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SUMMARY

Atlas identified the presence of Ghost bats and caves during their 2016 to 2021 surveys of the Sanjiv Ridge Project area. The Ghost bat is listed as *Vulnerable* under both federal and state legislation and a Matter of National Environmental Significance (MNES). Key findings relevant to impacts to Ghost bats and ghost bat caves within Stage 2 of the Sanjiv Ridge Project area include:

1. Specific impacts to Ghost bat caves from Stage 2 of the project are determined as:
 - Dazzler pit and associated works – no long-term impacts to Ghost bats, with possible short-term abandonment of non-critical adjacent caves.
 - Glen Herring pit and associated works – Presence of two groupings of critical habitat caves, GH-1 and GH-2, and two isolated ‘category 2’ critical habitat caves, CO-CA-20 and -22. Short-term abandonment is likely to occur at these caves during mining, but reoccupation and no long-term impact is expected, contingent on structural integrity of all caves being maintained. Despite a single observation of roosting Ghost bats, it is not necessary to protect one insignificant category 4 cave (CO-CA-34) due to expected low level of Ghost bat usage.
2. Any bats exhibiting short-term abandonment from caves within the project area as a result of mining activities are expected to utilise more distant Cat 2 and 3 caves in the district including but not limited to CO-CA-01, -06, -33, -35 (Mt Ada mine adit) and -42 (Mt Florence adit) as their preferred location. More distant Ghost bats hub are present at Warrawoona, Marble Bar and Mt Webber.
3. There is minimal short- or long-term impact on Ghost bat foraging expected.

To support persistence of the bat in the area, the following recommendations are made:

1. Ongoing protection of the critical habitat caves in the district from direct interference by Atlas' operations.
2. Preservation of all caves identified herein as viable Ghost bat roosts, with the exception of cave CO-CA-34, with emphasis placed on the three Category 2 caves (CO-CA-22, -24 and -27), and any caves in close proximity to pits.
 - The two category 2 caves in apartment blocks GH-1 and GH-2 (CO-CA-24, -27) together with the groups of caves, shelters and overhangs nearby (CO-CA-23, -25, -26, -28 & -29) are recommended for protection by suitable exclusion zones as they make up critical habitat groupings that are important for the species' persistence in the area (TSSC 2016a, Bat Call 2017).
 - The remaining isolated category 2 cave (CO-CA-22) and category 3 caves adjacent to the pits and haul road (CO-CA-20, -21 & -30)) are also recommended for protection by suitable exclusion zones as the usage by Ghost bats may be more extensive than the single year of monitoring has recorded.
3. Restricting entry of personnel from all category 2 and 3 caves identified herein with the exception of survey activities. Periodic restricting of survey activities in accordance with a disruption protocol (Appendix B) that is aligned to the breeding cycle of the Ghost bat is recommended.
4. Ongoing monitoring of Ghost Bat activity at the category 2 caves in the project area to better understand bat movements and impacts. Timing of monitoring is recommended to be aligned to the project's development, production and closure schedules.
5. Production blast planning at caves CO-CA-22, -24 and -27 should follow recommendations for maximum in-ground vibration limits to protect the caves' ability to remain viable as a category 2 roost (i.e. to ensure that the cave is not destroyed, blocked or a new rear entrance opened) during future mining operations including drill and blast operations and ore removal operations.
6. During the mining operations, monitoring of the in-ground vibration levels and cave conditions should follow recommendations and be undertaken with feed back to the blasting planning in an adaptive manner to ensure that the caves remain viable as diurnal roosts for the species.
7. Should Ghost bats be found to be roosting diurnally in the caves deemed critical habitat in September leading up to the critical maternity period of October to December, and a blasting campaign be planned nearby during this period, then the caves are to be temporarily sealed while empty of Ghost bats to ensure that there is no direct impact on females that are gravid or their pups after parturition.
8. An alternative to closing caves on an "as required" basis during single reproductive seasons, it is considered viable to close all critical habitat category 2 and category 3 caves in apartment blocks

to Ghost bat occupation while mining is carried out at the project. This viability is due to the proximity of three other major Ghost bats hubs (Warrawoona, Marble Bar and Mt Webber, all within 40 km) that will allow the bats to relocate away during the mining operations and return to the retained caves once mining is completed.

Group	Caves (categories)	Recommended mitigation				Cave may be removed based on PGb usage
		Avoid Disturbing Note 1.	Entry Protocol	Blast monitoring	PGb usage monitoring	
Adjacent to Glen Herring Pit						
Apt. Block GH-1	CO-CA-27 (2)	Yes	Yes	Yes	Yes	
	CO-CA-28 (4)	Yes				
	CO-CA-29 (4)	Yes				
Apt. Block GH-2	CO-CA-23 (3)	Yes	Yes		Yes	
	CO-CA-24 (2)	Yes	Yes	Yes	Yes	
	CO-CA-25 (3)	Yes	Yes		Yes	
	CO-CA-26 (4)	Yes			Yes	
Isolated caves	CO-CA-20 (3)	Yes	Yes		Yes	
	CO-CA-22 (2)	Yes	Yes	Yes	Yes	
	CO-CA-34 (4)					Yes
Adjacent to Glen Herring Haul Road						
Isolated caves	CO-CA-21 (3)	Yes	Yes		Yes	
	CO-CA-30 (3)	Yes	Yes		Yes	
Isolated Cave Reference Sites						
PGb roost	CO-CA-35 Mt Ada (45) Adit	Yes	Yes		Yes	
PGb roost	CO-CA-31 (3)	Yes	Yes			
PGb roost	CO-CA-32 (2)	Yes	Yes			
PGb roost	CO-CA-33 (2)	Yes	Yes		Yes	
PGb roost	CO-CA-42 Mt Florence Adit	Yes	Yes		Yes	
PLNb & PGb roost	CO-CA-01 (2)	As per Stage 1 Sig. Species Mgt Plan.				
PLNb & PGb roost	CO-CA-05 (2)	Yes	Yes		Yes	

Note 1: Temporary closure permitted only as required by Significant Species Management Plan.

In consideration of the above findings and recommendations, it is anticipated that the proposed Sanjiv Ridge Stg 2 project will not have a significant impact on Ghost bats or Ghost bat caves.

Sanjiv Ridge Stage 2 Ghost bat review, July 2021.

Atlas Iron (Atlas) have recently carried out a series of echolocation surveys for the presence of Ghost bat (*Macroderma gigas*) (PGb) at the proposed Sanjiv Ridge Stage 2 (SMR stg 2) project area in the Pilbara, figure 1. This memorandum summarises the results of those surveys, defines two cave groups, six isolated caves nearby the proposed development and five additional caves and one adit distant from the development envelope that are important to the species. It discusses potential impacts to those caves and provides recommendations for ongoing management of the caves and groups.

