the presence and nature of any heritage values previously recorded and registered within the area.

The AHIS search is also utilised to determine whether any heritage assessments have previously been conducted within the application area and if any heritage reports containing information relevant to the application area have been registered with the DPLH.

Prior to field work, the survey area boundaries were entered into the DPLH's Aboriginal Heritage Inquiry System (AHIS) to learn whether any registered Aboriginal sites or other heritage places (OHPs) have been recorded within the area. Registered Aboriginal sites are those areas that have been assessed by the ACMC as constituting sites under the Act. OHPs include places for which data has been lodged with the DPLH but is pending assessment by the ACMC, and places that have been assessed by the ACMC as not constituting registered Aboriginal sites (listed as stored data / not a site).

Unpublished material (heritage reports not registered with the DPLH) available for review is also researched prior to field work and included in the heritage assessment results where relevant.

2.2 Field assessment method

The method outlined below was approved and endorsed by participating Traditional Owners.

To identify any archaeological and ethnographic heritage values within the survey areas, a pedestrian transect method was utilised. This involved the Terra Rosa heritage consultants walking the two outer transects with a handheld Garmin GPS unit and an Apple iPad, with the remainder of the heritage team spaced evenly in between. This spacing ranged between 20 m and 30 m, depending on the terrain and vegetation coverage of each area.

When areas of archaeological or ethnographic heritage value were identified, an avoidance boundary was defined around the extent of the site. Such areas were deemed **not clear** for inclusion in the proposed works.

During assessment of the work area, the Yugunga-Nya Traditional Owners were invited to give feedback regarding the project. Any relevant concerns raised were discussed amongst the heritage team and heritage management recommendations were recorded.

Upon conclusion of the field trip a debrief was conducted to offer the Traditional Owners the opportunity to discuss and comment upon the field method and the sites identified, including mitigation strategies and recommendations.

A draft report was reviewed by YMAC and the Yugunga-Nya Traditional Owners, prior to dissemination of results to KOP. The review process ensures that culturally sensitive information is appropriately indicated, and the recommendations discussed amongst the heritage team are made in accordance with the Traditional Owners' suggestions. This process provides Terra Rosa with feedback which is considered during the final editing of the report.

3 Desktop research

Desktop research results, including a search of the DPLH's AHIS, and a review of any relevant, unpublished heritage reports, are presented below.

3.1 AHIS research

The boundaries of the survey areas were searched on the Aboriginal Heritage Inquiry System (AHIS) to establish the presence or absence of registered Aboriginal sites and OHPs (status L or S) previously catalogued by the DPLH. The search revealed no registered Aboriginal sites and no OHPs within the survey areas. Status abbreviations are defined in section 2.1.

The AHIS was also searched for reports detailing the results of previous heritage surveys within the survey areas. No heritage reports are catalogued as being relevant to the survey areas.

The absence of registered Aboriginal sites and OHPs within the survey areas does not necessarily indicate an absence of heritage places or objects within the area. Any previous heritage assessments undertaken within the area may have lacked the scope to record and register identified heritage places or heritage objects. Alternatively, the lack of registered Aboriginal sites and OHPs may be resultant of the area having not been subjected to heritage assessment.

3.2 Unpublished material

One heritage survey report relevant to the survey areas was provided to Terra Rosa by KOP prior to the commencement of field work. This material is not registered with the DPLH; however, KOP has provided the report as the information contained within it is relevant to the current heritage assessment.

Quartermaine, G. and Shaw, K. 1991, *Report on a Preliminary Investigation for Aboriginal Sites in the Porlell Project Area, South-East of Meekatharra,* Report prepared for W. Richmond.

This report relates to a project located adjacent to the existing Gabanintha Mine encompassing an area of 700 hectares extending in a north-west – south-east direction of approximately 15 kilometres from Gabanintha. It is likely the Porlell project was very close to (or overlapping) Kop Ventures E51/1510-I exploration lease.

This report mentions three registered Sites, Mt Yagahong, Yakong, and Nowthanna Hill but unfortunately does not elaborate any further on any cultural values other than to state that "the potential for other Aboriginal Sites being located in the area was 'moderate' and that Aboriginal people have indicated that there may be other unrecorded ethnographic sites present in the general area" (Quartermaine and Shaw, 1991: 7).

4 Fieldwork results

The archaeological and ethnographic work area clearance heritage survey is **complete** for the Gabanintha Project area (see maps 4 - 6).

