Miralga Creek Project:

Conservation Significant Vertebrate Fauna Impact Assessment

Biologic Environmental Survey

Report to Atlas Iron Ltd

February 2020

DOCUMENT STATUS				
Version No.	Author	Review / Approved for Issue	Approved for Issue to	
			Name	Date
1	D. Gleeson	C. Knuckey	M. Goggin, D. Morley	31/01/2020
2	D. Gleeson	C. Knuckey	M. Goggin, D. Morley, F. Jones	21/02/2020
3	A. Jenkins	C. Knuckey	M. Goggin, D. Morley, F. Jones	27/02/2020

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EXECUTIVE SUMMARY

The proposed Miralga Creek Project is located approximately 100 kilometres (km) south-east of Port Hedland in the Pilbara Region of Western Australia. Atlas Iron Limited (Atlas Iron) is the proponent and is seeking to construct and operate an iron ore mine and associated supporting infrastructure. This Assessment provides a detailed summary of the recent survey work completed within the proposed Miralga Creek Project area to date and assesses the potential impacts from implementation of the proposed development on species listed under the under the *Biodiversity Conservation Act 2016* (BC Act) and the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act).

The systematic framework within which this Environmental Impact Assessment (EIA) was completed comprised:

- Identification of potential key receptor species and habitats relevant to the assessment;
- Identification of input sources (both direct and indirect) to define potential impacts;
- Assessment of the significance of these potential impacts on the key receptors; and
- Identification of areas of potential management to mitigate the impacts on the key receptors.

Thirty-eight species of conservation significance have been recorded within the vicinity of the Study Area, based on the results of the desktop assessment and field surveys, comprising ten mammals, 24 birds and four reptiles. Seven of these species have been recorded within the Study Area; Ghost Bat (*Macroderma gigas*), Pilbara Leaf-nosed Bat (*Rhinonicteris aurantia*), Northern Quoll (*Dasyurus hallucatus*), Northern Brushtail Possum (*Trichosurus vulpecula arnhemensis*), Grey Falcon (*Falco hypoleucos*), Peregrine Falcon (*Falco peregrinus*) and Western Pebble-mound Mouse (*Pseudomys chapmani*). The Ghost Bat, Pilbara Leaf-nosed Bat and Northern Quoll are Matters of National Environmental Significance (MNES) under the EPBC Act. The Northern Brushtail Possum and Grey Falcon are also treated as a MNES for the purposes of this Assessment as both species are currently under consideration to be listed as Vulnerable under the EPBC Act.

Despite not having yet been recorded, a further five species of conservation significance identified in the desktop review (Biologic, 2019c) are considered “Likely” to occur within the Study Area: Pilbara Olive Python (*Liasis olivaceus barroni*), Black-lined Ctenotus (*Ctenotus nigrilineatus*), Gane’s Blind Snake (*Anilios ganei*), Brush-tailed Mulgara (*Dasycercus blythi*) and Spectacled Hare-Wallaby (*Lagorchestes conspicillatus leichardti*). The remaining species are regarded as Possible, Rarely, Unlikely or Highly Unlikely, to occur

Habitat mapping across the Study Area includes a total of six broad fauna habitat types (excluding disturbed areas). This comprises, in decreasing order of extent, Low Stony Hills, Stony Plain, Sandy Plain, Major Drainage Line, Hillcrest/Hillslope, and Gorge/Gully habitats.

Gorge/Gully habitat was considered to be of high significance as it provides potential denning and foraging habitat for Northern Quolls, Pilbara Olive Python and Northern Brushtail Possum. This habitat also provides primary foraging habitat for the Ghost Bat and the Pilbara Leaf-nosed Bat, as well as potential roosting habitat for the Ghost Bat and potential nocturnal refuges for the Pilbara Leaf-nosed Bat.

Hillcrest/Hillslope habitat was considered of high significance as it provides supporting habitat for Northern Quoll and Pilbara Olive Python. Peregrine Falcons may also potentially use the cliff areas for breeding habitat. This habitat type also supports numerous caves that are considered significant habitat for the Ghost Bat and Pilbara Leaf-nosed Bat.

The Major Drainage Line habitat was deemed to be of high significance as it provides dispersal and foraging habitat for Northern Quoll, Ghost Bat, Pilbara Leaf-nosed Bat, Pilbara Olive Python and Northern Brushtail Possum. Foraging and breeding habitat for Grey Falcon and foraging habitat for the Peregrine Falcon.

Impact Assessment

Eight potential sources of impact that may arise due to the Project were considered in this Assessment, namely: removal, fragmentation or modification of habitat; vehicle strike; introduced species; increased light; noise and vibration; dust; changed fire regimes and modification of water regimes.

Land clearance is listed as a Key Threatening Process under the EPBC Act, and fauna habitat loss as a direct result of land clearing and excavation is considered the primary impact of the proposed Miralga Creek Project on terrestrial vertebrate fauna. Habitat loss and degradation is expected to occur throughout most of the habitats present, including those considered of high significance. The scale of impact is expected to be Moderate (especially within areas of land clearing for the proposed pits, stockyard and waste dump) to Low (for the proposed road between Miralga West and Miralga East through predominantly Sand Plain habitat). Although direct impacts of habitat loss from land clearing can be calculated, indirect impacts to local and regional populations are difficult to quantify.

<u>Northern Quoll</u>

The Northern Quoll is listed as Endangered under the EPBC Act and BC Act. This species has been recorded within the Study Area in high densities. Within the Study Area, high quality denning and foraging habitat for the species is found within the Gorge/ Gully and Hillcrest/ Hillslope habitats and foraging and dispersal habitat is found in the Major Drainage Line habitats. At a local scale, the species is likely to experience a Low to Moderate level of impact, primarily from removal, fragmentation and modification of habitat, but also potentially vehicle strike and the increased threat of introduced species. Low level impacts may also be experienced by increased light and noise and changed fire regimes. As the population occurring within the Study Area meets the definition of a ‘high-density population’ and thus a population

'important for the long-term survival of the species', the impacts to the species are likely to be significant as defined by the Commonwealth Department of Agriculture, Water and the Environment (DAWE).

Ghost Bat

Ghost Bat are listed as Vulnerable under the EPBC Act and the BC Act. Evidence of Ghost Bats occurrence was recorded at ten caves within the Study Area. Although the majority of habitats occurring within the Study Area would likely be used for foraging and dispersal by the Ghost Bat, roosting caves are restricted to the Hillcrest/Hillslope and Gorge/Gully habitats.

The Project will result in the removal or significant impact on two Night Roost caves, CMRC-02 and CMRC-01, and will potentially cause disruption to a further eleven due to those caves being located within 500 m of proposed mining pits. A potential maternity cave (CMRC-15) is located approximately 30 m of a proposed pit and may also be impacted; at the time of writing additional studies are being undertaken by Atlas in relation to the potential impacts and management of the cave.

At a local scale, the species is likely to experience a Low to Moderate level of impact, primarily from removal, fragmentation and modification of habitat, but also potentially noise and vibration and dust. Low level impacts may also potentially be experienced due to vehicle strike, introduced species and changed fire regimes. The Project is likely to have a significant impact on the species, as defined by DAWE.

Pilbara Leaf-nosed Bat

The Pilbara Leaf-nosed Bat is listed as Vulnerable under the EPBC Act and the BC Act and has been confirmed in the Study Area. All habitat types in the Study Area are used by this species, however, Hillslope/Hillcrest and Major Drainage Line habitats are especially frequented. The Project will result in the removal or significant impact on two nocturnal roost caves, namely CMRC-02 and CMRC-01, and will potentially cause disruption to a further eleven due to those caves being located within 500 m of proposed mining pits. CMRC-15 was regarded as the most significant cave in the Study Area to the species (though still a nocturnal refuge) and its entrance is located ~30 m from a proposed pit. The impacts considered to be of most significance for this species is habitat loss and degradation as well as potentially vehicle strike. However, this impact is unlikely to extend beyond the Study Area to the regional level and the Project is not likely to have a significant impact on the species, as defined by the DAWE.

Northern Brushtail Possum

The Northern Brushtail Possum is listed as Vulnerable under the EPBC Act (pending) and Vulnerable under the BC Act and has been confirmed in the Study Area. The habitat types in the Study Area most suitable to support this species is the Major Drainage Line habitat, as well as other habitat that provides tree hollows and denning sites, such as the Gorge/Gully habitat.

The impact considered to be of most significance for this species is habitat loss and degradation. However, overall the Project is not likely to have a significant impact on the species on a local or regional scale.

Grey Falcon

The Grey Falcon is listed as Vulnerable under the EPBC Act (pending) and Vulnerable under the BC Act, and has been confirmed in the Study Area. This species uses all habitat types in the Study Area and the Major Drainage Line provides nesting habitat. At a local scale the species is likely to experience a Low to Moderate level of impact, primarily from removal, fragmentation and modification of habitat, but also potentially vehicle strike, the increased threat of introduced species and increased levels of light. Low level impacts may also be experienced due to increased levels of noise, dust and changed fire regimes. However, Moderate level impacts are unlikely to extend beyond the Study Area to the regional level and the Project is not likely to have a significant impact on the species, as defined by the DAWE.

Other Species

The Peregrine Falcon (BC Act, Other Specially Protected Species), Western Pebble-mound Mouse (DBCA, Priority 4), Night Parrot (EPBC and BC Act, Endangered), Greater Bilby (EPBC and BC Act, Vulnerable), Spotted Ctenotus (DBCA, Priority 2), Long-tailed Dunnart (DBCA, Priority 4), Short-tailed Dunnart (DBCA, Priority 4) as well as 17 species of Migratory bird, were recorded or regarded as likely and/or possibly occurring in the Study Area, though none of these are likely to experience more than a low level of impact at the local and regional scale, if present.

Management

It is recommended that all aspects of the Project be designed with mitigation of impacts on native fauna considered. It is understood that Atlas will implement a range of adaptive management strategies for Project design and operation, including a significant species management plan, blast management plan, surface water procedure, and groundwater management procedure. The potential significant impacts to fauna and fauna habitats highlighted in this report should be considered and mitigation measures to reduce the impact be incorporated into relevant management plans and procedures and be used to address any knowledge gaps discussed.

1. INTRODUCTION

1.1 Background

Atlas Iron Pty Ltd (Atlas) commissioned Biologic Environmental Survey (Biologic) to undertake a vertebrate fauna impact assessment (this Assessment) for the development of the proposed Miralga Creek Project (the Project). The Project is located approximately 100 kilometres (km) south-east of Port Hedland in the Pilbara bioregion of Western Australia. The area considered for this Assessment, and during previous baseline surveys, covers approximately 7,835 hectares (ha) and is hereafter to referred to as the Study Area (Figure 1.1). This Assessment is based on data obtained and analysed during a vertebrate fauna baseline survey conducted over the area, via numerous field trips, between May and July 2019 (Biologic, 2019c).

1.2 Project Description

The Project will involve the construction and operation of an iron ore mine and associated supporting infrastructure. Specifically, the Project will comprise three orebodies, Miralga East, Miralga West and Sandtrax. Miralga East and Miralga West are located in the central section of the Study Area while Sandtrax is located approximately 15 km east. Five open-cut, above groundwater, pits covering a total area of 28 ha are planned for the Project, comprising three for Miralga East, one for Miralga West and one for Sandtrax. The Project will also include a stockyard, screening and crushing plant, explosives magazine and other infrastructure. Once crushed, ore will be hauled from the Project via haulage trucks along the existing Abydos East Link Road (Outback Ecology, 2012b), which was developed and used to service the now closed Abydos DSO project, to Marble Bar Road and then on to Utar Point east or Port Hedland.

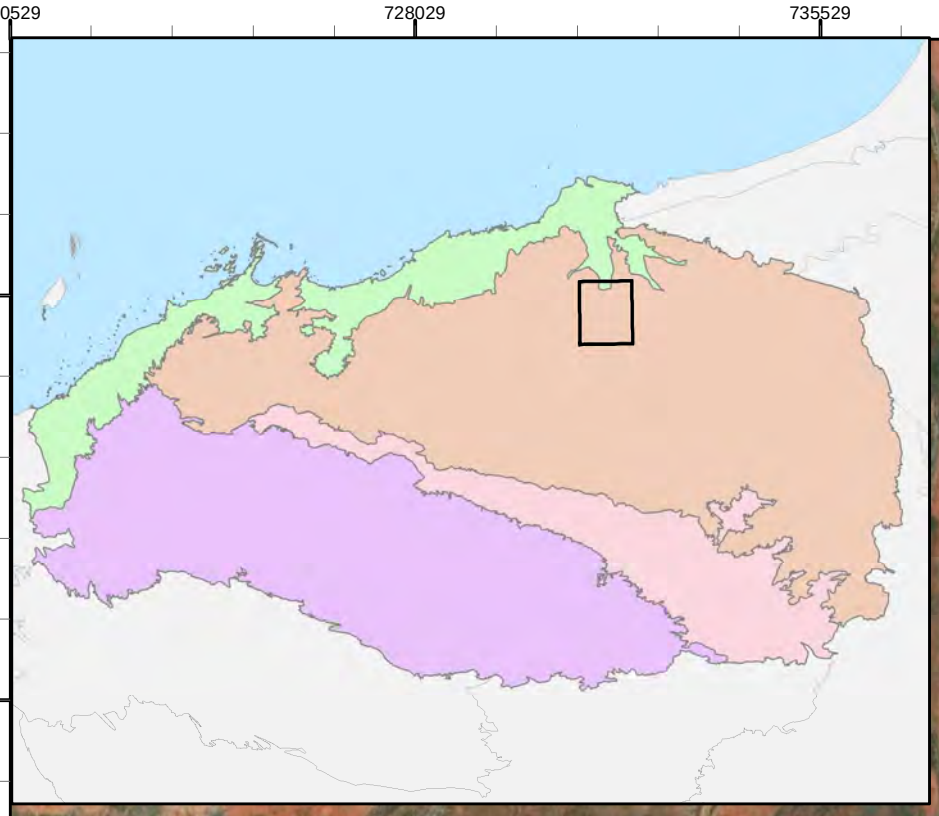
The area focussed as part of this Assessment (the Development Envelope) comprises a 621 ha parcel of land that is contained completely within the Study Area. At the time of this Assessment, the exact disturbance footprint for the Project had not yet been finalised; thus, the entire Development Envelope (Figure 1.1) has been considered for the purposes of assessing potential impacts of the Project. An Indicative Disturbance Footprint, which covers approximately 285 ha, is however presented (Figure 1.1). The Indicative Disturbance Footprint is contained entirely within the Development Envelope. Regardless of the final layout of the Disturbance, Atlas has committed to locating the Project within the Study Area and disturbing no more than 285 ha. An approximate breakdown of the Indicative Disturbance Footprint is presented in Table 1.1.

Table 1.1: Breakdown of the Indicative Disturbance Footprint

Component	Portion of Study Area	
	Hectares	%
Haul Road	74.32	0.94
Laydown	10.22	0.13
Magazine	0.92	0.01
Pit	27.83	0.36
Ramp	25.08	0.32
Rockfall Area	2.37	0.03
Run of Mine (ROM)	29.43	0.37
Stockpile (Mineralised Waste)	0.63	0.01
Stockyard	73.45	0.94
Waste Dump	40.69	0.52
Total	**284.94**	**3.62**

720529 728029 735529 743029 750529 758029

7705253 7697753 7690253 7682753 7675253 7667753 7660253



Shaw River

Miralga Creek

Legend

- Study Area
- Development Envelope
- Indicative Disturbance Footprint
- Waterway

IBRA Subregions

- Chichester
- Fortescue
- Hamersley
- Roebourne

biologic Environmental Survey

N

1:140,000

0 1.5 3 6 km

Atlas Iron

Miralga Creek Vertebrate Fauna Impact Assessment

Fig. 1.1: The Study Area, Development Envelope and Disturbance Footprint

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

Size A3. Created 21/01/2020

1.3 Scope and Objectives

The overarching objective of this Assessment was to identify and assess the potential impact of the Project on broad fauna habitats, vertebrate fauna assemblages and vertebrate fauna of conservation significance within the Study Area. This will be achieved by:

- Identification of potential key receptor species and habitats relevant to this Assessment. This Assessment will be specific to the species of conservation significance and fauna assemblages identified as potentially occurring within the Study Area and/ or those that have previously been recorded within the Study Area;
- Identification of input sources to define potential impacts (both direct and indirect) for the potential key receptor species. The impacts are based on areas considered likely to be impacted prior to and following modification of the Study Area;
- Assessment of the significance of these potential impacts on the potential key receptor species, in relation to extent, duration, magnitude (local and regional) and certainty; and
- Identification of areas of potential management to mitigate the impacts of these sources on the potential key receptor species.

This Assessment was carried out in a manner consistent with the following documents developed by the Western Australian Environmental Protection Authority (EPA) and the Commonwealth Department of Agriculture, Water and the Environment (DAWE - formerly the Department of Environment and Energy [DoEE]):

- DoE (2013) Matters of National Environmental Significance: Significant Impact Guidelines 1.1 Environment Protection and Biodiversity Conservation Act 1999;
- DoE (2016) EPBC Act referral guideline for the endangered Northern Quoll (*Dasyurus hallucatus*)*;*
- DoE (TSSC, 2016b) Conservation Advice: *Rhinonicteris aurantia* (Pilbara form), Pilbara Leaf-nosed Bat;
- EPA (2016) Environmental Factor Guideline: Terrestrial Fauna;
- EPA (2016) Technical Guidance: Terrestrial Fauna Surveys; and
- EPA (2018) Statement of Environmental Principles, Factors and Objectives.

1.4 Assessment of Significance

1.4.1 Fauna Habitats

Fauna habitats may be significant if they provide habitat important to the life history of a significant species, i.e. breeding, feeding and roosting or aggregation areas, or where they are unique or isolated habitats, for example wetlands, in the landscape or region (EPA, 2016). These significant fauna habitats are also a focus of this Assessment.

1.4.2 Fauna Species

Terrestrial fauna may be significant for a range of reasons, including (EPA, 2016):

- being identified as a threatened or priority species;
- being a species with restricted distribution;
- enduring a degree of historical impact from threatening processes; or
- providing an important function required to maintain the ecological integrity of a significant ecosystem.

For the purposes of this Assessment, species considered to be of conservation significance are those that are afforded protection under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) and/or the Western Australian *Biodiversity Conservation Act 2016* (BC Act). A summary of applicable legislation and status codes is provided in Table 1.2. For some species, there is insufficient information to determine their status. These species are also considered by the EPA and DBCA as being of conservation significance for all development related approvals and are listed on a 'Priority List' that is regularly reviewed and maintained by the DBCA (Table 1.2).

Table 1.2: Definitions and terms for fauna of conservation significance

Agreement, Act or List	Status Codes
Federal	
***Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act)** The Department of the Environment and Energy lists threatened fauna, which are determined by the Threatened Species Scientific Committee (TSSC) as per criteria set out in the Act. The Act lists fauna that are considered to be of conservation significance under one of eight categories (listed under 'Status Codes').	• Extinct (EX) • Extinct in the Wild (EW) • Critically Endangered (CE) • Endangered (EN) • Vulnerable (VU) • Conservation Dependent (CD) • Migratory (MG) • Marine (MA)
State	
***Biodiversity Conservation Act 2016* (BC Act)** At a state level, native fauna are protected under the *Biodiversity Conservation Act 2016*. Species in need of conservation are given a ranking ranging from Critically Endangered to Vulnerable.	• Extinct (EX) • Extinct in the Wild (EW) • Critically Endangered (CE) • Endangered (EN) • Vulnerable (VU) • Migratory (MI) • Conservation Dependent (CD) • Other Specially Protected (OS)
DBCA Priority List DBCA produces a list of Priority species that have not been assigned statutory protection under the *Biodiversity Conservation Act 2016*. This system gives a ranking from Priority 1 to Priority 4.	• Priority 1 (Poorly known species) (P1) • Priority 2 (Poorly known species) (P2) • Priority 3 (Poorly known species) (P3) • Priority 4 (Rare, Near Threatened, and other species in need of monitoring) (P4)

2. SURVEY EFFORT

A field survey was undertaken in the Study Area in 2019 by Biologic (2019c) and is summarised in Table 2.1. In addition, earlier field surveys were completed for the nearby Panorama Project (Bamford Consulting, 2001; Bat Call, 2020; Biologic, 2019a; Biota, 2007; MWH, 2014a, 2015, 2016; Outback Ecology, 2012a) and at least some of this area included in these field surveys overlapped the Study Area (Table 2.1).

Table 2.1: Summary of terrestrial fauna surveys conducted within the Study Area

Survey Title	Year of Survey	Survey Type	Survey Effort	Conservation Significant Species Recorded
Miralga Creek Project: Level 2 Vertebrate Fauna and Short-range Endemic Invertebrate Fauna Assessment (Biologic, 2019c)	May and July 2019	Level 2 survey	• Habitat assessments (152 locations) • Systematic trapping (8 sites) • Targeted Northern Quoll trapping (1,200 trap nights at 5 sites) • Targeted Northern Quoll motion camera transects (650 motion camera nights at 3 sites) • Avifauna sampling • Ultrasonic bat recording (46 recording nights at 18 locations) • Acoustic recording targeting Night Parrot (72 recording nights at 12 locations) • Motion cameras (63 motion camera nights at 12 locations) • Targeted searches • Nocturnal surveys • Opportunistic records	• Northern Quoll (89 records from 15 sites) • Pilbara Leaf-nosed Bat (35 records from 14 sites) • Ghost Bat (recorded 25 times) • Western Pebble-mound Mouse (15 records from 15 sites) • Northern Brushtail Possum (1 individual) • Grey Falcon (3 records) • Peregrine Falcon (2 records)

Survey Title	Year of Survey	Survey Type	Survey Effort	Conservation Significant Species Recorded
Panorama Project Mine Site and Haul Road Corridor Targeted Fauna Survey (Biota, 2007)	2006	Level 1 and Level 2 Survey	• Systematic trapping (4 sites) • Avifauna sampling • Targeted Northern Quoll trapping (300 trap nights at 3 sites) • Targeted Spectacled Hare Wallaby trapping (40 trap nights at 1 site) • Bat sampling harp traps (18 trap nights at 6 sites) • Targeted searches • Nocturnal surveys • Opportunistic records	• Northern Quoll (1 individual) • Pilbara Leaf-nosed Bat (9 individuals) • Spectacled Hare-wallaby (1 individual, 4 records) • Ghost Bat (numerous observations) • Western Pebble-mound Mouse (1 individual)
Panorama Project Area Baseline Fauna Study as part of the Sulphur Springs Feasibility Study (Bamford Consulting, 2001)	June and September 2001	Level 2 Survey	• Systematic trapping (5 sites) • Avifauna sampling • Bat sampling • Targeted searches • Nocturnal surveys • Opportunistic records	• Northern Quoll (16 individuals) • Pilbara Leaf-nosed Bat (3 individuals) • Spectacled Hare-wallaby (2 records) • Ghost Bat (165 individuals) • Western Pebble-mound Mouse (2 records)
Miralga Creek Review (Bat Call, 2020)	May and June 2019	N/A	• Review of Biologic survey (Biologic, 2019b)	• Pilbara Leaf-nosed Bat • Ghost Bat
Abydos Northern Quoll Monitoring Survey (Biologic, 2019a; MWH, 2014a, 2015, 2016; Outback Ecology, 2012a)	2012, 2014-2017, 2019	Northern Quoll Monitoring Survey	• Targeted Northern Quoll trapping (140 trap nights at 1 site in 2012, 2014-2017, 100 trap nights at 1 site in 2019).	• Northern Quoll (2012 – 3 individuals, 2014 – 2 individuals, 2019 – 3 individuals)

3. KEY RECEPTORS

3.1 Fauna Habitats

Six broad fauna habitats have been mapped across the Study Area (excluding cleared areas). This comprises, in decreasing order of extent (Figure 3.1, Table 3.1):

- Low Stony Hills,
- Stony Plain,
- Sandy Plain,
- Major Drainage Line,
- Hillcrest/Hillslope; and
- Gorge/Gully habitats.

Three of these habitat types (Hillcrest/Hillslope, Gorge/Gully, and Major Drainage Line habitats) were deemed to be of relatively high significance for vertebrate fauna due to the potential to provide habitat for species of conservation significance.

Gorge/Gully habitat was considered to be of high significance as it provides potential denning and foraging habitat for Northern Quolls, Pilbara Olive Python and Northern Brushtail Possum. This habitat also provides primary foraging habitat for the Ghost Bat and the Pilbara Leaf-nosed Bat, as well as potential roosting habitat for the Ghost Bat and potential nocturnal refuges for the Pilbara Leaf-nosed Bat.

Hillcrest/Hillslope habitat was considered of high significance as it provides supporting habitat for Northern Quoll and Pilbara Olive Python. Peregrine Falcons may also potentially use the cliff areas for breeding habitat. This habitat type also supports numerous caves that are considered significant habitat for the Ghost Bat and Pilbara Leaf-nosed Bat.

The Major Drainage Line habitat was deemed high significance as it provides dispersal and foraging habitat for Northern Quoll, Ghost Bat, Pilbara Leaf-nosed Bat and the Pilbara Olive Python, Northern Brushtail Possum. Foraging and breeding habitat for Grey Falcon and Northern Brushtail Possum, and foraging habitat for the Peregrine Falcon is also present.

Sandy Plain habitat provides primary foraging habitat for Ghost Bats, Pilbara Leaf-nosed Bat, Grey Falcon and Peregrine Falcon; however, it is not critical to the survival of any of these species. The Sandy Plain habitat type does provide potential habitat for the Greater Bilby and Night Parrot, which are considered possible to occur. The remaining habitats (Stony Plain and Low Stony Hills) were deemed to have a low significance as these habitats support few species of high conservation value and such species are not dependent on these habitats at the broad scale.

The values and reasons for significance for each of these habitats are summarized in Table 3.1 below, and presented in Figure 3.1.

Table 3.1: The extent of fauna habitats within the Study Area, and their significance

Habitat	Habitat Value Score	Reason for Significance	Area within Study Area	
			ha	%
Gorge/ Gully	High	• Northern Quoll, Pilbara Olive Python and Northern Brushtail Possum – provides potential denning and foraging habitat • Ghost Bat and Pilbara Leaf-nosed Bat – provides primary foraging habitat. • Caves and overhangs may provide potential nocturnal refuge (Pilbara Leaf-nosed Bat) or roosting habitat (Ghost Bat)	4.58	0.1
Hillcrest/ Hillslope	High	• Northern Quoll and Pilbara Olive Python – denning habitat. • Peregrine Falcons – cliff areas may provide potential breeding habitat • Caves and overhangs may provide potential nocturnal refuge (Pilbara Leaf-nosed Bat) or roosting habitat (Ghost Bat)	429.79	5.5
Major Drainage	High	• Northern Quoll, Ghost Bat, Pilbara Leaf-nosed Bat, Pilbara Olive Python and Northern Brushtail Possum - provides dispersal and foraging habitat • Grey Falcon – breeding/nesting and foraging habitat • Peregrine Falcon – foraging habitat • Migratory water birds – spring fed or long-standing pools which occur following rainfall events may provide occasional habitat	996.32	12.6
Sand Plain	Moderate	• Ghost Bat, Pilbara Leaf-nosed Bat, Grey Falcon and Peregrine Falcon – foraging habitat • Greater Bilby, Night Parrot, Brush-tailed Mulgara – provides habitat	1,535.85	19.5
Stony Plain	Low	• Western Pebble-Mound Mouse – provides habitat • Peregrine Falcon – foraging habitat • Night Parrot – roosting/nesting and foraging habitat • This habitat is broadly represented within and in the broader vicinity of the Study Area	2,328.41	29.5
Low Stony Hills	Low	• Western Pebble-Mound Mouse – provides habitat • Peregrine Falcon – foraging habitat • This habitat is common and widespread within the Study Area and more broadly across the Pilbara region.	2,586.3	32.8
		Total	**7,881.13**	**100**

3.2 Habitat Features

3.2.1 Caves

Sixteen caves have been recorded across the Study Area (Biologic, 2019c) and may provide significant habitat for a number of species of conservation significance. Evidence of the occurrence of Ghost Bats was recorded at ten of these caves (Biologic, 2019c). Ghost Bats were observed at four separate caves (CMRC-06, CMRC-07, CMRC-14 and CMRC-15). CMRC-06 and CMRC-15 are Category 2 (diurnal roost caves with regular occupancy) while

CMRC-07 and CMRC-14 are Category 3 (roost caves with occasional occupancy) (Table 3.2). CMRC-15 may be a maternity roost for this species.

Thirteen caves were confirmed or identified as potential roost caves for Ghost Bat, comprising eight identified as night roosts, three as confirmed day roosts (including one also identified as a possible maternity roost) and two potential day roosts (Table 3.2).

No evidence of diurnal roosting of the Pilbara Leaf-nosed Bat was observed within the caves in the Study Area or indicated by ultrasonic call recordings. A significantly high number of calls were consistently recorded at cave CMRC-15, indicating this to be of high importance for the species.

The most significant caves recorded in the Study Area for both species were CMRC-06, CMRC-07, CMRC-14 and CMRC-15, having recorded a total of 18 individual Ghost Bats.