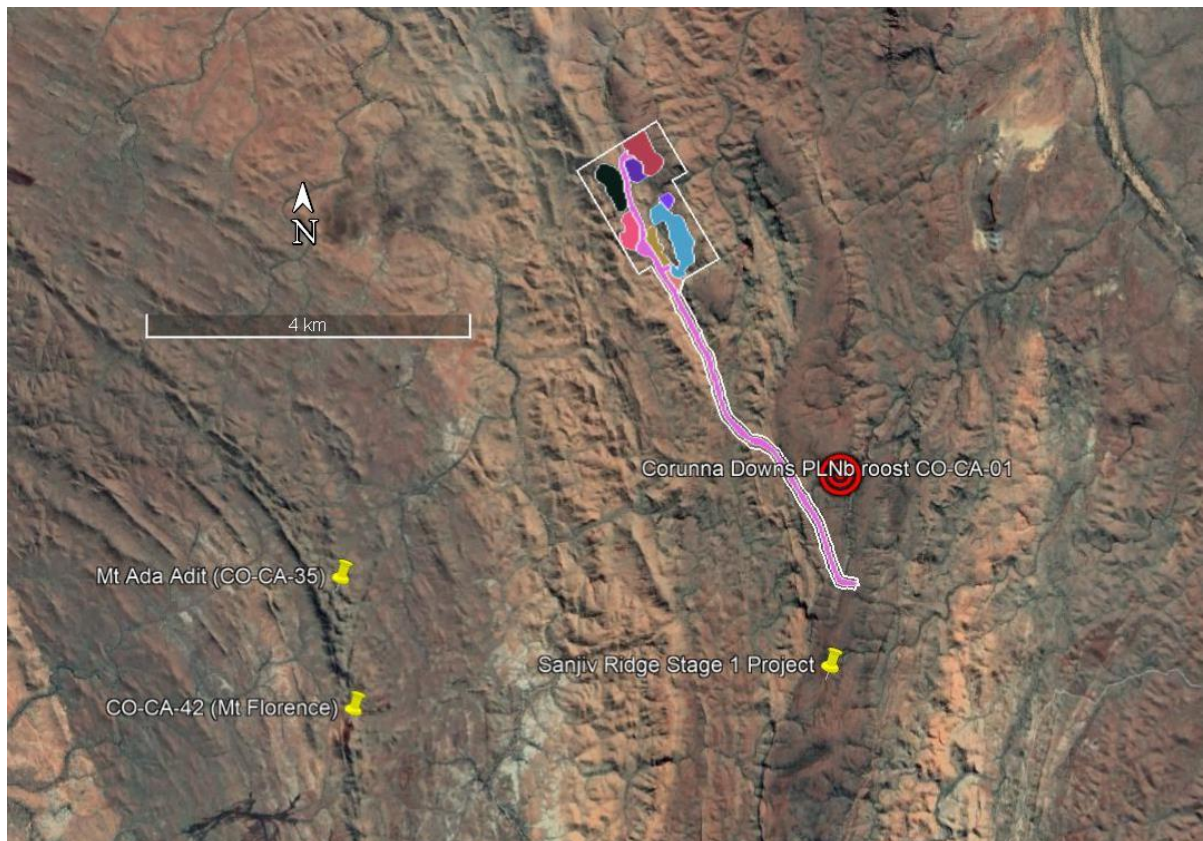


Figure 1: Sanjiv Ridge Stg 2 proposed development envelope. Corunna Downs PLNb is a large permanent PLNb and Ghost bat roost in a natural cave. Mt Ada and Mt Florence Adits are small Ghost bat colonies in historical underground mines.

The echolocation surveys were carried out as targeted cave assessments (Biologic 2020, 2021) using SM4 ultrasonic bat detectors (Wildlife Acoustics, USA) located at various sites. For the surveys, data reduction was carried out using Bat Call's standard review processes for Ghost bat calls, figure 2. Call detections, singly or in groups, made just prior to dawn civil twilight (CT) followed by similar call detection patterns subsequent to dusk CT suggested diurnal roosting of bats at that cave. When these calls were detected in groups over periods of a few to 30 minutes, the number of ultrasonic calls recorded

suggested that a similar number of Ghost bat were entering and re-exiting the caves on that day. Audible social calls also confirm presence however these are not used to indicate numbers present as individual Ghost bats are known to call repeatedly while hanging in the entrance of their roost caves.

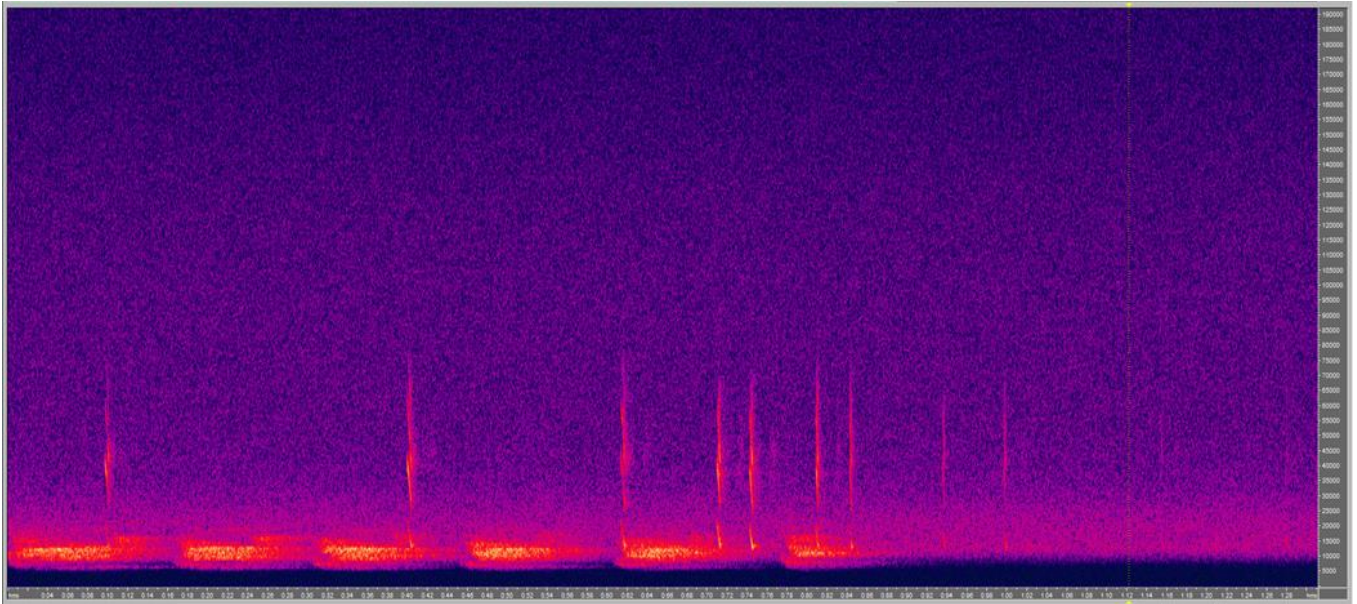


Figure 2: Example of a Ghost Bat audible social and inaudible ultrasonic call sequence

The Ghost bat is an obligate cave roosting bat that is widespread across the Pilbara (McKenzie and Bullen 2009) where it is under pressure from loss of roosting habitat (TSSC 2016a). The Ghost bat is listed as vulnerable under federal and state legislation. It has been the subject of detailed observations for many years and, more recently, to several mid and long-term monitoring programs including BHP’s programs at Mining Area C / South Flank, Rio Tinto’s programs at West Angelas and in the Robe Valley and Calidus Gold’s project at Warrawoona (author’s unpublished data). These observations have shown that for roosting, Ghost bats:

- have a small number of historical/abandoned underground mine roosts in the East Pilbara where large numbers are permanently present, and other natural cave roosts where small numbers are present either permanently or periodically,
- are constantly moving between most other available caves in both the East Pilbara and the Hamersley Ranges and adjacent plains.

