



# **Sanjiv Ridge** Pilbara Leaf-nosed Bat Monitoring 2024

Report to Atlas Iron Pty Ltd

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## Executive Summary

Atlas Iron Pty Ltd (Atlas) operates the Sanjiv Ridge Project (the Project, located approximately 33 kilometres (km) south of Marble Bar, Western Australia. Stage 1 of the Project was approved on 12 March 2020, with Stage 2 approved on 13 September 2022. Pilbara leaf-nosed bat (*Rhinonictoris aurantis*, Pilbara form), which is listed as Vulnerable under the *Environment Protection and Biodiversity Conservation Act 1999* and *Biodiversity Conservation Act 2016*, has been previously recorded in the Project area. As part of the Project's approvals, *Significant Species Management Plans – Sanjiv Ridge* (SSMP) were developed to manage several species of significance recorded within the Stage 1 and Stage 2 areas, including the Pilbara leaf-nosed bat (Atlas Iron, 2017, 2023). The SSMPs prescribe a monitoring program, including surveys conducted pre-mining (baseline), during active mining and post-mining, to assess the local population of the species for the life of the Project.

Annual monitoring surveys within the Stage 1 area have been undertaken in accordance with the 2017 SSMP since 2017 (Atlas Iron, 2017). In addition to the annual monitoring program, continuous monitoring of bat activity and microclimate has been underway at two key monitoring sites since 2020 (CO-CA-01 and CO-CA-03). In May 2024, Atlas commissioned Biologic to undertake the eighth annual monitoring survey of Pilbara leaf-nosed bat for the Project. This survey also represents the fifth survey conducted since active mining operations commenced.

The monitoring program incorporates 11 monitoring sites, comprising six impact sites located within 1 km of the Sanjiv Ridge indicative disturbance envelope and five control sites located more than 1 km from the indicative disturbance envelope. These sites include diurnal roosts, nocturnal refugia and potential foraging habitat.

The field survey was conducted between 15–25 July 2024. Methods were consistent with previous monitoring, including ultrasonic recording to determine the presence and activity of Pilbara leaf-nosed bat; microclimate (temperature and relative humidity) monitoring of accessible caves; and photo monitoring to identify any temporal changes (including surface water levels) in the structure and quality of habitat at each site.

At the time of the first annual monitoring survey in 2020, disturbance comprised small areas of clearing for exploration and historical mining activities, and general degradation due to pastoralism. Clearing for mine development, and construction, commenced in 2020 and ore extraction activities commenced in 2021. Mining related activities, including construction of haul roads, ore extraction and processing continued in 2022, 2023 and 2024. Additional mining related activities that have commenced since the previous annual monitoring

period include a new haul road constructed in November 2023, approximately 560 meters (m) east of CO-CA-01; and construction of Razorback pit which commenced in December 2023, ~145 m west of CO-CA-03. Proximity of mining activity to the 11 monitoring sites during the current annual and continuous monitoring periods remained unchanged from the previous year.

During the current annual monitoring period, Pilbara leaf-nosed bat calls were recorded at all six impact monitoring sites. Activity levels at all sites were lower than previously recorded in 2023. CO-CA-01, CO-CA-03 and CO-CA-05 are continuing to be used in 2024 as diurnal roosts and CO-WS-01 and CO-WS-03 continue to be visited during foraging. When compared to average baseline (pre-mining) activity levels (2014-2019), bat activity during the current monitoring period were statistically (50-98%) lower than overall baseline levels at all six impact monitoring sites. While this could indicate a response to mining activity, the level of activity recorded at all control sites (exception MW-CA-02 where data not available), was also statistically (91-100%) lower than baseline levels.

A comparison between the baseline (2014-2019) and grouped active mining (2020-2024) monitoring periods also showed that bat activity levels recorded during active mining were 30-94% lower than those recorded during the baseline period for all 11 monitoring sites. The difference was statistically significant for all sites, with the exception of MW-CA-02. While the decline (30-91% lower) at impact sites may indicate some mining-related effects, it should be noted that the levels of activity recorded at control roosts during active mining were also (35-94%) lower than those recorded during the baseline period. The decrease in activity at foraging locations is likely associated with the decrease in activity at roosts. The decrease at all sites may represent a decrease in the size of the population inhabiting the Sanjiv Ridge area and may be more reflective of changes at a broader, regional scale. However, no clear patterns between activity levels and environmental factors, such as rainfall, were determined.

It remains possible that mining activity is influencing activity levels in the Sanjiv Ridge Study Area to some extent. As there is no evidence that mining disturbance is affecting the microclimate of the roosts (through structural damage), the most likely mechanism by which mining activity may be affecting activity levels in the Sanjiv Ridge Study Area, is ongoing disturbance to foraging and dispersal habitat surrounding the roosts. Importantly, there is no evidence that the suitability of the majority of roosts themselves (except CO-CA-01) have changed. The microclimate of CO-CA-01 was warmer during the current monitoring period than recorded in previous years since mining commenced. Microclimate conditions at CO-CA-01 fell within the preferred range for roosting approximately 54% (temperature) to 67% of sampling nights, a reduction from previous years. Despite this, roosting continued to be observed at CO-CA-01, as well as CO-CA-03 and CO-CA-05. The warmer microclimate at

CO-CA-01 (and other roosts) is likely a result of similar warmer ambient conditions recorded during the current monitoring period,

In accordance with the SSMP, Atlas is committed to employing specific corrective actions when the following key performance indicators (KPIs) relating to CO-CA-01 and CO-CA-03 are not met:

- *No significant damage to cave CO-CA-01 and cave CO-CA-03*

Site assessments during the current monitoring period revealed no signs of damage to CO-CA-01 and CO-CA-03 from mining operations, and therefore the KPI has been met.

- *Ongoing use of cave CO-CA-01 by Pilbara leaf-nosed bats during operation*

Calls recorded at CO-CA-01 indicate that the roosts continues to be used as a diurnal roost by Pilbara leaf-nosed bat throughout the current monitoring period, and therefore the KPI has been met.

- *No greater than 50% decline of Pilbara leaf-nosed bat activity levels in CO-CA-01 over two consecutive monitoring periods compared to the average baseline level (2014 to 2019)*

A 50% decline in Pilbara leaf-nosed bat activity levels at CO-CA-01 were recorded during the current monitoring period, when compared to average baseline activity levels. During the previous 2023 monitoring period, a 23% decline in bat activity levels from baseline levels were recorded at CO-CA-01. As Pilbara leaf-nosed bat activity has not been recorded at a greater than 50% decline for two consecutive years (2024 and 2023), the KPI has been met during the current monitoring period. As control sites also recorded significantly lower activity levels recently compared with baseline levels, it is likely regional, environmental factors such as higher ambient and cave temperatures, rainfall and wildfire events, as well as potentially mining-related activities (at impact sites only), is influencing Pilbara leaf-nosed activity within the Study Area. The effects of regional and localised factors on bat activity within the Study Area, and specifically CO-CA-01 as it relates to KPIs outlined in the SSMP, will continue to be investigated through the course of the monitoring program.

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# 1 Introduction

## 1.1 Project Background

Atlas Iron Pty Ltd (Atlas) is developing the Sanjiv Ridge Project (formerly known as the Corunna Downs Project), an iron ore project located in the Pilbara region of Western Australia, 33 kilometres (km) south of Marble Bar (Figure 1.1). Stage 1 of the Sanjiv Ridge Project (the Stage 1 Project) (Figure 1.1) was approved on 12 March 2020 (Ministerial Statement Number: 1125) and mining commenced in 2020. Stage 2 of the Sanjiv Ridge Project was approved on 13 September 2022 (Ministerial Statement Number: 1197) and mining related activities commenced in November 2023.

As part of the Project's approvals, a Significant Species Management Plan – Corunna Downs (SSMP) was developed to manage several species of significance recorded within the Stage 1 Project area (2017 SSMP) (Atlas Iron, 2017) and Stage 2 Project area (2023 SSMP) (Atlas Iron, 2023). The 2017 SSMP requires Atlas to undertake an annual monitoring program for the Pilbara leaf-nosed bat (*Rhinonicteris aurantia* – Pilbara form) for the life of the Project. The aim of the program is to assess the effectiveness of Atlas's management measures against performance objectives and associated key performance indicators (KPIs).

Should any of the KPIs not be met, Atlas is required to implement corrective actions, as detailed within the 2017 SSMP. Annual monitoring surveys have been undertaken in accordance with the SSMP since 2017. In addition to the annual monitoring program, continuous monitoring of bat activity and microclimate has been underway at two key monitoring sites (CO-CA-01 and CO-CA-03) since 2020 (Biologic, 2021a, 2022c, 2023, 2024). Previously, continuous monitoring at CO-CA-03 had been included under the 2017 SSMP. Since mining has commenced within the Stage 2 Project area in late 2023, the current monitoring period represents the first instance where reporting associated with monitoring at CO-CA-03 was undertaken in accordance with the Corunna Downs CO-CA-03 and CO-WS-14 Monitoring Strategy (Monitoring Strategy) (Biologic, 2020a). Accordingly, a separate report has been developed to discuss the findings relating to continuous monitoring at CO-CA-03 and will not be discussed further in this report (Biologic, in prep.).

Table 1.1: Performance objectives and key performance indicators (2017 SSMP)

Performance Objective	Key Performance Indicator
No significant damage to identified caves that would prevent their ongoing use by Pilbara leaf-nosed bats.	No significant damage to cave CO-CA-01 and cave CO-CA-03.
	Ongoing use of cave CO-CA-01 by Pilbara leaf-nosed bats during operation.
	Use of cave CO-CA-03 by Pilbara leaf-nosed bats, following cessation of mining.
No significant decline in Pilbara leaf-nosed bat population.	No greater than 50% decline of Pilbara leaf-nosed bat activity levels in CO-CA-01 over two consecutive monitoring periods compared to the average baseline level (2014 to 2019).
	Recolonisation of CO-CA-03 by Pilbara leaf-nosed bats post-mining (performance against this criterion only needs to be measured, where annual monitoring finds that the Pilbara-leaf nosed bat temporarily abandons cave CO-CA-03 during mining).

Adapted from Atlas Iron (2017)

## 1.2 Survey Scope and Objectives

### 1.2.1 Annual Monitoring

Atlas commissioned Biologic Environmental Survey Pty Ltd (Biologic) to undertake the eighth annual monitoring survey of Pilbara leaf-nosed bat within the Study Area. This survey also represents the fifth annual survey conducted since mining commenced in 2020. The overarching objective of this survey was to assess changes in the levels of Pilbara leaf-nosed bat activity at 11 monitoring sites which comprise roosting and foraging habitat (refer to Section 1.4). Any changes in bat activity levels will then be discussed in relation to Project developments, seasonal fluctuations in bat activity, and environmental variables (such as rainfall and fire events). Specific comment will be made on relevant performance objectives outlined in the 2017 SSMP (Atlas Iron, 2017). Specifically, this report provides:

- quantitative data on Pilbara leaf-nosed bat activity within the Study Area, as per the methods employed during previous monitoring surveys;
- information on changes to the condition and characteristics of roosts and foraging locations used by Pilbara leaf-nosed bats, via photo-point monitoring data;
- temperature and humidity data to understand the microclimate of each roost prior to and since the commencement of mining; and
- a comparison of bat activity between this survey, previous baseline monitoring surveys and comparable regional sites to discern Pilbara leaf-nosed bat population trends.

### 1.2.2 Continuous Monitoring

Atlas commissioned Biologic to undertake a seventh year of continuous monitoring of Pilbara leaf-nosed bat activity and microclimate at CO-CA-01, an important diurnal roost within the Study Area. The overarching objective of this assessment was to gather ultrasonic and microclimate data to inform assessments conducted under the 2017 SSMP. Specifically, this report provides:

- quantitative continuous data on Pilbara leaf-nosed bat activity at CO-CA-01;
- continuous microclimate (relative humidity (RH) and temperature) data over a 12-month period (1 January–31 December 2024) at CO-CA-01; and
- a comparison of bat activity and microclimate at CO-CA-01 between monitoring periods, with consideration of Project developments, seasonal fluctuations in bat activity, and environmental variables (such as rainfall and fire events).

### 1.3 Compliance

Monitoring was carried out in consideration of the following guidelines and recommendations developed by the relevant state and federal regulatory bodies, as well as the SSMP:

- Atlas Iron (2017) Significant species management plan – Corunna Downs;
- Bat Call (2021) A review of Pilbara leaf-nosed bat ecology, threats and survey requirements;
- DEWHA (2010) EPBC Act survey guidelines for Australia’s threatened bats; and
- EPA (2020) Technical guidance: Terrestrial vertebrate fauna surveys for environmental impact assessment.

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CO-CA-18

CO-WS-03

CO-WS-01

CO-CA-01

CO-CA-10

CO-CA-05

CO-WS-08

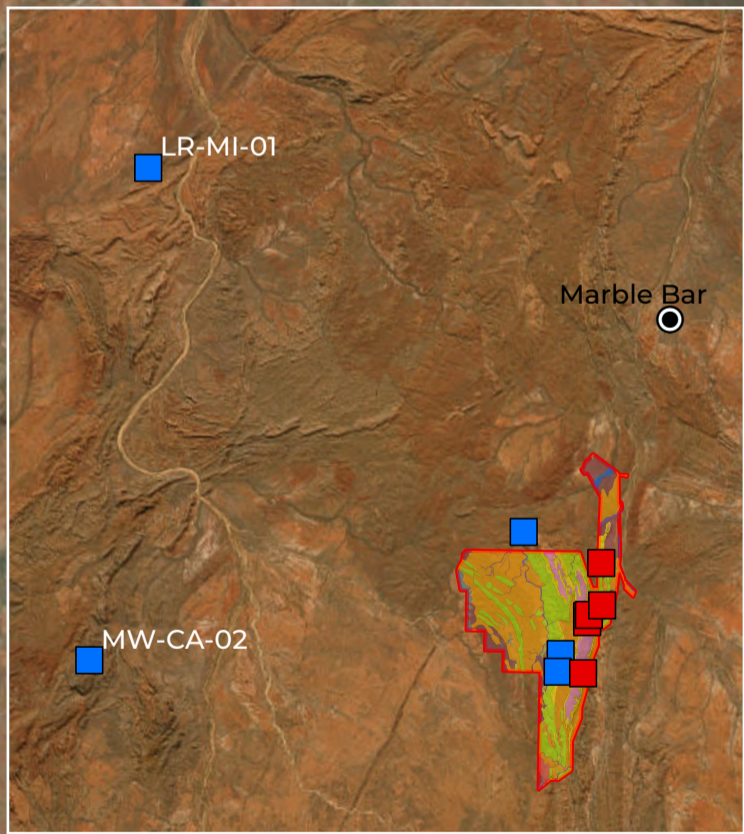
CO-WS-13

CO-CA-03

LR-MI-01

Marble Bar

MW-CA-02



LEGEND

- Study Area
- Fauna Habitat:
  - Calcrete
  - Drainage Line
  - Granite Outcrop
  - Granitic Upland
  - Ironstone Ridgetop
  - Riverine
- Rocky Foothill
- Rocky Ridge and Gorge
- Sandy Plain
- Spinifex Stony Plain
- Stony Rise
- Monitoring Site:
  - Control
  - Impact



Scale 1:110,000

0 2 4 Km

Coordinate System: GDA2020 MGA Zone 50 Transverse Mercator Created: 12/11/2024



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Sanjiv Ridge Pilbara leaf-nosed bat Monitoring 2024

Figure 1.1: Study Area and monitoring sites

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#### 1.4 Species of Interest: Pilbara leaf-nosed bat (*Rhinionicteris aurantia*)

The Pilbara leaf-nosed bat is listed as Vulnerable under the *Environmental Protection and Biodiversity Conservation Act 1999* (EPBC Act), and the *Western Australian Biodiversity Conservation Act 2016* (BC Act). The Pilbara leaf-nosed bat represents a population of the orange leaf-nosed bat that is geographically isolated from tropical populations of the species by 400 km of the Great Sandy Desert (Armstrong, 2001). It is restricted to the Pilbara region of Western Australia, where it is thought to occur as a single interbreeding population comprising multiple colonies (TSSC, 2016). At least 17 confirmed diurnal roosts (including maternity roosts) and 31 unconfirmed roosts are known to occur in the Pilbara region (Bat Call, 2021), although unpublished data suggests these numbers underestimate the number of roosts present across the Pilbara.

Pilbara leaf-nosed bats typically roost in undisturbed caves, deep fissures or abandoned mine shafts (Armstrong, 2000, 2001). The species' limited ability to conserve heat and water (Baudinette *et al.*, 2000) means they are believed to require warm (28-32°C) and very humid (85-100%) roost sites to persist in arid and semi-arid climates (Armstrong, 2001; Churchill, 1991). Roost sites with such attributes are relatively uncommon in the Pilbara and the limiting factor of the species' distribution (Armstrong, 2001). During the dry season (April to October), individuals are believed to aggregate in roosts that provide a suitably warm, humid microclimate (Armstrong, 2000, 2001; Bullen & McKenzie, 2011). While in the wet season (November to March), when conditions are generally wetter and more humid, individuals typically disperse, roosting in seasonally suitable features (Armstrong, 2000, 2001; Bullen & McKenzie, 2011).

The importance of a roost site to Pilbara leaf-nosed bat can be categorised according to its potential nature of use by the species. The Monitoring Strategy classified caves used by Pilbara leaf-nosed bats based on the categories provided by TSSC (2016). Since then, updated classifications have been provided in *A review of Pilbara Leaf-nosed bat ecology, threats and survey requirements* (Bat Call, 2021). This followed a classification system defined by Bat Call (2021) in a report prepared for the Australian Government Department of Agriculture, Water and the Environment (DAWE). Most roost types are considered critical habitat essential for the long-term survival of the species (Table 1.2).

Foraging sites surrounding known or suspected roosts can be critical to the survival of the species as the species forages within the vicinity of roost caves and more broadly along waterbodies with suitable fringing vegetation supporting prey species (TSSC, 2016). The species is predicted to travel up to 20 km from roost caves during nightly foraging (Cramer *et al.*, 2016) in the dry season and up to 50 km during the wet season (Bullen, 2013). The importance of potential foraging habitat can be categorised following a classification system defined by (Bat Call, 2021) (Table 1.3).

