

Mesa H
Ghost Bat, *Macroderma gigas* - Contextual Study
September 2017

Prepared for
Robe River Mining Co. Pty Ltd



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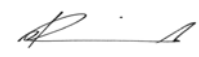
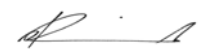
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Abbreviations and Definitions

Abbreviation	Definition
Adit	The entrance to a mine shaft that is horizontal or near horizontal.
Bat Call WA	Bat Call WA Pty Ltd
Biologic	Biologic Environmental Survey
Biota	Biota Environmental Services
BOM	Bureau of Meteorology
cm	Centimetres
Contextual survey area	The survey area between the Mesa A Operation and Mesa H deposit that the contextual field survey was completed within (94,582 ha)
Desktop survey area	A 30 km radius around the Mesa H survey area that the desktop assessment was undertaken
EPBC Act	<i>Environment Protection and Biodiversity Conservation Act 1999</i>
Fecundity	The reproductive rate of an organism or population
g	Grams
GDA	Geocentric Datum of Australia
GIS	Geographical Information System
HSE	Health, safety and environment
IBRA	Interim Biogeographic Regionalisation for Australia
km	Kilometres
m	Metres
Mesa H survey area	The Mesa H development envelope (4,930 ha)
Midden	A collection of scats and animal remains that indicate a frequently used feed site
mm	Millimetres
MNES	Matter of National Environmental Significance
Mt	Mount
Robe River Mining	Robe River Mining Co Pty Ltd
Scat	Faecal matter
SM2	SM2BAT SongMeter bat detectors (Wildlife Acoustics Inc USA)
WC Act	<i>Wildlife Conservation Act 1950</i>
°C	Degrees Celsius

Executive Summary

Astron was commissioned by Robe River Mining Co Pty Ltd to undertake a contextual analysis for the conservation significant Ghost Bat (*Macroderma gigas*) within the vicinity of the Mesa H survey area. The Ghost Bat has recently been upgraded to Vulnerable under the *Environment Protection and Biodiversity Conservation Act 1999* and Schedule 3 under the *Wildlife Conservation Act 1950*. The Mesa H survey area is approximately 4,930 ha and encompasses potential future mine and infrastructure. The contextual survey area is approximately 94,582 ha and encompasses areas west of Mesa H through to the Mesa A Operation. The purpose of this assessment is to identify significant habitats for the Ghost Bat in the vicinity of the Mesa H survey area and to discuss this habitat in a local and regional context.

The first stage of the assessment involved a desktop review. This review combined data from database searches and previous surveys from within a 30 km radius of the Mesa H survey area. The review indicated that 79 Ghost Bat records, including six diurnal roosts (five confirmed and one potential) and three maternal roosts (one confirmed and two potential) have been recorded within 30 km of the Mesa H survey area (the desktop survey area). This includes two diurnal roost sites that have been previously identified within the Mesa H survey area.

The second stage of the assessment was a field survey involving mapping of potential habitat and targeted survey for the Ghost Bat within the contextual survey area. Survey effort was concentrated to the west of Mesa H, specifically along the Robe Valley, as this area lacked recent Ghost Bat records/data and the Robe Valley to the east of Mesa H had been recently surveyed. Habitats of the contextual survey area were assessed and mapped on their ability to support Ghost Bats, in particular the presence of roosting sites, feed cave sites and quality foraging sites. Habitats were mapped as:

- High quality habitat: potential/confirmed roosting habitat.
- Moderate quality habitat: potential/confirmed nocturnal feeding roosts and quality foraging habitat.
- Low quality habitat: widespread foraging habitat.

The vast majority of the contextual survey area (90,425.3 ha and 95.6%) contains habitat considered as being of low quality habitat for Ghost Bats, including approximately 4,716.1 ha within the Mesa H survey area. A total of 2,531.1 ha (2.7%) of the contextual survey area contains habitat considered as being of moderate quality habitat for Ghost Bats, including approximately 270.4 ha within the Mesa H survey area. A total of 256 ha (0.3%) of the contextual survey area contains habitat considered as being of high quality habitat for Ghost Bats, including only 4.1 ha within the Mesa H survey area.

During the field survey an additional 26 nocturnal feeding roosts, four diurnal roosts and two potential maternal roosts were recorded in the contextual survey area; however, no new roost sites were located in the Mesa H survey area. Since the field survey was completed, further targeted cave assessments have reassessed some of these caves and it is considered that only four diurnal roosts (three confirmed and one potential) and one potential maternal roost occurs within the contextual survey area. No new roosts were recorded within the Mesa H survey area.

Although high quality habitat is present within the Mesa H survey area, the majority of the high quality habitat (98.4%) and roost sites are located in areas outside the Mesa H survey area. The most significant Ghost Bat habitats in the contextual survey area are located within the gorges on the

lower Robe Valley Mesas, Mesa G and the gorge system along the Buckland Hills to the south of Mesa H, although the only confirmed maternal roost occurs at Mesa F. The gorge to the south of Mesa H was too large to properly survey within the scope of this assessment and only received a preliminary assessment. A maternal roost and two diurnal roosts were identified, however based on the geology and size of the gorge system, more roost sites are expected.

The land systems mapping for the contextual survey area shows relationships between the Robe and Newman systems and the presence of both diurnal and maternal roost sites. Within the contextual survey area approximately 96% of the Newman system and 75% of the Robe system are located outside of the Mesa H survey area, indicating that both of these land systems are well represented locally and are widespread throughout the Pilbara.

The number of Ghost Bat records from the desktop assessment and field survey suggest that the Ghost Bat is common and widespread in small numbers within the Robe Valley and the vicinity of Mesa H. The contextual survey area occurs in the Hamersley subregion where Ghost Bats are widespread but occur in small numbers (approximately 350 individuals) and relatively few breeding records exist. Little is known about this species' roost site fidelity, seasonal movements or local population estimates in the Pilbara, let alone in the contextual survey area or the roost sites identified in this assessment.

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1 Introduction

1.1 Project Background

Robe River Mining Co. Pty. Ltd (the Proponent), is evaluating the potential development of the Mesa H deposit (Mesa H) located adjacent to the Mesa J Operation and approximately 13 km to the southwest of the town of Pannawonica. A key component of the pre-feasibility and feasibility studies being undertaken is the environmental surveys which are required to inform the environmental assessment process for the potential development of the Mesa H deposit (Figure 1). Astron Environmental Services (Astron) has been commissioned to undertake a number of these environmental surveys.

This report presents the outcome of a contextual analysis of conservation significant fauna, specifically the Matter of National Environmental Significance (MNES) species the Ghost Bat (*Macroderma gigas*), within the vicinity of the Mesa H survey area. The status of the Ghost Bat has recently been upgraded to Vulnerable under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) and Schedule 3 under the *Wildlife Conservation Act 1950* (WC Act).

1.2 Scope and Objectives

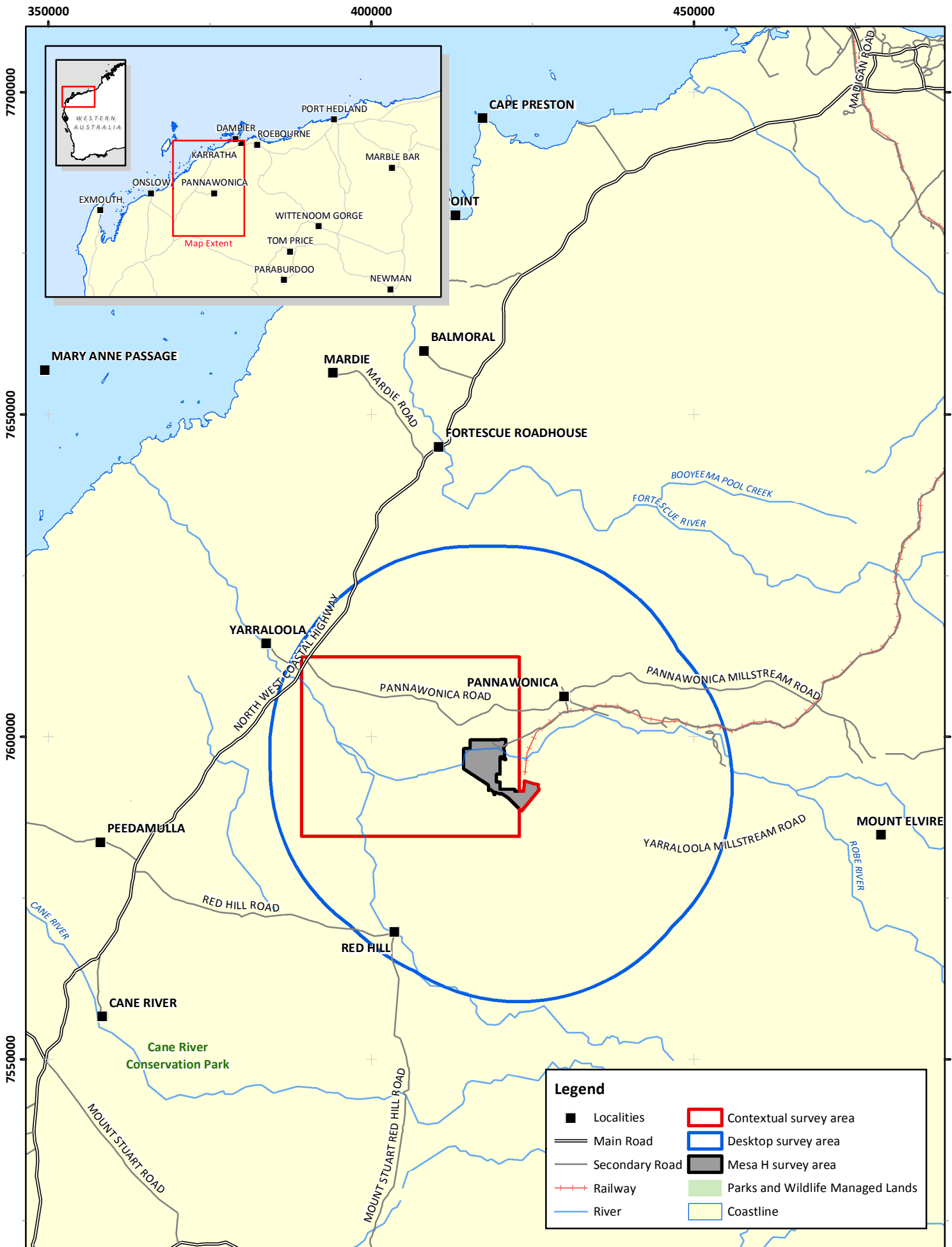
The purpose of this assessment is to identify significant habitats for the Ghost Bat in the vicinity of the Mesa H survey area and to discuss this habitat in a local and regional context.

To obtain a contextual overview of this species within the vicinity of the Mesa H survey area, Astron undertook a desktop review and targeted fauna survey for the Ghost Bat. The desktop assessment combined data from database searches and previous surveys from within a 30 km radius of the Mesa H survey area (desktop survey area; Figure 1).

A number of recent biological surveys have been completed within the Robe Valley, in particular at Mesa H and areas to the east (Bungaroo, Middle Robe). These assessments have provided data on the Ghost Bats presence and habitat within these areas. The field component of this survey concentrated on the Robe Valley to the west of Mesa H (contextual survey area) where recent Ghost Bat specific data were lacking. The contextual survey area is approximately 94,582 ha and covers the Robe Valley between the Mesa A Operation (Mesa A) and Mesa H (Figure 1).

Astron conducted the contextual study in accordance with the following:

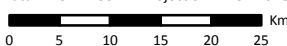

- Position Statement No. 3 (Environmental Protection Authority 2002)
- Guidance Statement No. 56 (Environmental Protection Authority 2004)
- Technical Guide – Terrestrial Vertebrate Fauna Surveys for Environmental Impact Assessment (Environmental Protection Authority and Department of Environment and Conservation 2010)
- Survey Guidelines for Australia’s Threatened Bats (Department of the Environment, Water, Heritage and the Arts 2010).



Robe River Mining Co. Pty Ltd
 Mesa H - Ghost Bat, *Macroderma gigas* - Contextual Study



Figure 1: Survey area regional location

Author: J. Trainer	Date: 31-08-2017	Datum: GDA 1994 - Projection: MGA Zone 50  
Drawn: C. Dyde	Figure Ref: 14269-16BIDR-1RevB_170831_Fig01	

2 Environmental Context

2.1 Geology and Soils

The contextual survey area occurs on the Hamersley Basin which overlies the Archaean Pilbara Craton and comprises of mafic and felsic volcanics, shale, siltstone, sandstone and conglomerate, as well as dolomite and banded iron formation. The area is extensively deformed with the rocks being folded and faulted (van Vreeswyk et al. 2004). The surface geology of the contextual survey area comprises 13 different geological units (Stewart et al. 2008) (Table 1). Geological mapping of the contextual survey area and surrounds is presented in Figure A.1 (Appendix A).

Table 1: Geological units of the contextual survey area.

Geological name	Label	Area (ha) within the contextual survey area
Marra Mamba Iron Formation: chert, ferruginous chert, jaspilite, banded iron formation, minor shale, siltstone, mudstone	Achm	2,419
Mount McRae Shale and Mount Sylvia Formation: interbedded shale, chert, banded iron-formation	Ashm	4,640
Jeerinah Formation: shale, sandstone, siltstone, mudstone, dolomite, local microbanded chert, jaspilite, conglomerate; fine-grained massive rhyolite; mafic tuff with local accretionary lapilli and agglomerate; thin basalt/dolerite and andesitic basalt flows	Awfj	476
Robe Pisolite: pisolitic, oolitic and massive limonite, goethite and hematite deposits containing fossil wood fragments; iron ore	Czlr	9,777
Nanutarra Formation: shale, ferruginous and glauconitic quartz sandstone, siltstone, micaceous siltstone; poorly sorted conglomerate	Kswn	9,345
Boolgeeda Iron Formation: fine-grained, finely laminated, dark grey-brown to black flaggy iron-formation, minor chert, jaspilite, shale	Lchb	1,445
Brockman Iron Formation: banded iron-formation, chert, mudstone and siltstone	Lchk	7,437
Weeli Wollie Formation: banded iron-formation (commonly jaspilitic), mudstone, siltstone; common interlayered metadoleritic sills	Lchw	87
Woongarra Rhyolite: rhyolite, rhyodacite, rhyolitic volcanoclastic breccia and banded iron formation	Lfhw	1,581
Wyloo Group: shale, sandstone, greywacke, dolomite, phyllite, quartz-mica schist, felsic volcanic rocks, chert, chert breccia, mudstone, siltstone, conglomerate	Lsy	8,449
Ashburton Formation: mudstone interbedded with sandstone and dolomite; intruded by sills	Lsya	1,049
Alluvium 38485: channel and flood plain alluvium; gravel, sand, silt, clay, locally calcreted	Qa	14,524
Colluvium 38491: colluvium, sheetwash, talus; gravel piedmonts and aprons over and around bedrock; clay-silt-sand with sheet and nodular kankar; alluvial and aeolian sand-silt-gravel in depressions and broad valleys in Canning Basin; local calcrete, reworked laterite	Qrc	33,352

Soils of the contextual survey area are typically shallow and of poor quality; soils in the area of the Mesa A Operation are pisolitic limonite gravels, whilst the river landform is characterised by sand, gravel, pebbles and stones. The drainage zones surrounding are red shallow loams (van Vreeswyk et al. 2004).

2.2 Surface Water and Hydrology

The Robe River is considered a seasonal watercourse. It intersects the contextual survey area, flowing in an east-west orientation. A number of permanent pools in the river were observed within the contextual survey area. Numerous creeks and smaller drainage lines stem from the Robe River; drainage lines were also noted down the gullies of the surrounding mesas. There are no regionally significant wetlands in proximity.

2.3 Land Systems

Land systems of the Western Australian rangelands were mapped by the Department of Agriculture and Food to outline their distributions and provide comprehensive descriptions of biophysical resources, including soil and vegetation condition. A total of 102 land systems occur in the Pilbara bioregion covering 181,723 km², of which 12 occur in the contextual survey area (Table 2). The distribution of these land systems within the contextual survey area is shown in Figure A.2 (Appendix A).

Table 2: Distribution of land systems within the contextual survey area and Pilbara bioregion (van Vreeswyk et al. 2004).

Land system	Total area within Pilbara bioregion (ha)	Total area within the contextual survey area (ha)	Proportion within the contextual survey area (%)
Boolgeeda: Stony lower slopes and plains below hill systems supporting hard and soft spinifex grasslands and mulga shrublands	961,847	16,779	1.7%
Cane: Alluvial plains and flood plains supporting snakewood shrublands, soft and hard spinifex grasslands and tussock grasslands	81,798	496	0.6%
Capricorn: Rugged sandstone hills, ridges, stony footslopes and interfluves supporting low acacia shrublands or hard spinifex grasslands with scattered shrubs	698,396	3,508	0.5%
Marallina: Sandy surfaced alluvial plains supporting soft spinifex grasslands and minor hard spinifex and tussock grasslands	41,825	1,269	3%
McKay: Hills, ridges, plateaux remnants and breakaways of meta sedimentary and sedimentary rocks supporting hard spinifex grasslands	425,967	1,881	0.4%
Nanutarra: Low mesas and hills of sedimentary rocks supporting soft and hard spinifex shrubby grasslands	77,423	14,198	18.3%
Newman: Rugged jaspilite plateaux, ridges and mountains with hard spinifex	1,994,339	15,898	0.8%
River: Active flood plains, major rivers and banks supporting grassy eucalypt woodlands, tussock grasslands and soft spinifex grasslands	481,994	5,553	1.1%
Robe: Low limonite mesas and buttes supporting soft spinifex (and occasionally hard spinifex) grasslands	128,680	10,967	8.3%
Sherlock: Stony alluvial plains supporting snakewood shrublands with patchy tussock grasses and spinifex grasslands	38,662	10,403	26.9%
Stuart: Gently undulating stony plains supporting hard and soft spinifex grasslands and snakewood shrublands	276,800	4,146	1.5%
Urandy: Stony plains, alluvial plains and drainage lines supporting shrubby soft spinifex grasslands	132,039	9,484	7.2%
TOTAL	5,339,770	94,582	N/A

2.4 Vegetation and Flora

Pre-European vegetation has been mapped across the Pilbara region at a scale of 1:1,000,000 (Beard 1975). The contextual survey area is located in the Stuart Hills and Hamersley Plateau physiographic units of the Fortescue Botanical District (Figure A.3, Appendix A). These physiographic units are described as:

Hamersley: a compact unit defined by the outcropping of jaspilite and dolomite, with some shale, siltstone and volcanics. Vegetation is described as:

- ranges – tree steppe of *Eucalyptus brevifolia* (likely to represent *E. leucophloia*) over *Triodia wiseana* hummock grasslands
- valley plains – mulga (*Acacia aneura* complex) low woodlands, or tussock grasslands on cracking clay soils
- basalt hills – mosaic of mulga low woodland and *Acacia pyrifolia* and *Triodia* species shrub steppe.

Stuart Hills: this unit consists mostly of plains, gently undulating pediplains extending out from Breakaways and residuals capped by Robe pisolites, and stony hills and steeply dissected pediments on fine-grained sandstone, shale and dolomite. Vegetation is described as:

- hills and plains – *Triodia wiseana* and *T. basedowii* hummock grasslands with sparse shrubs, particularly *Acacia bivenosa*
- Drainage lines – *Corymbia hamersleyana* and *C. candida* occur occasionally, with *Senna* species and ephemerals
- major rivers – *Eucalyptus camaldulensis* and *Acacia citrinoviridis* along river and mulga low woodland on river flats and tributaries.

Nine pre-European vegetation units, 29, 82, 93, 157, 583, 603, 605, 609 and 620 (Shepherd, Beeston, and Hopkins 2002), are associated with the contextual survey area:

29: 'Sparse low woodland; mulga, discontinuous in scattered groups,

82: 'Hummock grasslands, low tree steppe; snappy gum over *Triodia wiseana*',

93: 'Hummock grasslands, shrub steppe; kanji over soft spinifex',

157: 'Hummock grasslands, grass steppe; hard spinifex, *Triodia wiseana*',

583: 'Hummock grasslands, sparse shrub steppe; kanji and *Acacia bivenosa* over hard spinifex *Triodia basedowii* and *T. wiseana*',

603: 'Hummock grasslands, sparse shrub steppe; *Acacia bivenosa* over hard spinifex',

605: 'Hummock grasslands, shrub steppe, *Acacia pachycarpa* and waterwood over soft spinifex',

609: 'Mosaic: Hummock grasslands, open low tree steppe; bloodwood with sparse kanji shrubs over soft spinifex/Hummock grasslands, open low tree steppe; snappy gum over *Triodia wiseana*' and

620: 'Hummock grasslands, shrub steppe; snakewood over soft spinifex.