The evidence from this work shows that the usage of caves falls into four broad categories. These can be described in a similar manner to the categories in TSSC (2016b) suitably modified for Ghost bat usage. Firstly, there are the caves and historical underground mines (adits and declines) that are used continuously as diurnal roosts by large numbers of Ghost bats for long periods of time, “category 1”

caves. These are “source” locations (Dunning *et al.* 2018) for other caves in the district that have occasional or “sink” type usage. Secondly there are caves that are used regularly as diurnal roosts by small numbers of Ghost bats but not continuously, “category 2” caves. Thirdly there are caves that are occasionally used as diurnal roosts and as nocturnal roosts for feeding and resting more frequently, “category 3” caves. And finally, survey work in recent years has shown that virtually any deep overhang, shelter or cave is subject to a nocturnal visit and/or an opportunistic roosting visit, “category 4” sites. All category 1, 2 and category 3 caves in apartment blocks (see below) are considered to be critical habitat. Detailed definitions for cave categories are given in Appendix A below.

Ghost bat breeding populations are known from a small number of maternity roosts in the Pilbara and reproduce during the northern wet season with parturition typically occurring in the last week of October or the first week of November (Churchill 2008; authors unpublished observations). The largest of these colonies are in “category 1” abandoned historical gold mines in the East Pilbara and number up to several hundred (Armstrong and Anstee 2000; TSSC 2016a; author’s unpublished observations). Colony sizes at these sites varies over time based on seasonal, climatic and other factors. For example, the counts at Kohinoor Adit in the Northern Territory, a category 1 site, have varied between 300 in 1981, 1,500 in 1990 and then down to 550 in 2013 (TSSC 2016a). At two East Pilbara category 1 sites within 25 km of Sanjiv Ridge, variable colony sizes have been recorded between 2017 and 2021. At the Comet mine near Marble Bar, manual counts of exiting bats were 130 in May 2017 rising to 275 in May 2021 (author’s unpublished data). At Klondyke Queen mine, also near Marble Bar, manual counts of exiting bats were 265 in September 2017, 450 in July 2018, 475 in April 2019 and 70 in February 2021 (authors unpublished data). These variations are above those possible based on natural recruitment alone and indicate that bats have congregated at these preferred sites during this period, possibly due to the reduced rainfall received in the east Pilbara between 2017 and 2019 and have begun to spread across the landscape following higher rainfalls in 2020 and 2021. Most other populations across the Pilbara and adjacent Ashburton regions are typically between five and twenty-five individuals in local groups (author’s unpublished data). For these groups to persist the bats need an “apartment block” of roosting opportunities (TSSC 2016a; Bat Call 2017), 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). These groups are known to reproduce in good years using suitable “category 2” natural roost caves. Examples are a group numbering 5 to 10 including reproducing females at West Angelas caves in 1980 (Dr Nic Dunlop pers. comm.), a small

group including reproducing females at caves at Nammuldi/Silvergrass area (Hamersley Iron 1999), observation of a heavily pregnant female at a cave near Mt Robinson by the author in 2013, a group numbering 14 including four juveniles at another cave near Mt Robinson in 2015 (Mr. Morgan O’Connell pers. comm.) and a group of 25 including gravid females at another cave near Mt Robinson in 2017 (Mr. Morgan O’Connell pers. comm.). None of these caves are permanently occupied (author’s unpublished observations). The Ghost bat is also known to spread great distances on an annual cycle from these locations depending upon seasonal weather conditions and availability of suitable day roosts. Sporadic records of Pilbara Ghost bats have been identified in the Gascoyne (author’s unpublished data) and the Little Sandy Desert (sightings by W.H. Butler at Durba Springs in 1971 and others since). Genetic work by Worthington Wilmer and Armstrong (summarised in Woinarski *et al.* 2014) suggests that the females remain or return to the district of their birthplace and that the males can move between districts.

Published information on Ghost bat foraging habitat is sparse. Early published data suggest that the bats use a restricted foraging range of less than 2 km from the diurnal roost (TSSC 2016a). However more recent studies indicate that the bats forage much more widely (~12-15 km from roost cave, Dietsch *et al.* 2016; Augusteyn *et al.* 2018; authors unpublished GPS satellite tracking data), utilise all productive habitats in the Pilbara with the possible exception of treeless spinifex plains (in particular those that have been recently burnt) and forage on a very wide range of prey. Authors unpublished data records regular nightly round trips of up to 25 km in length to a range of foraging sites up to 11 km from the diurnal roost cave and potentially include a total of 38,000 ha over multiple nights. Types of foraging sites regularly visited include cave entrances (where preferred bat species exit), riparian lines, thicker woodlands in productive areas, thin woodlands on plains, thin woodlands on rolling hills with incised gullies and in thin woodlands on the tops of ridge lines (authors unpublished data). Foraging areas are not exclusive and are known to be used by multiple individuals (Tidemann *et al.* 1985). In addition, a Ghost bat marked at Klondyke Queen has been recorded arriving at the Comet mine, over 20 km distant (Mr Morgan O’Connell pers comm).

Ghost bat detection at SMR stg 2 is shown to be consistent with the year-round presence of Ghost bats in the East Pilbara. Ghost bats and/or scat piles were observed or recorded using echolocation recordings at all twelve caves surveyed/monitored within or nearby the development envelope. In addition, there are confirmed permanent “category 2” colonies of Ghost bats (Biologic 2020, 2021) at the nearby historical underground Mt Ada gold mine and at several district caves. At any cave where diurnal

roosting was indicated (apart from Mt Ada and Mt Florence adits), the numbers of bats identified as roosting diurnally suggest that a maximum between five and 20 were present during the survey periods.

Additional information provided by Atlas for this study are:

- SMR stg 2 – Development envelope and indicative footprint information at vsn 5. Email attachments dated 18 August 2021 (herein referred to as Atlas 2021),
- Sanjiv Ridge Stage 2, Ghost bat and Pilbara Leaf-nosed Bat Monitoring and Regional Survey (Biologic 2021a),
- Sanjiv Ridge Stage 2, Vertebrate Fauna Impact Assessment (Biologic 2021b),
- Geotechnical Assessment of Bat Caves at Sanjiv Ridge Stage 2 (PSM 2021).