Table 1.2: Roost categories for Pilbara leaf-nosed bat

Category	Description	Typical Features	Importance to Pilbara leaf-nosed bat
Category 1	Maternity roost sites with year-round occupancy (proven presence of young).	Deep, dark caves with at least one roosting chamber behind a narrow entrance or in-cave constriction, a ceiling over 1.5 m in height, steady microclimate and high humidity, within flying range of a permanent water source.	Critical habitat essential for the long-term survival of the species.
Category 2	Diurnal roost sites with regular occupancy (no proven presence of young).	These sites are similar to Category 1 sites but are usually less complex (e.g. may only contain a single chamber), have a more variable microclimate, and/or are located in less productive areas which may only periodically attract Pilbara leaf-nosed bats.	Critical habitat essential for the long-term survival of the species.
Category 3	Diurnal roost sites with occasional occupancy.	These sites are similar to Category 1 and 2 sites but are usually less complex (e.g. may only contain a single chamber), have a more variable microclimate, and/or are located in less productive areas which may only periodically attract Pilbara leaf-nosed bats.	Critical habitat essential for the long-term survival of the species.
Category 4	Nocturnal roost sites with opportunistic usage.	Caves and deep overhangs which may be visited during the night during foraging activity, but are unlikely to support diurnal roosting (e.g. roosting locations are exposed or exhibit low levels of humidity)	Not considered critical habitat for Pilbara leaf-nosed bat, but still important for the persistence of the species within a local area.

Adapted from information presented by (Bat Call, 2021).

Table 1.3: Foraging habitat categories for Pilbara leaf-nosed bat

Habitat Rating	Description	Typical Features
0 (Poor)	Unlikely to be used by the species.	Open ground with no vegetation cover.
1 (Low)	Unlikely to be used for foraging but may be traversed during dispersal.	Open plains and low hills with simple vegetation structure (e.g. one or two-layer with no trees); or minor ridgelines, gullies and mesas with minimal caves and overhangs and sparse vegetation cover.
2 (Moderate)	May be used occasionally for foraging.	Plains and low hills with simple vegetation structure (e.g. one or two-layer with no trees) and at least one ephemeral water source nearby; or ridgelines, gullies and mesas with caves and overhangs and at least one ephemeral water source nearby.
3 (High)	Likely to be used for foraging if located within flying range of a diurnal roost.	Plains and low hills with complex vegetation structure (e.g. three-layer) and at least one ephemeral water source nearby; or ridgelines, gullies, mesas and gorges with complex vegetation structure, caves and overhangs and at least one ephemeral water source nearby.
4 (Very high)	Very likely to be used for foraging and/or as a source of drinking water, if located within flying range of a diurnal roost.	Plains and low hills with complex vegetation structure (e.g. three-layer) and semi-permanent or permanent surface water; or ridgelines, gullies, mesas and gorges with complex vegetation structure, caves and overhangs, and semi-permanent or permanent surface water.
5 (Outside diurnal roost)	Areas outside permanently occupied roosts where Pilbara leaf-nosed bats are present nightly.	n/a

Adapted from information presented by (Bat Call, 2021).

## 2 Methods

### 2.1 Survey Licensing

The field survey was conducted under the Department of Biodiversity, Conservation and Attractions' (DBCA) Regulation 27 "Fauna Taking (Biological Assessment)" licence, issued to Chris Knuckey (licence number BA27000450-2b). Under Section 40 of the BC Act, threatened species sampling was completed under a DBCA "Authorisation to Take or Disturb Threatened Species" issued to Chris Knuckey (authorisation number TFA 2021-0065-2).

The survey was conducted under the *Animal Welfare Act 2002* Licence to Use Animals for Scientific Purposes (License No. U244/2022-2024), administered through the Department of Primary Industries and Regional Development (DPIRD). This licence is enabled through Biologic's chosen Animal Ethics Committee (AEC), Murdoch University, under permit RW3354/21.

### 2.2 Survey Timing

The Pilbara bioregion has a semi-desert to tropical climate, with rainfall occurring sporadically throughout the year, although mostly during summer (Thackway & Cresswell, 1995). Summer rainfall is usually the result of tropical storms in the north or tropical cyclones that impact upon the coast and move inland (Leighton, 2004). Winter rainfall is generally lighter and is the result of cold fronts moving north easterly across the state (Leighton, 2004). The average annual rainfall for the Pilbara bioregion ranges from 200-350 millimetres (mm), although there are significant fluctuations between years, with some locations receiving up to 1,200 mm in some years (McKenzie *et al.*, 2009).

The annual monitoring survey was conducted over 11 days from 15-25 July 2024. Survey timing corresponded with the Pilbara 'winter' months and the end of the wet season. Similar to previous surveys since 2017, the annual monitoring survey was undertaken during the beginning of the mating period for Pilbara leaf-nosed bats and thus the period over which bats aggregate for breeding purposes (TSSC, 2016).

According to the Bureau of Meteorology (BoM) weather station (approximately 14 km north-east of the Study Area), average minimum (13.1°C) and maximum (28.2°C) temperatures during the annual monitoring survey were slightly warmer than long-term July averages (minimum: 12.2°C; maximum: 27.7°C) and temperatures recorded during the previous monitoring survey (Figure 2.1; Table 2.1) (Biologic, 2024). Ambient relative humidity levels recorded during the annual monitoring survey (recorded at 9.00am and 3.00pm) ranged between 19.7–32.5% (Table 2.1). No rainfall was recorded during the annual monitoring survey (Table 2.1). Weather conditions during the annual monitoring survey were suitable for Pilbara leaf-nosed bat activity and detection.

For Pilbara leaf-nosed bats, the new moon typically coincides with increased activity for the species (Biologic unpublished data). The current survey commenced during a first quarter moon phase (i.e. a half-moon), followed by a full moon on 21 July 2024. This is later in the moon phase than previous surveys and therefore illumination levels would have been brighter (average 85.9% illumination) in general than previous surveys between 2020 and 2023 (ranging between 12.2% and 80.8% illumination) (Table 2.1) (Biologic, 2019a, 2021a, 2021b, 2023, 2024; MWH, 2018a, 2018b).

Average monthly temperatures recorded at Marble Bar across the 12 months (January to December 2024) were 0.2°C to 4.4°C warmer than long-term conditions for both minimum (10 out of 12 months) and maximum (nine out of 12 months) temperatures (Figure 2.1). Between January and December 2024, Marble Bar station recorded 457.0 millimetres (mm) of rainfall, 74.4 mm higher than the long-term average rainfall for the same period (382.6 mm) (BoM, 2024) (Figure 2.1). Considerably higher than average rainfall occurred in March, November and December 2024, while lower than average rainfall was recorded in the six months prior to the annual survey, primarily due to reduced rainfall in January (37.6 mm, compared to long-term average of 107.3 mm) and February 2024 (39.6 mm, compared to long-term average of 82.7 mm) (Figure 2.1).

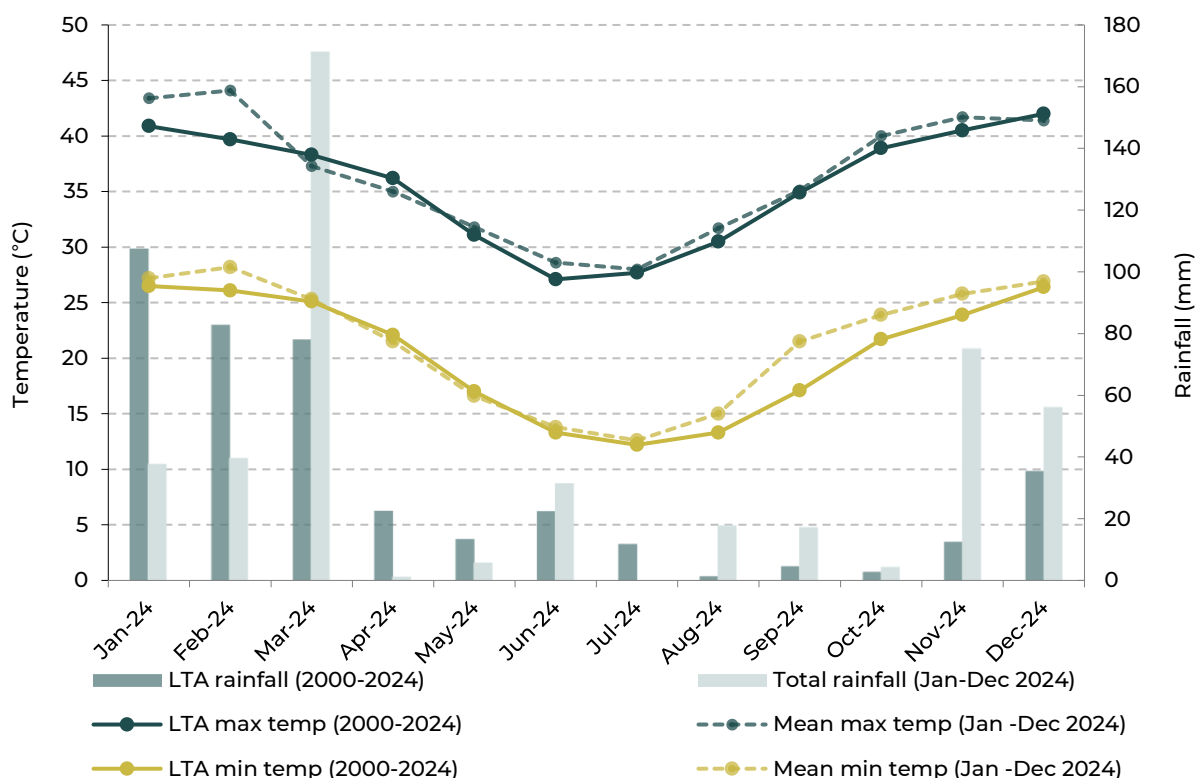


Figure 2.1: Climate data recorded at BOM Marble Bar station

Source: (BoM, 2024).

Table 2.1: Daily weather data recorded at Marble Bar during the field survey

Date	Temperature (°C)		Rainfall (mm)	Relative Humidity (%)		Civil Twilight		Moon Illumination (%)
	Min	Max		0900	1500	Dusk	Dawn	
15/07/2024	11.9	30.2	0	32	21	18:00	06:15	57
16/07/2024	15.8	27.7	0	22	13	18:00	06:14	66
17/07/2024	14.0	27.5	0	25	18	18:01	06:14	75
18/07/2024	-	29.5	0	23	16	18:01	06:14	84
19/07/2024	13.4	27.9	0	64	36	18:01	06:14	91
20/07/2024	17.4	26.9	0	26	22	18:02	06:14	96
21/07/2024	11.9	26.9	0	23	15	18:02	06:13	99
22/07/2024	10.9	29.8	0	26	13	18:02	06:13	100
23/07/2024	9.7	29.9	0	27	11	18:03	06:13	98
24/07/2024	12.3	28.2	0	57	28	18:03	06:12	93
25/07/2024	13.4	25.2	0	33	24	18:03	06:12	86
<b>Average</b>	<b>13.1</b>	<b>28.2</b>	-	<b>32.5</b>	<b>19.7</b>	<b>18:01</b>	<b>06:13</b>	<b>85.9</b>

Source: BoM (2024), Geoscience Australia (2024).

## 2.3 Survey Personnel

The annual monitoring survey was undertaken by experienced zoologists, whom collectively have over 30 years' experience undertaking fauna surveys, including within the Pilbara region (Table 2.2). Monitoring equipment deployed in the long-term were maintained as required and data were collected on a three-monthly basis by Atlas or Biologic personnel.

Table 2.2: Field survey personnel

Biologic Personnel	Position	Qualification	Experience
Mark Gresser	Senior Zoologist	BSc (Hons) Biological Sciences, Conservation and Wildlife Biology, Animal Biology	10 years' fauna zoology/ ecology 9 years' EIA (consulting) 10 years' field survey
Aidan Williams	Senior Zoologist	BSc Conservation Biology and Botany	10 years' field survey 9 years' EIA (consulting) 7 years' vertebrate fauna zoology/ ecology
Georgina Mattner	Zoologist	BSc Animal Ecology	3 years' field survey 3 years' EIA (consulting) 3 years' vertebrate fauna zoology/ ecology
Stephen McGrath	Zoologist	BSc Animal Ecology	6 years' field survey 8 years' EIA (consulting) 2 years' vertebrate fauna zoology/ ecology

## 2.4 Monitoring Sites

The monitoring program incorporates 11 monitoring sites, comprising six impact sites located within 1 km of the Project's indicative disturbance envelope and five control sites located more than 1 km from the Project's indicative disturbance envelope (Atlas Iron, 2017) (Figure 1.1). These sites include diurnal roosts, nocturnal refuges and potential foraging habitat (Table 2.3). Note that while control site LR-MI-01 is over 10 km from the indicative disturbance envelope for the Sanjiv Ridge Project, the site may be located in closer proximity to other mining operations (e.g. Miralga Creek, approximately 5 km from LR-MI-01) in the region.

Table 2.3: Summary of monitoring sites

Site	Site Type	Location		Roost Category <sup>2</sup>	Description	Water Seepage	Water Presence
		Latitude	Longitude				
<b>Impact</b>							
CO-CA-01 <sup>1</sup>	Cave	-21.4198	119.6737	Category 1: permanent diurnal roost	Cave located at top of rocky ridge face in rocky ridge and gorge habitat. A spring system is located ~40m from the entrance. The cave contains two main chambers connected by a constriction, with Pilbara leaf-nosed bats observed roosting in the rear chamber.	Yes	N/A
CO-CA-03	Cave	-21.4678	119.6711	Category 2: non-permanent maternity roost	Cave located at the bottom of a major gorge in rocky ridge and gorge habitat. The cave is located next to water seepage which feeds a water source at the cave entrance. The cave is characterised by two main chambers connected by a constriction, with Pilbara leaf-nosed bats observed roosting in rear chamber. Water seepage has been observed intermittently from the cave walls.	Yes	N/A
CO-CA-05	Cave	-21.4247	119.6742	Category 3: transitory diurnal roost	Cave in rocky ridge and gorge habitat.	No	N/A
CO-CA-10	Cave	-21.4187	119.6755	Category 4: nocturnal refuge	Cave in rocky ridge and gorge habitat.	No	N/A
CO-WS-01	Foraging/drinking location	-21.4105	119.6872	-	Permanent water source in rocky ridge and gorge habitat	N/A	Yes
CO-WS-03	Foraging/drinking location	-21.3752	119.6858	-	Semi-permanent water source in rocky ridge and gorge habitat	N/A	Yes
<b>Control</b>							
CO-CA-18	Cave	-21.3503	119.6161	Category 4: nocturnal refuge	Cave in rocky ridge and gorge habitat	No	N/A
MW-CA-02	Cave	-21.4631	119.2303	Category 1: permanent diurnal roost	Cave situated along ridge in rocky ridge and gorge habitat. Entrance is small leading to a wide, shallow chamber divided by low ceiling. Cave reaches back to an unknown distance (view obscured by ceiling). Bats observed roosting in rear of cave.	No	N/A

Site	Site Type	Location		Roost Category <sup>2</sup>	Description	Water Seepage	Water Presence
		Latitude	Longitude				
LR-MI-01	Mine adit	-21.0509	119.2766	Category 1: permanent diurnal roost	Abandoned mine adit in undulating grassland plain at the base of a large ironstone ridge system. Old vertical mine adit in plains serves as entrance to roost. Surrounding vegetation mainly consists of <i>Triodia</i> under sparse <i>Acacia inaequilatera</i> .	No	N/A
CO-WS-08	Foraging/drinking location	-21.4518	119.6509	-	Semi-permanent water source in rocky ridge and gorge habitat	N/A	Yes
CO-WS-13	Foraging/drinking location	-21.4666	119.6485	-	Semi-permanent water source in rocky ridge and gorge habitat	N/A	Yes

<sup>1</sup>CO-CA-01 and CO-CA-03 are monitored continuously (refer to Section 2.5).

<sup>2</sup>Based on the classification system developed by Bat Call (2021) (refer to Section 1.4).

## 2.5 Survey Methods

### 2.5.1 Habitat and Disturbance Monitoring

Formal cave, water source and habitat assessments have been conducted at each monitoring site since 2017 to characterise the quality and complexity of habitat provided for the Pilbara leaf-nosed bat.

During the current survey, photos were taken at pre-established points (Appendix A). Each photo was compared to photos captured in previous years to describe temporal changes in the structure and quality of each monitoring site. Any habitat changes, which may include changes caused by natural events (i.e. fire) or by anthropological disturbance (i.e. mining activity) were documented.

### 2.5.2 Microclimate

The microclimate of each accessible monitoring cave was assessed via either short-term deployments of loggers during the annual survey, or (in the case of CO-CA-01 and CO-CA-03) loggers which record microclimate continuously (Table 2.4). Due to restricted access, it was not possible to assess microclimate at sites LR-MI-01 and MW-CA-02. All microclimate loggers were set to record temperature (°C) and relative humidity (RH, %) every three hours at set times, i.e. at 12.00am, 3.00am, 6.00am, 9.00am, 12.00pm, 3.00pm, 6.00pm and 9.00pm.

Table 2.4: Microclimate logger deployments

Site	Logger Type	Date of First Reading	Date of Final Reading	Number of Sampling Nights
<b>Annual</b>				
<b>Impact</b>				
CO-CA-01	EWS <sup>1</sup>	16/07/2024	22/07/2024	7
CO-CA-03	EWS	16/07/2024	22/07/2024	7
CO-CA-05	H21-USB <sup>2</sup>	16/07/2024	22/07/2024	7
CO-CA-10	H21-USB	16/07/2024	22/07/2024	7
<b>Control</b>				
CO-CA-18	HOBO MX2301A <sup>3</sup>	16/07/2024	22/07/2024	7
LR-MI-01	N/A	-	-	N/A
MW-CA-02	N/A	-	-	N/A
<b>Continuous</b>				
CO-CA-01	EWS <sup>1</sup>	01/01/2024	04/04/2024	- (No data due to technical issue with logger)
	EWS <sup>1</sup>	05/04/2024	31/12/2024	269

Site	Logger Type	Date of First Reading	Date of Final Reading	Number of Sampling Nights
				(Due to technical issue with logger, RH data is patchy between 06-11/11/2024)

<sup>1</sup> EWS systems consist of a HMP60 Vaisala Intercap Humidity and Temperature Probe installed inside the cave and attached via a cable to an EWS Switch Data Logger (EWS Switch) located outside the cave. An EWS Switch is a solar-powered multi-communications transmitter that utilises either (and can be switched between) satellite or cellular connection for transmission of microclimate data to a web portal, allowing data to be accessed remotely.