Table 3 summarises the current and pre-European extent of these nine vegetation units in the Pilbara and the contextual survey area.

Table 3: Extent of pre-European vegetation in the contextual survey area (Government of Western Australia 2014).

Vegetation association	Extent in the contextual survey area (ha)	Current extent in Pilbara bioregion (ha)
29	11,943	1,132,939
82	14,710	2,550,898
93	6,315	3,038,471
157	25	198,409
583	11,793	243,111
603	13,999	55,764
605	24,133	114,115
609	2,278	72,765
620	9,385	15,539

2.5 Ghost Bat, *Macroderma gigas*

2.5.1 Distribution and Conservation Status

The status of the Ghost Bat (*Macroderma gigas*) has been recently upgraded to Vulnerable under the Commonwealth EPBC Act and Schedule 3 under the Western Australian WC Act. This is due to the fact that the Ghost Bat has undergone a substantial decline across its distribution, including an estimated decline greater than 30% in the Pilbara population (Department of the Environment and Energy 2016).

Ghost Bats occur in the Pilbara (Armstrong and Anstee 2000; McKenzie and Bullen 2009), Kimberley including several islands (McKenzie and Bullen 2012), northern sections of the Northern Territory (including Groote Eylandt), and coastal and near coastal eastern Queensland from Cape York to near Rockhampton (Richards et al. 2008). Burbidge et al. (2009), using modern, historical and subfossil data, found that the Ghost Bat occurred in 37 of Australia's 85 bioregions, and that it was extinct in 12 bioregions.

The Pilbara Ghost bat population is estimated at 1,500 to 2,000 based on recently published estimates. This includes estimates of approximately 600 (N.L. McKenzie pers. comm. in McKenzie and Hall 2008); approximately 1,200 (Armstrong and Anstee 2000) and Robert Bullen's unpublished database summarising data from a range of surveys carried out in recent years by Pilbara mining companies, including Rio Tinto and other organisations (summarised in Department of the Environment and Energy (2016)). These recent data (estimates less than 15 years old) cover the entire Pilbara bioregion. Current population estimates in the Hamersley and Chichester subregions are approximately 350 and 1,500 respectively (author's unpublished database summarised in Department of the Environment and Energy (2016)).

Ghost bat breeding populations are known from a small number of maternal roosts in the Pilbara, the largest of these colonies are in abandoned mines in the Chichester subregion and number up to several hundred (Armstrong and Anstee 2000). There is no known large, permanent maternal roost in the Hamersley subregion (Bat Call WA 2016a). Hamersley Range populations are between 5 and 25 individuals in local groups (Bat Call WA 2016a). Multiple records including visual observations and the presence of cave middens of the Ghost bat have been detected on the various mesas within the Robe River valley (Bat Call WA 2016a).

2.5.2 Relevant Biology/Ecology

The Ghost Bat is the largest microchiropteran bat in Australia, weighing up to 150 g and having a wingspan of 60 cm. It is Australia's only carnivorous bat. Its fur is light to dark grey above and paler below (Plate 1). It has long ears which are joined together, large eyes, a simple noseleaf and no tail (Richards et al. 2008). The Ghost Bat occurs in a wide range of habitats from the arid Pilbara to tropical savanna woodlands and rainforests and has a broad diet comprising small mammals including other bats, birds, reptiles, frogs and large insects (Boles 1999; Schulz 1986; Pettigrew et al. 1986).

In the Pilbara, pregnancy in Ghost Bats has been recorded from August until September and births occurred from October until December (Armstrong and Anstee 2000). Hoyle et al. (2001), who studied the southernmost known colony in Queensland, found that female bats gave birth to a single young in late spring and females bred at age two to three years. At Mount Etna, Toop (1985) found that pregnant females congregated in the warmest caves and gave birth over a month commencing in mid-October. As caves became warmer as summer progressed, some mothers shifted the young to other caves. Juvenile bats commenced flying at seven weeks with all young capable of flight by the end of January. Ghost bats disperse widely when not breeding, but concentrate in relatively few maternal roost sites when breeding. Few of these sites are known (Worthington Wilmer 2012; Richards et al. 2008), and most are not protected or managed.

Bat Call WA (2016a) describes the roosting requirements of Ghost Bats: "For Ghost Bats to persist the bats need an 'apartment block' of roosting opportunities, at least one deep cave with characteristics of a maternal roost, multiple caves/shelters and overhangs in close proximity offering nocturnal feeding and refuge opportunities, a productive set of gullies and gorges locally, and a productive foraging area within a 5 km to 10 km radius, usually including a good quality riparian line and appropriate protection from human interference."

Ghost Bats hunt their prey in two primary ways. They hunt birds and bats at cave entrances and elsewhere "air-to-air" by swooping from above or from a perch (Bat Call WA 2016a). They also hunt ground level prey in their target food size range by dropping onto the prey from a perch, either tree branch or rock outcrop (Bat Call WA 2016a). Their diet includes small mammals such as other bats, birds, reptiles, frogs and large insects. The proportion of food items in the diet varies with availability and reported foraging areas vary from a few km to over 10 km from the roost cave (Bat Call WA 2016a).

Roost sites include caves, rock crevices and disused mine adits. In the Hamersley Range in the Pilbara, preferred roosting habitat appears to be caves beneath bluffs of low rounded hills composed of Marra Mamba geology, and larger hills of Brockman Iron Formation; in the eastern Pilbara caves beneath bluffs composed of Gorge Creek Group geology and granite rockpiles are preferred (Armstrong and Anstee 2000). Ghost Bats use three types of roost regularly, these being nocturnal roosts or feeding sites, diurnal or diurnal roosts that may be permanent or semi-permanent sites and maternal roosts that are diurnal roosts with the range of characteristics allowing regular or permanent occupancy:

- Nocturnal roosts or feeding sites are only used at night, either habitually or for transitory visits. They are typically shallow caves and shelters that are well lit during the day. They are often high in the strata and may be well or poorly insulated from the elements. They usually contain guano scatters and/or midden(s) of various sizes containing guano and food scraps.
- Diurnal roosts are generally deep, complex caves or disused mines that contain domed ceilings, fissures or passages which create a stable microclimate. They typically have one or

more large chambers at or beyond the twilight area with additional fissures or chambers at the rear in the fully dark regions. They have a minimum roof height in the chambers of 2 m to 3 m providing protection from attack by terrestrial predators. They are often at mid-levels or lower in the strata and are well insulated overhead providing a stable temperature environment (McKenzie and Bullen 2009; Armstrong and Anstee 2000; Hall et al. 1997; Leitner and Nelson 1967). They typically contain multiple scat piles and middens of guano and food remains that include feathers and skeletal materials.

- Maternal roosts are diurnal roosts that provide additional features listed above that are able to support a reproducing population. These features usually include an interior chamber that is rising toward the rear thereby trapping warmer and more humid air at the top allowing suitable conditions to form during the period when reproductive females and pups are present (Armstrong and Anstee 2000; Churchill 1991; Churchill and Helman 1990; Pettigrew et al. 1986).

2.5.3 Threats

Threats to the Ghost Bat have been outlined by Woinarski et al. (2014) and are summarised in Table 4.

Table 4: Summary of threats to the Ghost Bat (Woinarski, Burbidge, and Harrison 2014).

Threat factor	Consequence rating	Extent over which threat may operate	Evidence base
Disturbance of (human visitation at) maternal roost sites	Severe	Moderate	Ghost Bats easily disturbed and may abandon sites where disturbance occurs (K. Armstrong pers. comm., cited in. Woinarski et al. 2014).
Habitat loss: destruction of, or disturbance to, roost sites (and nearby areas) due to mining	Moderate-severe	Moderate	Mt Etna and surrounding area contains maternal roost sites; some maternal roost sites destroyed; Mt Etna now protected in a national park and visited by tourists; declines reported at Mt Etna following mining (Worthington Wilmer 2012); Mount Consider cave west of Cairns destroyed; other sites still vulnerable; most Pilbara roosts are vulnerable to iron ore mining and the deterioration and disturbance of old underground gold and copper mines.
Collision with fences, especially those with barbed wire	Moderate	Moderate	Ghost Bats have low fecundity and survival (Hoyle et al. 2001), often fly at about fence height and substantial numbers are known to be killed when colliding with fencing wire (McKenzie and Bullen 2009; Armstrong and Anstee 2000).
Collapse or reworking of old mine adits	Minor-moderate	Minor-moderate	Many of the known nursery roosts are in old mine workings that are collapsing, flooding or subject to disturbance (Armstrong 2001; Hall et al. 1997) e.g. the Pine Creek colony roosts in an adit that is in danger of collapse (Richards et al. 2008).
Contamination by mining residue at roost sites	Moderate	Moderate	Several roosting sites in old mines have high levels of pollutants.

Threat factor	Consequence rating	Extent over which threat may operate	Evidence base
Disease	Unknown	Unknown	A possible herpes type virus appears to be affecting the Mt Etna population, but pathology yet to be confirmed (J. Augusteyn pers. comm., cited in Woinarski et al. 2014).

3 Methodology

3.1 Desktop Assessment

Database searches were conducted to identify previous Ghost Bat records within the desktop survey area, a 30 km radius from Mesa H (Table 5). The 30 km radius search area was used as it encompasses all of the recent survey work completed within the Robe Valley including the contextual survey area.

Table 5: Database searches and regional literature.

Source		Information	Administrating agency
Databases	<i>NatureMap</i> (Department of Parks and Wildlife 2016a)	List of species recorded, including threatened fauna	Department of Parks and Wildlife
	Threatened Species Database (Department of Parks and Wildlife 2016b)	List and details of conservation significant fauna species recorded in vicinity of survey area	
Regional literature	Stewart, Sweet et al. (2008)	Surface geology of Australia	N/A
	Beard (1975)	Vegetation associations of the Pilbara region	N/A
	Van Vreeswyk, Payne et al. (2004)	Land Systems (geology, soils, and topography) and vegetation associations of the Pilbara region	N/A
	Previous survey reports and GIS data	List of fauna, particularly conservation significant species, previously recorded within or adjacent to study area	Various consultant reports

Relevant fauna surveys that have previously been commissioned by Rio Tinto within the vicinity of the contextual survey area and reviewed as part of this assessment are:

- Astron (2014), 'Mesa H Level 1 Flora, Vegetation and Fauna Assessment', unpublished report for Rio Tinto Iron Ore
- Astron (2016a), 'Bungaroo Level 2 Fauna Assessment', unpublished report for Rio Tinto Iron Ore
- Astron (2016b), 'Mesa H Level 2 Fauna Assessment', unpublished report in prep. for Rio Tinto Iron Ore
- Astron (2016c), 'Middle Robe and East Deepdale Level 2 Fauna Assessment', unpublished report for Rio Tinto Iron Ore
- Bat Call WA (2016a). 'Mesa B and C Ghost Bat Roost Cave Assessment, July 2016', unpublished report for Rio Tinto
- Bat Call WA (2017a) 'Robe Valley Mesa A to Mesa 2405A, impact of mining on Ghost bat presence and activity, April 2017, including assessment of caves on Mesas F and G', unpublished report for Rio Tinto

- Bat Call WA (2017b) 'Robe Valley Mesa H, Ghost Bat Roost Assessment, April 2017', unpublished report for Rio Tinto
- Bat Call WA (2017c) 'Robe Valley Mesas A and C, Ghost Bat Roost Cave Assessment, April 2017', unpublished report for Rio Tinto
- Biota Environmental Sciences (Biota) (2005) 'Fauna Habitats and Fauna Assemblage of Mesa A and G, near Pannawonica', unpublished report for Robe River Iron Associates
- Biota (2006), 'Fauna Habitats and Fauna Assemblage of the Mesa A Transport Corridor and Warramboos', unpublished report prepared for Rio Tinto Iron Ore
- Biota (2009), 'Mesa G Baseline Fauna Survey', unpublished report for Rio Tinto Iron Ore
- Biota (2010), 'Greater Bungaroo Seasonal Fauna Survey', unpublished report for Rio Tinto Iron Ore
- Biota (2011), 'Robe Valley Mesas Fauna Survey', unpublished report for Rio Tinto Iron Ore
- Biologic Environmental Survey (2014), 'Yarraloola Targeted Fauna Survey', unpublished report for Rio Tinto Iron Ore.
- MWH Australia (2015) 'Level 2 Terrestrial Fauna Surveys: Mesa B-C, Warramboos BWT and Highway to Tod Bore', unpublished report for Rio Tinto Iron Ore.

3.2 Field Survey

3.2.1 Timing and Personnel

Survey effort was concentrated to the west of Mesa H, specifically along the Robe Valley, as this area lacked recent Ghost Bat records/data. The Robe Valley to the east of Mesa H was previously surveyed by Astron in 2015 as part of the Middle Robe/ East Deepdale and Bungaroo fauna surveys and the presence of Ghost Bat activity and potential roost sites assessed. The current field survey was undertaken by John Trainer and Matthew Love, both of whom have over five years of experience conducting Level 2 fauna surveys, including bat monitoring surveys. The field survey was conducted from 3 to 9 June 2016.

Daily weather observations recorded from the Mesa J Operation were used to describe local rainfall and temperatures during the survey. During the survey 39.6 mm rain was received (between 5 and 8 June, with heavy rain occurring between 5 and 7 June) and daily maximum temperatures ranged between 20.5°C and 32.5°C. Night time minimum temperatures varied greatly with warm temperatures experienced from 3 to 6 June (19.4°C to 21.8°C) and cooler temperatures from 7 to 9 June (7.7°C to 14.6°C). A total of 271 mm rainfall was recorded at Mesa J in the 12 months preceding the survey; 133 mm below the annual average of 404 mm at Pannawonica (Station 5069) (Figure 2). Rainfall in the 12 weeks preceding the survey was less than half of the long-term mean for the same period, with 56 mm recorded (Bureau of Meteorology 2016).

□

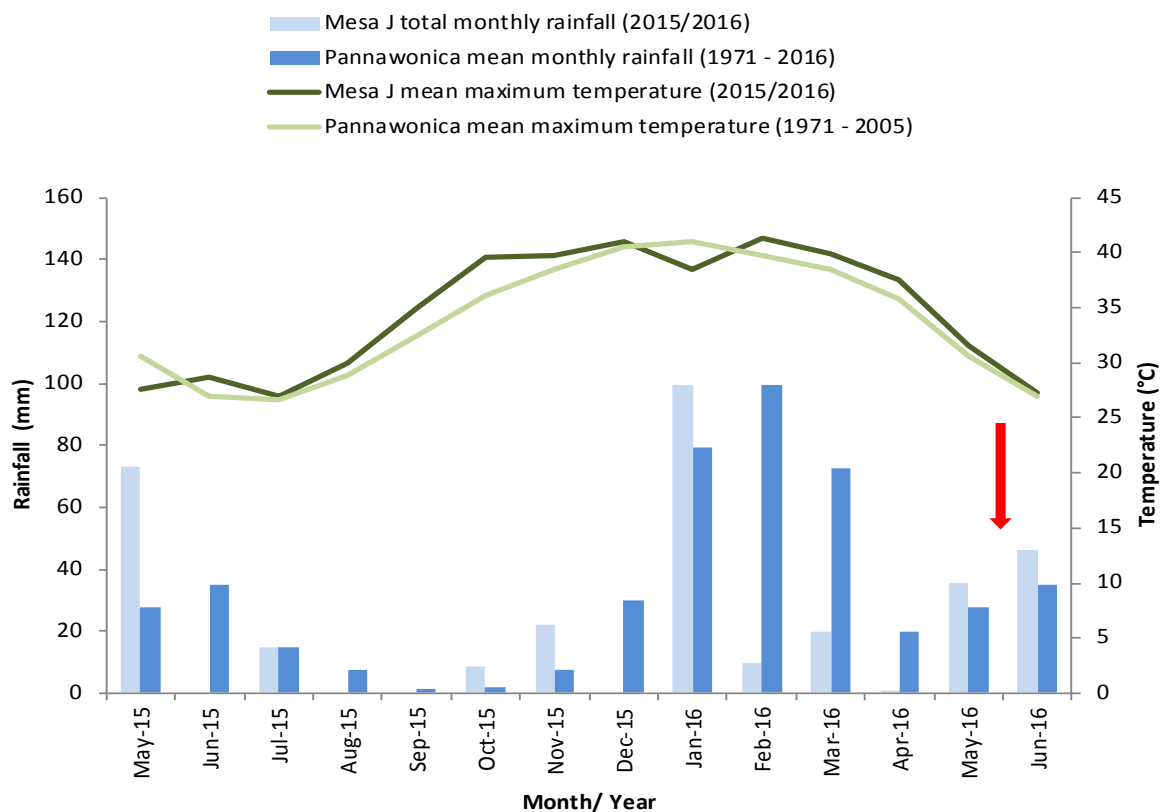


Figure 2: Pannawonica mean monthly rainfall (1971 – 2015) and Mesa J total recorded rainfall (2015/2016), and Pannawonica mean monthly maximum temperatures (1971 – 2016), and Mesa J mean monthly maximum temperatures in the 12 months preceding the survey. Red arrow indicates field survey timing. Pannawonica data from Bureau of Meteorology (2016) and Rio Tinto (2015, 2016).

3.2.2 Acoustic Bat Survey

A total of eight SM2BAT SongMeter (Wildlife Acoustics Inc USA) bat detectors were used at 12 locations completing 35 nights of overnight bat acoustic recordings. The units were situated at the entrance of caves or overhangs or permanent water sources where Ghost Bats were considered likely to forage or roost (Plate 2). One SM2 unit and the associated data for two locations was lost when the unit was crushed under a rock collapse following heavy rain, resulting in only 34 nights of bat recordings at 10 locations (Figure 3).

Due to the unique call characteristics of the Ghost Bat the SM2 units were set up to provide the best chance of recording and identifying Ghost Bat calls and reduce interference/feedback caused by the recording of Pilbara Leaf-nosed Bat (*Rhinioncteris aurantia*) calls. This included the use of both ultrasonic and audio microphones to record the inaudible echolocation calls and the audible social calls used by the Ghost Bat. Analysis of recordings was undertaken by Robert Bullen (Bat Call WA 2016b, Appendix B).

3.2.3 Habitat Assessment

Habitats of the contextual survey area were assessed and mapped on their ability to support Ghost Bats, in particular the presence of roosting sites, feeding sites and quality foraging sites. In this report unless otherwise stated the term ‘roost sites’ is the collective term for both maternal and diurnal roosts. Significant rocky habitats such as gorges, cliffs and breakaways were identified from aerial photographs or visual inspection during the field survey. If accessible, these habitat features

were traversed by foot during the day and any caves or overhangs were inspected for signs of Ghost Bats and assessed on their suitability as roost caves or feeding sites.

Any cave or overhang that contained Ghost Bat scats and/or feeding remnants (typically feathers and small animal bones) were classified as nocturnal roosts/feeding sites and had their location recorded. The overall concentration of nocturnal roosts/feeding sites is used to indicate the key locations where Ghost Bats forage (given their methods of hunting discussed in Section 2.5.2) and their distribution through the contextual survey area. The focus of the survey was to find and assess the presence of diurnal roosts and maternal roosts. Diurnal roosts were identified by the presence of Ghost Bats (visual observation, presence of scats or low call numbers from acoustic recordings) within or at a complex cave. Maternal roosts were identified by the presence of multiple Ghost Bats (visual observation or high call numbers from acoustic recordings) within or at a complex cave. For this assessment, a complex cave is defined as one which contains domed chambers, internal passages or fissures and is deep enough to provide a different microclimate (stable temperature and elevated humidity) to the ambient.