This memorandum addresses:

- the potential impact of the project including cumulative impacts associated with Stages 1 and 2 on the broader presence of the species in the area.
- the direct and indirect impacts to two groups containing identified category 2 and 3 caves and provides recommendations for their ongoing management.
- the direct and indirect impacts to three identified isolated category 2 and 3 caves adjacent to the Glen Herring pit footprint and provides recommendations for their ongoing management.
- the direct and indirect impacts to four identified category 2 and 3 caves adjacent to the Glen Herring haul road and provides recommendations for their ongoing management.
- The direct impact on Ghost bat foraging habitat.

Table 1: Site recording period and location details.

All data taken from Biologic (2021a; 2021b). Scat age: fresh, recent, old assessed as under 1 month old, 1 to 6 months and over 6 months old respectively.

Cave	Lat / Long	Date of assessment	Cave exposure and aspect	Cave depth (m)	Number of chambers	Chamber height (m)	Ghost bats observed or calls recorded. Estimated number roosting diurnally in brackets	Ghost bat scats/middens present
CO-CA-20	-21.3971 119.6559	May 2020 Jan-Feb 2021 July 2021	South	15	2	1.5	Occasional foraging visits Occasional diurnal roosting (1-2) Occasional foraging visits	
CO-CA-21	-21.4164 119.6625	May 2020 Jan 2021	North-west	10	2	21	Occasional diurnal roosting (1)	
CO-CA-22	-21.3921 119.6524	Jan-Feb 2021 May 2021 July 2021	South-west	20	2	2	Continuous diurnal roosting (3-10) Continuous diurnal roosting (2-5) Continuous diurnal roosting (1-3)	

Sanjiv Ridge Stg 2 review – July 2021

Cave	Lat / Long	Date of assessment	Cave exposure and aspect	Cave depth (m)	Number of chambers	Chamber height (m)	Ghost bats observed or calls recorded. Estimated number roosting diurnally in brackets	Ghost bat scats/middens present
CO-CA-23	-21.3964 119.6540	May 2020 Jan 2021 July 2021	West	10+	1	1.5	May - Continuous diurnal roosting (~10) Jan - Occasional visits July – Regular diurnal roosting (1-3)	
CO-CA-24	-21.3966 119.6539	Jan-Feb 2021 20 th May 2021 Jun-Jul 2021	South-west	6+	1	3	Up to 20 PGB observed roosting. Regular diurnal roosting detected. Diurnal roosting (2-5) in May and 5-10 in July	Scats
CO-CA-25	-21.3961 119.6536	Jan 2021 July 2021	South-west	7	1	4	Jan - Occasional diurnal roosting (1-2) July – Regular diurnal roosting (1-2)	Scats
CO-CA-26	-21.3957 119.6536	Jan 2021 July 2021	West	5	1	3.5	Occasional diurnal roosting (1) Occasional diurnal roosting (1)	
CO-CA-27	-21.3945 119.6569	Jan-Feb 2021 July 2021	South-east,	8	1	5	Up to 14 PGB observed roosting. Continuous diurnal roosting detected Jan-Feb. Regular roosting by 2-5 in July	
CO-CA-28	-21.3949 119.6571	Jan 2021 July 21	East	2	1	2	Occasional diurnal roosting (1-2) Occasional diurnal roosting (1)	
CO-CA-29	-21.3949 119.6573	Jan-Feb 2021 July 2021	North-east,	5	1	2	Continuous diurnal roosting (1-3) Regular diurnal roosting (1-3)	Scats
CO-CA-30	-21.4032 119.6518	28 Jan 2021 July 2021	South	12	2	1	Diurnal roosting (1-2) Regular diurnal roosting (1-4)	Scats
CO-CA-31	-21.3895 119.6727	Jan 2021	South-east	12	1	2.5	Roosting PGB seen Jan 2021	Scats
CO-CA-32	-21.4098 119.64250	Jan 2021	West	15	1	2.5	Eight roosting PGBs seen Continuous diurnal roosting by multiple PGB (2-8)	Scats
CO-CA-33	-21.5197 119.6612	Jan 2021 July 2021	South-west	20	2	3	Continuous diurnal roosting by multiple PGB, also possible juvenile PGB calls recorded in Jan. Continuous diurnal roosting (~5) in July	Scats
CO-CA-34	-21.3972 119.6552	July 2021	South-east	5	1	3	Up to 6 PGB observed roosting, Jan 2021. Regular foraging visits, July 2021	Scats
CO-CA-35 Mt Ada Adit	-21.4236 119.6135	Jan-Feb 2021 July 2021	South-west	Mine adit			Continuous diurnal roosting by 2 to 5 PGB, also possible juvenile PGB calls recorded in Jan. Continuous roosting (5-10) in July	
CO-CA-01	-21.4198 119.6733	Ongoing monitoring	PLNb Cat 1 roost	28	2	5	Continuous diurnal roosting by multiple PLNb and PGB.	
CO-CA-05	-21.4249 119.6742	July-Aug 2017	West				Diurnal roosting by multiple PGB (Bat Call 2018).	
CO-CA-06	-21.4249 119.6742	July-Aug 2017	South	35	1	6	Diurnal roosting by multiple PGB (Bat Call 2018).	Scats
Co-CA-42 Mt Florence adit	-21.4470 119.6154	July 2021		Mine adit			Regular diurnal roosting (1-3)	

SMR stg 2 Cave Groupings and Isolated significant caves

There are two groups of caves that comprise “apartment Blocks” significant for Ghost bat reproduction, and five isolated caves at SMR stg 2 that have been surveyed between 2020 and 2021 for Ghost bat usage. In addition, there are seven district reference sites that have significant PGB presence recorded.

Cave Group GH-1 (Glen Herring pit).

Cave group GH-1 is a group of caves nearby the proposed Glen Herring pit, figure 3, table 2. There are three caves in this group significant to Ghost bats that are subject to disturbance. Caves CO-CA-27 is category 2 representing critical habitat and CO-CA-28 and -29 are Cat. 4. The closest is 125 m from the proposed pit edge facing east away from the proposed pit. Their inner most extremity of each is therefore closer to the pit edge. Although two are Cat 4, the grouping has been shown to be capable of supporting females during the reproduction period. Regarding Geotech stability, the interiors of each of the three have been assessed as intact/blocky (PSM 2021) which indicates careful planning for nearby blasting is required to retain them as viable roosts.