<sup>2</sup> These consist of a temperature and humidity probe installed inside the given cave and attached via a cable to a MicroStation unit located outside the cave. Data can be collected via USB connection between the MicroStation and a laptop.

<sup>3</sup> Portable, battery-powered devices (data collected via Bluetooth connection between device and mobile device).

### 2.5.3 Ultrasonic Recording

SongMeter ultrasonic recorders (SM4BATs; Wildlife Acoustics, USA) were used to record Pilbara leaf-nosed bat calls to help describe levels of bat activity at all monitoring sites. For the two sites being continuously monitored (CO-CA-01 and CO-CA-03), previously installed solar-powered SMs have been collecting data continuously since their deployments and include the current annual monitoring period. For the remaining eight sites, SMs were deployed temporarily during the current survey for a minimum of seven nights (Table 2.5). These deployments involved positioning an SM to provide an unobstructed 'line of sight' between the microphone and the likely bat flyway at the cave entrance or water source. All SMs were preconfigured to activate at astronomical sunset each day and deactivate at astronomical sunrise the following morning. Audio settings which were configured to define the range of volume and frequencies being recorded were selected following the manufacturer's recommendations for bat detection (Wildlife Acoustics, 2017).

Ultrasonic data were collected at CO-CA-01 during the annual survey. However, upon analysis, the data were not considered reliable due to technical issues with the SM unit. Similarly, bat activity was not monitored for the entirety of the 12 month continuous monitoring period, with gaps in ultrasonic data recordings as indicated in Table 2.5.

Table 2.5: Ultrasonic recorder deployments

Site	Deployment Date	Retrieval Date	Sampling Nights
<b>Annual</b>			
<b>Impact</b>			
CO-CA-01 <sup>1</sup>	16/07/2024	23/07/2024	-
CO-CA-03	16/07/2024	23/07/2024	7
CO-CA-05	16/07/2024	23/07/2024	7
CO-CA-10	16/07/2024	23/07/2024	7
CO-WS-01	16/07/2024	23/07/2024	7

Site	Deployment Date	Retrieval Date	Sampling Nights
CO-WS-03	16/07/2024	23/07/2024	7
<b>Control</b>			
CO-WS-08	16/07/2024	23/07/2024	7
CO-WS-13	16/07/2024	23/07/2024	7
CO-CA-18	16/07/2024	23/07/2024	7
LR-MI-01	16/07/2024	23/07/2024	7
MW-CA-02 <sup>1</sup>	N/A	N/A	N/A
<b>Continuous</b>			
CO-CA-01 <sup>1</sup>	01/01/2024	06/06/2024	158
	07/06/2024	16/08/2024	-
	17/08/2024	11/09/2024	26
	12/09/2024	03/10/2024	-
	04/10/2024	31/12/2024	89

<sup>1</sup> Ultrasonic data was not available for the entirety of the monitoring period

## 2.5.4 Opportunistic Observations

During the deployment, maintenance, and retrieval of monitoring equipment, primary (i.e. direct observation of species) or secondary (e.g. scats, remains etc.) evidence of Pilbara leaf-nosed bat presence was recorded.

## 2.6 Data Analysis

### 2.6.1 Ultrasonic Analysis

All recordings were analysed by Robert Bullen of Bat Call WA using standardised bat call detection techniques. Raw files were first scanned for Pilbara leaf-nosed bat calls using Kaleidoscope software (Wildlife Acoustics, USA), then reviewed for significant times and call numbers using Cool Edit software (Adobe, USA). The total number of calls and the time of the first and last call for each sampling night were recorded. During analysis, a recording night was considered from astronomical sunset to sunrise the following day. Because any individual is likely to emit multiple calls at any site during any night, the total number of calls was treated as a measure of 'activity' rather than providing a total number of individuals present. While activity is likely to reflect individuals present, the exact correlation between the two is likely to vary per site (i.e., depending on how the bats use and navigate the site) and per night (e.g. other animals present may change the time spend at a particular site).

Roosting at a monitoring site was indicated if one of the following criteria were satisfied: (1) if last call during the previous recording night occurred after dawn, (2) if first call during the current monitoring night was within ≤10 minutes of dusk or (3) if last call during the previous

recording night occurred  $\leq 10$  minutes before dawn or first call during the current monitoring night was within  $\leq 30$  minutes of dusk.

Estimated mean call counts were used to compare the current annual monitoring period with previous periods since mining operations commenced. Data for monitoring site CO-CA-01 extend back to 2014, while data for the remaining sites extend back to preliminary recordings during the 2016 vertebrate fauna survey (MWH, 2016) and previous baseline monitoring survey (MWH, 2018a). It is important to note that the terrestrial vertebrate fauna survey was conducted in a different season to the monitoring surveys.

## 2.6.2 Statistical Analysis

To take natural fluctuations into account and in accordance with the SSMP, available data from previous baseline surveys were combined. This provided a robust overall average baseline level (2014–2019) for each monitoring site against which current Pilbara leaf-nosed bat activity can be compared. Call data was considered suitable for inclusion if it was collected between 15 May–4 October of each baseline year between 2014 and 2019 and subsequent monitoring years during active mining. This timing reflects when Pilbara leaf-nosed bats are most likely to be roosting and/or using monitoring caves within the Sanjiv Ridge area.

Statistics were calculated with R version 4.4.2 (R Core Team, 2024). Call counts were modelled with a generalised additive model (GAM) with the R package *mgcv* (Wood, 2011), negative binomial distribution of the response and a log link. Fixed effects were derived from cave-year combinations and smoothing functions were used to fit non-linear seasonalities by year. Model means were estimated individually for baseline (2014–2019), post-baseline years (2020, 2021, 2022, 2023 and 2024) and a grouped post-baseline period (2020–2024). Percentage differences from baseline and associated p-values were determined by contrasting these estimated means with the R package *emmeans* (Lenth, 2025). Model diagnostics were performed using the R package *DHARMA* (Hartig, 2024).

## 3 Results and Discussion

### 3.1 Habitat and Disturbance Monitoring

At the time of the first annual monitoring survey since mining commenced in 2020, disturbance comprised small areas of clearing for exploration and historical mining activities, and general degradation due to pastoralism (Biologic, 2019b, 2019c). Clearing for mine development, and construction commenced in 2020, and ore extraction activities commenced in 2021 and have continued through to the current monitoring period (Biologic, 2021a, 2022a, 2023, 2024). Additional mining-related activities commenced between the 2023 survey and the current annual survey, although did not approach closer to impact sites than those previously reported (Table 3.1). While it was noted that mining-related noise was audible at some sites (particularly CO-CA-01 and CO-CA-10) during the current field survey, no additional physical disturbances were noted at any sites from photo monitoring undertaken. The nature of mining-related activities occurring within the Study Area during the current monitoring period included:

- Ongoing development of Sparrow Lake (formerly Split Rock) pit, including drilling, blasting and clearing, with the closest disturbance 450 m west of impact site CO-CA-03 and 1.4 km east of control site CO-WS-13.
- Development of Razorback pit activities in December 2023, 145 m south of impact CO-CA-03, with blasting and ore-production commencing in May 2024. Active mining ceased on 22 July 2024.
- Development of Glen Herring haul road (associated with Stage 2) in November 2023, 560 m and 280 m west of impact sites CO-CA-01 and CO-CA-05, respectively, and ongoing.
- Ongoing development of Runway North pit, including drilling, blasting and ore-extraction, approximately 295 m, 350 m and 485 m east of CO-CA-10, CO-CA-05 and CO-CA-01, respectively.
- Use of haul roads and access tracks throughout the Study Area, with one haul road located immediately adjacent to impact site CO-WS-01, camp access track or haul roads as close as 190 m, 310 m, 390 m and 556 m east of impact sites CO-CA-05, CO-CA-10, CO-CA-01 and CO-WS-03, respectively, and 480 m west of impact site CO-CA-03.

Vegetation adversely affected by a wildfire that burned along the ridgetop near CO-CA-01, CO-CA-05, CO-CA-10 and CO-WS-03 on 16 December 2022 showed evidence of continued regeneration (Table 3.1). Five of the 11 monitoring sites are located adjacent to, or near, seasonally inundated or permanent drainage lines. The distribution and surface levels of water pools present in the Study Area can vary between years (Table 3.1; Appendix A).

Table 3.1: Monitoring site habitat attributes and disturbance information

Site	Record of Disturbance <sup>1</sup>					2024 (current survey)		
	2017	2018	2019	2020	2021			
<b>Impact</b>								
CO-CA-01	None recorded.	None recorded.	None recorded.	None recorded.	Haul road developed within ~390 m to east. Pit (Runway North) developed within ~485 m to east. Pit (Runway South) developed within ~600 m to east.	No additional disturbances recorded. Haul road activities continued within ~390 m to east. Ore production activities associated with Runway North pit continued within ~485 m to east. Ore production activities associated with Runway South pit continued within ~600 m to east.	Wildfire following 2022 survey (16 December 2022) on ridgetop. Entrance to cave unburnt. Haul road activities within ~390 m to east. Ore production activities associated with Runway North pit within ~485 m to east. Ore production activities associated with Runway South pit within ~600 m to east.	No additional disturbances recorded during annual survey. Vegetation regeneration after fire apparent. Haul road activities continued (Stage 2, commenced November 2023) ~560 m to south-west. Haul road activities continued within ~390 m to east. Ore production activities associated with Runway North pit continued within ~485 m to east. Ore production activities associated with Runway South pit continued within ~600 m to east and ceased in April 2024 (prior to annual survey).
CO-CA-03	None recorded.	None recorded.	None recorded.	None recorded.	Wildfire following the 2020 monitoring survey. Exploration activities undertaken within ~121 m to east. Haul road developed within ~480 m to west.	Pit (Split Rock) developed within ~450m to west. Haul road activities continued within ~480 m to west.	No additional disturbances recorded during annual survey. Ore production activities associated with Split Rock pit continued within ~450m to west. Haul road activities continued within ~480 m to west.	Mining related activities associated with Razorback pit (commenced December 2023) continued within ~120 m to south-west (June 2024), with blasting, ore-production, and hauling commencing in May 2024 and ceasing on 22 July 2024.. Ore production activities associated with Sparrow Lake (formerly Spilt Rock) pit continued within ~450m to west. Haul road activities continued within ~480 m to west.
CO-CA-05	None recorded.	None recorded.	None recorded.	None recorded.	Haul road developed within ~191 m to south- east. Pit (Runway North) developed within ~350 m to east. Pit (Runway South) developed within ~513 m to south-east.	No additional disturbances recorded. Haul road activities continued within ~191 m to east. Ore production activities associated with Runway North pit continued within ~350 m to east. Ore production activities associated with Runway South pit continued within ~513 m to south-east.	Wildfire following 2022 survey (16 December 2022) on ridgetop. Haul road activities continued within ~191 m to east. Ore production activities associated with Runway North pit continued within ~350 m to east. Ore production activities associated with Runway South pit continued within ~513 m to south-east.	No additional disturbances recorded during annual survey. Vegetation regeneration after fire apparent. Haul road activities continued (Stage 2, commenced November 2023) ~288 m to west. Haul road activities continued within ~191 m to east. Ore production activities associated with Runway North pit continued within ~350 m to east. Ore production activities associated with Runway South pit continued within ~513 m to south-east and ceased in March 2024 (prior to annual survey).
CO-CA-10	None recorded.	None recorded.	None recorded.	None recorded.	Pit (Runway North) developed within ~294 m to east. Haul road developed within ~310 m to east. Pit (Runway South) developed within ~470 m to south-east.	No additional disturbances recorded. Ore production activities associated with Runway North pit continued within ~294 m to east. Haul road activities continued within ~310 m to east. Ore production activities associated with Runway South pit continued within ~470m to south-east.	Wildfire following 2022 survey (16 December 2022) on ridgetop. Patchy burnt areas in close proximity to cave entrance. Ore production activities associated with Runway North pit continued within ~294 m to east. Haul road activities continued within ~310 m to east. Ore production activities associated with Runway South pit continued within ~470m to south-east.	No additional disturbances recorded during annual survey. Vegetation regeneration after fire apparent. Ore production activities associated with Runway North pit continued within ~294 m to east. Haul road activities continued within ~310 m to east. Ore production activities associated with Runway South pit continued within ~470m to south-east and ceased in March 2024 (prior to annual survey).

Site	Record of Disturbance <sup>1</sup>							
	2017	2018	2019	2020	2021	2022	2023	2024 (current survey)
CO-WS-01	None recorded.	None recorded.	Recent fire ~200m away (at the north east).	No additional disturbances recorded. Regeneration post fire.	Haul road developed within ~27 m to west. Substantial rockfall observed at the southern end of the site.	No additional disturbances recorded. Previous rockfall remains in-situ. Haul road activities continued within ~27 m to west.	Wildfire following 2022 survey (16 December 2022) on ridgetop. Previous rockfall remains in-situ. Haul road activities continued within ~27 m to west.	No additional disturbances recorded during annual survey. Vegetation regeneration after fire apparent. Haul road activities continued within ~27 m to west. Ore production activities associated with Runway South pit continued within 1 km to the south-south-west and ceased in March 2024 (prior to annual survey). Ore production activities associated with Runway North pit continued within 1 km to the south-west.
CO-WS-03	None recorded.	None recorded.	None recorded.	Shallow surface excavation of Pit (Borrow) within ~462 m to north-east. Haul road developed within ~556 m to east.	No additional disturbances recorded. Mine associated activities continued within ~462 m to north-east. Haul road activities continued within ~556 m to east.	No additional disturbances recorded. Mine associated activities continued within ~462 m to north-east. Haul road activities continued within ~556 m to east.	Wildfire following 2022 survey (16 December 2022) on ridgetop. Mine associated activities continued within ~462 m to north-east. Haul road activities continued within ~556 m to east.	No additional disturbances recorded during annual survey. Mine associated activities continued within ~462 m to north-east. Camp access/haul road activities continued within ~556 m to east.
<b>Control</b>								
CO-WS-08	Downstream impacts from cattle were evident, however the recorder was located upstream in the gorge where the impacts from cattle were limited.	No additional disturbance recorded.	Weeds.	No additional disturbance recorded.	No additional disturbance recorded.	No additional disturbances recorded.	No additional disturbances recorded.	No additional disturbances recorded during annual survey.
CO-WS-13	Downstream impacts from cattle were evident, however the recorder was located upstream in the gorge where the impacts from cattle were limited.	No additional disturbance recorded.	No additional disturbance recorded.	No additional disturbance recorded.	No additional disturbance recorded.	No additional disturbances recorded.	Waste dump associated with Split Rock pit developed within ~1.4 km to east.	No additional disturbances recorded during annual survey. Mining related activities associated with Sparrow Lake (formerly Split Rock) pit continued within ~1.4 km to east.
CO-CA-18	None recorded.	Impacts from cattle were evident at the base of the slope, however the recorder was located uphill where the impacts from cattle were limited.	No additional disturbance recorded.	No additional disturbance recorded.	No additional disturbance recorded.	No additional disturbances recorded.	Wildfire following 2022 survey (16 December 2022) on ridgetop.	No additional disturbances recorded during annual survey.

Site	Record of Disturbance <sup>1</sup>							
	2017	2018	2019	2020	2021	2022	2023	2024 (current survey)
LR-MI-01	No additional disturbance recorded. Clearing and excavation associated with historic mining activity noted in 2012 (Outback Ecology, 2012). Abydos East Link Road passing ~550m to the north of the monitoring cave noted in 2013 (Outback Ecology, 2013).	No additional disturbance recorded.	Collapse of secondary entrance (LR-MI-02, entrance was under some tin sheeting that partially blocked the shaft).	No additional disturbance recorded.	No additional disturbance recorded.	No additional disturbances recorded.	No additional disturbances recorded.	No additional disturbances recorded during annual survey.
MW-CA-02	None recorded.	None recorded.	None recorded.	None recorded.	None recorded.	None recorded.	None recorded.	None recorded

<sup>1</sup>Distances to mining related disturbances as part of Sanjiv Ridge Project are based on spatial data provided by Atlas.

## 3.2 Microclimate

### 3.2.1 Annual Monitoring

Generally, all caves exhibited relatively stable temperatures during the current monitoring period, compared to ambient temperatures outside the caves. Cave temperatures during the current monitoring period were slightly warmer compared to the previous monitoring period (Table 3.2) (Biologic, 2024). Impact caves CO-CA-01 and CO-CA-03 exhibited stable temperature levels consistent with the range which supports roosting by Pilbara leaf-nosed bats (i.e. preferred temperature range of 28-32°C; Armstrong, 2001) (Table 3.2).

Table 3.2: Temperature data at monitoring caves during the current monitoring period

Site	Day-time (9am to 6pm) Temperature (°C)				Night-time (9pm to 6am) Temperature (°C)			
	Min	Max	Average (±SE)	Diff	Min	Max	Average (±SE)	Diff
<b>Impact</b>								
CO-CA-01	32.00	32.25	32.10 (±0.02)	0.25	32.00	32.25	32.07 (±0.02)	0.25
CO-CA-03	31.25	31.38	31.31 (±0.01)	0.13	31.25	31.38	31.32 (±0.01)	0.13
CO-CA-05	29.68	29.96	29.80 (±0.01)	0.28	29.72	29.98	29.82 (±0.01)	0.26
CO-CA-10	28.15	28.43	28.28 (±0.02)	0.28	28.15	28.43	28.31 (±0.02)	0.28
<b>Control</b>								
CO-CA-18	24.35	25.69	25.38 (±0.05)	1.34	25.08	25.69	25.41 (±0.03)	0.61

During the current monitoring period, the relative humidity at CO-CA-01 and CO-CA-03 were relatively stable and consistent with the preferred relative humidity range of 85-100% (Churchill, 1991) required for Pilbara leaf-nosed bat roosting and their use as diurnal roosts (Category 1 and 2 respectively) (Table 3.3). Similarly, CO-CA-05, CO-CA-10 and CO-CA-18 exhibited stable, but much lower, relative humidity levels. For example, relative humidity levels at CO-CA-05 were 32.09% during the day (daily average between 9am to 6pm) and 33.33% at night (daily average 6pm to 9am) (Table 3.3). When compared to previous annual monitoring periods, relative humidity levels were similar, or lower than the natural variation previously recorded, including 2023 (averaged 33.19% during the day and 33.03% at night), 2022 (averaged 35.20% during the day and 34.40% at night), 2021 (averaged 48.04% during the day and 51.90% at night), and 2020 (averaged 91.10% during the day and 91.30% during the night across the monitoring period).

