Warrawoona Gold Project:

Conservation Significant Bat Species Impact Assessment

Biologic Environmental Survey

Report to Calidus Resources Ltd

October 2019

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			Name	Date
1	R. Bullen, C. Brooks	R. Bullen, M. O'Connell	Kate George	September 2019
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3	C. Knuckey	R. Bullen, M. O'Connell	Kate George	October 2019
4	C. Knuckey, C. Brooks	R. Bullen, M. O'Connell	Kate George	October 2019
5	C. Knuckey	-	Kate George	October 2019

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

EXECUTIVE SUMMARY

The Warrawoona Gold Project (Warrawoona) is located approximately 20 km south of Marble Bar in the Pilbara Region of Western Australia. Calidus Resources Limited (Calidus) is the proponent and is seeking to further develop the Warrawoona Gold Project.

This Impact Assessment provides a detailed summary of the recent survey work completed within the Warrawoona Gold Project area to date, and assesses the potential impacts from implementation of the proposed development to bat fauna listed under the under the *Biodiversity Conservation Act 2016* (BC Act) and the *Environmental Protection and Biodiversity Conservation Act 1999* (EPBC Act). These species are the Ghost Bat (*Macroderma gigas*) and Pilbara Leaf-nosed Bat (*Rhinonicteris aurantius*), both listed as Vulnerable under these Acts.

Investigations

Eight surveys targeting the two species of conservation significance have been undertaken in the area since 2016. This includes surveys monitoring population size fluctuations, and two VHF tracking studies to document key dispersal and foraging habitats. Key survey outcomes include:

- confirmed the regional significance of the Klondyke Queen and Bow Bells South roosts. Klondyke Queen representing a Maternity Roost for Ghost Bat and a Permanent Diurnal Roost for the Pilbara Leaf-nosed Bat. Bow Bells South represents a Diurnal Roost for the Ghost Bat and a Permanent Diurnal Roost for the Pilbara Leaf-nosed Bat.
- preferred foraging grounds for both species is likely to be out of the Study Area, with both species predominantly preferring areas to the north of the Warrawoona Ranges, although Pilbara Leaf-nosed Bats were consistently using the proposed Klondyke Pit and TSF as a flight path.

Potential Impact

Calidus is seeking to further develop the Warrawoona Project as follows:

- Develop an open pit and cutback an existing satellite open pit
- Develop an underground mine below the main Klondyke Open Pit
- Construct a conventional Carbon in Leach (CIL) processing plant
- Store tailings in a ‘valley fill’ Tailings Storage Facility (TSF)
- Construct waste rock dumps (WRD) and additional elements such as internal roads and material stockpiles.
- Construct support infrastructure including an accommodation village, wastewater treatment plants, mine water treatment plant, surface water management structures and power station.

Any modification or degradation of the primary roosts (Klondyke Queen and Bow Bells South) is considered to be the greatest risk of development to both species; however, Calidus have

committed to avoiding Klondyke Queen and Bow Bells South by establishing a ~32 ha Mining Exclusion Zone that contains a number of old workings with night/nocturnal roosts.

Given the proximity of the Klondyke pit to the Klondyke Queen roost, a geotechnical assessment was undertaken to assess the potential secondary effects of vibration from blasting on Klondyke Queen. The assessment found that if the modelled design parameters are utilised, drill and blast activities can safely occur to within 185 m of the Klondyke Queen and will not result in vibration exceeding that of human comfort levels, or result in collapse of this sensitive receiver (Martin, 2018). Geotechnical Consultant Peter O'Bryan and Associates reviewed the blasting recommendations by Martin (2018) and endorsed the finding that if the blasting recommendations are followed, it is unlikely that the integrity or stability of the Klondyke Queen will be compromised (Peter O'Bryan & Associates, 2019).

Given the proximity of development to the two known roosts, some level of impact is expected. Removal of habitat is considered to be the most significant impact source and likely to have a moderate magnitude of impact at the local and a low magnitude at the regional scale for both the Ghost Bat and the Pilbara Leaf-nosed Bat. The total indicative disturbance footprint for the proposed development within the Study Area is estimated to be 378.6 ha. The main areas of land disturbance are associated with the construction of a Tailings Storage Facility (TSF) (142.5 ha), Waste Rock Disposal (WRD) (95.1 ha), and Mining Pits (37.1 ha). In terms of direct loss of roost habitat, the proposed Klondyke Pit will result in the removal of five old workings (KQ488, Cuban, Kopckes Reward, Britannia, and St George 3). All workings are low value roosts for either Pilbara Leaf-nosed Bat (Nocturnal Refuge) and/or Ghost Bat (Night Roost).

Vibration, artificial lighting and/or noise, modification of water regimes and altered water quality, were also assessed as impact sources having a moderate level of impact to both the Ghost Bat and Pilbara Leaf-nosed Bat at the local scale, although only a low or negligible level at the regional scale. Vehicle strike was also assessed as having a moderate level of impact at the local scale for the Pilbara Leaf-nosed Bat.

Vibration - While drilling and blasting activity may not impact upon the structure of the roosts themselves, the proximity of Klondyke Queen to the Klondyke pit will mean that individuals of both species will experience small, but long-term, effects of vibration and noise. Given the long-term nature of the disturbance the population of both species roosting within maybe impacted during the mining process.

Artificial Lighting and/or Noise - The effects of artificial lighting on both species is relatively understudied, however given the proximity of the proposed pit to the Klondyke Queen roost, most individuals inhabiting Klondyke Queen will experience some level of artificial lighting. The degree to which this may impact upon each species is unknown but at the very least foraging and flight patterns are likely to be affected as a result of artificial lighting.

Modification of Water Regimes - The lower levels of the Klondyke Queen workings are thought to be connected to the water table (GRM, 2019), and therefore dewatering the Klondyke

Pit may reduce humidity in the adjacent Klondyke Queen workings. As the Pilbara Leaf-nosed Bat is dependent on humid microclimates (Baudinette *et al.*, 2000; Churchill, 2008) this may cause the Pilbara Leaf-nosed Bat to abandon the Permanent Diurnal Roost inside the Klondyke Queen workings and return to the nearest main permanent roost (Bow Bells South). Given the fluctuations of the Pilbara Leaf-nosed Bat population at Klondyke Queen, when compared to Bow Bells South (3 km west), abandonment of Klondyke Queen is unlikely to have a significant impact to the species at the regional scale, given the likely continued presence of the species elsewhere on the Warrawoona Range. The effect this will have on the Ghost Bat population within Klondyke is unclear, while literatures suggests that a higher humidity is required for the species, Ghost Bats have been recorded roosting and reproducing in caves that have low humidity levels (R. Bullen *pers. comm.* 2019).

Altered Water Quality – Alteration of water quality may impact both species through the presence of cyanide in the ore slurry at the proposed Tailing Storage Facility (TSF). There is an absence of data to support a <50 mg/L WAD cyanide discharge for the two conservation significant bat fauna present, and it is therefore crucial that the commitment to a concentration of WAD cyanide discharge <30 mg/L, based on data from a similar mining operation in NSW, is upheld. Water regimes may be impacted by the alteration for groundwater regimes which may impact upon the humidity of the roosts. Nickel arsenic will also be present in the Klondyke pit post-closure and may therefore impact upon drinking individuals; however, given that the pit will increase in salinity over time, it is not expected that wildlife will use the water for drinking and therefore be unaffected by its presence.

For Pilbara Leaf-nosed Bats vehicle strike is assessed as a moderate impact due to the species inquisitive nature coupled with the increased vehicle traffic adjacent to roosts. 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 and for this reason dust is believed to have a moderate level of impact to the species.

Mitigation

It is recommended that all aspects of the Project be designed with mitigation to impacts on native fauna considered.

It is understood that Calidus will implement a range of adaptive management plans for Project operation, including a significant species management plan, blasting management plan and procedures, metalliferous drainage management procedure, cyanide and groundwater management procedures. The significant impacts to bat fauna and their associated roost and foraging habitats highlighted in this report should be considered and incorporated into these management plans and used to address the noted knowledge gaps discussed.

It is highly recommended that monitoring programs be maintained for the life of the Project to confirm the continued presence and levels of activity at diurnal roosts, night refuges or in open habitats such as over pools or water sources.

1. INTRODUCTION

1.1 Project Description and Location

Warrawoona Gold Project (hereafter referred to as the Study Area). The Study Area for the project covers approximately 1,822 ha is located approximately 20 km south of Marble Bar within the Pilbara region of Western Australia (Figure 1.1).

Calidus Resources Limited (Calidus) is the proponent of this project. The Warrawoona Gold Project is upon the Warrawoona Ranges greenstone belt which has been worked since the late 1800s and has over 200 historic workings (mostly small shafts, stopes, and diggings). Of particular interest are the Klondyke Queen and Bow Bells South historical underground gold mines, which have been reported as significant roosting sites for conservation significant bat species (Biologic, 2017d, 2018, 2019f; Hall *et al.*, 1997), and have been monitored by Calidus since 2016.

Calidus is seeking to further develop the Warrawoona Project as follows:

- Develop an open pit and cutback an existing satellite open pit
- Develop an underground mine below the main Klondyke Open Pit
- Construct a conventional Carbon in Leach (CIL) processing plant
- Store tailings in a 'valley fill' Tailings Storage Facility (TSF)
- Construct waste rock dumps (WRD) and additional elements such as internal roads and material stockpiles.
- Construct support infrastructure including an accommodation village, wastewater treatment plants, mine water treatment plant, surface water management structures and power station.

1.2 Scope and Objectives

Within Western Australia, native fauna are protected under the *Biodiversity Conservation Act 2016* (BC Act) and at a national level under the *Environmental Protection and Biodiversity Conservation Act 1999* (EPBC Act). Two conservation significant bat species, the Ghost Bat *Macroderma gigas* and the Pilbara Leaf-nosed Bat *Rhinonicteris aurantius* are known to permanently occur within the Study Area in high numbers. Both are listed as Vulnerable under the EPBC Act and the BC Act, and are considered Matters of National Environmental Significance (MNES) (DoE, 2013a).

This report aims to provide a detailed summary of the recent targeted bat survey work completed within the Warrawoona Gold Project to date, and to use these data along with available published literature to assess the potential impacts from implementation of the proposed development for these two species.

The impacts are based on areas considered likely to be impacted prior to and following modification of the Study Area. This report is intended to support environmental approvals under Part IV of the Western Australian *Environmental Protection Act 1986* (EP Act).

The impact assessment relevant to other conservation significant fauna species present within the Study Area is detailed in Biologic (2019b). These species will not be discussed further in this document.

1.3 Assessment of Significance

This impact assessment was carried out in a manner consistent with the following documents developed by the Western Australian Environmental Protection Authority (EPA), the Department of Biodiversity, Conservation and Attractions (DBCA - formally Department of Parks and Wildlife [DPaW]), the Commonwealth Department of Environment and Energy (DoEE- formally the Department of Environment [DoE]), Department of Sustainability, Water, Population, and Communities (DSEWPaC) and Department of Environment, Water, Heritage and Arts (DEWHA):

- EPA (2016a) Environmental Factor Guideline: Terrestrial Fauna
- EPA (2016b) Technical Guidance: Survey Methods for Terrestrial Vertebrate Fauna (developed in collaboration with DBCA);
- EPA (2016c) Technical Guidance: Terrestrial Fauna Surveys;
- EPA (2018b) Statement of Environmental Principles, Factors and Objectives;
- TSSC (2016a): Conservation Advice: *Macroderma gigas;*
- TSSC (2016b) Conservation Advice: *Rhinonicteris aurantia (Pilbara form), Pilbara Leaf-nosed Bat*; and
- DEWHA (2010) Survey Guidelines for Australia's Threatened Bats.

1.3.1 Terrestrial fauna significance

Terrestrial fauna may be significant for a range of reasons, including:

- being identified as a threatened or priority species;
- species with restricted distribution;
- degree of historical impact from threatening processes; or
- providing an important function required to maintain the ecological integrity of a significant ecosystem (EPA, 2016a).

For the purposes of this report, species are deemed to be of conservation significance if they afforded protection under the EPBC Act and BC Act.

The Pilbara Leaf-nosed Bat is eligible for listing as Vulnerable as the species meets three criteria in the EPBC Act and Regulations (TSSC, 2016b);

- **Criterion 1:** It has undergone, is suspected to have undergone or is likely to undergo in the immediate future a substantial reduction in numbers;
- **Criterion 2:** Its geographic distribution is precarious for the survival of the species and is limited; and
- **Criterion 3:** The estimated total number of mature individuals is limited, and the number is likely to continue to decline. Its geographic distribution is precarious for its survival.

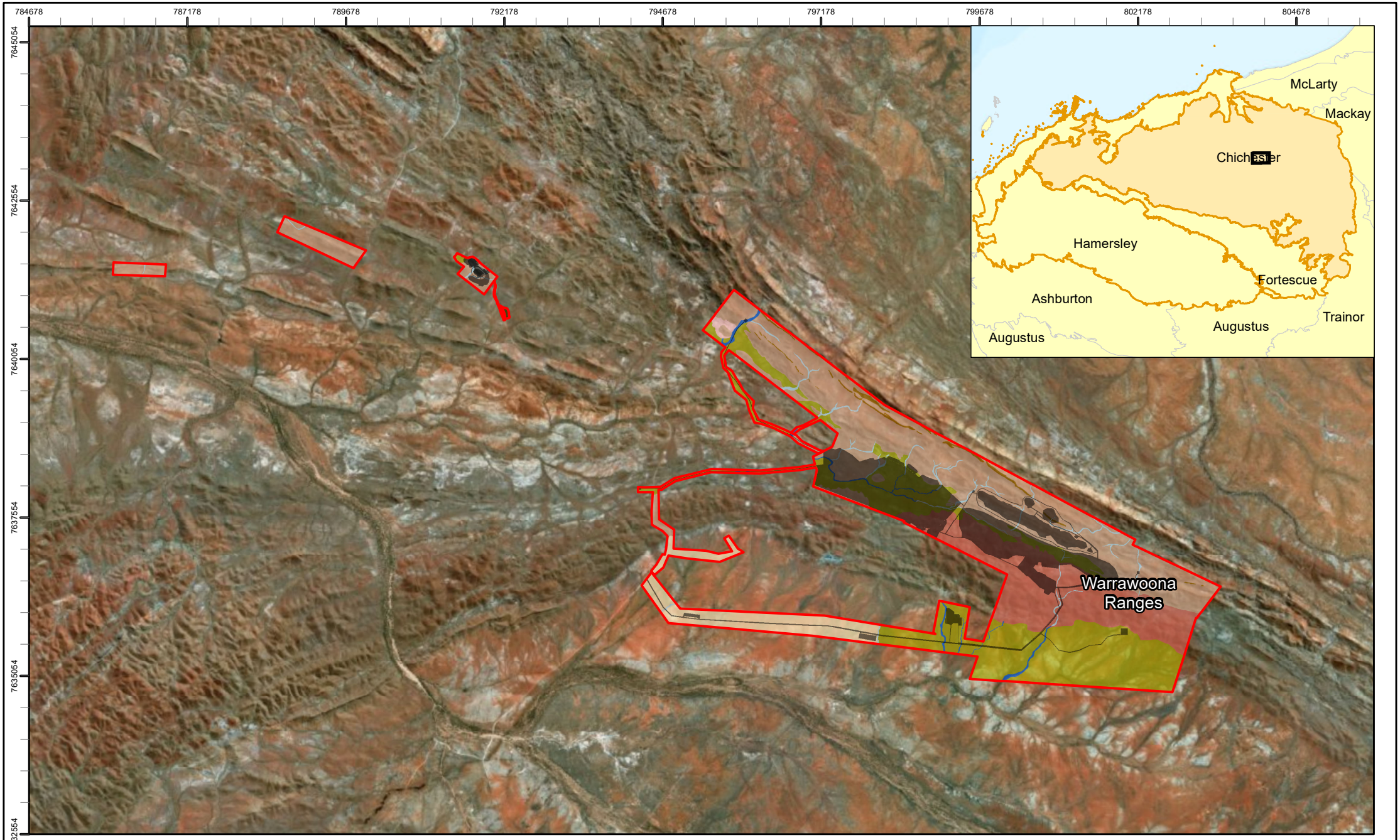
The Ghost Bat is eligible for listing as Vulnerable as the species meets Criteria 1 and 3 in the EPBC Act and Regulations as described above (TSSC, 2016a).

1.3.2 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, 2016a).

1.3.3 Impacts

A 'significant impact' is 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, 2013a). 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 (DoE, 2013a).



Legend

- Study Area
- Disturbance footprint

Habitat

- Claypan
- Disturbed
- Hillcrest/Hillslope
- Medium Drainage Line
- Minor Drainage Line
- Rocky Breakaway
- Rounded Hills
- Sandplain
- Stony Plain

biologic Environmental Survey

N

1:75,000

0 0.75 1.5 3 km

Calidus Resources - Warrawoona Gold Project
2019 Significant Species Survey
Warrawoon Bat Species Impact Assessment
Figure 1.1: Study Area and Regional Location

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

Size A4. Created 24/09/2019

2. PREVIOUS STUDIES

Eight surveys targeting the two conservation bat species utilising methods appropriate for their detection have been undertaken in the Study Area since 2016. This includes studies monitoring population sizes and fluctuations, assessments on changes to roosting habitat, a genetic study, and two recent tracking studies investigating foraging habitat within the Study Area. These surveys have been summarised below in Sections 2.1 and 2.2, and in Table 2.1.