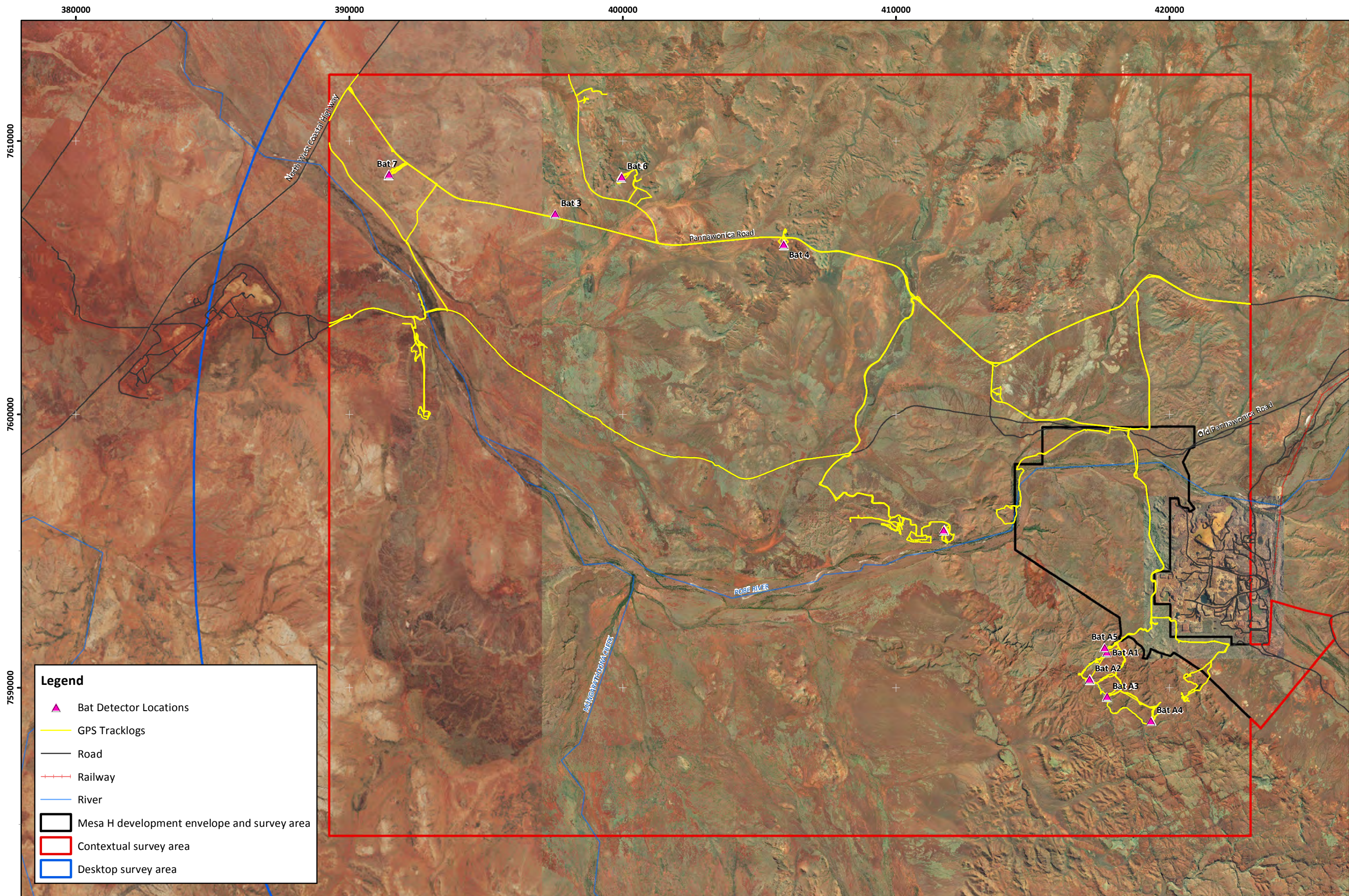
Cave assessment datasheets were completed at each roost site to document the caves’ physical characteristics and their potential to support Ghost Bats. The following details were recorded on each datasheet:

- location – coordinates measured using a handheld GPS (GDA94)
- location on slope – the position of the cave on the slope relative to the top of the slope
- local foraging habitat – broad vegetation description, approximate distance to any nearby water
- entrance description – including aspect and approximate dimensions
- internal description (if visible) – cave depth and height; presence of features such as rear passages, domed chambers
- evidence of bats
- photographs of the cave entrance.

Habitats were rated and mapped as high, moderate or low quality based on the significance each habitat has within the Ghost Bat’s ecological requirements. The Ghost Bat habitats were classified according to the criteria detailed in Table 6 and a summary of survey effort is provided in Figure 3.

Table 6: Suitability/significance of habitat criteria for Ghost Bats.

Species	High quality habitat <i>Potential/confirmed roosting habitat</i>	Moderate quality habitat <i>Potential/confirmed feeding sites and quality foraging habitat</i>	Low quality habitat <i>Widespread foraging habitat</i>
Ghost Bat <i>Macroderma gigas</i>	Rocky habitats containing, or classified as likely to contain, maternal roosts and/or diurnal roosts.	Habitats containing or likely to contain shallow feeding sites/nocturnal roosts; areas of permanent water sources and gorges suitable for foraging and are likely to be used on a regular basis.	Widespread habitat providing foraging potential only.



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 Mesa H - Ghost Bat, *Macroderma gigas* - Contextual Study

Figure 3: Survey effort

Author: J. Trainer

Drawn: C. Dyde

Date: 05-09-2017

Coordinate System: GDA 1994 MGA Zone 50
 0 1 2 3 4 5 Kilometres



Figure Ref: 14269-16BIDR-1RevB_170905_Fig03_SurvEff

3.3 Survey Limitations

To identify how complete the contextual survey was, it was assessed against the potential limitations suggested in Guidance Statement 56 for fauna surveys (Environmental Protection Authority 2004). Table 7 lists the key limitations of the targeted Ghost Bat survey.

Heavy rainfall was experienced on three of the six survey nights (5 to 7 June 2016) which affected the SM2 unit's ability to record Ghost Bats. The noise of the rain drowns out all frequency ranges including those where the SM2 unit record bat calls. Additionally, the heavy rain may have reduced the activity levels of Ghost Bats. The survey guidelines for Australia's threatened bats suggest that surveys not be conducted on windy, cold or rainy nights (Department of the Environment, Water, Heritage and the Arts 2010). While not preferred conditions, the rain did not fall during all post dusk and pre-dawn periods and that allowed an adequate chronology of the emergence of the bat species to be recorded (Bat Call WA 2016b).

Data was lost from two locations when the rockfall crushed one of the SM2 units. Although relative abundance data were lost, the occurrence of Ghost Bats at both sites could still be confirmed due to the presence of scats. The occurrence of Ghost Bats in the area is well documented in previous biological reports and as this survey focused on the identification of roost sites rather than the presence/absence of this species it is not deemed a significant limitation.

The heavy rain also created issues with access as many of the tracks were unable to be safely driven on for three of the survey days. As such, on these days access was limited to areas surrounding sealed roads or well used tracks. Overall, this did not impact the survey effort as it just adjusted the areas of focus to sites closer to the main tracks during those days.

Many of the roost caves could not be assessed properly due to the health and safety limitations that did not allow field personnel to enter caves. Internal dimensions were limited to what could be identified visually from the entrance of each cave. To properly assess the size and significance of each roost site, an internal assessment of each cave is required.

Although Mesa H has been extensively surveyed for fauna, only a fraction of the surrounding area has been directly assessed for Ghost Bat presence/suitability. Due to the size of the contextual survey area and the survey effort (two personnel for six survey days) not all areas could be ground-truthed. The contextual survey area was mapped based on the topography identified in the field survey and from aerial photographs and as such it provides an assessment of the likelihood of roost sites. The only way to confirm the presence of roost sites is to walk the gorge/breakaway habitats and assess each cave individually; this was outside of the designated scope for this project. The survey effort and breakaway/gorge locations assessed are displayed in Figure 3. However, the intensity of both the current survey and historical surveys undertaken in the vicinity of Mesa H was considered adequate to identify and assess potential areas of significance.

Table 7: Statement of limitations for the targeted Ghost Bat survey.

Potential limitation	Statement regarding potential limitations
(i) Competency/experience	The ecologists responsible for conducting the survey have extensive experience in conducting Level 2 vertebrate surveys, including targeted bat surveys in the Pilbara.
(ii) Scope What faunal groups were sampled and were some sampling methods not able to be employed because of constraints such as weather conditions.	The survey scope was able to be completed with a total of 35 nights of SM2 acoustic recording and cave assessments undertaken in significant habitats. Internal cave inspections could not be undertaken due to HSE issues. Harp trapping or thermal imaging was not required as part of the scope of this survey.
(iii) Proportion of fauna identified, recorded and/or collected	This was a targeted Ghost Bat survey and did not record any other species or assemblages. It is not possible to determine Ghost Bat abundance/population number from echolocation records; Ghost Bat activity levels provide a relative measure of the population within the contextual survey area.
(iv) Sources of information Previously available information (whether historic or recent) as distinct from new data.	Adequate information was available from database searches and previous studies in the Mesa H survey area and desktop survey area and region.
(v) Proportion of task achieved Further work which might be needed?	The field survey and the desktop assessment were undertaken and considered complete. Any further data required such as population estimates and numbers using each maternal roost are outside of the scope of this assessment and would require a more detailed work program.
(vi) Timing/weather/season/cycle	The heavy rain experienced during much of the survey period limited the recording ability of the SM2 units and potentially the activity levels of the Ghost Bats. The presence of Ghost Bats in the area is well documented in previous biological reports and as this survey focused on the identification of roost sites rather than the presence/absence of this species it is not deemed a significant limitation.
(vii) Disturbances e.g. fire, flood, accidental human intervention which affected results of survey	A rockfall caused by heavy rain crushed a SM2 unit, losing four nights of data from two separate locations. The data lost were from feeding sites that contain Ghost Bat scats. Although relative abundance data was lost, the presence of Ghost Bats at both sites could still be confirmed. Therefore, the loss of the SM2 unit did not significantly affect the results of the survey.
(viii) Intensity In retrospect, was the intensity adequate?	The intensity of the surveys was considered adequate to ground-truth the desktop assessment and to assess potential areas of significance.
(xi) Completeness Was the relevant area fully surveyed?	Due to the large survey area and the fact that assessments had to be completed on foot, not all breakaways/gorges could be assessed. The points of interest identified during the desktop assessment were suitably covered with all other areas mapped via aerial photographs.
(x) Resources Degree of expertise available in animal identification to taxon level.	All personnel involved in identification have extensive experience in conducting bat monitoring surveys in the Pilbara. All bat call identifications were conducted by Robert Bullen (Bat Call WA) who is considered an expert in this field.
(xi) Remoteness and/or access problems	The majority of significant habitats were able to be accessed by vehicle or on foot. There were two areas classified as high quality

Potential limitation	Statement regarding potential limitations
	<p>habitat that were not able to be assessed due to lack of access. Due to safety and heritage related constraints, internal inspections of caves were not permitted. Ghost Bat roost caves were assessed by external visual observation only, with the internal structure beyond visual boundaries unknown. Cave assessments were used to provide an indication as to whether Ghost Bats were recorded or may utilise the caves as habitat.</p>
<p>(xii) Availability of contextual information e.g. biogeographic information on the region.</p>	<p>Database searches and previous fauna surveys in the desktop survey area provided by Rio Tinto provided contextual information.</p>

4 Results

4.1 Desktop Assessment

The database searches and literature review indicate that 79 Ghost Bat records (not including records from the current survey) exist within 30 km of the Mesa H survey area (Figure 4). The majority of these records (approximately 53%) are from the identification of scats (42 records) or acoustic records (15 records). These types of records provide information on the presence of this species at the location but do not provide the relative abundance or habitat context (i.e. foraging individual vs roost site).

Where Ghost Bat records were identified as occurring at a cave, but its dimensions or habitat context were not stated, some inferences were used to classify the record. Unless specifically stated, any caves that contain scats or feeding material are classified as nocturnal feeding roosts, that have a visual record of a single Ghost Bat are classified as a potential diurnal roost, and caves with visual records of multiple Ghost Bats are classified as a potential maternal roost. Only records of roost sites that are supported by cave assessments and/or visual sightings or high call readings from acoustic recordings are stated as confirmed roost locations. For many of the potential roost sites, the consultant's reports provided limited information on the cave dimensions, habitat context or use by Ghost Bats; as such, little can be inferred from these records.

From the desktop assessment (not including records from the current survey) a total of seven diurnal roost sites (six confirmed and one potential) and two maternal roost sites (one confirmed and one potential) have been previously recorded in the wider desktop survey area. A summary of the Ghost Bat records from previous ecological surveys is presented in Table 8 and the comprehensive data from the desktop assessment is detailed in Appendix C. The numbers of diurnal and maternal roosts are high for some earlier surveys; however, more recent targeted assessments have reassessed these caves, and fewer maternal and diurnal roosts have been confirmed. A summary of diurnal and maternal roosts confirmed following the current survey and more recent targeted caves assessments is presented in Table 9.

The most significant record from the desktop assessment was a potential maternal roost (reference number 11, Appendix C) on Mesa F where 24 Ghost Bats were captured in harp traps at a cave (Biota Environmental Sciences 2009). This cave was confirmed as a permanent maternal roost (MF01) in 2017 when 70 individuals were found to be present (Bat Call WA 2017a). This cave had two entrances opening into a mid-size chamber. It had multiple internal chambers between 2.5 m and 7 m high. The cave was located approximately 4 km from the Robe River.

One cave on Mesa B (MBC-05) was determined to be a diurnal roost with the ability to support a maternity colony (Bat Call WA 2016a). This cave included an internal shape adequately deep and dark along with a high domed chamber at the rear, multiple nocturnal roost opportunities, multiple daytime refuge opportunities, multiple early evening observation sites and a major productive riparian zone within 5 km (Bat Call WA 2016a).

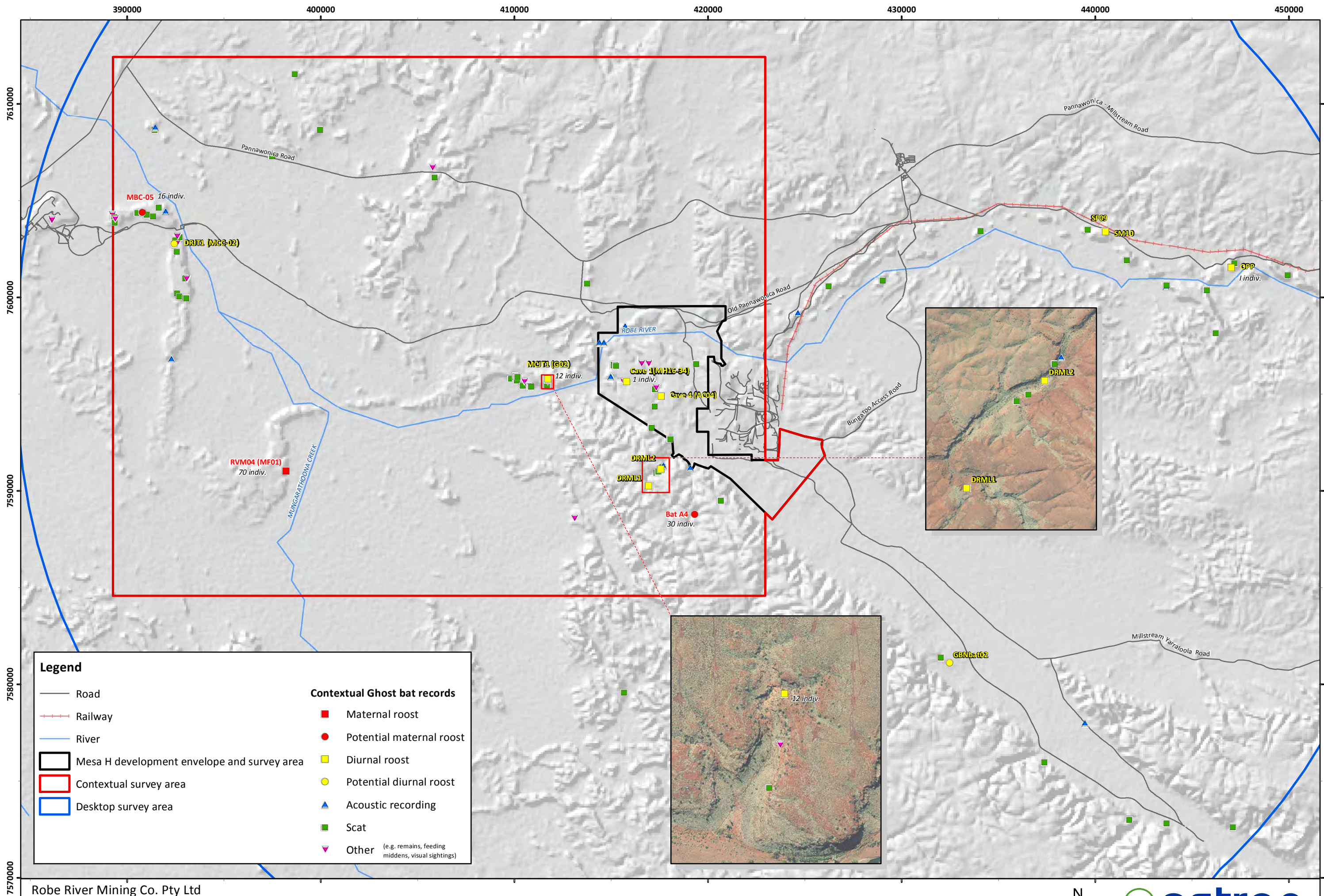
Table 8: Summary of Ghost Bat records from biological surveys in the vicinity of Mesa H.

Report title	Company	Year of report	Distance from Mesa H	Ghost Bat records
Mesa H Level 1 Flora, Vegetation and Fauna Assessment	Astron	2014	Within Mesa H	7 diurnal roosts 4 acoustic records 2 remains
Middle Robe and East Deepdale Level 2 Fauna	Astron	2016	4 km to 35 km	1 maternal roost 4 diurnal roosts 12 nocturnal feeding roosts 4 acoustic records
Bungaroo Level 2 Fauna Assessment	Astron	2016	12 km to 35 km	12 nocturnal feeding roosts
Mesa H Level 2 Flora, Vegetation and Fauna Assessment	Astron	2016	Within Mesa H	1 nocturnal feeding roost 1 acoustic record
Fauna Habitats and Fauna Assemblage of Mesa A and G, near Pannawonica	Biota	2005	3 km to 32 km	1 diurnal roost (1visual sighting)
Fauna Habitats and Fauna Assemblage of the Mesa A Transport Corridor and Warrambo	Biota	2006	22 km to 29 km	1 nocturnal feeding roost
Mesa G Baseline Fauna Survey	Biota	2010	4 km	1 maternal roost 1 individual caught
Greater Bungaroo Seasonal Fauna Survey	Biota	2010	13 km	1 diurnal roost
Robe Valley Mesas Fauna Survey	Biota	2011	16 km to 22 km	1 maternal roost 1 acoustic record
Yarraloola Targeted Fauna Survey	Biologic	2014	6 km to 18 km	2 visual sightings 1 nocturnal feeding roost
Mesa B and C Ghost Bat Roost Cave Assessment, July 2016	Bat Call WA	2016	25 km to 32 km	1 diurnal roost (possible maternal roost) 1 probable diurnal roost 18 nocturnal feeding roosts
Robe Valley Mesas A and C, Ghost Bat Roost Cave Assessment, April 2017	Bat Call WA	2017	25 km to 35 km	3 nocturnal feeding roosts (1 potential diurnal roost)

Report title	Company	Year of report	Distance from Mesa H	Ghost Bat records
Robe Valley Mesa A to Mesa 2405A, impact of mining on Ghost bat presence and activity, April 2017, including assessment of caves on Mesas F and G	Bat Call WA	2017	3 km to 18 km	1 maternal roost (70 individuals sighted) 1 diurnal roost 1 nocturnal feeding roost
Robe Valley Mesa H, Ghost Bat Roost Assessment, April 2017	Bat Call WA	2017	Within Mesa H	2 diurnal roosts (possible maternal roosts) 9 nocturnal feeding roosts
Level 2 Terrestrial Fauna Surveys: Mesa B-C, Warrambo BWT and Highway to Tod Bore	MWH Australia	2015	25 km to 45 km	2 nocturnal feeding roosts 1 acoustic record

Table 9: Summary of Ghost Bat records from the literature and current survey within the desktop, contextual and Mesa H survey areas.