As a result of the survey:

- The surveyed areas are partially clear for work to proceed:
    - **Two not clear areas** were identified and should be avoided in order to avoid breaches of s17 of the Act; and
    - **One** exclusion zone was established on section of ridge which had ethnographic values associated with the landform.
- **40** isolated artefacts were identified (see appendix 3); and

Table 1 and maps 4 - 6, provide further clarification of these results. A spatial data package containing all results from this work area clearance assessment is appended to this report.

Table 1: Results of the work area clearance survey

'Not clear' area	Survey area	Comments
Not Clear 1	Gabanintha North Area 3	Artefact scatter identified during the survey
Not Clear 2	Gabanintha North Area 3	Relocated basal grindstone and muller identified within the survey area
Ridge Exclusion	Gabanintha North Area 3	See recommendations

Plate 2: Yugunga-Nya Traditional Owners

Plate 3: Survey team inspecting country

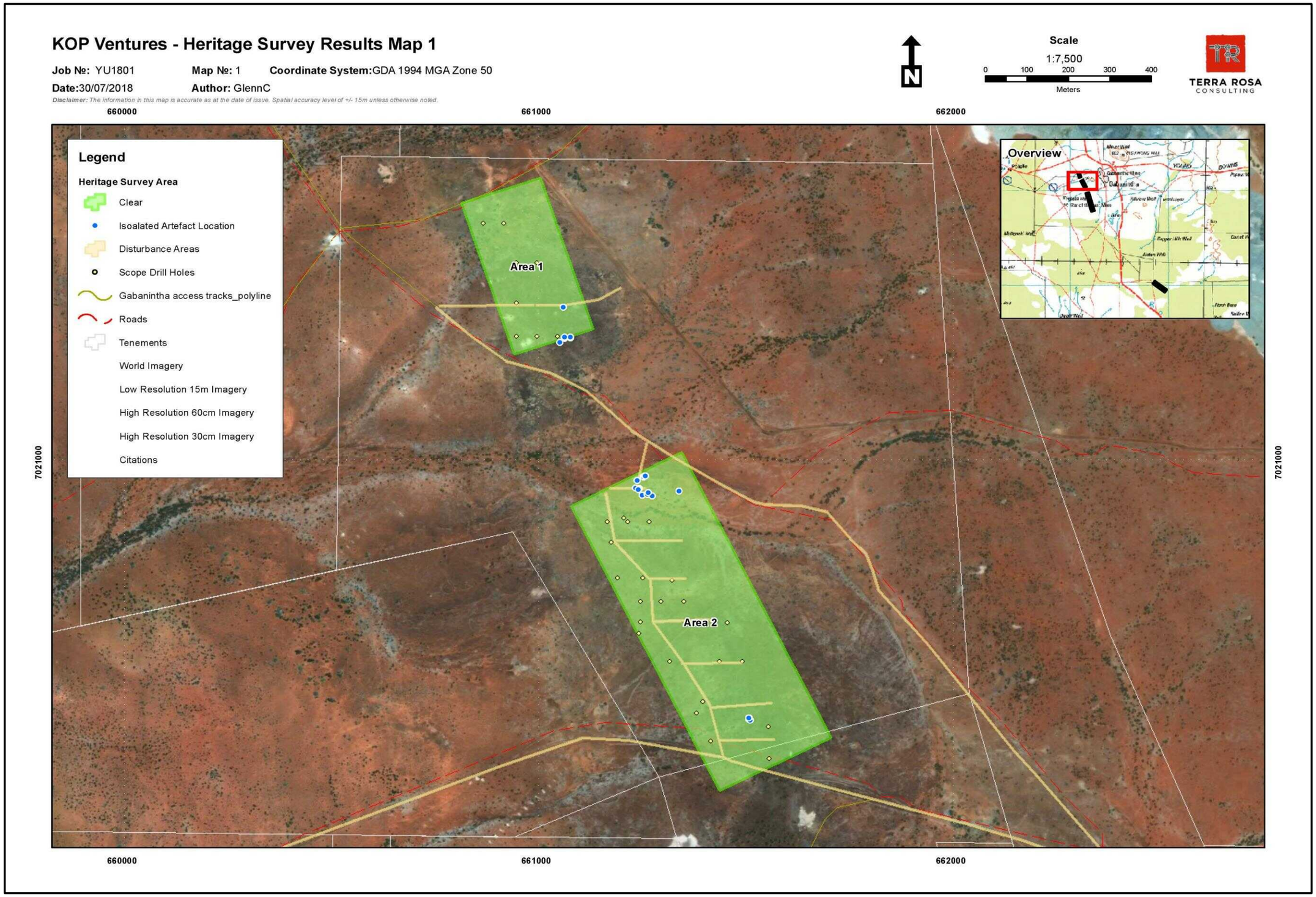
Plate 4: Survey team consulting project maps