Table 2.1 Summary of targeted bat survey effort conducted within the Study Area

Study	Objective	Season	Reference
Monitoring bats of conservation significance near Marble Bar, Western Australia: November 2016	Pilbara Leaf-nosed Bat and Ghost Bat Monitoring • Baseline data on usage and occupancy of mines in the Marble Bar area	Early Dry Season	Specialised Zoological (2017b)
Monitoring bats of conservation significance near Marble Bar, Western Australia: April 2017	Pilbara Leaf-nosed Bat and Ghost Bat Monitoring • Baseline data on usage and occupancy of mines in the Marble Bar area	Late Wet Season	Specialised Zoological (2017a)
Pilbara Ghost Bat Genetic Project 2017 (Unpublished report prepared for the BHP Billiton Iron Ore Pty Ltd).	Ghost Bat Genetic Project • Genetic and hormone analyses of ghost bat tissue and scats for increasing knowledge of cave use and movement by bats.	Late Wet Season	Biologic (2017b)
Warrawoona Targeted Bat Assessment September 2017	Pilbara Leaf-nosed Bat and Ghost Bat Monitoring • Population estimates (ultrasonic recordings and video censuses) • Assess underground workings within the Study Area in terms of providing roosting habitat for Pilbara Leaf-nosed Bat and Ghost Bat	Late Dry Season	Biologic (2017d)
Warrawoona Targeted Bat Assessment – July 2018	Pilbara Leaf-nosed Bat and Ghost Bat Monitoring • Population estimates (ultrasonic recordings and video censuses)	Dry Season	Biologic (2018)
Warrawoona Targeted Bat Assessment – April 2019	Pilbara Leaf-nosed Bat and Ghost Bat Monitoring • Population estimates (ultrasonic recordings and video censuses)	Late Wet Season	Biologic (2019f)
Warrawoona Gold Project: VHF Bat Foraging Studies July 2018	Pilbara Leaf-nosed Bat and Ghost Bat Foraging Study (VHF) • Use VHF tracking to assess foraging habitats and movement patterns	Dry Season	Biologic (2019e)
Warrawoona Gold Project: VHF Bat Foraging Studies April 2019	Pilbara Leaf-nosed Bat and Ghost Bat Foraging Study (VHF) • Use VHF tracking to assess foraging habitats and movement patterns	Late Wet Season	Biologic (2019d in prep)

2.1 Population Monitoring Studies

Annual monitoring of the conservation significant bat populations within the Study Area has been undertaken since 2016, which has included five targeted surveys and a Ghost Bat genetic study. The targeted surveys have utilised ultrasonic recordings of bat calls and population censuses via video recordings to determine baseline data on usage and monitor occupancy of potential and known roosts within the Study Area. Of particular interest to these surveys were the Klondyke Queen and Bow Bells South mines, which confirmed their status as diurnal (Pilbara Leaf-nosed Bat) or maternity roosts (Ghost Bat) for the species. A summary of the results of these surveys, including the most recent classification of the roosts surveyed, is presented in Table 2.2 and Appendix A.

The Ghost Bat genetic study undertaken in 2017 (Biologic, 2017b) was a broad-scale investigation into cave usage and bat movement within the Pilbara, undertaken at 74 caves or adits across seven surveys including individuals captured at Klondyke Queen and Comet. The study found that individuals from these sites were genetically clustered within the Chichester subregion. However, genetic diversity was consistently high amongst regional populations, consistent with high levels of dispersal providing genetic connectivity.

2.2 VHF Foraging Habitat studies

Two VHF tracking studies have been conducted within the Study Area to date, in 2018 and 2019 (Biologic, 2019d, 2019e). The purpose of the studies was to gain a better understanding of the movements of the two bat species occurring within the Study Area and to determine areas of significant habitats, particularly with regards to foraging grounds. This was completed through attaching digitally encoded VHF transmitters to Pilbara Leaf-nosed Bats and Ghost Bats, which were detected by an automated VHF tracking system designed to record movement.

In general, it was determined that the proposed Klondyke Pit and TSF were not significant foraging grounds for either species, although Pilbara Leaf-nosed Bats were consistently using these development areas as a flight path. Ghost Bats tended to leave the Study Area upon emergence from their diurnal roost, using flight paths outside the Study Area along the northern edge of the Warrawoona Ranges. The preferred foraging grounds for both species are likely to be out of the Study Area, particularly to the plains north of the Warrawoona Ranges, and for Pilbara Leaf-nosed Bats also the region north-west of Bow Bells. Copenhagen did not represent a crucial foraging ground or water source for either species; however, its significance may increase towards the end of the dry season. The 2019 study also recorded a single Ghost Bat individual roosting and foraging at the Comet mine for three consecutive evenings over the course of the study (Biologic, 2019d). This individual was originally observed to be a resident at Klondyke Queen where it was also tagged (Biologic, 2019d).

Table 2.2 Roost classification of mine workings within the Study Area, with annual activity levels

Site	Roost significance (highest recorded)		In Study Area	In Klondyke Mine Footprint	Outside Study Area
	Pilbara Leaf-nosed Bat	Ghost Bat			
Bow Bells Block 1	Nocturnal Refuge	Night Roost	X		
Bow Bells South - Adit	Permanent Diurnal Roost	Occasional Diurnal Roost	X		
Bow Bells South - Shaft	Permanent Diurnal Roost	Occasional Diurnal Roost	X		
Britannia	Nocturnal Refuge	-	X	X	
British Exploration of Australia	Nocturnal Refuge	-	X		
Comet	Nocturnal Refuge	Permanent Maternity Roost			X
Copenhagen Open Cut	Foraging site	Foraging site	X		
Criterion	Nocturnal Refuge	Possible occasional Diurnal Roost	X		
Cuban	Nocturnal Refuge	Night roost	X		
Dawson City	Nocturnal Refuge	Occasional Diurnal Roost	X		
Dead Camel	Destroyed (was Nocturnal Refuge)	Destroyed	X	X	
Gauntlet	Nocturnal Refuge	Night Roost	X		
Gauntlet SE	Nocturnal Refuge	Night Roost	X		
Gift – Decline	Nocturnal Refuge	-	X		
Gift – Shaft	Nocturnal Refuge	-	X		
Golden Gauntlet	Nocturnal Refuge	-	X		
Klondyke 1 East	Nocturnal Refuge	Night Roost	X		
Klondyke 1 west	Nocturnal Refuge	Night Roost	X		
Klondyke Boulder	Nocturnal Refuge	Possible occasional Diurnal Roost	X		
Klondyke Queen - Adit	Permanent Diurnal Roost	Permanent Maternity Roost	X		
Klondyke Queen – Hill Top	Permanent Diurnal Roost	Permanent Maternity Roost	X		
Klondyke Queen – Open Cut	Permanent Diurnal Roost	Permanent Maternity Roost	X		
Klondyke Queen 488	Nocturnal Refuge	Night Roost	X		

Site	Roost significance (highest recorded)		In Study Area	In Klondyke Mine Footprint	Outside Study Area
	Pilbara Leaf-nosed Bat	Ghost Bat			
Kopckes Reward	Nocturnal Refuge	-	X	X	
Marble Bar Copper	Nocturnal Refuge	Foraging Site			X
Mullan's	Nocturnal Refuge	Possible Diurnal Roost	X		
St George	Nocturnal Refuge	Night Roost	X	X	
St George 3	Nocturnal Refuge	-	X	X	
Trible Event NW	Nocturnal Refuge	Night Roost	X		
Trump	Nocturnal Refuge	Foraging site			X
Wheel of Fortune East	Nocturnal Refuge	Night Roost	X		

3. KEY RECEPTORS

3.1 Bat fauna of Conservation Significance

3.1.1 Ghost Bat

Conventionally accepted as *Macroderma gigas* (TSSC, 2016a), *Macroderma* is a monotypic genus endemic to Australia. Their range is now restricted to the Pilbara, the Kimberley, the northern part of the Northern Territory, coastal and near coastal Queensland from Cape York to near Rockhampton (Churchill, 2008), and Western Queensland (TSSC, 2016a). The distribution of Ghost Bats in the Pilbara is determined by the presence of suitable roosting sites, either natural caves or man-made mines and adits. Natural roosts generally comprise deep, complex caves beneath bluffs or low rounded hills composed of Marra Mamba or Brockman Iron Formation (Armstrong & Anstee, 2000). Armstrong and Anstee (2000) reported high relative humidity (82 - 84 %) at two known maternity roosts in the Hamersley Ranges. The remaining caves had relative humidity readings of between 14 - 31 %. Caves used by the species can be classified into five types: night roosts, night/possible diurnal roosts, diurnal roosts, diurnal roosts/possible maternity roosts and maternity roosts.

Most known breeding locations for this species occur in the Chichester subregion of the Pilbara, which also contains the largest populations for the species, largely restricted to disused mines (Armstrong & Anstee, 2000; Biologic, 2017a). The largest colonies occur around Bamboo Creek, Marble Bar and Nullagine (R. Bullen, *pers. comm*.). A number of these roosts have disappeared, or show evidence of collapse, flooding, human intrusion or nearby active mineral exploration (TSSC, 2016). There are few known maternity roosts in natural caves in the Pilbara, with the largest confirmed observations known from natural caves occurring in the Robe Valley near Pannawonica (15-35 individuals sighted in separate caves) (R. Bullen, *pers. comm*.).

Two sites within the Study Area, Klondyke Queen (permanent maternity roost) and Bow Bells South (occasional diurnal roost), are considered significant Ghost Bat roosts (Biologic, 2019f). The Ghost Bat was first confirmed at Klondyke Queen in 1957, approximately twelve years subsequent to the cessation of mining. Since this time the species has been confirmed consistently, via visual observations, from the Klondyke Queen adit. Breeding activity of the species was confirmed during the early 1990's (Hall *et al.*, 1997), with several gravid and lactating females recorded. The consistent presence of the species indicates that the Klondyke Queen roost is likely to be permanent and represent a maternity site. The highest count of the species at the adit is 475, recorded via visual counts and infra-red video in April 2019 (Biologic, 2019f) (Table 1.1). The population of Ghost Bat in the Warrawoona Study Area is estimated to be 500 individuals *(*R. Bullen *pers comms,* 3 October 2019*).*

The species has also been recorded at various disused mines within the vicinity of the Study Area, specifically at Bow Bells, Comet (breeding records), Coronation, Marble Bar Copper and

Trump mines (Armstrong & Anstee, 2000; Hall *et al.*, 1997). Together with other large colonies such as Lalla Rookh, the subregion is known to support a population of approximately 1,500 individuals (TSSC, 2016a). Table 3.1 below summarizes the population estimates of the species at the Klondyke Queen in the Study Area.

Table 3.1 Previous counts of Ghost Bat recorded at Klondyke Queen

Date	*No Recorded	Notes	Source
1957	#		Armstrong and Anstee (2000)
28/05/1959	287	May have contained repeat individuals	Douglas (1967)
01/05/1981	40		Hall *et al.* (1997)
08/07/1987	8		
21/09/1992	#	2 gravid and 2 with mammae present females; 5 males	
22/12/1992	#	4 lactating females; 1 with mammae present;	
03/10/1993	#	3 gravid females, 6 males with abdominal testes	
11/04/1993	#	3 females with mammae, 8 males with scrotal testes	
24/04/1994	98+	12 males, 1 female	
14/07/1994	20+	2 gravid females	
18/07/1995	40+		
20/06/1996	30+		
12/06/2001	254		Biota (2001)
13/06/2001	338		
29/06/2001	108	On nights after drilling activity	
30/06/2001	127		
01/07/2001	107		
02/07/2001	121		
03/07/2001	128		
04/07/2001	106		
05/07/2001	366		
Feb 2006	185	Visual count of bats exiting	McKenzie and Bullen (2009)
07/11/2016	366	No refers to observed, 352 recorded via camera	Specialised Zoological (2017b)
08/11/2016	80	No refers to observed, 102 recorded via camera	
22/04/2017	24		Specialised Zoological (2017a)
28/04/2017	28		
05/05/2017	200+	Five captured, four females and one male	Biologic (2017b)
Sept 2017	265	Visual count of bats exiting	Biologic (2017d)
July 2018	450	Visual count of bats exiting	Biologic (2018)
April 2019	475	Visual count of bats exiting and infra-red video	Biologic (2019f)

Where '+' is noted, means this was the minimum number of bats present at the time
'#' indicates bats confirmed present but no count was completed
* Methods to achieve this figure may have varied

3.1.2 Pilbara Leaf-nosed Bat

The Pilbara Leaf-nosed Bat (*Rhinonicteris aurantius*) population existing within the Pilbara is geographically isolated from the tropical populations of Leaf-nosed Bat by approximately 400 km of the Great Sandy Desert (Armstrong, 2001). The Pilbara population is regarded as representing a single interbreeding population comprising multiple colonies (TSSC, 2016b). Recently updated conservation advice stated that there were at least 10 confirmed day roosts (including maternity roosts), and a further 23 unconfirmed roosts throughout the Pilbara region (TSSC, 2016b), although this is likely to be an underestimate based on unpublished data.

Across northern Australia the species is reliant on roost sites in caves or mine adits with stable, very hot (28 – 32 ºC) and very humid (96 – 100 %) microclimates (Churchill, 2008). This is a result of their limited ability to conserve heat and water (Armstrong, 2001; Churchill, 1991). Caves and abandoned mines deep enough to create this environment are relatively uncommon in the Pilbara (van Dyck & Strahan, 2008), which limits the availability of diurnal roosts for this species.

Two Pilbara Leaf-nosed Bat colonies are confirmed to be present within the Study Area; a large colony at Bow Bells South and a small number of diurnally roosting bats at the Klondyke Queen. Both are considered Permanent Diurnal Roosts (Biologic, 2019f), with observations of pregnant bats exiting the Bow Bells South adit in January 2019 (R. Bullen *pers comms* in Biologic, 2019f). The numbers at Klondyke have fluctuated substantially the colony was discovered (Table 3.2), The population of the Pilbara Leaf-nose Bat on the Warrawoona Study Area is estimated at approximately 1500-2000 individuals. Pilbara Leaf-nosed Bat counts within the Klondyke Queen complex and Bow Bells South fluctuate depending on which roost the individuals are utilising at the time of monitoring (R. Bullen *pers comms,* 3 October 2019), although bats have consistently been confirmed roosting within the adit in addition to large number of echolocation calls associated with these observations.

TSSC (2016b) categorises underground refuges used by the Pilbara Leaf-nosed Bat into one the following standard categories:

- *Permanent diurnal roosts* (Priority 1*)* —occupied year-round and likely the focus for some part of the 9-month breeding cycle; considered as critical habitat that is essential for the daily survival of the Pilbara Leaf-nosed Bat
- *Non-permanent breeding roosts* (Priority 2) —evidence of usage during some part of the 9-month breeding cycle (July–March), but not occupied year-round; considered as critical habitat that is essential for both the daily and long-term survival of the Pilbara Leaf-nosed Bat.
- *Transitory diurnal roosts* (Priority 3) —occupied for part of the year only, outside the breeding season (i.e. April–June), and which could facilitate long distance dispersal in the region; considered as critical habitat that is essential for both the daily and long-term survival of the Pilbara Leaf-nosed Bat.

- *Nocturnal refuge* (Priority 4) —occupied or entered at night for resting, feeding or other purposes, with perching not a requirement. Excludes overhangs. Not considered critical habitat but are important for persistence in a local area.

The classification of the roosts present within the Study Area, and therefore their significance for the species, are presented below in Table 2.2.

The foraging habitat of the Pilbara Leaf-nosed Bat is also classified into priority categories based on their importance for the species, as defined in Table 3.3 below and shown on Figure 5.2. Based on these categories, the Study Area potentially provides a large area of potential foraging habitat for the species. Despite this, the VHF tracking studies (Biologic, 2019d, 2019e) concluded that the preferred foraging grounds for the species extends outside the Study Area boundary, particular north-west of the Bow Bells roost, and in plains north of the Warrawoona Ranges.