Roost sites	Literature reviewed			Current survey		All sources			
	Mesa H survey area	Contextual survey area	Desktop survey area	Mesa H survey area	Contextual survey area	Mesa H survey area	Contextual survey area	Desktop survey area	Total
Maternal	0	1	0	0	0	0	1	0	1
Potential maternal	0	1	0	0	1	0	2	0	2
Diurnal	2	0	3	0	3	2	3	3	8
Potential diurnal	0	0	1	0	1	0	1	1	2



Legend

- Road
- - - Railway
- River
- ▭ Mesa H development envelope and survey area
- ▭ Contextual survey area
- ▭ Desktop survey area

Contextual Ghost bat records

- Maternal roost
- Potential maternal roost
- Diurnal roost
- Potential diurnal roost
- ▲ Acoustic recording
- Scat
- ▼ Other (e.g. remains, feeding middens, visual sightings)

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Figure 4: Ghost Bat records in the desktop survey area

Author: J. Trainer

Drawn: C. Dyde

Coordinate System: GDA 1994 MGA Zone 50

0 2 4 6 8 10 Kilometres



Date: 05-09-2017

Figure Ref: 14269-16BIDR-1RevB_170905_Fig04_Desktop

4.2 Field Survey

4.2.1 Habitat Assessments

Habitats were classified as high, moderate or low corresponding to the resources they provide to the Ghost Bat's ecological requirements (Table 10). Data collected from the cave assessments undertaken during the survey are detailed in Appendix C and the habitat mapping presented in Figure 5.

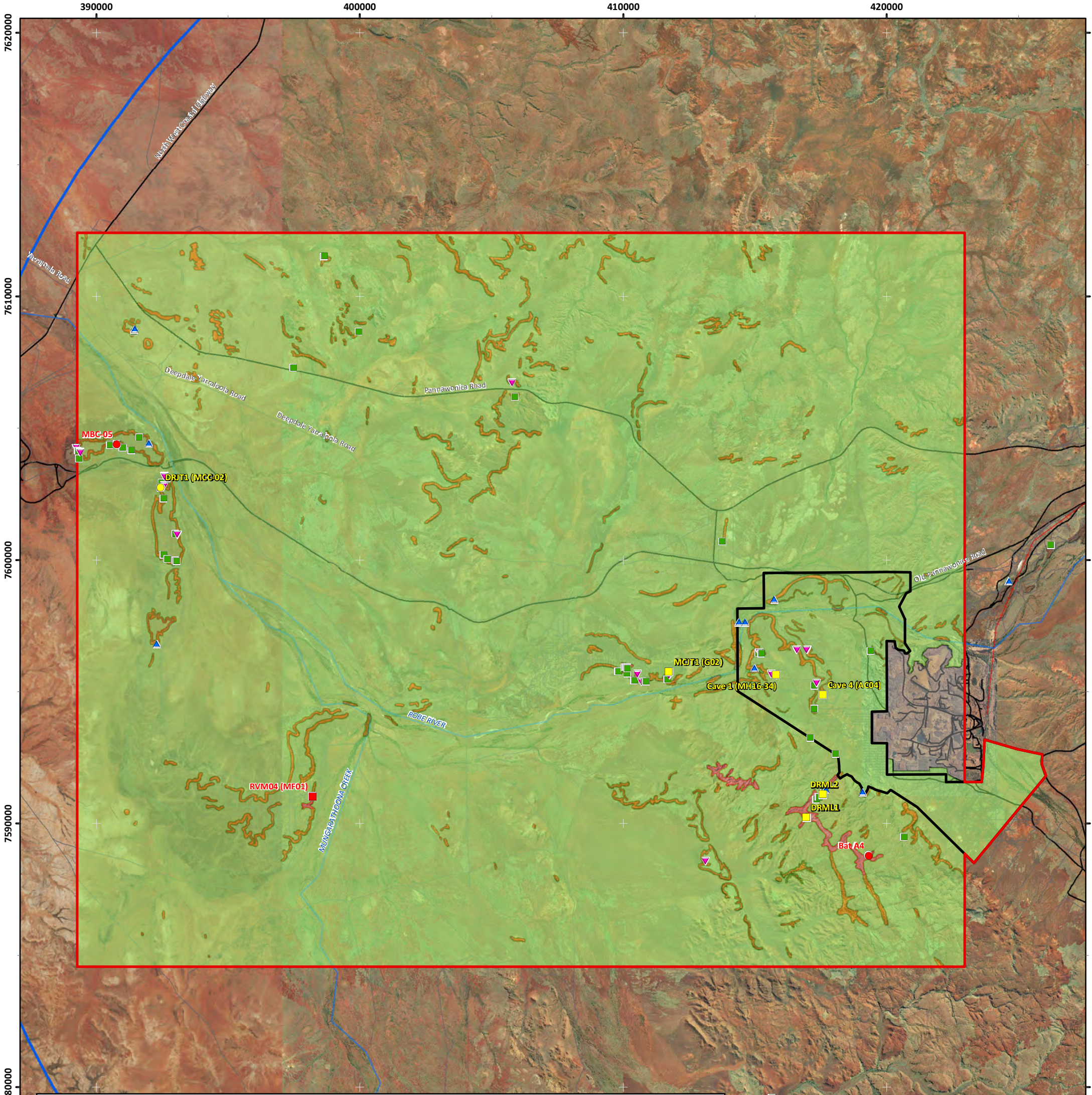
High quality habitats correspond to the locations where diurnal roosts or maternal roosts were identified or areas where aerial photography showed the topography corresponded to significant gorges or landforms likely to contain suitable caves for roost sites. High quality habitat was restricted to the gorge system located directly south of the Mesa H survey area (Plate 3), the gorges located within Mesa G (Plate 4), gorges on the western side of Mesa H, and the area surrounding the potential maternal roost in Mesa F to the south-west of the contextual survey area. A total of 248.7 ha (0.3%) of the contextual survey area and 4.1 ha (0.1%) of the Mesa H survey area contain habitat considered as being high quality habitat for Ghost Bats.

Moderate quality habitats correspond to rocky breakaways and cliffs where feeding sites were recorded or considered likely to occur and sites where permanent/semi-permanent water sources occur. These areas were mapped based on the type of geology identified in the field visit or from the topography identified from aerial photographs. The areas mapped as moderate quality habitat lack the significant gorges and gullies likely to contain suitable caves for roost sites (Plate 5). Permanent/semi-permanent water sources were classified as moderate quality habitat due to the fact they are likely to be important foraging sites used on a regular basis. A total of 2,531.1 ha (2.7%) of the contextual survey area and 270.4 ha (6.3%) of the Mesa H survey area contain habitat considered as being moderate quality habitat for Ghost Bats.

Low quality habitats correspond to areas of rocky hills, low hills, stony/clay plain and drainage lines where caves were not recorded or considered unlikely to occur. Ghost Bats forage over a variety of habitat types, as such all natural habitats within the contextual survey area provide foraging habitat for this species. Besides foraging these areas do not provide another biological function such as roosting or breeding sites. The vast majority of the contextual survey area (90,425.3 ha and 95.6%) and the Mesa H survey area (4,624.8 ha and 93.6%) contain habitat considered as being low quality habitat for Ghost Bats.

Table 10: Summary of habitat quality in the contextual survey area.

Habitat quality	Area in the contextual survey area (ha)	Proportion in the contextual survey area	Area in the Mesa H survey area (ha)	Proportion in the Mesa H survey area
High quality habitat	248.7	0.3%	4.1	0.1%
Moderate quality habitat	2,531.1	2.7%	270.4	6.3%
Low quality habitat	90,425.3	95.6%	4264.8	93.6%
No potential habitat (disturbed)	1,376.3	1.4%	0	0



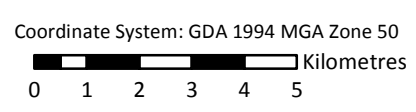
Legend		
	Road	
	Track	
	Railway	
	River	
	Survey area	
	Desktop survey area	
	Mesa H development envelope and survey area	
Fauna Habitat Mapping		
	High quality habitat	
	Moderate quality habitat	
	Low quality habitat	
	Disturbed	
Contextual Ghost bat records		
	Maternal roost	
	Potential maternal roost	
	Diurnal roost	
	Potential diurnal roost	
	Acoustic recording	
	Scat	
	Other	(e.g. remains, feeding middens, visual sightings)

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 Mesa H - Ghost Bat, *Macroderma gigas* - Contextual Study

Figure 5: Ghost Bat habitat mapping



Author: J. Trainer	Date: 05-09-2017
Drawn: C. Dyde	Figure Ref: 14269-16BIDR-1RevB_170905_Fig05_HabMap



4.2.2 Nocturnal Feeding Roosts

During the field survey a total of 26 nocturnal feeding roosts were identified by the presence of Ghost Bat scats and feeding debris. The nocturnal feeding roosts were typically open overhangs along breakaway habitat or in small caves. Scats and feed debris were usually concentrated on the ground under the domed sections of caves/overhangs, indicating a favoured foraging area and feeding location. Sites frequently used often have a large build-up of scats (middens) indicating prolonged use (Plate 6 and Plate 7).

Although foraging evidence is associated with rocky habitats and nocturnal feeding roosts, Ghost Bats forage over all habitat types only returning to nocturnal feeding roosts to eat their prey. Nocturnal feeding roosts were recorded across the contextual survey area in all rocky habitats surveyed indicating the foraging habitat for this species is widespread. Nocturnal feeding roosts are not mapped as part of this assessment.

4.2.3 Significant Roost Sites

During the field survey, four diurnal roosts and two potential maternal roosts were recorded (Table 11). With the exception of the diurnal roost site on the northern side of Mesa C, the roost sites were all located in either side gorges of the southern face of Mesa G or in the large gorge system located directly south of Mesa H. Both potential maternal roosts were large complex caves that were located on the southward facing sections of gorge systems. Based on observations from the field survey, the gorges with southward facing walls generally contained the most suitable geology and conditions to form complex, deep caves.

Since the field survey was completed, further targeted cave assessments have assessed one of the diurnal roosts (DRJT1) as a nocturnal feeding roost and possibly a diurnal roost (MCC02) (Bat Call WA 2017c) and one of the potential maternal roosts (MCJT1) with 12 individual Ghost Bats sighted as only a diurnal roost (G02) (Bat Call WA 2017a).



Plate 1: Ghost Bat (photo credit Gina Barnet).



Plate 2: Typical SM2 unit set up.



Plate 3: Large gorge south of Mesa H 'high quality habitat'.



Plate 4: Gorge in Mesa G 'high quality habitat'.



Plate 5: Mesas show typical 'moderate quality habitat'.









Plate 6: Ghost Bat scats.



Plate 7: Ghost Bat feeding debris.

Table 11: Ghost Bat roost locations recorded during the current survey.

Ghost Bat evidence	Site code	Location	Entrance description (H x W)	Internal description (H x W)	Photo
Diurnal roost - Ghost Bat scats present	DRJT1*	Mesa C	Tight (1.5 m x 2 m)	Domed cavern (3 m x 8 m) on top of cave entrance	
Diurnal roost - no scats but presence expected due to cave dimensions	DRML1	Gorge south of Mesa H	Open, adit like (35 m x 15 m)	Multiple caverns (20 m x 20 m) and rear passages	
Diurnal roost - no scats but presence expected due to cave dimensions	DRML2	Gorge south of Mesa H	Open (6 m x 12 m)	Large, narrow crevices approx. 15 m high, small domed cavern	

Ghost Bat evidence	Site code	Location	Entrance description (H x W)	Internal description (H x W)	Photo
Potential maternal roost - 3 individuals sighted	A4	Gorge south of Mesa H	Open and large (20 m x 40 m)	60 m deep with 3 large domed chambers and 2 rear passages	
Potential maternal roost - 12 individuals sighted	MCJT1^	Gorge in Mesa G	Complex with multiple tight entrances	40 m deep with multiple domed caverns and rear passages	
Diurnal roost - no scats but presence expected due to cave dimensions	RCML1	Gorge in Mesa G	Open (15 m x 30 m)	25 m deep with 3 rear passages and an open domed cavern	

*since survey, roost confirmed as a nocturnal feeding roost, possible diurnal roost (MCC-02) (Bat Call WA 2017c)

^since survey, roost confirmed as a diurnal roost only (G02) (Bat Call WA 2017a)

4.3 Environmental Context and Ghost Bat Records

The habitat mapping and Ghost Bat records from both the desktop assessment and the field survey in the contextual survey area were compared against the geological mapping (Stewart et al. 2008), land systems (van Vreeswyk et al. 2004) and the pre-European vegetation mapping (Beard 1975). The mapping data that most consistently correlated to the Ghost Bat habitat mapping and records were the land systems mapping.

Land systems mapping is a comprehensive description of biophysical resources including soil and vegetation condition across the Pilbara. As the Ghost Bat requires caves for its important ecological requirements (feeding, roosting and breeding), land systems that contain critical habitat were identified and mapped. The associations of each land system with Ghost Bat habitats and records are detailed in Table 12 and mapped in Figure 6.

The Newman and Robe land systems contain the most significant Ghost Bat habitat and they coincide with the majority of the high quality habitat (99%), diurnal roosts and maternal roosts (both potential and confirmed). The Newman land system is the most important of these as it supports the high quality habitat and roost sites at Mesa B, C, G and the gorge system south of Mesa H. The only exception to this is the maternal roost (RVM04/MF01) at Mesa F (reference number 11 in Appendix C) that occurs in the Boolgeeda system. However, this site occurs only 60 m from the boundary of the Boolgeeda land system and the Robe system suggesting some association with the Robe land system.

Moderate quality Ghost Bat habitat and nocturnal feeding roosts are strongly associated with the Newman, Robe and Nanutarra land systems with 92.5% of the moderate habitat and all but three of the nocturnal feeding roosts in the contextual survey area occurring in these three land systems. The Newman, Robe and Nanutarra land systems (Van Vreeswyk et al. 2004) are described below.

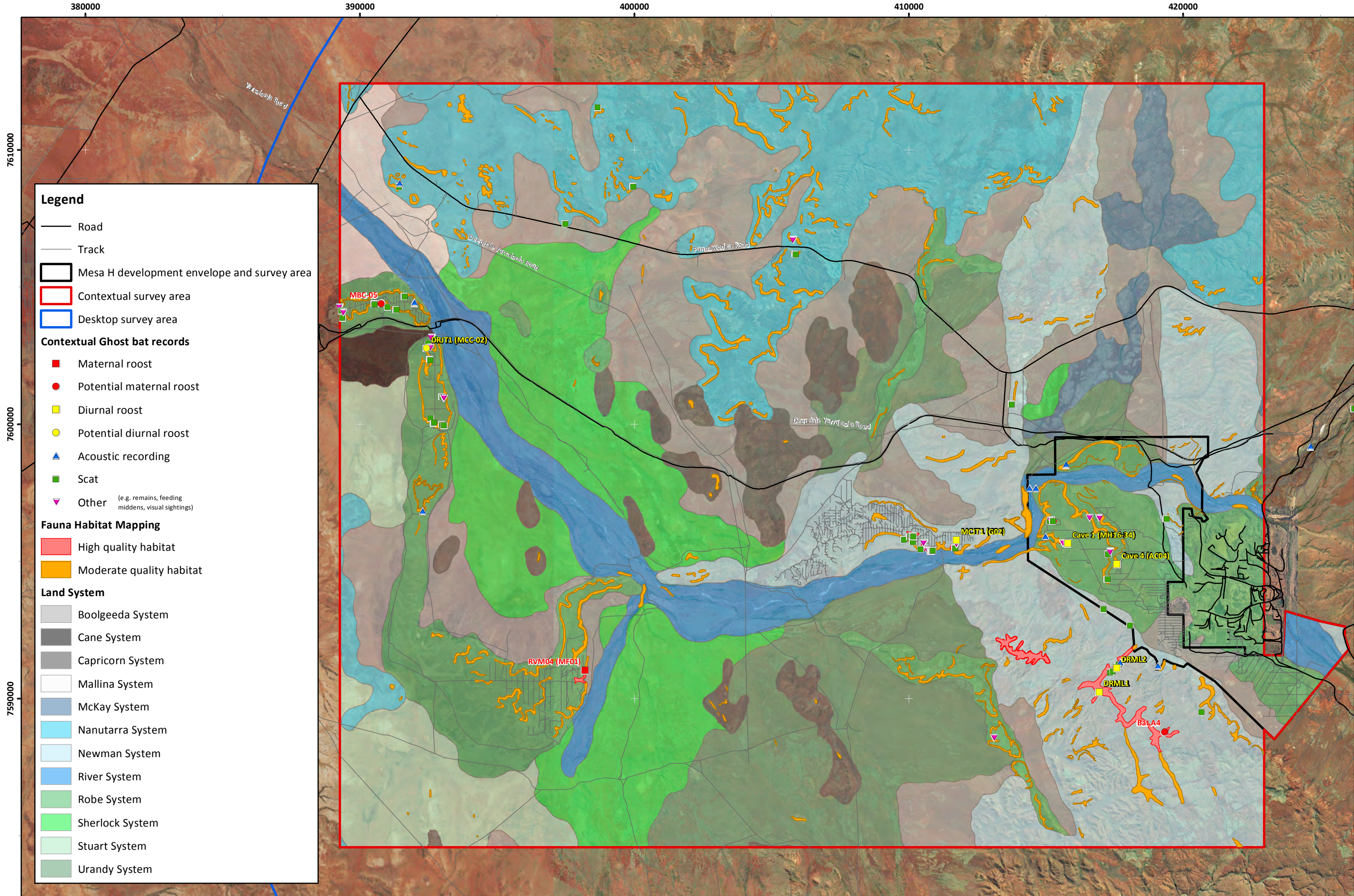
Newman system: extensive high plateaux, mountains and strike ridges with vertical escarpments and steep scree slopes and more gently inclined lower slopes; moderately spaced dendritic and rectangular tributary drainage patterns of narrow valleys and gorges with narrow drainage floors and channels. The system contains iron ore deposits which are currently being mined and deposits which are likely to be mined in the future. Approximately 14,580 km² of this Land system occurs in the Pilbara and is widespread between Pannawonica and Newman.

Robe system: erosional surfaces; formed by partial dissection of old Tertiary surfaces, dissected plateaux and long lines of low mesas along present and past river valleys, indented near vertical breakaway faces and steep slopes with limonite outcrop and pisolitic gravelly mantles, restricted gravelly lower slopes and closely to moderately spaced narrow tributary drainage floors. The system contains iron deposits which are currently being mined or which may be mined in the future. Approximately 850 km² of this Land system occurs in the Pilbara and is widespread between Pannawonica, Port Hedland and Newman, with a concentration south of Pannawonica.

Nanutarra system: erosional surfaces; formed by partial dissection of an old plateau of marine sediments - low plateaux, dissected plateaux, mesas, buttes and low hills with rounded crests, short stony footslopes with parallel and radial drainage patterns, narrow dendritic drainage zones and creeklines between dissected plateaux and mesas. Approximately 697 km² of this Land system occurs in the Pilbara and is concentrated to the west of Pannawonica.

Table 12: Ghost Bat habitat compared against land system mapping within the contextual and Mesa H survey areas.

Land System	Mesa H survey area		Contextual survey area		
	Moderate quality habitat (ha)	High quality habitat (ha)	Moderate quality habitat (ha)	High quality habitat (ha)	Ghost Bat records
Boolgeeda	0	0	118.2	2.1	1 maternal roost
Capricorn	0	0	33.2	0	Nil
Nanutarra	0	0	880.4	0	6 nocturnal feeding roosts 1 visual sighting record
Newman	20.7	0	583.1	234.6	1 potential maternal roost 3 diurnal roosts 18 nocturnal feeding roosts 2 acoustic records 2 visual sighting records
River	38.3	0	109.8	0.04	3 nocturnal feeding roosts 1 acoustic record
Robe	211.4	4.1	878.2	11.9	1 potential maternal roost 2 diurnal roosts 1 potential diurnal roost 33 nocturnal feeding roosts 4 acoustic records 3 visual sighting/remains records
Sherlock	0	0	9.5	0	Nil
Stuart	0	0	4	0	Nil
Urandy	0	0	14.7	0	Nil
Total	270.4	4.1	2,531.1	248.7	82 records



Robe River Mining Co. Pty Ltd
 Mesa H - Ghost Bat, *Macroderma gigas* - Contextual Study

Figure 6: Ghost Bat habitat mapping and land systems

Author: J. Trainer

Drawn: C. Dyde

Date: 05-09-2017

Coordinate System: GDA 1994 MGA Zone 50
 0 1 2 3 4 5 Kilometres



Figure Ref: 14269-16BIDR-1RevB_170905_Fig06_LSHabMap

5 Discussion and Conclusions

Mesa H has been extensively surveyed with four biological surveys conducted within the last five years (the current survey; Astron Environmental Services 2014, 2016b; Bat Call WA 2017b; Biota Environmental Sciences 2011). As such, the presence and habitat for the Ghost Bat in the Mesa H survey area is well documented. The Mesa H survey area contains 22 Ghost Bat records (including caves, individuals and acoustic recordings) accounting for approximately 28% of all Ghost Bat records from the desktop survey area. Following recent targeted cave assessments, a total of two confirmed diurnal roosts occur within the Mesa H survey area. Significant habitat for Ghost Bats in the Mesa H survey area occur in the small sections of a gorge/breakaway habitat (approximately 4.1 ha mapped as high quality habitat) located along the western side of Mesa H and a small portion of a gorge system to the south (and outside) of the Mesa H survey area (Figure 5). The number of records is to be expected given the geology of the Mesa H survey area and the fact it has been extensively surveyed in recent years.