Such variation in relative humidity is expected, as levels are more sensitive to changes in local weather conditions (such as rainfall) than temperature. Relative humidity values recorded during the current monitoring period are consistent with CO-CA-05's use as a transitory

diurnal roost (Category 3), and CO-CA-10 and CO-CA-18 use as nocturnal refuges (Category 4) (Table 1.3) (Bat Call, 2021).

Table 3.3: Relative humidity data at monitoring caves during the current monitoring period

Site	Day-time (9am to 6pm) RH(%)				Night-time (9pm – 6am) RH (%)			
	Min	Max	Average (±SE)	Diff	Min	Max	Average (±SE)	Diff
<b>Impact</b>								
CO-CA-01	89.09	90.44	89.93 (±0.08)	1.35	86.63	90.43	88.88 (±0.14)	3.80
CO-CA-03	88.26	89.43	88.83 (±0.05)	1.17	88.31	89.12	88.81 (±0.04)	0.91
CO-CA-05	27.08	38.92	32.09 (±0.66)	11.84	29.91	38.59	33.33 (±0.44)	8.68
CO-CA-10	23.83	50.07	29.64 (±1.25)	26.24	19.14	46.17	30.29 (±1.29)	27.04
<b>Control</b>								
CO-CA-18	23.06	43.78	28.41 (±1.26)	20.72	22.11	41.92	28.82 (±1.14)	19.81

Currently, there is no evidence to suggest the microclimate of these monitoring sites has deviated from natural conditions (despite being slightly warmer than the previous year) between annual monitoring periods due to activities associated with mining operations. Mining-related activities have not approached closer to the 11 monitoring sites since the previous annual monitoring period (refer to Section 3.1). As there has been no change in the physical condition of these sites from the previous monitoring period, the likelihood of mining activities having had an impact on the microclimate of monitoring sites is considered to be negligible.

### 3.2.2 Continuous Monitoring

For nine to ten months of the current continuous monitoring period (January to December 2024), warmer than average ambient minimum and maximum temperatures were recorded at Marble Bar (Section 2.2). The internal temperatures of CO-CA-01 were relatively stable, and there were minimal daily or seasonal fluctuations compared with ambient conditions. Consequently, as a result of warmer ambient temperatures, temperatures within CO-CA-01 during the current continuous monitoring period were the warmest ever recorded (1.96 to 2.05°C higher) since mining commenced in 2020 (Biologic, 2020b, 2022b, 2023) (Table 3.4). Temperatures within the cave fell within the preferred range of 28 to 32°C for roosting by Pilbara leaf-nosed bats, approximately 54% of the nights sampled (primarily between July and December 2024) (Table 3.4; Figure 3.1).

Following on from the previous continuous monitoring period, relative humidity inside CO-CA-01 continued to remain relatively stable during the current monitoring period (Table 3.5; Figure 3.2)(Biologic, 2023). Relative humidity fell within the preferred range of 85% to 100% for roosting by Pilbara leaf-nosed bats for approximately 67% of the 271 nights sampled

(Table 3.5; Figure 3.2). Relative humidity levels recorded during the current continuous monitoring period (58.92% to 99.47%) were similar to relative humidity levels recorded during previous monitoring periods (Biologic, 2020b, 2022b, 2023) (Table 3.5).

Table 3.4: Temporal comparison of temperature data recorded inside CO-CA-01

Summary Statistics – Temperature (°C) <sup>1</sup>	Jan to Dec 2020 (Biologic, 2020b)	Jan to Dec 2021 (Biologic, 2022b)	Jan to Dec 2022 (Biologic, 2023)	Jan to Dec 2023 (Biologic, 2024)	Jan to Dec 2024 (current survey)
Mean Daytime (9am to 6pm)	30.30 ± 0.01	30.74 ± 0.03	31.05 ± 0.42	31.01 ± 0.02	32.26± 0.03
Mean Night-time (6pm to 9am)	30.19 ± 0.03	30.70 ± 0.03	31.04 ± 0.47	31.00 ± 0.02	32.24± 0.03
Minimum	27.59	29.12	29.25	29.75	30.88
Maximum	32.5	32.75	32.75	32.62	34.25
Number of recording nights within preferred range (28 to 32°C) (%)	359 out of 361 nights (99.45%)	363 out of 363 nights (100%)	349 out of 349 nights (100%)	242 out of 242 nights (100%)	146 out of 271 nights (53.87%)

<sup>1</sup>Doesn't include records where microclimate data was not recorded

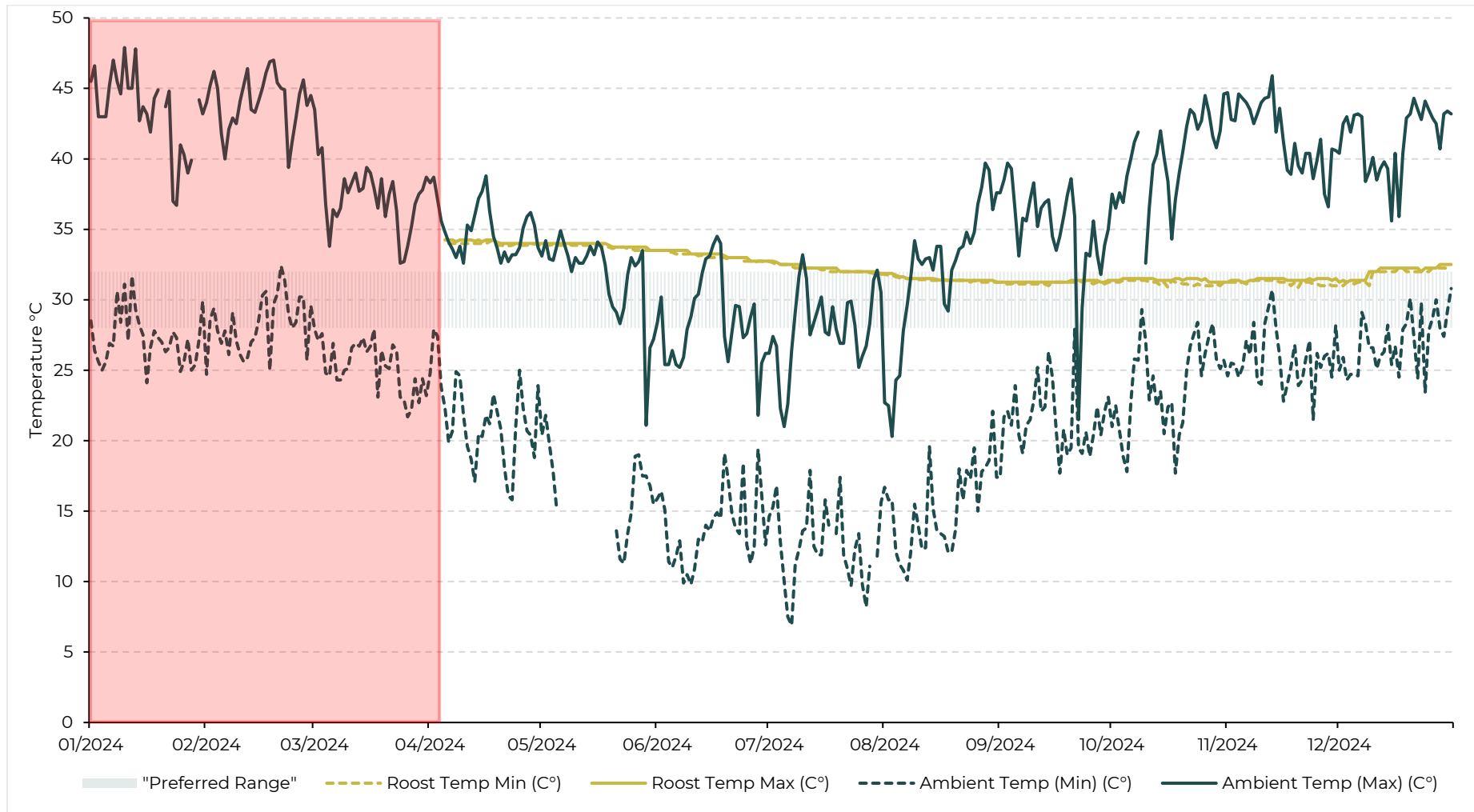


Figure 3.1: Daily temperature range recorded inside CO-CA-01 during the 2024 continuous monitoring period compared with ambient temperature

Note: red box indicates where microclimate data was not available

Table 3.5: Temporal comparison of relative humidity data recorded inside CO-CA-01

Summary Statistics – RH (%) <sup>1</sup>	Jan to Dec 2020 (Biologic, 2020b)	Jan to Dec 2021 (Biologic, 2022b)	Jan to Dec 2022 (Biologic, 2023)	Jan to Dec 2023 (Biologic, 2024)	Jan to Dec 2024 (current survey)
Mean Daytime (9am to 6pm)	84.63 (± 0.39)	95.24 (± 0.10)	95.29 (± 1.35)	94.06 (± 0.14)	88.81 (± 0.11)
Mean Night-time (6pm to 9am)	85.71 (± 0.36)	95.30 (± 0.09)	95.37 (± 1.52)	94.16 (± 0.13)	87.79 (± 0.11)
Minimum (%)	51.34	87.81	89.09	84.41	58.92
Maximum (%)	100	100	100	100	99.47
Percentage of recordings within preferred range (85 to 100%)	150 out of 250 nights (60.00%)	178 out of 178 nights (100%)	324 out of 324 nights (100%)	240 out of 242 nights (99.17%)	182 out of 271 nights (67.16%)

<sup>1</sup>Doesn't include records where microclimate data was not recorded



Figure 3.2: Daily relative humidity range recorded inside CO-CA-01 during the current continuous monitoring period

Note: red box indicates where relative humidity data was not available

### 3.3 Ultrasonic Recording

#### 3.3.1 Annual Monitoring

Pilbara leaf-nosed bats were detected at nine of the 11 monitoring sites during the current monitoring period (Table 3.6; Figure 3.3; Appendix B). No calls were recorded at CO-WS-08 and ultrasonic data at MW-CA-02 were not available for the current annual survey period. Ultrasonic calls were recorded at CO-CA-01, however data was not included in analysis as accuracy of data was uncertain. Based on the timing of calls, Pilbara leaf-nosed bats during the current survey period are continuing to roost diurnally at all sites (where data were available) which have previously been identified as permanent diurnal roosts (control site LR-MI-01). Roosting also continued at (impact) non-permanent maternity roost CO-CA-03, and transitory diurnal roost CO-CA-05 (Table 3.7). Roosting was not observed at impact site (nocturnal refuge) CO-CA-10 during the current monitoring period.

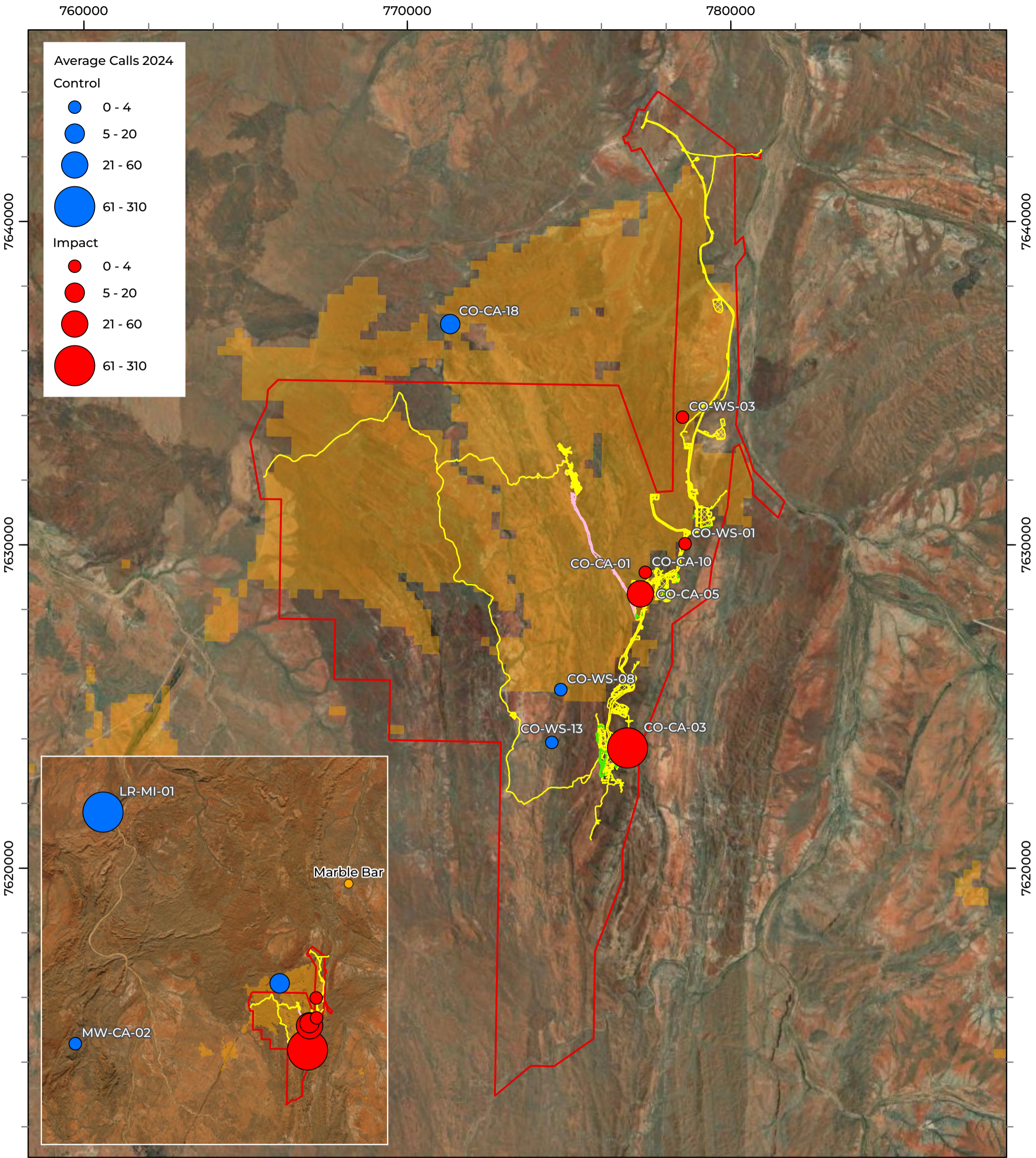
Table 3.6: Pilbara leaf-nosed bat activity recorded during the monitoring period

Site	Number of Calls per Recording Night				Diurnal Roosting Indicated? <sup>1</sup>
	Observed Mean	SE	Minimum	Maximum	
CO-CA-01 <sup>2</sup>	N/A	N/A	N/A	N/A	N/A
CO-CA-03	188	37.91	97	389	Yes (every day)
CO-CA-05	56	14.89	26	131	Yes (every day)
CO-CA-10	4	1.81	0	14	No
CO-WS-01	2	0.71	0	4	N/A
CO-WS-03	4	0.87	1	8	N/A
CO-WS-08	0	0	0	0	N/A
CO-WS-13	4	0.99	0	7	N/A
CO-CA-18	15	7.83	0	56	No
LR-MI-01	267	62.88	101	529	Yes (every day)
MW-CA-02 <sup>3</sup>	-	-	-	-	-

<sup>1</sup>Based on interpretation of timing of calls by Bat Call (Bob Bullen pers. comms, 2024).

<sup>2</sup>Despite ultrasonic calls being recorded at CO-CA-01, data were not considered suitable for analysis.<sup>3</sup>Ultrasonic data not available for MW-CA-02 as cave not accessible at the time of survey.

Note: '-' = no sampling



**LEGEND**

- Study Area
- Wildfire December 2022

Development Envelope

Stage 1

- Disturbance at end of July 2024
- Disturbance at end of July 2023

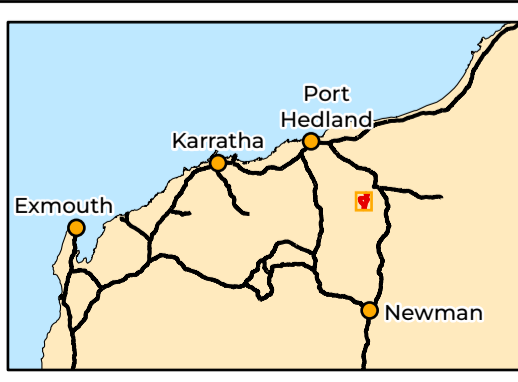
Stage 2

- Disturbance at end of July 2024

Scale 1:110,000

0 2 4 Km

Coordinate System: GDA2020 MGA Zone 50  
Transverse Mercator Created: 19/11/2024



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Sanjiv Ridge Pilbara leaf-nosed bat Monitoring 2024

Figure 3.3: Average nightly Pilbara leaf-nosed bat activity

Table 3.7: Average timing of Pilbara leaf-nosed bat calls at monitoring sites

Site	Average	
	Hours ± Civil Dusk (17:37 <sup>1</sup> )	Hours ± Civil Dawn (06:38 <sup>2</sup> )
<b>Impact</b>		
CO-CA-01	N/A	N/A
CO-CA-03	+22.8 minutes	+1 hour, 39.4 minutes
CO-CA-05	+1 hour, 37.2 minutes	+1 hour, 10.6 minutes
CO-CA-10	+2 hour, 52.8 minutes	+1 hour, 51 minutes
CO-WS-01	+1 hour, 35.4 minutes	+4 hours, 35.7 minutes
CO-WS-03	+1 hour, 30 minutes	+4 hours, 25.2 minutes
<b>Control</b>		
CO-WS-08	-	-
CO-WS-13	+1 hour, 45.8 minutes	+3 hours, 5.8 minutes
CO-CA-18	+3 hours, 25.8 minutes	+5 hours, 33.6 minutes
LR-MI-01	+53.4 minutes	+1 hour, 10.7 minutes
MW-CA-02	-	-

<sup>1</sup>17 minutes earlier than previous year; <sup>2</sup>23 minutes earlier than previous year.