Table 3.2: Previous counts of Pilbara Leaf-nosed Bat recorded at Klondyke Queen

Date	*Estimated Population	Notes	Source
1967	-	Douglas (1967) netted the mine entrance on multiple occasions in search of Ghost Bat, no *R. Aurantia* were recorded.	Douglas (1967)
1/05/1981	~350 (between 300 and 500)	Comprising 40 non-pregnant females and 35 males. Bats commenced exodus half an hour after sunset. They appeared to time their exits with other bats (*V. Finlaysoni and Taphozous* spp.). Two and a half hours after sunset *R. Aurantia* began to return. Two hours later the ratio of *R. Aurantia* returning had exceeded those leaving	Churchill *et al.* (1988)
21/09/1992	1+	One male (no breeding evidence)	Hall *et al.* (1997)
14/07/1994	5+	One female, four males (no breeding evidence)	
18/07/1995	7+	One female, five males (no breeding evidence)	
1/06/1996	5+	Exact date within month unknown	Armstrong (2001)
1/09/1996	4	Exact date within month unknown	
1/05/1997	2	Exact date within month unknown	
1/09/1997	1	Exact date within month unknown	
1/03/1998	2	Exact date within month unknown	
1/12/1998	2	Exact date within month unknown	
12/06/2001	10+		Armstrong (2010) Biota (2001)
13/06/2001	10+		
29/06/2001	10+		
30/06/2001	10+		
1/07/2001	10+		
2/07/2001	10+		
3/07/2001	10+		
4/07/2001	10+		
5/07/2001	10+		
8/11/2016	+	152 calls, first record +8 after civil twilight	Specialised Zoological (2017b)
9/11/2016	+	96 calls, first record -12 before civil twilight	
10/11/2016	+	73 calls, first record -8 before civil twilight	
26/04/2017	+	23 calls recorded from adit, 72 recorded from roof, first call was 1.47 hours after civil twilight	Specialised Zoological (2017a)
27/04/2017	+	56 calls recorded from adit, 226 recorded from roof, first call was 0.59 minutes after civil twilight	
28/04/2017	+	77 calls recorded from adit, 307 recorded from roof, first call was 12 minutes after civil twilight	
29/04/2017	+	98 calls recorded from adit, 457 recorded from roof, first call was 13 minutes after civil twilight	
5/05/2017	+	Individuals recorded acoustically at the adit entrance near civil twilight	Biologic (2017b)
Sept 2017	+	>3000 calls recorded acoustically, and bats sighted visually at the adit entrance near civil twilight	Biologic (2017d)
July 2018	+	>4,800 calls recorded acoustically, and bats sighted visually at the mine entrances near civil twilight, however a video recording within the upper adit confirmed that there were no bats roosting diurnally.	Biologic (2018)
April 2019	~1500	1,500 recorded exiting by IR-lit video on a single night	Biologic (2019f)

'+' indicates the minimum number of individuals present - or if no number indicates that bats were present

Table 3.3 Classification of habitat types within the Warrawoona Study Area with priority foraging habitats of Pilbara Leaf-nosed Bat, as defined by TSSC (2016b)

Foraging habitat category	Priority	Description	Availability within the Warrawoona Study Area	Area (ha) (% of Study Area)
Gorges with pools	Priority 1 (sites of relatively large biomass production, sometimes containing caves)	Watercourses through upland areas bounded by sheer rock walls for parts of their length, often containing pools that remain for weeks or months;	No gorges with pools are recorded in the Study Area. Temporary waterbodies are likely to present in the Claypan or Major Drainage Line after significant rainfall events.	0
Gullies	Priority 2 (less biomass production than Priority 1 gorge habitat)	Primary drainage with limited riparian development in upland rocky habitats, sometimes containing small pools that may last for weeks	Gorge/gully habitat is not a recorded habitat type within the Study Area. Minor gullies may exist in the Rounded Hills habitat.	0
Rocky outcrop	Priority 3	Areas of exposed rock at the top of rocky outcrop and mesa hills that contain caves and overhangs, and boulder piles in the granite terrains	Rocky breakaway habitat is recorded in the Study Area, running in a linear fashion along the northern edge of the Study Area. Although it represents the highest quality Priority 3 foraging habitat within the Study Area, only 18.6 ha of this habitat type has been recorded, and such represents a small proportion of the total area. The Rounded hills habitat type may potentially present some sections of rocky outcrop, as may the Hillcrest/ hillslope.	18.6 (1.0 %)
Major watercourses	Priority 4 (generally supports higher productivity of biomass than the surrounding habitats)	Riparian vegetation on flat land plus the main gravelly or sandy channel of the riverbed, sometimes containing pools that persist for weeks or months	The Study Area is dissected by both Medium Drainage Line and Minor Drainage Line, associated with drainage from the Hillcrest/ hillslopes and ranges throughout the Study Area. It is likely that temporary waterbodies will be present in these habitat types after significant rainfall events. The Claypan habitat may also contain suitable Priority 4 habitat through inundation after heavy rainfall events.	55.5 (3.1 %)
Open grassland and woodland	Priority 5	Dominated by Triodia, on lowland plains, colluvial slopes and hilltops.	The Sandplain, Stony Plain, Hillcrest/ hillslope, and Rounded hills habitat types recorded in the Study Area are associated with *Triodia* hummock grassland, with scattered *Eucalyptus* trees and mallee, and *Acacia* and *Grevillea* shrubs. Combined, these habitat types make up the vast majority of the Study Area.	1,742.0 (95.9 %)

4. Potential Impact Sources

The broad threatening processes for fauna of the Pilbara include the expansion of mining, agriculture, and tourism, which leads to over-grazing, frequent wildfires, exotic species (promoting predation and competition), and changed hydrological regimes (Carwardine *et al.*, 2014). Of these threats, impact sources inherent to the proposed development of the Study Area were identified. Impact sources result in an impact and can be generally categorised as either direct or indirect (EPA, 2016a). These impact sources can be permanent or temporary, and result in changes to fauna or fauna habitat beyond the immediate development (EPA, 2016a).

4.1 Direct

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

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), including the clearing of land and vegetation for mining activities (including mine pits, tailing storage facilities and waste rock landforms) and associated infrastructure (*e.g.* roads and pipelines) (EPA, 2016a).

Within the Study Area, the removal, fragmentation, or modification of fauna habitat will occur through activities such as clearing of vegetation, the removal of topsoil and landforms, and potential roost collapse from Drill and Blast events. The total indicative disturbance footprint for the proposed development within the Study Area is estimated to be 378.6 ha. The main areas of land disturbance are associated with the construction of a Tailings Storage Facility (TSF) (142.5 ha), Waste Rock Disposal (WRD) (95.1 ha), and Mining Pits (37.1 ha).

Table 4.1: Breakdown of disturbance footprint with fauna habitats

Habitat	Study Area	In Development Footprint	
	ha	ha	%
Disturbed	5.9	3.40	57.63
Claypan	**6**	0.00	0.00
Medium Drainage Line	**18**	5.80	31.35
Rocky Breakaway	**18**	0.71	3.82
Minor Drainage Line	**31**	7.14	23.03
Sandplain	**137**	10.15	7.41
Rounded Hills	**339**	88.23	26.03
Stony Plain	**548**	142.77	26.05
Hillcrest/Hillslope	**718**	120.02	16.72
	1,822	378.23	

Construction of roads (16 m wide to accommodate heavy vehicles) provides a source of habitat fragmentation within the Study Area, and even highly mobile species such as bats may experience some disruptions if they are unwilling to fly across large cleared areas while foraging (Hopkins, 2015).

The Ghost Bat is known to occur in close proximity to mining, for example at the Abydos DSO Project, Wodgina DSO Project, Mt Webber DSO Project, BHP Cattle Gorge, BHP MAC, and Poondano mine site. However, the presence of Pilbara-Leaf nosed Bat adjacent to mining is less well documented. This species is known to be sensitive to disturbances within or in close proximity to roost caves (TSSC, 2016b) and are known to abandon caves where construction or mining activities occur within 50 m of the roost (Bullen & Creese, 2014). Displaced bats are susceptible to death through dehydration, particularly during the dry season (Churchill, 2008).

There are currently three known Pilbara Leaf-nosed Bat permanent roost caves in reasonably close proximity to active large-scale open cut mining operations. These are the Atlas Iron Mt Webber mine at ~ 1 km, Ratty Spring at ~ 1.3 km and Paraburdoo East roost at ~ 2 km from active open cut pits. In addition, the no longer active BHP Cattle Gorge mine is within 500 m of a roost. Ongoing monitoring has confirmed that these four caves (three at active mines and one at an inactive mine) have remained viable diurnal roosts for the species and remain maternity roost candidates (B. Bullen *pers. comm*. 2019). The opportunity for the bat species to respond to disturbances in the short term is assumed to be limited by the availability of suitable alternative roosts nearby (TSSC, 2016b). The nearest proven Permanent Diurnal Roost to the proposed Project is Bow Bells South, located approximately 3.6 kilometres west of the proposed Klondyke open pit. Operational impacts such as noise dust, light and vibration impact to Bow Bells South are likely to be minimal as the workings are deep and complex and far from the main Klondyke Pit, Plant and Camp.

In terms of direct loss of roost habitat, the proposed Klondyke Pit will result in the removal of five old workings (KQ488, Cuban, Kopckes Reward, St George 3 and Britannia). All five workings are low value roosts for either Pilbara Leaf-nosed Bat (Nocturnal Refuge) and/or Ghost Bat (Night Roost) (Table 4.2).

Table 4.2 Summary of roosts from within and proximal to the Warrawoona Gold Project to be removed during mining

Workings	Location	Type of Roost	
		Pilbara Leaf-nosed Bat	Ghost Bat
KQ488	-21.3381, 119.8949	Nocturnal Refuge	Night Roost
Cuban	-21.3411, 119.8997	Nocturnal Refuge	Night Roost
Britannia	-21.3417, 119.9013	Nocturnal Refuge	-
Kopckes Reward	-21.3424, 119.9032	Nocturnal Refuge	-
St George 3	-21.3385, 119.8992	Nocturnal Refuge	

In terms of foraging habitat, and based on priority foraging habitat classifications as defined by TSSC (2016b), the majority of the Study Area (96.6%) represents foraging habitat Category 5 (open grassland), with no Category 1 or Category 2 foraging habitat recorded within the Study Area (Table 3.3). VHF foraging studies indicate that in general, both Ghost Bat and Pilbara Leaf-nosed Bat forage outside the Study Area (Biologic, 2019d, 2019e). However, although the quantitative loss of foraging habitat is not anticipated to have a significant impact on either species, bats may experience disruptions if they are unwilling to fly across large cleared areas to get to foraging areas (Hopkins, 2015), particularly north and south of the Warrawoona Ranges.

4.1.2 Vibration

The potential instability of historic underground workings is regarded as a significant threat, contributing to the Vulnerable listing status of both Pilbara Leaf-nosed Bat and Ghost Bat species (TSSC, 2016a, 2016b). Sites such as Klondyke Queen have already experienced several small collapses (TSSC, 2016a). Blasting within the proposed adjacent Klondyke Pit could cause further instability of the Klondyke Queen workings.

Blast It Global was engaged to assess the effects of blasting at the proposed Klondyke Pit on the structure of the roost at Klondyke Queen, based on vibration limits evaluated in Martin (2012). A set of blast parameters were modelled for potential blast vibration, air blast overpressure and fly rock to determine a safe set of blast parameters at the Warrawoona Gold Project (Martin, 2018). The modelled parameters determined that drill and blast activities could safely occur to within 185 m of the Klondyke Queen workings without vibration exceeding relevant comfort levels, or resulting in a collapse at the roost (Martin, 2018). It should be noted that this blast assessment report is a desktop study of the proposed blasting parameters to be used on the Warrawoona Gold Project, and not an assessment of the actual roost location

Geotechnical Consultant Peter O'Bryan and Associates reviewed the recommendations by Martin (2018), and endorsed the finding that if the blasting recommendations are followed, than it is unlikely that the integrity or stability of the Klondyke Queen will be compromised (Peter O'Bryan & Associates, 2019).

A 200 m buffer has also been applied to the underground in a vertical context from the bottom of the KQ workings. Given that blasts in an underground mine are significantly smaller compared to an open pit (e.g. 10,000 t vs. 100,000 t) and use much smaller blast hole diameters (76 mm vs. 102 mm) it was considered that the vibration would be less than what was modelled by (Martin, 2018)

Based on these risks, it is highly recommended that a Significant Species Management Plan (SSMP) with adaptive management be implemented for the life of the Project until the criteria of the mine closure plan have been achieved. This is in recognition that despite predictions based on species-specific research and mining studies, the outcomes for the local colonies from disturbance to significant roost sites and flight paths are not definitively known. The commencement of development in the Study Area from east to west towards the roost may allow for potential impacts to be regularly monitored, with risks mitigated, as they arise.

4.2 Indirect

The impact sources most commonly causing indirect impacts to bat fauna are discussed below in relation to the development proposed within the Study Area and are summarized in Table 4.3.

4.2.1 Introduced Species

Introduced species pose a range of potential impacts to Pilbara fauna species. These include over-grazing and land degradation from introduced herbivores (e.g. camels, goats, pigs, donkeys), competition (e.g. rabbits, cats), habitat degradation from weeds (e.g. Buffel grass), 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 (Carwardine *et al.*, 2014). 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 (Biota, 2014).

Feral cats have been recorded within the Study Area via motion camera (Biologic, 2019a). Other invasive predators (Red foxes *Vulpes vulpes*) and grazers (e.g. camel *Camelus dromedarius*) have been recorded multiple times in the vicinity of the Study Area (Bamford Consulting, 2009; ecologia Environment, 2012; How *et al.*, 1991) and by their nature are likely to become present. Buffel grass (*Cenchrus ciliaris*) is listed as high ecological impact and rapid invasiveness (DBCA, 2019), and has been previously recorded in the Study Area, as has European cattle *Bos taurus* (Biologic, 2017c).

However, the two bat species have 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). Although some population declines could be attributable to competition for prey with foxes and feral cats (Duncan *et al.*, 1999; TSSC, 2016a), invasive species are unlikely to have a significant effect overall, and in comparison to other key threats. Carwardine *et al.* (2014) estimated a 50-75 % persistence probability for the Pilbara Leaf-nosed Bat both without and with strategies to abate these threats.

There is evidence that Ghost bats predate on cane toads and are susceptible to their toxicity (Purtill 2014; White et al. 2016). Cane Toads are not currently established in the Pilbara, and the Project is unlikely to increase the opportunity for Cane Toads to become established. Cane Toads absorb water through their skin from dew or any moist material and need constant access to moisture to survive (Child, 2009; Cohen, 1996) The location of the project at the top of the catchment away from permanent and semi-permanent pools is advantageous, however it is recognised mining activity may assist in the rate of spread of this invasive species through vehicle movements and available surface water in the form of, TSF and waste water treatment facilities. Adaptive management implemented through the SSMP will provide the opportunity to monitor for significant increases to introduced fauna.

4.2.2 Increased light and/ or Noise

Altered light environments may affect foraging, reproduction, migration, and communication of fauna species (Longcore & Rich, 2004). The most likely disturbance responses on 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. Artificial lighting has been shown to change the established flight routes and delay commuting behaviour in other small bat species, with the potential of forcing bats to use suboptimal flight routes or cause isolation from preferred foraging sites (Cramer *et al.*, 2016; Stone *et al.*, 2009). In addition, the strong and persistent lighting used at mine sites creates a ‘perpetual full moon’ (Longcore & Rich, 2004) that has the potential to affect the timing of activity in crepuscular and nocturnal species and to allow diurnal and crepuscular predators to become facultative nocturnal predators (Gaston *et al.*, 2012).

Excessive light is likely to have an effect on the natural foraging behaviour of Pilbara Leaf-nosed Bat, which is thought to be attracted to light sources (Cramer *et al.*, 2016). Long-term studies at Mt Dove have however shown that Pilbara Leaf-nosed Bat activity is not negatively impacted by artificial illumination and can possibly increase presumably due to increased foraging resources available ((C. Knuckey, unpub data - cited in Atlas Iron, 2019). The Camp and Plant are planned to be located behind hills so as to not impact on the Klondyke Queen roost entrances. Temporary mobile lighting will be installed in active mine pits and active

operational areas; however, lights will be directed inwards towards mine activities to minimise lighting effects on fauna in adjacent areas.

Both Ghost Bats and Pilbara Leaf-nosed Bats are known to be susceptible to disturbance including noise, vibration and dust impacts (R. Bullen pers comms 2019; Martin, 2012; Martin, 2018), and have an observed tendency to vacate roosts in response (K. N. Armstrong, unpub obs; Armstrong, 2001). Armstrong (2001) suggested that “a gradual decline in numbers” at Klondyke Queen after the 1980’s was correlated with an increase in mining activity, which included excavation of another adit beneath the older Klondyke Queen and a drilling program in 1994-1995. However, Armstrong (2010) observed that significant impacts were unlikely for short-term drilling further than 25m from a roost entrance and 85m from the roost location within the mine. Behavioural changes due to vibration in the roost will be unknown until development commences.

Increased noise, vibration and light levels will be associated with all elements of the proposed development within the Study Area, most likely around the pit area and roads, on a 24-hour basis. As these impacts are largely associated with blasting activities, which will be restricted to daytime operations, habitat most likely to be at risk are those workings that supports the species within the Klondyke Queen Adit. The buffer on the eastern edge at the pit crest is 200 metres from the Klondyke Queen Adit entrance. This is considered adequate, primarily because of the topography between the Klondyke Queen workings and the western edge of the proposed Klondyke Pit. The proposed Klondyke Pit is located on a separate hill on the opposite side of a creek line which acts as a natural shield and minimises noise and vibration impacts (from haulage, drilling and blasting activities) from reaching the workings. Armstrong (unpublished data; in Cramer *et al.*, 2016) noted that in a range of contexts such as proximity to nearby haul roads, blasting, dust, noise and light, as long as the caves or gullies nearby remain intact, there has been no observation that bats vacate an area or structure during the period when mining is undertaken. Adaptive management implemented through the SSMP will provide the opportunity to monitor and mitigate any significant impacts arising from increased noise, vibration, and light levels to the local bat colonies.

4.2.3 Dust

Ghost bats detect prey via sound; they also 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 (R. Bullen *pers comms*; TSSC, 2016a). Dust can also indirectly affect fauna by altering the structure and composition of native vegetation (Farmer, 1993), impacting faunal assemblages by reducing both food and habitat resources. Airborne dust clouds can bury the preferred foraging habitat for bats under stored overburden (TSSC, 2016a).

Within the Study Area, increased dust emissions may result from the pit mining (crushing, post blasting), dumping of waste rock material at waste rock dumps, and from vehicle movements

on haul roads. However, with the plant position behind a hill, and given that dust suppression strategies are implemented including the Martin (2018) recommendations, the likelihood that the Ghost Bat and Pilbara Leaf-nosed Bat colonies will be affected by dust deposition near significant habitat (e.g. caves, roosts) is low.

4.2.4 Changed Fire Regimes

Fire is a natural process in the Pilbara that commonly arises through lightning strike. However, changes to fire regimes, such as an increase in frequency and intensity, can have negative ecological impacts (Carwardine *et al.*, 2014), that can vary between fauna species.

The proposal may either increase the frequency of fires (*e.g*. expanded traffic network and increased traffic movements, or an increase in grassy fuel load) or reduce the scale/extent of natural wildfires, as a result of infrastructure acting as firebreaks and on-site management (*i.e.* fire suppression). Consideration of fire frequency is relevant to the maintenance of suitable foraging habitat for the two bat species, especially when females are lactating and might require greater food resources. Duncan *et al.* (1999) noted that some population declines for Ghost Bat could be attributable to prey lost through habitat modification by fire. Ghost Bat populations have been known to leave an area and then return as the undergrowth regenerates; however Pilbara Leaf-nosed Bats do not abandon primary roosting caves when an area is reduced by fire as long as the local water resource is not affected, and presumably the local insect populations remain in place at the water resource (Bullen & McKenzie, 2011).

Extensive burning of the preferred foraging zone in the plains north of the Study Area in May 2018 (Landgate, 2019) did not appear to have deterred the local colony of Ghost Bats and Pilbara Leaf-nosed Bats from using the area during both the 2018 and 2019 VHF surveys (Biologic, 2019d, 2019e). No significant impacts from changed fire regimes on the local colonies present at Warrawoona are foreseen.