Although high quality habitat is present within the Mesa H survey area, the majority of roost sites (including the more important one maternal and two potential maternal roosts) and high quality habitat (98.4%) are located in areas outside of the Mesa H survey area boundary. The most significant Ghost Bat habitats in the contextual survey area are located within the gorges on the lower Robe Valley Mesas, Mesa G and the gorge system to the south of (and outside) Mesa H, although the only confirmed maternal roost occurs on Mesa F. The gorges on Mesa G contained one diurnal roost, one potential maternal roost on Mesa B and one potential diurnal roost on Mesa C. The gorge to the south of Mesa H was too large to properly survey in the time available and only received a preliminary assessment. One potential maternal roost and two diurnal roosts (all confirmed) were identified; however, based on the geology and size of the gorge system more roost sites are expected.

In the Chichester subregion Ghost Bats are more numerous (approximately 1,500 to 2,000 individuals) and are focused in medium to large groups around roosts in abandoned mine shafts and adits. The contextual survey area occurs in the Hamersley subregion where Ghost Bats are more widespread, occur in smaller numbers (approximately 350 individuals) and where relatively few breeding records exist (Department of the Environment and Energy 2016). Observations from the survey and the desktop components support this statement with all roost sites containing a small numbers of individuals (1 to 70 individuals).

All of the records obtained through the desktop assessment were collected by environmental consultants and were therefore biased towards mining tenements in the area, specifically along the Robe Valley. The majority of records are from scats and acoustic recordings; although a number of targeted cave assessments have been conducted in recent years, and therefore do not reflect the location of roost sites (Bat Call WA 2016a, 2017a, 2017b, 2017c). The number of Ghost Bat records from the desktop assessment and field survey suggest that the Ghost Bat is well distributed across the Robe Valley and within the vicinity of the Mesa H survey area but in small numbers.

Armstrong and Anstee (2000) stated that roost sites in the Hamersley Ranges are associated with the Marra Mamba Iron and Brockman Iron formations. In the contextual survey area, roost sites were associated with the Robe Pistolite and Brockman Iron formations but not with the Marra Mamba Iron formations. However, the geological formation mapping does not correlate as strongly with potential Ghost Bat habitat as the land systems mapping does. In the contextual survey area, the land systems mapping shows relationship between the Robe and Newman systems and the presence of both diurnal and maternal roost sites. Within the contextual survey area approximately 96% of the Newman system and 75% of the Robe system are located outside of the Mesa H survey area, indicating that both of these land systems are well represented locally and are widespread

throughout the Pilbara (Table 2). Nocturnal feeding roosts are expected to occur across all rocky habitats in all of the land systems; however, during the field survey they were not found in some land systems due to the fact that survey effort focused on likely roost locations rather than a broad scale assessment. As such, the habitat mapping gives a clearer indication of potential presence of nocturnal feeding roosts (moderate quality habitat) rather than the feeding site records.

The key threat to the Ghost Bat is the habitat loss and degradation due to mining activities (McKenzie and Hall 2008). The species' slow reproductive rate, and the lack of suitable habitat which restricts its movement, renders it vulnerable to threats and localised extinctions (Queensland Department of Environment and Heritage Protection 2015). The Pilbara population is genetically distinct at both a regional and local scale (Armstrong et al. in prep). The genetic isolation of each subpopulation suggests areas are unlikely to be recolonised if a local extinction occurs (Queensland Department of Environment and Heritage Protection 2015). In the Pilbara, most known breeding sites of the Ghost Bat are confined to underground gold/copper mines that are now collapsing or being open cut, and to caves in banded ironstone strata that may be mined out over the next 30 to 50 years. On current trends, most of its Pilbara roost sites may be destroyed over the next 30 years (Woinarski et al. 2014). Numbers are likely to decline by over 30% in Western Australia in the future with local extinction in areas such as the central and eastern Hamersley Range, with the extent of occupancy likely to decline by over 10,000 km² (Bullen pers. comm., Department of the Environment and Energy 2016). However, barbed wire fences are being replaced in crucial areas and breeding sites are being identified for protection (Department of Parks and Wildlife 2015), which may reduce the current rate of decline.

The survey was completed prior to the known breeding period of this species in the Pilbara and the survey methods employed, specifically the lack of harp trapping, mist netting or thermal tracking cameras means that maternal roosts were identified on the presence of multiple Ghost Bats rather than breeding records. Relatively little is known about this species' roost site fidelity, seasonal movements or local population estimates in the Pilbara, let alone in the contextual survey area or the roost sites identified in this assessment.

6 References

- Armstrong, KN 2001, 'The roost habitat and distribution of the orange leaf-nosed bat, *Rhinonicteris aurantius*, in the Pilbara region of Western Australia', *Wildlife research*, vol. 28, pp. 95-104.
- Armstrong, KN & Anstee, SD 2000, 'The ghost bat in the Pilbara: 100 years on', *Australian Mammalogy*, vol. 22, pp. 93-101.
- Armstrong, KN, Chavand, O & Worthington-Wilmer, J In prep, 'Population genetic assessment of the Pilbara Ghost Bat *Macroderma gigas* (Chiroptera: Megadermatidae)'.
- Astron Environmental Services 2014, *Mesa H - Level 1 Flora, Vegetation and Fauna Assessment*, unpublished report for Rio Tinto Iron Ore.
- Astron Environmental Services 2016a, *Bungaroo Iron Ore Mine and Infrastructure Project, Level 2 Fauna Assessment*, unpublished report for Rio Tinto Iron Ore.
- Astron Environmental Services 2016b, *Mesa H Level 2 Fauna Assessment*, unpublished report in preparation for Robe River Mining Co. Pty Ltd.
- Astron Environmental Services 2016c, *Middle Robe and East Deepdale Level 2 Fauna Assessment*, unpublished report for Rio Tinto Iron Ore.
- Bat Call WA 2016a, *Mesa B and C Ghost Bat Roost Cave Assessment, July 2016*, unpublished report for Rio Tinto.
- Bat Call WA 2016b, *Mesa H contextual fauna survey, Pilbara WA, June 2016: Echolocation Survey of Bat Activity*, unpublished report for Astron Environmental Services.
- Bat Call WA 2017a, *Robe Valley Mesa A to Mesa 2405A, Impact of Mining on Ghost Bat Presence and Activity, April 2017, Including Assessment of Caves on Mesas F and G, April 2017*, unpublished report for Rio Tinto.
- Bat Call WA 2017b, *Robe Valley Mesa H, Ghost Bat Roost Assessment, April 2017*, unpublished report for Rio Tinto.
- Bat Call WA 2017c, *Robe Valley Mesas A and C, Ghost Bat Roost Cave Assessment, April 2017*, unpublished report for Rio Tinto.
- Beard, JS 1975, *Vegetation Survey of Western Australia, Pilbara. 1:1 000 000 Vegetation Series. Explanatory Notes to Sheet 5*, University of Western Australia Press, Nedlands, Western Australia.
- Biologic Environmental Survey 2014, *Dietary Analysis Results From Scats Collected During a Targeted Survey for Northern Quolls, Pilbara Olive Pythons and Pilbara Leaf-nosed Bats at Yarraloola*, unpublished report for Rio Tinto Iron Ore.
- Biota Environmental Sciences 2005, *Fauna Habitats and Fauna Assemblage of Mesa A and G, Near Pannawonica*, unpublished report for Robe River Iron Associates.
- Biota Environmental Sciences 2006, *Fauna Habitats and Fauna Assemblage of the Mesa A Transport Corridor and Warramboe*, unpublished report for Robe River Iron Associates.
- Biota Environmental Sciences 2009, *Mesa G Baseline Fauna Survey*, unpublished report for Rio Tinto Iron Ore.
- Biota Environmental Sciences 2010, *Greater Bungaroo Seasonal Fauna Survey*, unpublished report for Rio Tinto Iron Ore.
- Biota Environmental Sciences 2011, *Robe Valley Mesas Fauna Survey*, unpublished report for Rio Tinto Iron Ore.

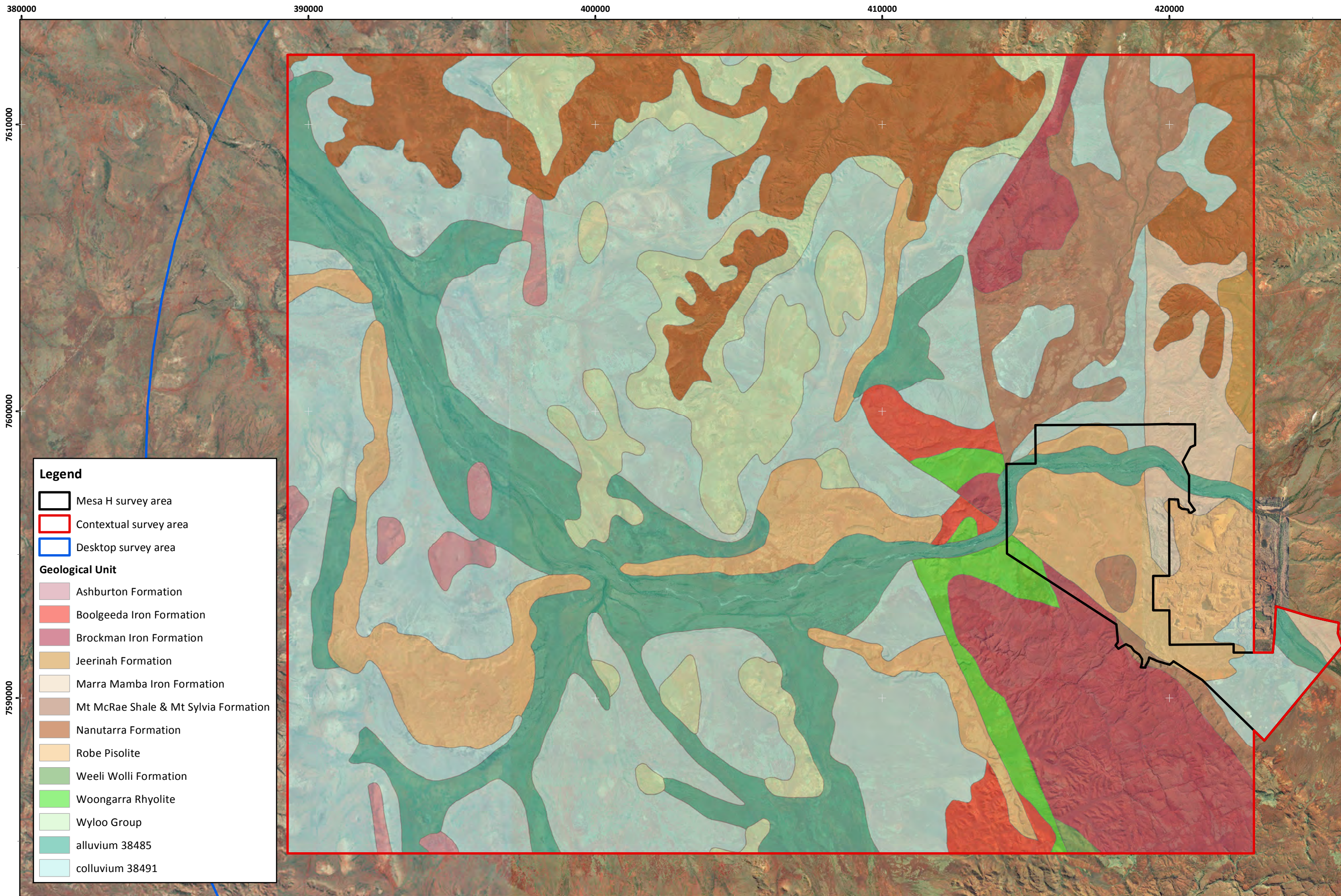
- Boles, WE 1999, 'Avian prey of the Australian Ghost Bat *Macroderma gigas* (Microchiroptera: Megadermatidae): prey characteristics and damage from predation', *Australian Zoologist*, vol. 31, pp. 82-91.
- Burbidge, AA, McKenzie, NL, Brennan, KEC, Woinarski, JCZ, Dickman, CR, Baynes, A, Gordon, G, Menkhorst, PW & Robinson, AC 2009, 'Conservation status and biogeography of Australia's terrestrial mammals', *Australian Journal of Zoology*, vol. 56, pp. 411-22.
- Bureau of Meteorology 2016, *Climate data online*, <<http://www.bom.gov.au/climate/data/index.shtml>>.
- Churchill, SK 1991, 'Distribution, abundance and roost selection of the orange horseshoe-bat, *Rhinonycteris aurantius*, a tropical cave dweller', *Wildlife research*, vol. 18, pp. 343-53.
- Churchill, SK & Helman, PM 1990, 'Distribution of the ghost bat, *Macroderma gigas*, (Chiroptera: Megadermatidae) in central and south Australia', *Australian Mammalogy*, vol. 13, pp. 149-56.
- Department of Parks and Wildlife 2015, *Submission on the nomination for listing Macroderma gigas (ghost bat)*, received 25 November 2015.
- Department of Parks and Wildlife 2016a, 'NatureMap database search', Vol. 2016.
- Department of Parks and Wildlife 2016b, 'Threatened and Priority Ecological Communities database', Department of Parks and Wildlife, Kensington.
- Department of the Environment, Water, Heritage and the Arts, 2010, *Survey guidelines for Australia's threatened bats: Guidelines for detecting bats listed as threatened under the Environment Protection and Biodiversity Conservation Act 1999*, Commonwealth of Australia.
- Department of the Environment and Energy 2016, *Conservation Advice for Macroderma gigas (ghost bat)*, Threatened Species Scientific Committee, Canberra.
- Environmental Protection Authority 2002, *Terrestrial Biological Surveys as an Element of Biodiversity Protection, Position Statement 3*, Environmental Protection Authority, Perth.
- Environmental Protection Authority 2004, *Terrestrial Fauna Surveys for Environmental Impact Assessment in Western Australia, Guidance Statement 56*, Environmental Protection Authority, Perth.
- Environmental Protection Authority & Department of Environment and Conservation 2010, *Technical Guide – Terrestrial Vertebrate Fauna Surveys for Environmental Impact Assessment*, Environmental Protection Authority, Perth.
- Government of Western Australia 2014, *2014 Statewide Vegetation Statistics Incorporating the CAR Reserve Analysis (Full Report)*, Parks and Wildlife, Perth.
- Hall, L, Richards, G, McKenzie, N & Dunlop, N 1997, 'The importance of abandoned mines as habitat for bats', in P Hales and D Lamb (eds), *Conservation Outside Nature Reserves*, The University of Queensland, Brisbane, pp. 326-33.
- Horton, J & Clark, J 2001, 'Water table decline alters growth and survival of *Salix gooddingii* and *Tamarix chinensis* seedlings', *Forest Ecology and Management*, vol. 140, pp. 239-47.
- Hoyle, SD, Pople, AR & Toop, GJ 2001, 'Mark-recapture may reveal more about ecology than about population trends: Demography of a threatened ghost bat (*Macroderma gigas*) population', *Austral Ecology*, vol. 26, pp. 80-92.
- Leitner, P & Nelson, JE 1967, 'Body temperature, oxygen consumption and heart rate in the Australian false vampire bat *Macroderma gigas*', *Comparative Biochemistry and Physiology*, vol. 21, pp. 65-74.

- McKenzie, N & Hall, L 2008, 'Macroderma gigas', *IUCN red list of threatened species*, Version 2012.1. Available on the internet at: <http://www.iucnredlist.org>.
- McKenzie, NL & Bullen, RD 2009, 'The echolocation calls, habitat relationships, foraging niches and communities of Pilbara microbats', *Records of the Western Australian Museum Supplement* 78, pp. 123-55.
- McKenzie, NL & Bullen, RD 2012, 'An acoustic survey of zoophagic bats on islands in the Kimberley, Western Australia, including data on the echolocation ecology, organisation and habitat relationships of regional communities', *Records of the Western Australian Museum Supplement* 81, pp. 67-107.
- MWH Australia 2015, *Level 2 Terrestrial Fauna Surveys: Mesa B-C, Warramboe BWT and Highway to Tod Bore*, unpublished report for Rio Tinto Iron Ore.
- Pettigrew, JD, Baker, GB, Baker-Gabb, D, Baverstock, G, Coles, R, Conole, L, Churchill, S, Fitzherbert, K, Guppy, A, Hall, L, Helman, P, Nelson, J, Proddel, D, Pulsford, I, Richards, G, Schulz, M & Tidemann, CR 1986, 'The Australian ghost bat, *Macroderma gigas*, at Pine Creek, Northern Territory', *Macroderma*, vol. 2, no. 1, pp. 8-19.
- Queensland Department of Environment and Heritage Protection 2015, *Submission on the listing assessments to assist the Threatened Species Scientific Committee*, received 25 November 2015.
- Richards, GC, Hand, S, Armstrong, KA & Hall, LS 2008, 'Ghost Bat *Macroderma gigas*', in S Van Dyck and R Strahan (eds), *The Mammals of Australia*, Reed New Holland, Chatswood, pp. 449-50.
- Rio Tinto Iron Ore 2015, 'Mesa J Weather Data', from 8/01/2014 to 7/10/2015.
- Rio Tinto Iron Ore 2016, 'Mesa J Weather Data', from 02/09/2015 to 22/06/2016.
- Schulz, M 1986, 'Vertebrate prey of the ghost bat, *Macroderma gigas*, at Pine Creek, Northern Territory', *Macroderma*, vol. 2, pp. 59-62.
- Shepherd, DP, Beeston, GR & Hopkins, AJM 2002, 'Native Vegetation in Western Australia: Extent, Type and Status', *Resource Management Technical Report 249*, Department of Agriculture, Western Australia.
- Stewart, AJ, Sweet, IP, Needham, RS, Raymond, OL, Whitaker, AJ, Liu, SF, Phillips, D, Retter, AJ, Connolly, DP & Stewart, GR 2008, 'Surface Geology of Australia 1: 1 000 000 Scale, Western Australia [Digital Dataset]', The Commonwealth of Australia, Geoscience Australia (<http://www.ga.gov.au>), Canberra.
- Toop, GJ 1985, 'Habitat requirements, survival strategies and ecology of the ghost bat, *Macroderma gigas* Dobson (Microchiroptera, Megadermatidae) in central coastal Queensland', *Macroderma*, vol. 1, pp. 37-41.
- van Vreeswyk, AME, Payne, AL, Leighton, KA & Hennig, P 2004, *An inventory and condition survey of the Pilbara region, Western Australia. Technical Bulletin No. 92*, Department of Agriculture and Food, Perth.
- Woinarski, JCZ, Burbidge, AA & Harrison, PL 2014, *The Action Plan for Australian Mammals 2012*, CSIRO Publishing, Collingwood.
- Worthington Wilmer, J 2012, 'Ghost Bat *Macroderma gigas*', in LK Curtis, AJ Dennis, KR McDonald, PM Kyne and SJS Debus (eds), *Queensland's Threatened Animals*, CSIRO, Canberra, pp. 382-3.