Note: '-' = no sampling

### 3.3.2 Continuous Monitoring

Pilbara leaf-nosed bats were detected on 100% of recording nights (274 sampling nights) at CO-CA-01 during the current continuous monitoring period (Appendix C). Call rates at CO-CA-01 were highest in May and June 2024, coinciding with the start of the breeding season, when individuals aggregate for mating purposes (TSSC, 2016) (Figure 3.4). Lower numbers of calls were recorded between February and March, and November to December 2024 (Figure 3.4; Appendix C). The number of calls per recording night at CO-CA-01 ranged from 411 calls in December 2024 to 1,843 calls in May 2024, averaging 746 calls per recording night over the entire continuous monitoring period.

Pilbara leaf-nosed bats were roosting diurnally every night sampled at CO-CA-01, demonstrating that diurnal roosting likely occurred continuously throughout the continuous monitoring period (Appendix C).

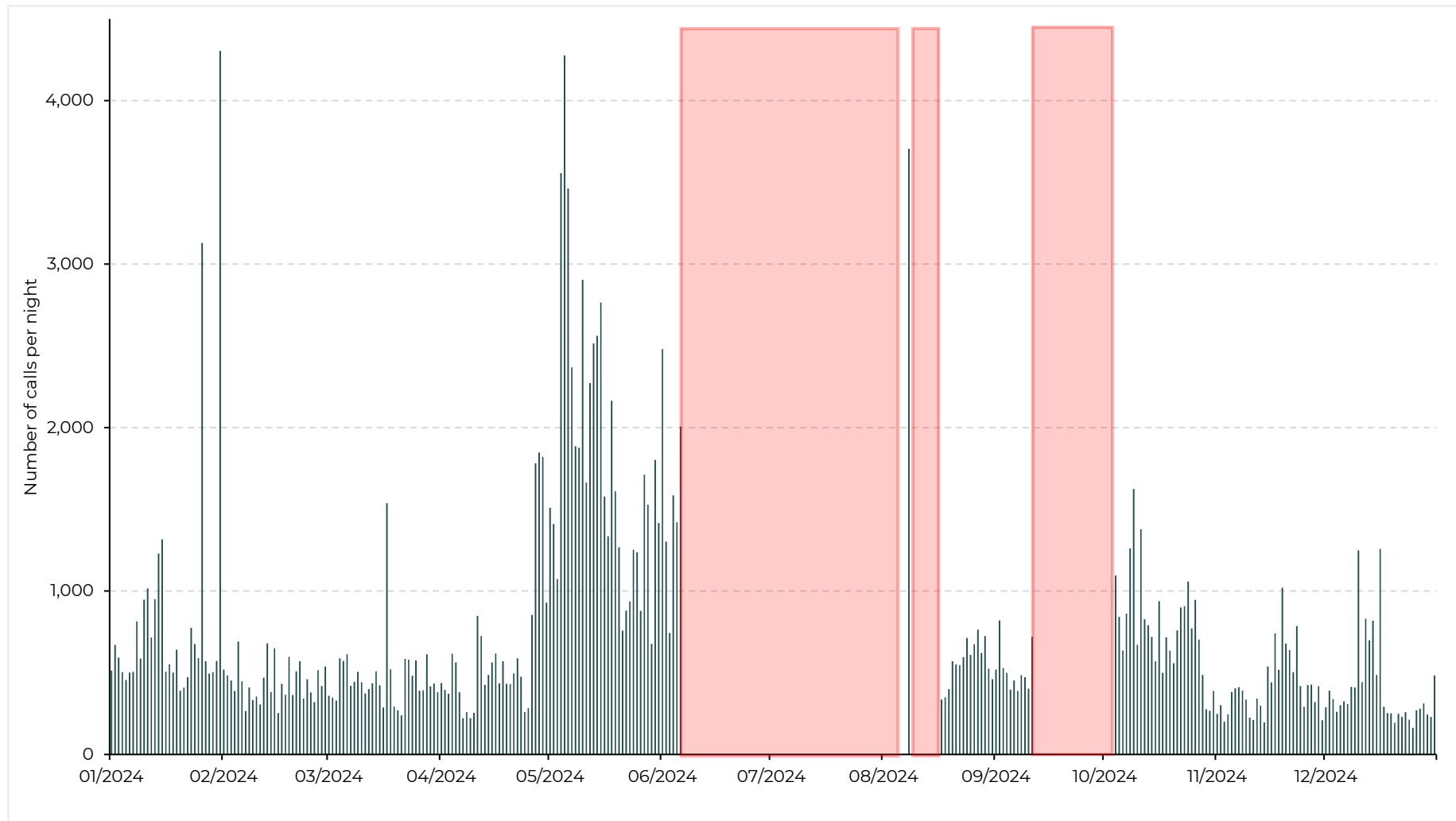


Figure 3.4: Pilbara leaf-nosed bat calls recorded at CO-CA-01 between January–December 2024.

Note: red box indicates where ultrasonic data was not available

## 3.4 Temporal Trends

### 3.4.1 Annual Monitoring

Pilbara leaf-nosed bats were recorded at nine of the 11 monitoring sites during the current monitoring period, with the exception of CO-WS-08 and MW-CA-02. Despite data not being available at MQ-CA-02 due to access concerns, it is likely the species was present during the current monitoring period, based on previous activity levels (Table 3.8). Previously, in 2023, the species were recorded at all monitoring sites (Biologic, 2023).

During the current monitoring period, lower levels of Pilbara leaf-nosed bat activity (as determined by GAM estimated mean number of calls) were recorded at all ten monitoring sites sampled (data not available for MW-CA-02), when compared to the previous monitoring period (Table 3.8; Figure 3.5; Figure 3.6). The reduction in calls at impact sites during the current monitoring period ranged from 35% (CO-CA-01) to 95% (CO-CA-10) less than the previous year (Table 3.8; Figure 3.5; Figure 3.6). This is in contrast to 2023, which recorded an increase (or similar levels) in Pilbara leaf-nosed bat activity at all six impact sites (and three control sites) from the 2022 monitoring period (Biologic, 2024).

As the colonies roosting within CO-CA-01 and CO-CA-03 represent the most likely source of Pilbara leaf-nosed bats foraging within the Study Area, it is expected that activity levels at foraging locations CO-WS-01, CO-WS-03, CO-WS-08 and CO-WS-13 reflect the activity levels observed at CO-CA-01 and CO-CA-03 (Table 3.8; Figure 3.6). Activity recorded at all ten monitoring sites (data not available at MW-CA-02) during the current monitoring period represents the lowest activity recorded since mining commenced in 2020 (Table 3.8; Figure 3.5; Figure 3.6). With the exception of an increase observed at some impact sites between 2022 and/or 2023, bat activity at impact monitoring sites between consecutive years has declined since the commencement of active mining in 2020 (Table 3.8; Figure 3.5; Figure 3.6).

Roosting continued to be recorded during the current monitoring period at impact sites where previously indicated, except nocturnal refuge CO-CA-10, where roosting was observed on one night during the previous monitoring period, but not during the current monitoring period. Roosting continued to be recorded during the current monitoring period at control sites where previously indicated, including LR-MI-01, with information on roosting at MW-CA-02 unavailable.

Pilbara leaf-nosed bat activity during the current monitoring period was lower relative to overall pre-mining (baseline 2014-2019) levels at ten of the 11 monitoring sites (Table 3.8;

Figure 3.8; Appendix D). Current activity levels ranged from 50% (CO-CA-01) to 98% (CO-CA-03) lower (statistically significant,  $p \leq 0.05$ ) than average baseline levels at all six impact sites (

Figure 3.8; Table 3.9; Appendix D; refer to Section 4.2). Similarly, bat activity recorded during the 2020, 2021, 2022 and 2023 active mining monitoring periods were lower than baseline levels at most impact sites, except CO-CA-10 in 2023 and CO-CA-05 in 2020 (Table 3.8). Impact site CO-CA-01 recorded a 50% decline from baseline levels during the current survey, and a 23% decline from baseline levels in 2023. Note that previously reported activity levels during specific monitoring years and baseline levels has been reanalysed during the current monitoring period using a GAM. This reanalysis has resulted in slightly different reported estimated mean number of calls and percentage differences for the current and previous monitoring periods, including the baseline period. Previous estimated mean number of calls are compared against revised estimated means in Appendix D.

Bat activity at four of the five control sites during the current monitoring period (excluding MW-CA-02), were statistically lower than baseline levels, ranging from 91% (CO-CA-18) to 100% (CO-WS-08) lower (Table 3.8; Table 3.9;

Figure 3.8). This is similar to findings during previous active mining monitoring periods, where bat activity was lower than baseline activity levels at all five control sites (excluding LR-MI-01 and MW-CA-02 in 2021, where bat activity was higher than baseline levels). When grouped, Pilbara leaf-nosed bat activity for active mining years (2020-2024) compared to baseline levels were lower at all 11 monitoring sites (statistically lower at ten sites, including six impact and four control sites), ranging from 30% (CO-CA-01) to 91% (CO-CA-03) lower at impact sites, and 35% (MW-CA-02) to 94% (CO-WS-08) lower at control sites (Table 3.8; Table 3.9;

Figure 3.9).

Table 3.8: Temporal trends in Pilbara leaf-nosed bat activity during active mining monitoring periods

Site	Mean Number of Calls per Sampling Night ± SE						
	2020	2021	2022	2023	2024 (current survey)	Baseline (2014-2019)	Active Mining (2020-2024)
<b>Impact</b>							
<b>CO-CA-01</b>	3,272 ± 384	2,712 ± 319	2,137 ± 251	2,668 ± 313	1,743 ± 348	3,487 ± 377	2,451 ± 257
<b>CO-CA-03</b>	1,503 ± 180	3,662 ± 430	791 ± 93	1,437 ± 183	182 ± 27	11,062 ± 1,133	1,026 ± 104
<b>CO-CA-05</b>	1,245 ± 454	402 ± 146	92 ± 34	296 ± 115	41 ± 15	696 ± 157	223 ± 41
<b>CO-CA-10</b>	6 ± 2	6 ± 3	12 ± 5	59 ± 23	3 ± 1	41 ± 9	10 ± 2
<b>CO-WS-01</b>	18 ± 6	22 ± 8	12 ± 5	6 ± 2	2 ± 1	43 ± 9	9 ± 2
<b>CO-WS-03</b>	9 ± 3	-	24 ± 9	10 ± 4	3 ± 1	31 ± 7	9 ± 2
<b>Control</b>							
<b>CO-WS-08</b>	3 ± 1	14 ± 5	15 ± 6	2 ± 1	0	44 ± 9	2 ± 1
<b>CO-WS-13</b>	10 ± 4	15 ± 6	5 ± 2	4 ± 2	3 ± 1	79 ± 17	6 ± 1
<b>CO-CA-18</b>	56 ± 20	45 ± 16	71 ± 26	105 ± 38	11 ± 4	126 ± 27	46 ± 8
<b>LR-MI-01</b>	2,050 ± 747	10,011 ± 3,273	1,274 ± 398	925 ± 291	271 ± 69	4,964 ± 991	1,456 ± 235
<b>MW-CA-02</b>	26,866 ± 8,846	56,309 ± 20,434	-	9,152 ± 2,880	-	37,173 ± 7,341	24,013 ± 5,021

Note: Mean estimates were derived from generalized additive model

Note: '-' = no sampling

Table 3.9: Trends in Pilbara leaf-nosed bat activity (mean number of calls) in relation to mining activity

Site	Pre-mining (2014-2019) Mean* Number of Calls ( $\pm$ SE)	Active Mining (2020-2024) Mean Number of Calls	Significant Difference (pre-mining vs active mining)	Mean* Number of Calls (current survey)	Significant Difference (pre-mining vs current survey)
<b>Impact</b>					
CO-CA-01	3,487 $\pm$ 377	2,451 $\pm$ 257	$p < 0.05$ significant	1,743 $\pm$ 348	$p \ll 0.05$ significant
CO-CA-03	11,062 $\pm$ 1,133	1,026 $\pm$ 104	$p \ll 0.05$ significant	182 $\pm$ 27	$p \ll 0.05$ significant
CO-CA-05	696 $\pm$ 157	223 $\pm$ 41	$p \ll 0.05$ significant	41 $\pm$ 15	$p \ll 0.05$ significant
CO-CA-10	41 $\pm$ 9	10 $\pm$ 2	$p < 0.05$ significant	3 $\pm$ 1	$p \ll 0.05$ significant
CO-WS-01	43 $\pm$ 9	9 $\pm$ 2	$p < 0.05$ significant	2 $\pm$ 1	$p \ll 0.05$ significant
CO-WS-03	31 $\pm$ 7	9 $\pm$ 2	$p < 0.05$ significant	3 $\pm$ 1	$p \ll 0.05$ significant
<b>Control</b>					
CO-WS-08	44 $\pm$ 9	2 $\pm$ 1	$p \ll 0.05$ significant	0	$p \ll 0.05$ significant
CO-WS-13	79 $\pm$ 17	6 $\pm$ 1	$p \ll 0.05$ significant	3 $\pm$ 1	$p \ll 0.05$ significant
CO-CA-18	126 $\pm$ 27	46 $\pm$ 8	$p \ll 0.05$ significant	11 $\pm$ 4	$p \ll 0.05$ significant
LR-MI-01	4,964 $\pm$ 991	1,456 $\pm$ 235	$p \ll 0.05$ significant	271 $\pm$ 69	$p \ll 0.05$ significant
MW-CA-02	37,173 $\pm$ 7,341	24,013 $\pm$ 5,021	$p = 0.998$	-	$p < 0.05$ significant

Note ' - ' indicates no sampling

Note: p values greater than 0.05 indicate there is not enough evidence to detect a significant difference

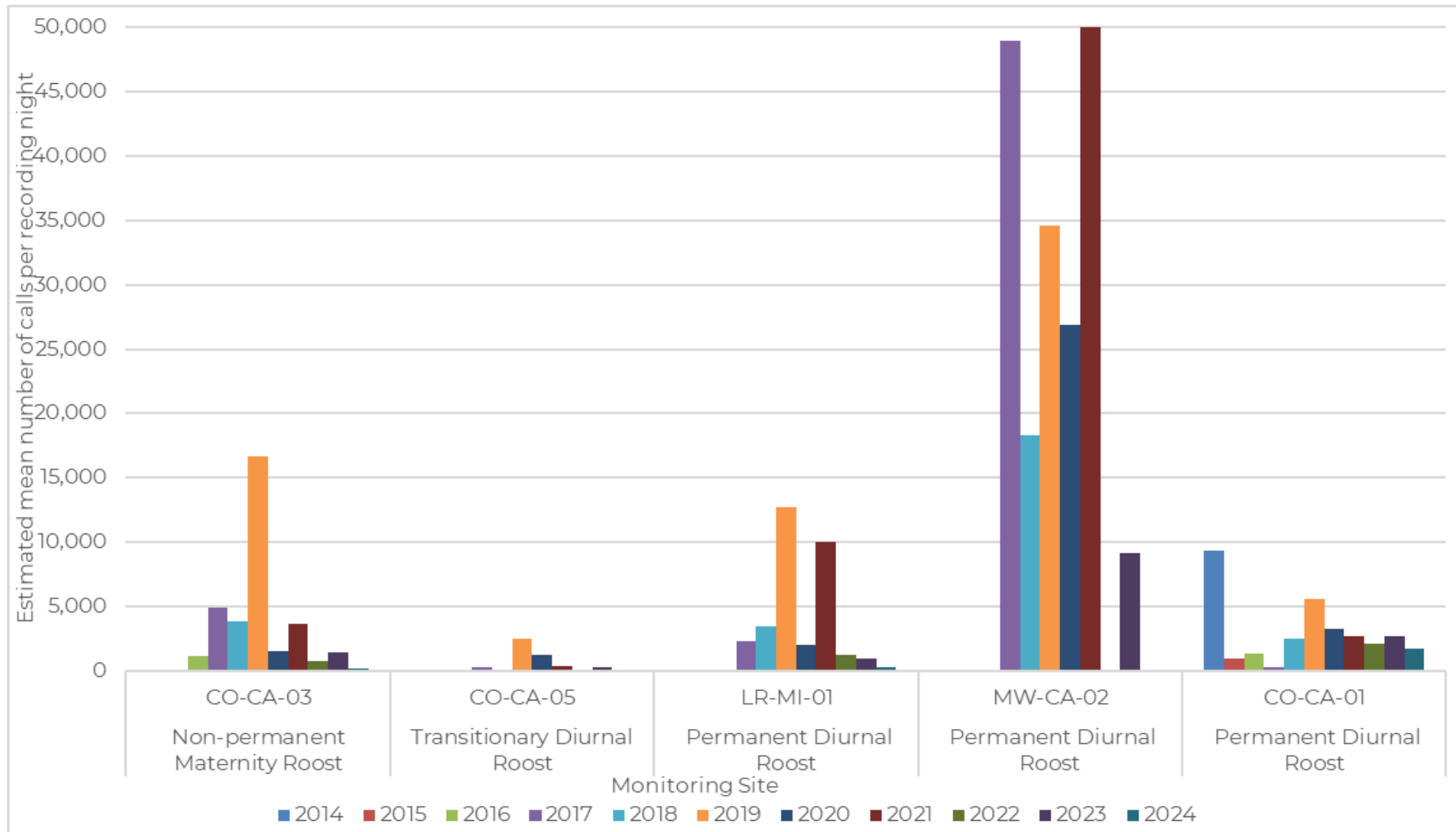


Figure 3.5: Pilbara leaf-nosed bat activity levels at roost monitoring sites over time

Note data was not available for MW-CA-02 in 2022 and 2024.