4.2.5 Vehicle Strike

Vehicle strike is a known threat to conservation significant fauna of the Pilbara, including nocturnal species such as bats that forage or travel near roads at night. Mortalities due to vehicle collisions at night may increase as both species often forage close to the ground (Churchill, 2008). The Pilbara Leaf-nosed Bat is known to be susceptible to strikes from vehicles (TSSC, 2016b), with five records of the species in the Pilbara from roadkill (Fortescue Roadhouse, 1990; near Tom Price, 1995; near Yarrie, 2005), or specimens found in carparks, presumably after falling off a vehicle (Millstream, no date; Karratha, 1985) (Armstrong, 2001). The proposal will expand the road network and increase traffic volumes in the Study Area, with an indicative total land disturbance of roads and pipeline/ powerline corridors of 36.37 ha; approximately 29 km of roads, comprising a main road of ~7.6 km and 21.4 km worth of internal mine roads and maintenance tracks (‘slower’ tracks). Although local decline of the species may occur if a busy haul or access road is to be located close to a known roost or foraging site

(TSSC, 2016b), vehicle movements at night (when Ghost Bat and Pilbara Leaf-nosed Bat are active) are greatly reduced compared with daytime vehicle movements and are generally limited to in-pit operations.

A threat often associated with road infrastructure is entanglement in barbed wire, particularly for Ghost Bats and other large species due to their low elevation flying pattern while commuting (Armstrong & Anstee 2000). Substantial numbers are known to be killed when colliding with fencing wire (Armstrong & Anstee, 2000; McKenzie & Bullen, 2009), however there will be no barbed wire on the mining operation.

4.2.6 Altered Water Quality

Waste structures, including tailings storage facilities and waste rock dumps can cause impacts to water quality during operations and/or after operations cease (EPA, 2018a). In the gold industry, cyanide is the most significant contaminant influencing wildlife, and is known to cause significant mortality events when present above a critical toxicity threshold (Griffiths *et al.*, 2014), particularly for migratory birds and bats (Eisler & Wiemeyer, 2004). Cyanide will be used in the processing plant in the leaching of gold from ore and the elution of gold from carbon. The cyanide solution will be pumped from the storage tank to the leaching circuit, where it will be added to the ore slurry. This process is an environmental risk if it is not managed appropriately.

At 'no discharge' mine facilities, 50 mg/L Weak Acid Dissociable (WAD) cyanide for solutions accessible to wildlife is widely recognised by the mining industry as a water quality benchmark for the protection of wildlife (Donato *et al.* 2007). This level is derived from observations in both the USA and Australia, where bird mortalities tend to occur when the WAD cyanide concentration increases above 50 mg/L (Donato et al. 2007). In recognition of this benchmark, and in the absence of data to support a <50 mg/L WAD cyanide discharge for the Ghost Bat and Pilbara Leaf-nosed Bat, Calidus commits to a concentration of WAD cyanide discharge <30 mg/L, based on data from a similar mining operation in NSW (Griffiths *et al.*, 2014). This level is likely to, following volatilization of cyanide post discharge, result in an even lower WAD cyanide in the supernatant.

Preliminary test work has also confirmed that post cyanide destruction via methods such as the Caros Acid method, increases the conductivity of the tailing's slurry. Some bats have been witnessed avoiding waterbodies with a conductivity of greater than 5.0 dS/m (R Bullen *pers comm* 2019), thus it is possible that this may further reduce the risk of bats being impacted by the water quality at the TFS.

Another conservation initiative by Calidus is the proposed ~30 ha Mining Exclusion Zone. This "bat apartment block" includes a freshwater dam as an attractant away from any contaminated water and twice daily usage monitoring of the TSF decant by wildlife.

Potential impacts to water quality from waste rock includes Nickel Arsenic Zone (NAZ) waste within the Bulk/Fresh-Waste-Zone of the Klondyke Pit. This waste has been identified as a source of soluble arsenic (Graeme Campbell and Associates Pty Ltd, 2019) and will be managed via the Warrawoona Metalliferous Drainage Management Procedure (Trajectory, 2019).

In addition to this, it is highly recommended that a SSMP with adaptive management be implemented that specifically includes monitoring of potential cyanide toxicity and adverse changes to water sources. This is in recognition that despite predictions based on bat research and other mining studies, the outcomes for the local colonies from this impact source are not definitively known as species-specific studies into cyanide toxicity have not been undertaken for the targeted bat species.

4.2.7 Modification of Water Regimes

Within the Pilbara, the growth of the mining industry presents new challenges for water management, from mine de-watering causing groundwater drawdown, to alteration of flow regimes and creation of new water sources on the surface (Carwardine *et al.*, 2014).

Dewatering causing modification or loss of habitat is the most likely factor to impact the Pilbara Leaf-nosed Bat at Warrawoona. Dewatering is required to access the ore within the proposed Klondyke Pit (GRM, 2019). The lower levels of the Klondyke Queen workings are thought to be connected to the water table (GRM, 2019), and therefore dewatering the Klondyke Pit may reduce humidity in the adjacent Klondyke Queen workings. As the Pilbara Leaf-nosed Bat is dependent on humid microclimates (Baudinette *et al.*, 2000; Churchill, 2008) this may cause the Pilbara Leaf-nosed Bat to abandon the Permanent Diurnal Roost inside the Klondyke Queen workings and return to the Bow Bells South adit as the nearest main permanent roost. Given the fluctuations of the Pilbara Leaf-nosed Bat population at Klondyke Queen, when compared to Bow Bells (3 km west), abandonment of Klondyke Queen is unlikely to have a significant impact to the species at the regional scale, given the likely continued presence of the species elsewhere on the Warrawoona Range.

The indirect impacts of dewatering on the foraging habitat of the Pilbara Leaf-nosed bat should also be considered, as it has the potential to alter the quality and productivity of the permanent spring and river–pool ecosystems used by foraging bats (Cramer *et al.*, 2016). Both VHF tracking studies conducted in the Study Area found that the Copenhagen pit is visited by a small proportion of the Pilbara-Leaf nosed Bat colony (Biologic, 2019d, 2019e), with consistently low numbers of ultrasonic calls recorded at the site each year, increasing towards the end of the dry season (Biologic, 2017d, 2018, 2019f). The drawdown impact from dewatering at Copenhagen, after the seven months of mining, is predicted to extend out radially to around 500 m from the pit perimeter. Although the site provides some foraging resources, the Copenhagen mine does not represent the only water source within the local region, with a

review of the district suggesting that regionally there may be at least another four sites (located within 3-15 km of the Klondyke pit) with ephemeral water pools (Biologic, 2018), and therefore dewatering impacts are not expected to be significant for the species.

Dewatering the Klondyke Queen is not anticipated to impact the Ghost Bat colony. In the Pilbara, Ghost bats have been recorded roosting and reproducing in caves that have low humidity levels (R. Bullen *pers. comm.* 2019). It is possible that the often-repeated reliance on high humidity for roosting may not be a significant influence for populations in the Pilbara or may be either supplied by rainwater percolating through the rock above or supplied by the presence of the bats themselves (R. Bullen *pers. comm.* 2019). At both the Klondyke Queen and Comet mines, large numbers of Ghost bats have been observed roosting in chambers well above and not directly connected to the water table with close to ambient conditions present. However, there is not enough evidence to conclusively remove the requirement of humidity for the species at these roosts, particularly at certain periods of the breeding cycle.

With the exception of the remote Comet pit roost and Criterion roost, all of the other identified areas are located within the Brockman Hat Cutting catchment area (GRM, 2019). The entrance to the Klondyke Queen underground workings at elevation 281.0 m AHD is situated some 8 m above the 273.0 mAHD invert elevation of the ephemeral watercourse immediately to the southeast of the roost and approximately 2 m above the lowest crest elevation of 279.0 mAHD at the western end of the Klondyke Pit. Therefore, no potential flooding impacts are envisaged as a result of developing the TSF or Klondyke Pit within the Brockman Hay Cutting Creek catchment.

Table 4.3: Summary of the relationship between impact sources, pathways and ultimate impacts on fauna that may arise from development within the Study Area

Impact Source	Occurrence of impact within the Warrawoona Study Area	Impact Pathways		Potential impacts on fauna
Removal, fragmentation or modification of habitat (including reduced or prevention of access to feeding or roosting habitats)	• Total land disturbance of 378.6 ha (including roads, mining pits, Tailings Storage Facility, processing plant, camp etc). • The mining of the Klondyke Pit will result in the removal of five old workings (KQ488, Cuban, Kopckes Reward, St George 3 and Britannia). • All five workings are lower value roosts for Pilbara Leaf-nosed Bat (Nocturnal Refuge) and/or Ghost Bat (Night Roost).	Direct	• Habitat loss or reduction in condition	• Mortality or displacement of individuals • Population fragmentation • Decline in population size • Local extinction • Reduction in carrying capacity • Reduced in 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., loss or modification of roosts). • Erosion and altered drainage patterns.	
Vibration	• Drilling and blasting for the Klondyke pit • Drilling and blasting associated with the Klondyke underground • Vibration from nearby heavy machinery	Direct	• Habitat modification or loss due to structural changes (i.e., loss or modification of roosts).	• Mortality or displacement of individuals • Decline in population size • Reduction in carrying capacity • Reduced in reproductive success • Reduction in diversity
		Indirect	• Disturbance responses or other behavioural changes in individual animals •	
Introduced species	• Feral cats (Biologic, 2019a) and Buffel grass (Biologic, 2017c) have been recorded within the Study Area • Other invasive species such as red foxes, cattle, donkey have been recorded in the vicinity • Cane toads have not been recorded in the Study Area.	Direct	• Habitat degradation and loss, from grazers and weeds. • Competition for resources. • Predation • Increased mortality from toxic introduced species	• Mortality of individuals. • Decline in population size
		Indirect	• Introduction/spread of disease. • Increased fuel loads from grassy weeds	
Increased light and/or noise	• Light spill will occur particularly in the mine pit and around infrastructure and roads. Light placement and design will minimise light spill	Direct	• Disturbance responses or other behavioural changes in individual animals, as targeted bat species are light sensitive. • Species using audible cues for foraging and socialisation may experience disruption.	• Displacement of individuals • Reduction in reproductive success • Decline in population size • Reduction in diversity • Reduction in carrying capacity • Local extinction

Impact Source	Occurrence of impact within the Warrawoona Study Area	Impact Pathways		Potential impacts on fauna
		Indirect	• Habitat modification or loss due to structural changes from vibration (i.e. roosts in mining adits). • Changes in prey item aggregation, resulting in changes to foraging behaviour	
Dust	• Dust emissions will increase, particularly after blasting. Dust deposition can also be expected adjacent unsealed roads and mine pits,	Direct	• Impact to vision following events causing high dust levels	• Displacement of individuals • Reduction in foraging success • Reduction in carrying capacity • Reduction in faunal diversity.
		Indirect	• Habitat modification due to degradation of vegetation or topsoil modification	
Changed fire regimes	• Unspecified.	Indirect	• Habitat modification; high frequency or intensity can reduce understorey habitat cover and reduce food sources. • Low frequency fires can result in dominance of senescent vegetation and high fuel loads	• Reduction in carrying capacity. • Reduction in faunal diversity.
Vehicle strike	• Indicative total land disturbance of roads and pipeline/ powerline corridors of 36.37 ha. approximately 29 km of roads, comprising a main road of ~7.6 km and 21.4 km worth of internal mine roads and maintenance tracks ('slower' tracks)	Direct	• Collision with animals.	• Mortality of individuals • Decline in population size
Altered water quality	• Known production of cyanide waste to occur in TSF. Cyanide level is expected to be contained to < 30mg/L • Nickel arsenic levels within the Klondyke pit post closure	Direct	• Mortality or illness due to decreased water quality, from cyanide and Nickel arsenic in water sources. • Disturbance responses from the bat colonies (as water-dependent species)	• Mortality/ displacement of individuals • Temporal changes in carrying capacity • Temporal changes in population size • Local extinction
		Indirect	• Pollution to water sources resulting in changes to prey availability and distribution	

Impact Source	Occurrence of impact within the Warrawoona Study Area	Impact Pathways		Potential impacts on fauna
Modification of water regimes	• Some reduction to pre-mining runoff for surface catchments present • Advanced dewatering will occur in the Klondyke pit	Direct	• Dewatering impacting known water sources such as the Copenhagen open pit	• Displacement of individuals • Temporal changes in carrying capacity
		Indirect	• Reduction in habitat quality due to changes in water seepage and roost humidity. • Habitat modification arising from local hydrogeological changes, including change in distribution and abundance of vegetation • Dewatering and discharge resulting in changes to prey availability and distribution.	• Mortality/ displacement of individuals • Temporal changes in carrying capacity • Temporal changes in population size Local extinction

4.3 Cumulative Impacts

The EPA have an obligations to consider the impacts of the development with consideration of the cumulative impact with other existing or reasonably foreseeable activities, developments and land uses (EPA, 2018c). The cumulative loss of fauna habitats is difficult to quantify at a regional scale due to the lack of Pilbara wide survey work, a non-standardised approach to mapping between consultants and proponents, and the lack of availability of this information. For this report, the cumulative impact on each habitat type was assessed using publicly available information on other Pilbara Leaf-nosed Bat roosts in the surrounding region.

Both the Pilbara Leaf-nosed Bats and Ghost Bats are well presented in the local area. Six localities known to contain roosts in the surrounding 75 km for the Pilbara Leaf-nosed Bat and three are known to occur for the Ghost Bat. Despite none being planned for development, all occur on mining leases and/or are associated with historical mining projects (i.e. abandoned adits), and therefore may be subject to development in the future. Furthermore, to Lalla Rookh and Cooper Hills, the roosts represent abandoned mines with unknown long-term stability (Cramer *et al.*, 2016). Two previously important roosts Bulletin and All Nations have been abandoned due to recent mining activity (TSSC, 2016a).

Table 4.4: Pilbara Leaf-nosed Bat roosts known to occur in the surrounding area

Site	Roost Type	Population Estimate	Distance Warrawoona Gold Project	Potential Impact and mitigation	Reference
Warrawoona Gold Project	Permanent Diurnal Roost (Klondyke Queen Adit & Bow Bells South Adit)	1500-2000	N/A	Removal of 4 nocturnal refuge from the Klondyke Pit footprint and one refuge from St George pit	Biologic (2018c), Biologic (2019)
Comet Mine	Nocturnal Refuge	Unknown	~20 km north-west	None - Site is a tourist Mine no known development planned – as per publicly available information	Biologic (2019)

Site	Roost Type	Population Estimate	Distance Warrawoona Gold Project	Potential Impact and mitigation	Reference
Corunna Downs	Non-permanent breeding roost Permanent diurnal roost Nocturnal refuge	400 to 600	~50 km south-west	Potential to impact 1x Non-permanent breeding roost and 1 x Permanent diurnal roost Non-permanent breeding roost (cave CO-CA-03) protected by A 50 metre buffer Permanent diurnal roost (cave CA-CO-01) protected by a 340-metre buffer Loss of one nocturnal refuge CO-CA-15 Retention of 13 nocturnal refuges	Bat Call (2018) Atlas Iron Pty Ltd (2019)
Lalla Rookh	Maternity Roost	1500	~75 km west	No known development planned – as per publicly available information.	EPA (2014)
Mt Webber	Maternity Roost	1000	~50 km south-west	Caves off impact areas and with buffer	EPA (2014) Atlas Iron Pty Ltd (2014)
Copper Hills	Diurnal Roost	200	~40 km south	No known development planned – as per publicly available information.	R Bullen *pers. comm.* 2019
Bamboo Creek	-	-	~75 km north-east	-	(TSSC, 2016b)

Table 4.5: Ghost Bat roosts known to occur in the surrounding area

Site	Roost Type	Population Estimate	Distance Warrawoona Gold Project	Potential Impact and Mitigation	Reference
Warrawoona Gold Project	Permanent Diurnal Roost (Klondyke Queen Adit & Bow Bells South Adit)	500	N/A	Removal of five roosts (two night roosts from within the Klondyke Pit footprint; (KQ488 and Cuban).	Biologic (2018c), Biologic (2019)
Comet Mine	Nocturnal Refuge	Unknown	~20 km north-west	None – sits upon mineral exploration lease and previously mined for gold	Biologic (2019)
Lalla Rookh	Maternity Roost	200	~75 km west	None – sits upon mineral exploration lease and previously mined for gold	(TSSC, 2016a)

Site	Roost Type	Population Estimate	Distance Warrawoona Gold Project	Potential Impact and Mitigation	Reference
Bulletin	Nil (previously Maternity Roost)	406	~75 km north-east	Roost apparently abandoned due to mining activity (TSSC, 2016a)	(TSSC, 2016a)
All Nations	Nil (previously Maternity Roost)	Unknown	~65 km south	Roost apparently abandoned due to mining activity (TSSC, 2016a)	(TSSC, 2016a)

4.4 Criteria for Assessing Significance

The terms “significant impact” and “significant effect” are not defined in the EP Act 1986. Therefore, the significance of each potential impact identified in the Study Area is assessed using criteria defined by Biologic as per Table 4.6 below, and are considered in detail for each conservation significant species in Table 5.1.

Table 4.6 Impact criteria used for each impact source assessed in the Study Area

Criteria	Assessment value	Definition
Duration	Short-term	<1 year
	Long-term	Years – decades | Life of Mine (LOM)
	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 exists 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. IMPACT ASSESSMENT

5.1 Impacts to Conservation Significant Bat Habitats

Land clearance is listed as a Key Threatening Process under the EPBC Act. Disturbance and degradation to significant habitat is considered the primary impact of the Project on bat fauna,

both through direct loss of roosts and foraging habitat, and indirect roost disturbances via increased sound, vibration, dust, light, and changes to water quality. As discussed in Section 4.1, the proposed development of the Klondyke Pit will result in the removal of five old mine workings (KQ488, Cuban, Kopckes Reward, St George 3, and Britannia). All five workings are low value roosts for Pilbara Leaf-nosed Bat (Nocturnal Refuge) and/or Ghost Bat (Night Roost). There is expected to be some level of disturbance to the Klondyke Queen roost, especially from drill and blast activities; however, mitigation strategies are expected to minimize these impacts. Additionally, groundwater drawdown associated with dewatering of the pit may impact upon microclimate within the roost itself.