Table 3.2: Caves recorded in the Study Area

Name	Latitude	Longitude	Significance		Comments
			Ghost Category	Pilbara Leaf-nosed Bat	
CMRC-01	-20.9718	119.4351	Night Roost	Unknown	• No Ghost Bats observed • ~3 recent (1–6 months) Ghost Bat scats
CMRC-02	-21.0245	119.3175	Potential Night Roost	Unknown	• No Ghost Bats or scats observed, although entire extent of cave could not be accessed for safety reasons
CMRC-03	-21.1096	119.1875	Night Roost	Nocturnal Refuge	• No Ghost Bats observed • ~20 recent (1–6 months) Ghost Bat scats • 5 Pilbara Leaf-nosed Bat calls
CMRC-04	-21.027	119.3137	Night Roost	Nocturnal Refuge	• No Ghost Bats or scats observed, but suitable size and depth for night roosting • 30 and 3 Pilbara Leaf-nosed Bat calls recorded over two nights, indicating night visitation
CMRC-06	-21.027	119.313	Day Roost	Nocturnal Refuge	• 1 Ghost Bat observed • ~4 recent (1–6 months) Ghost Bat scats • 6 Pilbara Leaf-nosed Bat calls
CMRC-07	-21.1094	119.1864	Day Roost	Unknown	• 1 Ghost Bat observed (Phase 1) • No Ghost Bat scats recorded
CMRC-08	-21.0273	119.3123	Night Roost	Unknown	• No Ghost Bats observed • ~50 fresh (<1 month) Ghost Bat scats

Name	Latitude	Longitude	Significance		Comments
			Ghost Category	Pilbara Leaf-nosed Bat	
CMRC-10	-21.0269	119.3133	Night Roost	Unknown	• No Ghost Bats or scats observed, but suitable size and depth for night roosting
CMRC-12	-21.0262	119.3127	No usage for Ghost Bat	Unknown	• No Ghost Bats or scats observed • Possible slits/crevices in the back of cave
CMRC-13	-20.9731	119.4334	Night Roost	Unknown	• No Ghost Bats observed • ~70 fresh (<1 month) Ghost Bat scats recorded
CMRC-14	-20.9731	119.4327	Day Roost	Unknown	• Six Ghost Bats observed (flushed into CMRC-15) (Phase 2), 800 scats recorded (Phase 2)
CMRC-15	-20.9727	119.4299	Potential Maternity Roost	Nocturnal Refuge	• Six Ghost Bats observed (flushed from CMRC-14 into cave) (Phase 2) • Foraging evidence of Ghost Bat recorded • ~4,000 fresh (<1 month) Ghost Bat scats • Nightly Pilbara Leaf-nosed Bat calls ranged from 70 to 825 and suggestion night visitation
CMRC-16	-20.9729	119.4118	No usage for Ghost Bat	Unknown	• No Ghost Bats or scats observed • Slits/crevices present in the rear of the cave, but these could not be visually inspected
CMRC-17	-20.9729	119.413	No usage for Ghost Bat	Unknown	• No Ghost Bats or scats observed • Large cave
CMRC-18	-20.9736	119.4139	Potential Day Roost	Unknown	• No Ghost Bats observed • ~40 recent (1–6 months) Ghost Bat scats
CMRC-19	-21.1078	119.1863	Night Roost	Nil	• No Ghost Bats observed • ~100 fresh (<1 month) Ghost Bat scat
Unsurveyed Cave	-20.974	119.4379	Potential Day Roost	Unknown	• Heritage group found GB in cave

3.2.2 Water Features

Sixteen water features were recorded in the Study Area. Four of these water features are likely to represent intermediate to permanent water sources on account of their groundwater dependence (Biologic, 2019c). Gorges with pools represent priority foraging habitat for the Pilbara Leaf-nosed Bat (TSSC, 2016b), and generally considered productive habitat features of a landscape providing resources for the Northern Quoll (Oakwood, 1997) and the Pilbara Olive Python (Pearson, 2006).

An artificial water source, a turkey nest dam, is also present in the Study Area. Both Pilbara Leaf-nosed Bats and Ghost Bat calls were recorded at this turkey nest dam (Biologic, 2019c).

Table 3.3: Water Features recorded in the Study Area

Name	Permanent Water	Conservation Significant species recorded
WMRC-01	Permanent	Ghost Bat, PLNB, Northern Brushtail Possum
WMRC-02	Permanent	PLNB, Northern Quoll
WMRC-03	No	PLNB
WMRC-04	No	
WMRC-05	No	Northern Quoll scat (nearby)
WMRC-06	No	
WMRC-07	No	
WMRC-08	No	
WMRC-09	No	
WMRC-10	No	
WMRC-11	No	
WMRC-12	No	
WMRC-13	No	
WMRC-14	Permanent	PLNB
WMRC-15	Permanent	
VMRC-16	Artificial	PLNB, Ghost Bat

721151 728651 736151 743651 751151 758651

7705253 7697753 7690253 7682753 7675253 7667753 7660253

Legend

- Study Area
- Development Envelope
- Indicative Disturbance Footprint
- Cave
- Water Feature

Habitat

- Gorge/Gully
- Hillcrest/ Hillslope
- Low Stony Hills
- Major Drainage Line
- Sandy Plain
- Stony Plain

biologic Environmental Survey

N

1:140,000

0 1.5 3 6 km

Atlas Iron

Miralga Creek Vertebrate Fauna Impact Assessment

Fig. 3.1: Broad fauna habitats and habitat features of the Study Area

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

Size A3. Created 21/01/2020

3.3 Vertebrate Fauna Species

A total of 358 species of vertebrate fauna were identified during the desktop assessment as previously being recorded and/or having the potential to occur in the Study Area. Of these, 38 species are of conservation significance, comprising ten mammals, 24 birds and four reptiles. These are discussed further below in Section 3.3.1 and Section 3.3.2.

Note that there are 'no unique assemblages', no species with restricted ranges, or species required for ecological integrity recorded in the Study Area.

3.3.1 Species Recorded in the Study Area

Seven species of conservation significance have been recorded within the Study Area:

- Northern Quoll (*Dasyurus hallucatus*) - Endangered under the EPBC Act and BC Act;
- Ghost Bat (*Macroderma gigas*) - Vulnerable under the EPBC Act and the BC Act;
- Pilbara Leaf-nosed Bat (*Rhinonicteris aurantius*) - Vulnerable under the EPBC Act and the BC Act;
- Northern Brushtail Possum (*Trichosurus vulpecula arnhemensis*) – Vulnerable under the BC Act;
- Grey Falcon (*Falco hypoleucos*) – Vulnerable under the EPBC Act (pending) and Vulnerable under the BC Act;
- Peregrine Falcon (*Falco peregrinus*) - listed as Other Specially Protected Species under the BC Act; and
- Western Pebble-mound Mouse (*Pseudomys chapmani*) – listed as a Priority 4 by DBCA.

These species were all recorded during the field survey undertaken in the Study Area in 2019 by Biologic (Biologic, 2019c). Each of these records are discussed in further detail below.

Northern Quoll

A total of 89 records of Northern Quolls were recorded from 15 sites within the Study Area. Forty-four of these records were from trapped Northern Quoll, representing 28 unique individuals. Similarly, the Northern Quoll was recorded 35 times from motion camera captures, which comprised 10-11 unique individuals. A further ten records came from secondary evidence (i.e. scats and tracks).

Northern Quoll are known to occur within a range of habitats, including ironstone and sandstone ridges, scree slopes, granite boulders and outcrops, drainage lines, riverine habitats dissected rocky escarpments, open forest of lowland savannah and woodland (Braithwaite & Griffiths, 1994; Oakwood, 1997, 2002, 2008). Rocky habitats tend to support higher densities, as they offer protection from predators and are generally more productive in terms of availability of resources (Braithwaite & Griffiths, 1994; Oakwood, 2000). Northern Quoll are likely to occur within Gorge/Gully and Hillcrest/Hillslope habitats where suitable denning/shelter and/or

foraging habitat is present, in addition to Major Drainage habitat for foraging and/or dispersal. These habitats form part of the core habitats critical to the survival of Northern Quoll (DoE, 2016).

Ghost Bat

Evidence of the occurrence of Ghost Bats was recorded at ten caves within the Study Area. The Ghost Bat was recorded 25 times within the Study Area (five times from direct observation of individuals at night and within or flushed from caves, ten times from ultrasonic call recordings and ten times from secondary evidence - scats).

Ghost Bats roost in deep, complex caves beneath bluffs of low, rounded hills, granite rock piles and abandoned mines (Armstrong & Anstee, 2000). These features often occur within habitats including gorge/gully, hill crest/hill slope and low hills (Armstrong & Anstee, 2000). Ghost Bats are known to require a number of suitable caves throughout their home ranges; both due to temporal factors (i.e. night/ feeding roosts for feeding throughout the duration of the night, as well as day roosts for resting), and seasonal factors (use of certain caves as maternity roosts, depending on the right environmental conditions). The presence of day roosts and/ or maternity roosts in an area is the most important indicator of suitable habitat for Ghost Bats, and these caves are generally the primary focus of conservation and/or monitoring (DBCA, 2019b).

Pilbara Leaf-nosed Bat

Pilbara Leaf-nosed Bats were recorded 35 times from 14 sites suggesting that the species forages widely throughout the Study Area. Several caves were recorded in the Study Area, however, no evidence of diurnal roosting was observed within these caves or indicated by ultrasonic call recordings. Instead, it is likely that the Pilbara Leaf-nosed Bats recorded during the field survey originated from the Lalla Rookh roost which is also a known Permanent Diurnal Roost for the species (Biologic, 2019a).

Pilbara Leaf-nosed Bats roost in undisturbed caves, deep fissures or abandoned mine shafts. The Pilbara Leaf-nosed Bat's limited ability to conserve heat and water (Armstrong, 2001) means it requires warm (28–32ºC) and very humid (85–100%) roost sites in caves (Armstrong, 2001; Churchill, 1991) and/or mine shafts as these enable the individuals to persist in arid climates by limiting water loss and energy expenditure (van Dyck & Strahan, 2008). Such caves are relatively uncommon in the Pilbara (Armstrong, 2000; Armstrong & Anstee, 2000), which limits the availability of diurnal roosts for this species. During the dry season, approximately March to August, Pilbara Leaf-nosed Bats aggregate in colonies within caves that provide a suitably warm, humid microclimate; however, the species disperses from these main colonies during the wet season, approximately September to February, when suitably humid caves are more widely available (TSSC, 2016b). The level of dispersal in the wet season may also be influenced by the seasonal availability of food resources (Churchill, 1994).

Northern Brushtail Possum

A single female Northern Brushtail Possum was trapped at a site located along Miralga Creek. Northern Brushtail Possums are largely known for inhabiting gorges and major drainage lines with Eucalypt woodland (DBCA, 2012; van Dyck & Strahan, 2008); however, within the Pilbara region, the species is sparsely distributed and often only encountered in low abundance (DBCA, 2019a). The nearest record of the species to the Study Area is located approximately 80 km southwest of the Study Area (DBCA, 2019a). Suitable habitat for the species is present within all Major Drainage habitat within the Study Area, in addition to suitable rocky habitat being present within Gorge/Gully habitat.

Grey Falcon

The Grey Falcon was recorded on three occasions. On one occasion, a group comprising two adults and two young was observed, suggesting that the species may be nesting within the Study Area, most likely within riparian vegetation along Miralga Creek or the Shaw River. The species is likely to forage over most habitats within the Study Area, particularly within Sand Plain, Stony Plain and Major Drainage habitats.

The species commonly nests in timbered areas, particularly tall trees along watercourses, and forages in open or more sparsely vegetated habitats (Garnett ***et al.***, 2011).

Peregrine Falcon

The Peregrine Falcon was recorded on two occasions, represented by a single individual, in the east of the Study Area within the Hillcrest/ Hillslope habitat. The individuals were seen resting on a rocky ledge within the area and could possibly nesting in the area. The species is considered to occur within the Study Area as a resident due to the availability of suitable nesting and foraging habitat throughout the Study Area. Suitable nesting sites were observed within most Hillcrest/Hillslope and Gorge/Gully habitat mapped within the Study Area, particularly in areas where large steep rock faces and ledges were present, and Major Drainage habitat where tall trees are present. Due to the species large foraging range, foraging may occur within all broad fauna habitats mapped within the Study Area, with foraging range likely to fluctuate with resources availability.

The species typically nests on rocky ledges occurring on tall, vertical cliff faces or occasionally within tall trees occurring along major drainage lines and has occasionally been recorded nesting in human made structures providing high vantage points, such as radio-towers (Olsen & Olsen, 1989).

Western Pebble-mound Mouse

Fifteen pebble mounds made by Western Pebble-mound Mice were recorded during the survey, including three active mounds and twelve inactive mounds. The species is likely to commonly occur throughout the Study Area in Stony Plain and Low Stony Hill habitats where suitable burrowing substrate and mount materials (pebbles and small rocks) are present.

The Western Pebble-mound Mouse occurs almost exclusively on low undulating stony hills and the gentler slopes of rocky ranges where the ground is covered with a stony mantle and vegetated by hard spinifex, often with a sparse overstorey of eucalypts and scattered shrubs (Anstee & Armstrong, 2001).

3.3.2 Species Potentially Occurring in the Study Area

Other species of conservation significance may occur in the Study Area despite not having yet been recorded. Based on the occurrence of nearby records and the types of habitats present in the Study Area, a further five species of conservation significance identified in the desktop review (Biologic, 2019c) are considered "Likely" to occur within the Study Area. These are:

- Pilbara Olive Python, listed as Vulnerable under the EPBC Act and BC Act;
- Black-lined Ctenotus (*Ctenotus nigrilineatus*), listed as a Priority 1 by the DBCA;
- Gane's Blind Snake (*Anilios ganei*), listed as Priority 1 by the DBCA;
- Brush-tailed Mulgara (*Dasycercus blythi*) listed as a Priority 4 by DBCA; and
- Spectacled Hare-Wallaby (*Lagorchestes conspicillatus leichardti*), listed a Priority 4 species by DBCA.

Twenty-two species are considered "Possible" or "Rarely" to occur. The majority of these species (17) are Migratory shorebirds and waterbirds. The species considered "Possible" or "Rarely" to occur are:

- Night Parrot (*Pezoporus occidentalis*), listed as Endangered under the EPBC Act and BC Act;
- Greater Bilby (*Macrotis lagotis*), listed as Vulnerable under the EPBC Act and BC Act;
- Spotted Ctenotus (*Ctenotus uber johnstonei*), listed as Priority 2 species by the DBCA;
- Long-tailed Dunnart (*Sminthopsis longicaudata*), listed as a Priority 4 by DBCA; and
- Short-tailed Mouse (*Leggadina lakedownensis*), listed as a Priority 4 species by the DBCA.
- Migratory birds, listed as Migratory under the EPBC and BC act:
    - Osprey (*Pandion haliaetus*);
    - Fork-tailed Swift (*Apus pacificus*);
    - Oriental Plover (*Charadrius veredus*);
    - Oriental Pratincole *(Glareola maldivarum);*
    - Barn Swallow (*Hirundo rustica*);
    - Gull-billed Tern *(Gelochelidon nilotica*);
    - Caspian Tern (*Hydroprogne caspia);*
    - Sharp-tailed Sandpiper (*Calidris acuminate)*;
    - Curlew Sandpiper (*Calidris ferruginea*);
    - Pectoral Sandpiper (*Calidris melanotos*);
    - Black-tailed Godwit *(Limosa limosa);*

- Eastern Curlew *(Numenius madagascariensis)*
- Wood Sandpiper *(Tringa glareola);*
- Common Sandpiper *(Tringa hypoleucos*);
- Common Greenshank *(Tringa nebularia);*
- Marsh Sandpiper *(Tringa stagnatilis);* and
- Glossy Ibis *(Plegadis falcinellus).*

The remaining three species of conservation significance are considered “Unlikely” or “Highly Unlikely” to use the Study Area. These are all marine and waterbird that have very specific habitat preferences, that are not represented by the Study Area.

718215 725715 733215 740715 748215 755715

7702511
7695011
7687511
7680011
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7665011
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Biologic (2019)

- Ghost Bat
- Grey Falcon
- Northern Brushtail Possum
- Northern Quoll
- Pilbara Leaf-nosed Bat
- Western Pebble-mound Mouse, Ngadji

Desktop Assessment

- Greater Bilby (VU - EPBC/BC Act)
- Ghost Bat (VU - EPBC/BC Act)
- Northern Quoll (EN - EPBC/BC Act)
- Northern Short-tailed Mouse (P4 - DBCA)
- Pilbara Leaf-nosed Bat (VU - EPBC/BC Act)
- Pilbara Olive Python (VU - EPBC/BC Act)
- Spectacled Hare-wallaby (P4 - DBCA)
- Western Pebble-mound Mouse (P4 - DBCA)

Legend

- Study Area
- Indicative Disturbance Footprint
- Development Envelope

biologic Environmental Survey

N

1:140,000

0 1.5 3 6 km

Atlas Iron

Miralga Creek Vertebrate Fauna Impact Assessment

Fig. 3.2: Significant fauna records within, and within the vicinity of, the Study Area

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

Size A3. Created 21/01/2020

4. SOURCES OF POTENTIAL IMPACTS

Broad threatening processes for fauna of the Pilbara include such events as over-grazing, frequent wildfires, exotic species promoting predation and competition, changed hydrological regimes, and the expansion of mining, agriculture, and tourism (Carwardine *et al.*, 2014). Of these threats, impact sources inherent to the Project were identified. The mechanisms by which the impact sources can arise can be generally categorised as either direct, indirect, or both (EPA, 2016). These impact sources can be permanent or temporary, and result in changes to fauna or fauna habitat beyond the immediate development (EPA, 2016) or, in this case, beyond the Indicative Disturbance Footprint or even the Development Envelope.

4.1 Direct

Direct impacts reduce the diversity and abundance of species in an area through mortality or displacement of individuals or populations (EPA, 2016). The impact source most commonly causing direct impacts to fauna is the removal, fragmentation or modification of habitat (EPA, 2016).

4.1.1 Removal, Fragmentation or Modification of Habitat

Habitat loss is the single most important factor in the continuing decline of nearly all species of conservation significance (Cogger *et al.*, 1993; Garnett *et al.*, 2011; Woinarski *et al.*, 2014) and results from activities associated with the clearing of land and vegetation for mining (including waste rock and water storage) and infrastructure (e.g. roads and pipelines) (EPA, 2016).

Associated with this loss is habitat fragmentation, that can cause division and isolation of local populations of animals through disruption of movement patterns (Debinski & Holt, 2000). Species most likely to experience such isolation would be those inhabiting continuous stretches of habitat (e.g. gorges or rocky breakaways) and those with less mobility, such as sub-fossorial herpetofauna and small terrestrial mammals (e.g. Western Pebble-Mound Mouse). A reduction in population size and reduced gene flow between separated local groups of these animals could result in founder effects, genetic drift and increased inbreeding and exacerbate local extinctions (Furlan *et al.*, 2012; Lande, 1999). Clearing for infrastructure, such as roads and pipelines, could also increase edge effects on the adjacent vegetation, causing altered levels of predation, restricting or increasing fauna movements, and altering assemblage structure (Goosem, 2001), resulting in an impact area larger than the actual cleared footprint.

The removal, fragmentation, or modification of fauna habitat will occur through activities such as clearing of vegetation, and the removal of topsoil and landforms. The total Indicative Disturbance Footprint for the Project is estimated to be approximately 284.94 hectares (ha). The main areas of land disturbance are associated with the construction of a Stockyard (73.45 ha), Waste Dump (40.69 ha), ROM (29.43 ha) and Mining Pits (27.83 ha).

Two caves (CMRC-15 and CMRC-02) are within the Indicative Disturbance Footprint and a third cave (CMRC-01) is located approximately three metres outside. No water features lie within the Indicative Disturbance Footprint. Note that the disturbance footprint areas reported in this document are approximate and subject to minor change.

4.1.2 Vehicle Strike

Vehicle strike is a known threat to conservation significant fauna of the Pilbara, particularly for nocturnal species foraging or travelling near roads at night and species that tend to be active on roads (e.g. basking, foraging) during daytime. For example, Northern Quolls are known to cross roads, (Dunlop *et al.*, 2014) and are opportunistic foragers known to scavenge roadkill (Radford, 2012), which can lead to vehicle strike and mortality. Pilbara Olive Pythons are slow-moving, and many have died on roads due to a natural instinct to remain still in response to the vibrations of an approaching vehicle (Pearson, 2006). Road deaths caused deliberately by motorists are a recognised threat to Pilbara Olive Pythons, particularly when they are often mistakenly identified as a poisonous brown snake (TSSC, 2008b). Road and rail traffic is known to cause mortality of Greater Bilbies (Bradley, 2015), and there is a record of a Greater Bilby vehicle strike in the Pilbara at McPhee Creek from 2012 (Outback Ecology, 2012c).

The Project will expand the track network and increase traffic volumes in the Study Area, with an indicative total land disturbance of roads of approximately 74.32 ha. In addition, major roads shall be up to 16 m wide for two-way traverse and designed to accommodate heavy vehicles, presenting a higher risk of collision with vertebrate fauna. The existing Abydos East Link Road (Outback Ecology, 2012b), which was developed and used to service the now closed Abydos DSO project, will be used to haul crushed ore from the Project via haulage trucks to Marble Bar Road and then on to Utar Point east or Port Hedland.

4.2 Indirect

The impact sources which most commonly cause indirect impacts to fauna are discussed below in relation to Project and are summarized in Table 4.1.

4.2.1 Introduced Species

Introduced species pose a range of potential impact sources to Pilbara fauna. Potential impacts from introduced species include over-grazing and land degradation from introduced herbivores (e.g. camels *Camelus dromedarius*, goats *Capra aegagrus*), competition (e.g. rabbits *Oryctolagus cuniculus*, cats *Felis catus*), habitat degradation from weeds (e.g. Buffel Grass *Cenchrus ciliaris*), poisoning from cane toads (Prugh *et al.*, 2009), disease (e.g. toxoplasmosis (Dickman, 1996)), and most critically, the introduction of feral predators such as cats and red foxes (*Vulpes vulpes*) (Carwardine *et al.*, 2014). There is ample evidence that predation by introduced species such as feral cats is a primary factor in the decline of numerous taxa (Burbidge & McKenzie, 1989). In addition, management of invasive species using poison (e.g.

1080 poison) is identified as a threat for some mammal species (Woinarski *et al.*, 2014). Northern Quolls are identified as possibly being more susceptible to the toxin than other dasyurids (Calver *et al.*, 1989).

Although weeds and feral animals are not a mining specific impact, there is the potential for a range of invasive species to be introduced or attracted to the area as a result of operational activities such as the expanded traffic network and increased traffic movements, waste and water management, and human habitation. Feral predators are considered likely to occur in greater numbers near areas of human settlement and roads/tracks (Andrews, 1990; Brown *et al.*, 2006; Lach & Thomas, 2008; Mahon *et al.*, 1998).

Once established, the presence of introduced species is considered a permanent impact, as modification to the habitat within the Study Area (i.e. clearing of large areas) opens up landscape for these species, enhancing their ability to forage, transit and therefore reside in the area. Furthermore, the concluding of pest management procedures after mine closure will allow these species to permanently establish in the Study Area.

Buffel grass is listed as high ecological impact and rapid invasiveness (DBCA, 2019c), and has been previously recorded in the Study Area, as has the Cat, European Cattle and the Camel (Biologic, 2019c). Red Foxes have been recorded in the vicinity of the Study Area (Outback Ecology, 2011; WAM *et al.*, 1991) and by their nature, are likely to become present.

4.2.2 Increased Light

Altered light environments may affect foraging, reproduction, migration, and communication (Longcore & Rich, 2004). The most likely disturbance responses of native fauna from increases in light spill are the avoidance of illuminated areas previously used for foraging by light-sensitive species, or changes to prey item aggregation for insectivorous species resulting in changes to foraging behaviour. However, there is a lack of research into the impact of these factors on native fauna in the Pilbara. Temporary mobile lighting will be installed in active mine pits and active operational areas.

4.2.3 Increased Noise

Species using audible cues for breeding activity, especially birds and amphibians, may experience disruption to breeding cycles or reduced breeding success due to increased noise. For example, traffic noise is thought to negatively impact on bird and amphibian communities by masking territorial or mate attracting calls (Parris & Schneider, 2009; Shannon *et al.*, 2014). Other behavioural responses to increased noise levels are reduced foraging time, through minimisation to exposure and by increased vigilance behaviour (Shannon *et al.*, 2014).

However, there is a lack of research into the impact of these factors on native fauna in the Pilbara. Increased noise and vibration will be associated with all elements of the Project, particularly around the pit area and roads.

4.2.4 Dust

Dust can indirectly affect fauna by altering the structure and composition of native vegetation (Farmer, 1993). Dust interferes with photosynthesis, respiration and transpiration and allows penetration of gaseous pollutants (Farmer, 1993). Most plant communities can be adversely affected by dust deposition, resulting in alteration of plant community structure (Prajapati, 2012). However, no prior studies have been able to detect a significant adverse impact of airborne dust on plant function in the Pilbara (Grierson, 2015). A decline in vegetation quality impacts faunal assemblages by reducing both food and habitat resources.

Within the Study Area, increased dust emissions may result from the pit mining, dumping of waste rock material and from vehicle movements on haul roads.

4.2.5 Altered Fire Regimes

Fire is a natural process in the Pilbara that commonly arises through lightning strike. However, changes to fire regimes, particularly when fires are too frequent or intense, can have negative ecological impacts (Doherty *et al.*, 2016). For example, understory growth that provides many reptiles and mammals with protection from predators can be lost when fires are too frequent or intense as can certain food resources, such as seeding grass for graminivorous birds (Carwardine *et al.*, 2014). The impacts of an altered fire regime can vary between fauna species, and low frequency fires may also have an impact; for example, inhibiting movement through retention of high vegetation cover for Greater Bilbies (Bradley, 2015). Altered fire regimes have been identified as one of the causes of decline or extinction of medium-sized mammals in arid Australia (Burbidge & McKenzie, 1989; Burrows *et al.*, 2006).

Although difficult to predict, it is possible that the Project may increase the frequency of fires due to increased incidences of ignition caused by an expanded traffic network and increased traffic movements or an increase in grassy fuel load. Conversely, the Project may instead reduce the scale/extent of natural wildfires due to infrastructure acting as firebreaks and on-site management (i.e. fire suppression).

4.2.6 Modification of Water Regimes

Within the Pilbara, the growth of the mining industry presents new challenges for water management, from alteration of flow regimes and creation of new water sources on the surface (Carwardine *et al.*, 2014). The main ephemeral water course within the Study Area is the Shaw River, which flows in a northerly direction though the western section of the Study Area before ultimately discharging into the De Grey River. A second ephemeral river, Miralga Creek, runs through the eastern part of the Study Area before joining with the Shaw River. There is potential that inappropriate river crossing may impact waterflow along these water courses impacting habitat downstream.

Additionally, due to the proximity of the proposed pit area to cave CMRC-15, a potential maternity cave for the Ghost Bat, there is potential that natural surface water seepage, through the rock, into this cave may be impacted. Any impact to water recharge into this cave has the potential to impact microclimate and roost suitability for this species. However, the level to which microclimate could be influenced by this, and may impact this species, is relatively unknown.

Table 4.1: Summary of the relationship between impact sources and outcomes on fauna that may arise from the Project

Impact source	Occurrence of impact within the Miralga Creek Study Area	Impact pathways and potential impacts		Potential outcomes on fauna
Removal, fragmentation or modification of habitat (including reduced or prevention of access to feeding or roosting habitats)	• Total land disturbance of approximately 284.94 ha* (including haul road, mining pit, ROM, waste dump etc).	Direct	• Habitat loss or reduction in condition	• Mortality or displacement of individuals • Population fragmentation • Decline in population size • Local extinction • Reduction in the carrying capacity of the environment, or a reduction in the species or individuals that the environment can support *i.e.* where population size levels off through time • Reduced reproductive success • Reduction in diversity
		Indirect	• Habitat fragmentation and/or reduction in habitat quality of adjacent areas. • Habitat modification or loss due to structural changes (i.e. shafts and adits). • Responses to disturbance or other behavioural changes in individual animals • Erosion and altered drainage patterns.	
Vehicle Strike	• Indicative total length of roads and pipeline/ powerline corridors of 7.6 km length (approximately 40 ha disturbance* • Records of conservation significant fauna being struck by vehicles in the region e.g. Greater Bilby (Outback Ecology, 2012c)	Direct	• Collision with animals.	• Mortality or injury of individuals • Decline in population size
Introduced Species	• Camel, Dog/dingo and European Cattle and Buffel grass have been recorded within the Study Area (Biologic, 2019c). • Other invasive species such as Red Fox, Cat, Pig, Goat, Donkey, Horse, Sheep, Water Buffalo and Domestic Pigeon have been recorded in the vicinity.	Indirect	• Habitat degradation and loss (from grazers and weeds) • Competition for resources. • Predation • Increased mortality from toxic introduced species • Increased mortality resulting from use of poisons as part of management (e.g. 1080 poison) • Introduction/spread of disease. • Increased fuel loads from grassy weeds	• Mortality of individuals. • Decline in population size. • Local extinction.

Impact source	Occurrence of impact within the Miralga Creek Study Area	Impact pathways and potential impacts		Potential outcomes on fauna
Increased light	• Unquantified. Temporary mobile lighting will be installed in active mine pits and active operational areas.	Direct	• Responses to disturbance or other behavioural changes in individual animals, especially for light sensitive species.	• Displacement of individuals • Decline in population size • Disruption to breeding
		Indirect	• Changes in prey item aggregation for insectivorous species, resulting in changes to foraging behaviour	
Vibration and noise	• Vibration from the operation of heavy machinery and site works, including blasting.	Indirect	• Responses to noise disturbance or other behavioural changes in individual animals • Species using audible cues for breeding activity may also experience disruption to breeding cycles or reduced breeding success. • Habitat modification or loss due to structural changes from vibration (i.e. shafts, adits).	• Displacement of individuals • Reduction in carrying capacity • Reduction in faunal diversity • Disruption to breeding
Dust	• Unspecified but increases certain to occur, particularly after blasting • Potential impacts due to dust settlement will be predominantly concentrated near dust-generating activities such as pit blasting and in close proximity to haul roads.	Indirect	• Potential habitat modification due to degradation of vegetation or topsoil modification may occur	• Displacement of individuals • Reduction in carrying capacity • Reduction in faunal diversity.
Changed Fire Regimes	• Unspecified.	Indirect	• Habitat modification; high frequency or intensity fires can reduce understorey habitat cover and reduce food sources such as seeding grass for graminivorous birds. High frequency fires may impact fire sensitive species (e.g. Mulga) or increase dominance of early stage Triodia communities. • Low frequency fires can result in dominance of senescent vegetation and high fuel loads.	• Reduction in carrying capacity. • Changes in species • Reduction in faunal diversity.