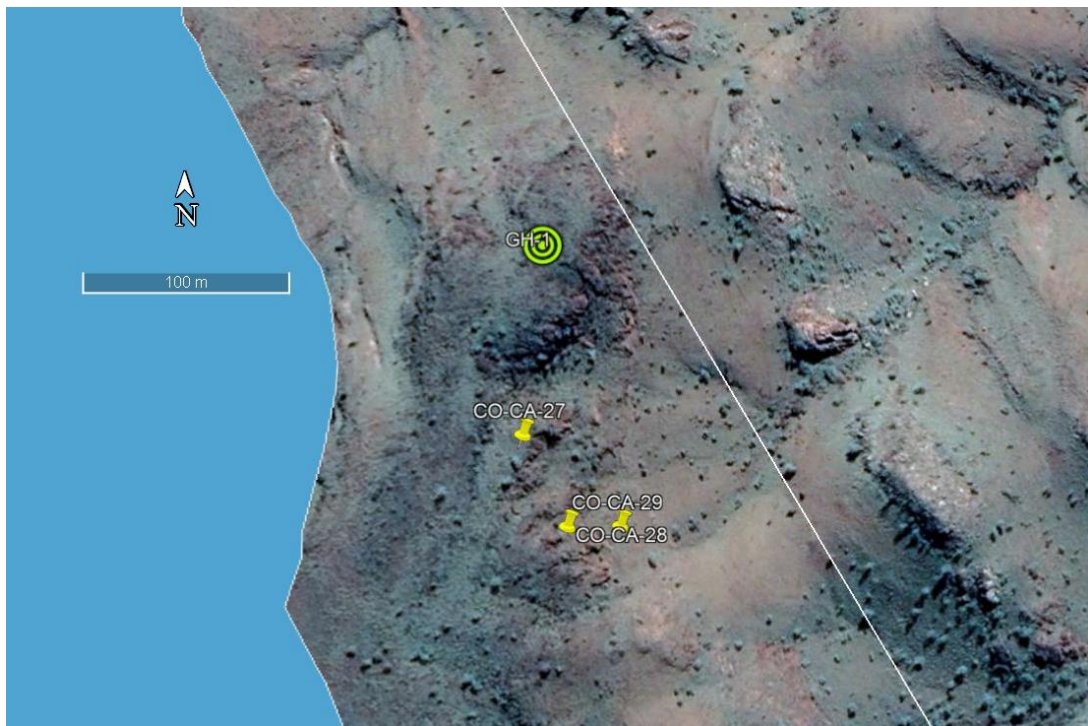


Figure 3. SMR stg 2 Project (Glen Herring pit). Ghost bat cave group GH-1.

Cave Group GH-2 (Glen Herring pit).

Cave group GH-2 is a group of caves nearby the proposed Glen Herring pit, figure 4, table 2. There are four caves in this group significant to Ghost bats that are subject to disturbance. One cave (CO-CA-24) is category 2, two caves (CO-CA-23 and -25) are category 3, all three representing critical habitat, and

CO-CA-26 is a Cat. 4. The entrances to all four are within 30 m of the pit boundary facing west away from the proposed pit. Their inner most extremity is therefore closer to the pit edge. While made up of reasonably shallow caves, this grouping has been shown to be capable of supporting females during the reproduction period. Regarding Geotech stability, the interiors of each of the caves have been assessed as either intact (CO-CA-25) or blocky (CO-CA-23, -24 and -26) which indicates careful planning for nearby blasting is required to retain them as viable roosts (PSM 2021).



Figure 4. SMR stg 2 Project (Glen Herring South). Ghost bat cave group GH-2.

Isolated caves nearby Glen Herring pit.

This group comprises three caves within 50 m of the proposed Glen Herring pit (figure 5, table 2). Cave CO-CA-20 (Cat 3) faces south away from the pit, CO-CA-22 (Cat 2 critical habitat) faces west away from the pit. Both caves are significant to Ghost bats as indicated by diurnal roosting during the female's reproduction period and are subject to disturbance by the mining operations. Cave CO-CA-34 lies immediately adjacent to the proposed pit boundary. Despite the observation of six Ghost bats roosting in late January 2021, this is a shallow Cat 4 overhang that is not assessed as significant for ongoing presence of Ghost bats.

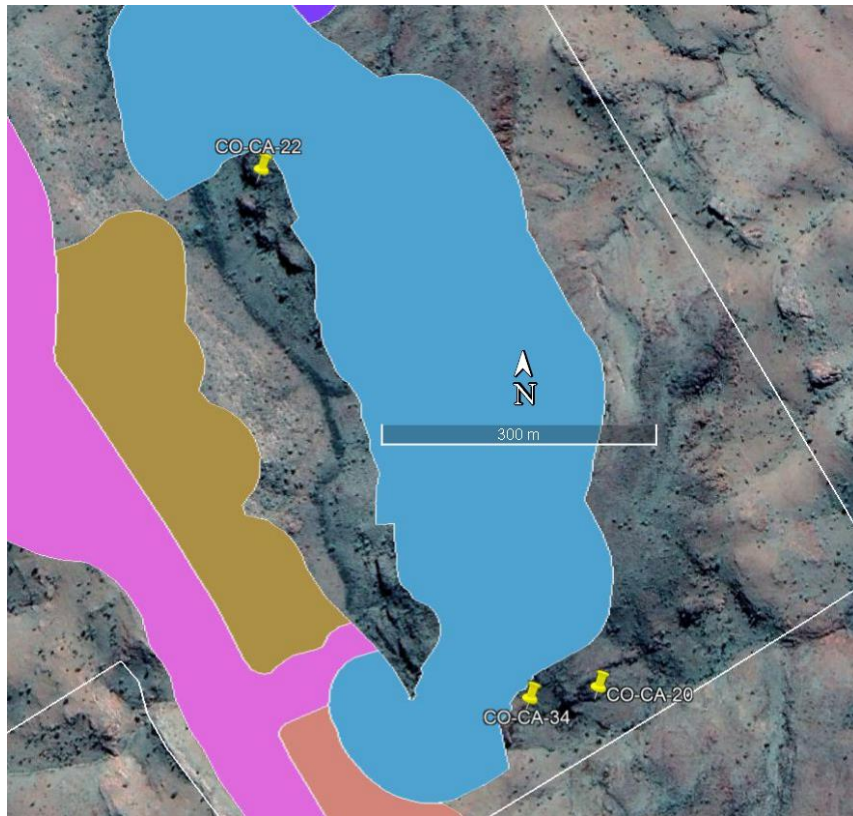


Figure 5. Ghost bat roost caves adjacent to Glen Herring pit.

Isolated caves nearby the SMR stg 2 haul road.

This group comprises two caves within nearby the proposed haul road (figure 6, table 2). CO-CA-30 is a Cat 3 that faces west away from the haul road, is 300 m distant, and has a low ridge between it and the road. CO-CA-21 (Cat 3) is immediately adjacent to the road. Both are potentially subject to disturbance by the future light and heavy-vehicle movements.

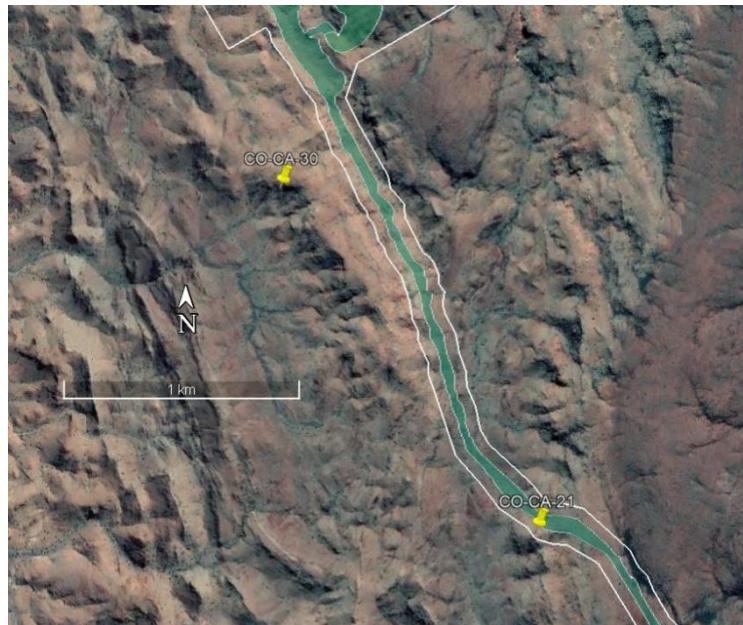


Figure 6. Ghost bat roost caves adjacent to SMR stg 2 haul road.