Although both species generally use preferred foraging grounds outside of the Study Area boundaries (Biologic, 2019d, 2019e), there is expected to be some loss or degradation to potential foraging habitat and flight paths occurring within the Study Area (Figure 5.1 and Figure 5.2).The scale of impact of habitat loss in the Study Area is expected to range from large areas of land clearing for the proposed Klondyke Pit, TSF, and WRD, through to minimal loss in the Sandplain habitat from a proposed access track. Habitat loss or degradation is going to occur on the greatest scale in the Hillcrest/Hillslope and Stony Plain habitats from these development activities and construction. Both are classified as Priority 5 Pilbara Leaf-nosed Bat foraging habitat (Figure 5.2).

Other impacts to fauna habitat include potential changes to fire regimes, dust deposition impacting vegetation and water quality, and increases in the abundance of introduced species including grazers (e.g. European cattle) and weeds (e.g. Buffel grass) (Section 4.2). These are not considered to significantly impact the conservation significant bat fauna present.

5.2 Impacts to Conservation Significant Bat Fauna

The final impact to the regional and local population of conservation significant bat fauna (*i.e.* loss or displacement of individuals), is difficult to quantify and not well demonstrated. The extent and magnitude of other impact sources, such as noise, light, or changed fire regimes, has also not been well researched for the bat fauna present.

Apart from habitat loss, degradation, or fragmentation, the impact source most likely to affect bat fauna is the pollution or modification of water quality and water regimes. Table 5.1 below summarises the direct and indirect impact sources potentially affecting the bat fauna of conservation significance confirmed in the Study Area.

Table 5.1 Potential impacts to bat species of conservation significance potentially occurring in the Study Area

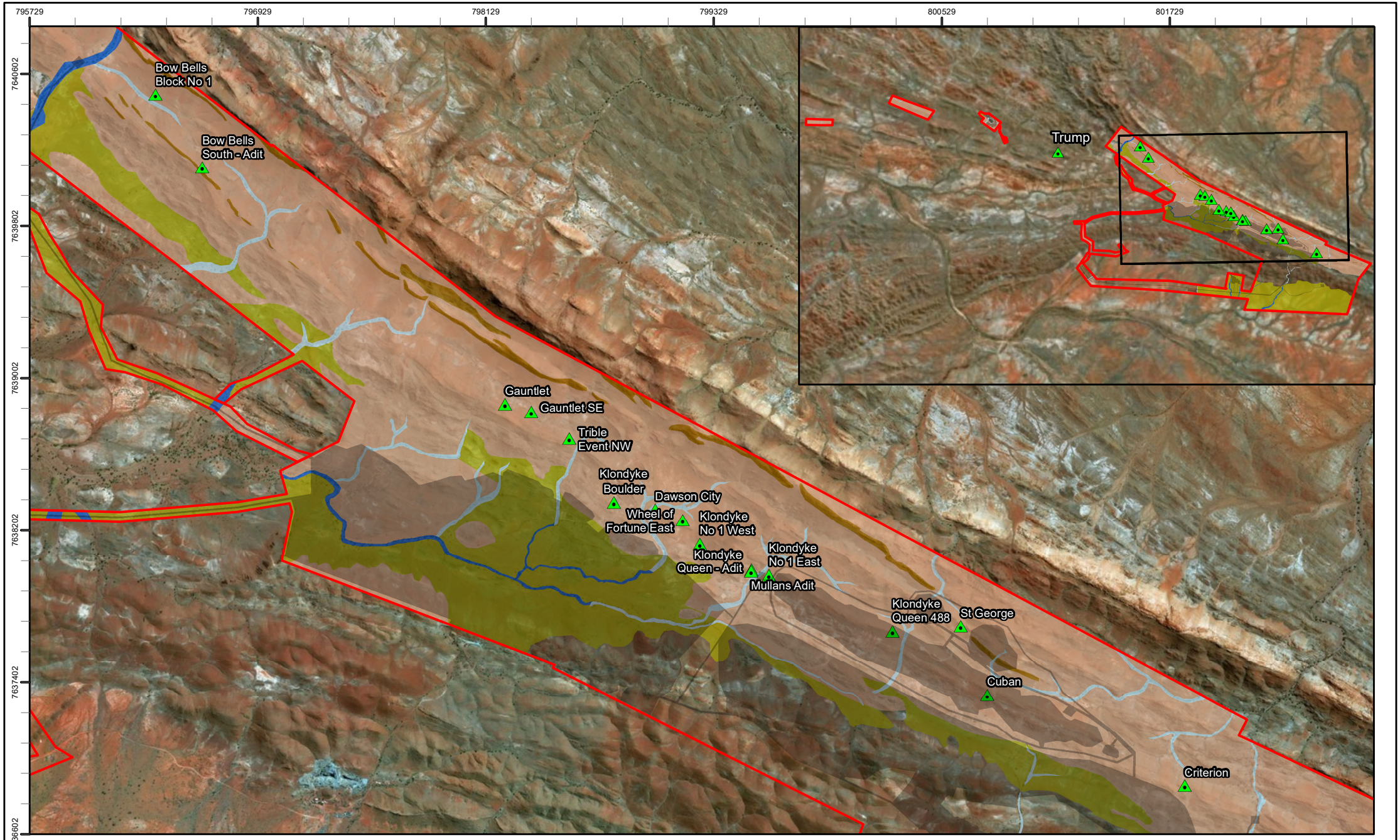
			Impact					
Species	**Likelihood of occurrence**	**Impact Source**	**Extent**	**Duration**	**Magnitude (Local)**	**Magnitude (Regional)**	**Consequence of impact**	**Certainty (Level of Confidence)**
<u>Ghost Bat</u> *Macroderma gigas* **EPBC Act** Vulnerable **BC Act** Vulnerable	Confirmed	Removal, fragmentation or modification of habitat	Removal and fragmentation of habitat - Primary impact is the extent of clearing and extent of barrier to movement in core habitat (known roosts), and foraging/dispersal habitat in Rocky Breakaway, Hillcrest/ hillslope, Rounded Hills and Medium/Minor Drainage Line	Permanent	**Moderate** – The mining of the Klondyke Pit will result in the removal of five old mine workings (KQ488, Cuban, Kopckes Reward, St George 3 and Britannia). KQ488 and Cuban are classified as Night Roosts for the species. A number of good quality refuges nearby Klondyke Queen are required to protect the Ghost Bat colony long term (R. Bullen pers comms, 2019). Development will also remove foraging habitat present in the Rocky Breakaway, Hillcrest/ hillslope, Rounded Hills and Medium/Minor Drainage Line habitat types. Ghost bats do not appear to be regularly using the proposed TSF site or Copenhagen pit as foraging resources (Biologic, 2019d). VHF tracking studies (Biologic, 2019d, 2019e) found that Ghost bats are intermittently using the proposed Klondyke Pit area as a flight path to preferred foraging grounds outside of the Study Area, most likely to the plains north and south of the Warrawoona Ranges. Highly mobile species such as bats may experience disruptions if they are unwilling to fly across large cleared areas while foraging (Hopkins, 2015).	**Low** – the species is confirmed to leave the Study Area nightly to forage in the plains north and south of the Warrawoona Ranges, and individuals have been recorded roosting in large colonies outside of the Study Area at Comet, Lalla Rookh and other disused mines (Biologic, 2019d, 2019e)	• 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 • Loss of genetic diversity	**Moderate/High** – Numerous targeted surveys have confirmed the classification of the workings to be removed as low-significance roosts (Biologic, 2017d, 2018, 2019f). Two VHF tracking surveys have confirmed the intermittent use of the proposed Klondyke Pit as a flight path outside of the Study Area to preferred foraging grounds (Biologic, 2019d, 2019e).
		Vibration and noise	Significant roosts within the Study Area, primarily Klondyke Queen and Bow Bells South	Long-term (LOM)	**Moderate –** Ghost Bats are known to be susceptible to disturbance including vibration and noise (R. Bullen pers comms 2019; Martin, 2012; Martin, 2018), and have an observed tendency to vacate roosts in response (K. N. Armstrong, unpub obs; Armstrong, 2001). The potential instability of historic underground workings is regarded as a significant threat, contributing to the Vulnerable listing status of both Pilbara Leaf-nosed Bat and Ghost Bat species (TSSC, 2016a, 2016b). Sites such as Klondyke Queen have already experienced several small collapses (TSSC, 2016a). Blasting within the proposed adjacent Klondyke Pit could cause further instability of the Klondyke Queen workings. If blasting parameters are adhered to, the development is unlikely to have structural consequences for Klondyke Queen (Martin, 2018). The 200 m buffer between the proposed Klondyke Pit and Klondyke Queen is considered adequate to minimize disruption, and the separating hill and creek line habitat will act as a natural shield and minimise noise impacts (from haulage, drilling and blasting activities) from reaching the workings. However, long-term blasting (vibration) during the mining operation may have an effect on the behavior of individuals roosting within Klondyke Queen and cause a reduction in population during this period. A production bore is located approximately 120 m from the entrance of the Klondyke Queen – the noise from the associated generator will emit ongoing noise at the entrance of the roost. Calidus have committed to sound barricading at this generator although a low-level noise will still be present.	**Low –** the species is known to roost in the surrounding area at various other locations such as Lalla Rookh and Comet. As such, any decline in the Klondyke population may be absorbed by these locations during the blasting period and allow bats to return post closure	• Disruption to breeding cycles • Reduction in population size	**Moderate –** The assessment completed by (Martin, 2018) found that if the modelled design parameters are utalised, drill and blast activities can safely occur to within 185 m of the Klondyke Queen and will not result in vibration exceeding that of human comfort levels, or result in collapse of this sensitive receiver. Geotechnical Consultant Peter O'Bryan and Associates reviewed the blasting recommendations by (Martin, 2018) and endorsed the finding that if the blasting recommendations are followed, it is unlikely that the integrity or stability of the Klondyke Queen will be compromised. While there is confidence surrounding the amount which vibration will be at the Klondyke there is still uncertainty surrounding the levels to which this may impact upon the species.
		Introduced species	Extent of distribution of introduced predators and invasive weeds.	Long term	**Low** – 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 and foxes, and introduced grazers, will not significantly increase with suitable monitoring and management, although feral cats have been recorded in the Study Area (Biologic, 2019a). There is recent evidence that Ghost Bats predate on Cane Toads and are susceptible to their toxicity (Purtill, 2014). If cane toads expand into the Pilbara, the presence of artificial water sources may attract these introduced species. Ghost bats have 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, 2017c)	**Negligible –** The presence of introduced predators and invasive weeds may be exacerbated by the proposed development however, the threat of such species is not expected to escalate at a regional level due to the proposed development.	• 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.*, 2016).

			Impact					
Species	**Likelihood of occurrence**	**Impact Source**	**Extent**	**Duration**	**Magnitude (Local)**	**Magnitude (Regional)**	**Consequence of impact**	**Certainty (Level of Confidence)**
		Increased light	Extent of ground disturbance in roosting/ foraging/dispersal areas	Long-term (LOM)	**Low** – 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. However, the 200 m buffer between the proposed Klondyke Pit and Klondyke Queen is considered adequate to minimize disruption, especially if lights are directed inwards towards mine activities to minimise lighting effects on adjacent areas.	**Negligible** – localized increases to light, noise and vibration from mining activities is not expected to detrimentally impact on regional Ghost Bat colonies.	• Possible dispersal from greatly enhanced levels of light and noise disturbance during mining activities • Changes to prey distribution	**Moderate** – Although not for blasting disturbance, Armstrong (2010) identified that significant impacts at Klondyke Queen and King were unlikely for short-term disturbance from drilling further than 25m from the roost entrance and 85m from the roost location within the mine.
		Dust	Extent of disturbance causing significant dust settlement e.g. pit blasting, haul roads.	Long-term (LOM)	**Low** - Ghost Bats are known to be susceptible to disturbance such as dust impacts (R. Bullen pers comms 2019; 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). Habitat most likely to be at risk are those workings that support the Ghost Bat within the proximity to the proposed Klondyke Pit. However, the likelihood that the Ghost Bat colony will be affected by dust deposition near significant habitat (e.g. caves, roosts) is low.	**Negligible** – there is unlikely to be a significant impact on a regional scale to Ghost Bat from increased dust levels.	• Disruption to foraging behaviors • Alteration/degradation of habitat	**Moderate** – the impact of dust on individuals and foraging habitat is not well studied for Ghost Bats in the Pilbara.
		Changed fire regimes	Extent of disturbance from fire in foraging/ denning areas	Long term	**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 proposed development may increase the frequency of fire, it is not expected to have a significant impact on the species.	**Low** - extensive burning of the preferred foraging zone in the plains north of the Study Area in May 2018 (Landgate, 2019) did not appear to have deterred the local colony of Ghost Bats from using the area during both the 2018 and 2019 VHF surveys (Biologic, 2019d, 2019e).	• 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.
		Vehicle strike	Extent of expansion of existing road and track network	Long-term (LOM)	**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 greatly reduced compared with daytime vehicle movements and are generally limited to in-pit operations.	**Low** – there is unlikely to be a significant increase to strike of Ghost Bat in the region.	• Loss of individuals • Reduction in local population size	**Moderate/High** – there are no recorded vehicular collisions with Ghost Bats in the Study Area. Management of vehicles within core habitat for conservation significant fauna needs to be implemented.
		Altered water quality	Extent of existing and future water sources	Permanent	**Low –** Cyanide will be produced in the leaching of gold from ore, which will be added to the ore slurry. Cyanide is known to cause significant mortality events when present above a critical toxicity threshold (Griffiths *et al.*, 2014), particularly for migratory birds and bats (Eisler & Wiemeyer, 2004). to significantly impact upon the local population. Moderately high levels of Nickel arsenic may be present in the Klondyke pit lake post closure and may directly impact upon the health of individuals drinking from it. It has been indicated that over time this water source will also become saline (Trajectory, 2019). On the assumption that this is the case, bats and other wildlife may not be significantly affected as they typically avoid drink from hyper saline water over 3200 ppm (B. Bullen *pers. comms.*). The importance of open waterbodies to the species is not well understood but not believed to be a significant requirement for the species. The TSF may influence prey availability in the local area, although this is expected to be minimal and Ghost Bats infrequently utilise this area for foraging (Biologic, 2019e).	**Low** – Assuming that there is no impact caused by a decrease in humidity, there is not expected to be a to impact to the regional population.	• Loss of individuals or reduction in population size from reduction in humidity in roosts	**Low –** Published data suggests humidity may be a significant factor influencing roost site selection for the species - a moderate to high relative humidity of 50−100 percent (Armstrong & Anstee, 2000; Churchill, 1991; Churchill & M., 1990; Pettigrew *et al.*, 1986; J. Toop unpup. data in TSSC, 2016a). However Ghost bats have been recorded roosting and reproducing in caves that have low humidity levels (R. Bullen *pers comm* 2019).
		Modification to water regimes	Extent of Study Area (surface water). Extent of groundwater drawdown (groundwater)	Long-term	**Moderate** – The Klondyke Queen workings will likely fully dewater within two years of the commencement of mining. after the end of mining (GRM, 2019). Modelling suggests the Klondyke Queen workings may not begin to resaturate for at least a decade after mine closure, if not longer (Martin, 2012). This is likely to influence the humidity levels within the Klondyke Queen. However, this may not significantly impact the local colony of Ghost Bats, as there is some conjecture regarding the importance of humidity to the species - Ghost bats have been recorded roosting and reproducing in caves that have low humidity levels (R. Bullen *pers comm* 2019).	**Low –** The displacement and or loss of individuals is not expected to widen beyond the local scale.	• Loss of individuals from reduction in water quality (e.g. cyanide) leading to mortality/displacement • Loss of foraging habitat during mining • Loss of prey items utilizing water sources	**Moderate** – there have been no studies specifically investigating the effects of cyanide on Ghost Bats, and cyanide toxicosis risks to bats remain ambiguous. However, cyanide is known known to cause significant mortality events when present above a critical toxicity threshold (Griffiths *et al.*, 2014).