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Appendix A: Environmental Context Figures

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Robe River Mining Co. Pty Ltd
 Mesa H - Ghost Bat, *Macroderma gigas* - Contextual Study

Figure A.1: Geological Units of the contextual survey area

Author: J. Trainer

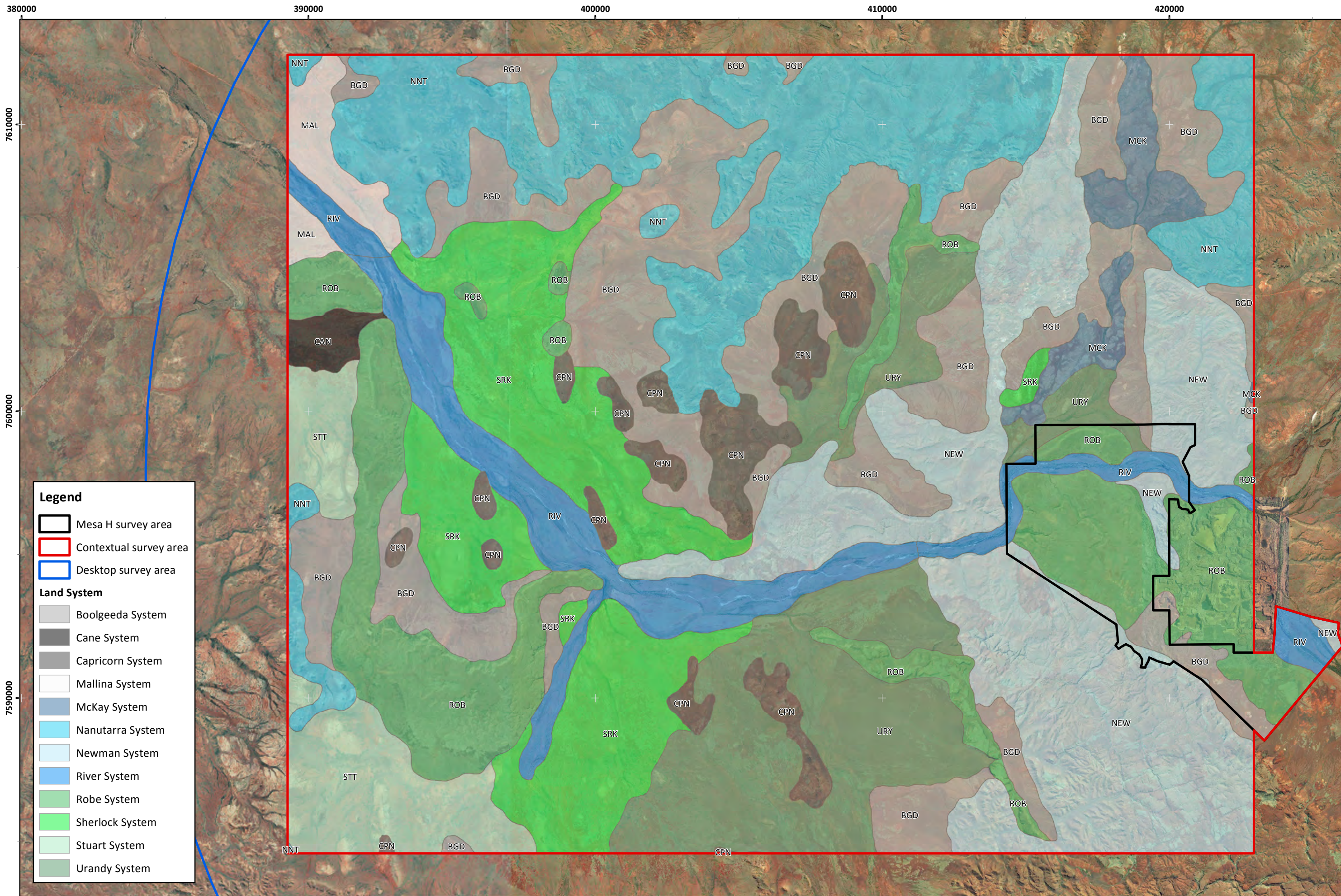
Drawn: C. Dyde

Date: 14-07-2016

Coordinate System: GDA 1994 MGA Zone 50
 0 1 2 3 4 5 Kilometres



Figure Ref: 14269-16BIDR-1RevA_160714_FigA1_Geo



Robe River Mining Co. Pty Ltd
 Mesa H - Ghost Bat, *Macroderma gigas* - Contextual Study

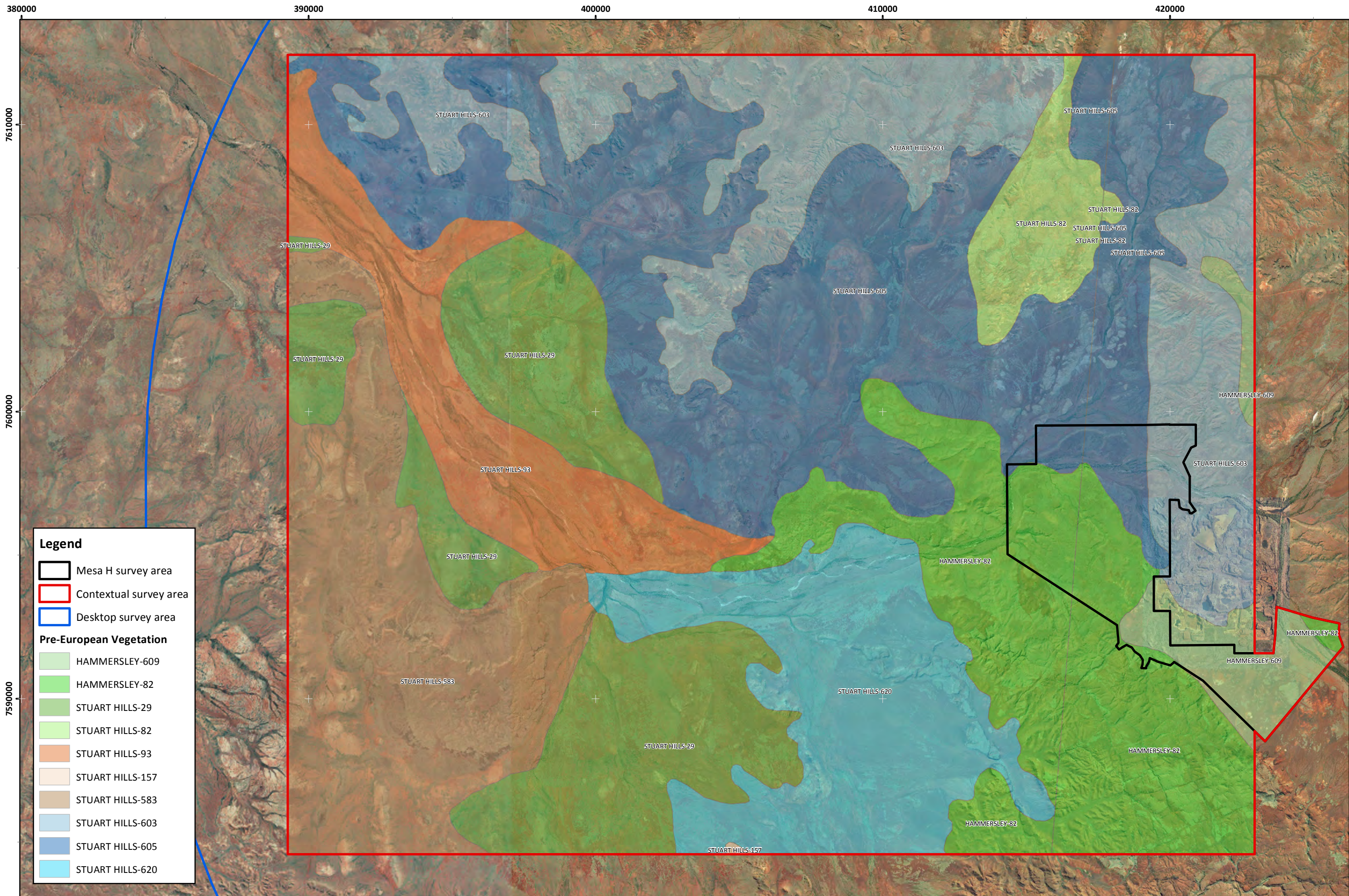
Figure A.2: Land Systems of the contextual survey area

Author: J. Trainer

Drawn: C. Dyde

Date: 14-07-2016

Figure Ref: 14269-16BIDR-1RevA_160714_FigA2_LandSys



Robe River Mining Co. Pty Ltd
 Mesa H - Ghost Bat, *Macroderma gigas* - Contextual Study

Figure A.3: Pre-European Vegetation of the contextual survey area

Author: J. Trainer

Drawn: C. Dyde

Date: 14-07-2016

Coordinate System: GDA 1994 MGA Zone 50
 0 1 2 3 4 5 Kilometres



Figure Ref: 14269-16BIDR-1RevA_160714_FigA3_PreEuroVeg

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Appendix B: Bat Call WA Report

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**Mesa H contextual fauna survey,
Pilbara WA,
June 2016**

Echolocation Survey of Bat Activity.

Prepared for Astron Environmental Services

Bat Call WA Pty Ltd
ABN 26 146 117 839
43 Murray Drive
Hillarys Western Australia 6025
bullen2@bigpond.com
+61 8 9402 1987
+61 488 930 735

Prepared by:
R. D. Bullen – Bat Call WA
Issue 2
29 August 2017

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Document Revision History

Issue	Date	Revision History
A	16 June 2016	Initial draft prepared for Astron
1	23 July 2016	First issue incorporating client comments
2	29 Aug 2017	Second issue incorporating client comments

Summary

Bat species presence, with an estimate of activity level, is presented for ten sites near Mesa H along the Robe River valley in the Pilbara, WA. Astron Environmental Services (Astron) carried out an echolocation based survey during June 2016. Bat Call WA has reviewed the recordings made and provided species lists for the bats present.

Nine species of echolocating bats were recorded including the two EPBC Act listed species from the Pilbara, the Orange Leaf-nosed Bat, Pilbara form (*Rhinonicteris aurantia*) (PLNb) and the Ghost bat (*Macroderma gigas*). Ghost bat calls were detected at four sites, all cave entrances or overhangs. PLNb calls were detected foraging in medium numbers at one site and in low numbers at five sites. A summary of call numbers and timing is provided. Activity levels for the common species are provided by site. No previously unidentified PLNb roost is indicated by these data

Habitats

The sites for the survey were chosen by Astron. Details of the sites are presented in Table 1. Three were in cave entrances, six under overhangs and one was on a semi-permanent pool within a gorge. The locations are shown in relation to Robe River valley features in Figure 1.

Characteristics of the calls recorded are presented in Table 2.

Bat Fauna

An assemblage of nine echolocating species was confirmed as present at the study sites, Tables 2 and 3. Species activity levels were low to high, which is expected for the study area habitat and the time of year, see criteria below.

Multiple Ghost bat calls were detected at four sites, Bat A1, 'A4, '2 and '7 although the patterns of calls at these sites were interrupted by nights with extensive rainfall and also probably impacted by two nights with low temperatures, see below. The pattern though is adequate to show that Ghost bats are using most well defined caves and some overhangs in the district.

PLNb were detected at six of the sites. One site, Bat A4 had a medium activity level with a total of 140 calls being recorded over six nights. Five sites had low activity levels. Detections within 60 minutes of dusk civil twilight (CT) were recorded at the three southern sites. The earliest time differentials from dusk CT were at site 'A4, 30 minutes on the 6th June (overcast night with rainfall periods), 35 minutes at 'A2 and 50 minutes at 'A3. The latest calls were between 25 and 45 minutes before CT, on the 6th June at 'A4, and at sites 'A3 and 'A1, Figure 1. The closest call to CT at Bat 2 was 90 minutes and the single call at Bat 7 was close to midnight. These time differentials, together with the progressively increasing time differentials from south to north, indicate that the PLNb probably originated from a known roost approximately 10 km south of the study area.

Taxonomy presented herein is after Reardon *et al.* (2014) and Jackson and Groves (2015).

Survey Timing, Moon Phase and Weather

The echolocation survey was conducted between 3rd and 8th June 2016.

The first four sampling evenings were warm with minimum overnight temperatures between 15 and 20^oC while the last two were cold with temperatures around 10^oC. Rain fell on the nights of 4th, 5th and 6th June. The moon in this period was new.

During the survey, sunset, sunrise, dusk and dawn CT were within two minutes of 17:39, 06:49, 18:03 and 06:25 respectively.

Survey Team

Sites were chosen and detectors placed by Astron ecologists. Bob Bullen of Bat Call WA completed analysis of echolocation recordings.

Sampling

The survey consisted of completing a total of 34 overnight bat sound recordings, beginning at twilight, at ten locations within the survey area. The recordings were “continuous” (Hyder *et al.* 2010) made using SM2BAT+ SongMeter (Wildlife Acoustics Inc., USA) detectors. The jumper and audio settings used followed the manufacturer’s recommendations for bat detection contained in the user manual (Wildlife Acoustics 2010).

For the recordings, once reformatted as .wav files, COOL EDIT 2000 (now available as AUDITION from Adobe Systems Inc.) was used to display each sequence for identification. Calls were identified manually. Only good quality call sequences were used. Details of calls analysed are provided in Table 2 as recommended by Australasian Bat Society (ABS 2006). Reference data for the species identified are available in Bullen and McKenzie 2002, McKenzie and Bullen 2003 and McKenzie and Bullen 2009.

Bat activity was then characterised as “Low”, “Medium” or “High” based on the rate of call sequences recorded.

- Low species activity is referred when a species is recorded with call spacing less often than ten minutes.
- Medium species activity refers to call recordings more often than 10 minutes but less often than two minutes apart for at least an hour followed by sporadic records for the remainder of the session.
- High species activity refers to call recording more often than two minutes apart for at least two hours followed by reasonably regular records for the remainder of the session.

Survey Limitations

The sites surveyed were accessible on foot and the SM2, using an omnidirectional microphone, was set on the ground with the microphone horizontal. Species are unlikely to be under-represented as a result.

Bat species density away from cave or adit entrances is impossible to estimate from echolocation records. Bat activity is therefore substituted as an approximate guide to the relative numbers of each species using the study area.

Heavy rain on three nights and cold temperatures on two nights have resulted in lower than typical bat call numbers for the time of year.

References

- ABS (2006). Recommendations of the Australasian Bat Society Inc for reporting standards for insectivorous bat surveys using bat detectors. *The Australasian Bat Society Newsletter* 27: 6-9.
- Bullen R.D. and McKenzie N.L. (2002). Differentiating Western Australian *Nyctophilus* (Chiroptera: Vespertilionidae) echolocation calls. *Australian Mammalogy*. 23: 89-93
- Hyder, B.M., Dell, J. and Cowan, M.A. (eds) (2010). *Technical guide – Terrestrial vertebrate fauna surveys for environmental impact assessment*. Technical report of the Environmental Protection Authority and the Department of Environment and Conservation.
- Jackson, S. and Groves, C (2015). *Taxonomy of Australian Mammals*. CSIRO Publishing: Collingwood Vic.
- McKenzie N.L. and Bullen R.D. (2003). Identifying Little Sandy Desert bat species from their echolocation calls. *Australian Mammalogy* 25: 73-80.
- McKenzie, N.L. and Bullen R.D. (2009). The echolocation calls, habitat relationships, foraging niches and communities of Pilbara microbats. *Rec. West. Aust. Mus.* Supplement 78:123-155.
- Reardon, T.B., McKenzie, N.L., Cooper, S.J., Appleton, B. Carthew, S. and Adams, M. (2014). A molecular and morphological investigation of species boundaries and phylogenetic relationships in Australian free-tailed bats *Mormopterus* (Chiroptera: Molossidae). *Australian Journal of Zoology*, available on-line 23 April 2014.
- Wildlife Acoustics (2010). Song Meter User Manual, Model SM2, with Song Meter SM2BAT 192kHz Stereo or 384kHz Mono Ultrasonic Recorders addendum.

Table 1 Site Specific details.

	Date	Recording Time	Habitat	Easting	Northing
Bat A1	3-6 June	Four overnight recordings using SM2 SN 15289	Overhang in gorge	417714	7591311
Bat A2	3-8 June	Four overnight recordings using SM2 SN 13947	Semi-permanent pool in gorge	417078	7590311
Bat A3	3-8 June	Six overnight recordings using SM2 SN 14909	Overhang in gorge	417723	7589676
Bat A4	3-8 June	Six overnight recordings using SM2 SN 15281	Cave entrance	419326	7588792
Bat A5	7-8 June	Two overnight recording using SM2 SN 15289	Cave entrance	417641	7591471
Bat 2	4-8 June	Five overnight recordings using SM2 SN 15337	Cave entrance	411741	7595774
Bat 3	4 June	One overnight recording using SM2 SN 8027	Overhang	397545	7607340
Bat 4	4-5 June	Two overnight recordings using SM2 SN 7634	Overhang	405894	7606227
Bat 6	6-7 June	Two overnight recordings using SM2 SN 7634	Overhang	399978	7608691
Bat 7	6-7 June	Two overnight recordings using SM2 SN 8027	Overhang	391468	7608781

Note 1: Coordinates are Zone 50K

Table 2: Summary of Echolocation call characteristics for microbat species present.

Genus species Authority	Common name	Typical F_{peak} kHz Note 1	Ave. Q Note 1	Typical Duration msec	Typical Call Shape
<i>Austronomus australis</i> (Gray 1838) Note 2	White-striped free-tailed bat	12	7	12 - 23	CF– shallow FM
<i>Chaerephon jobensis</i> (Miller 1902)	Northern free-tailed bat	22	5	8 - 15	Shallow FM
<i>Chalinolobus gouldii</i> (Grey 1841)	Gould’s wattled bat	32	10	7 - 11	FM
<i>Macroderma gigas</i> (Dobson 1880)	Ghost bat	20 – 52 variable	2 – 20 variable	variable	Complex FM
<i>Rhinonictoris aurantia</i> (Gray 1845)	Pilbara leaf-nosed bat	120	30	5 - 8	CF
<i>Saccolaimus flaviventris</i> (Peters 1867)	Yellow-bellied sheath-tailed bat	18	9	12 - 21	CF - FM
<i>Scotorepens greyii</i> (Gray 1843)	Little broad-nosed bat	38	10	7 - 13	FM
<i>Taphozous georgianus</i> Thomas 1915	Common sheath-tailed bat	24.5	14	9 - 18	CF– shallow FM
<i>Vespadelus finlaysoni</i> (Kitchener, Jones and Caputi 1987)	Inland cave bat	55	14	4 - 8	FM

Note 1: F_{peak} and Q are defined in McKenzie and Bullen 2003, 2009.

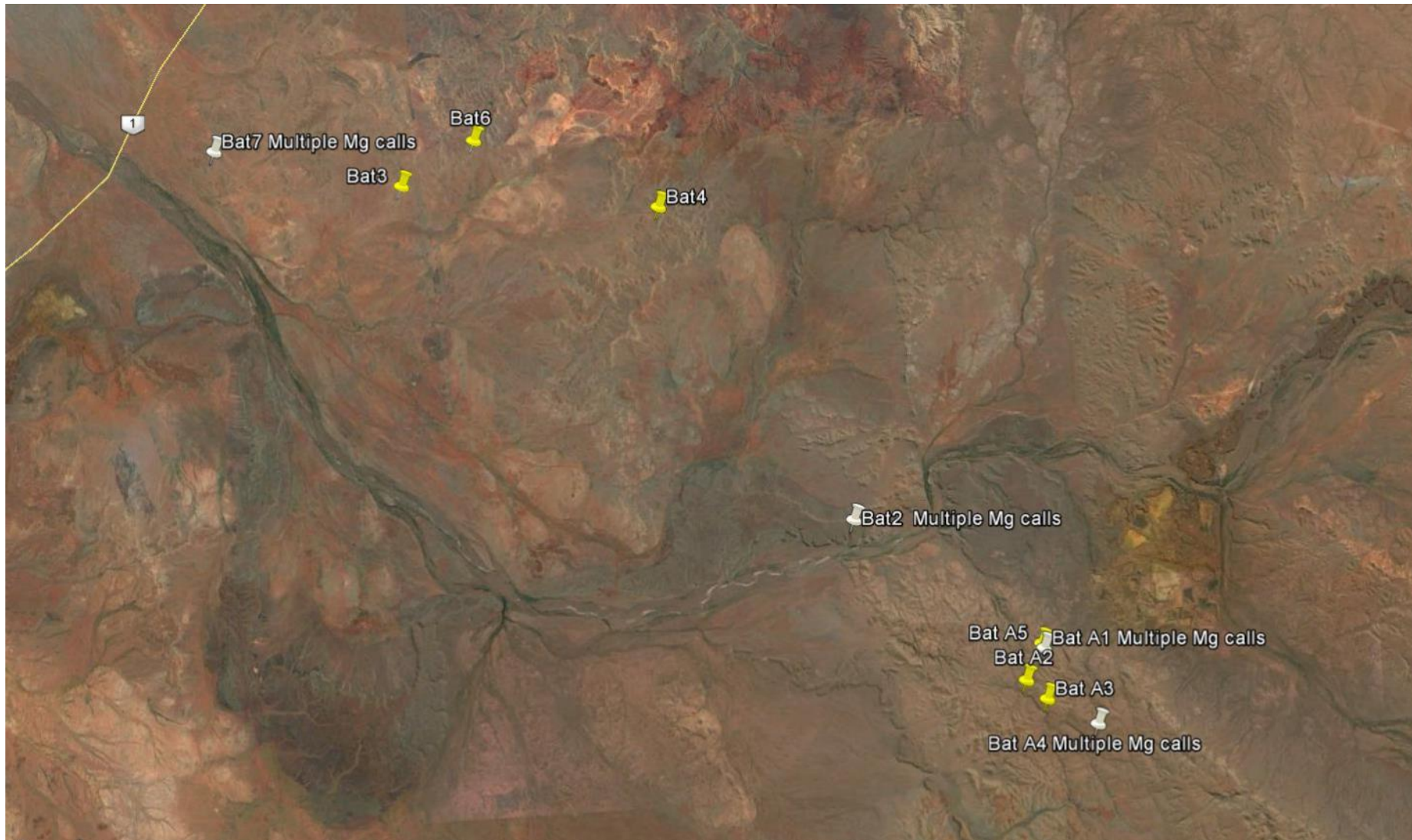
Note 2: Taxonomy follows Jackson and Groves (2015). *A. australis* was known until recently as *Tadarida australis*.