Reference caves distant from the SMR stg 2 project.

This group comprises eight caves between 320 m and 10 km of the proposed SMR stg 2 development envelope (figure 7, table 2). Six of the caves are Cat 2, CO-CA-01, -05, -32, -33, -35 (Mt Ada adit) and -42 (Mt Florence adit). CO-CA-06 and -31 are Cat 3. Each cave is either proven or a probable significant PGB roost capable of supporting reproducing females. Each is able to support PGB that are disturbed from the caves closer to the mining operation and the distances from the development envelope to the two most significant sites in this group with proven permanent diurnal occupation, CO-CA-01 and CO-CA-35 Mt Ada adit are between 1.2 and 6.5 km, Table 2.



Figure 7. Significant isolated Ghost bat roost caves distant from SMR stg 2 project. CO-CA-33 is 10 km to the south of Stage 2 development envelope.

Table 2: Cave grouping and isolated cave categorisation details.

Cave Group	Distance to CO-CA-01 and Mt Ada Cat. 2 roosts(km)	Cave	Assessed PGb roost category	Remarks supporting categorisation of cave.	Distance from entrance to nearest proposed pit or haul road (m)	Internal structural assessment. (See PSM 2021)
Apartment block group GH-1	3.2	CO-CA-27	Cat 2	Single chamber cave of moderate depth. Up to 14 PGb present Jan 2021. Regular roosting by 2-5 in July 2021	88	Intact-Blocky
	6.1	CO-CA-28	Cat 4	Overhang in cave group. Occasional visits only.	144	Intact-Blocky
		CO-CA-29	Cat 4	Overhang in cave group. Occasional visits only.	117	Intact-Blocky
Apartment block group GH-2	3.3	CO-CA-23	Cat 3	Single chamber cave of moderate depth. Continuous roosting recorded May 2021. Occasional roosting in July 2021.	28	Blocky
	5.8	CO-CA-24	Cat 2	Single chamber cave of moderate depth. Diurnal roosting recorded Jan, May & July 2021	20	Blocky
		CO-CA-25	Cat 3	Single chamber cave of moderate depth. Diurnal roosting recorded Jan and July 2021	30	Intact
		CO-CA-26	Cat 4	Single chamber cave of shallow depth. Occasional diurnal roosting recorded Jan 2021. Visits only in July 2021	22	Intact
Isolated caves nearby Glen Herring pit	3.1 & 6.0	CO-CA-20	Cat 3	Multi-chamber cave of moderate depth. Occasional diurnal roosting recorded Jan & July 2021	52	Blocky
	3.8 & 6.1	CO-CA-22	Cat 2	Continuous roosting recorded of up to 10 PGb Jan, May & July 2021	28	Intact
		CO-CA-34	Cat 4	Deep overhang. Visits only in July 2021.	15	Intact-Blocky
Isolated caves nearby haul road.	1.2 & 5.4	CO-CA-21	Cat 3	Multi-chamber cave of moderate depth. Occasional diurnal roosting recorded Jan 2021. Visits only in July 2021.	30	N/A
	2.9 & 5.1	CO-CA-30	Cat 3	Multi-chamber cave of moderate depth. Diurnal roosting recorded Jan & July 2021	310	N/A
District caves-adits		CO-CA-01	Cat 2	Continuous PGb roosting recorded during long term monitoring	540	N/A
		CO-CA-05	Cat 2		310	N/A
		CO-CA-06	Cat 3	Deep single chamber cave with a record of multiple roosting bats	3.6 km	N/A
		CO-CA-31	Cat 3	Single chamber cave of moderate depth. Multiple PGb diurnal roosting recorded Jan 2021	1.8 km	N/A
		CO-CA-32	Cat 2	Single chamber cave of moderate depth. Multiple PGb diurnal roosting recorded Jan 2021	1.5 km	N/A
		CO-CA-33	Cat 2	Multi-chamber deep cave. Multiple PGb diurnal roosting and large midden recorded Jan & July 2021	10 km	N/A
		CO-CA-35 Mt Ada Adit	Cat 2	Continuous roosting recorded of up to 10 PGb Jan and May 2021. Up to 13 in July 2021.	5.2 km	N/A
	CO-CA-42 Mt Flo'ce Adit	Cat 2	Regular roosting recorded of up to 3 PGb July 2021	5.8 km	N/A	

Potential impact on SMR stg 2 Caves

Potential Impact on Cave Groups GH-1 and GH-2 including isolated caves nearby the Glen Herring pit and the haul road.

When production is underway nearby, sound, vibration and dust levels are likely to cause the Ghost bats to abandon all twelve caves adjacent to the pit and haul road, Table 2, in the short term due to the short distances to the proposed pit boundaries and activities. If the significant cat 2 and 3 caves are managed and remain unblocked by the nearby blasting and associated vibration and if the inner extremities of the caves are not intersected by the pit wall creating new rear entrances or airways that disrupt the internal microclimate, the viability of the caves as diurnal roosts will be maintained, and Ghost bats will be likely to re-occupy the caves once the disturbance moves away.

A blasting assessment is recommended to be developed to provide a blasting plan against a maximum in-ground vibration level at each of these significant caves nearby the Glen Herring pit to retain the primary roof structure and outer and inner chambers intact but not necessarily retain in place any loose ceiling blocks. This is consistent with retaining the caves as viable diurnal roosts. This type of assessment, to produce a set of blast parameters that ensure the retention of the primary structure of caves adjacent to blasting, has been implemented at other mine sites within WA. This approach is considered appropriate to ensure the protection of the caves nearest to the proposed SMR stg 2 activities (in particular Groups GH-1 and GH-2, but by inference, all others nearby. This includes the localised effects of in-ground vibration, air-blast, fly-rock and block displacement. However, during blasting and other mining operations in Glen Herring pit, the small distances and high levels of sound and vibration involved are expected to cause the Ghost bats to temporarily abandon the caves. To achieve the objective of retaining the caves as viable category 2 or 3 roosts with suitable internal microclimate, surrounded by viable lower category caves subsequent to the mining operations, an over-conservative approach to blast planning based on the following is recommended:

- A maximum peak particle velocity (PPV) from blast vibrations to protect the structural integrity of caves to be determined by a detailed blasting assessment,
- all blasts to be designed for less than 85% of the peak PPV value,
- monitoring of in-ground vibration levels at caves during blasting operations,
- cessation of blasting if PPV over 100% of the peak value is measured until the cause of the exceedance is identified, a cave inspection is carried out, and steps implemented to prevent reoccurrence.