			Impact					
Species	**Likelihood of occurrence**	**Impact Source**	**Extent**	**Duration**	**Magnitude (Local)**	**Magnitude (Regional)**	**Consequence of impact**	**Certainty (Level of Confidence)**
<u>Pilbara Leaf-nosed Bat</u> *Rhinonicteris aurantius* **EPBC Act** Vulnerable **BC Act** Vulnerable	Confirmed	Removal, fragmentation or modification of habitat	Primary impact is the extent of clearing and extent of barrier to movement in core habitat (known roosts), and foraging/dispersal habitat in Hillcrest/ hillslope, Rounded Hills and Medium/Minor Drainage Line	Permanent	**Moderate** - The mining of the Klondyke Pit will result in the removal of five old workings (KQ488, Cuban, Kopckes Reward, St George 3, and Britannia). These are classified as Nocturnal Refuges for the species. Klondyke Queen and Bow Bells South are classified as Permanent Diurnal Roosts for the species (Biologic, 2019f). If blasting parameters are adhered to, the development is unlikely to have structural consequences for Klondyke Queen (Martin, 2018). Highly mobile species such as bats may experience disruptions if they are unwilling to fly across large cleared areas while foraging (Hopkins, 2015). Development will remove foraging habitat present in the Rocky Breakaway, Hillcrest/ hillslope, Rounded Hills and Medium/Minor Drainage Line habitat types. VHF tracking studies (Biologic, 2019d, 2019e) found that Pilbara Leaf-nosed Bats moved back to the Study Area periodically throughout the night for shorter periods of time, indicating that they were intermittently using the upper ranges for night-resting, feeding and/or social interactions. The bats were also intermittently using the proposed Klondyke Pit as a flight path, and on occasion the TSF area. Individuals also visited the Copenhagen pit during the studies (Biologic, 2019d, 2019e). As such, proposed development is likely to impact on the species to some extent.	**Low** – Although a local decline has the potential to contribute to a regional decline, especially if critical habitat is lost and a significant proportion of the regional population is affected (TSSC, 2016b), this is unlikely from the proposed development. The most significant roost (Bow Bells South) is located 3.6 km from the proposed Klondyke Pit.	• Loss/displacement of individuals during vegetation clearing and mining developments • Loss of foraging/ dispersal/ denning habitat • Disruption to breeding cycles • Reduction in population size • Increase in population isolation • Loss of genetic diversity	**Moderate** - Numerous targeted surveys have confirmed the classification of the workings to be removed as low-significance roosts (Biologic, 2017d, 2018, 2019f). Two VHF tracking surveys have confirmed the use of the proposed Klondyke Pit as a flight path outside of the Study Area to preferred foraging grounds (Biologic, 2019d, 2019e).
		Vibration and noise	Significant roosts within the Study Area, primarily Klondyke Queen and Bow Bells South	Long-term (LOM)	**Moderate –** The potential instability of historic underground workings is regarded as a significant threat, contributing to the Vulnerable listing status of both Pilbara Leaf-nosed Bat and Ghost Bat species (TSSC, 2016a, 2016b). Sites such as Klondyke Queen have already experienced several small collapses (TSSC, 2016a). Blasting within the proposed adjacent Klondyke Pit could cause further instability of the Klondyke Queen workings. The species is also recorded as susceptible to noise and vibration impacts. However, Armstrong (Cramer *et al.*, 2016) 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 (Armstrong, unpubl. data in Cramer *et al.*, 2016). This includes proximity to narrow buffers, nearby haul roads, blasting, dust, noise and light. The 200 m buffer between the proposed Klondyke Pit and Klondyke Queen is considered adequate to minimize disruption. The separating hill and creek line habitat will act as a natural shield and minimise noise and vibration impacts (from haulage, drilling and blasting activities) from reaching the workings. If blasting parameters are adhered to, the development is unlikely to have structural consequences for Klondyke Queen (Martin, 2018). However, long-term blasting (vibration)n during the mining operation may have an effect on the behavior of individuals roosting within Klondyke Queen and cause a reduction in population during this period.	**Low –** the species is known to roost in the surrounding area at various other locations such as Lalla Rookh and Bow Bells South. As such, any decline in the Klondyke population may be absorbed by these locations during the blasting period and allow bats to return post closure	• Disruption to breeding cycles • Reduction in population size	**Moderate –** The assessment completed by (Martin, 2018) found that if the modelled design parameters are utalised, drill and blast activities can safely occur to within 185 m of the Klondyke Queen and will not result in vibration exceeding that of human comfort levels, or result in collapse of this sensitive receiver. Geotechnical Consultant Peter O'Bryan and Associates reviewed the blasting recommendations by (Martin, 2018) and endorsed the finding that if the blasting recommendations are followed, it is unlikely that the integrity or stability of the Klondyke Queen will be compromised. While there is confidence surrounding the amount which vibration will be at the Klondyke there is still uncertainty surrounding the levels to which this may impact upon the species
		Introduced species	Extent of distribution of introduced predators and invasive weeds.	Long term	**Low** - 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 and foxes, and introduced grazers, will not significantly increase with suitable monitoring and management, although feral cats have been recorded in the Study Area (Biologic, 2019a). 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, 2017c). Invasive species are unlikely to have a significant effect overall, and in comparison, to other key threats. While there is likely to be indirect impacts associated with a general decrease in ecosystem functionality.	**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.

			Impact					
Species	**Likelihood of occurrence**	**Impact Source**	**Extent**	**Duration**	**Magnitude (Local)**	**Magnitude (Regional)**	**Consequence of impact**	**Certainty (Level of Confidence)**
		Increased light	Extent of ground disturbance in roosting/ foraging/dispersal areas	Long term	**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.*, 2016), which may make it more susceptible to vehicle strike or predation. However, the 200 m buffer between the proposed Klondyke Pit and Klondyke Queen is considered adequate to minimize disruption, especially if lights are directed inwards towards mine activities to minimise lighting effects on adjacent areas.	**Negligible** – there is unlikely to be a significant impact on a regional scale to Pilbara Leaf-nosed Bat from increased light or noise levels.	• Loss of individuals • Temporary reduction in population size	**Moderate** - There are currently four Pilbara Leaf-nosed Bat permanent roost caves outside of the Study Area that exist in reasonably close proximity to active large-scale open cut mining operations.
		Dust	Extent of disturbance causing significant dust settlement e.g. pit blasting, haul roads.	Long term	**Low** - The species is recorded as susceptible to dust impacts, although Armstrong (Cramer *et al.*, 2016) noted that there has been no observation that bats vacate an area or structure during the period when mining is undertaken, including proximity to dust. Habitat most likely to be at risk are those workings that support the Pilbara Leaf-nosed Bat within the proximity to the proposed Klondyke Pit. However, the likelihood that the Pilbara Leaf-nosed Bat colony will be affected by dust deposition near significant habitat (e.g. caves, roosts) is low.	**Negligible** – there is unlikely to be a significant impact on a regional scale to Pilbara Leaf-nosed Bat from increased dust levels.	• Temporary disruption to foraging behaviors • Alteration/degradation of habitat	**Moderate** - Pilbara Leaf-nosed Bats are recorded as susceptible to dust impacts; however, the impact on individuals and foraging habitat is not well studied for the species.
		Changed fire regimes	Extent of disturbance from fire in foraging/ denning areas	Long term	**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 proposed development may increase the frequency of fire, it is not expected to have a significant impact on the species.	**Low** - extensive burning of the preferred foraging zone in the plains north of the Study Area in May 2018 (Landgate, 2019) did not appear to have deterred the local colony of Pilbara Leaf-nosed Bats from using the area during both the 2018 and 2019 VHF surveys (Biologic, 2019d, 2019e).	• 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.
		Vehicle strike	Extent of expansion of existing road and track network	Long term	**Low** – 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 (DoE, 2015). Local decline of the species may occur if a busy haul or access road is to be located close to a known roost or 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 (DoE, 2015).	• Loss of individuals • Temporary reduction in population size	**Moderate/High** - the species is known to be susceptible to strikes from vehicles (TSSC, 2016b). However, there are no recorded vehicular collisions with Pilbara Leaf-nosed Bats in the Study Area.
		Altered water quality	Extent of existing and future water sources	Long term	**Low –** Cyanide will be produced in the leaching of gold from ore, which will be added to the ore slurry. Cyanide is known to cause significant mortality events when present above a critical toxicity threshold (Griffiths *et al.*, 2014), particularly for migratory birds and bats (Eisler & Wiemeyer, 2004). Pilbara Leaf-nosed Bats are commonly associated with open water bodies, which can be attributed the species limited ability to conserve water. As such, Cyanide will be produced in the leaching of gold from ore, which will be added to the ore slurry. Cyanide is known to cause significant mortality events when present above a critical toxicity threshold (Griffiths *et al.*, 2014), particularly for migratory birds and bats (Eisler & Wiemeyer, 2004). At 'no discharge' mine facilities, 50 mg/L Weak Acid Dissociable (WAD) cyanide for solutions accessible to wildlife is widely recognised by the mining industry as a water quality benchmark for the protection of wildlife. If Calidus commits to a concentration of WAD cyanide discharge of <30 mg/L this unlikely to significantly impact upon the local population. Moderately high levels of Nickel arsenic may be present in the Klondyke pit lake post closure and may directly impact upon the health of individuals drinking from it. It has been indicated that over time this water source will also become saline (Trajectory, 2019). On the assumption that this is the case, bats and other wildlife may not be significantly affected as they typically avoid drink from hyper saline water over 3200 ppm (B. Bullen *pers. comms.*).	**Low** – This impact source is not expected to extend to regional populations but may impact upon individuals dispersing from other roosts	• Loss of individuals or reduction in population size from reduction in humidity in roosts • Loss of individuals from reduction in water quality (e.g. cyanide) leading to mortality/displacement • Loss of foraging habitat during mining • Loss of prey items utilizing water sources	**Moderate** – There have been no studies specifically investigating the effects of cyanide on Pilbara Leaf-nosed Bats, and cyanide toxicosis risks to bats remain ambiguous. In recognition of the two species of

			Impact					
Species	**Likelihood of occurrence**	**Impact Source**	**Extent**	**Duration**	**Magnitude (Local)**	**Magnitude (Regional)**	**Consequence of impact**	**Certainty (Level of Confidence)**
		Modification of water regimes	Extent of Study Area (surface water). Extent of groundwater drawdown (groundwater)	Long-term	**Moderate** – Due to their limited ability to conserve heat and water (Armstrong, 2001; Churchill, 1991), the species is reliant on roost sites in caves or mine adits with stable, very hot (28 – 32 ºC) and very humid (96 – 100 %) microclimates (Baudinette *et al.*, 2000; Churchill, 2008). The Klondyke Queen workings will likely fully dewater within two years of the commencement of mining. after the end of mining (GRM, 2019). Modelling suggests the Klondyke Queen workings may not begin to resaturate for at least a decade after mine closure, if not longer (Eisler & Wiemeyer, 2004). This is likely to influence the humidity levels within the Klondyke Queen. Based on plans of the historic mine workings at Bow Bells, the underground void could extend 30m (or more) below the current water table. Therefore, if drawdown impacts of a few meters result from Klondyke mine dewatering, the majority of the Bow Bells underground workings are predicted to remain saturated (GRM, 2019). Dewatering may lead to the Pilbara Leaf-nosed Bat abandoning the Permanent Diurnal Roost inside the Klondyke Queen workings and returning to the nearest main permanent roost at Bow Bells South, 3 km to the west. The flooded Copenhagen pit is regarded as an important drinking source to the local colony. Although the site provides some foraging resources, the Copenhagen mine does not represent the only water source within the local region available to the local population.	**Low** – As the Bow Bells South roost is unlikely to impacted by the proposed development, it is very likely that a Pilbara Leaf-nosed Bat colony will remain within the Warrawoona Ranges	• Loss of individuals or reduction in population size from reduction in humidity in roosts • Loss of foraging habitat during mining • Loss of prey items utilizing water sources	**Moderate –** The Pilbara Leaf-nosed Bat is known to be dependent on humid microclimates (Baudinette *et al.*, 2000; Churchill, 2008), and so reductions in humidity to Klondyke Queen will likely have an impact to the species. The degree to which Copenhagen is important during the end of the dry season or during drought periods is not known.



Legend

- Study Area
- Roost sites
- Disturbance footprint

Habitat

- Hillcrest/Hillslope
- Medium Drainage Line
- Minor Drainage Line
- Rocky Breakaway
- Stony Plain

biologic Environmental Survey

N

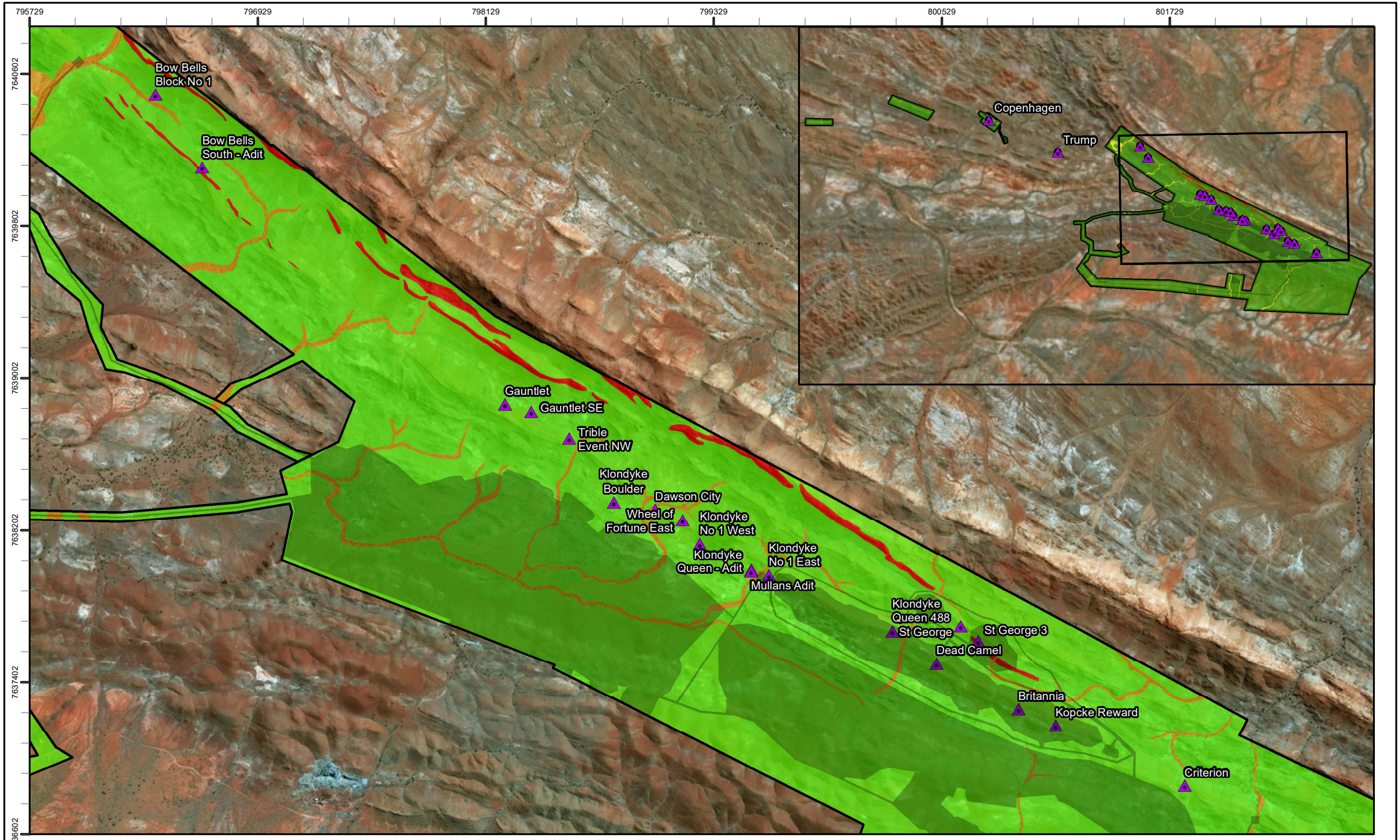
1:25,000

0 0.275 0.55 1.1 km

Calidus Resources - Warrawoona Gold Project
2019 Significant Species Survey
Warrawoon Bat Species Impact Assessment
Figure 5.1: Known Ghost Bat roost sites within the Study Area and potential foraging habitat

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

Size A4. Created 24/09/2019



Legend

- Study Area
- Roost sites
- Disturbance footprint

Habitat

- Priority 3 - Rocky Breakaway
- Priority 4 - Claypan; Medium Drainage Line; Minor Drainage Line
- Priority 5 - Hillcrest/Hillslope; Rounded Hills; Sandplain; Stony Plain

biologic Environmental Survey

N

1:25,000

0 0.275 0.55 1.1 km

Calidus Resources - Warrawoona Gold Project
2019 Significant Species Survey
Warrawoon Bat Species Impact Assessment
Figure 5.2: Known Pilbara Leaf-nosed Bat roost sites within the Study Area and potential foraging habitat

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

Size A4. Created 24/09/2019

5.3 Impacts to Matters of National Environmental Significance

Under the EPBC Act an action will require approval from the minister if the action has, will have, or is likely to have, a significant impact on a matter of national environmental significance. In addition to assessing a species risk under specific risks to the Study Area (Section 5.2), both bat species are listed as a "Matter of National Importance" DoE (2013b) and have been assessed in accordance to DoE guidelines as to whether the proposal will have a significant impact on their survival. The likelihood of a significant impact (likely or unlikely), followed that of DoE (2013b), whereby '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" DoE (2013a). The criteria assessed for each species also followed significant impact criteria for Vulnerable species by DoE (2013b) as well as the conservation listing advice for each species (TSSC, 2016a, 2016b).

The definitions of important populations for these MNES species has been described below, and the results of this assessment have been summarized in Table 5.2.

5.3.1 Vulnerable species

Both the Ghost Bat and Pilbara Leaf-nosed Bat are classified as Vulnerable under the EPBC Act and BC Act. An 'important population' of a Vulnerable species is defined by DoE (2013b) 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.

The Pilbara Leaf-nosed Bat in the Pilbara and upper Gascoyne represent one interbreeding biological population comprising multiple colonies (Armstrong, unpublished genetic data in TSSC, 2016b). This isolated population is of national significance given that individuals show evidence of divergence from those further north in terms of morphology, echolocation call characteristics and genetic identity, and are regarded as an Evolutionary Significant Unit (Armstrong, 2005; Armstrong, 2002; Armstrong, 2006; Armstrong & Coles, 2007). The colony of Ghost Bats within the Study Area falls within the Chichester genetic region; however genetic analysis suggests that there is a single, large, highly diverse genetic population of ghost bats in the Pilbara region with significant movement between caves (Biologic, 2017b). The targeted bat report conducted in 2019 placed the population estimate as 475 individuals (Biologic, 2019f); which represents up to one third of the current Pilbara population size of 1500-2000 individuals (TSSC, 2016a). Based on the high activity levels and population estimates, the colony of Ghost Bats at Klondyke Queen is also considered an important population (Biologic, 2017d, 2018, 2019f).

The 'habitat critical to the survival of a species or ecological community' is defined by (DoE, 2013b) 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.