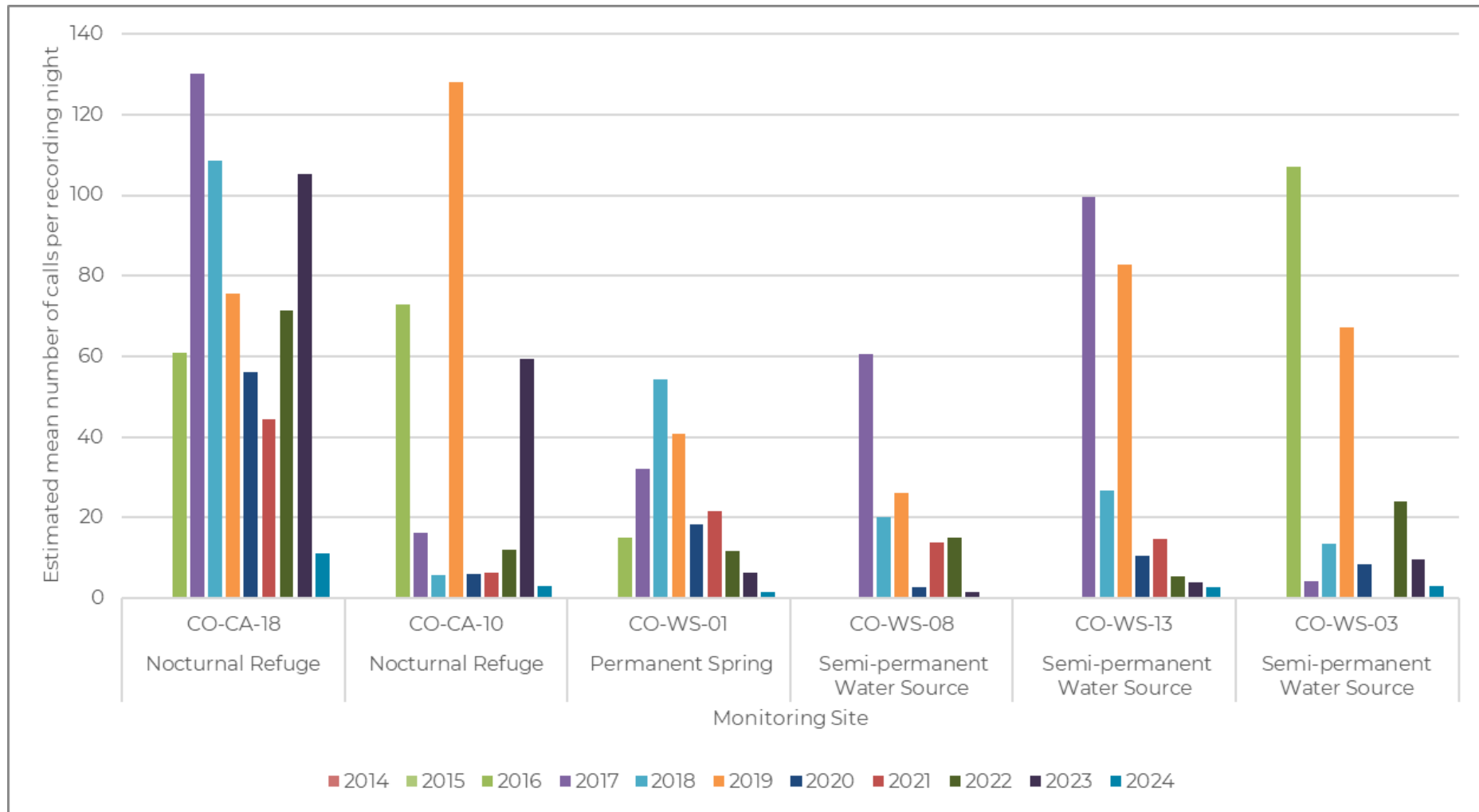


Figure 3.6: Pilbara leaf-nosed bat activity levels at nocturnal refuge and foraging location monitoring sites over time

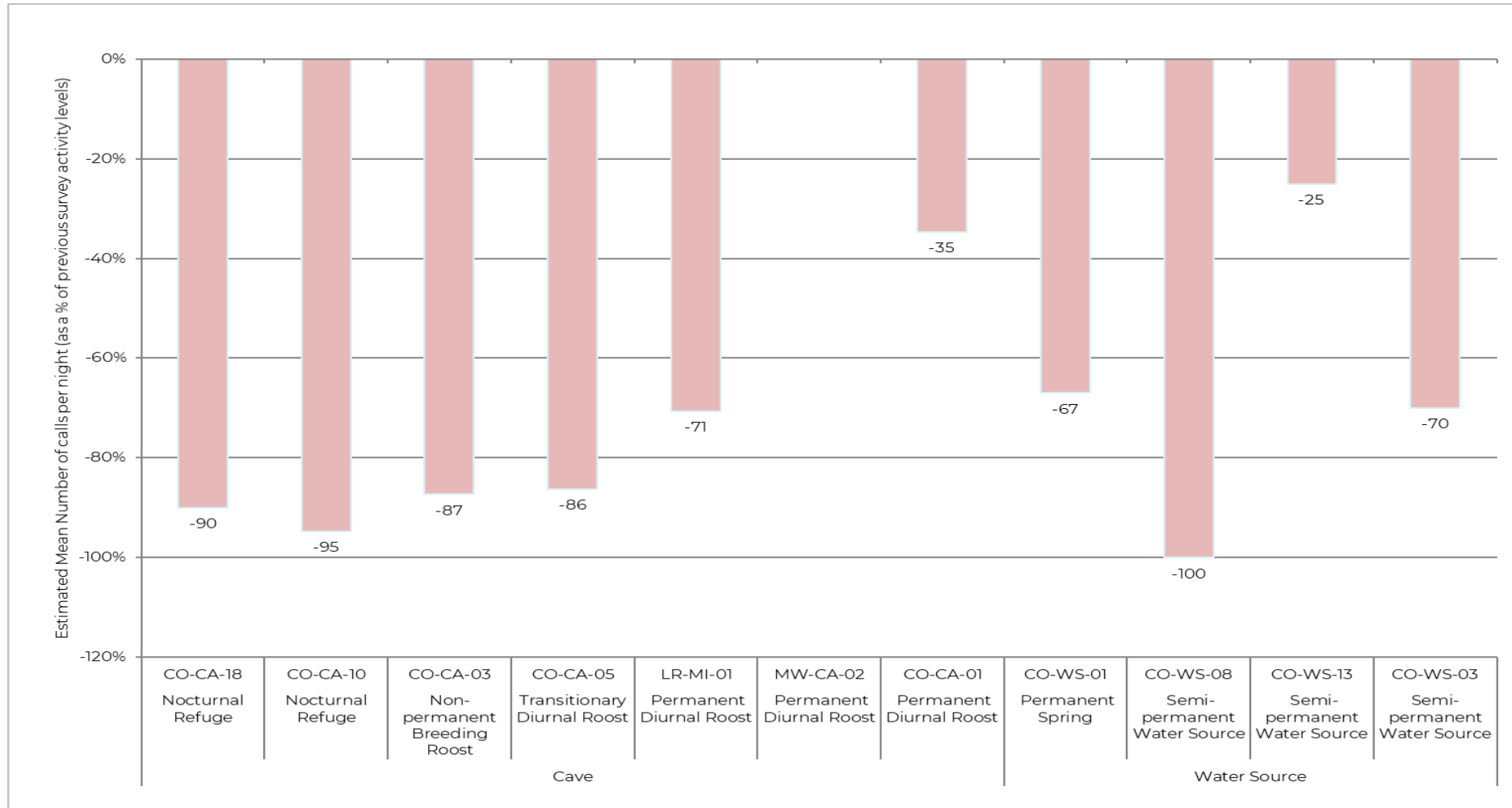


Figure 3.7: Comparison of average Pilbara leaf-nosed bat activity during current monitoring period by site type, as a percentage from the previous monitoring period

Note: Ultrasonic data not available for MW-CA-02 during the current survey.

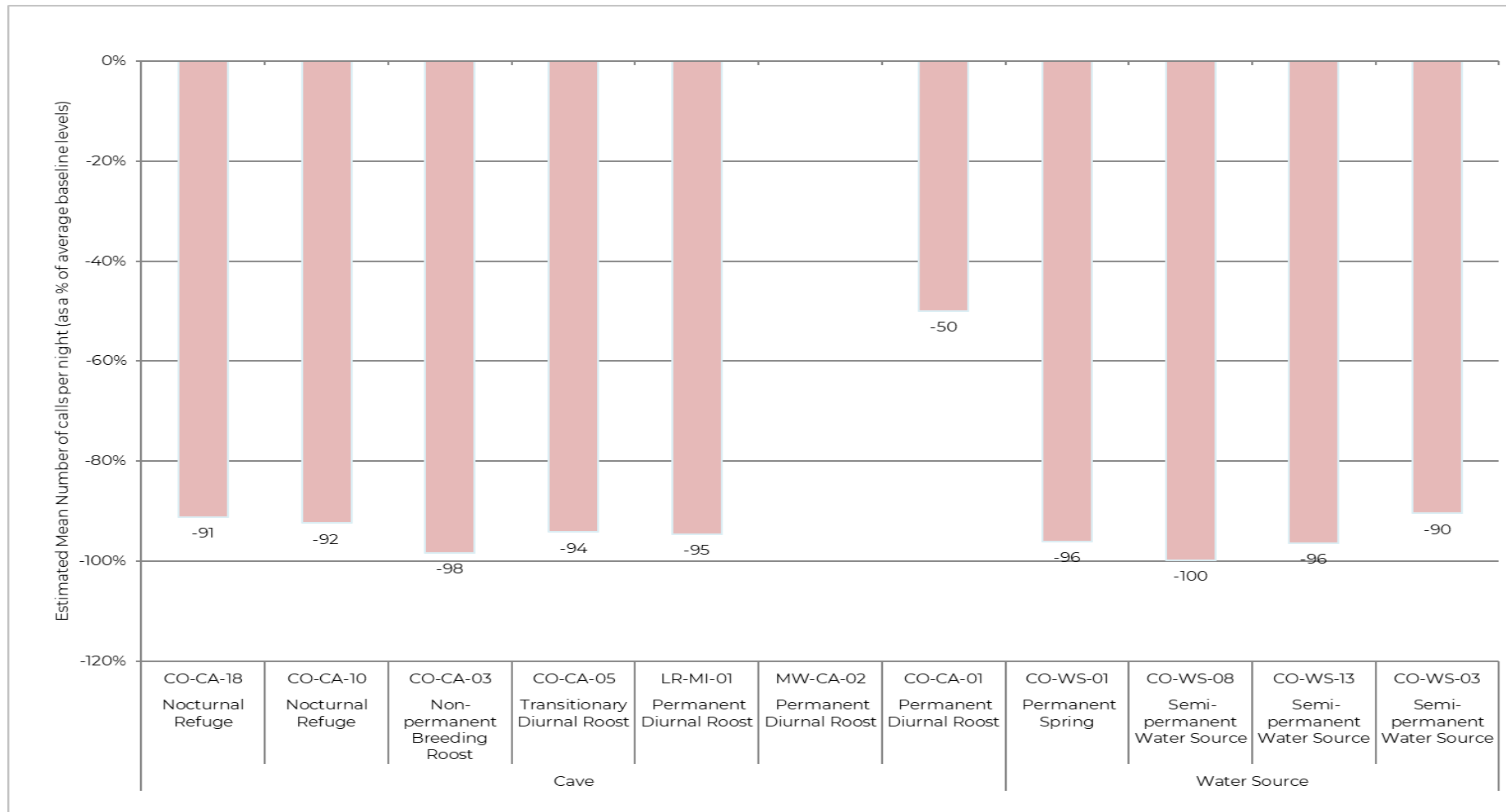


Figure 3.8: Comparison of average Pilbara leaf-nosed bat activity during current monitoring period by site, as a percentage of baseline levels (2014-2019).

Note: Ultrasonic data not available for MW-CA-02 during the current survey.

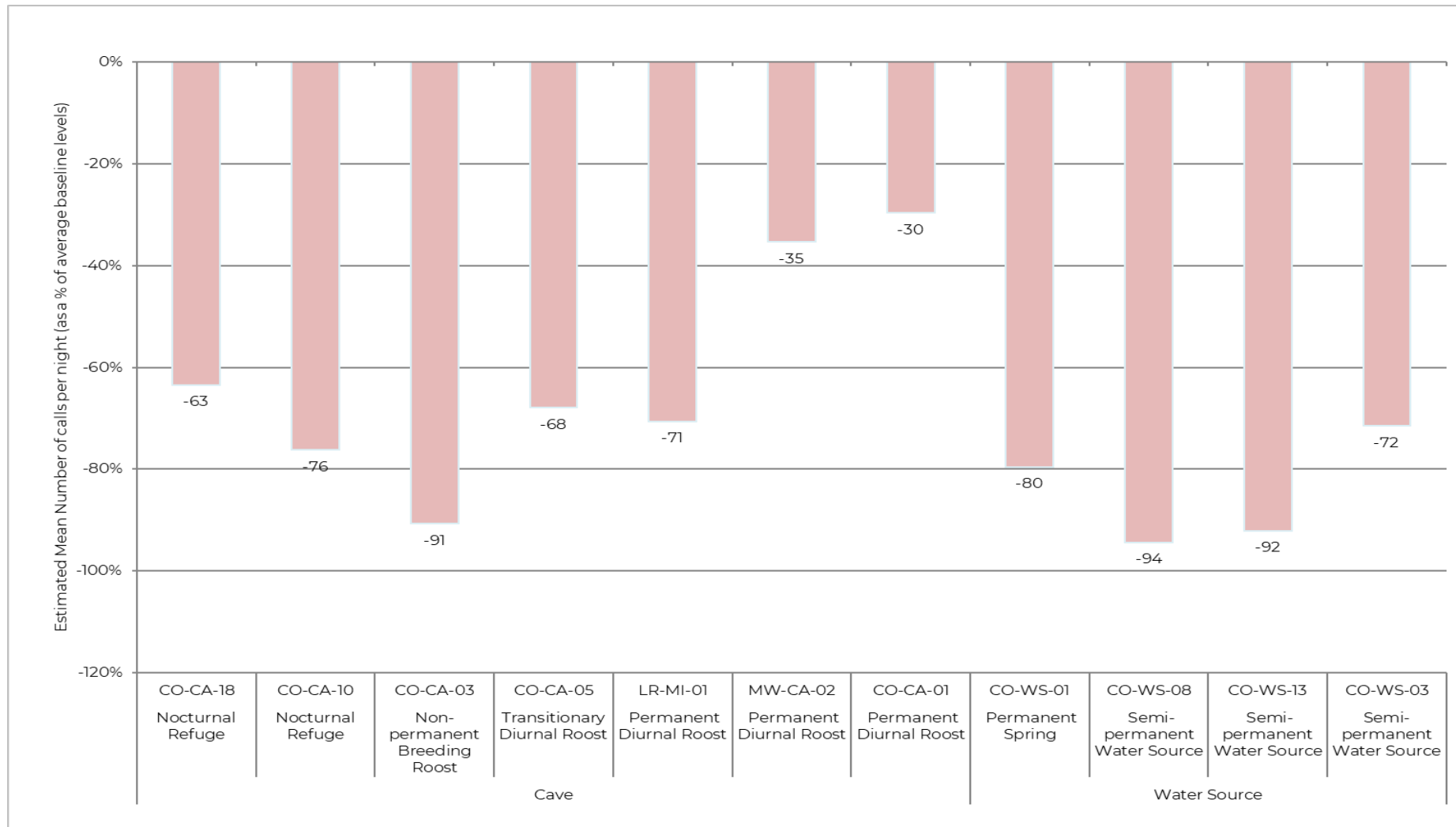


Figure 3.9: Comparison of average Pilbara leaf-nosed bat activity during active mining (2020-2024) by site, as a percentage of baseline levels (2014-2019).

Taking the status of the monitoring caves into account (i.e. control or impact) allows differences in Pilbara leaf-nosed bat activity over time to be investigated relating to mining-related disturbance versus natural fluctuation. As described above, changes have been recorded in current bat activity from previous monitoring periods and more broadly, changes in pre-mining activity compared to active mining activity at both impact and control monitoring sites. It is expected that impact sites will be affected by mining operations, due to their close proximity to activities and ongoing disturbance to surrounding foraging and dispersal habitat.

Mining operations were ongoing during the current monitoring period, with additional mining-related activities commencing in November and December 2023, following the previous annual monitoring period. Mining operations associated with Razorback pit commenced in December 2023 and approached within 145 m of impact site CO-CA-03, approximately 295 m closer than previously reported in 2023, although still further than the closest previous mining-related disturbance (in 2021) at this site (Table 3.1). Construction of a haul road associated with Stage 2 of the project commenced in November 2023 and approached within 560 m west of CO-CA-01, although not closer than previously reported mining-related activity (haul road and ore extraction within 390 and 485 m, respectively) (Table 3.1). It is important to consider the possibility that ongoing disturbance of foraging and dispersal habitat as a result of mining activities is impacting bat activity at the sites, even if proximity to activity hasn't altered significantly between monitoring periods.

CO-CA-01 is the only known permanent diurnal roost and CO-CA-03 the only known non-permanent maternity roost for Pilbara leaf-nosed bats in the Study Area. It is likely that any changes in activity at CO-CA-01 and CO-CA-03 will naturally lead to changes in activity at nearby nocturnal refuge sites (CO-CA-05, CO-CA-10 and CO-CA-18) and water sources (CO-WS-01, CO-WS-03, CO-WS-08 and CO-WS-13). Although lower bat activity at impact sites during the current monitoring period may suggest that mining activity is having an impact, whether mining is having a significant impact on Pilbara leaf-nosed bat activity is unclear as lower activity at control sites has also been observed.

Control sites (located at least 1,500 m [CO-WS-08] to over 10 km [LR-MI-01 and MW-CA-02] from active mining operations) also experienced a decline in bat activity between baseline and active mining monitoring periods, and any influence on bat activity from the close proximity of mining operations will be difficult to distinguish from regional factors. Lalla Rookh (LR-MI-01) and MW-CA-02 are both known permanent diurnal roosts for Pilbara leaf-nosed bat in the broader region, outside of the Study Area. The lower Pilbara leaf-nosed bat activity observed at control sites during the current monitoring period compared to baseline levels suggests that the regional and/or local population of the species' may be experiencing a decline caused by other environmental and/or ecological mechanisms. This is supported

by fluctuations in Pilbara leaf-nosed bat activity observed at monitoring sites during periods where mining activities had yet to commence (i.e. 2014 to 2019) (Figure 3.5).