Impact source	Occurrence of impact within the Miralga Creek Study Area	Impact pathways and potential impacts		Potential outcomes on fauna
Modification of water regimes	• Minor reduction to pre-mining runoff for surface catchments present • Unquantified impacts to microclimate of cave CMRC-15 adjacent to pit	Direct	• Disturbance response from water-dependent species (e.g. migratory avian species, bat species)	• Mortality/ displacement of individuals • Temporal changes in carrying capacity • Temporal changes in population size • Temporal changes in diversity
		Indirect	• Habitat modification arising from local hydrogeological changes, including change in cave microclimate	

** Note – disturbance footprint areas reported in this document are approximate and subject to minor change.*

5. CRITERIA FOR ASSESSING IMPACTS

5.1 Within Western Australia

The terms “significant impact” and “significant effect” are not defined in the *Environmental Protection Act 1986*. Therefore, the prediction of significance for each potential impact identified in the Study Area is assessed using criteria considered by the EPA in their referral process (EPA, 2018). These criteria were considered and defined by Biologic in Table 5.1 below, and are considered in detail for each conservation significant species in Table 6.2. In summary, the magnitude for every potential impact source to every species is assessed as Negligible, Low, Moderate or High.

Table 5.1: Impact criteria used to assess the extent for each potential impact source

Criteria	Assessment value	Definition
Duration	Short-term	>1 year
	Long-term	Years – decades
	Permanent	Indefinitely
Magnitude	Negligible	Displacement or loss of condition in individual animals
	Low	Loss of individuals but no measurable change in population size
	Moderate	Demonstrable change in population
	High	Population persistence threatened
Certainty	Data deficient	Insufficient data exist to quantify the impact pathway or the species’ ecological response
	Low	The impact has not been documented during similar mining developments, but anecdotal accounts, literature reviews of other data suggest it could arise
	Moderate	A reasonable body of data exist to support the assessment, or the impact has occurred during similar mining developments and would reasonably be expected to arise from the current proposal
	High	The impact is quantifiable and can be predicted with confidence from a reasoned evidence base

5.2 Matters of National Environmental Significance

For species considered Matters of National Environmental Significance (MNES), significant impact criteria developed by DoE (2013) are also used to assess impacts. The criteria assessed for each species also followed significant impact criteria for Endangered and Vulnerable species by DoE (2013) as well as the conservation listing advice for specific species where available (i.e. DBCA, 2017; DEWHA, 2008; TSSC, 2005).

For this Assessment the definition of a ‘significant impact’ follows that of the DAWE, being an impact, which is important, notable, or of consequence, having regard to its context or intensity. Whether or not an action is likely to have a significant impact depends upon the sensitivity, value, and quality of the environment which is impacted, and upon the intensity, duration, magnitude and geographic extent of the impacts (DoE, 2013). The DoE (2013) state that for an

impact to be 'likely', it is not necessary for a significant impact to have a greater than 50% chance of happening; it is sufficient if a significant impact on the environment is a real or not remote chance or possibility.

For this Assessment, species listed as MNES (DoE, 2013) that have been confirmed to occur or are Likely to Occur within the Study Area have been assessed in accordance with DoE guidelines (DoE, 2013) to determine whether the Project will have a significant impact on their survival. Fauna listed under the EPBC Act but considered Possible or Unlikely to occur in the Study Area are not considered in this Assessment.

The definitions of important populations for each MNES species has been described below, and the results of this assessment have been summarized in Section 6.3 and Table 6.3.

5.2.1 Endangered Species

The Northern Quoll is classified as Endangered under the EPBC Act and has been confirmed to occur in the Study Area. The Northern Quoll referral guidelines (DoE, 2016) define populations important for the long-term survival of the species as;

- high density quoll populations, which occur in refuge-rich habitat critical to the survival of the species, including where Cane Toads are present
- occurring in habitat that is free of cane toads and unlikely to support cane toads upon arrival i.e. granite habitats in WA, populations surrounded by desert and without permanent water; or
- subject to ongoing conservation or research actions (i.e. populations being monitored by government agencies or universities or subject to reintroductions or translocation).

A high density population may be characterised by numerous camera triggers of multiple individuals across multiple cameras and or traps on the site (DoE, 2016)**.**

Given these definitions, the Northern Quolls recorded within the Study Area are likely to be from a resident population which is important for the long-term survival of the Northern Quoll. The estimated population size in the Study Area is comparable to that of Indee Station (annual population sizes between 3 – 12 females and 0 – 3 males) which is considered to offer the area of highest suitability for northern quolls in the Pilbara (Hernandez-Santin ***et al.***, 2019).

For the Northern Quoll, habitat critical to the survival of the species is defined by DoE (2016) as: habitat within the modelled distribution of the Northern Quoll, which provides shelter for breeding, refuge from fire or predation and potential poisoning from Cane Toads. Dispersal and foraging habitat associated with or connecting populations important for the long-term survival of the Northern Quoll are also considered habitat critical to the survival of the Northern Quoll (DoE, 2016). Habitat for the Northern Quoll present within the Study Area is discussed in Section 6.1.

5.2.2 Vulnerable Species

The following species are classified as Vulnerable under the EPBC Act and will be considered as MNES for the purposes of this Assessment: Ghost Bat, Pilbara Leaf-nosed Bat and Pilbara Olive Python. The Northern Brushtail Possum and Grey Falcon are being considered for Vulnerable status under the EPBC Act at the time of writing this report and have also been considered.

An 'important population' of a Vulnerable species is defined by DoE (2013) as a population that is necessary for a species' long-term survival and recovery. This may include populations identified as such in recovery plans, and/or that are:

- key source populations either for breeding or dispersal;
- populations that are necessary for maintaining genetic diversity; and/or
- populations that are near the limit of the species range.

'Habitat critical to the survival of a species or ecological community' is defined by DoE (2013) as areas that are necessary:

- for activities such as foraging, breeding, roosting, or dispersal;
- for the long-term maintenance of the species or ecological community (including the maintenance of species essential to the survival of the species or ecological community, such as pollinators);
- to maintain genetic diversity and long-term evolutionary development; and/or
- for the reintroduction of populations or recovery of the species or ecological community.

Habitat for these species present within the Study Area is discussed in Section 6.1.

6. IMPACT ASSESSMENT OF KEY RECEPTORS

6.1 Impacts to Fauna Habitats

Land clearance is listed as a Key Threatening Process under the EPBC Act, and loss of habitat for fauna, as a direct result of land clearing and excavation, is considered the primary impact of the Project on terrestrial vertebrate fauna. The estimated quantity of each habitat that will be potentially impacted by the Project is presented in Table 6.1. Habitat loss and degradation will likely occur throughout most of the habitats present, including those considered of high significance, the Gorge/Gully, Hillcrest/Hillslope and Major Drainage (Table 6.1).

The scale of impact is expected to be Moderate (especially within areas of land clearing for the proposed pits, stockyard and waste dump) to Low (for the proposed road between Miralga West and Miralga East through predominantly Sand Plain habitat). Habitat loss or degradation is going to occur on the greatest scale in the Stony Plain and Low Stony Hills habitats from development activities and construction. However, there is habitat connectivity outside of the Development Envelope in the Study Area and beyond. In addition, none of the habitat types are restricted within or to the Study Area.

Potential indirect impacts on fauna habitat may include changes to fire regimes, reduction in habitat quality from dust deposition, and increases in the abundance of introduced species (Section 4.2).

Table 6.1: The types and values of fauna habitats within the Study Area, and the estimated quantity of each that will be potentially impacted by the Project

Habitat	Habitat Value Score	Total in Study Area		Total in Development Envelope		% of Study Area habitat in the Development Envelope
		ha	%	ha	%	
Gorge/Gully	High	4.58	0.1	0.76	0.1	16.59
Hillcrest/Hillslope	High	429.79	5.5	58.87	9.5	13.70
Major Drainage	High	996.32	12.6	19.58	3.2	1.97
Sand Plain	Moderate	1,535.85	19.5	67.70	10.9	4.41
Stony Plain	Low	2,328.41	29.5	306.53	49.4	13.16
Low Stony Hills	Low	2,586.30	32.8	167.36	26.9	6.47
Total		**7,881.25**	**100**	**620.8**	**100**	

6.2 Potential Impacts to Habitat Features

Thirteen caves are located within 500 m of a pit. These caves are likely to be affected by indirect impacts such as noise, dust and lighting. Three of these caves are likely to be impacted at a higher level and are discussed separately below.

Two caves are likely to be lost or impacted significantly by the Project, namely CMRC-02 and CMRC-01. At the time of writing additional studies are being undertaken by Atlas in relation to potential impacts on CMRC-15 (a potential maternity cave) and management of this cave.

CMRC-02 is located in the West Miralga area and will be lost, however, this isolated Night Roost is not considered important to the long-term presence of the Ghost Bat locally (Bat Call, 2020). The isolated CMRC-01, is also not considered important to the long-term presence of the Ghost Bat locally (Bat Call, 2020) and is likely to be impacted by the Project as it lies less than 3 m from the proposed Miralga East 1 pit.

CMRC-15, a potential maternity cave, is located in the Miralga East area. The entrance of this cave is located approximately 30 m from the Miralga East 1 pit. The inner reaches of this cave are much closer, approximately 15 m or less, from the proposed pit wall below the crest (Bat Call, 2020). Therefore, there is potential that this cave could be impacted directly through vibration, causing structural collapse. Additionally, this could be impacted indirectly through reduction in water catchment reducing surface water infiltration and therefore reduction of microclimate. Any bats roosting in this cave at the time of mining will also be impacted directly through noise, vibration, dust and lighting. At the time of writing, additional studies are being undertaken by Atlas in relation to potential impacts on CMRC-15 and management of this cave.

There are 15 water features in the Study Area. Any water features near the Project, particularly those near the pits, the waste dump and other infrastructure associated with ongoing disturbances, may be affected by decreased water quality due to temporary water run-off. However, the impact of temporary water run-off is likely to be Low due to, firstly, the distance between the pits and the water features and, secondly, the nature of the topography present.

Roads are planned to be constructed across Miralga Creek and the Shaw River. The construction, maintenance and use of these roads will need to be managed appropriately to avoid impacts to water features located downstream. Providing appropriate controls are in place (e.g. culverts are used to ensure flow is not impeded), the impact on water features located downstream is likely to be Low.

6.3 Potential Impacts on Fauna Species

Overall, habitat removal and degradation are together considered to be the primary impact to conservation significant fauna within the Study Area. Potential increases to the abundance of introduced species due to the Project could impact most conservation significant fauna in the Study Area via a range of means including predation, competition for food resources, and further habitat degradation, especially by introduced grazers. Vehicle strike may also have a moderate impact on some species.

Table 6.2 below summarises the potential impacts of the Project on fauna of conservation significance that are confirmed to occur or are thought likely to occur in the Study Area. Other

vertebrate fauna within the Study Area, including common and widespread species, would also be subject to a similar range of impacts.

It should be noted that, as for all developments, the direct and indirect impact sources that may affect key receptor species can be difficult to quantify and predict in advance of developments occurring. Although land clearing or degradation may be estimated, the final impact to the local populations or regional distribution of a species is difficult to quantify. The extent and magnitude of other impact sources, such as noise, light, or changed fire regimes, have not been well researched for Pilbara fauna species, and the final impact assessment is limited in its accuracy.

6.3.1 Potential Impacts on Species Recorded in the Study Area

Northern Quoll

Within the Study Area, high quality denning and foraging habitat for the species is found within the Gorge/ Gully and Hillcrest/ Hillslope habitats and foraging and dispersal habitat is found in the Major Drainage Line habitats. At a local scale, the species is likely to experience a Low to Moderate level of impact, primarily from removal, fragmentation and modification of habitat, but also potentially vehicle strike and the increased threat of introduced species. Low level impacts may also be experienced by increased light and noise and changed fire regimes. As the population occurring within the Study Area meets the definition of a 'high-density population' and thus a population 'important for the long-term survival of the species', the impacts to the species are likely to be significant as defined by DAWE.

Ghost Bat

Although the majority of habitats occurring within the Study Area would likely be used for foraging and dispersal by the Ghost Bat, roosting caves are restricted to the Hillcrest/Hillslope and Gorge/Gully habitats.

The Project will result in the removal or significant impact on two nocturnal roost caves, namely CMRC-02 and CMRC-01, and will potentially cause disruption to a further eleven due to those caves being located within 500m of proposed mining pits. At the time of writing, additional studies are being undertaken by Atlas in relation to potential impacts on CMRC-15 (a potential maternity cave) and management of this cave.

At a local scale, the species is likely to experience a Low to Moderate level of impact, primarily from removal, fragmentation and modification of habitat, but also potentially noise and vibration and dust. Low level impacts may also potentially be experienced due to vehicle strike, introduced species and changed fire regimes. The Project is likely to have a significant impact on the species, as defined by DAWE.

Pilbara Leaf-nosed Bat

All habitat types in the Study Area are used by this species, however, Hillslope/Hillcrest and Major Drainage Line habitats are especially frequented. The Project will result in the removal

or significant impact on two nocturnal roost caves, namely CMRC-02 and CMRC-01, and will potentially cause disruption to a further eleven due to those caves being located within 500 m of proposed mining pits – including CMRC-15 which appears to be an important nocturnal refuge for the species. The impacts considered to be of most significance for this species is habitat loss and degradation as well as potentially vehicle strike. However, this impact is unlikely to extend beyond the Study Area to the regional level and the Project is not likely to have a significant impact on the species, as defined by the DAWE.

Northern Brushtail Possum

The habitat types in the Study Area most suitable to support this species is the Major Drainage Line habitat, as well as other habitat that provides tree hollows and denning sites, such as the Gorge/Gully habitat. The impact considered to be of most significance for this species is habitat loss and degradation. However, overall the Project is not likely to have a significant impact on the species on a local or regional scale, as defined by the DAWE.

Grey Falcon

This species uses all habitat types in the Study Area and the Major Drainage Line provides nesting habitat. At a local scale the species is likely to experience a Low to Moderate level of impact, primarily from removal, fragmentation and modification of habitat, but also potentially vehicle strike, the increased threat of introduced species and increased levels of light. Low level impacts may also be experienced due to increased levels of noise, dust and changed fire regimes. However, Moderate level impacts are unlikely to extend beyond the Study Area to the regional level and the Project is not likely to have a significant impact on the species, as defined by the DAWE.

Peregrine Falcon

Potential nesting habitat for the Peregrine Falcon is present within Hillcrest/Hillslope, Gorge/Gully and Major Drainage Line habitat. The impact considered to be of most significance for this species is loss of a portion of habitat. However, overall the Project is not likely to have a significant impact on the species on a local or regional scale.

Western Pebble-mound Mouse

The habitat type in the Study Area most suitable to support the Western Pebble-mound Mouse is the Low Stony Hills habitat but this species will also use Stony Plain habitats. The impact considered to be of most significance for this species is habitat loss and degradation. However, overall the Project is not likely to have a significant impact on the species on a local or regional scale.

6.3.2 Potential Impacts on Species Potentially Occurring in the Study Area

The Pilbara Olive Python, Black-lined Ctenotus, Gane's Blind Snake, Brush-tailed Mulgara and Spectacled Hare-wallaby were not recorded in the Study Area but are likely to occur because

suitable habitat is present. Similarly, The Night Parrot, Greater Bilby, Spotted Ctenotus, Long-tailed Dunnart and Short-tailed Mouse were not recorded but are considered possible to occur in the Study Area. Generally, the impact considered to be of most significance for these species is habitat loss and degradation. Further detail of this and other potential impacts due to the Project is provided in Table 6.2. Overall the Project is not likely to have a significant impact on these species on a local or regional scale.

The habitat type in the Study Area most suitable to support migratory bird species is the Major Drainage Line habitat. The impact considered to be of most significance for migratory bird species is habitat loss and degradation. However, overall the Project is not likely to have a significant impact on these species on a local or regional scale.

Table 6.2: Potential impacts to vertebrate species of conservation significance potentially occurring in the Study Area

Species	Likelihood of occurrence	Impact source	Impact					
			Extent	Duration	Magnitude (Local)	Magnitude (Regional)	Potential consequence of impact	Certainty (Level of Confidence)
Species recorded within the Study Area								
Northern Quoll *Dasyurus hallucatus* **EPBC Act** Endangered **BC Act** Endangered	Confirmed (Biologic, 2019c)	Removal, Fragmentation or Modification of Habitat	Primary impact is the extent of clearing on core habitat (Hillcrest/ Hillslope, Gorge/Gully and Major Drainage Line)	Permanent	**Moderate –** The population within the Study Area is most likely permanent and considered a high-density population important for the long-term survival of the species. Although their semelparous nature (Oakwood, 2000) may make them susceptible to local extinction, the species does have good dispersal ability (Spencer, 2013; Woolley, 2015). Approximately 429.79 ha of Hillcrest/ Hillslope habitat (which contains important denning/shelter habitat) is present in the Study Area. A comparatively smaller portion of this (58.87 ha) is contained within the Development Envelope of the Project. The Project is also likely to impact on key foraging and dispersal habitat (Major Drainage Line). The site where 11 female and seven male Northern Quolls were recorded during field surveys (VMRC-99) represents high value denning/shelter and foraging habitat for breeding females of the population occurring within the Study Area (Biologic, 2019c) and lies partially inside the Development Envelope. It is important to note that VMRC-99 was a targeted Northern Quoll trapping site comprised of two parallel lines of 25 cage traps spaced approximately 10-30 m apart (i.e. a transect). The marker denoting VMRC-99 on Figure 3.3 from the *Miralga Creek Project: Vertebrate and SRE Invertebrate Fauna Assessment* only represents the start of the transect. Due to the layout of the transect, a large portion of VMRC-99 lies within the Indicative Disturbance Footprint and many of the 18 Northern Quolls captured at this site were actually captured within the Indicative Disturbance Footprint. The records of Northern Quolls in relation to the Indicative Disturbance Footprint are shown in Figure 6.1. The preferred habitat of the Northern Quoll extends well outside the Study Area and good dispersal habitat is also present along the Major Drainage Line which would be minimally impacted by the Project (19.58 ha is within the Development Envelope compared to 996.32 ha in the Study Area). Hence, the Project is unlikely to cause fragmentation of habitat. In the short-term individuals displaced by the Project would be expected to disperse into nearby suitable habitat, though the removal of habitat will reduce the long-term carrying capacity of the area.	**Low –** The preferred habitat for the Northern Quoll extends well outside the Study Area and the species is widespread in a regional context. In the Pilbara, the distribution of Northern Quolls is already fragmented (Hill & Ward, 2010), though regional genetic analysis indicates this has no impact upon genetic diversity (Spencer, 2013). Thus, the Project is not expected to significantly increase fragmentation of habitat on a regional scale.	• Loss/displacement of individuals during vegetation clearing and mining developments • Loss of foraging/ dispersal/ denning habitat • Reduction in local population size	**High** – habitat loss and fragmentation by mining and infrastructure development is well recorded as a potential impact on the Northern Quoll in the Pilbara (Cramer *et al.*, 2016b; Woinarski *et al.*, 2014)
		Vehicle Strike	Extent of expansion of existing road and track network	Long term (life of mine)	**Moderate –** Northern Quolls are known to cross roads (Dunlop *et al.*, 2014), and are opportunistic foragers known to scavenge roadkill (Radford, 2012). The species is regularly recorded from both vehicle strike and from being crushed in machinery (Cramer *et al.*, 2016b). The widening of a single access track was found to significantly increase mortalities and led to the extirpation of a population of eastern quolls in Tasmania (Jones, 2000). Although no records of vehicle strike of Northern Quoll exist within the Study Area, there are records from the adjacent Abydos DSO project (MWH, 2015, 2016). Therefore, road use within denning and foraging habitat would increase the likelihood of mortality.=. The threat of vehicle strike is likely to subside substantially post life of the mine.	**Low –** Although the Project will increase vehicle traffic generally in the region, and thus increase the likelihood of roadkill, the number of individuals affected regionally are likely to be low.	• Loss of individuals • Reduction in population size	**High** – there may be unrecorded deaths from vehicular collisions within the Study Area (MWH, 2015, 2016).

Species	Likelihood of occurrence	Impact source	Impact					
			Extent	Duration	Magnitude (Local)	Magnitude (Regional)	Potential consequence of impact	Certainty (Level of Confidence)
		Introduced Species	Predominantly in and around disturbed areas.	Permanent	**Moderate –** Feral predators are considered likely to occur in greater numbers near areas of human settlement and roads/tracks and are therefore likely to increase as a result of development of the Project. The threat posed by cats to the Northern Quoll is thought to be severe, although the impacts of cats may be reduced in rugged refuge areas (Woinarski ***et al.***, 2014). Northern Quoll are susceptible to cane toad toxins (Hill & Ward, 2010), and if cane toads expand south through the Pilbara, any temporary creation of artificial water sources from discharge may attract these introduced species. Invasive weed species may disadvantage Northern Quolls through inhibiting movement or fostering inappropriate fire regimes (Hill & Ward, 2010).	**Low –** The presence of introduced predators and invasive weeds may be exacerbated by the Project. However, this is not likely to have a significant impact on top of background levels already present.	• Loss of individuals from predation • Reduction in population size • Loss of prey items from competition • Alteration/degradation of habitat	**Moderate** – there are no records of Cane toads expanding into the Pilbara although they are predicted to invade the region (Cramer ***et al.***, 2016b). The degree to which feral predators are present in the Study Area currently, compared to the potential increase due to development of the Project is relatively unknown, though expected to increase.
		Increased Light	Predominantly concentrated near pits and other mining infrastructure that will be used at night when required.	Long-term (life of mine)	**Low –** Northern Quolls are known to occur around mine sites and human dwellings, and to shelter amongst mine infrastructure such as vehicles, machinery and laydown areas (Oakwood, 2008) where there are enhanced levels of light and noise. There may be a higher concentrations of prey items e.g. insects around lights (Oakwood, 2008), thus affecting normal behaviour and movements.	**Negligible –** Increased levels of light will not affect individuals outside of the Study Area.	• Possible dispersal from greatly enhanced levels of light disturbance, especially in denning areas • Changes to prey distribution	**Low** –The extent to which the Northern Quoll may be affected by light is not well understood, though they are known to occur around mine sites.
		Increased Noise	Near mine infrastructure and roads, especially near pits which is where blasting will occur.	Long-term (life of mine)	**Low –** Northern Quolls are known to occur around mine sites and human dwellings, and to shelter amongst mine infrastructure such as vehicles, machinery and laydown areas (Oakwood, 2008) where there are enhanced levels of light and noise. Though individuals may disperse from pit areas during active mining activities.	**Negligible –** Increased noise will not affect individuals outside of the Study Area.	• Possible dispersal from greatly enhanced levels of noise disturbance, especially in denning areas	**Low** – The extent to which the Northern Quoll may be affected by noise is not well understood, though they are known to occur around mine sites.
		Dust	Predominantly concentrated near dust-generating activities such as pit blasting and in close proximity to haul roads.	Long-term (life of mine)	**Low** – Northern Quolls have been observed persisting in close proximity to active mines that generate substantial amounts of dust (Nasir ***et al.***, 2017). Some contaminants from dust caused by mining activities have been shown to accumulate in the organs of Northern Quolls (Nasir ***et al.***, 2017), however, this evidence came from a manganese mine. In comparison, iron ore dust is considered typically benign (Breathsafe, 2020). Additionally, individuals may disperse from area of increased dust if foraging resources are also reduced.	**Negligible –** Increased levels of dust will not affect individuals outside of the Study Area.	• Disruption to foraging behaviours • Alteration/degradation of habitat	**Low** - The extent to which the species may be affected by dust is not well understood
		Altered Fire Regimes	Extent of disturbance from altered fire regime in foraging/ denning areas	Long-term (life of mine)	**Low –** Northern Quolls cope with fire in rocky habitats (Cook, 2010). The most detrimental local impact of fire on Northern Quolls is likely to be through consequential changes in habitat structure and floristics (Hill & Ward, 2010); however certain habitats such as deeply incised Valleys, Gorge/ Gully habitats and Rock Outcrops provide refuge from fire. Fire may also affect reproductive characteristics of Northern Quolls, or cause increased predation after removal of cover (Hill & Ward, 2010).	**Low –** The season, frequency, extent and severity of fires are all likely to be key factors influencing regional Northern Quoll populations (Hill & Ward, 2010). Fires inadvertently started in the Study Area may potentially escape and burn beyond of the boundary and subsequently impact on populations in the surrounding region.	• Possible loss of prey items, • Loss of foraging/ dispersal/ denning habitat • Potential change in breeding cycles • Loss of individuals from increased predation	**Moderate** – altered fire regimes (causing habitat change and loss) is well recorded as a potential impact for Northern Quoll in the Pilbara (Cramer ***et al.***, 2016b; Woinarski ***et al.***, 2014).
		Modification of Water Regimes	Extent of disturbance to the Major Drainage Line habitat	Long-term (life of mine)	**Low** – Northern Quoll have a heavy reliance on Drainage Line habitats, such as the Major Drainage Line habits, for dispersal (DoE, 2016). Any impacts to this habitat may impact upon movements within and outside of the Study Area.	**Low –** Northern Quoll have a heavy reliance on Drainage Line habitats, such as the Major Drainage Line habits, for dispersal (DoE, 2016). Any impacts to this habitat may impact upon movements within and outside of the Study Area.	• Loss of foraging and dispersal habitat	**Moderate** – the degree to which road crossing will impact the local water regimes within the Study Area is relatively unknown, though expected to be minimal with correct management.

Species	Likelihood of occurrence	Impact source	Impact					
			Extent	Duration	Magnitude (Local)	Magnitude (Regional)	Potential consequence of impact	Certainty (Level of Confidence)
Ghost Bat *Macroderma gigas* **EPBC Act** Vulnerable **BC Act** Vulnerable	Confirmed (Biologic, 2019c)	Removal, Fragmentation or Modification of Habitat	Primary impact is the extent of clearing (and extent of barrier to movement) of/near roosts which mainly occur in Hillcrest/Hillslope and Gorge/Gully habitat. All of the types of habitat found within the Study Area are suitable for the Ghost Bat to use for foraging and dispersal and may also be impacted by the Project. Two caves known to be used by the species may also be impacted by the proposed development	Permanent	**Moderate** – In the Study Area, roosts mainly occur in Hillcrest/Hillslope and Gorge/Gully habitat. Although no long-term impacts to Ghost bats are predicted in the Sandtrax area, there may be short-term abandonment (Bat Call, 2020). In the Miralga West area, one insignificant cave (CMRC-02) will be lost, however, this isolated Night Roost is not considered important to the long-term presence of the Ghost Bat locally (Bat Call, 2020). Nearby caves (including a Diurnal Roost CMRC-06) may be abandoned in the short-term although this is considered unlikely (Bat Call, 2020). Short-term abandonment is likely to occur at all caves within the Miralga East area during mining but reoccupation is expected contingent on sound structural integrity of the caves post mining (Bat Call, 2020). The isolated CMRC-01, is not considered important to the long-term presence of the Ghost Bat locally (Bat Call, 2020) and is likely to be impacted by the Project as it lies less than 3 m from the proposed Miralga East 1 pit. In the Miralga East area, a potential maternity cave (CMRC-15) with its entrance located approximately 30 m from the Miralga East 1 pit. The inner reaches of this cave are much closer, approximately 15 m from the proposed pit wall below the crest (Bat Call, 2020). The Ghost Bats are likely to abandon this cave due to noise, vibration and dust but will re-occupy the cave once mining ceases providing the cave remains undamaged and the inner extremities of the cave is not intersected by the pit wall (Bat Call, 2020). At the time of writing, additional studies are being undertaken by Atlas in relation to potential impacts on CMRC-15 (a potential maternity cave) and management of this cave. All of the types of habitat found within the Study Area are suitable for the Ghost Bat to use for foraging and the Project would disturb only a portion of each. Water features are important for the Ghost Bat as foraging and drinking sources. No water features are found within the Indicative Disturbance Footprint.	**Low** – Lalla Rookh is a permanent Ghost Bat roost which lies outside of the Study Area, approximately 3 km southwest of the Miralga deposits. Any bats exhibiting short-term abandonment from caves due to the Project are expected to use Lalla Rookh as their preferred location (Bat Call, 2020). The extent to which Lalla Rookh and the surrounding foraging grounds have reached their carrying capacity is unknown and thus has potential to impact the species at a regional scale. Highly mobile species such as bats may experience disruptions if they are unwilling to fly across large cleared areas while foraging (Hopkins, 2015). The flight paths within the Study Area and beyond preferred by Ghost Bats are not known.	• Loss/displacement of individuals during vegetation clearing and mining developments • Loss of foraging/ dispersal habitat • Disruption to breeding cycles • Reduction in population size • Increase in population isolation	**Moderate** - Any bats exhibiting short-term abandonment from caves due to the Project are expected to use Lalla Rookh as their preferred location (Bat Call, 2020). However, the extent to which Lalla Rookh and the surrounding foraging grounds have reached their carrying capacity is unknown.
		Vehicle Strike	Extent of expansion of existing road and track network	Long-term (life of mine)	**Low** – Mortalities due to vehicle collisions at night may increase as the species often forages close to the ground (Churchill, 2008), However, vehicle movements at night (when Ghost Bat are active) are much lower compared to daytime vehicle movements and are generally limited to in-pit operations. No vehicle strikes are known from Lalla Rookh which runs alongside the Abydos link road and serviced haulage truck outside of the Abydos DSO Project (C. Knuckey *per. comms*.).	**Low** – Vehicle usage will increase outside of the Development, such as adjacent to the Lalla Rookh maternity roost. Thus, there is a low chance that individuals may be impacted. However, no vehicle strikes are known from Lalla Rookh which runs alongside the Abydos link road and serviced haulage truck outside of the Abydos DSO Project (C. Knuckey *per. comms*.).	• Loss of individuals • Reduction in local population size	**Moderate** – there may be unrecorded vehicular collisions with Ghost Bats in the region.
		Introduced Species	Predominantly in and around disturbed areas.	Permanent	**Low** – Invasive species are unlikely to have a significant effect on Ghost Bats in the Study Area in comparison to other key threats. It is anticipated that numbers of feral predators, such as feral cats and foxes, and introduced grazers, will not significantly increase with suitable monitoring and management. There is recent evidence that Ghost Bats prey on Cane Toads and are susceptible to their toxicity (Purtill, 2014). If Cane Toads expand into the Pilbara, the water sources present in the Study Area may attract these introduced species.	**Negligible** – The presence of introduced predators and invasive weeds may be exacerbated by the Project. However, the threat posed by introduced species is not expected to escalate at a regional level due to the Project.	• Loss of individuals from predation • Reduction in population size • Loss of prey items due to competition • Alteration/degradation of habitat	**Moderate** - there are no records of Cane toads expanding into the Pilbara although they are predicted to invade the region (Cramer *et al.*, 2016a).
		Increased Light	Predominantly concentrated near pits and other mining infrastructure that will be used at night when required.	Long-term (life of mine)	**Low** – Recent research has shown that the effect of artificial light on cave-dwelling bats varies depending on species and also the type of light (Straka *et al.*, 2020). Ghost Bats are known to be susceptible to disturbance (R. Bullen, *pers. comms.* 2019), and strong light sources may confuse or blind foraging Ghost Bats. Ghost Bats are likely to abandon some caves, especially those in the Miralga East area, due artificial light may also contribute. Reoccupation is expected contingent on sound structural integrity of the caves post mining (Bat Call, 2020).	**Low** – localized increases to light from mining activities is not expected to detrimentally impact Ghost Bat colonies in the broader region. Low levels of light may impact bats at the nearby Lalla Rookh maternity roost, though this has not significantly affected the colony during operation of the Abydos DSO project (Biologic, 2019a).	• Possible dispersal from greatly enhanced levels of light during mining activities • Changes to prey distribution	**Moderate** – Recent research has shown that the effect of artificial light on cave-dwelling bats varies depending on species and also the type of light (Straka *et al.*, 2020). Research is required to determine the impact of the types of lights used in mining on the Ghost Bat.