For the Pilbara Leaf-nosed Bat, underground diurnal roosts are considered critical to the survival of the species given their reliance on warm, humid roost microclimates for maintaining their heat and water balance (Armstrong, 2001; Baudinette *et al.*, 2000; Churchill, 1991). Therefore, both Bow Bells South and Klondyke Queen, classified as Permanent Diurnal Roosts (Priority 1) (Section 3.1), and are considered "critical habitat for daily survival, occupied year-round and likely to be the focus for some part of the 9-month breeding cycle", as defined by TSSC (2016b). Observations of pregnant bats exiting the Bow Bells South adit were made in January 2019 (R. Bullen pers comms in Biologic, 2019f). As classified in Table 3.3, the Study Area contains high priority foraging habitat for the Pilbara Leaf-nosed Bat; however the species is seen to consistently forage outside of the Study Area on a nightly basis, returning to the upper ranges periodically during the night for night-resting, feeding and/or social interactions (Biologic, 2019d, 2019e). Therefore, the habitat within the Study Area is not considered critical foraging habitat; however, it does offer crucial flight paths and dispersal opportunities.

For Ghost Bats, the Klondyke Queen (Permanent Maternity Roost), Bow Bells South (Occasional Diurnal Roost) are considered critical habitat for the species for their breeding activity. However, two VHF tracking studies (Biologic, 2019d, 2019e) found that Ghost bats preferred foraging grounds outside of the Study Area, most likely to the plains north and south of the Warrawoona Ranges, and only intermittently used the proposed Klondyke Pit area as a flight path to these areas.

Impacts to habitat for the Pilbara Leaf-nosed Bat and Ghost Bat present within the Study Area is discussed in Section 5.1 and shown in Figure 5.1 and Figure 5.2.

Table 5.2 Significance of the Project to fauna considered Matters of National Environmental Significance

Species	National Listing	Likelihood of occurrence	MNES Significant Impact Criteria	Likelihood of a significant impact	Comments/Assessment
Ghost Bat *Macroderma gigas*	Vulnerable	Confirmed	1. Lead to a long-term decrease in the size of an important population of a species	**Likely**	The colony within the Warrawoona Study Area is considered an important population based on the consistently high population size and activity level (Biologic, 2017d, 2018, 2019f). The targeted bat report conducted in 2019 placed the population estimate as 475 individuals (Biologic, 2019f); which represents up to one third of the current known Pilbara population size of 15-2000 individuals (TSSC, 2016a). Although adaptive management will monitor the Ghost Bat population in advance of any disturbance and adjust/refine the management measures accordingly, impacts to the size of the colony at Klondyke Queen are possible and remain at a significant risk level.
			2. Reduce the area of occupancy of an important population	**Unlikely**	The colony is planned to persist within the Klondyke Queen mine, and mitigation measures for potential impacts are in place or planned. Displaced individuals are likely to roost at Bow Bells south (Occasional Diurnal Roost), or have been recently recorded moving north and roosting short-term at Comet mine, 30km north-west (Biologic, 2019d). The Project is unlikely to have a significant impact on the species based on this criterion.
			3. 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, 2017b). The local colony is planned to persist within the Klondyke Queen mine and mitigation measures for impacts are in place or planned. The Project is unlikely to have a significant impact on the species based on this criterion.
			4. Adversely affect habitat critical to the survival of a species	**Likely**	Impact on the Klondyke Queen Mine housing the Ghost bat colony, the roost itself being the critical habitat, is planned to be mitigated with adaptive management but remains at a significant risk level from possible indirect impacts. Blasting controls and limits on movements of heavy vehicles will reduce the risk of collapse due to the adjacent planned mining. Appropriate management of the tailings pond containing cyanide is also planned. Dewatering associated with the mine pit may impact upon on the humidity within the roost, although the implications for this are unclear.

Species	National Listing	Likelihood of occurrence	MNES Significant Impact Criteria	Likelihood of a significant impact	Comments/Assessment
			5. Disrupt the breeding cycle of an important population	**Unlikely**	The colony is planned to persist within the Klondyke Queen mine (Permanent Maternity Roost) and mitigation measures for impacts are in place or planned. Bow Bells South has not been confirmed as a breeding roost despite multiple surveys (Biologic, 2017d, 2018, 2019f); however, there are breeding records at Comet mine (Armstrong & Anstee, 2000). The Project is unlikely to have a significant impact on the species based on this criterion.
			6. 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 colony is planned to persist within the Klondyke Queen mine. The area impacted by the proposed mine's operations (378.6 ha) is a small percentage of the overall foraging habitat available. In addition, the species utilises foraging habitat outside of the Study Area in the plains to the north and south of the Warrawoona Ranges as its preferred foraging grounds (Biologic, 2019d, 2019e). The Project is unlikely to have a significant impact on the species based on this criterion.
			7. Result in invasive species that are harmful to a vulnerable species becoming established in the vulnerable species' habitat	**Unlikely**	The colony is planned to persist within the Klondyke Queen mine and no significant impacts from invasive species introduced by the mine's operations are foreseen. The Project is unlikely to have a significant impact on the species based on this criterion.
			8. 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 unlikely to have a significant impact on the species based on this criterion, and the colony is planned to persist within the Klondyke Queen mine.
			9. Interfere substantially with the recovery of the species.	**Unlikely**	Impact on the size of the Ghost bat colony is planned to be mitigated, but the fluctuations in population size of the colony present during the mining operation cannot be foreseen. Any limited reduction during operations is expected to recover following completion of the operations. Any major reduction of the colony size during operations will initiate adaptive management procedures to further mitigate or remove impacts. The Project is unlikely to have a significant impact on the species based on this criterion.

Species	National Listing	Likelihood of occurrence	MNES Significant Impact Criteria	Likelihood of a significant impact	Comments/Assessment
Pilbara Leaf-nosed Bat *Rhinonicteris aurantius*	Vulnerable	Confirmed	1. Lead to a long-term decrease in the size of an important population of a species	**Likely**	The colony within the Warrawoona Study Area is considered of regional significance based on the genetic distinctiveness from northern populations, and consistently high population size and activity level (TSSC, 2016b). The colony is part of the greater Pilbara population, which is regarded as a 'important population' and therefore "The loss of, or unmitigated disturbance to, roosts constituting habitat critical to the survival of the PLNB (Priority 1 and 2 refuges, especially those with a known or suspected large colony size), is highly likely to lead to a long-term decrease in the size of the PLNB population." (TSSC, 2016b) The colony is planned to persist within the Bow Bells South mine, over 3 km distant from the mine's operations, and mitigation measures for impacts are in place or planned. Dewatering of roost sites presents the highest risk to the species due to their dependency on high humidity environments. Although the risk of cyanide poisoning is considered low, the species potential dependency on local water resources during the height of the dry season may still present this impact source as a risk. Therefore, the Project is considered likely to have a significant impact on the species based on this criterion.
			2. Reduce the area of occupancy of an important population	**Unlikely**	Aside from roosting, Pilbara Leaf-nosed Bats use the Study Area as a flight path to preferred foraging grounds outside of the Warrawoona Ranges, occasionally also using areas such as the Copenhagen pit, proposed TSF area, and area north-west of Bow Bells for foraging (Biologic, 2019d, 2019e). The colony is planned to persist within the Bow Bells South mine and mitigation measures for impacts are in place or planned. Therefore, the Project is unlikely to have a significant impact on the species based on this criterion.
			3. Fragment an existing important population into two or more populations	**Unlikely**	The Pilbara Leaf-nosed Bat in the Pilbara and upper Gascoyne represent one interbreeding biological population comprising multiple colonies (Armstrong, unpublished genetic data in TSSC, 2016b). This isolated population is of national significance. However, the colony is planned to persist within the Bow Bells South mine and mitigation measures for impacts are in place or planned. Therefore, the Project is unlikely to have a significant impact on the species based on this criterion.

Species	National Listing	Likelihood of occurrence	MNES Significant Impact Criteria	Likelihood of a significant impact	Comments/Assessment
			4. Adversely affect habitat critical to the survival of a species	**Likely**	Both Bow Bells South and Klondyke Queen are classified as Permanent Diurnal Roosts (Priority 1), and are considered "critical habitat for daily survival, occupied year-round and likely to be the focus for some part of the 9-month breeding cycle", as defined by TSSC (2016b). The colony is planned to persist within the Bow Bells South mine, although Klondyke Queen will likely be impacted following dewatering. The area impacted by the mine's operations is a small percentage of the overall foraging habitat available, although the proposed Klondyke Pit area is used as a regular flight path for the species (Biologic, 2019d, 2019e). Appropriate management of the tailing pond containing cyanide is also planned.
			5. Disrupt the breeding cycle of an important population	**Likely**	Bow Bells South and Klondyke Queen are classified as Permanent Diurnal Roosts (Biologic, 2019f), with observations of pregnant bats exiting the adit in January 2019 (R. Bullen pers comms in Biologic, 2019f). The colony is planned to persist within the Bow Bells South mine that is distant from the mine's operations and mitigation measures for impacts are in place or planned. Abandonment of Klondyke Queen is likely following dewatering activities
			6. 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 colony is planned to persist within the Bow Bells South mine and the area impacted by the mine's operations at 378.6 ha is a small percentage of the overall foraging habitat available. In addition, the species utilises foraging habitat outside of the Study Area in the plains to the north of the Warrawoona Ranges as its preferred foraging grounds as well as the area north-west of Bow Bells, and Copenhagen (Biologic, 2019d, 2019e). The Project is unlikely to have a significant impact on the species based on this criterion.
			7. Result in invasive species that are harmful to a vulnerable species becoming established in the vulnerable species' habitat	**Unlikely**	The colony is planned to persist within the Bow Bells South mine and no significant impacts from invasive species introduced by the mine's operations are foreseen. The Project is unlikely to have a significant impact on the species based on this criterion.
			8. 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 unlikely to have a significant impact on the species based on this criterion, and the colony is planned to persist within the Bow Bells South mine.

Species	National Listing	Likelihood of occurrence	MNES Significant Impact Criteria	Likelihood of a significant impact	Comments/Assessment
			9. Interfere substantially with the recovery of the species.	**Unlikely**	Potential impact on the size of the Pilbara Leaf-nosed Bat colony is planned to be mitigated but the fluctuation in population size of the colony during the mining operation cannot be foreseen. Any reduction during operations is expected to recover following completion of the operations. The Project is unlikely to have a significant impact on the species based on this criterion.

6. GENERAL MANAGEMENT AND MITIGATION

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

Mitigation has the principal aim of avoiding significant impacts and should be applied in a hierarchical order. 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

The EPA (2014) mitigation hierarchy is:

1. Avoid

Due to the distance from the eastern edge of the Klondyke pit and the presence of Ghost Bat maternity roost within the Klondyke Queen workings, a 32-hectare mining exclusion zone is proposed by Calidus. The exclusion zone includes the Pilbara Leaf-nosed Bat buffer of 200 metres and will incorporate the following historic workings:

- Klondyke Queen Adit
- Klondyke Queen Shaft
- Klondyke Boulder - Nocturnal Refuge (PLNB) and Possible occasional Diurnal Roost (Ghost Bat)
- Dawson City - PLNB Nocturnal Refuge (PLNB) and occasional Diurnal Roost (Ghost Bat)
- Wheel of Fortune East - Nocturnal Refuge (PLNB) and Night Roost (Ghost Bat)
- Klondyke No 1 West - Nocturnal Refuge (PLNB) and Night Roost (Ghost Bat)
- Mullins Adit - Nocturnal Refuge (PLNB) and Diurnal Roost (Ghost Bat)
- Klondyke No 1 East- Nocturnal Refuge (PLNB) and Night Roost (Ghost Bat)

The Mining Exclusion Zone is based on recommendations from Bat Call WA:

“Generally, Ghost Bats of the Pilbara occur in small groups of 10 or less. For these groups to persist in an area my research from several BHP and Rio Tinto iron ore projects has shown that the bats need an “apartment block” of roosting opportunities, at least one deep cave with characteristics of a maternity roost, multiple caves/shelters and overhangs in close proximity offering nocturnal feeding and refuge opportunities, a local productive set of gullies and gorges, a productive foraging area within 5-10 km radius, usually including a good quality riparian line

or ephemeral fresh water lake bed and appropriate protection from human interference (author's unpublished data).

We now have data from our monitoring of the sites nearby Klondyke Queen that Ghost Bats use the roosting opportunities offered by adits and shafts (Klondyke Boulder and Dawson City plus others) during night time resting and foraging bouts. We also know from observation that Ghost Bats can be easily flushed from their diurnal roost caves in day light, including my own obs of bats being flushed from the Klondyke Queen, and Bow Bells by nothing more than my approach on foot.

When flushed in daylight they almost immediately go to an alternate refuge where they hang for a while before returning to the diurnal roost cave. I have also observed on at least three occasions raptors attempting to intercept the Ghost bats on the wing in daylight, one years ago that was successful. The combined evidence from the above is that a number of good quality refuges nearby Klondyke Queen will be required to protect the Ghost Bat colony long term. Natural refuge caves, shelters and overhangs are limited in that area, so I have requested the area west to the creek line beyond Klondyke Boulder to give a series of good opportunities" - R Bullen pers comm (May 2019).

The TSF has been positioned in the hills rather than the plains to the south of the Project area to avoid impact to Bat foraging areas.

2. Minimise

Clearing for the Warrawoona Project will be controlled and minimised by ground disturbance procedures.

The potential for contract with cyanide will be minimised by the use of cyanide destruct circuit as per cyanide monitoring procedures.

The potential for destabilisation of the Klondyke Queen workings will be minimised by following adaptive blast management techniques and developing the project from east to west.

3. Rehabilitate

The Project will employ progressive rehabilitation where possible and will manage for Closure via the site closure plan.

Calidus also commits to the establishment of a freshwater dam within the Mining Exclusion Zone provide a drinking resource, which may serve as a drinking resource during the life of the mine (only).

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 and is an integral part of mining activities. Annual monitoring programmes for the bat fauna have been undertaken since 2016 (Biologic, 2017d, 2019c, 2019f; Specialised Zoological, 2017a, 2017b). Continuation of

these programs will assist in identifying if population declines occur beyond what is expected and inform strategic adaptive management strategies during or subsequent to development. Additionally, where impacts are identified as ‘moderate’, but certainty is ‘moderate’ or ‘low’, monitoring is recommended to inform strategic adaptive management strategies.

Table 6.1 details potential mitigation and management strategies for each impact source identified in the Study Area.

Table 6.1 Potential mitigation and management strategies for each impact source identified in the Study Area (adapted from DoE, 2016; TSSC, 2016a, 2016b)

Impact source	Potential mitigation
Removal, fragmentation or modification of habitat	• Critical roosting and breeding habitat for both species, the Klondyke Queen and Bow Bells mines, are planned to be retained without modification. • Ensure no entry into conservation areas with signage (except for necessary environmental management and monitoring). • Investigate strategies to reduce impacts of high frequency traffic on fauna created by the haul road corridors. • Implement a progressive rehabilitation and closure plan to ensure disturbed areas are rehabilitated as soon as practicable. No mitigation of the cleared area is possible during the mine's operations • Maintain a standardised monitoring programme to confirm continued presence and levels of activity at diurnal roosts, night refuges or in open habitats such as over pools. Baseline information should be collected as early as possible before works commence, methods should be non-invasive such as making acoustic or video recordings, the design should be standardised to allow long term comparisons and the programme should include triggers and contingencies in the event that a negative influence of nearby development-related activity is detected. • The SSMP Standard Operating Procedures should detail how to remove roosts without having individuals present inside.
Vibration	• Ensure blasting in completed in line with the parameters specified by Martin (2018) • Adaptive management as mining progresses from east to west towards Klondyke Queen.
Introduced Species	• Implement quarantine and hygiene controls to prevent the inadvertent introduction of Cane Toads and other introduced species (including weeds). • Conduct monitoring and control of feral animals and implement management measures to prevent the increase of feral species numbers and control the attraction of any new feral species • Prepare and implement a weed management strategy to prevent the spread of existing weed species and the establishment of new weeds, with priority on habitat-modifying weeds.

Impact source	Potential mitigation
Increased Light and/ or Noise	• Best available technology to minimise noise emissions from mining operations will be implemented. • Reduce traffic and equipment usage at night to minimise noise disruption • All blasting practices should have procedures and designs that are adhered to and ensure that acceptable vibration levels are not exceeded • Blasting should commence at safe distances from the closest sensitive sites to ensure that techniques are well established, and the air overpressure site equation can be established. • Planning is in place, including the location of the plant and accommodation village, to minimise artificial lighting of the bat roost entrances. • Lights will be directed inwards towards mine activities to minimise lighting effects on fauna in adjacent areas.
Dust	• Blasting activities will be restricted to daytime operations when bats are not active. • The buffer eastern edge at the pit crest is 200 m from the Klondyke Queen Adit entrance. This is considered to be adequate, primarily because of the topography between the Klondyke Queen workings and the western edge of the proposed Klondyke Pit. • The proposed Klondyke Pit is located on a separate hill on the opposite side of a creek line which acts as a natural shield and minimises dust, noise and vibration impacts (from haulage, drilling and blasting activities) from reaching the workings. • Industry best practice dust control strategies will be implemented for mobile plant operations, including dust suppression measures to reduce the effects of dust on vegetation and natural water bodies, and hence on fauna habitats and assemblages. This includes management of vehicle speed on unsealed roads, and proximity of habitats to blasting and excavation
Changed Fire Regimes	• Manage fuel loads of weeds to reduce risk of high fire intensity. • Prepare and implement a strategy for prevention of unplanned fires • Educate and train staff about equipment and procedures to act on unexpected fire events. • Industry best practice fire control strategies will be implemented for all operations.