Prior to and during mining operations, suitable exclusion zone(s) will be created around the nearby significant caves to minimise entry and/or inadvertent damage by personnel. During mining and blasting operations in-ground vibration levels, together with the overall cave condition, must be monitored to ensure that the caves remain viable as category 2 or 3 roosts. In addition, the development of the pit behind the cave must be carefully monitored to ensure that it does not intersect the inner extremities of the caves.

In addition to the above provisions, if Ghost bats are known to be diurnally roosting in any of the significant cat 2 or 3 caves during September prior to the wet-season reproductive period of October to December inclusive, and, there is blasting programmed for those months nearby the cave, then the critical habitat caves, all category 2 and category 3 caves in apartment blocks, should be sealed temporarily when empty of bats to ensure that no reproducing female and/or her pup is present and therefore disturbed to the point of losing the foetus or pup. See appendix B for further details.

Potential impact on Ghost bat foraging area

As presented above, Ghost bats will forage in any highly or moderately productive habitat that has suitable perches for its foraging strategy. High and medium value habitats include gorge/gully, hill crest/hillslope, major drainage lines and thinly wooded sand plains. For the proposed development envelope including the haul road allowance, the total Ghost bat habitat (high, medium and low productivity) is 250 ha. Based on author's current data, the total area available for foraging by Ghost bats including all the areas surrounding the development envelope out to 12.5 km radius from the Glen Herring pits is approximately 50,000 ha of which the impact total is 0.5%. There is no short- or long-term impact on Ghost bat foraging expected based on this reduction. In combination with the Stage 1 of the project to the east, the impact area will rise significantly but will not rise to a level that will reduce Ghost bat foraging success.

Recommendations.

The results of the 2020 and 2021 surveys are consistent with the use of the caves within the study areas by Ghost bat, with low numbers confirmed roosting diurnally during both wet and dry seasons. All nineteen caves had evidence of recent foraging visits and/or had observed presence/call patterns that indicated diurnal roosting. The patterns indicate that two groups of caves within the development envelope are important for the persistence of the species in the area. Both groups are assessed to include category 2 roosts with the probability of supporting reproducing bats. In addition, there are three isolated caves within the development envelope and two adjacent to the haul road that are assessed as significant for the species in the area. The objectives of the recommendations are:

1. Protection of the critical habitat caves
2. Protection of the gravid females and their pups during the reproductive season
3. Allowing the ongoing use of the caves in the area in conjunction with and following “best practice” mining operations.

The recommendations included here-in are from a single year of monitoring, therefore it is expected that the seasonal cycles exposed may not cover the full utilisation of the caves by Ghost bat. Therefore, to support persistence of the bat in the area, the following recommendations are made:

1. Ongoing protection of the critical habitat caves in the district from direct impact by Atlas’ operations.
2. Preservation of all caves identified herein as viable Ghost bat roosts, with the exception of cave CO-CA-34, with emphasis placed on the three Category 2 caves (CO-CA-22, -24 and -27), and any caves in close proximity to pits.
 - The two category 2 caves in apartment blocks GH-1 and GH-2 (CO-CA-24, -27) together with the groups of caves, shelters and overhangs nearby (CO-CA-23, -25, -26, -28 & -29) are recommended for protection by suitable exclusion zones as they make up critical habitat groupings that are important for the species’ persistence in the area (TSSC 2016a, Bat Call 2017).
 - The remaining isolated category 2 cave (CO-CA-22) and category 3 caves adjacent to the pits and haul road (CO-CA-20, -21 & -30)) are also recommended for protection by suitable exclusion zones as the usage by Ghost bats may be more extensive than the single year of monitoring has recorded.
3. Restricting entry of personnel from all category 2 and 3 caves identified herein with the exception of survey activities. Periodic restricting of survey activities in accordance with a

disruption protocol (Appendix B) that is aligned to the breeding cycle of the Ghost bat is recommended.

4. Ongoing monitoring of Ghost Bat activity at the category 2 caves in the project area to better understand bat movements and impacts. Timing of monitoring is recommended to be aligned to the project's development, production and closure schedules.
5. Production blast planning at caves CO-CA-22, -24 and -27 should follow recommendations for maximum in-ground vibration limits to protect the caves' ability to remain viable as a category 2 roost (i.e., to ensure that the cave is not destroyed, blocked or a new rear entrance opened) during future mining operations including drill and blast operations and ore removal operations.
6. During the mining operations, monitoring of the in-ground vibration levels and cave conditions should follow recommendations and be undertaken with feed back to the blasting planning in an adaptive manner to ensure that the caves remain viable as diurnal roosts for the species.
7. Should Ghost bats be found to be roosting diurnally in the caves deemed critical habitat in September leading up to the critical maternity period of October to December, and a blasting campaign be planned nearby during this period, then the caves are to be temporarily sealed while empty of Ghost bats to ensure that there is no direct impact on females that are gravid or their pups after parturition.
8. An alternative to closing caves on an "as required" basis during single reproductive seasons, it is considered viable to close all critical habitat category 2 and category 3 caves in apartment blocks to Ghost bat occupation while mining is carried out at the project. This viability is due to the proximity of three other major Ghost bats hubs (Warrawoona, Marble Bar and Mt Webber, all within 40 km) that will allow the bats to relocate away during the mining operations and return to the retained caves once mining is completed.

Table 3: Summary of recommendations based on Ghost bat usage as they apply to the caves included herein.

Group	Caves (categories)	Recommended mitigation				Cave may be removed based on PGb usage
		Avoid Disturbing Note 1	Entry Protocol	Blast monitoring	PGb usage monitoring	
Adjacent to Glen Herring Pit						
Apt.	CO-CA-27 (2)	Yes	Yes	Yes	Yes	
Block	CO-CA-28 (4)	Yes				
GH-1	CO-CA-29 (4)	Yes				

Apt. Block GH-2	CO-CA-23 (3)	Yes	Yes		Yes	
	CO-CA-24 (2)	Yes	Yes	Yes	Yes	
	CO-CA-25 (3)	Yes	Yes		Yes	
	CO-CA-26 (4)	Yes			Yes	
Isolated caves	CO-CA-20 (3)	Yes	Yes		Yes	
	CO-CA-22 (2)	Yes	Yes	Yes	Yes	
	CO-CA-34 (4)					Yes
Adjacent to Glen Herring Haul Road						
Isolated caves	CO-CA-21 (3)	Yes	Yes		Yes	
	CO-CA-30 (3)	Yes	Yes		Yes	
Isolated Cave Reference Sites						
PGb roost	CO-CA-35 Mt Ada (45) Adit	Yes	Yes		Yes	
PGb roost	CO-CA-31 (3)	Yes	Yes			
PGb roost	CO-CA-32 (2)	Yes	Yes			
PGb roost	CO-CA-33 (2)	Yes	Yes		Yes	
PGb roost	CO-CA-42 Mt Florence Adit	Yes	Yes		Yes	
PLNb & PGb roost	CO-CA-01 (2)	As per Stage 1 Sig. Species Mgt Plan.				
PLNb & PGb roost	CO-CA-05 (2)	Yes	Yes		Yes	

Note 1: Temporary closure permitted only as required by the Significant Species Management Plan.