Species	Likelihood of occurrence	Impact source	Impact					
			Extent	Duration	Magnitude (Local)	Magnitude (Regional)	Potential consequence of impact	Certainty (Level of Confidence)
		Increased Noise	Near mine infrastructure and roads, especially near pits which is where blasting will occur.	Long-term (life of mine)	**Moderate** – Ghost Bats are susceptible to disturbance including vibration and noise (Martin, 2012; Martin, 2018), and have an observed tendency to vacate roosts in response (TSSC, 2016a). Ghost Bats are likely to abandon some caves, especially those in the Miralga East area, during mining due to noise and vibration but reoccupation is expected contingent on sound structural integrity of the caves post mining (Bat Call, 2020).	**Low** – the species is known to roost in the surrounding area at Lalla Rookh. Any bats which abandon caves within the Project area as a result of mining activities are expected to utilise Lalla Rookh as their preferred location (Bat Call, 2020). However, the extent to which Lalla Rookh and the surrounding foraging grounds have reached their carrying capacity is unknown and thus has potential to impact the species at a regional scale. Increased levels of noise and vibration may affect individuals outside of the Study Area along the haulage route.	• Possible dispersal from greatly enhanced levels of noise during mining activities • Disruption to breeding cycles • Reduction in population size	**Moderate** – there is uncertainty surrounding the noise and vibration thresholds that the Ghost Bat will tolerate, though many mines have operated without Ghost Bat abandonment, including the Abydos DSO project (Biologic, 2019a)
		Dust	Predominantly concentrated near dust-generating activities such as pit blasting and in close proximity to haul roads.	Long-term (life of mine)	**Moderate** – Ghost Bats are believed to be susceptible to disturbance such as dust (Martin, 2012; Martin, 2018). Ghost bats have excellent vision and it is possible that high dust levels could irritate the eyes or reduce vision and affect their ability to capture prey (TSSC, 2016a). Ghost Bats are likely to abandon some caves, especially those in the Miralga East area, during mining due to dust but reoccupation is expected contingent on sound structural integrity of the caves post mining (Bat Call, 2020).	**Low** – the species is known to roost in the surrounding area at Lalla Rookh. Any bats which abandon caves within the Project area as a result of mining activities are expected to utilise Lalla Rookh as their preferred location (Bat Call, 2020). However, the extent to which Lalla Rookh and the surrounding foraging grounds have reached their carrying capacity is unknown and thus has potential to impact the species at a regional scale. Increased levels of noise and vibration may affect individuals outside of the Study Area along the unsealed section of the haulage route.	• Disruption to foraging behaviours • Alteration/degradation of habitat	**Moderate** – the impact of dust on individuals and foraging habitat is not well studied for Ghost Bats in the Pilbara ,though many mines have operated without Ghost Bat abandonment, including the Abydos DSO project (Biologic, 2019a)
		Altered Fire Regimes	Extent of disturbance from altered fire regime in foraging and roosting areas	Long-term (life of mine)	**Low** – Consideration of fire frequency is relevant to the maintenance of suitable foraging habitat, especially when females are lactating and might require greater food resources (TSSC, 2016a). Although the Project may inadvertently change the frequency of fire, it is not expected to have a significant impact on the species due to the ability to forage widely across a landscape (Augusteyn ***et al.***, 2018).	**Low –** Fires inadvertently started in the Study Area may potentially escape and burn beyond of the boundary and subsequently impact on populations in the surrounding region. However, this would probably be a rare occurrence given the control measures that would be expected to be in place as part of the Project.	• Temporary loss of foraging/ dispersal habitat • Possible temporary loss of prey items	**Moderate** – although some population declines could be attributed to prey lost through habitat modification by fire (Duncan ***et al.***, 1999), there is a lack of research into the impact on changes to season, frequency and extent of fires on a local and regional scale for Ghost Bats.
		Modification of Water Regimes	Extent of Study Area (surface water). Habitat features reliant of specific water regimes	Permanent	**Moderate** – It is believed that Ghost Bat roost selection is in part related to temperature and humidity (Armstrong & Anstee, 2000; Churchill & M., 1990; Pettigrew ***et al.***, 1986). Thus, diurnal roosts and potential maternity roosts within the Study Area are likely to contain specific parameters required by the species and are most likely fed through water recharge through the surrounding geology. The removal habitat in close-proximity to such features has the potential to impact aquifer recharge and therefore microclimate of particular caves – one cave of particular concern is CMRC-15, located ~30 m from Miralga East pit 1. Any alterations to the recharge of water features in the Study Area may also impact upon the local foraging capacity of a site.	**Low** – alteration of water regimes within the Study Area is unlikely to be a significant issue outside of the Study Area.	• Loss of roosting (including potential breeding) habitat during mining • Loss of prey items utilizing water sources	**Low** – the degree to which cave microclimate may be influenced by the proposed development remains untested. Similarly, there is no contemporary evidence to confirm the importance of microclimate to the species within the Pilbara.
<u>Pilbara Leaf-nosed Bat</u> *Rhinonicteris aurantius* **EPBC Act** Vulnerable **BC Act** Vulnerable	Confirmed (Biologic, 2019c)	Removal, Fragmentation or Modification of Habitat	Primary impact is the extent of clearing and extent of barrier to movement in foraging/dispersal habitat in all habitats, especially Hillslope/Hillcrest and Major Drainage Line habitat Two caves known to be used by the species may also be impacted by the proposed development	Permanent	**Moderate** – The Pilbara Leaf-nosed Bat is likely to forage nightly within the Study Area, however, the caves in the Study Area are probably not used for diurnal roosting as no evidence of this was found during field surveys (Biologic, 2019c). Two caves that may be used as nocturnal roosts (CMRC-01 and CMRC-02) by this species will be removed or significantly impacted by the Project. All of the types of habitat found within the Study Area are suitable for the Pilbara Leaf-nosed Bat to use for foraging and the Project would disturb only a portion of each.	**Low** – Lalla Rookh is a permanent diurnal roost for the species, which lies outside of the Study Area, approximately 3 km southwest of the Miralga deposits (Biologic, 2019a). A local population decline has the potential to contribute to a population decline at a regional level, especially if critical habitat is lost and a significant proportion of the regional population is affected (TSSC, 2016b). However, this is unlikely to result from the Project.	• Loss/displacement of individuals during vegetation clearing and mining developments • Loss of foraging/ dispersal habitat • Disruption to breeding cycles • Reduction in population size • Increase in population isolation	**Moderate** - Highly mobile species such as bats may experience disruptions if they are unwilling to fly across large cleared areas while foraging (Hopkins, 2015). The flight paths within the Study Area and beyond preferred by Pilbara Leaf-nosed Bats are not known.

Species	Likelihood of occurrence	Impact source	Impact					
			Extent	Duration	Magnitude (Local)	Magnitude (Regional)	Potential consequence of impact	Certainty (Level of Confidence)
		Vehicle Strike	Extent of expansion of existing road and track network	Long-term (life of mine)	**Moderate** – the species is known to be susceptible to strikes from vehicles (TSSC, 2016b). Five records of the species in the Pilbara are from roadkill (Fortescue Roadhouse, 1990; near Tom Price, 1995; near Yarrie, 2005), or specimens found in carparks, presumably after falling off the vehicle (Millstream, no date; Karratha, 1985) (Armstrong, 2001). They tend to fly relatively low and display a curiosity for light sources, which increase the chance of mortality along roads (Cramer ***et al.***, 2016a) Local decline of the species may occur if a busy haul or access road is to be located close to a known foraging site. However, vehicle movements at night (when Pilbara Leaf-nosed Bats are active) are greatly reduced compared with daytime vehicle movements and are generally limited to in-pit operations.	**Low** – sporadic occurrences of roadkill are unlikely to have a significant regional impact on the population size.	• Loss of individuals • Reduction in local population size	**High** - the species is known to be susceptible to strikes from vehicles (TSSC, 2016b).
		Introduced Species	Predominantly in and around disturbed areas.	Permanent	**Low** – The Pilbara Leaf-nosed Bat has been exposed to the degradation and modification of natural habitats caused by introduced species such as invasive weeds, domestic herbivores and other larger feral ungulates since the arrival of Europeans (TSSC, 2016b). Buffel grass has been recorded within the Study Area (Biologic, 2019c). Invasive species are unlikely to have a significant effect overall, and in comparison, to other key threats. It is anticipated that numbers of feral predators, such as feral cats may increase during the development, and are a known predator of the species (Woolley ***et al.***, 2019). Though the number of individuals is expected to be low.	**Low** – there is unlikely to be a significant impact on a regional scale to Pilbara Leaf-nosed Bat from introduced species.	• Loss of individuals from predation • Reduction in population size • Loss of prey items from competition • Alteration/degradation of habitat	**Moderate –** the impacts of feral predators, such as feral cats and foxes, and introduced grazers, upon the species is relatively unknown.
		Increased Light	Predominantly concentrated near pits and other mining infrastructure that will be used at night when required.	Long-term (life of mine)	**Low** – The species displays a curiosity for light sources (TSSC, 2016b), and foraging Pilbara Leaf-nosed Bats have been recorded as attracted to artificial lights (car headlights, head torches and mine site lights) (Cramer ***et al.***, 2016a), which may make it more susceptible to vehicle strike or predation. The Pilbara Leaf-nosed Bat has been observed to tolerate lighting associated with mining (MWH, 2014b).	**Negligible** – there is unlikely to be a significant impact on a regional scale to the Pilbara Leaf-nosed Bat from increased levels of light.	• Disruption to foraging behaviours	**Moderate** - there is uncertainty surrounding the light thresholds that the Pilbara Leaf-nosed Bat will tolerate with respect to lighting.
		Increased Noise	Near mine infrastructure and roads, especially near pits which is where blasting will occur.	Long-term (life of mine)	**Low** – The Pilbara Leaf-nosed Bat is recorded as being susceptible to the impacts of noise and vibration. However, Armstrong (Cramer ***et al.***, 2016a) noted that there has been no observation that bats vacate an area or structure during the period when mining is undertaken, as long as the caves or gullies nearby remain intact (Cramer ***et al.***, 2016a)	**Low** – the Pilbara Leaf-nosed Bats recorded in the Study Area are thought to have originated from the Lalla Rookh roost (R. Bullen ***pers. comm.***, cited in Biologic (2019c) which lies outside of the Study Area, approximately 3 km southwest of the Miralga deposits. Increased levels of noise and vibration are not expected to significantly affect individuals outside of the Study Area, including at the Lalla Rookh roost – haul trucks operated past here for the Abydos DSO project with no obvious disruption (Biologic, 2019a).	• Possible dispersal from greatly enhanced levels of noise during mining activities • Reduction in population size	**Moderate** – there is uncertainty surrounding the noise and vibration thresholds that the Pilbara Leaf-nosed Bat will tolerate.
		Dust	Predominantly concentrated near dust-generating activities such as pit blasting and in close proximity to haul roads.	Long-term (life of mine)	**Low** - The species is recorded as being susceptible to dust impacts, although Armstrong (Cramer ***et al.***, 2016a) noted that there has been no observation that bats vacate an area or structure during the period when mining is undertaken, including when in proximity to dust.	**Negligible** – on a regional scale, there is unlikely to be a significant impact from increased dust levels on the Pilbara Leaf-nosed Bat.	• Temporary disruption to foraging behaviours • Alteration/degradation of habitat	**Moderate** - Pilbara Leaf-nosed Bats are recorded as being susceptible to the impacts of dust; however, the impact on individuals and foraging habitat is not well studied for the species.
		Altered Fire Regimes	Extent of disturbance from altered fire regime in foraging and roosting areas.	Long-term (life of mine)	**Low** – Consideration of fire frequency is relevant to the maintenance of suitable foraging habitat, especially when females are lactating and might require greater food resources (TSSC, 2016b). Although the Project may inadvertently change the frequency of fire, it is not expected to have a significant impact on the species.	**Low** - Fires inadvertently started in the Study Area may potentially escape and burn beyond of the boundary and subsequently impact on populations in the surrounding region. However, this would probably be a rare occurrence given the control measures that would be expected to be in place as part of the Project.	• Loss of foraging/ dispersal habitat • Possible temporary loss of prey items	**Moderate** – although some population declines could be attributed to prey lost through habitat modification by fire (Duncan ***et al.***, 1999), there is a lack of research into the impact on changes to season, frequency and extent of fires on a local and regional scale for Pilbara Leaf-nosed Bats.

Species	Likelihood of occurrence	Impact source	Impact					
			Extent	Duration	Magnitude (Local)	Magnitude (Regional)	Potential consequence of impact	Certainty (Level of Confidence)
		Modification of Water Regimes	Extent of Study Area (surface water). Habitat features reliant of specific water regimes	Permanent	**Moderate** – Pilbara Leaf-nosed Bats are highly reliant of humid conditions at roost sites, namely diurnal roosting sites but also likely nocturnal refuges (Armstrong, 2001; Baudinette ***et al.***, 2000). Thus, nocturnal refuges within the Study Area are likely to contain specific parameters required by the species and are most likely fed through water recharge through the surrounding geology. The removal habitat in close-proximity to such features has the potential to impact aquifer recharge and therefore microclimate of particular caves – one cave of particular concern is CMRC-15, located ~30 m from Miralga East pit 1. Any alteration s to the recharge of water features in the Study Area may also impact upon the local foraging capacity of a site which are believed to be important foraging locations to the species (Biologic, 2019c).	**Low** – alteration of water regimes within the Study Area is unlikely to be a significant issue outside of the Study Area.	• Loss of foraging habitat during mining • Loss of prey items utilizing water sources	**Low** – the degree to which cave microclimate may be influenced by the proposed development remains untested.
<u>Northern Brushtail Possum</u> *Trichosurus vulpecula arnhemensis* **EPBC Act** Vulnerable (nomination only) **BC Act** Vulnerable	Confirmed (Biologic, 2019c)	Removal, Fragmentation or Modification of Habitat	Primary impact is the extent of clearing on core habitat (Major Drainage Line) as well as other habitat that provides tree hollows and ground refuges (e.g. Gorge/Gully habitat)	Permanent	**Moderate –** Within Western Australia, the former range of the Brushtail Possum has been considerably reduced by habitat clearing and predation by foxes, including in large areas of arid country (DBCA, 2012). A small amount of Gorge/Gully habitat (0.76 ha) lies within the Development Envelope. The preferred habitat of the Northern Brushtail Possum (Major Drainage Line) extends well outside the Study Area, including along Miralga Creek where an individual was recorded (Biologic, 2019c). Major Drainage Line habitat would be minimally impacted by the Project (19.58 ha is within the Development Envelope compared to 996.32 ha in the Study Area) (Figure 6.4). Hence, the Project is unlikely to cause fragmentation of habitat for this species. Individuals displaced by the Project would be expected to disperse into nearby suitable habitat.	**Low –** Little ecological information is known about the Pilbara population, although it is most often recorded from gorges and major drainage lines that contain large hollow-bearing Eucalypts (DBCA, 2019a). The preferred habitat for this species therefore extends well outside the Study Area. Although the species is widespread in a regional context, it is infrequently recorded in the Pilbara region. The Project is not expected to further significantly increase fragmentation of habitat on a regional scale.	• Loss/displacement of individuals during vegetation clearing and mining developments • Loss of foraging/ dispersal/ hollow habitat • Reduction in population size • Increase in population isolation	**Low** – Little ecological information is known about the Pilbara population of the Northern Brushtail Possum. Additionally, there is some conjecture as to whether the population of the region represents the *Trichosurus vulpecula arnhemensis* (indicated by WAM) or *Trichosurus vulpecula hypoleucos* (indicated by DBCA) which is not considered to be Threatened (H. Anderson *in prep.*).
		Vehicle Strike	Extent of expansion of existing road and track network	Long-term (life of mine)	**Low –** Brushtail Possums are known to cross roads (Giffney ***et al.***, 2009), and this can lead to vehicle strike and mortality. With a potential reproductive rate of nearly two per year (Kerle, 1998), it is probable that populations of the Northern Brushtail Possum can readily recover from individual deaths.	**Low –** there is unlikely to be a significant increase to vehicular strike of Northern Brushtail Possums in the region due to the Project.	• Loss of individuals • Reduction in population size	**Moderate** – there may be unrecorded vehicular strikes within the region and the extent to which this occurs is relatively unknown.
		Introduced Species	Predominantly in and around disturbed areas.	Permanent	**Low –** The Northern Brushtail Possum is regarded as a 'critical weight range' mammal, and thus more susceptible to pressure from introduced predators (Burbidge & McKenzie, 1989). Invasive weed species may disadvantage Northern Brushtail Possum through inhibiting movement or fostering inappropriate fire regimes.	**Low –** although predation by introduced species is recorded as one of most significant threats to the species, there is unlikely to be a significant increase in regional predation from the Project.	• Loss of individuals from predation • Reduction in population size • Loss of prey items from competition • Alteration/degradation of habitat	**Moderate** – The degree to which feral predators are present in the Study Area currently, compared to the potential increase due to development of the Project is relatively unknown, though expected to increase.
		Increased Light	Predominantly concentrated near pits and other mining infrastructure that will be used at night when required.	Long-term (life of mine)	**Low –** Brushtail Possums are known to occur around human habitation and activities (Roetman & Daniels, 2009) where there are enhanced levels of light and noise. However, there are no specific studies on the impact of light on the northern subspecies. There may be higher concentrations of prey items e.g. insects around lights (Oakwood, 2008). There is unlikely to be a significant impact from increased light to local individuals.	**Low –** there is unlikely to be a significant impact from increased light to Northern Brushtail Possum in the broader region.	• Possible dispersal from greatly enhanced levels of light, especially in denning areas	**Moderate** – Although Brushtail Possums are well-known to commonly co-inhabit with humans, the extent to which the northern subspecies of Brushtail Possum is affected by light is not researched.
		Increased Noise	Near mine infrastructure and roads, especially near pits which is where blasting will occur.	Long-term (life of mine)	**Low –** Brushtail Possums are known to occur around human habitation and activities (Roetman & Daniels, 2009) where there are enhanced levels of light and noise. However, there are no specific studies on the impact of noise on the northern subspecies. There may be higher concentrations of prey items e.g. insects around lights (Oakwood, 2008). There is unlikely to be a significant impact from increased noise to local individuals.	**Low –** there is unlikely to be a significant impact from increased noise to Northern Brushtail Possum in the region.	• Possible dispersal from greatly enhanced levels of noise, especially in denning areas	**Moderate** – Although Brushtail Possums are well-known to commonly co-inhabit with humans, the extent to which the northern subspecies of Brushtail Possum is affected by noise is not researched.
		Dust	Predominantly concentrated near dust-generating activities such as pit blasting and in close proximity to haul roads.	Long-term (life of mine)	**Low** – The impact of dust from mines has not been studied for the Northern Brushtail Possum. Some degradation of foraging habitat is likely to occur. Iron ore dust is considered typically benign (Breathsafe, 2020).	**Negligible –** Increased levels of dust are not expected to affect individuals outside of the Study Area.	• Temporary disruption to foraging behaviours • Alteration/degradation of habitat	**Moderate** – the impact of dust on individuals and foraging habitat is not well studied for Brushtail Possums.

Species	Likelihood of occurrence	Impact source	Impact					
			Extent	Duration	Magnitude (Local)	Magnitude (Regional)	Potential consequence of impact	Certainty (Level of Confidence)
		Altered Fire Regimes	Extent of disturbance from altered fire regime in foraging and denning areas	Long term (life of mine)	**Low –** On a local level, inappropriate fire regimes are likely to impact any individuals present through consequential changes in habitat structure and floristics. In particular, the availability of the tree hollows and ground refuges (hollow logs, rockpiles and the burrows of other animals) utilized by the species (Kerle ***et al.***, 1992) will be detrimentally impacted by frequent fire. Fire may also cause increased predation after removal of cover (Carwardine ***et al.***, 2014). However, the high fecundity of the species means that they can readily recover from short periods of unfavourable conditions within their preferred habitat (Kerle, 1998).	**Low –** Although the season, frequency, extent and severity of fires are all likely to be a factor influencing Northern Brushtail Possum populations, the Project is unlikely to have an impact on a regional scale.	• Loss of foraging/ dispersal/ denning habitat, in particular refuges • Possible loss of prey items, although species is omnivorous (Cruz ***et al.***, 2012) • Loss of individuals from increased predation	**Moderate** – altered fire regimes (causing habitat change and loss) is well recorded as a potential impact for critical weight range mammals in the Pilbara (Cramer ***et al.***, 2016b; Woinarski ***et al.***, 2014).
		Modification of Water Regimes	Extent of existing and future water sources	Long term (life of mine)	**Low –** Within the Pilbara the species is most often recorded from gorges and major drainage lines that contain large hollow-bearing Eucalypts (DBCA, 2019a); therefore, modification to existing water regimes and water quality from mining activities may impact suitable habitat within the Study Area. Morton (1990) emphasized the importance of drought refuges, and Kerle ***et al.*** (1992) believe that for Brushtail Possum, these refuges may need sufficient ground water supplies for the survival of palatable trees and shrubs.	**Low –** Sources of permanent water are of high ecological value in the Pilbara (Carwardine ***et al.***, 2014); however changes to water quality or regimes from the Project is unlikely to have an impact on regional populations.	• Changes to foraging/ dispersal/ habitat within Major Drainage Lines • Displacement of individuals	**Low** – Little ecological information is known about the Pilbara population, and although the species may require drought refuges with sufficient groundwater, this requires further study.
<u>Grey Falcon</u> *Falco hypoleucos* **EPBC Act** Vulnerable (nomination only) **BC Act** Vulnerable	Confirmed (Biologic, 2019c)	Removal, Fragmentation or Modification of Habitat	Extent of clearing in all habitat types but especially Major Drainage Line which provides nesting habitat	Permanent	**Moderate –** The Grey Falcon uses all of the habitat types in the Study Area for hunting, but the Major Drainage Line habitat is particularly suitable for nesting. Breeding within the Major Drainage Line habitat of the Study Area (or vicinity of) was evidenced by a group of four individuals including two young (Biologic, 2019c). Approximately 19.58 ha of Major Drainage Line habitat lies within the Development Envelope. This species is mobile and can move away from disturbances such as habitat to be cleared as part of the Project. However, recent research has shown that the Grey Falcon is a 'reluctant nomad' and that if conditions become unsuitable for breeding, these birds prefer to stay and forego breeding than to search for more favourable conditions (Schoenjahn, 2018). Only if conditions become a risk to their survival are they likely to move on and then, when they do, they move no further than necessary (Schoenjahn, 2018).	**Low –** The Project is unlikely to have an impact on the Grey Falcon at a regional scale due to its being a habitat generalist, its high mobility and its large distribution.	• Displacement of individuals during vegetation clearing and mining developments. • Permanent loss of habitat. • Future breeding attempts may be foregone.	**Moderate** – the species is highly mobile and a habitat generalist. However, evidence of breeding individuals was observed in the Study Area and the Project may impact future breeding attempts.
		Vehicle Strike	Extent of expansion of existing road and track network	Long-term (life of mine)	**Moderate** – Whether Grey Falcons scavenge carrion at all has been disputed although they do have a tendency to consume their prey on the ground, sometimes by the side of roads and track (Schoenjahn, 2018) which may put them at some risk to being struck by vehicles.	**Low –** there is unlikely to be a significant increase in vehicular strike of the Grey Falcon in the region due to the Project.	• Loss of individuals • Reduction in population size	**Moderate** – there may be unrecorded vehicular strikes within the region
		Introduced Species	Predominantly in and around disturbed areas	Permanent	**Moderate –** Introduced predators are identified as a possible major threat to the species within roosting habitat, as individuals frequently roost on bare ground exposing them to predation (Schoenjahn, 2018) (e.g. cats and foxes). Additionally, introduced species may compete for prey items.	**Low –** although predation by introduced species is recorded as one of most significant threats to the species, there is unlikely to be a significant increase in regional predation from the Project.	• Loss of individuals from predation • Reduction in population size • Alteration/degradation of habitat, including increases to fuel load	**Moderate** – the impact of introduced predators on the species is not well documented although the threat is nonetheless regarded as a major threat likely to impact the species.
		Increased Light	Predominantly concentrated near pits and other mining infrastructure that will be used at night when required.	Long-term (life of mine)	**Moderate** – Increased light spilling into areas where Grey Falcons are roosting on the ground may potentially put them at increased risk of predation from cats and foxes. However, this is not researched.	**Negligible –** there is unlikely to be a significant impact from increased light levels to the Grey Falcon in the wider region.	• Possible dispersal from greatly enhanced levels of light, especially in roosting areas • Disruption to breeding	**Low** – The effects of increased light on Grey Falcons is not researched.
		Increased Noise	Near mine infrastructure and roads, especially near pits which is where blasting will occur.	Long-term (life of mine)	**Low** – The effect of elevated levels of noise on the Grey Falcon is unknown. It is probable that this species would react to sudden, loud noises (e.g. from blasting) by at least temporarily dispersing. However, individuals of this species tend to move on only if conditions become a risk to their survival when they do, they move no further than necessary (Schoenjahn, 2018). The Grey Falcon tends to stay and forego breeding rather than search for more favourable conditions (Schoenjahn, 2018). Research on loud noises produced by auditory deterrents such as gas cannons has shown that birds are scared away in the short term but then quickly habituate to the noises (Donato ***et al.***, 2007; Transport Canada, 1998). It is possible that the Grey Falcon would habituate to increased levels of noise caused by the Project.	**Negligible –** there is unlikely to be a significant impact from increased noise on the Grey Falcon in the wider region.	• Possible dispersal from greatly enhanced levels of noise • Disruption to breeding	**Low** – The effects of increased noise on Grey Falcons is not researched.