Impact source	Potential mitigation
Vehicle Strike	• Vehicle movements at night (when Ghost Bat and Pilbara Leaf-nosed Bat are most active) are greatly reduced compared with daytime vehicle movements and are generally limited to in-pit operations. • Report and record road kills. • Prevent unauthorised off-track driving • Implement measures to minimise roadkill – such measures could include changing the speed and times at which vehicles travel and signage • 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

Altered Water Quality	• Cyanide reduction/destruction will be combined with fauna monitoring protocols (including bat monitoring) that will be detailed in the SSMP. Management protocols will allow for adaptive management of WAD cyanide discharge concentrations within the approved maxima as the project progresses and data becomes available.
	• A summary of the cyanide and TSF control strategies are:
	  • Automated cyanide detection in the plant will frequently test for WAD cyanide concentration in the hopper(s)
	  • Containment of all tailing's waters within the TSFs, processing plant and processing plant dams
	  • Provision of emergency containment channels alongside tailings storage pipelines to and from the TSF
	  • Maintenance of process pipe work, equipment and leak detection equipment
	  • Use of cyanide destruction/reduction method tailings slurry to permissible levels before the processing plant slurry discharge is pumped to the TSF
	  • Routine monitoring and reporting of tailings facility flows, ground water and employee work areas for cyanide levels
	• Routine patrols of tailings and process areas to ensure the potential for spillage, dust or native fauna and flora impacts are minimised.
	• Calidus has also proposed a ~32 ha Mining Exclusion Zone ("bat apartment block") including a freshwater dam as an attractant away from any contaminated water,

Modification of Water Regimes	• Monitor activity over course of dewatering to determine impacts – put controls in place if population decline recorded

Impact source	Potential mitigation
Other Project Designs	• Potential significant impacts to the Ghost Bat and Pilbara Leaf-nosed Bat colonies at the Klondyke Queen and Bow Bells mines are recognised and communicated to mine planners. • An adaptive SSMP should contains specific management for these fauna species of conservation significance, and reviewed on a regular basis • Infrastructure such as the plant and accommodation village are located in locations to minimise these impacts. • TSF will be designed and managed to minimise impact on the species at risk. • Educate mine site personnel and contractors with respect to fauna of conservation significance.

7. CONCLUSION

This Impact Assessment provides a detailed summary of the recent survey work completed within the Warrawoona Gold Project area to date targeting bat fauna of conservation significance and assesses the potential impacts from implementation of the proposed development.

Two key receptors were identified within the Study Area; two species of bat fauna of conservation significance, and their associated roosting and foraging habitats. Both bat species (Ghost Bats and Pilbara Leaf-nosed Bats) are considered Matters of National Environmental Significance. Nine sources may affect the targeted fauna were identified.

The extent and magnitude of some of these impact sources, such as noise, light, humidity, or changed fire regimes, has not been well researched for Ghost Bats and Pilbara Leaf-nosed Bats, and the final impact is limited in its accuracy in this regard.

Any modification or degradation of the primary roosts (Klondyke Queen and Bow Bells South) is considered to be the greatest risk of development to both species; however, Calidus have committed to avoiding these areas during the proposed development. However, given the proximity of the Klondyke pit to the Klondyke Queen roost, a geotechnical assessment was undertaken to assess the potential secondary effects of vibration from blasting on Klondyke Queen. The assessment found that if the modelled design parameters are utilised, drill and blast activities can safely occur to within 185 m of the Klondyke Queen and will not result in vibration exceeding that of human comfort levels, or result in collapse of this sensitive receiver (Martin, 2018). Geotechnical Consultant Peter O'Bryan and Associates reviewed the blasting recommendations by Martin (2018) and endorsed the finding that if the blasting recommendations are followed, it is unlikely that the integrity or stability of the Klondyke Queen will be compromised (Peter O'Bryan & Associates, 2019).

Given the proximity of development to the two known roosts, some level of impact is expected. Removal of habitat is considered to be the most significant impact source and likely to have a moderate magnitude of impact at the local and a low magnitude at the regional scale for both the Ghost Bat and the Pilbara Leaf-nosed Bat. The total indicative disturbance footprint for the proposed development within the Study Area is estimated to be 378.6 ha. The main areas of land disturbance are associated with the construction of a Tailings Storage Facility (TSF) (142.5 ha), Waste Rock Disposal (WRD) (95.1 ha), and Mining Pits (37.1 ha). In terms of direct loss of roost habitat, the proposed Klondyke Pit will result in the removal of five old workings (KQ488, Cuban, Kopckes Reward, St George 3 and Britannia). All four workings are low value roosts for either Pilbara Leaf-nosed Bat (Nocturnal Refuge) and/or Ghost Bat (Night Roost)

Vibration, artificial lighting and/or noise, modification of water regimes and altered water quality, were also assessed as impact sources having a moderate level of impact to both the Ghost Bat and Pilbara Leaf-nosed Bat at the local scale, although only a low or negligible level at the

regional scale. Vehicle strike was also assessed as having a moderate level of impact at the local scale for the Pilbara Leaf-nosed Bat.

Vibration - While drilling and blasting activity may not impact upon the structure of the roosts themselves, the proximity of Klondyke Queen to the Klondyke pit will mean that individuals of both species will experience small, but long-term, effects of vibration and noise. Given the long-term nature of the disturbance the population of both species roosting within maybe impacted during the mining process.

Artificial Lighting and/or Noise - The effects of artificial lighting on both species is relatively understudied, however given the proximity of the proposed pit to the Klondyke Queen roost, most individuals inhabiting Klondyke Queen will experience some level of artificial lighting. The degree to which this may impact upon each species is unknown but at the very least foraging and flight patterns are likely to be affected as a result of artificial lighting.

Modification of Water Regimes - The lower levels of the Klondyke Queen workings are thought to be connected to the water table (GRM, 2019), and therefore dewatering the Klondyke Pit may reduce humidity in the adjacent Klondyke Queen workings. As the Pilbara Leaf-nosed Bat is dependent on humid microclimates (Baudinette *et al.*, 2000; Churchill, 2008) this may cause the Pilbara Leaf-nosed Bat to abandon the Permanent Diurnal Roost inside the Klondyke Queen workings and return to the nearest main permanent roost. Given the fluctuations of the Pilbara Leaf-nosed Bat population at Klondyke Queen, when compared to Bow Bells South (3 km west), abandonment of Klondyke Queen is unlikely to have a significant impact to the species at the regional scale, given the likely continued presence of the species elsewhere on the Warrawoona Range. The effect this will have on the Ghost Bat population within Klondyke is unclear, while literatures suggests that a higher humidity is required for the species, Ghost Bats have been recorded roosting and reproducing in caves that have low humidity levels (R. Bullen *pers. comm.* 2019).

Altered Water Quality – Alteration of water quality may impact both species through the presence of cyanide in the ore slurry at the proposed Tailing Storage Facility (TSF). There is an absence of data to support a <50 mg/L WAD cyanide discharge for the two conservation significant bat fauna present, and it is therefore crucial that the commitment to a concentration of WAD cyanide discharge <30 mg/L, based on data from a similar mining operation in NSW, is upheld. Water regimes may be impacted by the alteration for groundwater regimes which may impact upon the humidity of the roosts. Nickel arsenic will also be present in the Klondyke pit post-closure and may therefore impact upon drinking individuals; however given that this naturally occurring chemical leads to an increased in salinity, it is not expected that wildlife will use the water for drinking and therefore be unaffected by its presence.

For Pilbara Leaf-nosed Bats vehicle strike is assessed as a moderate impact due to the species inquisitive nature coupled with the increased vehicle traffic adjacent to roosts. 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 and for this reason dust is believed to have a moderate level of impact to the species.

By adopting a systematic approach and considering a set of defined criteria supported by published research and recent surveys, this EIA is able to narrow down the potential impact sources for the targeted bat fauna to those most likely to be significantly enhanced by the proposed development activities. It is understood that Calidus will implement a range of adaptive management plans for Project operation, including a SSMP, blasting management plan and procedures, metalliferous drainage management plan, cyanide and groundwater management procedures.

The significant impacts to bat fauna and their associated habitats highlighted in this report should be considered and incorporated into these management plans and used to address the noted knowledge gaps discussed.

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Appendix A: Roost classification of mine workings within the Study Area, with annual activity levels

Site	Roost significance (highest recorded)		Pilbara Leaf-nosed Bat activity levels				Ghost Bat activity levels			
	Pilbara Leaf-nosed Bat	Ghost Bat	2019	2018 (Biologic, 2018)	2017 (Biologic, 2017b, 2017d; Specialised Zoological, 2017a)	2016 (Specialised Zoological, 2017b)	2019 Activity per night recorded	2018 (Biologic, 2018)	2017 (Biologic, 2017b, 2017d; Specialised Zoological, 2017a)	2016 (Specialised Zoological, 2017b)
Bow Bells Block 1	Nocturnal Refuge	Night Roost	Not sampled	Not sampled	58 (av calls/night) (Biologic, 2017d)	Not sampled	Not sampled	Not sampled	Not sampled	Not sampled
Bow Bells South - Adit	Permanent Diurnal Roost	Occasional Diurnal Roost	>1,750 (av calls/night)	> 2800 calls (548 individuals recorded exiting)	>4000 (Biologic, 2017d)	3-25 calls	11 recorded via video. >35 ultrasonic calls recorded per night.	Av 15 calls/night at adit	1 recorded via video-camera (Biologic, 2017d)	Present (no quantification of numbers)
Bow Bells South - Shaft	Permanent Diurnal Roost	Occasional Diurnal Roost	Not sampled	>4,200 av calls/night (Biologic, 2018)	>1,100 av calls/night (Biologic, 2017d)	Not sampled	Not sampled	~10 calls p.n. ultrasonic and social	~150 calls (Biologic, 2017d)	Not sampled
Britannia	Nocturnal Refuge	-	Not sampled	Not sampled	10 (av calls/night)	Not sampled	Not sampled	Not sampled	Not sampled	Not sampled
British Exploration of Australia	Nocturnal Refuge	-	Not sampled	Not sampled	9 calls av calls/night (Biologic, 2017d)	Not sampled	Not sampled	Not sampled	1 call	Not sampled
Comet	Nocturnal Refuge	Permanent Maternity Roost	2 (av calls/night)	~25 calls/night	5 calls (Biologic, 2017d)	No calls recorded	269 recorded visually	~130 calls (67 via visual counts)	105 recorded visually (Biologic, 2017d)	Present (>43)
Copenhagen Open Cut	Foraging site	Foraging site	23 (Range 20 - 26 calls per night)	Av 43 calls over 5 nights (range 27-68)	177 calls (Biologic, 2017d)	83 – 392 calls	No calls recorded	No calls recorded	No calls recorded	No calls recorded
Criterion	Nocturnal Refuge	Possible occasional Diurnal Roost	15 (av calls/night)	Not sampled	25 (Biologic, 2017d)	Not sampled	25 calls recorded	Not sampled	No calls recorded	Not sampled

Site	Roost significance (highest recorded)		Pilbara Leaf-nosed Bat activity levels				Ghost Bat activity levels			
	Pilbara Leaf-nosed Bat	Ghost Bat	2019	2018 (Biologic, 2018)	2017 (Biologic, 2017b, 2017d; Specialised Zoological, 2017a)	2016 (Specialised Zoological, 2017b)	2019 Activity per night recorded	2018 (Biologic, 2018)	2017 (Biologic, 2017b, 2017d; Specialised Zoological, 2017a)	2016 (Specialised Zoological, 2017b)
Cuban	Nocturnal Refuge	Night roost	Not sampled	Not sampled	-	Not sampled	Not sampled	Not sampled	10 calls	Not sampled
Dawson City	Nocturnal Refuge	Occasional Diurnal Roost	126 (Range 107 - 152 calls per night)	610 calls/night	>1000 calls per night (av 727) (Biologic, 2017d)	Not sampled	~10 calls p.n.	<5 calls on two nights, 1 individual recorded exiting	10 calls (Biologic, 2017d)	Not sampled
Dead Camel	Destroyed (was Nocturnal Refuge)	Destroyed	Not sampled	Not sampled	1 av calls/night (Biologic, 2017d)	Not sampled	Not sampled	Not sampled	No calls recorded	Not sampled
Gauntlet	Nocturnal Refuge	Night Roost	Not sampled	Not sampled	7 av calls/night (Biologic, 2017d)	Not sampled	Not sampled	Not sampled	1 call (Biologic, 2017d)	Not sampled
Gauntlet SE	Nocturnal Refuge	Night Roost	Not sampled	Not sampled	24 av calls/night (Biologic, 2017d)	Not sampled	Not sampled	Not sampled	1 call (Biologic, 2017d)	Not sampled
Gift – Decline	Nocturnal Refuge	-	Not sampled	Not sampled	25 av calls/night (Biologic, 2017d)	Not sampled	Not sampled	Not sampled	1 call (Biologic, 2017d)	Not sampled
Gift – Shaft	Nocturnal Refuge	-	Not sampled	Not sampled	132 av calls/night (Biologic, 2017d)	Not sampled	Not sampled	Not sampled	No calls recorded	Not sampled
Golden Gauntlet	Nocturnal Refuge	-	Not sampled	Not sampled	16 av calls/night (Biologic, 2017d)	Not sampled	Not sampled	Not sampled	No calls recorded	Not sampled
Klondyke 1 East	Nocturnal Refuge	Night Roost	Not sampled	Not sampled	7 av calls/night (Biologic, 2017d)	Not sampled	Not sampled	Not sampled	8 calls	Not sampled
Klondyke 1 west	Nocturnal Refuge	Night Roost	Not sampled	Not sampled	7 av calls/night (Biologic, 2017d)	Not sampled	Not sampled	Not sampled	4 calls (Biologic, 2017d)	Not sampled
Klondyke Boulder	Nocturnal Refuge	Possible occasional Diurnal Roost	79 (Range 65 - 93 calls per night)	1,070 av calls/night	1070 calls/night (Biologic, 2017d)	Not sampled	~3 calls p.n.	<5 calls	5 calls (Biologic, 2017d)	Not sampled

Site	Roost significance (highest recorded)		Pilbara Leaf-nosed Bat activity levels				Ghost Bat activity levels			
	Pilbara Leaf-nosed Bat	Ghost Bat	2019	2018 (Biologic, 2018)	2017 (Biologic, 2017b, 2017d; Specialised Zoological, 2017a)	2016 (Specialised Zoological, 2017b)	2019 Activity per night recorded	2018 (Biologic, 2018)	2017 (Biologic, 2017b, 2017d; Specialised Zoological, 2017a)	2016 (Specialised Zoological, 2017b)
Klondyke Queen - Adit	Permanent Diurnal Roost	Permanent Maternity Roost	~1,500 recorded exiting by IR-lit video	July 2018: >4800 calls and bats sighted	April 2017: Between 23 – 98 calls from the adit and 72 – 457 calls from the roof over four nights May 2017: Individuals recorded Sep 2017: >3000 calls and bats sighted	Nov 2016: 152, 96, and 73 calls over three nights (Specialised Zoological, 2017b)	~475 recorded exiting by IR-lit video	July 2018: 450 visual count of bats exiting	April 2017: 24 and 28 recorded May 2017: 200 recorded on camera, five individuals captured Sept 2017: 265 visual count of bats exiting	Nov 2016: 366 and 80 individuals observed over two nights
Klondyke Queen – Hill Top	Non-permanent Diurnal Roost	-	Not sampled	Not sampled	255 av calls/night (Biologic, 2017d)	Not sampled	Not sampled	Not sampled	~ 10 recorded visually (Biologic, 2017d)	Not sampled
Klondyke Queen – Open Cut	Non-permanent Breeding Roost	Maternity Roost	Not sampled	Not sampled	>3,000 av calls/night (Biologic, 2017d)	Not sampled	Not sampled	Not sampled	~ 5 recorded visually (Biologic, 2017d)	Not sampled
Klondyke Queen 488	Nocturnal Refuge	Night Roost	Not sampled	Not sampled	58 av calls/night (Biologic, 2017d)	Not sampled	Not sampled	Not sampled	4 calls (Biologic, 2017d)	Not sampled
Kopckes Reward	Nocturnal Refuge	-	Not sampled	Not sampled	5 av calls/night (Biologic, 2017d)	Not sampled	Not sampled	Not sampled	No calls recorded	Not sampled

Site	Roost significance (highest recorded)		Pilbara Leaf-nosed Bat activity levels				Ghost Bat activity levels			
	Pilbara Leaf-nosed Bat	Ghost Bat	2019	2018 (Biologic, 2018)	2017 (Biologic, 2017b, 2017d; Specialised Zoological, 2017a)	2016 (Specialised Zoological, 2017b)	2019 Activity per night recorded	2018 (Biologic, 2018)	2017 (Biologic, 2017b, 2017d; Specialised Zoological, 2017a)	2016 (Specialised Zoological, 2017b)
Marble Bar Copper	Nocturnal Refuge	Foraging Site	Not sampled	53 av calls/night (Biologic, 2018)	12 av calls/night (Biologic, 2017d)	Present (no quantification of numbers) (Specialised Zoological, 2017a, 2017b)	Not sampled	1 call (Biologic, 2018)	No calls recorded	Present (no quantification of numbers) (Specialised Zoological, 2017a)
Mullan's	Nocturnal Refuge	Possible Diurnal Roost	Not sampled	Not sampled	113 av calls/night (Biologic, 2017d)	Not sampled	Not sampled	Not sampled	13 calls (Biologic, 2017d)	Not sampled
St George	Nocturnal Refuge	Night Roost	Not sampled	Not sampled	6 av calls/night (Biologic, 2017d)	Not sampled	Not sampled	Not sampled	2 calls (Biologic, 2017d)	Not sampled
St George 3	Nocturnal Refuge	-	Not sampled	Not sampled	2 av calls/night (Biologic, 2017d)	Not sampled	Not sampled	Not sampled	No calls recorded	Not sampled
Trible Event NW	Nocturnal Refuge	Night Roost	Not sampled	Not sampled	25 av calls/night (Biologic, 2017d)	Not sampled	Not sampled	Not sampled	1 call (Biologic, 2017d)	Not sampled
Trump	Nocturnal Refuge	Foraging site	25 p/n	270 p/n	2 (Biologic, 2017d)	Technical error	~15 calls p/n	1-3 calls p/n	< 5 calls p.n.	Technical error (no calls recorded)
Wheel of Fortune East	Nocturnal Refuge	Night Roost	Not sampled	Not sampled	5 av calls/night (Biologic, 2017d)	Not sampled	Not sampled	Not sampled	1 call (Biologic, 2017d)	Not sampled