In consideration of the above findings and recommendations, it is anticipated that the proposed Sanjiv Ridge Stage 2 Project will not have a significant impact on Ghost bats or Ghost bat caves.

Yours sincerely



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Appendix A: Cave Habitat Classifications

Each cave identified during the survey has been categorised according to the following definitions based on Ghost bat (Ghost bats) usage:

Category 1 diurnal roost caves with permanent Ghost bat occupancy.

There are a number of documented permanent roost caves and underground mines in northern Australia, e.g., Tunnel Creek in the Kimberley and Kohinoor adit in the NT. These tend to have large but variable populations, e.g., Kohinoor's colony has grown from 300+ in 1981 to ~1,500 in 1990 and then reduced to 550 in 2013 (Woinarski *et al.* 2014). In the Pilbara, other than a number of historical underground mines e.g., Comet, Klondyke Queen, Lalla Rookh and Bamboo Creek which do have large populations of over 100 Ghost bats, very few such roosts in natural caves are documented. Those natural caves that may be permanently occupied have been observed with variable populations present. One example is a significant cave with a complex surrounding gully in the Robe Valley south-west of Pannawonica that has had Ghost bats present on most, if not all, survey visits. The colony size at this cave has varied from a few to over 70 recorded in April 2017 (Bat Call 2017). Where permanent presence at category 1 sites is proven, they must all be assumed to be maternity caves and are critical habitat for the species. No category 1 Ghost bat caves have been identified at Sanjiv Ridge Stage 2.

Category 2 diurnal roost caves with regular occupancy.

There are a number of Pilbara caves and adits where Ghost bats have regular, but not continuous, presence over long periods. These tend to be deep caves with ceiling heights in rear chambers of at least 1.5 m allowing multiple roosting opportunities for Ghost bats out of reach of predators. The longest continuous monitoring programs have been at Rio Tinto's West Angelas project and at BHP's Mining Area C and South Flank projects. At all three locations there are a number of caves with roosting Ghost bats records but none of these have had either permanent presence or consistently high numbers present. Numbers have varied between zero and five with very occasional counts of 20 or more (author's unpublished data). Based on recent monitoring of caves using ultrasonic call detectors, these caves have Ghost bats present for 25 to 75% of nights for mid to long periods but then may be abandoned for periods. There is insufficient data at present to see if there are any seasonal trends in these occupancy rates. These caves typically have a number of other caves, shelters and overhangs within a few hundred meters. Together they make up an "apartment block" grouping (TSSC 2016, Bat Call 2017) that supports the ongoing presence of the bats.

Recent analysis at West Angelas based on genetic sampling at five monitored caves in 2015 and 2017 (Ottewell *et al.* 2018) suggests that some Ghost bats tend to use particular caves regularly over a season or year, but others move between caves in the same period. Their analysis identifies 34 unique individuals at caves over those two years and indicated that the “genetic effective population size” was twelve. Two of the five caves have been shown by the long-term observations to have regular occupancy (Biologic 2016). In all surveys undertaken, Ghost bats have been either roosting in low numbers or there was evidence of recent roosting at the former and, with the exception of one survey, at the latter. The genetic analysis also supports this conclusion with presence of multiple bats over the two years of that study at these caves. Similar occupancy patterns have been recorded at several caves at the BHP projects. There are an increasing number of observations becoming available of pregnant Ghost bats or Ghost bats carrying pups at some of these caves, plus others (e.g. Silvergrass East cave SG-1, Hamersley Iron 1999) although again there is insufficient data to identify any trends other than to say that any cave that has regular occupancy must be assumed to be capable of supporting one or more reproducing females and their offspring. These caves are critical habitat for the species. There are a number of caves at Sanjiv Ridge that fall into this category.

Category 3 roost caves with occasional occupancy.

There are a large number of caves and adits where Ghost bats roost occasionally or rarely in small numbers of one to a few. Surveys in recent years have identified numerous caves that have Ghost bats scats or small food middens present but either no evidence of roosting bats or with rarely repeated presence observations, e.g., five of the seven monitored caves at West Angelas (Biologic 2016) show such a pattern with occasional Ghost bats present and/or intermittent evidence of recent occupancy. Reproducing females have been reported from at least two caves at West Angelas that ongoing observations indicate fall into this category, but no firm evidence exists that such caves are necessary for successful reproduction. When directly associated with a category 2 cave, they form an apartment block grouping that is considered critical habitat. Isolated caves are important habitat for the long-term preservation of the species in the area. There are a number of caves at Sanjiv Ridge that fall into this category.

Category 4 nocturnal roost caves, opportunistic usage.

Numerous observations suggest that the majority of caves and adits in the Pilbara are used in at least an opportunistic manner by itinerant Ghost bats. This may be anything from a single foraging visit to a longer visit with a resting period or possibly a feeding session. Evidence of such visits is the widespread presence of small numbers of scats found or occasional echolocation calls recorded during surveys.

These visits may or may not be repeated depending whether the bat is passing through a district or is a more permanent resident nearby. These caves are not important habitat for the long-term preservation of the species in the area.

Appendix B: Recommended Cave Disruption Protocol.

A conservative protocol is recommended to protect the reproducing females and their young during the most important part of their reproductive cycle. This covers the periods when:

- Gravid females are subject to premature birth due to either capture and handling or repeated flushing the bats from their diurnal roost caves.
- Females carrying newborns are subject to dropping them due to capture or disturbance.
- Non volant young in nurseries are subject to abandonment due to repeated disturbance of the mothers
- Newly volant young during the early adolescent period are subject to premature abandonment due to repeated disturbance of the mothers and/or young.

For Ghost bat category 1 (see Appendix A for definitions), category 2, and category 3 roost caves that are part of an important cave grouping, it is recommended that restrictions tighter than Governmental licencing limitations be enforced:

1. Successful survey sessions, i.e., when Ghost bats are captured or are present and disturbed, be limited to once per cave during the months of August, September and January,
2. Multiple survey entries per cave are allowed in August, September and January. The surveys should be done by one ecologist working quietly to minimise stressing the bats present and hopefully not flushing them. If a Ghost bat(s) is disturbed and flushed, the caves and their entrance areas be vacated allow the bat(s) to return and settle. Restrictions per 1. above then apply.
3. No cave entries should be carried out from October to December inclusive into caves that are not temporarily sealed. Damage assessments during blasting operations should be carried out from the entrance.
4. Survey entries in accordance with Governmental licencing limitations be allowed outside these periods.
5. Where category 2 and 3 caves are within the impact zone of a project drilling/blasting program, and after its proven that there are no Ghost bats inside, the caves may be temporarily sealed prior to the 1st October and remain inaccessible to the bats throughout the female's reproductive period.

For Ghost bat category 3 caves that are isolated and not part of an important grouping, and category 4 caves, it is recommended that normal survey activity in accordance with Governmental licencing limitations be allowed year-round including entries as appropriate.