Plate 5: Muller and Grindstone (scale 10 cm)

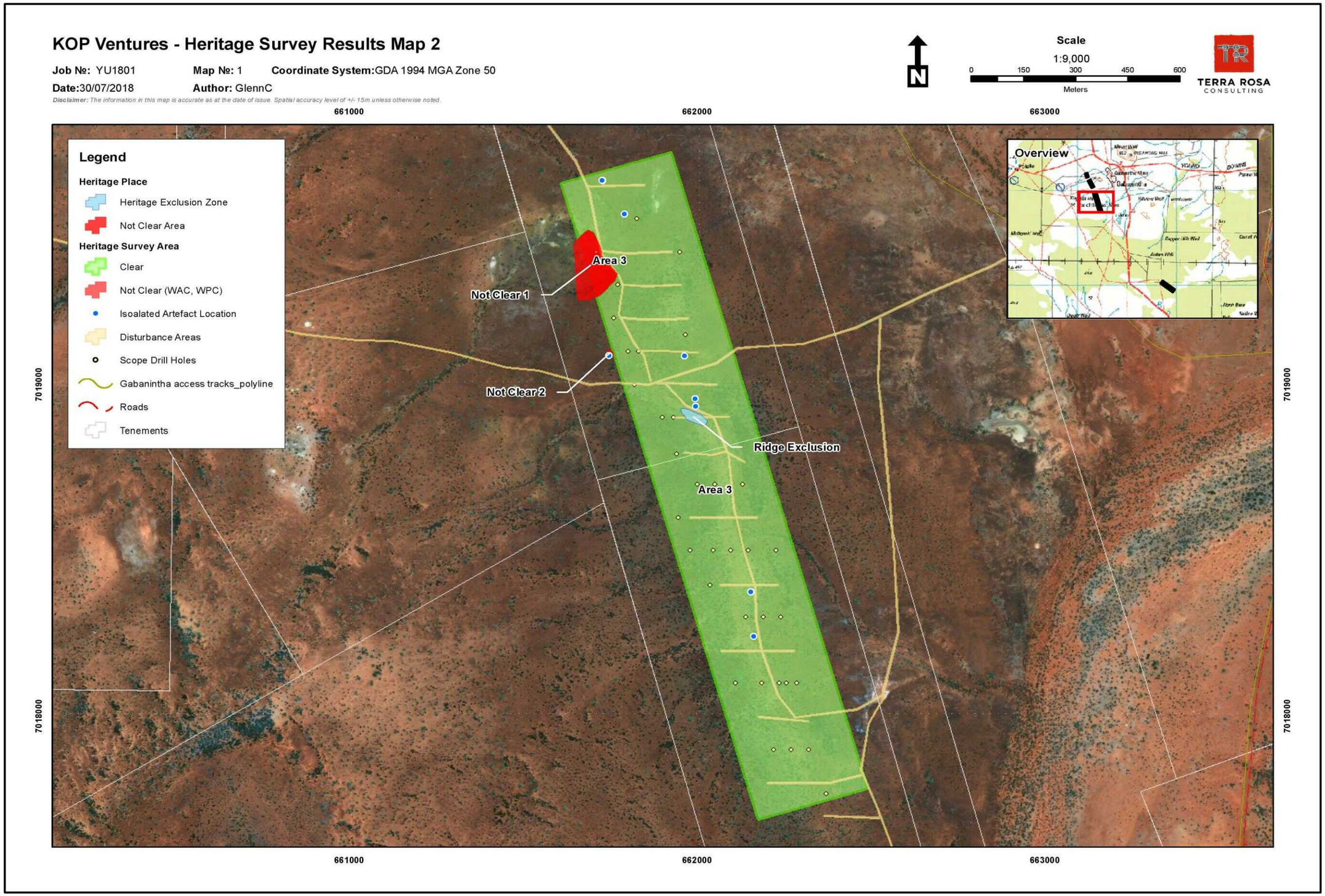
Plate 6: Survey area landscape terrain

Plate 7: Mt Yagahong

Map 4: Gabanintha North Areas 1 and 2 work area clearance results



Map 5: Gabanintha North Area 3 work area clearance results



Map 6: Gabanintha South Area 4 work area clearance results

5 Recommendations and conclusions

The following conclusions and recommendations have been approved by the Yugunga-Nya Traditional Owner representatives who were present during the fieldwork:

1 KOP is advised that the archaeological and ethnographic work area clearance of the Gabanintha Project areas are complete.