Species	Likelihood of occurrence	Impact source	Impact					
			Extent	Duration	Magnitude (Local)	Magnitude (Regional)	Potential consequence of impact	Certainty (Level of Confidence)
		Dust	Predominantly concentrated near dust-generating activities such as pit blasting and in close proximity to haul roads.	Long-term (life of mine)	**Low** – The impact of dust from mines has not been studied for the Grey Falcon. Some degradation of foraging habitat is likely to occur. Iron ore dust is considered typically benign (Breathsafe, 2020).	**Negligible –** Increased levels of dust are not expected to affect individuals outside of the Study Area.	• Disruption to foraging behaviours • Alteration/degradation of habitat	**Moderate** – the impact of dust on individuals and foraging habitat is not well studied for the Grey Falcon.
		Altered Fire Regimes	Extent of disturbance from altered fire regime in foraging and roosting areas	Long-term (life of mine)	**Low –** Frequent fire may impact the quality of nesting, roosting and foraging habitat available to the species.	**Low –** Fires inadvertently started in the Study Area may potentially escape and burn beyond of the boundary and subsequently impact on populations in the surrounding region. However, this would probably be a rare occurrence given the control measures that would be expected to be in place as part of the Project.	• Potential loss of nestling individuals from direct mortality • Possible loss of prey items	**Low** – The species response to fire and changes to fire regimes is not well documented.
		Modification of Water Regimes	Extent of existing and future water sources	Long term (life of mine)	**Low –** Within the Pilbara the species is most often recorded nesting within Drainage Lines with large Eucalypts (Schoenjahn, 2018); therefore, modification to existing water regimes and water quality from mining activities may impact suitable habitat within the Study Area.	**Low –** Sources of permanent water are of high ecological value in the Pilbara (Carwardine ***et al.***, 2014); however changes to water quality or regimes from the Project is unlikely to have an impact on regional populations.	• Changes to foraging/ dispersal/ habitat within Major Drainage Lines • Displacement of individuals	**Moderate** – The degree to which habitats within the Study Area will be impacted by altered water regimes is relatively unknown, though is expected to be minimal.
<u>Peregrine Falcon</u> *Falco peregrinus* **BC Act** Specially Protected	Confirmed (Biologic, 2019c)	Removal, Fragmentation or Modification of Habitat	Extent of clearing on core habitat. Potential nesting habitat is present within Hillcrest/Hillslope, Gorge/Gully and Major Drainage Line habitat	Permanent	**Moderate –** This species is a habitat generalist. It is highly mobile and can easily move away from disturbances, making it less susceptible to being impacted by the Project. The Hillcrest/Hillslope and Gorge/Gully provides suitable nesting sites particularly in areas where large steep rock faces and ledges are present, and the Major Drainage Line provides nesting opportunities where tall trees are present. All of these habitat types will be impacted by the Project, so some habitat will be lost, however, fragmentation of habitat is not likely to occur.	**Negligible –** Suitable habitat for the Peregrine Falcon is widespread and common in the region. The Project is unlikely to have an impact on this species at a regional scale due to its general habitat preference, high mobility and large distribution.	• Displacement of individuals during vegetation clearing and mining developments	**Moderate** – the species is highly mobile and a habitat generalist.
		Vehicle Strike	Extent of expansion of existing road and track network	Long-term (life of mine)	**Low** – Peregrine Falcons generally only occasionally scavenge carcasses (Olsen, 1995) (e.g. roadkill) so they are less likely to be struck by vehicles.	**Negligible –** there is unlikely to be a significant increase to vehicular strike of Peregrine Falcon in the region due to the Project.	• Loss of individuals • Reduction in population size	**Moderate** – there may be unrecorded vehicular strikes within the Study Area
		Introduced Species	Predominantly in and around disturbed areas	Permanent	**Low** – Increases in introduced species used as prey may benefit the Peregrine Falcon. Peregrine Falcon nestlings and fledglings may fall prey to introduced predators such as cats and foxes.	**Low** – there is unlikely to be a significant impact on a regional scale to the Peregrine Falcon from introduced species.	• Reduction in population size • Alteration/degradation of habitat, including increases to fuel load	**Moderate** – this species is known to occur in highly disturbed areas alongside introduced species.
		Increased Light	Predominantly concentrated near pits and other mining infrastructure that will be used at night when required.	Long-term (life of mine)	**Low –** The Peregrine Falcon is known to sometimes occur around human habitation and activities where there are enhanced levels of light (e.g. high-rise buildings in some Australian capital cities and power stations) and therefore has some ability to habituate to light disturbances.	**Negligible –** there is unlikely to be a significant impact from increased light levels to the Peregrine Falcon in the region.	• Possible dispersal from greatly enhanced levels of light, especially in roosting areas	**Moderate** – Although Peregrine Falcons are known to inhabit highly artificial environments (e.g. cities and power stations), the extent to which this species is affected by light is not well researched.
		Increased Noise	Near mine infrastructure and roads, especially near pits which is where blasting will occur.	Long-term (life of mine)	**Low –** The Peregrine Falcon is known to sometimes occur around human habitation and activities where there are enhanced levels of noise (e.g. high-rise buildings in some Australian capital cities and power stations) and therefore has some ability to habituate to noise disturbances.	**Negligible –** there is unlikely to be a significant impact from increased noise to the Peregrine Falcon in the region.	• Possible dispersal from greatly enhanced levels of noise	**Moderate** – Although Peregrine Falcons are known to inhabit highly artificial environments (e.g. cities and power stations), the extent to which this species is affected by noise is not well researched.
		Dust	Predominantly concentrated near dust-generating activities such as pit blasting and in close proximity to haul roads.	Long-term (life of mine)	**Low** – The impact of dust from mines has not been well-studied for the Peregrine Falcon. Some degradation of foraging habitat is likely to occur. Iron ore dust is considered typically benign (Breathsafe, 2020).	**Negligible –** Increased levels of dust are not expected to affect individuals outside of the Study Area.	• Disruption to foraging behaviours • Alteration/degradation of habitat	**Moderate** – the impact of dust on individuals and foraging habitat is not well-studied for the Peregrine Falcon.
		Altered Fire Regimes	Extent of disturbance from altered fire regime in foraging and roosting areas	Long-term (life of mine)	**Low –** Frequent fire may impact the quality of foraging habitat available to the species.	**Low –** Fires inadvertently started in the Study Area may potentially escape and burn beyond of the boundary and subsequently impact on populations in the surrounding region. However, this would probably be a rare occurrence given the control measures that would be expected to be in place as part of the Project.	• Potential loss of nestling individuals from direct mortality • Possible loss of prey items	**Low** – The species response to fire and changes to fire regimes is not well researched.

Species	Likelihood of occurrence	Impact source	Impact					
			Extent	Duration	Magnitude (Local)	Magnitude (Regional)	Potential consequence of impact	Certainty (Level of Confidence)
		Modification of Water Regimes	Extent of existing and future water sources	Long term (life of mine)	**Low –** Within the Pilbara the species is most often recorded foraging at Drainage Lines with large Eucalypts (Schoenjahn, 2018); therefore, modification to existing water regimes and water quality from mining activities may impact suitable habitat within the Study Area.	**Negligible –** there is unlikely to be a significant impact from altered water regimes to the Peregrine Falcon in the region.	• Changes to foraging/ dispersal/ habitat within Major Drainage Lines • Displacement of individuals	**Moderate** – The degree to which habitats within the Study Area will be impacted by altered water regimes is relatively unknown, though is expected to be minimal.
Western Pebble-mound Mouse *Pseudomys chapmani* **DBCA Priority** Priority 4	Confirmed (Biologic, 2019c)	Removal, Fragmentation or Modification of Habitat	Extent of clearing/ habitat modification of core habitat (Low Stony Hills but will also use Stony Plain)	Permanent / long term (life of mine)	**Low –** Individuals within mounds are known to have small "core" home ranges (0.29-0.93 ha), and do not use secondary mounds, indicating that they are utilising a patchy food resource (Anstee ***et al.***, 1997). Therefore, although the species occupies the habitat type of greatest extent in the Study Area (Low Stony Hills), they may not utilise the whole of this habitat type, occupying resource rich niches, and local disturbance may be significant. Given the Western Pebble-mound Mouse is a habitat specialist, the individuals within the Study Area are likely to be negatively impacted by any ground disturbances on a local level. However, clearing for roads is unlikely to cause a barrier to movement between local populations, as small rodents are known to readily cross roads and use culverts (Queensland Department of Main Roads, 2000).	**Low –** The distribution of the species is strikingly fragmented by unsuitable plains and it is unlikely that the species can disperse across substantial barriers within the region (Ford & Johnson, 2007). However, the species and its core habitat are widespread in the local region and throughout the Pilbara, and despite the smaller body size (which limits long-distance dispersal) (Whitmee & Orme, 2013), only minor or no impacts at a regional scale are expected.	• Loss/displacement of individuals during vegetation clearing and mining developments • Loss of core habitat • Reduction in population size • Increase in population isolation	**High** – there are multiple records of the Western Pebble-mound Mouse within the Study Area, and a portion of its core habitat would be impacted by the Project. Therefore, there is a high degree of certainty that habitat loss/modification will occur for this species.
		Vehicle Strike	Extent of expansion of existing road and track network	Long-term (life of mine)	**Low –** the species has multiple records within the Study Area and, as a rodent, has a high fecundity and "boom-bust" life-mode which enables populations to recover from individual deaths (Start ***et al.***, 2000).	**Negligible –** Although the Project will increase vehicle traffic generally in the region, and thus increase the likelihood of roadkill, the number of individuals affected regionally is not considered significant.	• Direct loss of individuals • Reduction in population size	**Moderate** – may be unrecorded deaths from vehicular collisions within the Study Area.
		Introduced Species	Predominantly in and around disturbed areas	Permanent	**Low –** Feral predators (e.g. cats, foxes, dogs *etc*) are considered likely to occur in greater numbers near areas of human settlement and roads/tracks (Andrews, 1990; Brown ***et al.***, 2006; Denny ***et al.***, 2002; Eco Logical, 2015; Lach & Thomas, 2008; Mahon ***et al.***, 1998). Predation by these species is likely to be a contributing factor to the decline of the species. However, this threat will be actively managed for the life of the Project.	**Low –** There is unlikely to be a significant increase in regional predation due to the Project.	• Loss of individuals from predation • Reduction in population size • Alteration/degradation of habitat	**Moderate** – Predators such as feral cats and foxes are unlikely to significantly increase with suitable monitoring and management.
		Increased Light	Predominantly concentrated near pits and other mining infrastructure that will be used at night when required.	Long-term (life of mine)	**Low –** The species is quite adaptable and may acclimatise to certain disturbances, such as artificial light as evident from active mounds observed adjacent to exploration camps (e.g. M. O'Connell, ***pers. obs.***).	**Negligible –** Increased light will not affect individuals outside of the Study Area.	• Possible dispersal from greatly enhanced levels of light • Changes to prey distribution	**Moderate** – species is known to tolerate a small amount of disturbance.
		Increased Noise	Near mine infrastructure and roads, especially near pits which is where blasting will occur.	Long-term (life of mine)	**Low –** The species is quite adaptable and may acclimatise to certain disturbances, such as noise as evident from active mounds observed adjacent to exploration camps (e.g. M. O'Connell, ***pers. obs.***).	**Negligible –** Increased noise will not affect individuals outside of the Study Area.	• Possible dispersal from greatly enhanced levels of noise	**Moderate** – species is known to tolerate a small amount of disturbance.
		Dust	Predominantly concentrated near dust-generating activities such as pit blasting and in close proximity to haul roads.	Long-term (life of mine)	**Low** – The impact of dust from mines has not been studied for the Western Pebble-mound Mouse. Some degradation of foraging habitat is likely to occur. Iron ore dust is considered typically benign (Breathsafe, 2020).	**Negligible –** Increased levels of dust are not expected to affect individuals outside of the Study Area.	• Temporary disruption to foraging behaviours • Alteration/degradation of habitat	**Moderate** – the impact of dust on individuals and foraging habitat is not well studied for the Western Pebble-mound Mouse.
		Altered Fire Regimes	Extent of disturbance from fire in core habitat areas	Long-term (life of mine)	**Low –** Western Pebble-Mound Mice persist in their core spinifex habitats, and mounds are still actively tended, after fires have removed surrounding vegetation (Start ***et al.***, 2000). Populations can retain density well in the initial post-fire period (Start ***et al.***, 2000).	**Low –** The Western Pebble-Mound Mouse has persisted in more fire-prone habitats, and it is noted as unlikely that fire has been a significant, causative factor in their decline (Start ***et al.***, 2000). Fires inadvertently started in the Study Area may potentially escape and burn beyond of the boundary and subsequently impact on the suitability of habitat in the surrounding region.	• Loss of individuals from direct mortality, and increased predation from loss of habitat cover • Loss of habitat cover (i.e. mature spinifex)	**Moderate** – The species is known to persist or recover well post-fire.
		Modification of Water Regimes	Extent of existing and future water sources	Long term (life of mine)	**Negligible –** there is unlikely to be a significant impact from altered water regimes to the species.	**Negligible –** there is unlikely to be a significant impact from altered water regimes to the species.	• Nil	**High** – Unlikely that habitats utilised by the species will be impacted by altered water regimes.
Species considered likely to occur within the Study Area								

Species	Likelihood of occurrence	Impact source	Impact					
			Extent	Duration	Magnitude (Local)	Magnitude (Regional)	Potential consequence of impact	Certainty (Level of Confidence)
Pilbara Olive Python *Liasis olivaceus barroni* **EPBC Act** Vulnerable **BC Act** Vulnerable	Likely	Removal, Fragmentation or Modification of Habitat	Extent of clearing in core habitat (Major Drainage Line, Gorge/Gully and Hillcrest/Hillslope)	Permanent / long term (life of mine)	**Moderate –** Although previously recorded multiple times approximately 11 km southwest of the Study Area (DBCA, 2019a), no evidence of the Pilbara Olive Python was recorded during the survey undertaken by Biologic (2019c). Nonetheless, potential foraging and dispersal habitat (Major Drainage Line, Gorge/Gully and Hillcrest/Hillslope) of the Pilbara Olive Python is likely to partially removed as part of the Project. Destruction of habitat is an identified threat to the species (TSSC, 2008b). Pilbara Olive Python may disperse over roads but drains and pits will represent barriers to movement so a degree of partial fragmentation of habitat may occur due to the Project.	**Low –** The species is known to be widespread in the surrounding region, and the preferred habitat for this species extends well outside the Study Area. Although males occupy a distinct home range, travelling up to 4 km during breeding season to locate females (Pearson, 2006), only minor impacts at a regional scale are expected.	• Loss/displacement of individuals during vegetation clearing and mining developments • Loss of foraging/ dispersal/ denning habitat • Reduction in population size • Increase in population isolation	**Moderate** – Some level of habitat disturbance appears to be tolerated by the Pilbara Olive Python. Numerous nearby records exist, and Pilbara Olive Pythons are a large species with higher dispersal capabilities and home ranges (Pearson, 2006; Tutt, 2004).
		Vehicle Strike	Extent of expansion of existing road and track network	Long-term (life of mine)	**Low –** Deliberate road kills, associated with increased road traffic from tourism and industry, are a listed threat for the species (TSSC, 2008b). The species is slow-moving, and many have died on roads due to a natural instinct to remain still in response to the vibrations of an approaching vehicle (Pearson, 2006). Although the existing haul road is intended to be used, other access tracks will be developed. In addition, actual road usage in general will increase substantially during the development and operation of the mine.	**Low –** The Project will contribute to increasing vehicular traffic in the region. Subsequently the likelihood of Pilbara Olive Pythons being struck by vehicles will also increase, however, the number of individuals affected regionally is expected to be low.	• Loss of individuals • Reduction in population size	**Moderate** – Vehicle strike is a well recorded threat for the species, and there may be unrecorded deaths from vehicular collisions within the Study Area.
		Introduced Species	Predominantly in and around disturbed areas	Permanent	**Low –** Predation by introduced species (cats, foxes, dogs), particularly on juveniles, is identified as a major threat (TSSC, 2008b). Predation by cats, foxes and dogs on the prey that the Pilbara Olive Python relies upon as a food source is also a threat (Ellis, 2013). Feral predators are considered likely to occur in greater numbers near areas of human settlement and roads/tracks (Andrews, 1990; Brown *et al.*, 2006; Lach & Thomas, 2008; Mahon *et al.*, 1998) Although the Cane Toad does not yet inhabit the Study Area, it is possible that it might invade the Study Area during the life of the Project. The impacts of Cane Toads on Pilbara Olive Pythons are not yet well known.	**Low –** The presence of introduced predators and invasive weeds may be exacerbated locally by the Project, however, there is unlikely to be a significant increase in regional predation due to the Project.	• Direct loss of individuals • Reduction in population size • Loss of prey items • Alteration/degradation of habitat	**Moderate** – predation by introduced species has been well recorded for the Pilbara Olive Python. Further research is required to determine the impact of Cane Toads on the Pilbara Olive Python.
		Increased Light	Predominantly concentrated near pits and other mining infrastructure that will be used at night when required.	Long term (life of mine)	**Low** - The extent to which the Pilbara Olive Python is affected by increased levels of light is not well understood, however, the main impact of light generated by the Project is likely to be possible dispersal from greatly enhanced levels of light and changes to prey distribution.	**Negligible –** there is unlikely to be a significant impact from increased light levels to the Pilbara Olive Python in the broader region.	• Possible dispersal from greatly enhanced levels of light • Changes to prey distribution	**Low** - The extent to which the species may be affected by increased levels of light is not well understood.
		Increased Noise	Near mine infrastructure and roads, especially near pits which is where blasting will occur.	Long term (life of mine)	**Low** - Although they lack eardrums, snakes possess inner ears which are able to pick up not only ground-borne vibrations but low frequency airborne sounds. Pilbara Olive Pythons disturbed by noise generated by the Project are likely to disperse from greatly enhanced levels of noise. Their ability to habituate to noise is not well known.	**Negligible –** there is unlikely to be a significant impact from increased noise levels to the Pilbara Olive Python in the broader region.	• Possible dispersal from greatly enhanced levels of noise	**Low** - The extent to which the species may be affected by increased levels of noise is not well understood.
		Dust	Predominantly concentrated near dust-generating activities such as pit blasting and in close proximity to haul roads.	Long term (life of mine)	**Low** - The extent to which the Pilbara Olive Python is affected by increased levels of dust is not well understood, however, the main impact of dust generated by the Project is likely to be the alteration/degradation of habitat.	**Negligible –** Increased levels of dust are not expected to affect individuals outside of the Study Area.	• Temporary disruption to foraging behaviours • Alteration/degradation of habitat	**Low** - The extent to which the species may be affected by increased levels of dust is not well understood.
		Altered Fire Regimes	Extent of disturbance from fire in foraging/ denning areas	Long term (life of mine)	**Low –** The most detrimental local impact of fire on the species is likely to be through consequential changes in habitat structure and floristics, and loss of prey items. Individuals are mobile, and dispersal habitat will not be removed by the Project, allowing individuals movement across the Study Area.	**Low –** the season, frequency and extent of fires across the Pilbara may play a key role in influencing the availability of habitat suitable for the Pilbara Olive Python in the region. Fires inadvertently started in the Study Area may potentially escape and burn beyond of the boundary and subsequently impact on the suitability of habitat in the surrounding region. However, this would probably be a rare occurrence given the control measures that would be expected to be in place as part of the Project.	• Loss of individuals from direct mortality • Increased vulnerability to predation due to loss of habitat cover • Loss of foraging/ dispersal/ denning habitat • Possible loss of prey items	**Low** - the response of species to changes in fire regimes is largely unknown and difficult to predict due to lack of data for season, frequency and extent of fires across the Pilbara, all of which may play a key role in influencing Pilbara Olive Python habitat suitability in the Pilbara bioregion

Species	Likelihood of occurrence	Impact source	Impact					
			Extent	Duration	Magnitude (Local)	Magnitude (Regional)	Potential consequence of impact	Certainty (Level of Confidence)
		Modification of Water Regimes	Extent of existing and future water sources	Long term (life of mine)	**Moderate –** Waterholes and sources are an important feature of Pilbara Olive Python core habitat in the Pilbara (Pearson, 2006). They have been observed to use artificial water sources, such as sewage treatment ponds and recreational lakes, along with overburden heaps and railway embankment (Pearson, 2006). Any alterations to surface water flows into natural water features may impact upon the species ability to forage in the Study Area	**Low –** Sources of permanent water are of high ecological value in the Pilbara (Carwardine ***et al.***, 2014); however changes to water quality or regimes from the Project is unlikely to have an impact on regional populations.	• Loss of foraging/ dispersal/ denning habitat • Loss of prey items utilizing water sources	**Moderate** - Habitat quality is strongly influenced by the presence of water sources (Pearson, 2006), and so alteration of existing water sources in the vicinity, or creation of new sources, is likely to influence the species.
Black-lined Ctenotus *Ctenotus nigrilineatus* **DBCA Priority** Priority 1	Likely	Removal, Fragmentation or Modification of Habitat	Extent of clearing on core habitat (Sand Plain and Stony Plain)	Permanent	**Low** – Habitat preferences for the Black-lined Ctenotus is not well-known. Previous records have, however, been collected from spinifex plains at the base of granite outcrops (How & Dell, 2004; WAM ***et al.***, 1991). This species is likely to occur within the Study Area as a resident within suitably vegetated areas in Sand Plain and Stony Plain habitat, which will be impacted by the Project. Despite extensive surveys it has very rarely been recorded (Craig, 2017). The closest record of Black-lined Ctenotus is located ~15 km southwest of the Study Area from 2018 (DBCA, 2019a). Any diggings (trenches etc.) are likely to provide barriers for movement for this small species.	**Low –** Little information is known about the distribution of the species. Minor or no impacts at a regional scale are expected.	• Loss/displacement of individuals during vegetation clearing and mining developments	**Low** – Little ecological information is known about the species (including habitat preferences) and there are very few records of the species.
		Vehicle Strike	Extent of expansion of existing road and track network	Long term (life of mine)	**Low –** Although the existing haul road is intended to be used, other access tracks will be developed. In addition, actual road usage in general will increase substantially during the development and operation of the mine. Subsequently the likelihood of the Black-lined Ctenotus (if it is present in the Study Area) being struck by vehicles will also increase, however, the number of individuals affected locally is expected to be low.	**Low –** The Project will contribute to increasing vehicular traffic in the region. Subsequently the likelihood of the Black-lined Ctenotus being struck by vehicles will also increase, however, the number of individuals affected regionally is expected to be low.	• Loss of individuals • Reduction in population size	**Moderate** – there may be unrecorded deaths from vehicular strikes within the Study Area
		Introduced Species	Predominantly in and around disturbed areas	Permanent	**Low –** Buffel grass is noted as threat for other threatened Ctenotus species through alteration of habitat structure and increasing fire hazard (TSSC, 2008a), and the weed has been recorded within the Study Area previously. Individuals of the species are likely to be preyed upon by introduced predators such as cats and foxes.	**Low –** There is unlikely to be a significant increase in predation at a regional level from the Project.	• Loss of individuals from predation • Reduction in population size • Alteration/degradation of habitat, including increases to fuel load	**Low** – the cause of the species decline is not well defined, and assumed to be from a range of impact sources, including predation (Crowley, 2008).
		Increased Light	Predominantly concentrated near pits and other mining infrastructure that will be used at night when required.	Long term (life of mine)	**Low** – The extent to which the Black-lined Ctenotus is affected by increased levels of light is not well understood, however, the main impact of light generated by the Project is likely to be possible dispersal from greatly enhanced levels of light and changes to prey distribution.	**Negligible –** there is unlikely to be a significant impact from increased light levels to the Black-lined Ctenotus in the broader region.	• Possible dispersal from greatly enhanced levels of light • Changes to prey distribution	**Low** - The extent to which the species may be affected by increased levels of light is not well understood.

Species	Likelihood of occurrence	Impact source	Impact					
			Extent	Duration	Magnitude (Local)	Magnitude (Regional)	Potential consequence of impact	Certainty (Level of Confidence)
		Increased Noise	Near mine infrastructure and roads, especially near pits which is where blasting will occur.	Long term (life of mine)	**Low** – Lab-based research of the effects of acute exposure to mining machinery noise on the behaviour of a different species of lizard demonstrated negative effects on the lizards' behaviour and welfare (Mancera ***et al.***, 2017). The effect of elevated levels of noise on the Black-lined Ctenotus is unknown. It is probable that this species would react to sudden, loud noises (e.g. from blasting) by at least temporarily retreating to a refuge or dispersing.	**Negligible** – there is unlikely to be a significant impact from increased noise levels to the Black-lined Ctenotus in the broader region.	• Possible dispersal from greatly enhanced levels of noise	**Low** - The extent to which the species may be affected by increased levels of noise is not well understood.
		Dust	Predominantly concentrated near dust-generating activities such as pit blasting and in close proximity to haul roads.	Long term (life of mine)	**Low** – The extent to which the Black-lined Ctenotus is affected by increased levels of dust is not well understood, however, the main impact of dust generated by the Project is likely to be the alteration/degradation of habitat.	**Negligible** – Increased levels of dust are not expected to affect individuals outside of the Study Area.	• Temporary disruption to foraging behaviours • Alteration/degradation of habitat	**Low** - The extent to which the species may be affected by increased levels of dust is not well understood.
		Altered Fire Regimes	Extent of disturbance from fire in core habitat areas	Long term (life of mine)	**Low** – Chapple et al. (2019) lists fire as a possible threat. The most detrimental local impact of fire on the species is likely to be through consequential changes in habitat structure and floristics, and loss of prey items.	**Low** – Fires inadvertently started in the Study Area may potentially escape and burn beyond of the boundary and subsequently impact on the suitability of habitat in the surrounding region. However, this would probably be a rare occurrence given the control measures that would be expected to be in place as part of the Project.	• Loss of individuals from direct mortality • Increased vulnerability to predation due to loss of habitat cover • Loss of foraging/ dispersal/ denning habitat • Possible loss of prey items	**Low** – The species response to fire and changes to fire regimes is not researched.
		Modification of Water Regimes	Extent of existing and future water sources	Long term (life of mine)	**Negligible** – there is unlikely to be a significant impact from altered water regimes to the species.	**Negligible** – there is unlikely to be a significant impact from altered water regimes to the species.	• Nil	**High** – Unlikely that habitats utilised by the species will be impacted by altered water regimes.
<u>Gane's Blind Snake</u> *Anilios ganei* **DBCA Priority** Priority 1	Likely	Removal, Fragmentation or Modification of Habitat	Extent of clearing on suitable habitats (predominantly Gorge/Gully and Major Drainage Line).	Permanent	**Low** – Gane's Blind Snake has been recorded form gorges and gullies within rocky habitats but may also be present in mulga and stony habitats (Mitchell ***et al.***, 2019). This species is likely to occur within the Study Area as a resident within suitable habitat (e.g. containing leaf litter) in Gorge/Gully, and/or Major Drainage Line habitats, which will be partially impacted by the Project.	**Low** – The species has fairly widespread distribution in the surrounding region (Mitchell ***et al.***, 2019), and the preferred habitat for this species extends well outside the Study Area. Only minor impacts at a regional scale are expected.	• Loss/displacement of individuals during vegetation clearing and mining developments • Loss of foraging/ dispersal habitat • Reduction in population size • Increase in population isolation	**Moderate** – Little ecological information is known about the species. Abundance is not well known (Mitchell ***et al.***, 2019).

Species	Likelihood of occurrence	Impact source	Impact					
			Extent	Duration	Magnitude (Local)	Magnitude (Regional)	Potential consequence of impact	Certainty (Level of Confidence)
		Vehicle Strike	Extent of expansion of existing road and track network	Long term (life of mine)	**Negligible** – It is not known whether this species would attempt to cross a road, but it is considered unlikely.	**Negligible** – there is unlikely to be a significant impact to this species due to vehicle strike in the region.	• Unknown - it is not known whether this species would attempt to cross a road, but it is considered unlikely.	**Data deficient** – Little ecological information is known about the species. It is not known whether this species would attempt to cross a road. Unreported incidents of vehicle strike may exist.
		Introduced Species	Predominantly in and around disturbed areas	Permanent	**Low** – Individuals of the species are likely to be preyed upon by introduced predators such as cats and foxes, however, this has not been researched.	**Low** – There is unlikely to be a significant increase in predation at a regional level from the Project.	• Loss of individuals from predation • Reduction in population size	**Data deficient** – Little ecological information is known about the species.
		Increased Light	Predominantly concentrated near pits and other mining infrastructure that will be used at night when required.	Long term (life of mine)	**Low** – Blind snakes have small, dark spots for eyes which are thought to probably only sense light and dark. Blind snakes also spend most of their time within burrows or under leaf litter and come to the surface infrequently, always at night and predominantly after rain (Cogger, 2014). It is not known whether increased lights due to the Project would affect to the Gane's Blind Snake, should this species be present.	**Negligible** – there is unlikely to be a significant impact from increased light levels to the Gane's Blind Snake in the broader region.	• Possible dispersal from greatly enhanced levels of light	**Low** - The extent to which the species may be affected by increased levels of light is not understood.
		Increased Noise	Near mine infrastructure and roads, especially near pits which is where blasting will occur.	Long term (life of mine)	**Low** – The extent to which the species may be affected by increased levels of noise is not understood.	**Negligible** – there is unlikely to be a significant impact from increased noise levels to the Gane's Blind Snake in the broader region.	• Possible dispersal from greatly enhanced levels of noise	**Low** - The extent to which the species may be affected by increased levels of noise is not understood.
		Dust	Predominantly concentrated near dust-generating activities such as pit blasting and in close proximity to haul roads.	Long term (life of mine)	**Low** – The extent to which the species may be affected by dust is not understood. However, the main impact of dust generated by the Project is likely to be the alteration/degradation of habitat.	**Negligible** – Increased levels of dust are not expected to affect individuals outside of the Study Area.	• Alteration/degradation of habitat	**Low** - The extent to which the species may be affected by increased levels of dust is not well understood.