Table 3. Survey microbat lists presented by site.

Site	<i>Austronomus australis</i>	<i>Chaerephon jobensis</i>	<i>Chalinolobus gouldii</i>	<i>Macroderma gigas</i>	<i>Rhinonictis aurantia</i> Note 1	<i>Saccolaimus flaviventris</i>	<i>Scotorepens greyii</i>	<i>Taphozous georgianus</i>	<i>Vespadelus finlaysoni</i>
Bat A1	Low	Low	Low	Low (Multiple calls detected)	Low (23 calls)	Low	Low	High	High
Bat A2	Low		Low		Low (20 calls)		Low	High	High
Bat A3	Low				Low (18 calls)	Low	Low	High	Low
Bat A4	Low	Low	Low	Low (Multiple calls detected)	Med (140 calls)		Low	High	High
Bat A5		Low					Low	Low	Low
Bat 2	Low	Low	Low	Med (Multiple calls detected)	Low (17 calls)		Low	High	Med
Bat 3		Low	Low					High	Low
Bat 4		Low	Low					Med	Low
Bat 6								Low	
Bat 7	Low	Low	Low	Low (two calls detected)	Low (1 call)			Med	Med

Note 1: Total number of calls detected during the recording period at the site

Figure 1. Detector sites in relation to features in the study area. White pins denote sites where Ghost bats were detected.



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Appendix C: Summary of Ghost Bat Records

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Table C.1: Summary of Ghost Bat records

Ref #	Report	Author	Year	Easting	Northing	Site code	Record type	Assessment	Assessment	Updated assessment	Within		Land system	Distance to Robe River or tributary	Cave dimensions (H x W)		Distance to Mesa H
											Contextual survey area	Desktop survey area			Entrance	Internal	
1	Fauna Habitats and Fauna Assemblage of Mesa A and G	Biota Environmental Sciences	2005	386106	7603985	MEA06 (MAI06-SH17)	Visual sighting	Cave	Potential diurnal roost - 1 individual sighted	Nocturnal feeding roost (MAI06-SH17; Bat Call WA 2017c)	No	Yes	Robe	5 km	Unknown	Unknown	29 km
2	Mesa H - Ghost Bat, <i>Macroderma gigas</i> - Contextual study	Astron Environmental Services	2016	391440	7608686	FCML8	Scat	Cave	Nocturnal feeding roost	-	Yes	Yes	Nanutarra	2 km	N/A	N/A	25 km
3	Mesa H - Ghost Bat, <i>Macroderma gigas</i> - Contextual study	Astron Environmental Services	2016	391468	7608781	BAT 7	Acoustic recording	Breakaway	Nocturnal feeding roost	-	Yes	Yes	Nanutarra	2 km	N/A	N/A	25 km
4	Robe Valley Mesas Fauna Survey	Biota Environmental Sciences	2011	392301	7596831	RVM03	Acoustic recording	Cave	-	-	Yes	Yes	Robe	3 km	N/A	N/A	22 km
5	Mesa H - Ghost Bat, <i>Macroderma gigas</i> - Contextual study	Astron Environmental Services	2016	392440	7602769	DRJT1 (MCC-02)	Scat	Large cave	Diurnal roost - cave assessment	Potential diurnal roost (MCC-02; Bat Call WA 2017c)	Yes	Yes	Robe	1 km	Tight (1.5 m x 2 m)	Domed cavern on top of entrance (3 m x 8 m)	22 km
6	Mesa H - Ghost Bat, <i>Macroderma gigas</i> - Contextual study	Astron Environmental Services	2016	392445	7602780	FCJT14	Scat	Cave	Nocturnal feeding roost	-	Yes	Yes	Robe	1 km	N/A	N/A	22 km
7	Mesa H - Ghost Bat, <i>Macroderma gigas</i> - Contextual study	Astron Environmental Services	2016	392577	7602375	FCJT16	Scat	Cave	Nocturnal feeding roost	-	Yes	Yes	Robe	1 km	N/A	N/A	22 km
8	Mesa H - Ghost Bat, <i>Macroderma gigas</i> - Contextual study	Astron Environmental Services	2016	392585	7600245	FCJT13	Scat	Cave	Nocturnal feeding roost	-	Yes	Yes	Robe	1 km	N/A	N/A	22 km
9	Fauna Habitats and Fauna Assemblage of the Mesa A Transport Corridor and Warrambo	Biota Environmental Sciences	2006	392718	7603137	MATHARP1 and 2	Scat	Breakaway	Nocturnal feeding roost	-	Yes	Yes	Robe	1 km	N/A	N/A	22 km
10	Mesa H - Ghost Bat, <i>Macroderma gigas</i> - Contextual study	Astron Environmental Services	2016	397502	7607326	FCJT3 (BAT 3)	Scat	Cave	Nocturnal feeding roost	-	Yes	Yes	Nanutarra	5 km	N/A	N/A	20 km

Ref #	Report	Author	Year	Easting	Northing	Site code	Record type	Assessment	Assessment	Updated assessment	Within		Land system	Distance to Robe River or tributary	Cave dimensions (H x W)		Distance to Mesa H
											Contextual survey area	Desktop survey area			Entrance	Internal	
11	Robe Valley Mesas Fauna Survey	Biota Environmental Sciences	2011	398218	7591036	RVM04 (MF01)	Harp trap and acoustic recording	Cave	Potential maternal roost - 24 individuals caught	Maternal roost – 70 individuals sighted (MF01; Bat Call WA 2017a)	Yes	Yes	Boolgeeda	4 km	Unknown	Unknown	16 km
12	Mesa H - Ghost Bat, <i>Macroderma gigas</i> - Contextual study	Astron Environmental Services	2016	398672	7611567	FCML7	Scat	Cave	Nocturnal feeding roost	-	Yes	Yes	Nanutarra	10 km	N/A	N/A	20 km
13	Mesa H - Ghost Bat, <i>Macroderma gigas</i> - Contextual study	Astron Environmental Services	2016	399979	7608691	FCML6 (BAT6)	Scat	Cave	Nocturnal feeding roost	-	Yes	Yes	Nanutarra	10 km	N/A	N/A	18 km
14	Yarraloola - Northern Quoll, Pilbara Olive Python and Pilbara Leaf-nosed Bat Targeted Survey	Biologic Environmental Survey Pty Ltd	2014	405774	7606714	1	Visual sighting	Unknown	-	-	Yes	Yes	Nanutarra	12 km	N/A	N/A	12 km
15	Mesa H - Ghost Bat, <i>Macroderma gigas</i> - Contextual study	Astron Environmental Services	2016	405895	7606227	FCJT4 (BAT4)	Scat	Cave	Nocturnal feeding roost	-	Yes	Yes	Nanutarra	12 km	N/A	N/A	12 km
16	Mesa H - Ghost Bat, <i>Macroderma gigas</i> - Contextual study	Astron Environmental Services	2016	409835	7595814	FCJT5	Scat	Cave	Nocturnal feeding roost	-	Yes	Yes	Newman	< 1 km	N/A	N/A	4 km
17	Mesa H - Ghost Bat, <i>Macroderma gigas</i> - Contextual study	Astron Environmental Services	2016	410059	7595897	FCJT6	Scat	Cave	Nocturnal feeding roost	-	Yes	Yes	Newman	< 1 km	N/A	N/A	4 km
18	Mesa H - Ghost Bat, <i>Macroderma gigas</i> - Contextual study	Astron Environmental Services	2016	410078	7595957	FCJT7	Scat	Cave	Nocturnal feeding roost	-	Yes	Yes	Newman	< 1 km	N/A	N/A	4 km
19	Mesa H - Ghost Bat, <i>Macroderma gigas</i> - Contextual study	Astron Environmental Services	2016	410143	7595939	FCML5	Scat	Cave	Nocturnal feeding roost	-	Yes	Yes	Newman	< 1 km	N/A	N/A	4 km
20	Mesa H - Ghost Bat, <i>Macroderma gigas</i> - Contextual study	Astron Environmental Services	2016	410151	7595728	FCML4	Scat	Cave	Nocturnal feeding roost	-	Yes	Yes	Newman	< 1 km	N/A	N/A	4 km

Ref #	Report	Author	Year	Easting	Northing	Site code	Record type	Assessment	Assessment	Updated assessment	Within		Land system	Distance to Robe River or tributary	Cave dimensions (H x W)		Distance to Mesa H
											Contextual survey area	Desktop survey area			Entrance	Internal	
21	Mesa H - Ghost Bat, <i>Macroderma gigas</i> - Contextual study	Astron Environmental Services	2016	410174	7595941	FCJT10 (BAT5)	Scat	Cave	Nocturnal feeding roost	-	Yes	Yes	Newman	< 1 km	N/A	N/A	4 km
22	Mesa H - Ghost Bat, <i>Macroderma gigas</i> - Contextual study	Astron Environmental Services	2016	410176	7595921	FCJT9	Scat	Cave	Nocturnal feeding roost	-	Yes	Yes	Newman	< 1 km	N/A	N/A	4 km
23	Mesa H - Ghost Bat, <i>Macroderma gigas</i> - Contextual study	Astron Environmental Services	2016	410440	7595459	FCJT2	Scat	Cave	Nocturnal feeding roost	-	Yes	Yes	Newman	< 1 km	N/A	N/A	4 km
24	Mesa G Baseline Fauna Survey	Biota Environmental Sciences	2009	410531	7595661	MSG06E (G01)	Harp trap	Breakaway	Potential maternal roost - 11 individuals caught	Foraging habitat (cave G01; Bat Call WA 2017a)	Yes	Yes	Newman	< 1 km	Unknown	Unknown	4 km
25	Mesa G Baseline Fauna Survey	Biota Environmental Sciences	2009	410688	7595388	MSGBAT01	Harp trap	Breakaway	1 individual caught	-	Yes	Yes	Newman	< 1 km	Unknown	Unknown	4 km
26	Mesa H - Ghost Bat, <i>Macroderma gigas</i> - Contextual study	Astron Environmental Services	2016	410826	7595410	FCML3	Scat	Cave	Nocturnal feeding roost	-	Yes	Yes	River	< 1 km	N/A	N/A	4 km
27	Mesa H - Ghost Bat, <i>Macroderma gigas</i> - Contextual study	Astron Environmental Services	2016	410869	7595409	FCML2	Scat	Cave	Nocturnal feeding roost	-	Yes	Yes	River	< 1 km	N/A	N/A	4 km
28	Mesa H - Ghost Bat, <i>Macroderma gigas</i> - Contextual study	Astron Environmental Services	2016	410886	7595414	FCML1	Scat	Cave	Nocturnal feeding roost	-	Yes	Yes	River	< 1 km	N/A	N/A	4 km
29	Mesa H - Ghost Bat, <i>Macroderma gigas</i> - Contextual study	Astron Environmental Services	2016	411696	7595502	FCJT1	Scat	Cave	Nocturnal feeding roost	-	Yes	Yes	Newman	< 1 km	N/A	N/A	3 km
30	Mesa H - Ghost Bat, <i>Macroderma gigas</i> - Contextual study	Astron Environmental Services	2016	411727	7595625	RCML1	Cave assessment	Large cave	Diurnal roost - cave assessment	-	Yes	Yes	Newman	< 1 km	Open (15 m x 30 m)	25 m deep with 3 rear passages and 1 open domed cavern	3 km
31	Mesa H - Ghost Bat, <i>Macroderma gigas</i> - Contextual study	Astron Environmental Services	2016	411740	7595774	MCJT1 (G02)	Acoustic recording and visual sighting	Large cave	Potential maternal roost - 12 individuals sighted	Diurnal roost (G02; Bat Call WA 2017a)	Yes	Yes	Newman	< 1 km	Complex with multiple tight entrances	40 m deep with multiple domed caverns and rear passages	3 km

Ref #	Report	Author	Year	Easting	Northing	Site code	Record type	Assessment	Assessment	Updated assessment	Within		Land system	Distance to Robe River or tributary	Cave dimensions (H x W)		Distance to Mesa H
											Contextual survey area	Desktop survey area			Entrance	Internal	
32	Yarraloola - Northern Quoll, Pilbara Olive Python and Pilbara Leaf-nosed Bat Targeted Survey	Biologic Environmental Survey Pty Ltd	2014	413118	7588574	4	Visual sighting	Unknown	-	-	Yes	Yes	Robe	6 km	N/A	N/A	6 km
33	Mesa H - Ghost Bat, <i>Macroderma gigas</i> - Contextual study	Astron Environmental Services	2016	413766	7600738	FCJT11	Scat	Cave	Nocturnal feeding roost	-	Yes	Yes	Newman	3 km	N/A	N/A	3 km
34	Mesa H Level 1 Flora, Vegetation and Fauna Assessment	Astron Environmental Services	2014	414408	7597657	Anabat 8	Acoustic recording	Robe River	Foraging habitat	-	Yes	Yes	River	< 1 km	N/A	N/A	Within Mesa H
35	Mesa H Level 1 Flora, Vegetation and Fauna Assessment	Astron Environmental Services	2014	414643	7597665	Anabat 7	Acoustic recording	Robe River	Foraging habitat	-	Yes	Yes	Robe	< 1 km	N/A	N/A	Within Mesa H
36	Mesa H Level 1 Flora, Vegetation and Fauna Assessment	Astron Environmental Services	2014	414995	7595902	Anabat 1	Acoustic recording	Breakaway	-	-	Yes	Yes	Robe	< 1 km	N/A	N/A	Within Mesa H
37	Mesa H Level 1 Flora, Vegetation and Fauna Assessment	Astron Environmental Services	2014	415149	7596502	Cave 2 (H18)	Scat, remains and visual sighting	Cave	Diurnal roost - 1 individual sighted	Nocturnal feeding roost (H18; Bat Call WA 2017b)	Yes	Yes	Robe	< 1 km	Complex with multiple tight entrances	Unknown	Within Mesa H
38	Mesa H Level 1 Flora, Vegetation and Fauna Assessment	Astron Environmental Services	2014	415159	7596483	OPP	Remains	Gorge/gully/cave	-	-	Yes	Yes	Robe	< 1 km	N/A	N/A	Within Mesa H
39	Mesa H Level 1 Flora, Vegetation and Fauna Assessment	Astron Environmental Services	2014	415162	7596482	OPP	Remains	Gorge/gully/cave	-	-	Yes	Yes	Robe	< 1 km	N/A	N/A	Within Mesa H
40	Mesa H Level 1 Flora, Vegetation and Fauna Assessment	Astron Environmental Services	2014	415168	7596492	Cave 3 (H18)	Visual sighting	Gorge/gully/cave	Diurnal roost - 1 individual sighted	Nocturnal feeding roost (H18; Bat Call WA 2017b)	Yes	Yes	Robe	< 1 km	Unknown	Unknown	Within Mesa H
41	Mesa H Level 1 Flora, Vegetation and Fauna Assessment	Astron Environmental Services	2014	415265	7596486	Cave 6	Scat	Cave	Potential diurnal roost - cave assessment	-	Yes	Yes	Robe	< 1 km	Complex with multiple tight entrances		Within Mesa H

Ref #	Report	Author	Year	Easting	Northing	Site code	Record type	Assessment	Assessment	Updated assessment	Within		Land system	Distance to Robe River or tributary	Cave dimensions (H x W)		Distance to Mesa H
											Contextual survey area	Desktop survey area			Entrance	Internal	
42	Yarraloola - Northern Quoll, Pilbara Olive Python and Pilbara Leaf-nosed Bat Targeted Survey	Biologic Environmental Survey Pty Ltd	2014	415676	7579617	"Stone"	Scat	Unknown	Nocturnal feeding roost	-	No	Yes	Rocklea	16 km	N/A	N/A	Within Mesa H
43	Mesa H Level 1 Flora, Vegetation and Fauna Assessment	Astron Environmental Services	2014	415739	7598526	Anabat 6	Acoustic recording	Riverine	Foraging habitat	-	Yes	Yes	Robe	< 1 km	N/A	N/A	Within Mesa H
44	Mesa H Level 1 Flora, Vegetation and Fauna Assessment	Astron Environmental Services	2014	415802	7595656	Cave 1 (MH16-34)	Visual sighting and scat	Cave	Diurnal roost – 1 individual sighted	Diurnal roost (MH16-34; Bat Call WA 2017b)	Yes	Yes	Robe	< 1 km	Complex with multiple tight entrances	Unknown	Within Mesa H
45	Mesa H - Ghost Bat, <i>Macroderma gigas</i> - Contextual study	Astron Environmental Services	2016	416948	7590247	DRML1	Cave assessment	Large cave	Diurnal roost - cave assessment	-	Yes	Yes	Newman	6 km	Open, adit like (35 m x 15 m)	Multiple caverns (20 m x 20 m) and rear passages	2 km
46	Mesa H Level 1 Flora, Vegetation and Fauna Assessment	Astron Environmental Services	2014	417109	7593285	Cave 5 (AC05)	Scat	Gorge cave	Potential diurnal roost-cave assessment	Nocturnal feeding roost (AC05; Bat Call WA 2017b)	Yes	Yes	Newman	5 km	Tight	Unknown	Within Mesa H
47	Mesa H - Ghost Bat, <i>Macroderma gigas</i> - Contextual study	Astron Environmental Services	2016	417354	7590957	FCML9	Scat	Cave	Nocturnal feeding roost	-	Yes	Yes	Newman	5 km	N/A	N/A	1 km
48	Mesa H - Ghost Bat, <i>Macroderma gigas</i> - Contextual study	Astron Environmental Services	2016	417447	7591014	FCML10	Scat	Cave	Nocturnal feeding roost	-	Yes	Yes	Newman	5 km	N/A	N/A	1 km
49	Mesa H - Ghost Bat, <i>Macroderma gigas</i> - Contextual study	Astron Environmental Services	2016	417580	7591118	DRML2	Cave assessment	Large cave	Diurnal roost - cave assessment	-	Yes	Yes	Newman	5 km	Open (6 m x 12 m)	Large, narrow crevices approx. 15 m high, small domed cavern	1 km
50	Mesa H Level 1 Flora, Vegetation and Fauna Assessment	Astron Environmental Services	2014	417586	7594896	Cave 3/ Anabat 9	Scat	Large cave	Potential diurnal roost	Diurnal roost (AC04; Bat Call WA 2017b)	Yes	Yes	Robe	3 km	Large open entrance	Unknown	Within Mesa H
51	Mesa H - Ghost Bat, <i>Macroderma gigas</i> - Contextual study	Astron Environmental Services	2016	417662	7591258	FCJT15	Scat	Cave	Nocturnal feeding roost	-	Yes	Yes	Newman	5 km	N/A	N/A	1 km