As a result of the survey:

- The survey area is partially clear for work to proceed:
  - **Two not clear areas** were identified and should be avoided in order to avoid breaches of s17 of the Act; and
  - **One** exclusion zone was established for the ridge feature in Gabanintha North Area 3.
- **40** isolated artefacts were identified (see appendix 3);

2 KOP is advised to undertake a review of previous ground disturbance activities within the Gabanintha Project area.

The Yugunga-Nya Traditional Owners request that Kop Ventures undertake a review of and map all ground disturbance activities that have previously occurred in the project area. Ground disturbance was noted to have taken place prior to this heritage survey being conducted. The findings and data of this review must be given to the Yugunga-Nya Traditional Owners representative YMAC.

3 KOP is advised that the Yugunga-Nya Traditional Owners would like KOP to minimise ground disturbance where possible.

The Yugunga-Nya Traditional Owners expressed concern about KOP causing excessive ground disturbance during their work program. They were worried about the cumulative impacts that ground disturbance can have on the land from an ethnographic and botanical perspective. Where possible KOP is advised to use existing tracks in order to minimise ground disturbance.

4 KOP is advised to avoid the ridge exclusion zone identified during the survey.

The Yugunga-Nya Traditional Owners indicated that they would like the ridge identified within Area 3 (Gabanintha North) to be avoided by future works. Furthermore, they recommend that the drill hole identified in close proximity to the ridge is rehabilitated.

The Yugunga-Nya Traditional Owners indicated that they had a cultural obligation to protect these sorts of features due to the ethno-botanical significance and recommend that wherever possible these types of features are avoided by KOP.

5 KOP is advised to limit disturbance to water ways.

The Yugunga-Nya Traditional Owners expressed concerns about the impact that drilling and water extraction would have on the local wildlife and the wellbeing of the land in general.

The Yugunga-Nya Traditional Owners do not want any drilling to occur within the major waterways. Additionally, they want KOP to ensure that the natural flow of waterways is not impeded by the proposed works.

6 KOP must develop a Cultural Heritage Management Plan to assist it better understand its responsibilities to the heritage values of the Yugunga-Nya Traditional Owners and under the Act.

The Yugunga-Nya Traditional Owners request that Kop Ventures work in consultation with the Traditional Owners to develop a Cultural Heritage Management Plan that addresses key outcomes including:

- The development of processes to ensure that appropriate heritage surveys are conducted by KOP Ventures prior to disturbing any previously undisturbed ground;
- The development of processes to ensure that areas 'not cleared' are avoided and not impacted; and
- The implementation of appropriate training for project personnel to ensure that relevant aspects of the Cultural Heritage Management Plan are properly implemented.

7 All KOP employees and contractors working within the project area must be made aware of and avoid the location and boundaries of not clear areas and be clearly instructed to restrict access and works to areas that have been surveyed.

KOP must avoid impact to the two not clear areas and the ridge exclusion zone delineated during the work area clearance survey and restrict their proposed works to the areas that have been surveyed and assessed as clear for works to proceed.

It is an offence to disturb an Aboriginal heritage place without prior written permission to do so under s16 or s18 of the Act. Financial penalties may be applied against individuals or corporations who disturb a heritage place. S18 of the Act details the statutory provisions for applications to be made to the Minister to utilise areas in which Aboriginal heritage places may exist and is subject to evaluation by the ACMC and the conditions of the Act.

8 If KOP proposes to alter the types of works or expand the exploration program, either in size or scale, beyond that cleared during the heritage survey, KOP must undertake further consultation with the Yugunga-Nya Traditional Owners.

KOP is advised that only areas subjected to a heritage assessment are clear for works to proceed. Should the program of works expand in size and scale, or should the proponent wish to conduct a different type of works, the Yugunga-Nya Traditional Owners must be engaged for a further heritage assessment.