As annual monitoring surveys for the Pilbara leaf-nosed bats have been undertaken in accordance with the SSMP since 2017, there are no differences in sampling methodology that can explain the variation in bat activity at impact and control monitoring sites between active mining years. Additionally, the surveys have been undertaken at a similar stage of the breeding season (i.e. June-August) and therefore cannot explain changes in bat activity over the monitoring program. The current field survey and monitoring period was undertaken at a slightly later moon phase (half-moon to full moon) than previous surveys, resulting in higher moon light levels (average 85.9% moon illumination during current field survey) than experienced during previous surveys (80.8% in 2023, 41.6% in 2022, 12.2% in 2021 and 23.9% in 2020) (Biologic, 2021a, 2022c, 2023, 2024). Typically, lower light levels associated with a new moon coincide with increased Pilbara leaf-nosed bat activity. It is therefore possible the higher light levels experienced during the current monitoring period have had an impact on Pilbara leaf-nosed bat activity, although the extent of impact on bat activity is unclear and unlikely to explain the levels of decline.

Microclimates recorded at all caves (note that microclimate was not monitored at LR-MI-01 and cave MW-CA-02) during the current monitoring period were generally within the expected range for the cave's roost categorisation (Table 1.2) (Bat Call, 2021). Relative humidity recorded within monitoring caves was generally similar to that recorded during previous monitoring periods. Temperatures within caves were warmer than those recorded during previous active mining monitoring periods. No natural or mining related disturbances to cave/ adit structures that may have affected internal microclimates were observed during the current monitoring period. The warmer conditions recorded at monitoring caves during the current monitoring period is likely a result of an increase in observed ambient minimum and maximum temperatures over the current monitoring period. It is likely the naturally warmer ambient temperatures leading to warmer cave temperatures are partially responsible for the observed changes in Pilbara leaf-nosed bat activity between monitoring periods.

There is no clear pattern between environmental factors that impact the availability and quality of foraging resources in the Study Area and observed Pilbara leaf-nosed bat activity during the current and previous monitoring periods. Wildfire events have previously been discussed as having the potential to disturb or reduce the availability of foraging habitat in a particular area (Biologic, 2023). A wildfire in December 2022 affected large areas of the Sanjiv Ridge project, however, as discussed in Biologic (2023), the impact of the fire on removing or reducing the quality of foraging resources may not have had an adverse impact on Pilbara

leaf-nosed bat activity levels in the Study Area, at least in 2023, where activity levels increased following the wildfire and between the 2022 and 2023 monitoring periods.

High levels of rainfall in the years' immediately preceding the 2023 monitoring period may have promoted an increase in the availability of foraging resources for bats in the Study Area in 2023. The impact of high levels of rainfall on bat activity may only have become apparent in 2023, as foraging resources reached a point where they supported greater levels of bat activity and potentially an increase in the population size of Pilbara leaf-nosed bats in the Study Area. Lower levels of rainfall preceding the current monitoring period may then provide a likely explanation for the lower bat activity levels, as foraging resources and availability may be affected by the drier conditions. However, when compared to previous monitoring periods where rainfall levels were similar or lower than the current monitoring period (e.g. 2020 and 2021 recorded 183.6 mm and 216.8 mm, respectively), bat activity levels were much lower in 2024, suggesting other factors may contributing to the decrease.

### 3.4.2 Continuous Monitoring

The (observed mean) number of calls per recording night at CO-CA-01 were substantially lower than those recorded during previous continuous monitoring periods (Table 3.10). Additionally, the minimum and maximum number of calls recorded during the current monitoring period were also considerably lower than those recorded in previous years (Table 3.10).

**Table 3.10: Temporal comparison of ultrasonic data recorded at CO-CA-01 during current continuous monitoring period**

	17 April 2019 to 24 April 2020 (Biologic, 2020b)	April 2020 to Dec 2021 ((Biologic, 2022b))	Jan to Dec 2022 (Biologic, 2022a)	Jan to Dec 2023) (Biologic, 2024)	Jan to Dec 2024 (Current survey)
Average calls per recording night	4,726	3,007	1,567	1,704	746
Lowest number of calls on a given night	470	215	215	297	163
Greatest number of calls on a given night	30,452	28,325	9,795	9,897	4,304
Total recording nights	281	635	349	357	274

Despite the average number of calls at CO-CA-01 being higher in 2023 compared to 2022, the general trend has been a decline in bat activity since active mining commenced in 2020 (Table 3.10). Since mining operations and associated activities commenced, the distances of related disturbance to habitat surrounding CO-CA-01 decreased up to and including 2022. These activities included construction of a haul road and ore extraction (commenced in 2021), within 390 and 485 m, respectively, of CO-CA-01. Disturbances to habitat surrounding these monitoring sites between 2020 and 2022 resulted in the clearing of vegetation (and therefore

removal and disturbance of foraging resources and dispersal habitat), which may have disrupted normal feeding and breeding behaviour, placing pressure on individuals and the population as a whole (TSSC, 2016). Mining operations were ongoing in 2023, with construction of a haul road associated with Stage 2 of the project approaching within 560 m west of CO-CA-01, in November 2023 and continued throughout the current continuous monitoring period (Table 3.1).

There were no natural or environmental disturbances resulting in changes to the internal structure of CO-CA-01 during the current continuous monitoring period. The microclimate at CO-CA-01 were generally warmer compared to previous monitoring periods, with relative humidity similar across monitoring years. Temperatures at CO-CA-01 fell within the preferred range for Pilbara leaf-nosed bats approximately 54% of sampling nights, compared to 99-100% of sampling nights in previous years since mining commenced.

Despite temperatures at CO-CA-01 being within the preferred range for Pilbara leaf-nosed bat roosting for approximately 54% of sampling nights, roosting continued throughout the current monitoring period, as for previous monitoring periods, in keeping with its categorisation as a permanent diurnal roost. However, it is likely that variations in the levels of Pilbara leaf-nosed bat activity between the current and previous monitoring periods may be partially due to the warmer internal microclimate of these caves. These warmer conditions are likely a result of warmer ambient weather conditions recorded in the region during the current monitoring period.

Overall, weather conditions between January and December 2024 were generally warmer and wetter than long-term averages for January to December, and the previous 2023 monitoring period (refer to Section 2.2). The 457.0 mm of rainfall recorded during 2024 was lower than the 553.8 mm recorded during the 2022 continuous monitoring period. Greater levels of rainfall prior to the 2023 monitoring period may have resulted in an increase in the availability of foraging resources for Pilbara leaf-nosed bat in the Study Area in 2023. This potential increase in foraging resources available to the species potentially then resulted in higher bat activity during 2023 at CO-CA-01, despite the lower rainfall for that year. The effects of rainfall may take some time to have an impact on the availability of foraging resources, and consequently Pilbara leaf-nosed bat activity within the Study Area. A reduction in rainfall in 2023 may then have impacted the availability of resources and therefore bat activity during the current monitoring period.

### 3.5 Predator Records

Ghost bats (*Macroderma gigas*), known predators of Pilbara leaf-nosed bats (Bat Call, 2021), were recorded at CO-CA-05, CO-CA-18 and LR-MI-01 during the current annual monitoring period. By comparison, ghost bats were recorded at CO-CA-01, CO-CA-03, CO-CA-05 and CO-

CA-18 during the previous annual monitoring period. Ghost bats were recorded at CO-CA-01 regularly throughout the continuous monitoring period (nine out of the 12 months), with greatest ghost bat activity recorded in January and May 2024. Introduced predators are also active in the Study Area (e.g. feral cat *Felis catus*); however, no predation of Pilbara leaf-nosed bats has been observed, and it is unknown whether the distribution, abundance or activity of introduced predators have changed during the monitoring program.

### 3.6 Limitations and Constraints

The EPA outlines a number of factors that can affect the adequacy of fauna surveys (EPA, 2020). These were assessed in relation to the significant species annual monitoring surveys and no significant limitations were identified (Table 3.11).

Table 3.11: Survey limitations

Potential limitation or constraint	Applicability to the current monitoring period	Limitation
Availability of data and information	All contextual resources required to complete the survey were available (previous surveys, database searches, environmental information, climate data etc.). Contextual information on the habitats and landforms present within the Study Area, as well as previous records of Pilbara leaf-nosed bat is also well documented (MWH, 2018b).	No
Competency and experience of the survey team	The Biologic field personnel involved in the survey have a combined total of 30 years' experience undertaking fauna surveys in the Pilbara. Atlas or Biologic personnel collected microclimate and SongMeter data approximately every three months. Biologic have conducted surveys at Sanjiv Ridge for seven years and have experience with similar scopes throughout the Pilbara.	No
Scope of the survey	The scope was a monitoring survey and was conducted within that framework. All chosen methods were able to be executed as expected.	No
Timing, weather and season	Weather conditions were appropriate for detecting Pilbara leaf-nosed bat activity. The annual monitoring survey was undertaken immediately preceding and during a full moon (21 July 2024).	No
Disturbance that may have affected results	The monitoring program is designed to track the occurrence of disturbances within the Study Area. Signs of historical and recent disturbances observed in the Study Area were described.	No
Adequacy of the survey intensity	Monitoring was undertaken in accordance with the SSMP, using standardised and established techniques which are considered suitable for an ongoing monitoring program targeting significant species. The survey employed the same methods as were applied in previous years.	No
Proportion of survey achieved / access problems	All monitoring sites were accessible during the survey. Assessments were consistent across sites and comparable to previous surveys.	No

Potential limitation or constraint	Applicability to the current monitoring period	Limitation
Problems with data and analysis	<p>Due to access constraints, microclimate data was not available at MW-CA-02 (and ultrasonic data) and LR-MI-01 during the current monitoring period (refer to Section 2.5.2 and Section 2.5.3).</p> <p>The nature of using GAM to determine changes in bat activity results in the re-estimation of estimated mean number of calls per recording night from those previously reported (including percentage differences). Also, using a model that adjusts for seasonality each year may confound other potential impacts on bat activity not related to mining operations, as further monitoring data becomes available.</p>	Partial

## 4 Conclusion

### 4.1 Summary

The current survey was successful in collecting data to assess patterns of Pilbara leaf-nosed bat activity at the 11 monitoring sites within the Study Area identified by the SSMP. Replicable sampling methods were successfully applied to obtain data about the way these sites are being used by the species during the current monitoring period. Together with the results of previous and subsequent monitoring surveys, these data will assist Atlas to identify whether mining activities associated with the Project are having a significant impact on the suitability of the sites for use by Pilbara leaf-nosed and/or the way the sites (and more generally the Study Area) are used by Pilbara leaf-nosed bat.

Pilbara leaf-nosed bat calls were recorded at all six impact monitoring sites during the current monitoring period, with activity levels lower than overall baseline levels at all six impact sites. While this could indicate a response to mining activity, the level of activity recorded at all control sites during the current monitoring period were also substantially lower than the baseline period. Similarly, activity levels at all monitoring sites except one during the current monitoring period were lower than previously recorded during the 2023 monitoring period. The level of reduction in activity levels from those recorded in 2023 at impact sites ranged from -35% (CO-CA-01) to -95% (CO-CA-10) and control sites ranged from -25% (CO-WS-13) to -100% (CO-WS-08).

The decrease in activity at foraging locations is likely associated with the decrease in activity at the roosts (i.e. foraging activity will decrease if less bats are actively roosting in the area). The observed decline in Pilbara leaf-nosed bat activity at both impact and control sites could represent a decrease in the size of the population which uses the Sanjiv Ridge Study Area and surrounding roosts. Consequently, the results of the current monitoring period suggest the changes in Pilbara leaf-nosed bat activity are not localised and occur at a broader, regional level.

A comparison of all data between the baseline and during active mining periods reveals that activity levels recorded during the grouped active mining years are statistically lower than those recorded during the baseline period for all six impact monitoring sites. While this may indicate a mining-related effect, it should be noted that the levels of activity recorded at all control sites (statistically lower at four of the five control sites), during grouped active mining years (noting that no data were available at MW-CA-02 during the current monitoring period or 2022) were also lower than those recorded during the baseline period. These results suggest that changes in activity levels within the Sanjiv Ridge Study Area are reflective of changes across the broader the region. No clear pattern has been observed between bat activity levels each monitoring year and environmental factors such as rainfall and wildfire

that affect availability and quality of foraging resources. Increased moon light levels during the current monitoring period may have affected bat activity, however, similar to other environmental factors, the extent and scale of impact is unclear, but is unlikely to have had a significant impact on bat activity.

It remains possible that mining activity is influencing activity levels in the Sanjiv Ridge Study Area to some extent. As there is no evidence that mining disturbance is affecting the microclimate of the roosts, the most likely mechanism by which mining activity may be affecting activity levels in the Sanjiv Ridge Study Area is ongoing disturbance to foraging and dispersal habitat around the roosts. Importantly, there is no evidence that the suitability of the majority of roosts (with the exception of CO-CA-01) themselves have changed. More specifically, there is no evidence of damage to the structure of any of the roosts, and the microclimates of most caves (except CO-CA-01). At CO-CA-01, the microclimate was generally warmer and less humid than conditions recorded in previous monitoring years. Temperatures were 1.21°C to 1.96°C warmer than previous years, and relative humidity fluctuated by 40.55%, compared to minor fluctuations (10.91-15.59%) recorded in previous years. The only exception was in 2020, when a similar fluctuation (up to 48.66% between maximum and minimum) in relative humidity was recorded. CO-CA-01 (despite the warmer and drier conditions), CO-CA-03 and CO-CA-05 are continuing to be used as diurnal roosts. Additionally, CO-WS-01 and CO-WS-03 are continuing to be visited during foraging.

## 4.2 Relevance of Findings to Management Commitments

In accordance with the SSMP (Atlas Iron, 2017), Atlas are committed to employing specific management actions when the following three key performance indicators are not met:

*Key Performance Indicator 1: No significant damage to cave CO-CA-01 and cave CO-CA-03.*

The closest ground disturbances to CO-CA-01 is a haul road located 390 m to the east (constructed in 2021), followed by ongoing (constructed in 2021) ore extraction activities 485 m east at Runway Pit North. More recently, construction of a haul road commenced in November 2023, approximately 560 m to the west. Clearing associated with previous exploration activity in 2021 approaches within 121 m to the west of CO-CA-03, with more recent clearing undertaken in December 2023 approximately 145 m to the south-west. While ongoing throughout the current monitoring period, mining-related activities did not approach closer to CO-CA-01, or with greater intensity, than that recorded during the previous monitoring year. Site assessment and analysis of photo monitoring points revealed no damage to the structural integrity of CO-CA-01 as a result of mining operations during the

current monitoring period. Therefore, this KPI has been met. Information relating to CO-CA-03 will be discussed in a separate report (Biologic, in prep.).

*Key Performance Indicator 2: Ongoing use of cave CO-CA-01 by Pilbara leaf-nosed bats during operation.*

Continuous monitoring of ultrasonic calls between January and December 2024 at CO-CA-01 indicate the roost continues to be used as a diurnal roost by Pilbara leaf-nosed bat, and therefore the KPI has been met for the current monitoring period.

*Key Performance Indicator 3: 'No greater than 50% decline of Pilbara leaf-nosed bat activity levels in CO-CA-01, over two consecutive monitoring periods compared to the average baseline level (2014 to 2019).'*

The current monitoring period recorded a statistically significant ( $p \leq 0.05$ ) 50% decline in bat activity (estimated mean number of calls) at CO-CA-01, when compared to average baseline activity levels. The previous 2023 monitoring period recorded a 23% decline (no evidence this difference was statistically significant) in bat activity from average baseline levels at CO-CA-01. As the decline has not been 50% or greater at CO-CA-01 over two consecutive monitoring periods, the KPI has been met. As control sites also recorded significantly lower activity levels recently compared with baseline levels, it is likely regional, environmental factors such as higher ambient and cave temperatures, rainfall and wildfire events, as well as potentially mining-related activities (at impact sites only), is influencing Pilbara leaf-nosed activity within the Study Area. The effects of regional and localised factors on bat activity within the Study Area, and specifically CO-CA-01 as it relates to KPIs outlined in the SSMP, will continue to be investigated through the course of the monitoring program.

### 4.3 Recommendations

As the monitoring program for Pilbara leaf-nosed bats at Sanjiv Ridge Project continues over time, and as more data is added each year, the current GAM will continue to re-estimate seasonal patterns within the data. This will result in different estimated mean number of calls per recording night being calculated each year, thereby changing historical reported percentage differences in bat activity between baseline and active mining monitoring years. Additionally, using GAM for future monitoring under the SSMP may result in the seasonal effect being confounded with other changes that may occur as a result of mining-related activities, particularly where impact sites have been sampled for more days than control sites. As mining operations at Sanjiv Ridge Project progress, this is likely to become an increasing concern when it comes to interpreting the potential effects of mining-related activities on Pilbara leaf-nosed bats at monitoring sites.




A second approach, using a generalised linear mixed model (GLMM), will provide unbiased (not adjusted for seasonality) estimated mean number of calls per recording night, for the purpose of assessing changes in Pilbara leaf-nosed bat activity against KPIs in consecutive years. The likely causes for observed changes in bat activity across monitoring years would then be investigated, separate to the model. It is therefore recommended a GLMM be applied to ultrasonic data collected for future monitoring at Sanjiv Ridge Project. The data that enters the model should represent the same sampling period as much as possible. Additionally, the percentage differences could be bootstrapped to give an estimate of their uncertainty. Note that with the use of a GLMM, historically reported bat activity levels and subsequent KPI outcomes may change.