Species	Likelihood of occurrence	Impact source	Impact					
			Extent	Duration	Magnitude (Local)	Magnitude (Regional)	Potential consequence of impact	Certainty (Level of Confidence)
		Altered Fire Regimes	Extent of disturbance from fire in core habitat areas	Long term (life of mine)	**Low** – The most detrimental local impact of fire on the species is likely to be through consequential changes in habitat structure and increased vulnerability to predation.	**Low** – Fires inadvertently started in the Study Area may potentially escape and burn beyond the boundary and subsequently impact on the suitability of habitat in the surrounding region. However, this would probably be a rare occurrence given the control measures that would be expected to be in place as part of the Project.	• Loss of individuals from direct mortality • Increased vulnerability to predation due to loss of habitat cover • Loss of foraging/ dispersal/ denning habitat • Possible loss of prey items	**Low** – The species response to fire and changes to fire regimes is not researched.
		Modification of Water Regimes	Extent of existing and future water sources	Long term (life of mine)	**Negligible** – there is unlikely to be a significant impact from altered water regimes to the species.	**Negligible** – there is unlikely to be a significant impact from altered water regimes to the species.	• Nil	**High** – Unlikely that habitats utilised by the species will be impacted by altered water regimes.
<u>Brush-tailed Mulgara</u> (*Dasycercus blythi*) **DBCA Priority** Priority 4	Likely	Removal, Fragmentation or Modification of Habitat	Extent of clearing on core habitat (primarily Sand Plain)	Permanent	**Low** – Mulgara have a low propensity for dispersal once a home range has been established, with high site fidelity recorded (Masters, 2003; Thompson & Thompson, 2007). There is only one habitat type considered highly suitable to support the Brush-tailed Mulgara within the Study Area (Sand Plain). Although disturbance would occur due to the Project within this habitat type, studies have suggested that the species can tolerate a moderate local reduction in cover (to 15 %) of its preferred habitat (Masters ***et al.***, 2003).	**Low** – The preferred habitat for this species extends well outside the Study Area, and the species is widespread in a regional context. Hence, low impacts at a regional scale are expected.	• Loss/displacement of individuals during vegetation clearing and mining developments • Loss of foraging/ burrowing habitat • Reduction in population size • Increase in population isolation	**High** – It is known that Mulgara do not disperse readily, and this species was not recorded within the Study Area. The preferred habitat type is likely to be impacted through planned disturbance; however the species can tolerate a **Moderate** local reduction in cover of its preferred habitat (Masters ***et al.***, 2003).
		Vehicle Strike	Extent of expansion of existing road and track network	Long-term (life of mine)	**Low** – There is the possibility of vehicle strike to Mulgara within the Study Area (if there is a population present despite the lack of records). However, the probability is likely low and the ability for the population to recover is likely high.	**Low** – Although the Project will increase vehicle traffic generally in the region, and thus increase the likelihood of roadkill, the number of individuals affected regionally will be low.	• Direct loss of individuals • Reduction in population size	**Low** – there may be unrecorded deaths from vehicular collisions within the Study Area.
		Introduced Species	Predominantly in and around disturbed areas	Permanent	**Low** – Brush-tailed Mulgara is preyed upon by feral predators (e.g. cats, foxes, dogs etc.) (Woinarski ***et al.***, 2014, 2015). Feral predators are considered likely to occur in greater numbers near areas of human settlement and roads/tracks (Denny ***et al.***, 2002; Eco Logical, 2015). Introduced grazers such as cattle have been found to favour dune swales as "alleyways", and mammal diversity in habitat types suitable to support Mulgara is lower in areas grazed by cattle (Frank ***et al.***, 2008). The combination of threat from both grazers and introduced predators poses a Moderate risk to the species.	**Low** – although predation by introduced species is recorded as one of most significant threats to Brush-tailed Mulgara, there is unlikely to be a significant increase in regional predation from the Project.	• Direct loss of individuals • Reduction in population size • Degradation of foraging/ burrowing habitat by introduced grazers	**Moderate** – predation by introduced species is well recorded for the species.
		Increased Light	Predominantly concentrated near pits and other mining infrastructure that will be used at night when required.	Long term (life of mine)	**Negligible** – This species has not been recorded in the Study Area. Notwithstanding, if the species is present in the Study Area, it is likely to be present in low densities and in areas away from the proposed infrastructure and any associated increased levels of light.	**Negligible** – there is unlikely to be a significant impact to this species in the broader region due to increased light levels.	• Possible dispersal from greatly enhanced levels of light, if present.	**Low** - The extent to which the species may be affected by increased levels of light is not well understood.

Species	Likelihood of occurrence	Impact source	Impact					
			Extent	Duration	Magnitude (Local)	Magnitude (Regional)	Potential consequence of impact	Certainty (Level of Confidence)
		Increased Noise	Near mine infrastructure and roads, especially near pits which is where blasting will occur.	Long term (life of mine)	**Negligible** – This species has not been recorded in the Study Area. Notwithstanding, if the species is present in the Study Area, it is likely to be present in low densities and in areas away from the proposed infrastructure and any associated increased levels of noise.	**Negligible** – there is unlikely to be a significant impact to this species in the broader region due to increased noise levels.	• Possible dispersal from greatly enhanced levels of noise, if present.	**Low** - The extent to which the species may be affected by increased levels of noise is not well understood.
		Dust	Predominantly concentrated near dust-generating activities such as pit blasting and in close proximity to haul roads.	Long term (life of mine)	**Negligible** – This species has not been recorded in the Study Area. Notwithstanding, if the species is present in the Study Area, it is likely to be present in low densities and in areas away from the proposed infrastructure and any associated increased levels of dust.	**Negligible** – Increased levels of dust are not expected to affect individuals outside of the Study Area.	• Alteration/degradation of habitat	**Low** - The extent to which the species may be affected by dust is not well understood.
		Altered Fire Regimes	Extent of disturbance from fire in foraging/ burrowing areas	Long term (life of mine)	**Low –** Fire can have a significant effect on Mulgara populations by loss of individuals and prey items (Masters ***et al.***, 2003). Mulgara are vulnerable to changes in vegetation cover through removal or fire, preferring a habitat mosaic that includes patchiness in cover and mature Spinifex hummocks, although they will continue to use burnt areas (Körtner ***et al.***, 2007). Mulgaras are also subjected to increased predation risk after removal of mature spinifex cover following fire (Körtner ***et al.***, 2007).	**Low** – The impact of fire on regional Brush-tailed Mulgara populations is likely to be influenced by the season, frequency, extent and severity of fires. Fires inadvertently started in the Study Area may potentially escape and burn beyond the boundary and subsequently impact on the suitability of habitat in the surrounding region. However, this would probably be a rare occurrence given the control measures that would be expected to be in place as part of the Project.	• Direct mortality from fire events • Loss of prey items (invertebrates and rodents) • Loss of foraging/ burrowing habitat • Loss of individuals from increased post-fire predation	**Moderate** – although the impacts of fire on a local scale, such as habitat removal and loss of prey items, have been studied (Körtner ***et al.***, 2007; Masters ***et al.***, 2003), there is a need for more certainty on the impact of fire on Mulgara on a regional level.
		Modification of Water Regimes	Extent of existing and future water sources	Long term (life of mine)	**Negligible** – there is unlikely to be a significant impact from altered water regimes to the species.	**Negligible** – there is unlikely to be a significant impact from altered water regimes to the species.	• Nil	**High** – Unlikely that habitats utilised by the species will be impacted by altered water regimes.
<u>Spectacled Hare-wallaby</u> (*Lagorchestes conspicillatus leichardti*) **DBCA Priority** Priority 3	Likely	Removal, Fragmentation or Modification of Habitat	Extent of clearing/ barrier to movement on core habitat (primarily Sandplain and Stony Plain)	Permanent	**Moderate** – there are no records within the Study Area, however, habitat suitable for the Spectacled Hare-wallaby will be removed by the Project (i.e. Sand Plain and Stony Plain habitats). There is connectivity to similar habitat outside the boundary. It is larger species with higher dispersal capabilities, thus would be able to move away from disturbances.	**Low** – Little is known of the regional distribution of this species; however, it is unlikely that any local impacts of the Project would manifest at a regional scale.	• Loss/displacement of individuals during vegetation clearing and mining developments • Loss of core habitat (Sand Plain and Stony Plain)	**Moderate** – The species is highly unlikely to experience significant loss of core habitat, and as a medium sized mammal the species is likely to be able to overcome local barriers to movement
		Vehicle Strike	Extent of expansion of existing road and track network	Long-term (life of mine)	**Low** – The Spectacled Hare-wallaby is more active at night, when it forages on shrubs, grasses, and herbs (Ingleby & Westoby, 1992). This reduces the likelihood of collisions with vehicles because vehicles associated with the Project will be less active at night.	**Low** – Although the Project will increase vehicle traffic generally in the region, and thus increase the likelihood of roadkill, the number of individuals affected regionally is not considered significant.	• Direct loss of individuals • Reduction in population size	**Moderate** – there may be unrecorded deaths from vehicular collisions within the Study Area.
		Introduced Species	Predominantly in and around disturbed areas	Permanent	**Low –** Significant threats to the species include predators and impacts to core habitat from grazing (Woinarski ***et al.***, 2014). Feral cats are thought to be responsible for the local extinction of the Spectacled Hare-wallaby on nearby Montebello Islands (Burbidge & Johnson, 1995).	**Low –** although predation by introduced species is recorded as one of most significant threats to the species, there is unlikely to be a significant increase in predation due to the Project in the broader region.	• Loss of individuals from predation • Reduction in population size • Alteration/degradation of habitat from grazers	**Moderate** – predation by introduced species is thought to have been responsible for the local extinction of the Spectacled Hare-wallaby on nearby Montebello Islands (Burbidge & Johnson, 1995).
		Increased Light	Predominantly concentrated near pits and other mining infrastructure that will be used at night when required.	Long term (life of mine)	**Negligible** – This species has not been recorded in the Study Area. Notwithstanding, if the species is present in the Study Area, it is likely to be present in low densities and in areas away from the proposed infrastructure and any associated increased levels of light.	**Negligible** – there is unlikely to be a significant impact to this species in the broader region due to increased light levels.	• Possible dispersal from greatly enhanced levels of light, if present.	**Low** - The extent to which the species may be affected by increased levels of light is not well understood.
		Increased Noise	Near mine infrastructure and roads, especially near pits which is where blasting will occur.	Long term (life of mine)	**Negligible** – This species has not been recorded in the Study Area. Notwithstanding, if the species is present in the Study Area, it is likely to be present in low densities and in areas away from the proposed infrastructure and any associated increased levels of noise.	**Negligible** – there is unlikely to be a significant impact to this species in the broader region due to increased noise levels.	• Possible dispersal from greatly enhanced levels of noise, if present.	**Low** - The extent to which the species may be affected by increased levels of noise is not well understood.
		Dust	Predominantly concentrated near dust-generating activities such as pit blasting and in close proximity to haul roads.	Long term (life of mine)	**Negligible** – This species has not been recorded in the Study Area. Notwithstanding, if the species is present in the Study Area, it is likely to be present in low densities and in areas away from the proposed infrastructure and any associated increased levels of dust.	**Negligible** – Increased levels of dust are not expected to affect individuals outside of the Study Area.	• Disruption to foraging behaviours • Alteration/degradation of habitat	**Low** - The extent to which the species may be affected by dust is not well understood.

Species	Likelihood of occurrence	Impact source	Impact					
			Extent	Duration	Magnitude (Local)	Magnitude (Regional)	Potential consequence of impact	Certainty (Level of Confidence)
		Altered Fire Regimes	Extent of disturbance from fire in core habitat areas	Long term (life of mine)	**Moderate** – All sites occupied by the species have potentially suitable shelters (shrubs, grass tussocks or spinifex hummocks) within 50 m of the feeding areas (Ingleby & Westoby, 1992). Although the Spectacled Hare-wallaby may feed in areas regenerating after fire (Maxwell ***et al.***, 1996), frequent fires can decrease the suitability of the core habitats to provide shelter for the species.	**Low** – Fires inadvertently started in the Study Area may potentially escape and burn beyond the boundary and subsequently impact on the suitability of habitat in the surrounding region. However, this would probably be a rare occurrence given the control measures that would be expected to be in place as part of the Project.	• Loss of individuals from direct mortality, • Increased predation from loss of habitat cover • Loss of habitat cover (i.e. mature spinifex) • Change in food availability	**Moderate** – the species is known to require shelter in close proximity to feeding sites, and any increases in fire frequency or severity is likely to decrease the habitat suitability within the Study Area.
		Modification of Water Regimes	Extent of existing and future water sources	Long term (life of mine)	**Negligible** – there is unlikely to be a significant impact from altered water regimes to the species.	**Negligible** – there is unlikely to be a significant impact from altered water regimes to the species.	• Nil	**High** – Unlikely that habitats utilised by the species will be impacted by altered water regimes.
Species considered possible to occur within the Study Area								
<u>Night Parrot</u> *Pezoporus occidentalis* **EPBC Act** Endangered **BC Act** Critically Endangered	Possible	Removal, Fragmentation or Modification of Habitat	Extent of clearing on core habitat (patches of unburnt spinifex grassland vegetation within Stony Plain and Sand Plain habitats)	Long term (life of mine)	**Low** – the Night Parrot is a habitat specialist in old age spinifex on Sand and Stony plain with Acacia (DPaW, 2017). The Study Area contains Sand Plain and Stony Plain habitat. However, due to recent fires, suitable habitat for the Night Parrot would be limited to the remaining patches of unburnt spinifex grassland vegetation within Sand Plain and Stony Plain habitats. Despite targeted surveys, the species has not been recorded in the Study Area (Biologic, 2019c). Night Parrots are known to fly up to 100 km per night (Burbidge, 2016), and, if present, would be able to avoid the impacts of habitat removal or modification due to the Project.	**Low** – Habitat removal or modification due to the Project is unlikely to have a significant impact on the species at a regional level as the Project is unlikely to significantly fragment habitat for this species.	• Loss/displacement of individuals during vegetation clearing and mining developments	**Moderate** – The nearest contemporary record of the Night Parrot is from Minga Well, approximately 125 km south of the Study Area (Davis & Metcalf, 2008). It is difficult to determine whether the remaining patches of unburnt spinifex grassland vegetation within the Sand Plain and Stony Plain habitats could sustain the Night Parrot as a resident.
		Vehicle Strike	Extent of expansion of existing road and track network	Long term (life of mine)	**Low** – Published accounts of Night Parrot behaviour suggest that the Night Parrot may be prone to vehicle strikes. Hamilton ***et al.*** (2017) observed a bird crouching on a road, 1-1.5m from the road edge. The bird did not fly when approached but ran under a slow-moving vehicle. A second observation recorded a bird emerging from the base of a group of Eremophila shrubs, and the bird ran across the road (Hamilton ***et al.***, 2017). However, the species is rare and has not been previously recorded in the Study Area despite targeted sampling undertaken by Biologic (2019c) in suitable habitat for the Night Parrot using acoustic recorders.	**Low** – The Project will increase vehicle traffic generally in the region and thus increase the likelihood of roadkill. However, the number of individual Night Parrots that are likely to be affected by vehicle strike in the broader region due to the Project is likely to be low given that this species is very rarely recorded.	• Direct loss of individuals • Reduction in population size	**Moderate** – it is unlikely that there are unrecorded deaths from vehicular collisions within the Study Area.
		Introduced Species	Predominantly in and around disturbed areas	Permanent	**Low** – TSSC (2008c) lists numerous threats arising from introduced species including; predation by feral cats and foxes, competition for food and degradation of habitat by livestock and feral herbivores, reduced availability of water due to consumption by camels and livestock and habitat degradation by rabbits and goats. However, the Night Parrot has not been recorded in the Study Area despite targeted surveys.	**Low** – although predation by introduced species is recorded as one of most significant threats to the Night Parrot, there is unlikely to be a significant increase in predation regionally due to the Project as many of these introduced species are already present.	• Loss of individuals from predation • Reduction in population size • Alteration/degradation of habitat, including increases to fuel load	**Moderate** – the impact of introduced predators on the Night Parrot is not well documented although the threat is nonetheless regarded as a major threat likely to impact the species.
		Increased Light	Predominantly concentrated near pits and other mining infrastructure that will be used at night when required.	Long term (life of mine)	**Negligible** – This species has not been recorded in the Study Area. Notwithstanding, if the species is present in the Study Area, it is likely to be present in low densities and in areas away from the proposed infrastructure and any associated increased levels of light.	**Negligible** – there is unlikely to be a significant impact to this species in the broader region due to increased light levels.	• Possible dispersal from greatly enhanced levels of light, if present.	**Low** - The extent to which the species may be affected by increased levels of light is not well understood.
		Increased Noise	Near mine infrastructure and roads, especially near pits which is where blasting will occur.	Long term (life of mine)	**Negligible** – This species has not been recorded in the Study Area. Notwithstanding, if the species is present in the Study Area, it is likely to be present in low densities and in areas away from the proposed infrastructure and any associated increased levels of light.	**Negligible** – there is unlikely to be a significant impact to this species in the broader region due to increased noise levels.	• Possible dispersal from greatly enhanced levels of noise, if present.	**Low** - The extent to which the species may be affected by increased levels of noise is not well understood.
		Dust	Predominantly concentrated near dust-generating activities such as pit blasting and in close proximity to haul roads.	Long term (life of mine)	**Negligible** – This species has not been recorded in the Study Area. Notwithstanding, if the species is present in the Study Area, it is likely to be present in low densities and in areas away from the proposed infrastructure and any associated increased levels of light.	**Negligible** – Increased levels of dust are not expected to affect individuals outside of the Study Area.	• Disruption to foraging behaviours • Alteration/degradation of habitat	**Low** - The extent to which the species may be affected by dust is not well understood.

Species	Likelihood of occurrence	Impact source	Impact					
			Extent	Duration	Magnitude (Local)	Magnitude (Regional)	Potential consequence of impact	Certainty (Level of Confidence)
		Altered Fire Regimes	Extent of disturbance from fire in core habitat areas	Long term (life of mine)	**Low** – The core habitat of the species is old age spinifex (>50 years) (DPaW, 2017) so changes to regimes that increase fires will detrimentally affect core habitat and likelihood of species persistence (TSSC, 2008c). However, it is difficult to determine whether the remaining patches of unburnt spinifex grassland vegetation within the Sand Plain and Stony Plain habitats of the Study Area can sustain the Night Parrot as a resident. Furthermore, the Night Parrot has not been recorded in the Study Area despite targeted surveys.	**Low** – The season, frequency, extent and severity of fires are all likely to be key factors influencing the species. The nearest contemporary record of the Night Parrot is from Minga Well, approximately 125 km south of the Study Area (Davis & Metcalf, 2008). Fires inadvertently started in the Study Area may potentially escape and burn beyond of the boundary and subsequently impact on the suitability of habitat in the surrounding region. However, this would probably be a rare occurrence given the control measures that would be expected to be in place as part of the Project.	• Loss of individuals from direct mortality, and increased predation from loss of habitat cover • Loss of habitat cover (i.e. mature spinifex) • Possible loss of food items	**Moderate** – core foraging and roosting habitat is known to require spinifex of a certain age. Therefore, fire is a known impact to core habitat requirements of the species. However, the species' occurrence in the region is not well-known.
		Modification of Water Regimes	Extent of existing and future water sources	Long term (life of mine)	**Negligible** – there is unlikely to be a significant impact from altered water regimes to the species.	**Negligible** – there is unlikely to be a significant impact from altered water regimes to the species.	• Nil	**High** – Unlikely that habitats utilised by the species will be impacted by altered water regimes.
<u>Greater Bilby</u> (*Macrotis lagotis*) **EPBC Act** Vulnerable **BC Act** Vulnerable	Possible	Removal, Fragmentation or Modification of Habitat	Extent of clearing on core habitat (primarily Sand Plain but also potentially Stony Plain)	Long term (life of mine)	**Low** – the Greater Bilby is a habitat specialist in Sand Plain (and potentially Stony Plain) habitats. Greater Bilbies are semi-fossorial and nocturnal, remaining in their burrows during the day and intermittently during the night for rest and refuge. They occur naturally as scattered, solitary individuals or small groups (Smythe & Philpott, 1968; Southgate, 1990). The loss or modification of core habitat may have a potential impact on the ability of the Study Area to support a population. However, no evidence of the Greater Bilby was found in the Study Area.	**Low** – Greater Bilbies are recorded as having low site fidelity and high mobility (Southgate ***et al.***, 2007). Males regularly move three to five kilometres between burrows on consecutive days and have been recorded moving up to 15 km in a few weeks (Southgate & Possingham, 1995). This high mobility, together with low population density, ensures that the area of occupancy is often far less than the extent of occurrence, and the distribution is highly fragmented within the Pilbara bio-region (Friend ***et al.***, 2012). The Project is unlikely to affect Greater Bilbies in the broader region.	• Loss/displacement of individuals during vegetation clearing and mining developments • Loss of foraging/ burrowing habitat • Reduction in population size	**Moderate** – The Greater Bilby is a habitat specialist so the removal of core habitat would impact any individuals if present in the Study Area. However, the species is known to have low site fidelity and high mobility.
		Vehicle Strike	Extent of expansion of existing road and track network	Long term (life of mine)	**Low** - The Greater Bilby is nocturnal. This reduces the likelihood of collisions with vehicles because vehicles associated with the Project will be less active at night.	**Low** – Although the Project will increase vehicle traffic generally in the region, and thus increase the likelihood of roadkill, the number of individuals affected regionally is not considered significant.	• Direct loss of individuals • Reduction in population size	**Moderate** – there may be unrecorded deaths from vehicular collisions within the Study Area.
		Introduced Species	Predominantly in and around disturbed areas	Permanent	**Low** – predation by cats is assumed to be a major driving factor in the decline of bilbies. Foxes are also considered a significant threat (Bradley, 2015). However, introduced species (particularly cats and foxes) are unlikely to significantly increase with suitable monitoring and management. If present the species is likely to be represented by a low density or transient population.	**Low** – Although cats are a significant threat to the species, they do co-occur with the Greater Bilby across its extant range. Bilby distribution is associated with an absence or scarcity of grazers and rabbits, which often target areas of prime Greater Bilby habitat in the Pilbara (Bradley, 2015). Such threats are already present in the region and unlikely to be significantly exacerbated by the Project.	• Loss of individuals from predation • Reduction in population size • Alteration/degradation of habitat	**Moderate** - there is a need to improve the understanding of the threat posed by introduced predators and herbivores (Dziminski & Carpenter, 2017).
		Increased	Predominantly concentrated near pits and other mining infrastructure that will be used at night when required.	Long term (life of mine)	**Negligible** – This species has not been recorded in the Study Area. Notwithstanding, if the species is present in the Study Area, it is likely to be present in low densities and in areas away from the proposed infrastructure and any associated increased levels of light.	**Negligible** – there is unlikely to be a significant impact to this species in the broader region due to increased light levels.	• Possible dispersal from greatly enhanced levels of light, if present.	**Low** - The extent to which the species may be affected by increased levels of light is not well understood.
		Increased Noise	Near mine infrastructure and roads, especially near pits which is where blasting will occur.	Long term (life of mine)	**Negligible** – This species has not been recorded in the Study Area. Notwithstanding, if the species is present in the Study Area, it is likely to be present in low densities and in areas away from the proposed infrastructure and any associated increased levels of noise.	**Negligible** – there is unlikely to be a significant impact to this species in the broader region due to increased noise levels.	• Possible dispersal from greatly enhanced levels of noise, if present.	**Low** - The extent to which the species may be affected by increased levels of noise is not well understood.
		Dust	Predominantly concentrated near dust-generating activities such as pit blasting and in close proximity to haul roads.	Long term (life of mine)	**Negligible** – This species has not been recorded in the Study Area. Notwithstanding, if the species is present in the Study Area, it is likely to be present in low densities and in areas away from the proposed infrastructure and any associated increased levels of dust.	**Negligible** – Increased levels of dust are not expected to affect individuals outside of the Study Area.	• Disruption to foraging behaviours • Alteration/degradation of habitat	**Low** - The extent to which the species may be affected by dust is not well understood.

Species	Likelihood of occurrence	Impact source	Impact					
			Extent	Duration	Magnitude (Local)	Magnitude (Regional)	Potential consequence of impact	Certainty (Level of Confidence)
		Altered Fire Regimes	Extent of disturbance from fire in core habitat areas	Long term (life of mine)	**Low** – It is known that smaller and more frequent fire increase habitat and resource diversity for bilbies (Bradley, 2015). Recently burnt habitat (within the last 1-3 years) is included as a suitable habitat type for Greater Bilby (DBCA, 2017), due to promotion of a key food source (Bradley, 2015).	**Low** – the scale and frequency of fires in the region are not expected to increase significantly due to the Project. Greater Bilbies are recorded as responding well to recent fires, as well as persisting in areas of low fire frequency (e.g. Gibson Desert) (Bradley, 2015).	• Loss of individuals from direct mortality, and increased predation from loss of habitat cover • Temporary change in food items (in the absence of plant food availability, bilbies are more reliant on invertebrate food sources).	**Moderate** - There is a need to improve the understanding of how fire regimes affect Greater Bilbies (Dziminski & Carpenter, 2017). In particular, there is a lack of knowledge concerning both increases in efficiency of predation on bilbies following fire (from decreased vegetation cover) and high vegetation cover becoming impenetrable to bilbies from a lack of fire (Bradley, 2015).
		Modification of Water Regimes	Extent of existing and future water sources	Long term (life of mine)	**Negligible** – there is unlikely to be a significant impact from altered water regimes to the species.	**Negligible** – there is unlikely to be a significant impact from altered water regimes to the species.	• Nil	**High** – Unlikely that habitats utilised by the species will be impacted by altered water regimes.
Spotted Ctenotus *Ctenotus uber johnstonei* **DBCA Priority** Priority 2	Possible	Removal, Fragmentation or Modification of Habitat	Extent of clearing on core habitat (Sand Plain)	Permanent	**Low** - The loss or modification of core habitat may have a potential impact on the ability of the Study Area to support a population. However, no evidence of the Spotted Ctenotus was found in the Study Area.	**Low** – Little information is known about the distribution of the species. Minor or no impacts at a regional scale are expected.	• Loss/displacement of individuals during vegetation clearing and mining developments	**Low** – Little ecological information is known about the species (including habitat preferences) and there are very few records of the species.
		Vehicle Strike	Extent of expansion of existing road and track network	Long term (life of mine)	**Low** – Although the existing haul road is intended to be used, other access tracks will be developed. In addition, actual road usage in general will increase substantially during the development and operation of the mine. Subsequently the likelihood of the Spotted Ctenotus being struck by vehicles (if it is present in the Study Area) will also increase, however, the number of individuals affected locally is expected to be low.	**Negligible** – there is unlikely to be a significant impact to this species due to vehicle strike in the broader region.	• Loss of individuals • Reduction in population size	**Moderate** – there may be unrecorded deaths from vehicular strikes within the Study Area
		Introduced Species	Predominantly in and around disturbed areas	Permanent	**Low** – Buffel grass is noted as threat for other threatened Ctenotus species through alteration of habitat structure and increasing fire hazard (TSSC, 2008a), and the weed has been recorded within the Study Area previously. Individuals of the species are likely to be preyed upon by introduced predators such as cats and foxes.	**Low** – There is unlikely to be a significant increase in predation at a regional level from the Project.	• Loss of individuals from predation • Reduction in population size • Alteration/degradation of habitat, including increases to fuel load	**Low** – Little ecological information is known about the species and there are very few records of the species.
		Increased Light	Predominantly concentrated near pits and other mining infrastructure that will be used at night when required.	Long term (life of mine)	**Low** - The extent to which the Spotted Ctenotus is affected by increased levels of light is not well understood, however, the main impact of light generated by the Project is likely to be possible dispersal from greatly enhanced levels of light and changes to prey distribution.	**Negligible** – Increased levels of light are not expected to affect individuals outside of the Study Area.	• Possible dispersal from greatly enhanced levels of light • Changes to prey distribution	**Low** - The extent to which the species may be affected by increased levels of light is not well understood.
		Increased Noise	Near mine infrastructure and roads, especially near pits which is where blasting will occur.	Long term (life of mine)	**Low** - Lab-based research of the effects of acute exposure to mining machinery noise on the behaviour of a different species of lizard demonstrated negative effects on the lizards' behaviour and welfare (Mancera ***et al.***, 2017). The effect of elevated levels of noise on the Spotted Ctenotus is unknown. It is probable that this species would react to sudden, loud noises (e.g. from blasting) by at least temporarily retreating to a refuge or dispersing.	**Negligible** – Increased levels of noise are not expected to affect individuals outside of the Study Area.	• Possible dispersal from greatly enhanced levels of noise	**Low** - The extent to which the species may be affected by increased levels of noise is not well understood.
		Dust	Predominantly concentrated near dust-generating activities such as pit blasting and in close proximity to haul roads.	Long term (life of mine)	**Low** - The extent to which the Spotted Ctenotus is affected by increased levels of dust is not well understood, however, the main impact of dust generated by the Project is likely to be the alteration/degradation of habitat.	**Negligible** – Increased levels of dust are not expected to affect individuals outside of the Study Area.	• Temporary disruption to foraging behaviours • Alteration/degradation of habitat	**Low** - The extent to which the species may be affected by increased levels of dust is not well understood.