6 Bibliography

Australia ICOMOS 2013, *The Burra Charter: The Australia ICOMOS charter for places of cultural significance 2013*, viewed 13 July 2018, <http://australia.icomos.org/wp-content/uploads/The-Burra-Charter-2013-Adopted-31.10.2013.pdf>

Commonwealth of Australia 2002, A*ustralian Natural Heritage Charter 2002*, 2nd edn, viewed 13 July 2018, <http://www.environment.gov.au/heritage/ahc/publications/commission/books/pubs/australian-natural-heritage-charter.pdf>

Commonwealth of Australia 2016, *Claimant summary – Nharnuwangga*, viewed 13 July 2018, <http://www.nntt.gov.au/searchRegApps/NativeTitleClaims/Pages/Determination_details.aspx?NNTT_Fileno=WCD2000/001>

Department of Planning, Lands and Heritage 2016, *Aboriginal Heritage Inquiry System*, viewed 13 July 2018, <http://maps.dia.wa.gov.au/AHIS2/>

Legislation

Aboriginal and Torres Strait Islander Heritage Protection Act 1984 (Commonwealth of Australia), viewed 13 July 2018, <http://www.comlaw.gov.au/Details/C2010C00807>

Aboriginal Heritage Act 1972 (Western Australia), viewed 13 July 2018, <http://www.austlii.edu.au/au/legis/wa/consol_act/aha1972164/>

Other relevant reports

Quartermaine, G. and Shaw, K. 1991, *Report on a Preliminary Investigation for Aboriginal Sites in the Porlell Project Area, South-East of Meekatharra*

Appendix 1 – Relevant sections of the Act

The below sections of the Act are referenced in the current report and included below for easy reference. A full copy of the Act is available online at http://www.austlii.edu.au/au/legis/wa/consol_act/aha1972164/.

s5 Application to places

This Act applies to —

a) any place of importance and significance where persons of Aboriginal descent have, or appear to have, left any object, natural or artificial, used for, or made or adapted for use for, any purpose connected with the traditional cultural life of the Aboriginal people, past or present;

b) any sacred, ritual or ceremonial site, which is of importance and special significance to persons of Aboriginal descent;

c) any place which, in the opinion of the Committee, is or was associated with the Aboriginal people and which is of historical, anthropological, archaeological or ethnographical interest and should be preserved because of its importance and significance to the cultural heritage of the State;

d) any place where objects to which this Act applies are traditionally stored, or to which, under the provisions of this Act, such objects have been taken or removed.

s6 Application to objects

1) Subject to subsection (2a), this Act applies to all objects, whether natural or artificial and irrespective of where found or situated in the State, which are or have been of sacred, ritual or ceremonial significance to persons of Aboriginal descent, or which are or were used for, or made or adapted for use for, any purpose connected with the traditional cultural life of the Aboriginal people past or present.

2) Subject to subsection (2a), this Act applies to objects so nearly resembling an object of sacred significance to persons of Aboriginal descent as to be likely to deceive or be capable of being mistaken for such an object.

    a. This Act does not apply to a collection, held by the Museum under section 9 of the Museum Act 1969, which is under the management and control of the Trustees under that Act.

3) The provisions of Part VI do not apply to an object made for the purpose of sale and which —

    a. is not an object that is or has been of sacred significance to persons of Aboriginal descent, or an object so nearly resembling such an object as to be likely to deceive or be capable of being mistaken for the same; or

    b. is an object of the kind referred to in paragraph (a) that is disposed of or dealt with by or with the consent of the Minister.

s15 Report of findings

Any person who has knowledge of the existence of any thing in the nature of Aboriginal burial grounds, symbols or objects of sacred, ritual or ceremonial significance, cave or rock paintings or engravings, stone structures or arranged stones, carved trees, or of any other place or thing

to which this Act applies or to which this Act might reasonably be suspected to apply shall report its existence to the Registrar, or to a police officer, unless he has reasonable cause to believe the existence of the thing or place in question to be already known to the Registrar.

s17 Offences relating to Aboriginal sites

A person who –

a. excavates, destroys, conceals or in any way alters any Aboriginal site; or
b. in any way alters, damages, removes, destroys, conceals, or who deals with in a manner not sanctioned by relevant custom or assumes the possession, custody or control of any object on or under an Aboriginal site,

commits an offence unless he is acting with the authorisation of the Registrar under section 16 or of the Minister under section 18.