Ref #	Report	Author	Year	Easting	Northing	Site code	Record type	Assessment	Assessment	Updated assessment	Within		Land system	Distance to Robe River or tributary	Cave dimensions (H x W)		Distance to Mesa H
											Contextual survey area	Desktop survey area			Entrance	Internal	
52	Mesa H - Ghost Bat, <i>Macroderma gigas</i> - Contextual study	Astron Environmental Services	2016	417714	7591311	Bat A1	Acoustic recording	Breakaway	Foraging habitat	-	Yes	Yes	Newman	5 km	N/A	N/A	1 km
53	Mesa H Level 1 Flora, Vegetation and Fauna Assessment	Astron Environmental Services	2014	418068	7592683	Cave 5	Scat	Gorge/gully/cave	Potential diurnal roost	Nocturnal feeding roost (Bat Call WA 2017b)	Yes	Yes	Newman	5 km	Tight	Unknown	Within Mesa H
54	Mesa H Level 2 Flora, Vegetation and Fauna Assessment	Astron Environmental Services	2016	419092	7591197	SN12791	Acoustic recording	Gorge	-	-	Yes	Yes	Newman	6 km	N/A	N/A	Within Mesa H
55	Mesa H - Ghost Bat, <i>Macroderma gigas</i> - Contextual study	Astron Environmental Services	2016	419326	7588792	Bat A4	Acoustic recording and visual sighting	Large cave	Potential maternal roost - 3 individuals sighted	-	Yes	Yes	Newman	8 km	Open and large (20 m x 40 m)	60 m deep with 3 large domed chambers and 2 rear passages	2 km
56	Mesa H Level 2 Flora, Vegetation and Fauna Assessment	Astron Environmental Services	2016	419408	7596586	OPP02	Scat	Breakaway	Nocturnal feeding roost	-	Yes	Yes	Newman	< 1 km	N/A	N/A	Within Mesa H
57	Mesa H - Ghost Bat, <i>Macroderma gigas</i> - Contextual study	Astron Environmental Services	2016	420680	7589526	FCJT12	Scat	Cave	Nocturnal feeding roost	-	Yes	Yes	Newman	7 km	N/A	N/A	1 km
58	Middle Robe East Deepdale Level 2 Fauna Assessment	Astron Environmental Services	2015	424651	7599195	SM12	Acoustic recording	Breakaway	-	-	No	Yes	Robe	< 1 km	N/A	N/A	4 km
59	Middle Robe East Deepdale Level 2 Fauna Assessment	Astron Environmental Services	2015	426240	7600597	OPP	Scat	Breakaway	Nocturnal feeding roost	-	No	Yes	Robe	< 1 km	N/A	N/A	6 km
60	Middle Robe East Deepdale Level 2 Fauna Assessment	Astron Environmental Services	2015	429041	7600905	Sf33	Scat	Breakaway cave	Nocturnal feeding roost	-	No	Yes	Robe	< 1 km	N/A	N/A	8 km
61	Bungaroo Level 2 Fauna Assessment	Astron Environmental Services	2015	432041	7581397	M17	Scat	Breakaway cave	Nocturnal feeding roost	-	No	Yes	Newman	< 1 km	N/A	N/A	13 km
62	Greater Bungaroo Seasonal Fauna Survey	Biota Environmental Sciences	2010	432484	7581130	GBNbat02	Harp trap	Cave	Potential diurnal roost	-	No	Yes	Boolgeeda	< 1 km	Unknown	Unknown	13 km
63	Middle Robe East Deepdale Level 2 Fauna Assessment	Astron Environmental Services	2015	434094	7603463	HA6	Scat	Breakaway	Nocturnal feeding roost	-	No	Yes	Robe	< 1 km	N/A	N/A	14 km
64	Bungaroo Level 2 Fauna Assessment	Astron Environmental Services	2015	437393	7575997	M14c	Scat	Breakaway	Nocturnal feeding roost	-	No	Yes	Newman	< 1 km	N/A	N/A	20 km

Ref #	Report	Author	Year	Easting	Northing	Site code	Record type	Assessment	Assessment	Updated assessment	Within		Land system	Distance to Robe River or tributary	Cave dimensions (H x W)		Distance to Mesa H
											Contextual survey area	Desktop survey area			Entrance	Internal	
65	Bungaroo Level 2 Fauna Assessment	Astron Environmental Services	2015	439477	7577992	MJ1	Acoustic recording	Breakaway	Nocturnal feeding roost	-	No	Yes	Newman	< 1 km	N/A	N/A	20 km
66	Middle Robe East Deepdale Level 2 Fauna Assessment	Astron Environmental Services	2015	439619	7603530	HA7	Scat	Breakaway	Nocturnal feeding roost	-	No	Yes	Robe	< 1 km	N/A	N/A	19 km
67	Middle Robe East Deepdale Level 2 Fauna Assessment	Astron Environmental Services	2015	440541	7603393	SM10	Acoustic recording	Breakaway	Diurnal roost – low call number	-	No	Yes	Robe	< 1 km	Open (1 m x 8 m)	10 m deep	19 km
68	Middle Robe East Deepdale Level 2 Fauna Assessment	Astron Environmental Services	2015	440543	7603387	SF09	Acoustic recording	Cave	Diurnal roost - low call number	-	No	Yes	Robe	< 1 km	Narrow entrance (1 m x 1 m)	6 m deep with a domed chamber	19 km
69	Middle Robe East Deepdale Level 2 Fauna Assessment	Astron Environmental Services	2015	441635	7601956	OPP	Scat	Breakaway	Nocturnal feeding roost	-	No	Yes	Robe	< 1 km	N/A	N/A	19 km
70	Bungaroo Level 2 Fauna Assessment	Astron Environmental Services	2015	441772	7573032	MJ19	Scat	Gorge	Nocturnal feeding roost	-	No	Yes	Newman	< 1 km	N/A	N/A	25 km
71	Middle Robe East Deepdale Level 2 Fauna Assessment	Astron Environmental Services	2015	443673	7600605	HA26	Scat	Stony hills and slopes	Nocturnal feeding roost	-	No	Yes	Robe	< 1 km	Shallow overhang	Two rear passages	20 km
72	Middle Robe East Deepdale Level 2 Fauna Assessment	Astron Environmental Services	2015	443675	7600570	SM14	Acoustic recording	Breakaway	-	-	No	Yes	Robe	< 1 km	N/A	N/A	20 km
73	Bungaroo Level 2 Fauna Assessment	Astron Environmental Services	2015	443690	7572830	M14b	Scat	Breakaway cave	Nocturnal feeding roost	-	No	Yes	Newman	< 1 km	N/A	N/A	26 km
74	Middle Robe East Deepdale Level 2 Fauna Assessment	Astron Environmental Services	2015	443694	7600663	HA26	Scat	Stony hills and slopes	Nocturnal feeding roost	-	No	Yes	Robe	< 1 km	Overhang 6 m deep	Tight rear passage dimensions unknown	20 km
75	Middle Robe East Deepdale Level 2 Fauna Assessment	Astron Environmental Services	2015	445777	7600412	OPP	Scat	Breakaway	Nocturnal feeding roost	-	No	Yes	Rocklea	< 1 km	Shallow overhang	Tight rear passage dimensions unknown	23 km
76	Middle Robe East Deepdale Level 2 Fauna Assessment	Astron Environmental Services	2015	446229	7598184	HA9	Scat	Breakaway	Nocturnal feeding roost	-	No	Yes	Robe	< 1 km	N/A	N/A	23 km
77	Middle Robe East Deepdale Level 2 Fauna Assessment	Astron Environmental Services	2015	447006	7601602	OPP	Scat	Breakaway	Nocturnal feeding roost	-	No	Yes	Robe	< 1 km	N/A	N/A	23 km
78	Middle Robe East Deepdale Level 2 Fauna Assessment	Astron Environmental Services	2015	447043	7601535	OPP	Visual sighting	Breakaway	Diurnal roost - 1 individual sighted	-	No	Yes	Robe	< 1 km	Unknown	8 m deep	25 km

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79	Bungaroo Level 2 Fauna Assessment	Astron Environmental Services	2015	447125	7572647	MJ30	Scat	Gorge cave	Nocturnal feeding roost	-	No	Yes	Newman	< 1 km	N/A	N/A	29 km
80	Middle Robe East Deepdale Level 2 Fauna Assessment	Astron Environmental Services	2015	447185	7601770	SF05	Scat	Cave	Nocturnal feeding roost	-	No	Yes	Robe	< 1 km	N/A	N/A	25 km
81	Middle Robe East Deepdale Level 2 Fauna Assessment	Astron Environmental Services	2015	447192	7601783	HA12	Scat	Breakaway	Nocturnal feeding roost	-	No	Yes	Robe	< 1 km	N/A	N/A	25 km
82	Bungaroo Level 2 Fauna Assessment	Astron Environmental Services	2015	448668	7569097	sm7634a	Acoustic recording	Large cave	Nocturnal feeding roost	-	No	No	Unknown	< 1 km	N/A	N/A	32 km
83	Bungaroo Level 2 Fauna Assessment	Astron Environmental Services	2015	448687	7569055	JO-BAT-2	Acoustic recording	Large cave	Nocturnal feeding roost	-	No	No	Unknown	< 1 km	N/A	N/A	32 km
84	Bungaroo Level 2 Fauna Assessment	Astron Environmental Services	2015	449452	7571114	M14	Scat	Breakaway cave	Nocturnal feeding roost	-	No	No	Unknown	< 1 km	N/A	N/A	32 km
85	Bungaroo Level 2 Fauna Assessment	Astron Environmental Services	2015	449703	7568370	M08	Scat	Breakaway cave	Nocturnal feeding roost	-	No	No	Unknown	< 1 km	N/A	N/A	34 km
86	Middle Robe East Deepdale Level 2 Fauna Assessment	Astron Environmental Services	2015	449948	7601179	Sf24	Scat	Cave	Nocturnal feeding roost	-	No	Yes	Robe	< 1 km	N/A	N/A	29 km
87	Bungaroo Level 2 Fauna Assessment	Astron Environmental Services	2015	450747	7568576	M08s	Scat	Cave	Nocturnal feeding roost	-	No	No	Unknown	< 1 km	N/A	N/A	34 km
88	Bungaroo Level 2 Fauna Assessment	Astron Environmental Services	2015	451025	7570122	Jt GB Cave 1	Scat	Gorge cave	Nocturnal feeding roost	-	No	No	Unknown	< 1 km	N/A	N/A	34 km
89	Middle Robe East Deepdale Level 2 Fauna Assessment	Astron Environmental Services	2015	455741	7594808	Sf12	Scat	Cave	Nocturnal feeding roost	-	No	Yes	Robe	< 1 km	N/A	N/A	35 km
90	Middle Robe East Deepdale Level 2 Fauna Assessment	Astron Environmental Services	2015	455987	7595300	SF13	Scat	Cave	Diurnal roost - cave assessment	-	No	No	Unknown	< 1 km	Open (25 m wide)	25 m deep	35 km
91	Middle Robe East Deepdale Level 2 Fauna Assessment	Astron Environmental Services	2015	456013	7595266	Sm20	Acoustic recording	Cave	Maternal roost - high call number	-	No	No	Unknown	< 1 km	Open (20 m wide)	20 m deep	35 km
92	Mesa B-C Cave Assessment, July 2016	Bat Call WA Pty Ltd	2016	389239	7604270	MBC-02	Cave assessment	Cave	Nocturnal feeding roost	-	No	Yes	Robe	2 km	Single entrance, 23.2 x 4.0	Cave 19.3 m deep with low domed roof 2.0m high.	25 km

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93	Mesa B-C Cave Assessment, July 2016	Bat Call WA Pty Ltd	2016	389341	7604165	MBC-06	Cave assessment	Cave	Nocturnal feeding roost	-	Yes	Yes	Robe	3 km	Single entrance, 5.0 x 1.0	Cave 10.7 m deep with domed ceiling in rear chamber 1.7m high.	25 km
94	Mesa B-C Cave Assessment, July 2016	Bat Call WA Pty Ltd	2016	389368	7603890	MBS-04	Cave assessment	Cave	Nocturnal feeding roost	-	Yes	Yes	Robe	3 km	Single entrance, 1.9 x 1.0	Shelter 1.5 m deep with domed ceiling 1.5m high.	25 km
95	Mesa B-C Cave Assessment, July 2016	Bat Call WA Pty Ltd	2016	389387	7604070	MBS-05	Cave assessment	Cave	Nocturnal feeding roost	-	Yes	Yes	Robe	3 km	Two entrance, 11.1 x 2.0 and 9.2 x 2.0	Shelter chambers 6.8 and 5.5 m deep, both with domed ceilings ~1.6m high.	25 km
96	Mesa B-C Cave Assessment, July 2016	Bat Call WA Pty Ltd	2016	390541	7604402	MBS-03	Cave assessment	Cave	Nocturnal feeding roost	-	Yes	Yes	Robe	2 km	Single entrance, 2.3 x 2.3	Shelter 7.2 m deep.	25 km
97	Mesa B-C Cave Assessment, July 2016	Bat Call WA Pty Ltd	2016	390791	7604400	MBC-05	Cave assessment	Cave	Diurnal roost (possible maternal roost) - 16 individuals sighted	-	Yes	Yes	Robe	2 km	Single entrance, Not measured due to presence of Ghost bats	Cave approx. 20 m deep. Not measured due to presence of Ghost bats	25 km
98	Mesa B-C Cave Assessment, July 2016	Bat Call WA Pty Ltd	2016	390809	7604425	MBC-04	Cave assessment	Cave	Nocturnal feeding roost	-	Yes	Yes	Robe	2 km	Single entrance, 7.6 x 2.5	Cave 13.3 m deep with domed roof 3.0m high and low rear chamber.	25 km
99	Mesa B-C Cave Assessment, July 2016	Bat Call WA Pty Ltd	2016	391009	7604273	MBS-01	Cave assessment	Cave	Nocturnal feeding roost	-	Yes	Yes	Robe	2 km	Single entrance, 14.3 x 2.5	Shelter 10.5 m deep with low domed roof 1.5m high.	25 km
100	Mesa B-C Cave Assessment, July 2016	Bat Call WA Pty Ltd	2016	391348	7604205	MBS-07	Cave assessment	Cave	Nocturnal feeding roost	-	Yes	Yes	Robe	2 km	Single entrance, 7.2 x 4.1	Cave with 12.2m deep with domed ceiling 2.7 high.	25 km

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101	Mesa B-C Cave Assessment, July 2016	Bat Call WA Pty Ltd	2016	391643	7604682	MBS-08	Cave assessment	Cave	Nocturnal feeding roost	-	Yes	Yes	Robe	< 1 km	Single entrance, 13.0 x 3.0	Shelter 11.0m deep with domed ceiling 2.0 high.	25 km
102	Mesa B-C Cave Assessment, July 2016	Bat Call WA Pty Ltd	2016	391999	7604441	MBC-01	Cave assessment	Cave	Nocturnal feeding roost	-	Yes	Yes	Robe	1 km	Single entrance 7.1 x 2.8 m	Internal domed chamber 1.5 m high	25 km
103	Mesa B-C Cave Assessment, July 2016	Bat Call WA Pty Ltd	2016	392498	7602976	MCC-04	Cave assessment	Cave	Nocturnal feeding roost	-	Yes	Yes	Robe	< 1 km	Two entrances, both 1.5 x 1.0	Internal domed chamber 2.5 m high	25 km
104	Mesa B-C Cave Assessment, July 2016	Bat Call WA Pty Ltd	2016	392569	7602798	MCC-05	Cave assessment	Cave	Nocturnal feeding roost	-	Yes	Yes	Robe	< 1 km	Single entrance, 4.7 x 2.7	Cave approx. 30 m deep	25 km
105	Mesa B-C Cave Assessment, July 2016	Bat Call WA Pty Ltd	2016	392587	7603154	MCS-14	Cave assessment	Cave	Nocturnal feeding roost	-	Yes	Yes	Robe	< 1 km	Single entrance, 4.3 x 2.4	Shelter 8.1 m deep with internal chamber with low ceiling.	25 km
106	Mesa B-C Cave Assessment, July 2016	Bat Call WA Pty Ltd	2016	392711	7600078	MCS-05	Cave assessment	Cave	Nocturnal feeding roost	-	Yes	Yes	Robe	< 1 km	Single entrance, 9.3 x 3.0	Shelter 9.7m deep	25 km
107	Mesa B-C Cave Assessment, July 2016	Bat Call WA Pty Ltd	2016	393014	7599998	MCS-03	Cave assessment	Cave	Nocturnal feeding roost	-	Yes	Yes	Robe	< 1 km	Single entrance, 15.1 x 3.3	Shelter 8.9 m deep	25 km
108	Mesa B-C Cave Assessment, July 2016	Bat Call WA Pty Ltd	2016	393017	7601019	MCS-11	Cave assessment	Cave	Nocturnal feeding roost	-	Yes	Yes	Robe	< 1 km	Single entrance, 11.0 x 2.5	Shelter 7.5 m deep	25 km
109	Mesa B-C Cave Assessment, July 2016	Bat Call WA Pty Ltd	2016	393067	7600967	MCS-10	Cave assessment	Cave	Nocturnal feeding roost	-	Yes	Yes	Robe	< 1 km	Single entrance, 12.1 x 3.2	Shelter 7.5 m deep with rear chamber with domed ceiling, not entered due to presence of snake	25 km
110	Mesa B-C Cave Assessment, July 2016	Bat Call WA Pty Ltd	2016	393071	7599984	MCS-02	Cave assessment	Cave	Nocturnal feeding roost	-	Yes	Yes	Robe	< 1 km	Single entrance, 11.3 x 2.0	Shelter 12.3 m deep	25 km
111	Mesa A-C Cave Assessment, April 2017	Bat Call WA Pty Ltd	2017	386122	7604019	A5	Cave assessment	Cave	Nocturnal feeding roost	-	No	Yes	Robe	6 km	Single wide entrance 5.3 x 3.6 m	Internal domed chamber 2.5 to 4.5 m high	28 km

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112	Mesa H Cave Assessment, April 2017	Bat Call WA Pty Ltd	2017	415625	7595659	MH-Opp 1S	Cave assessment	Cave	Nocturnal feeding roost	-	Yes	Yes	Robe	2 km	A small entrance among a group of overhangs. Entrance 1.5 x 1.5 m	Deep shelter with a two low domes	Within Mesa H
113	Mesa H Cave Assessment, April 2017	Bat Call WA Pty Ltd	2017	415782	7595640	MH16-35	Cave assessment	Cave	Nocturnal feeding roost	-	Yes	Yes	Robe	3 km	A shallow shelter among a group of overhangs	Shallow shelter ~5 m deep.	Within Mesa H
114	Mesa H Cave Assessment, April 2017	Bat Call WA Pty Ltd	2017	416587	7596590	H27	Cave assessment	Cave	Nocturnal feeding roost	-	Yes	Yes	Robe	2 km	Two entrances, one 8.6 x 3.8 m and another very small entrance to the north.	Shelter is 10.5 m deep with low roof and a low dome with a sinuous vertical pipe	Within Mesa H
115	Mesa H Cave Assessment, April 2017	Bat Call WA Pty Ltd	2017	416948	7596585	MH-Opp 2S (H26)	Cave assessment	Cave	Nocturnal feeding roost	-	Yes	Yes	Robe	2 km	small constricted entrance 0.7 x 1.5 m.	Shelter with small entrance and a low dome	Within Mesa H
116	Mesa H Cave Assessment, April 2017	Bat Call WA Pty Ltd	2017	417252	7594383	MH15-13 MH15-14	Cave assessment	Cave	Nocturnal feeding roost	-	Yes	Yes	Robe	4 km	Single entrance 2.7 x 2.5 m	Shelter is 9.0 m deep with low roof and a high pipe in the roof at the rear	Within Mesa H
117	Mesa H Cave Assessment, April 2017	Bat Call WA Pty Ltd	2017	417270	7595276	H01-A01 MH15-44	Cave assessment	Cave	Nocturnal feeding roost	-	Yes	Yes	Robe	3 km	Single wide entrance 9.0 x 1.5 m.	Shelter is 8 m deep with low roof and one low dome.	Within Mesa H
118	Mesa H Cave Assessment, April 2017	Bat Call WA Pty Ltd	2017	417330	7595332	MH-Opp 3S (H23)	Cave assessment	Cave	Nocturnal feeding roost	-	Yes	Yes	Robe	3 km	A large entrance among a group of overhangs. Entrance 8.0 x 4.0 m	Deep shelter with a two levels. Upper level accessed by three pipes ~1.0 m high.	Within Mesa H

Ref #	Report	Author	Year	Easting	Northing	Site code	Record type	Assessment	Assessment	Updated assessment	Within		Land system	Distance to Robe River or tributary	Cave dimensions (H x W)		Distance to Mesa H
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119	Level 2 Terrestrial Fauna Surveys: Mesa B-C, Warrambo BWT and Highway to Tod Bore	MWH Australia	2015	391022	7604299	B1	Cave assessment	Cave	Nocturnal feeding roost	-	Yes	Yes	Robe	2 km	Unknown	Unknown	25 km
120	Level 2 Terrestrial Fauna Surveys: Mesa B-C, Warrambo BWT and Highway to Tod Bore	MWH Australia	2015	392004	7604437	SM2-BC06	Cave assessment	Cave	Nocturnal feeding roost	-	Yes	Yes	Robe	2 km	Unknown	Unknown	25 km