Species	Likelihood of occurrence	Impact source	Impact					
			Extent	Duration	Magnitude (Local)	Magnitude (Regional)	Potential consequence of impact	Certainty (Level of Confidence)
		Altered Fire Regimes	Extent of disturbance from fire in core habitat areas	Long term (life of mine)	**Low** – The most detrimental local impact of fire on the species is likely to be through consequential changes in habitat structure and floristics, and loss of prey items.	**Low** – Fires inadvertently started in the Study Area may potentially escape and burn beyond of the boundary and subsequently impact on the suitability of habitat in the surrounding region. However, this would probably be a rare occurrence given the control measures that would be expected to be in place as part of the Project.	• Loss of individuals from direct mortality • Increased vulnerability to predation due to loss of habitat cover • Loss of foraging/ dispersal/ denning habitat • Possible loss of prey items	**Low** – The species response to fire and changes to fire regimes is not researched.
		Modification of Water Regimes	Extent of existing and future water sources	Long term (life of mine)	**Negligible** – there is unlikely to be a significant impact from altered water regimes to the species.	**Negligible** – there is unlikely to be a significant impact from altered water regimes to the species.	• Nil	**High** – Unlikely that habitats utilised by the species will be impacted by altered water regimes.
<u>Long-tailed Dunnart</u> *Sminthopsis longicaudata* **DBCA Priority** Priority 4	Possible	Removal, Fragmentation or Modification of Habitat	Extent of clearing on core habitat (Hillcrest/Hillslope, Gorge Gully, Low Stony Hills, Stony Plain)	Permanent	**Low** – The species is a habitat specialist to rocky scree and plateau areas and thus clearing of such habitat may directly impact the species (Burbidge ***et al.***, 2008). Clearing for tracks is unlikely to cause a barrier to movement between local populations, as small rodents are known to readily cross roads and use culverts (Queensland Department of Main Roads, 2000)	**Low** – In consideration of the species smaller body size (which limits long-distance dispersal), the highly patchy nature of records and the distance between populations, the dispersal ability of this species is potentially very poor (WAM, 2019). However, the core habitat extends beyond the Study Area boundary and is considered widespread in the region and throughout the Pilbara. Hence only minor impacts at a regional scale are expected.	• Loss/displacement of individuals during vegetation clearing and mining developments • Loss of core habitat • Reduction in population size • Increase in population isolation • Loss of genetic diversity	**Moderate** – no records exist within the Study Area; however, it is likely that habitat suitable for the species will be impacted by the Project.
		Vehicle Strike	Extent of expansion of existing road and track network	Long term (life of mine)	**Low** – no records of the species exist within the Study Area, and Long-tailed Dunnarts have a relatively high fecundity which allows populations to recover from individual deaths (McKenzie ***et al.***, 2008)	**Negligible** – there is unlikely to be a significant increase to vehicular strike of Long-tailed Dunnarts in the broader region due to the Project	• Direct loss of individuals • Reduction in population size	**Moderate** – there may be unrecorded deaths from vehicular collisions within the Study Area.
		Introduced Species	Predominantly in and around disturbed areas	Permanent	**Low** – Although predation by introduced species is listed as a threat, introduced species (particularly cats and foxes) are unlikely to significantly increase with suitable monitoring and management. Buffel grass is noted as a threat through alteration of habitat structure and increasing fire hazard (Crowley, 2008), and the weed has been recorded within the Study Area previously and unlikely to significantly impact habitats of the species.	**Low –** although predation by introduced species is recorded as one of most significant threats to the species, there is unlikely to be a significant increase in regional predation from the Project.	• Loss of individuals from predation • Reduction in population size • Alteration/degradation of habitat, including increases to fuel load	**Low** – the cause of the species' decline is not well defined, but assumed to be from a range of impact sources, including predation (Crowley, 2008).
		Increased Light	Predominantly concentrated near pits and other mining infrastructure that will be used at night when required.	Long term (life of mine)	**Low** - The extent to which the Long-tailed Dunnart is affected by increased levels of light is not well understood, however, the main impact of light generated by the Project is likely to be possible dispersal from greatly enhanced levels of light and changes to prey distribution.	**Negligible –** there is unlikely to be a significant impact to this species in the broader region due to increased light levels.	• Possible dispersal from greatly enhanced levels of light disturbance during mining activities • Changes to prey distribution	**Low** - The extent to which the species may be affected by increased levels of light is not well understood.
		Increased Noise	Near mine infrastructure and roads, especially near pits which is where blasting will occur.	Long term (life of mine)	**Low** - The extent to which the Long-tailed Dunnart is affected by increased levels of noise is not well understood, however, the main impact of noise generated by the Project, especially loud noises (e.g. from blasting) is likely to be possible dispersal.	**Negligible** – there is unlikely to be a significant impact to this species in the broader region due to increased noise levels.	• Possible dispersal from greatly enhanced levels of noise disturbance during mining activities	**Low** - The extent to which the species may be affected by increased levels of noise is not well understood.
		Dust	Predominantly concentrated near dust-generating activities such as pit blasting and in close proximity to haul roads.	Long term (life of mine)	**Low** - The extent to which the Long-tailed Dunnart is affected by increased levels of dust is not well understood, however, the main impact of dust generated by the Project is likely to be the alteration/degradation of habitat.	**Negligible** – Increased levels of dust are not expected to affect individuals outside of the Study Area.	• Alteration/degradation of habitat	**Low** - The extent to which the species may be affected by dust is not well understood.
		Altered Fire Regimes	Extent of disturbance from fire in core habitat areas	Long term (life of mine)	**Low** – the impact of changed fire regimes on this species is thought to be a contributing factor to its decline but is not well researched. Studies on other *Sminthopsis* species recorded that post-fire abundance was greatest at 4-9 years (mid succession habitat preference) (Wilson & Aberton, 2006).	**Low** – Fires inadvertently started in the Study Area may potentially escape and burn beyond of the boundary and subsequently impact on the suitability of habitat in the surrounding region. However, this would probably be a rare occurrence given the control measures that would be expected to be in place as part of the Project.	• Loss of individuals from direct mortality, and increased predation from loss of habitat cover • Possible loss of prey items	**Low** – The species response to fire and changes to fire regimes is not well documented.
		Modification of Water Regimes	Extent of existing and future water sources	Long term (life of mine)	**Negligible** – there is unlikely to be a significant impact from altered water regimes to the species.	**Negligible** – there is unlikely to be a significant impact from altered water regimes to the species.	• Nil	**High** – Unlikely that habitats utilised by the species will be impacted by altered water regimes.

Species	Likelihood of occurrence	Impact source	Impact					
			Extent	Duration	Magnitude (Local)	Magnitude (Regional)	Potential consequence of impact	Certainty (Level of Confidence)
Short-tailed Mouse *Leggadina lakedownensis* **DBCA Priority** Priority 4	Possible	Removal, Fragmentation or Modification of Habitat	Extent of clearing on core habitat (primarily Sandplain and Stony Plain habitats)	Permanent	**Low** – This species has been found to have a median home range of approximately 4.8 ha increasing to 5.3 ha in the breeding season (Moro & Morris, 2000). Habitat loss has been suggested as a threatening process for the Short-tailed Mouse (Kutt & Kemp, 2005). Habitat suitable for this species will be removed by the Project (i.e. Sand Plain and Stony Plain habitats). Populations of this species fluctuate dramatically in response to climatic conditions and availability of seed (Covacevich, 1995). Although there are multiple records approximately 16km to the northeast (Biologic, 2019c), the Short-tailed Mouse was not recorded within the Study Area.	**Low** – The core habitat of this species extends beyond the Study Area boundary and is considered widespread in the region and throughout the Pilbara. Hence only minor impacts at a regional scale are expected.	• Loss/displacement of individuals during vegetation clearing and mining developments • Loss of core habitat • Reduction in population size • Increase in population isolation • Loss of genetic diversity	**Moderate** – no records exist within the Study Area; however, it is likely that habitat suitable for the species will be impacted by the Project.
		Vehicle Strike	Extent of expansion of existing road and track network	Long term (life of mine)	**Low** – The Short-tailed Mouse has a median home range of approximately 4.8 ha increasing to 5.3 ha in the breeding season (Moro & Morris, 2000). Although data regarding the susceptibility of this species to collision with vehicles is lacking, it is reasonable to assume that mortality from vehicle strike could occasionally occur if roads are present an individual's home range. The Short-tailed Mouse is primarily nocturnal and shelters in burrows during the day (Moro & Morris, 2000) so is less active when vehicles are most in use due to the Project.	**Negligible** – there is unlikely to be a significant increase to vehicular strike of Short-tailed Mouse in the broader region due to the Project.	• Direct loss of individuals • Reduction in population size	**Moderate** – there may be unrecorded deaths from vehicular collisions within the Study Area.
		Introduced Species	Predominantly in and around disturbed areas	Permanent	**Low** – It has been suggested that predation by feral cats may be a threat to the Short-tailed Mouse (Kutt & Kemp, 2005). The alteration of ground cover via grazing by stock may also potentially be a threatening process, however, this is uncertain and requires further research (Kutt & Kemp, 2005).	**Low** – there is unlikely to be a significant impact on a regional scale to the Short-tailed Mouse from introduced species.	• Loss of individuals from predation • Reduction in population size • Alteration/degradation of habitat, including increases to fuel load	**Low** – (Kutt & Kemp, 2005) identified habitat degradation and predation from feral cats are likely to be threats to Short-tailed Mouse populations, however, this will need to be confirmed by research.
		Increased Light	Predominantly concentrated near pits and other mining infrastructure that will be used at night when required.	Long term (life of mine)	**Negligible** – This species has not been recorded in the Study Area. Notwithstanding, if the species is present in the Study Area, it is likely to be present in low densities and in areas away from the proposed infrastructure and any associated increased levels of light.	**Negligible** – there is unlikely to be a significant impact to this species in the broader region due to increased light levels.	• Possible dispersal from greatly enhanced levels of light disturbance during mining activities	**Low** - The extent to which the species may be affected by increased levels of light is not well understood.
		Increased Noise	Near mine infrastructure and roads, especially near pits which is where blasting will occur.	Long term (life of mine)	**Negligible** – This species has not been recorded in the Study Area. Notwithstanding, if the species is present in the Study Area, it is likely to be present in low densities and in areas away from the proposed infrastructure and any associated increased levels of noise.	**Negligible** – there is unlikely to be a significant impact to this species in the broader region due to increased noise levels.	• Possible dispersal from greatly enhanced levels of noise disturbance during mining activities	**Low** - The extent to which the species may be affected by increased levels of noise is not well understood.
		Dust	Predominantly concentrated near dust-generating activities such as pit blasting and in close proximity to haul roads.	Long term (life of mine)	**Negligible** – This species has not been recorded in the Study Area. Notwithstanding, if the species is present in the Study Area, it is likely to be present in low densities and in areas away from the proposed infrastructure and any associated increased levels of dust.	**Negligible** – Increased levels of dust are not expected to affect individuals outside of the Study Area.	• Alteration/degradation of habitat	**Low** - The extent to which the species may be affected by dust is not well understood.
		Altered Fire Regimes	Extent of disturbance from fire in core habitat areas	Long term (life of mine)	**Low** – altered fire regimes is likely to be a threat for this species. Populations of this species fluctuate dramatically in response to climatic conditions and availability of seed (Covacevich, 1995).	**Low** – Fires inadvertently started in the Study Area may potentially escape and burn beyond of the boundary and subsequently impact on the suitability of habitat in the surrounding region. However, this would probably be a rare occurrence given the control measures that would be expected to be in place as part of the Project.	• Loss of individuals from direct mortality, and increased predation from loss of habitat cover • Loss of habitat cover	**Low** – The species response to fire and changes to fire regimes is not well documented.
		Modification of Water Regimes	Extent of existing and future water sources	Long term (life of mine)	**Negligible** – there is unlikely to be a significant impact from altered water regimes to the species.	**Negligible** – there is unlikely to be a significant impact from altered water regimes to the species.	• Nil	**High** – Unlikely that habitats utilised by the species will be impacted by altered water regimes.
Migratory Bird Species considered to possibly or rarely occur within the Study Area								

Species	Likelihood of occurrence	Impact source	Impact					
			Extent	Duration	Magnitude (Local)	Magnitude (Regional)	Potential consequence of impact	Certainty (Level of Confidence)
Migratory Birds • Barn Swallow (MI) • Fork-tailed Swift (MI) • Sharp-tailed Sandpiper (MI) • Marsh Sandpiper (MI) • Pectoral Sandpiper (MI) • Wood Sandpiper (MI) • Curlew Sandpiper (CR/MI) • Common Sandpiper (MI) • Common Greenshank (MI) • Eastern Curlew (CR/MI) • Black-tailed Godwit (MI) • Oriental Pratincole (MI) • Oriental Plover (MI) • Gull-billed Tern (MI) • Caspian Tern (MI) • Osprey (MI) Glossy Ibis (MI)	Possibly or Rarely	Removal, Fragmentation or Modification of Habitat	Extent of clearing in Major Drainage Line	Permanent	**Low** - The preferred habitat of these migratory birds (Major Drainage Line) extends well outside the Study Area. Major Drainage Line habitat would be minimally impacted by the Project (19.58 ha is within the Development Envelope compared to 996.32 ha in the Study Area). Hence, the Project is unlikely to cause fragmentation of habitat for migratory species. These migratory species are highly mobile and can move away from disturbances such as habitat to be cleared as part of the Project. Individuals displaced by the Project would be expected to disperse into nearby suitable habitat.	**Low** – despite being migratory, there is unlikely to be a significant impact on a regional scale to these species due to their infrequent occurrence in the Study Area.	• Displacement of individuals during vegetation clearing and mining developments. • Permanent loss of habitat.	**Moderate** – no records exist within the Study Area; however, it is likely that some habitat suitable for these migratory species will be impacted by the Project.
		Vehicle Strike	Extent of expansion of existing road and track network	Long term (life of mine)	**Low** – Some species of migratory birds would be more susceptible to mortality due to collisions with vehicles than others. Notwithstanding, the species of migratory birds considered here would be rarely involved in collisions with vehicles due to their infrequent occurrence in the Study Area.	**Negligible** – there is unlikely to be a significant impact to this species due to vehicle strike in the broader region.	• Direct loss of individuals • Reduction in population size	**Moderate** – there may be unrecorded deaths from vehicular collisions within the Study Area.
		Introduced Species	Predominantly in and around disturbed areas	Permanent	**Low** – Potential impacts by introduced species attracted by the Project include degradation of habitat by livestock and feral herbivores and reduced availability of water due to consumption by camels and livestock. Invasive weed species may disadvantage migratory birds through inhibiting movement to waterbodies or fostering inappropriate fire regimes.	**Low** – there is unlikely to be a significant impact on a regional scale to these species from introduced species.	• Loss of individuals from predation • Reduction in population size • Alteration/degradation of habitat, including increases to fuel load	**Moderate** – impacts by introduced species on migratory birds are well recorded.
		Increased Light	Predominantly concentrated near pits and other mining infrastructure that will be used at night when required.	Long term (life of mine)	**Low** – the species of migratory birds considered here have not been recorded in the Study Area. If they do occur, they would only visit infrequently and would be less vulnerable to the impacts of increased lighting due to the Project.	**Negligible** – there is unlikely to be a significant impact to these species in the broader region due to increased light levels.	• Possible dispersal from greatly enhanced levels of light	**Moderate** – impacts of lighting on migratory birds are well recorded (DoEE, 2019).
		Increased Noise	Near mine infrastructure and roads, especially near pits which is where blasting will occur.	Long term (life of mine)	**Low** – It is probable that migratory species would react to sudden, loud noises (e.g. from blasting) by at least temporarily dispersing. Some birds habituate to noise (Donato ***et al.***, 2007; Transport Canada, 1998). However, as these migratory species would be infrequent visitors to the Study Area, individuals may simply move on rather than stay and habituate. Indeed, recent experimental research overseas has shown that some migratory bird species almost completely avoid traffic noise altogether (McClure ***et al.***, 2013).	**Negligible** – there is unlikely to be a significant impact to these species in the broader region due to increased noise levels.	• Possible dispersal from greatly enhanced levels of noise	**Low** – It is difficult to predict how different migratory species will respond to increased levels of noise.
		Dust	Predominantly concentrated near dust-generating activities such as pit blasting and in close proximity to haul roads.	Long term (life of mine)	**Low** – the species of migratory birds considered here have not been recorded in the Study Area. If they do occur, they would only visit infrequently and would be less vulnerable to the impacts of dust due to the Project.	**Negligible** – Increased levels of dust are not expected to affect individuals outside of the Study Area.	• Alteration/degradation of habitat	**Low** - The extent to which migratory birds may be affected by dust is not well understood.
		Altered Fire Regimes	Extent of disturbance from fire in core habitat areas	Long term (life of mine)	**Low** – The most detrimental local impact of fire on migratory bird species is likely to be through consequential changes in habitat structure and floristics, and loss of prey items. Individuals are highly mobile, and dispersal habitat will not be removed by the Project, allowing individuals (should they visit) movement across the Study Area.	**Low** – Fires inadvertently started in the Study Area may potentially escape and burn beyond of the boundary and subsequently impact on the suitability of habitat in the surrounding region. However, this would probably be a rare occurrence given the control measures that would be expected to be in place as part of the Project.	• Alteration/degradation of habitat	**Low -** The extent to which migratory birds may be affected by a change of fire regime in the Pilbara is not well researched.
		Modification of Water Regimes	Extent of existing and future water sources	Long term (life of mine)	**Low** – Waterholes and sources are an important feature for these species They have been observed to use artificial water sources they their use by such species is sporadic and opportunistic only. Any alterations to surface water flows into natural water features may impact upon the species ability to forage in the Study Area	**Negligible** – Alterations to water regime in the Study Area are not expected to affect individuals outside of the Study Area.	Loss of foraging/ habitat	**Moderate** – The degree to which these species use the Study Area is relatively unknown.

Note: coloured cells indicate a scale of magnitude significance, where yellow = Low, Orange = Moderate, and red = High.

6.4 Impacts to Matters of National Environmental Significance

Impacts to fauna listed as MNES under the EPBC Act are considered in Table 6.3.

The Northern Quoll was assessed under criteria recommended by DoE (2016). The Project is likely to cause a significant impact to the species based on two of these criteria: 'result in the loss of habitat critical to the survival of the Northern Quoll' and 'decrease the size of a population important for the long-term survival of the Northern Quoll'.

The remaining MNES species are listed as Vulnerable and were assessed, using the criteria recommended by DoE (2013) and TSSC (2016b) for the Pilbara Leaf-nosed Bat. To assess whether a significant impact is likely for the majority of these criteria it is necessary to determine whether a population meets the definition of an important population:

- All Pilbara Leaf-nosed Bat from the Pilbara region are regarded as representing a 'important population', though no aspect of the Project is likely to cause a significant impact based on the criteria assessed (Table 6.3).
- For the purposes of this assessment, the Ghost Bat was regarded as representing a 'important population'. Ghost Bat's in the Study Area form part of the Chichester subregional population, which contains the highest population in the Pilbara (TSSC, 2016a). The presence of a potential maternity cave also indicates that the population is likely to be a breeding and source population. Furthermore, the population represents individuals breeding and occupying natural caves of the region. This is important because it is recognised that the majority of the Chichester population is confined to artificial adits, such as Lalla Rookh, which are physically unstable and of interest to future mining development (TSSC, 2016a). Therefore natural breeding caves of the region are of increased importance, particularly given the longevity which they are likely to have over abandoned mining adits (100's of years versus 1,000's of years, J. Barnett pers. comms. in Biologic, 2016). At the time of writing, additional studies are being undertaken by Atlas in relation to potential impacts on CMRC-15 (a potential maternity cave) and management of this cave. If it can be demonstrated that CMRC-15 will not be impacted, the Project will be unlikely to have a significant impact on this species. Conversely, if damage to CMRC-15 cannot be avoided, the Project is likely to 'lead to a long-term decrease in the size of an important population of a species', 'adversely affect habitat critical to the survival of a species', and 'disrupt the breeding cycle of an important population', and therefore may have a significant impact on the species.
- There is some conjecture as to whether the population of Northern Brushtail Possums in the Pilbara region represents *Trichosurus vulpecula arnhemensis* (indicated by WAM) or *Trichosurus vulpecula hypoleucos* (indicated by DBCA); the latter is not considered to be threatened (H. Anderson *in prep*.). Even if the population in the Pilbara region is found to be *Trichosurus vulpecula arnhemensis*, this population is not near

the limit of the sub-species' range as Northern Brushtail Possums occur further to the south in the Hamersley Range (H. Anderson *in prep*.). The population inhabiting the Study Area would be unlikely to represent an 'important population' as defined by the (DoE, 2013). The Project is unlikely to have a significant impact on this species.

- The Grey Falcon occurring in the Study Area is not believed to represent a 'important population' on the basis that the Pilbara is believed to represent a "refugia to which the [Grey] Falcons may withdraw, and which provide foci for recolonization when conditions improve" (Olsen & Olsen, 1986). The Project is unlikely to have a significant impact on the species.
- The Pilbara Olive Python occurring in the Study Are not believed to represent an 'important population' based on definitions outlined by the (DoE, 2013). The Project is unlikely to have a significant impact on the species.

Table 6.3: Significance of the Project to fauna considered Matters of National Environmental Significance (confirmed or likely to occur)

Species	EPBC Act Listing	Likelihood of occurrence	MNES Significant Impact Criteria	Likelihood of Impact	Justification
Northern Quoll *Dasyurus hallucatus*	Endangered	Confirmed	Result in the loss of habitat critical to the survival of the Northern Quoll	**Likely**	The population within the Study Area is most likely permanent and considered a high-density population important for the long-term survival of the species. Approximately 429.79 ha of Hillcrest/Hillslope habitat (which contains important denning/shelter habitat) is present in the Study Area. A comparatively smaller portion of this (58.87 ha) is contained within the Development Envelope of the Project. The Project is also likely to impact on other key denning habitat in Gorge/Gully habitat and foraging and dispersal habitat (Major Drainage Line). The site where 11 female and seven male Northern Quolls were recorded during field surveys (VMRC-99) represents high value denning/shelter and foraging habitat for breeding females of the population occurring within the Study Area (Biologic, 2019c) and lies partially within the Development Envelope. It is important to note that VMRC-99 was a targeted Northern Quoll trapping site comprised of two parallel lines of 25 cage traps spaced approximately 10-30 m apart (i.e. a transect). The marker denoting VMRC-99 on Figure 3.3 from the *Miralga Creek Project: Vertebrate and SRE Invertebrate Fauna Assessment* only represents the start of the transect. Due to the layout of the transect, a large portion of VMRC-99 lies within the Indicative Disturbance Footprint and many of the 18 Northern Quolls captured at this site were actually captured within the Indicative Disturbance Footprint. The records of Northern Quolls in relation to the Indicative Disturbance Footprint are shown in Figure 6.1. As the Project is likely to disturb an amount of denning/shelter and foraging and dispersal habitat, it is likely that the Project will have a significant impact on the Northern Quoll based on this criterion.
			Decrease the size of a population important for the long-term survival of the Northern Quoll and therefore interfere with the recovery of the species	**Likely**	As defined by DoE (2016), the population existing within the Study Area is considered to be a high density population, as numerous camera triggers of multiple individuals across multiple cameras and traps has occurred. DoE (2016) describe that high-density Northern Quoll populations, which occur in refuge-rich habitat critical to the survival of the species are important for the long-term survival of the Northern Quoll. The Project will reduce the amount and quality of foraging and dispersal habitat, and potentially exacerbate threatening processes such as introduced species, habitat loss, altered fire regimes, vehicle collision, and therefore likely impact the population through a loss of individuals. The Project is likely to have a significant impact on the species based on this criterion.

Species	EPBC Act Listing	Likelihood of occurrence	MNES Significant Impact Criteria	Likelihood of Impact	Justification
			Introduce inappropriate fire regimes or grazing activities (i.e. increasing the risk of late dry season high intensity fires to the area) that substantially degrade habitat critical to the survival of the northern quoll or decrease the size of a population important for the long-term survival of the species	**Unlikely**	The Project would not increase the grazing pressure within the Study Area. Fires inadvertently started in the Study Area may potentially escape and burn beyond of the boundary and subsequently impact on populations in the surrounding region. However, this would probably be a rare occurrence and would be restricted to the life of mine. The Project is unlikely to cause a significant impact to the species based on this criterion.
			Fragment a population important for the long-term survival into two or more populations	**Unlikely**	Infrastructure of the Project is unlikely to restrict interaction between individuals. The species is regarded as having good dispersal capabilities (Spencer, 2013; Woolley, 2015) and the Study Area is surrounded by suitable habitat to disperse to and within (including Hillcrest/Hillslope habitat, Gorge/Gully and Major Drainage Line habitat). The Project is unlikely to cause significant impact to the Northern Quoll based on this criterion.
			Result in invasive species or increases of them that are harmful to the Northern Quoll becoming established in its habitat, namely cane toads, feral cats, red foxes or exotic grasses which increase fire risk.	**Unlikely**	The presence of invasive species including introduced predators and invasive weeds may be exacerbated by the Project. An increase in Cat and Red Fox numbers are of primary concern. However, this is not likely to have a significant impact on top of background levels already present. Appropriate measures to control Cats and Red Foxes would further minimise impacts on Northern Quolls. The Project is unlikely to have a significant impact on the species based on this criterion.
Ghost Bat *Macroderma gigas*	Vulnerable	Confirmed	Lead to a long-term decrease in the size of an important population of a species	**Likely** **(If CMRC-15 is damaged)**	Two caves are located within the Indicative Disturbance Footprint, and another is located within ~30 m. There is potential that the Project may impact upon a potential breeding site for the species (CMRC-15) – either directly through collapse and/ or indirectly through changing of microclimate. Should this cave be impacted there is strong potential to lead to the long-term decrease in the size of an important population.
				Unlikely **(if CMRC-15 is not damaged)**	At the time of writing, additional studies are being undertaken by Atlas in relation to potential impacts on CMRC-15 (a potential maternity cave) and management of this cave. If it can be demonstrated that CMRC-15 will not be impacted (either by collapse or change in microclimate), the Project will be unlikely to have a significant impact on the Ghost Bat based on this criterion.

Species	EPBC Act Listing	Likelihood of occurrence	MNES Significant Impact Criteria	Likelihood of Impact	Justification
			Reduce the area of occupancy of an important population	**Unlikely**	Two Night Roosts are likely to be removed by development of the Project. Short-term abandonment is likely to occur to some of the remaining caves within the Study Area during mining, but reoccupation is expected contingent on sound structural integrity of the caves post mining (Bat Call, 2020). All of the types of habitat found within the Study Area are suitable for the Ghost Bat to use for foraging and the Project would disturb only a portion of each. Water features are important for the Ghost Bat as foraging and drinking sources. No water features are found within the Indicative Disturbance Footprint. The Project is not likely to have a significant impact on the species based on this criterion.
			Fragment an existing important population into two or more populations	**Unlikely**	Genetic analyses suggest that there is a single, large, highly diverse genetic population of Ghost Bats in the Pilbara region with significant movement between caves (Biologic, 2017). The Project is unlikely to have a significant impact on the species based on this criterion.
			Adversely affect habitat critical to the survival of a species	**Likely** **(If CMRC-15 is damaged)**	Two caves are located within the Indicative Disturbance Footprint, and another is located within ~30 m. There is potential that the project may impact upon a potential breeding site for the species (CMRC-15) – either directly through collapse and/ or indirectly through changing of microclimate. Should this cave be impacted, there is strong potential the Project will adversely affect habitat critical to the survival of the species.
				Unlikely **(if CMRC-15 is not damaged)**	At the time of writing, additional studies are being undertaken by Atlas in relation to potential impacts on CMRC-15 (a potential maternity cave) and management of this cave. If it can be demonstrated that CMRC-15 will not be impacted (either by collapse or change in microclimate), the Project will be unlikely to have a significant impact on the Ghost Bat based on this criterion.
			Disrupt the breeding cycle of an important population	**Likely** **(If CMRC-15 is damaged)**	Two caves are located within the Indicative Disturbance Footprint, and another is located within ~30 m. There is potential that the project may impact upon a potential breeding site for the species (CMRC-15) – either directly through collapse and/ or indirectly through changing of microclimate. Should this cave be impacted, there is strong potential the Project will disrupt the breeding cycle of an important population

Species	EPBC Act Listing	Likelihood of occurrence	MNES Significant Impact Criteria	Likelihood of Impact	Justification
				Unlikely **(if CMRC-15 is not damaged)**	At the time of writing, additional studies are being undertaken by Atlas in relation to potential impacts on CMRC-15 (a potential maternity cave) and management of this cave. If it can be demonstrated that CMRC-15 will not be impacted (either by collapse or change in microclimate), the Project will be unlikely to have a significant impact on the Ghost Bat based on this criterion.
			Modify, destroy, remove or isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline	**Unlikely**	Two Night Roost caves are likely to be impacted by the Project. Short-term abandonment is likely to occur some of the caves within the Study Area during mining but reoccupation is expected contingent on sound structural integrity of the caves post mining (Bat Call, 2020). All of the types of habitat found within the Study Area are suitable for the Ghost Bat to use for foraging and the Project would disturb only a portion of each. Water features are important for the Ghost Bat as foraging and drinking sources. No water features are found within the Indicative Disturbance Footprint. The Project is not likely to have a significant impact on the species based on this criterion.
			Result in invasive species that are harmful to a vulnerable species becoming established in the vulnerable species' habitat	**Unlikely**	The presence of invasive species including introduced predators and invasive weeds may be exacerbated by the Project. However, this is not likely to have a significant impact on top of background levels already present. The Project is unlikely to have a significant impact on the species based on this criterion.
			Introduce disease that may cause the species to decline	**Unlikely**	The Project is not likely to introduce or increase transmission of any diseases relevant to this species. The Project is not likely to have a significant impact on the species based on this criterion.
			Interfere substantially with the recovery of the species.	**Unlikely**	The Project is unlikely to interfere substantially with any conservation recovery initiative for the species. The Project is unlikely to significant impact the species based on this criterion.

Species	EPBC Act Listing	Likelihood of occurrence	MNES Significant Impact Criteria	Likelihood of Impact	Justification
Pilbara Leaf-nosed Bat *Rhinonicteris aurantia*	Vulnerable	Confirmed	Lead to a long-term decrease in the size of the Pilbara Leaf-nosed Bat population	**Unlikely**	The Pilbara Leaf-nosed Bats recorded in the Study Area are thought to have originated from the Lalla Rookh roost (R. Bullen *pers. comm.* 13 June 2019 and 24 August 2019 cited in Biologic (2019c) which lies outside of the Study Area, approximately 3 km southwest of the Miralga deposits. The Lalla Rookh roost will not be disturbed by the Project. All of the types of habitat found within the Study Area are suitable for the Pilbara Leaf-nosed Bat to use for foraging and the Project would disturb only a portion of each. It is unlikely that the Project will have a significant impact on the species based on this criterion.
			Reduce the area of occupancy of the Pilbara Leaf-nosed Bat population	**Unlikely**	The Pilbara Leaf-nosed Bat is likely to forage nightly within the Study Area, however, the caves in the Study Area are probably not used for diurnal roosting as no evidence of this was found during field surveys (Biologic, 2019c). All of the types of habitat found within the Study Area are suitable for the Pilbara Leaf-nosed Bat to use for foraging and the Project would disturb only a portion of each. The Project is not likely to have a significant impact on the species based on this criterion.
			Adversely affect individuals or habitat critical to the survival of the Pilbara Leaf-nosed Bat	**Unlikely**	The Pilbara Leaf-nosed Bats recorded in the Study Area are thought to have originated from the Lalla Rookh roost (R. Bullen *pers. comm.* 13 June 2019 and 24 August 2019 cited in Biologic (2019c) which lies outside of the Study Area, approximately 3 km southwest of the Miralga deposits. The Lalla Rookh roost will not be disturbed by the Project. All of the types of habitat found within the Study Area are suitable for the Pilbara Leaf-nosed Bat to use for foraging and the Project would disturb only a portion of each. The Project is unlikely to have a significant impact on the species based on this criterion.
			Disrupt the breeding cycle of an important colony	**Unlikely**	The Pilbara Leaf-nosed Bat is likely to forage nightly within the Study Area, however, the caves in the Study Area are probably not used for diurnal roosting as no evidence of this was found during field surveys (Biologic, 2019c). The Pilbara Leaf-nosed Bats recorded in the Study Area are thought to have originated from the Lalla Rookh roost (R. Bullen *pers. comm.* 13 June 2019 and 24 August 2019 cited in Biologic (2019c) which lies outside of the Study Area, approximately 3 km southwest of the Miralga deposits. The Lalla Rookh roost will not be disturbed by the Project. Thus, the Project is not likely to have a significant impact on the species based on this criterion.
			Modify, destroy, remove or isolate or decrease the availability or quality of Pilbara Leaf-nosed Bat habitat to the extent that the Pilbara Leaf-nosed Bat is likely to decline	**Unlikely**	The caves in the Study Area are probably not used for diurnal roosting as no evidence of this was found during field surveys (Biologic, 2019c). All of the types of habitat found within the Study Area are suitable for the Pilbara Leaf-nosed Bat to use for foraging and the Project would disturb only a portion of each. Thus, the Project is unlikely to cause significant impact to the species based on this criterion.