s39 Functions of the Committee

1. The functions of the Committee are —
    a. to evaluate on behalf of the community the importance of places and objects alleged to be associated with Aboriginal persons;
    b. where appropriate, to record and preserve the traditional Aboriginal lore related to such places and objects;
    c. to recommend to the Minister places and objects which, in the opinion of the Committee, are, or have been, of special significance to persons of Aboriginal descent and should be preserved, acquired and managed by the Minister;
2. In evaluating the importance of places and objects the Committee shall have regard to —
    1. any existing use or significance attributed under relevant Aboriginal custom;
    2. any former or reputed use or significance which may be attributed upon the basis of tradition, historical association, or Aboriginal sentiment;
    3. any potential anthropological, archaeological or ethnographical interest; and
    4. aesthetic values.
3. Associated sacred beliefs, and ritual or ceremonial usage, in so far as such matters can be ascertained, shall be regarded as the primary considerations to be taken into account in the evaluation of any place or object for the purposes of this Act.

Appendix 2 – Artefact recording codes

Artefact Type: The following abbreviations for artefact types have been employed in this report.

ADB	*Burren adze*	**FF**	*Flake fragment*	**MUF**	*Muller fragment*
ADT	*Tula adze*	**GM**	*Geometric microlith*	**RUP**	*Re-touched/Utilised piece*
AF	*Angular fragment*	**HS**	*Hammer stone*	**SRF**	*Scraper fragment*
BL	*Blade*	**LBFL**	*Longitudinally broken flake – left*	**SPC**	*Single platform core*
BGF	*Basal grinding fragment*	**LBFM**	*Longitudinally broken flake – medial*	**SR**	*Scraper*
BGS	*Basal grindstone*	**LBFR**	*Longitudinally broken flake – right*	**TBFD**	*Transversely broken flake – distal*
CF	*Core fragment*	**LTBF**	*Longitudinally / transversely broken flake*	**TBFM**	*Transversely broken flake – medial*
CT	*Core tool*	**MPC**	*Multi-platform core*	**TBFP**	*Transversely broken flake – proximal*
F	*Complete flake*	**MU**	*Muller*	**NA**	*Not applicable/not present*

Lithology: This describes the material from which the artefact was manufactured. The following abbreviations have been employed in this report.

B	*Bone*	**DOL**	*Dolerite*	**MUD**	*Mudstone*
BS	*Basalt*	**GR**	*Granite*	**SIL**	*Silcrete*
BIF	*Banded ironstone formation*	**IS**	*Ironstone*	**SL**	*Siliceous limestone*
CA	*Canga*	**JS**	*Jasper*	**QI**	*Quartzite*
CH	*Chert*	**KAL**	*Kaolinite*	**QZ**	*Quartz*
CQ	*Crystal quartz*	**LM**	*Limestone*		
CY	*Chalcedony*	**LT**	*Laterite*		

Retouch and Usewear: This describes the visible signs used to identify tools and tool use, specifically the working of materials to form a tool or refine an existing tool and perforations and other wear resulting from tool use. The following abbreviations have been employed in this report.

AM	*All margins*	**DM**	*Distal margin*	**LLM**	*Left lateral margin*
PM	*Proximal margin*	**RLM**	*Right lateral margin*		

Appendix 3 – Isolated artefacts

Typology	Material	Easting	Northing
F	CH	661242	7020954
F	SIL	661255	7020917
F	SIL	661258	7020963
LBFR	CH	661258	7020964
F	SIL	661261	7020966
F	CH	661262	7020966
F	SIL	661262	7020966
BGF	BIF	661343	7020928
F	QZ	661512	7020354
F	CH	661515	7020352
LTBF	CH	661512	7020358
F	IS	661266	7020920
F	IS	661267	7020919
F	SIL	661279	7020915
SPC	QZ	661269	7020924
CF	CH	661239	7020935
F	CH	661247	7020934
F	DOL	661247	7020933
F	DOL	661245	7020931
F	CH	661056	7021300
F	SIL	661081	7021312
F	QZ	661081	7021313
BL	CH	661067	7021311
F	QZ	661067	7021312
TBFP	QZ	661067	7021312
SPC	SIL	661067	7021313
F	CH	661064	7021389
CH	SIL	661791	7019513
LBFL	SIL	662162	7018240
F	QZ	662155	7018374
TBFM	DOL	661996	7018933
F	DOL	661994	7018956
F	CY	661964	7019085
F	QZ	661728	7019614
F	CY	661728	7019615
SR	CY	661727	7019615
BGF	GR	661746	7019087
MUF	GR	661746	7019086
SPC	QZ	668875	7010074
F	CH	668656	7010136