Species	EPBC Act Listing	Likelihood of occurrence	MNES Significant Impact Criteria	Likelihood of Impact	Justification
Northern Brushtail Possum *Trichosurus vulpecula*	Vulnerable (pending)	Confirmed	Lead to a long-term decrease in the size of an important population of a species	**Unlikely**	This species is mobile and can move away from disturbances such as habitat to be cleared as part of the Project. The preferred habitat of the Northern Brushtail Possum (Major Drainage Line) extends well outside the Study Area, including along Miralga Creek where an individual was recorded (Biologic, 2019c). Major Drainage Line habitat would be minimally impacted by the Project (19.58 ha is within the Development Envelope compared to 996.32 ha in the Study Area). In addition, a small amount (0.76 ha) of Gorge/Gully habitat, also preferred by this species, lies within the Development Envelope. Individuals displaced by the Project would be expected to disperse into nearby suitable habitat. The Project is unlikely to have a significant impact on the species based on this criterion.
			Reduce the area of occupancy of an important population	**Unlikely**	Little ecological information is known about the Pilbara population, although it is most often recorded from gorges and major drainage lines that contain large hollow-bearing Eucalypts (DBCA, 2019a). Major Drainage Line habitat would be minimally impacted by the Project (19.58 ha is within the Development Envelope compared to 996.32 ha in the Study Area). In addition, a small amount of Gorge/Gully habitat (0.76 ha) lies within the Development Envelope. The Project is unlikely to have a significant impact on the species based on this criterion.
			Fragment an existing important population into two or more populations	**Unlikely**	Little ecological information is known about the Pilbara population, although it is most often recorded from gorges and major drainage lines that contain large hollow-bearing Eucalypts (DBCA, 2019a). The preferred habitat for this species therefore extends well outside the Study Area. Given the high mobility of this species and its wide distribution, the Project would not fragment an existing population into two or more populations. The Project is unlikely to impact upon an important population and thus unlikely to have a significant impact on the species based on this criterion.

Species	EPBC Act Listing	Likelihood of occurrence	MNES Significant Impact Criteria	Likelihood of Impact	Justification
			Adversely affect habitat critical to the survival of a species	**Unlikely**	The preferred habitat of the Northern Brushtail Possum (Major Drainage Line) extends well outside the Study Area, including along Miralga Creek where an individual was recorded (Biologic, 2019c). Major Drainage Line habitat would be minimally impacted by the Project (19.58 ha is within the Development Envelope compared to 996.32 ha in the Study Area). In addition, a small amount of Gorge/Gully habitat (0.76 ha) lies within the Development Envelope. Individuals displaced by the Project would be expected to disperse into nearby suitable habitat. The Project is unlikely to have a significant impact on the species based on this criterion.
			Disrupt the breeding cycle of an important population	**Unlikely**	The habitat types in the Study Area most suitable to support this species is the Major Drainage Line habitat, as well as other habitat that provides tree hollows and denning sites, such as the Gorge/Gully habitat. The impact considered to be of most significance for this species is habitat loss and degradation. Major Drainage Line habitat would be minimally impacted by the Project (19.58 ha is within the Development Envelope compared to 996.32 ha in the Study Area). In addition, a small amount of Gorge/Gully habitat (0.76 ha) lies within the Development Envelope. Furthermore, Major Drainage Line habitat continues well beyond the boundaries of the Study Area. The Project is unlikely to have a significant impact on the species based on this criterion.
			Modify, destroy, remove or isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline	**Unlikely**	Little ecological information is known about the Pilbara population, although it is most often recorded from gorges and major drainage lines that contain large hollow-bearing Eucalypts (DBCA, 2019a). Major Drainage Line habitat would be minimally impacted by the Project (19.58 ha is within the Development Envelope compared to 996.32 ha in the Study Area). In addition, a small amount of Gorge/Gully habitat (0.76 ha) lies within the Development Envelope. Furthermore, Major Drainage Line habitat continues well beyond the boundaries of the Study Area. The Project is unlikely to have a significant impact on the species based on this criterion.
			Result in invasive species that are harmful to a vulnerable species becoming established in the vulnerable species' habitat	**Unlikely**	The Northern Brushtail Possum is regarded as a 'critical weight range' mammal, and thus more susceptible to pressure from introduced predators (Burbidge & McKenzie, 1989). Invasive weed species may disadvantage Northern Brushtail Possum through inhibiting movement or fostering inappropriate fire regimes. However, this is not likely to have a significant impact on top of background levels already present. The Project is unlikely to have a significant impact on the species based on this criterion.

Species	EPBC Act Listing	Likelihood of occurrence	MNES Significant Impact Criteria	Likelihood of Impact	Justification
			Introduce disease that may cause the species to decline	**Unlikely**	Disease carried by introduced Black Rats (*Rattus rattus*) is considered to be a potential threat to the Northern Brushtail Possum (DoEE, 2020). Black Rats are known vectors for some diseases that have caused mammal extinctions elsewhere (Wyatt *et al.*, 2008). The Northern Brushtail Possum has historical evidence of major population decline due to epizootic disease although this was unlikely to be caused by the Black Rat (Abbott, 2006). In addition, the Black Rat has not been recorded in the Study Area. Furthermore, introduced species (including the Black Rat) are unlikely to significantly increase with suitable monitoring and management. The Project is not likely to have a significant impact on the Northern Brushtail Possum based on this criterion.
			Interfere substantially with the recovery of the species.	**Unlikely**	The Project is unlikely to interfere substantially with any conservation recovery initiative for the species. The Project is unlikely to have a significant impact on the species based on this criterion.
Grey Falcon *Falco hypoleucos*	Vulnerable (pending)	Confirmed	Lead to a long-term decrease in the size of an important population of a species	**Unlikely**	This species is mobile and can move away from disturbances such as habitat to be cleared as part of the Project. Recent research has shown that the Grey Falcon is a 'reluctant nomad' and that if conditions become unsuitable for breeding, these birds prefer to stay and forego breeding than to search for more favourable conditions (Schoenjahn, 2018). Major Drainage Line habitat is particularly suitable for nesting. Approximately 996.32 ha of Major Drainage Line habitat lies within the Study Area, however, only approximately 19.58 ha falls within the Development Envelope. Furthermore, Major Drainage Line habitat continues well beyond the boundaries of the Study Area. The Project is unlikely to have a significant impact on the species based on this criterion.
			Reduce the area of occupancy of an important population	**Unlikely**	This species is mobile and can move away from disturbances such as habitat to be cleared as part of the Project. However, recent research has shown that the Grey Falcon is a 'reluctant nomad' and only if conditions become a risk to their survival are they likely to move on and then, when they do, they move no further than necessary (Schoenjahn, 2018). The Grey Falcon uses all of the habitat types in the Study Area for hunting, but the Major Drainage Line habitat is particularly suitable for nesting. Approximately 996.32 ha of Major Drainage Line habitat lies within the Study Area, however, only approximately 19.58 ha falls within the Development Envelope. Furthermore, Major Drainage Line habitat continues well beyond the boundaries of the Study Area. The Project is unlikely to have a significant impact on the species based on this criterion.
			Fragment an existing important population into two or more populations	**Unlikely**	Given the high mobility of this species and its wide distribution, the Project would not fragment an existing population into two or more populations. The Project is unlikely to impact upon an important population and thus unlikely to have a significant impact on the species based on this criterion.

Species	EPBC Act Listing	Likelihood of occurrence	MNES Significant Impact Criteria	Likelihood of Impact	Justification
			Adversely affect habitat critical to the survival of a species	**Unlikely**	The Grey Falcon uses all of the habitat types in the Study Area for hunting, but the Major Drainage Line habitat is particularly suitable for nesting. Approximately 996.32 ha of Major Drainage Line habitat lies within the Study Area, however, only approximately 19.58 ha falls within the Development Envelope. Furthermore, Major Drainage Line habitat continues well beyond the boundaries of the Study Area. The Project is unlikely to have a significant impact on the species based on this criterion.
			Disrupt the breeding cycle of an important population	**Unlikely**	Breeding of Grey Falcons within the Major Drainage Line habitat of the Study Area was evidenced by a group of four individuals including two young (Biologic, 2019c). Recent research has shown that the Grey Falcon is a 'reluctant nomad' and that if conditions become unsuitable for breeding, these birds prefer to stay and forego breeding than to search for more favourable conditions (Schoenjahn, 2018). Only if conditions become a risk to their survival are they likely to move on and then, when they do, they move no further than necessary (Schoenjahn, 2018). Major Drainage Line habitat is particularly suitable for nesting. Approximately 996.32 ha of Major Drainage Line habitat lies within the Study Area, however, only approximately 19.76 ha falls within the Development Envelope. Furthermore, Major Drainage Line habitat continues well beyond the boundaries of the Study Area. The Project is unlikely to have a significant impact on the species based on this criterion.
			Modify, destroy, remove or isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline	**Unlikely**	The Grey Falcon uses all of the habitat types in the Study Area for hunting, but the Major Drainage Line habitat is particularly suitable for nesting. Approximately 996.32 ha of Major Drainage Line habitat lies within the Study Area, however, only approximately 19.76 ha falls within the Development Envelope. Furthermore, Major Drainage Line habitat continues well beyond the boundaries of the Study Area. The Project is unlikely to have a significant impact on the species based on this criterion.
			Result in invasive species that are harmful to a vulnerable species becoming established in the vulnerable species' habitat	**Unlikely**	Introduced predators are identified as a possible major threat to the species within roosting habitat, as individuals frequently roost on bare ground exposing them to predation (Schoenjahn, 2018) (e.g. cats and foxes). Additionally, introduced species may compete for prey items. The presence of invasive species including introduced predators and invasive weeds may be exacerbated by the Project. However, this is not likely to have a significant impact on top of background levels already present. The Project is unlikely to have a significant impact on the species based on this criterion.
			Introduce disease that may cause the species to decline	**Unlikely**	The Project is not likely to introduce or increase transmission of any diseases relevant to this species. The Project is not likely to have a significant impact on the species based on this criterion.
			Interfere substantially with the recovery of the species.	**Unlikely**	The Project is unlikely to interfere substantially with any conservation recovery initiative for the species. The Project is unlikely to have a significant impact on the species based on this criterion.

Species	EPBC Act Listing	Likelihood of occurrence	MNES Significant Impact Criteria	Likelihood of Impact	Justification
Pilbara Olive Python *Liasis olivaceous barroni*	Vulnerable	Likely	Lead to a long-term decrease in the size of an important population of a species	**Unlikely**	Although previously recorded multiple times approximately 11 km southwest of the Study Area (DBCA, 2019a), no evidence of the Pilbara Olive Python was recorded during the survey undertaken by Biologic (2019c). Nonetheless, potential foraging and dispersal habitat (Major Drainage Line, Gorge/Gully and Hillcrest/Hillslope) of the Pilbara Olive Python is likely to be partially removed as part of the Project. While the population of the Study Area may potentially represent a source population it is unlikely to meet the definition of a 'important population', as defined by (DoE, 2013), and therefore will not have a significant impact on the species based on this criterion.
			Reduce the area of occupancy of an important population	**Unlikely**	Potential foraging and dispersal habitat (Major Drainage Line, Gorge/Gully and Hillcrest/Hillslope) of the Pilbara Olive Python is likely to be partially removed as part of the Project. While the population of the Study Area may potentially represent a source population it is unlikely to meet the definition of a 'important population', as defined by (DoE, 2013), and therefore will not have a significant impact on the species based on this criterion.
			Fragment an existing important population into two or more populations	**Unlikely**	Infrastructure of the Project is unlikely to restrict interaction between individuals. The species is highly mobile and able to travel extensive distances (Pearson, 2006; Tutt, 2004) and the Study Area is surrounded by suitable habitat to disperse to and within (including Hillcrest/Hillslope habitat, Gorge/Gully and Major Drainage Line habitat). Pilbara Olive Python may disperse over roads but drains and pits will represent barriers to movement so a degree of partial fragmentation of habitat may occur due to the Project. The Project is unlikely to have a significant impact on the species based on this criterion.
			Adversely affect habitat critical to the survival of a species	**Unlikely**	Potential foraging and dispersal habitat (Major Drainage Line, Gorge/Gully and Hillcrest/Hillslope) of the Pilbara Olive Python is likely to be partially removed as part of the Project. The remaining potential habitat is unlikely to be adversely affected by the Project. Thus, the Project is not likely to have a significant impact on the species based on this criterion.
			Disrupt the breeding cycle of an important population	**Unlikely**	Although habitat potentially being used by the species (despite no evidence of use having been found) will be lost. After clearing has occurred, the Project is unlikely to have an ongoing adverse impact on the breeding cycle of a population, if indeed one is present. While the population of the Study Area may potentially represent a source population it is unlikely to meet the definition of a 'important population', as defined by (DoE, 2013), and therefore will not have a significant impact on the species based on this criterion.

Species	EPBC Act Listing	Likelihood of occurrence	MNES Significant Impact Criteria	Likelihood of Impact	Justification
			Modify, destroy, remove or isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline	**Unlikely**	The species is highly mobile and able to travel extensive distances (Pearson, 2006; Tutt, 2004). Potential foraging and dispersal habitat (Major Drainage Line, Gorge/Gully and Hillcrest/Hillslope) of the Pilbara Olive Python is likely to be partially removed as part of the Project. The remaining potential habitat is unlikely to be adversely affected by the Project. The Project is unlikely to have a significant impact on the species based on this criterion.
			Result in invasive species that are harmful to a vulnerable species becoming established in the vulnerable species' habitat	**Unlikely**	Predation by introduced species (cats, foxes, dogs), particularly on juveniles, is identified as a major threat (TSSC, 2008b). Predation by cats, foxes and dogs on the prey that the Pilbara Olive Python relies upon as a food source is also a threat (Ellis, 2013). The presence of invasive species including introduced predators and invasive weeds may be exacerbated by the Project. However, this is not likely to have a significant impact on top of background levels already present. The Project is unlikely to have a significant impact on the species based on this criterion.
			Introduce disease that may cause the species to decline	**Unlikely**	The Project is not likely to introduce or increase transmission of any diseases relevant to this species. The Project is not likely to have a significant impact on the species based on this criterion.
			Interfere substantially with the recovery of the species.	**Unlikely**	The Project is unlikely to interfere substantially with any conservation recovery initiative for the species. The Project is unlikely to significant impact the species based on this criterion.

717130 724630 732130 739630 747130 754630

7703547
7696047
7688547
7681047
7673547
7666047
7658547

Habitat

- Denning
- Dispersal/ Foraging
- Supporting

Legend

- Study Area
- Development Envelope
- Indicative Disturbance Footprint

Biologic (2019)

- Northern Quoll

Desktop Assessment

- Northern Quoll

biologic Environmental Survey

N

1:140,000

0 1.5 3 6 km

Atlas Iron

Miralga Creek Vertebrate Fauna Impact Assessment

Fig. 6.1: Potential Northern Quoll habitat within the Study Area

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

Size A3. Created 21/01/2020

718663 726163 733663 741163 748663 756163

7703562
7696062
7688562
7681062
7673562
7666062
7658562

Ghost Significance

- Day Roost
- Night Roost
- No usage for Ghost Bat
- Potential Day Roost
- Potential Maternity Roost
- Potential Night Roost

Habitat

- Core
- Dispersal/ Foraging
- Supporting

Legend

- Study Area
- Development Envelope
- Indicative Disturbance Footprint
- Water Feature

Biologic (2019)

- Ghost Bat

Third Party Records

- Ghost Bat

biologic Environmental Survey

N

1:140,000

0 1.5 3 6 km

Atlas Iron

Miralga Creek Vertebrate Fauna Impact Assessment

Fig. 6.2: Potential Ghost Bat habitat within the Study Area

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

Size A3. Created 21/01/2020

717861 725361 732861 740361 747861 755361

7704030
7696530
7689030
7681530
7674030
7666530
7659030

PLNB Significance

- Nil
- Nocturnal Refuge
- Unknown

Habitat

- Core
- Dispersal/ Foraging
- Supporting

Legend

- Study Area
- Development Envelope
- Indicative Disturbance Footprint
- Water Feature

Biologic (2019)

- Pilbara Leaf-nosed Bat

Desktop Assessment

- Pilbara Leaf-nosed Bat

biologic Environmental Survey

N

1:140,000

0 1.5 3 6 km

Atlas Iron

Miralga Creek Vertebrate Fauna Impact Assessment

Fig. 6.3: Potential Pilbara Leaf-nosed Bat habitat within the Study Area

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

Size A3. Created 21/01/2020

719059 726559 734059 741559 749059 756559

7705153
7697653
7690153
7682653
7675153
7667653
7660153

Habitat

- Potential Breeding
- Dispersal/ Foraging
- Supporting

Legend

- Study Area
- Development Envelope
- Indicative Disturbance Footprint

Biologic (2019)

- Northern Brushtail Possum

biologic Environmental Survey

N

1:140,000

0 1.5 3 6 km

Atlas Iron

Miralga Creek Vertebrate Fauna Impact Assessment

Fig. 6.4: Potential Northern Brushtail Possum habitat within the Study Area

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

Size A3. Created 21/01/2020

719646 727146 734646 742146 749646 757146

7704919
7697419
7689919
7682419
7674919
7667419
7659919

Habitat

- Potential Breeding
- Dispersal/ Foraging
- Supporting

Legend

- Study Area
- Development Envelope
- Indicative Disturbance Footprint

Biologic (2019)

- Grey Falcon record

biologic Environmental Survey

N

1:140,000

0 1.5 3 6 km

Atlas Iron

Miralga Creek Vertebrate Fauna Impact Assessment

Fig. 6.5: Potential Grey Falcon habitat within the Study Area

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

Size A3. Created 21/01/2020

712884 720384 727884 735384 742884 750384 757884

7706520
7699020
7691520
7684020
7676520
7669020
7661520
7654020

Habitat

- Core Habitat
- Dispersal/ Foraging
- Supporting

Legend

- Study Area
- Development Envelope
- Indicative Disturbance Footprint
- Water Feature

Desktop Assessment

- Pilbara Olive Python record

biologic Environmental Survey

N

1:165,000

0 1.75 3.5 7 km

Atlas Iron

Miralga Creek Vertebrate Fauna Impact Assessment

Fig. 6.6: Potential Pilbara Olive Python habitat within the Study Area

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

Size A3. Created 21/01/2020

7. GENERAL MANAGEMENT RECOMMENDATIONS

The following broad management recommendations have been developed as a guide for mitigating the potential impacts to fauna of conservation importance, their respective habitat, and native fauna assemblages in general.

Mitigation has the principal aim of avoiding significant impacts and should be applied in a hierarchical order. The EPA (2014) mitigation hierarchy is: Avoid, Minimise, Rehabilitate, Offset. Similarly, the DoE (2016) mitigation hierarchy is:

1. Avoid impacts – preserve populations and habitat to avoid further loss.
2. Mitigate impacts – prevent habitat degradation and retain habitat function.
3. Monitor effectiveness of mitigation – ensure mitigation is effective and feeds back into an adaptive management plan

Avoid

The Project will avoid permanently impacting most caves in the Study Area. However, two caves are likely to be impacted by the Project and another (CMRC-15), in the Miralga East area, is within close proximity to mining. Due to the potential significance of the cave to the Ghost Bat, impacts to this cave should be avoided, if practicable. The Ghost Bats are likely to abandon this cave due to noise, vibration and dust but may re-occupy the cave once mining ceases providing the cave remains undamaged and the inner extremities of the cave is not intersected by the pit wall (Bat Call, 2020), and microclimate of the cave is not impacted. The Project will not impact the Lalla Rookh maternity cave as it lies outside of the Study Area.

Habitat loss and degradation due to the Project will be minimised in those habitats considered of high significance, namely the Gorge/Gully, Hillcrest/Hillslope and Major Drainage habitats. Approximately 0.76 ha of Gorge/Gully habitat, 58.87 ha of Hillcrest/Hillslope habitat and 19.58 ha of Major Drainage Line habitat lies within the Development Envelope but only a portion of this would actually be disturbed by the Project.

Minimise

A Significant Species Management Plan (SSMP) incorporating adaptive management is expected to assist in minimising and mitigating potential impacts to conservation significant fauna species. Other management procedures would also be developed to minimise potential impacts of the Project, including Ground Disturbance Procedures which would control and minimise the impacts of clearing.

Rehabilitate

A progressive rehabilitation and closure plan is expected to ensure disturbed areas are rehabilitated as soon as practical. Any artificial water bodies created during mining activity should be removed. As part of the rehabilitation of the Project, efforts should be made to replace

the habitat of conservation significant fauna that has been removed. For example, native vegetation characteristic of remnant vegetation in the surrounding landscape should be planted. Similarly, waste landforms should be formed to contain rocky features which will provide denning habitat for the Northern Quoll and refuge for other fauna such as reptiles.

Offset

Unlike mitigation actions which occur on-site and reduce the direct impact of that particular project, offsets are undertaken outside of project areas to counterbalance significant residual impacts (EPA, 2014).

Management

Management recommendations should reduce impacts to individuals of fauna of conservation significance; however, it is unlikely that all impacts will be avoided. This is because habitat loss/ degradation is the primary threat posed to each of these species but is also an integral part of mining activities.

Annual monitoring programs should be implemented for conservation significant species occurring within the Study Area (e.g. Northern Quoll, Ghost Bat, Pilbara Leaf-nosed Bat), which will assist in identifying if population declines occur beyond what is expected and inform strategic adaptive management strategies during or subsequent to development.

Table 7.1 details potential mitigation and management strategies for each impact source potentially arising from the Project.

Table 7.1: Potential mitigation and management strategies for each impact source identified as potentially arising from the Project (adapted from DoE, 2016)

Impact source	Potential mitigation and management strategy
Removal, Fragmentation or Modification of Habitat	• Where practicable, minimise land disturbance and clearing activities in habitat known to or likely to support species of conservation significance, especially Gorge/Gully, Hillcrest/Hillslope and Major Drainage habitats. • Stockpile cleared vegetation, topsoil and oversize waste overburden separately to ensure maximum reuse of these resources in subsequent rehabilitation. • Consider timing of clearing activities to reduce the impact on nesting birds and weaning season of the Northern Quoll (July - September; Hernandez-Santin *et al*., 2019) • If possible, consider retaining corridors or linkages, for example culverts or underpasses underneath roads in key habitat areas, so that individuals can move between fragmented fauna habitats. • Investigate strategies to reduce impacts of high frequency traffic on fauna and barriers to fauna dispersal created by the haul road corridors. • Implement a progressive rehabilitation and closure plan to ensure disturbed areas are rehabilitated as soon as practicable. • Erect signage to ensure no entry into conservation significant areas of the Study Area (except for necessary environmental management and monitoring).
Vehicle Strike	• Implement measures to minimise roadkill, especially for nocturnal species or those prone to collisions with vehicles. Such measures could include speed limits, awareness signage, erecting fences or barriers, and providing alternative routes for fauna such as underpasses. • Rumble strips on roads have led to decreased rates of roadkill of nocturnal animals in some areas. • Report and record road kills. • Restrict unauthorised off-track driving.
Introduced Species	• Conduct monitoring and control of feral animals. • Implement management measures to prevent any new feral species from colonising the Study Area. • Employ housekeeping measures such as covering up landfill and bin management. • Modify existing habitat to make it less suitable for feral cats e.g. reduce fragmentation by rehabilitating tracks and clearings and making it more structurally complex with shelter and escape sites. • Prepare and implement a weed management procedure to prevent the spread of existing weed species and the establishment of new weeds, especially those that have the potential to modify habitat for conservation significant fauna species. • Implement quarantine and hygiene controls to prevent the inadvertent introduction of Cane Toads.
Increased light	• Design artificial lighting to illuminate designated operations areas and limit illumination of the surrounding landscape, especially as water sources and substantial rocky outcrops. • Lights will be directed inwards towards mine activities to minimise effects of lighting on fauna in adjacent areas.
Increased noise	• Avoid blasting at night to minimise noise disruption to nocturnal species. • Implement the Blasting Management Plan and use adaptive management to mitigate unforeseen impacts.

Impact source	Potential mitigation and management strategy
Dust	• Implement dust suppression measures to reduce the effects of dust on vegetation and natural water bodies, and hence on fauna habitats and fauna assemblages, including; management of vehicle speed on unsealed roads, and proximity of habitats to blasting and excavation
Altered Fire Regimes	• Manage fuel loads of those weeds known to alter fire patterns to reduce risk of high fire intensity. • Prepare and implement a strategy to manage unplanned fires. • Educate and train all staff about equipment and procedures to be used in response to unexpected fire events.
Modification of Water Regimes	• Minimise and manage impacts to natural surface hydrology to ensure the Major Drainage habitats are maintained. • Ensure any water bodies created during mining activity are of as high-water quality as can be attained. • Minimise the potential for waterbirds to be attracted to artificial water sources. • Implement Surface Water and Groundwater Management Procedures
Miscellaneous	• Implement a Significant Species Management Plan (SSMP) that contains specific management and monitoring targets for fauna of conservation significance recorded within the Study Area, to be reviewed on a regular basis. • Implement the Blast Management Plan. • Educate mine site personnel and contractors about fauna of conservation significance. • Any incident that results in the injury or death of a fauna species of conservation significance should be reported to DBCA and specimens should be retained (i.e. stored in a freezer) for further examination.

8. CONCLUSION

This Assessment provides a summary of the survey work completed within the Study Area to date and assesses the potential impacts of the Project on terrestrial fauna of conservation significance. The main threat to fauna in the Study Area is habitat loss as a result of direct clearing for the mine and mine infrastructure.

The largest impacts are likely to occur to species of elevated conservation significance, in particular the Northern Quoll. At a local scale the Northern Quoll is likely to experience a Low to Moderate level of impact, primarily from removal, fragmentation and modification of habitat, but also potentially vehicle strike and the increased threat of introduced species. Furthermore, as the population occurring within the Study Area meets the definition of a 'high-density population' and thus a population 'important for the long-term survival of the species', the impacts to the species are likely to be significant, as defined by DAWE.

The Ghost Bat is listed as Vulnerable under the EPBC Act and the BC Act. Evidence of the occurrence of Ghost Bats was recorded at ten caves within the Study Area. Although all of the habitat types found within the Study Area would probably be used by the Ghost Bat for foraging and dispersal, roost sites are the most significant feature to the species and are restricted to the Hillcrest/Hillslope and Gorge/Gully habitat. At a local scale the species is likely to experience a Low to Moderate level of impact, primarily from removal, fragmentation and modification of habitat, but also potentially noise and vibration, dust and change in water regimes. Low level impacts may also potentially be experienced due to vehicle strike, introduced species and changed fire regimes. Of primary concern to the species is the potential impact to CMRC-15, a Potential Maternity cave for the species. The Project is likely to have a significant impact on the species, as defined by DAWE

The Pilbara Leaf-nosed Bat is listed as Vulnerable under the EPBC Act and the BC Act and has been confirmed in the Study Area. All habitat types in the Study Area are used by this species, however, Hillslope/Hillcrest and Major Drainage Line habitats are especially frequented. The impacts considered to be of most significance for this species are habitat loss and degradation, as well as potentially vehicle strike. However, these impacts are unlikely to extend beyond the Study Area to the regional level and the Project is not likely to have a significant impact on the species, as defined by DAWE.

The Northern Brushtail Possum is listed as Vulnerable under the EPBC Act (pending) and BC Act and has been confirmed in the Study Area. The Major Drainage Line habitat is likely to provide core habitat for the species, although other habitat that contain tree hollows and ground refuges (e.g. Gorge/Gully habitat) are also likely to support the species. The impact considered

to be of most significance for this species is habitat loss and degradation. However, overall the Project is not likely to have a significant impact on the species on a local or regional scale.

The Grey Falcon is listed as Vulnerable under the EPBC Act (pending) and Vulnerable under the BC Act and has been confirmed in the Study Area. This species uses all habitat types in the Study Area for foraging although is restricted to the Major Drainage Line for nesting habitat. At a local scale the species is likely to experience a Low to Moderate level of impact, primarily from removal, fragmentation and modification of habitat, but also potentially vehicle strike, the increased threat of introduced species and increased levels of light. Low level impacts may also be experienced due to increased levels of noise, dust and changed fire regimes. However, this impact is unlikely to extend beyond the Study Area to the regional level and the Project is not likely to have a significant impact on the species, as defined by DAWE.

The Peregrine Falcon (BC Act, Other Specially Protected Species), Western Pebble-mound Mouse (DBCA, Priority 4), Night Parrot (EPBC and BC Act, Endangered), Greater Bilby (EPBC and BC Act, Vulnerable), Spotted Ctenotus (DBCA, Priority 2), Long-tailed Dunnart (DBCA, Priority 4), Short-tailed Dunnart (DBCA, Priority 4) as well as 17 species of Migratory bird, were recorded or regarded as likely and/or possibly occurring in the Study Area, though none of these are likely to experience more than a low level of impact at the local and regional scale, if present.

This Assessment, by adopting a systematic approach and by considering a set of defined criteria supported by published research, identifies the potential impact sources most likely to be enhanced by the Project in relation to species of conservation significance present or likely to be present. It is understood that Atlas will implement a range of adaptive management plans and procedures for Project operation. The significant impacts to fauna and fauna habitats highlighted in this report should be considered and mitigation strategies that reduce potential impacts should be incorporated into relevant management plans / procedures.

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