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## Appendix A: Significant species annual monitoring cave photo records

CO-CA-01					
Photo point ID	Location		Photo point ID	Location	
	Latitude	Longitude		Latitude	Longitude
<b>PPA</b>	<b>-21.41990</b>	<b>119.6738°</b>	<b>PPB</b>	<b>-21.4195°</b>	<b>119.6747°</b>
2017			2017	No photo available	
2018			2018		

CO-CA-01

2019



2019



2020



2020



CO-CA-01

2021



2021



2022



2022

No photo available

CO-CA-01

2023



2023



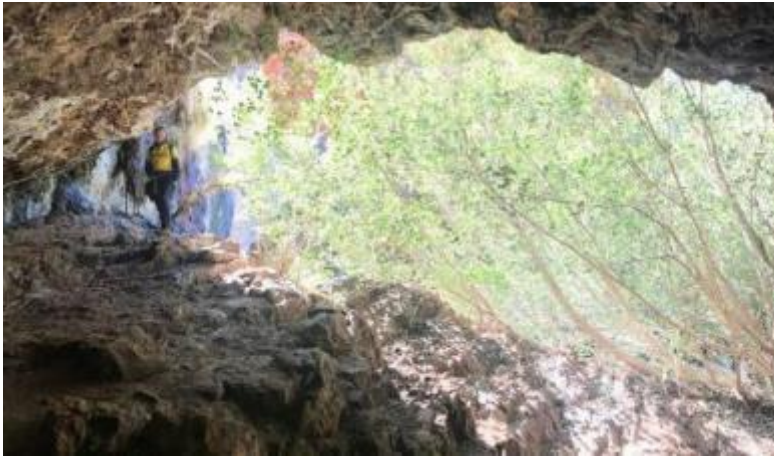


2024



2024



CO-CA-03					
Photo point ID	Location		Photo point ID	Location	
	Latitude	Longitude		Latitude	Longitude
<b>PPA</b>	<b>-21.4678°</b>	<b>119.6711°</b>	<b>PPB</b>	<b>-21.4681°</b>	<b>119.6717°</b>
2017			2017	No photo available	
2018			2018		

CO-CA-03

2019



2019

No photo available

2020



2020



CO-CA-03

2021



2021



2022



2022



CO-CA-03

2023



2023






2024

No photo available

2024

No photo available

CO-CA-05					
Photo point ID	Location		Photo point ID	Location	
	Latitude	Longitude		Latitude	Longitude
<b>PPA</b>	<b>-21.4248</b>	<b>119.6742</b>	<b>PPB</b>	<b>-21.4243</b>	<b>119.6737</b>
2017			2017	No photo available	
2018			2018		

CO-CA-05

2019



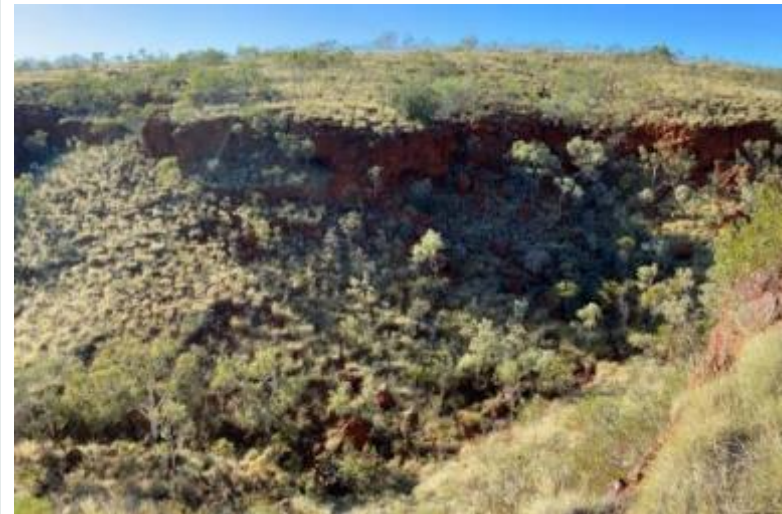
2019



2020



2020



CO-CA-05

2021



2021



2022



2022



CO-CA-05

2023



2023






2024



2024



CO-CA-10					
Photo point ID	Location		Photo point ID	Location	
	Latitude	Longitude		Latitude	Longitude
<b>PPA</b>	<b>-21.4187°</b>	<b>119.6754°</b>	<b>PPB</b>	<b>-21.4188</b>	<b>119.6755</b>
2017			2017	No photo available	
2018			2018		

CO-CA-10

2019



2019



2020



2020



CO-CA-10

2021



2021



2022



2022



CO-CA-10

2023



2023






2024



2024



CO-CA-18					
Photo point ID	Location		Photo point ID	Location	
	Latitude	Longitude		Latitude	Longitude
<b>PPA</b>	<b>-21.3503</b>	<b>119.6162</b>	<b>PPB</b>	<b>-21.3503</b>	<b>119.6162</b>
2017	No photo available		2017		
2018			2018		

CO-CA-18

2019



2019



2020



2020



CO-CA-18

2021



2021



2022



2022



CO-CA-18

2023



2023







2024



2024



CO-WS-01					
Photo point ID	Location		Photo point ID	Location	
	Latitude	Longitude		Latitude	Longitude
<b>PPA</b>	<b>-21.410206°</b>	<b>119.687559°</b>	<b>PPB</b>	<b>-21.410288°</b>	<b>119.687522°</b>
2017			2017		
2018			2018		

CO-WS-01

2019



2019



2020



2020



CO-WS-01

2021



2021









2022



2022



CO-WS-01	
2023	
2023	No photo available
2024	No photo available
2024	

CO-WS-03					
Photo point ID	Location		Photo point ID	Location	
	Latitude	Longitude		Latitude	Longitude
<b>PPA</b>	<b>-21.375197°</b>	<b>119.68582°</b>	<b>PPB</b>	<b>-21.375197°</b>	<b>119.68582°</b>
2017			2017		
2018			2018		

CO-WS-03

2019



2019



2020



2020



CO-WS-03

2021



2021



2022



2022



CO-WS-03

2023



2023







2024



2024



CO-WS-08					
Photo point ID	Location		Photo point ID	Location	
	Latitude	Longitude		Latitude	Longitude
<b>PPA</b>	<b>-21.451822°</b>	<b>119.650943°</b>	<b>PPB</b>	<b>-21.451749°</b>	<b>119.65099°</b>
2017			2017		
2018			2018		

CO-WS-08

2019



2019



2020



2020



CO-WS-08

2021



2021



2022



2022



CO-WS-08

2023



2023







2024



2024



CO-WS-13					
Photo point ID	Location		Photo point ID	Location	
	Latitude	Longitude		Latitude	Longitude
<b>PPA</b>	<b>-21.466594°</b>	<b>119.648519°</b>	<b>PPB</b>	<b>-21.466617°</b>	<b>119.648269°</b>
2017			2017		
2018			2018		

CO-WS-13

2019



2019



2020



2020



CO-WS-13

2021



2021



2022



2022



CO-WS-13

2023



2023







2024



2024



LR-MI-01					
Photo point ID	Location		Photo point ID	Location	
	Latitude	Longitude		Latitude	Longitude
<b>PPA</b>	<b>-21.0509</b>	<b>119.2766</b>	<b>PPB</b>	<b>-21.0507</b>	<b>119.2765</b>
2017			2017		
2018			2018		

LR-MI-01

2019



2019



2020



2020



LR-MI-01

2021



2021







2022



2022

No photo available

LR-MI-01			
2023		2023	
2024	No photo available	2024	No photo available

MW-CA-02					
Photo point ID	Location		Photo point ID	Location	
	Latitude	Longitude		Latitude	Longitude
<b>PPA</b>	<b>-21.4631</b>	<b>119.2303</b>	<b>PPB</b>	<b>-21.4631</b>	<b>119.2303</b>
2017			2017		
2018			2018		

MW-CA-02

2019



2019

No photo available

2020



2020



MW-CA-02

2021



2021



2022



2022

No photo available

MW-CA-02

2023



2023

No photo available

MW-CA-02

2024



2024



## Appendix B: Pilbara leaf-nosed bat calls - annual monitoring

Site	Date	Time of first call	Time of last call	Number of calls	Diurnal roosting indicated <sup>1</sup>
<b>CO-CA-01</b>	16/07/2024	N/A	N/A	N/A	N/A
	17/07/2024	N/A	N/A	N/A	N/A
	18/07/2024	N/A	N/A	N/A	N/A
	19/07/2024	N/A	N/A	N/A	N/A
	20/07/2024	N/A	N/A	N/A	N/A
	21/07/2024	N/A	N/A	N/A	N/A
	22/07/2024	N/A	N/A	N/A	N/A
<b>CO-CA-03</b>	16/07/2024	18:07	6:11	97	Yes
	17/07/2024	-	-	100	Yes
	18/07/2024	18:17	6:01	161	Yes
	19/07/2024	-	-	147	Yes
	20/07/2024	17:53	5:29	206	Yes
	21/07/2024	-	-	220	Yes
	22/07/2024	17:54	5:32	389	Yes
<b>CO-CA-05</b>	16/07/2024	23:42	5:37	49	Yes
	17/07/2024	18:38	6:07	131	Yes
	18/07/2024	18:08	5:51	40	Yes
	19/07/2024	18:19	5:43	26	Yes
	20/07/2024	18:34	5:10	28	Yes
	21/07/2024	18:13	4:50	30	Yes
	22/07/2024	19:06	4:49	88	Yes
<b>CO-CA-10</b>	16/07/2024	23:25	4:54	2	No
	17/07/2024	18:25	-	6	No
	18/07/2024	19:38	5:31	5	No
	19/07/2024	-	5:36	14	No
	20/07/2024	-	4:27	2	No
	21/07/2024	-	-	0	No
	22/07/2024	-	2:22	1	No
<b>CO-CA-18</b>	16/07/2024	22:20	-	2	No
	17/07/2024	20:29	0:49	56	No
	18/07/2024	20:44	2:06	5	No
	19/07/2024	-	-	0	No
	20/07/2024	22:08	-	4	No
	21/07/2024	20:25	-	10	No
	22/07/2024	21:13	0:17	31	No

Site	Date	Time of first call	Time of last call	Number of calls	Diurnal roosting indicated <sup>1</sup>
<b>CO-WS-01</b>	16/07/2024	-	-	0	
	17/07/2024	19:58	-	3	
	18/07/2024	18:25	0:06	4	
	19/07/2024	-	4:30	4	
	20/07/2024	-	-	0	
	21/07/2024	-	1:51	4	
	22/07/2024	19:17	-	1	
<b>CO-WS-03</b>	16/07/2024	19:46	-	4	
	17/07/2024	19:33	-	1	
	18/07/2024	19:06	2:43	5	
	19/07/2024	-	3:26	5	
	20/07/2024	18:32	-	8	
	21/07/2024	18:40	-	2	
	22/07/2024	-	0:27	3	
<b>CO-WS-08</b>	16/07/2024	-	-	0	
	17/07/2024	-	-	0	
	18/07/2024	-	-	0	
	19/07/2024	-	-	0	
	20/07/2024	-	-	0	
	21/07/2024	-	-	0	
	22/07/2024	-	-	0	
<b>CO-WS-13</b>	16/07/2024	-	-	0	
	17/07/2024	18:31	4:08	7	
	18/07/2024	18:45	1:34	6	
	19/07/2024	21:42	4:31	4	
	20/07/2024	19:48	3:52	2	
	21/07/2024	18:35	-	2	
	22/07/2024	19:01	3:32	6	
<b>LR-MI-01</b>	16/07/2024	18:41	5:43	318	Yes
	17/07/2024	18:26	5:46	529	Yes
	18/07/2024	18:33	5:51	413	Yes
	19/07/2024	18:34	4:43	101	Yes
	20/07/2024	18:44	5:23	120	Yes
	21/07/2024	18:46	4:36	112	Yes
	22/07/2024	18:22	6:09	277	Yes
<b>MW-CA-02</b>	16/07/2024	-	-	-	-
	17/07/2024	-	-	-	-

Site	Date	Time of first call	Time of last call	Number of calls	Diurnal roosting indicated <sup>1</sup>
	18/07/2024	-	-	-	-
	19/07/2024	-	-	-	-
	20/07/2024	-	-	-	-
	21/07/2024	-	-	-	-
	22/07/2024	-	-	-	-

<sup>1</sup> Based on interpretation of timing of calls by Bat Call (Bob Bullen pers. comms, 2024).

Note: '-' = no sampling

N/A – data not suitable for analysis

## Appendix C: Pilbara leaf-nosed bat calls – CO-CA-01 continuous monitoring

Date	Number of calls	Roosting indicated
1/01/2024	513	Yes
2/01/2024	671	Yes
3/01/2024	592	Yes
4/01/2024	504	Yes
5/01/2024	456	Yes
6/01/2024	501	Yes
7/01/2024	505	Yes
8/01/2024	814	Yes
9/01/2024	586	Yes
10/01/2024	947	Yes
11/01/2024	1,016	Yes
12/01/2024	715	Yes
13/01/2024	950	Yes
14/01/2024	1,229	Yes
15/01/2024	1,316	Yes
16/01/2024	506	Yes
17/01/2024	552	Yes
18/01/2024	500	Yes
19/01/2024	641	Yes
20/01/2024	390	Yes

Date	Number of calls	Roosting indicated
21/01/2024	409	Yes
22/01/2024	472	Yes
23/01/2024	774	Yes
24/01/2024	675	Yes
25/01/2024	590	Yes
26/01/2024	3,129	Yes
27/01/2024	571	Yes
28/01/2024	494	Yes
29/01/2024	504	Yes
30/01/2024	573	Yes
31/01/2024	4,304	Yes
1/02/2024	519	Yes
2/02/2024	484	Yes
3/02/2024	452	Yes
4/02/2024	389	Yes
5/02/2024	690	Yes
6/02/2024	447	Yes
7/02/2024	265	Yes
8/02/2024	410	Yes
9/02/2024	333	Yes
10/02/2024	354	Yes

Date	Number of calls	Roosting indicated
11/02/2024	306	Yes
12/02/2024	470	Yes
13/02/2024	680	Yes
14/02/2024	382	Yes
15/02/2024	650	Yes
16/02/2024	252	Yes
17/02/2024	432	Yes
18/02/2024	365	Yes
19/02/2024	598	Yes
20/02/2024	364	Yes
21/02/2024	509	Yes
22/02/2024	571	Yes
23/02/2024	342	Yes
24/02/2024	461	Yes
25/02/2024	379	Yes
26/02/2024	320	Yes
27/02/2024	515	Yes
28/02/2024	419	Yes
29/02/2024	539	Yes
1/03/2024	359	Yes
2/03/2024	348	Yes

Date	Number of calls	Roosting indicated
3/03/2024	329	Yes
4/03/2024	588	Yes
5/03/2024	573	Yes
6/03/2024	612	Yes
7/03/2024	420	Yes
8/03/2024	445	Yes
9/03/2024	505	Yes
10/03/2024	441	Yes
11/03/2024	373	Yes
12/03/2024	399	Yes
13/03/2024	436	Yes
14/03/2024	508	Yes
15/03/2024	423	Yes
16/03/2024	288	Yes
17/03/2024	1,538	Yes
18/03/2024	521	Yes
19/03/2024	292	Yes
20/03/2024	271	Yes
21/03/2024	239	Yes
22/03/2024	584	Yes
23/03/2024	579	Yes

Date	Number of calls	Roosting indicated
24/03/2024	482	Yes
25/03/2024	575	Yes
26/03/2024	390	Yes
27/03/2024	393	Yes
28/03/2024	612	Yes
29/03/2024	417	Yes
30/03/2024	433	Yes
31/03/2024	381	Yes
1/04/2024	437	Yes
2/04/2024	394	Yes
3/04/2024	371	Yes
4/04/2024	616	Yes
5/04/2024	563	Yes
6/04/2024	381	Yes
7/04/2024	222	Yes
8/04/2024	259	Yes
9/04/2024	222	Yes
10/04/2024	255	Yes
11/04/2024	847	Yes
12/04/2024	724	Yes
13/04/2024	426	Yes

Date	Number of calls	Roosting indicated
14/04/2024	487	Yes
15/04/2024	562	Yes
16/04/2024	618	Yes
17/04/2024	435	Yes
18/04/2024	570	Yes
19/04/2024	432	Yes
20/04/2024	431	Yes
21/04/2024	496	Yes
22/04/2024	587	Yes
23/04/2024	476	Yes
24/04/2024	259	Yes
25/04/2024	282	Yes
26/04/2024	855	Yes
27/04/2024	1,781	Yes
28/04/2024	1,847	Yes
29/04/2024	1,820	Yes
30/04/2024	929	Yes
1/05/2024	1,509	Yes
2/05/2024	1,409	Yes
3/05/2024	1,074	Yes
4/05/2024	3,556	Yes

Date	Number of calls	Roosting indicated
5/05/2024	4,276	Yes
6/05/2024	3,462	Yes
7/05/2024	2,368	Yes
8/05/2024	1,885	Yes
9/05/2024	1,877	Yes
10/05/2024	2,904	Yes
11/05/2024	1,663	Yes
12/05/2024	2,272	Yes
13/05/2024	2,515	Yes
14/05/2024	2,561	Yes
15/05/2024	2,765	Yes
16/05/2024	1,578	Yes
17/05/2024	1,335	Yes
18/05/2024	2,164	Yes
19/05/2024	1,611	Yes
20/05/2024	1,267	Yes
21/05/2024	757	Yes
22/05/2024	881	Yes
23/05/2024	936	Yes
24/05/2024	1,252	Yes
25/05/2024	1,237	Yes

Date	Number of calls	Roosting indicated
26/05/2024	878	Yes
27/05/2024	1,712	Yes
28/05/2024	1,528	Yes
29/05/2024	676	Yes
30/05/2024	1,802	Yes
31/05/2024	1,416	Yes
1/06/2024	2,481	Yes
2/06/2024	1,303	Yes
3/06/2024	743	Yes
4/06/2024	1,585	Yes
5/06/2024	1,420	Yes
6/06/2024	2,006	Yes
7/06/2024	N/A	N/A
8/06/2024	N/A	N/A
9/06/2024	N/A	N/A
10/06/2024	N/A	N/A
11/06/2024	N/A	N/A
12/06/2024	N/A	N/A
13/06/2024	N/A	N/A
14/06/2024	N/A	N/A
15/06/2024	N/A	N/A

Date	Number of calls	Roosting indicated
16/06/2024	N/A	N/A
17/06/2024	N/A	N/A
18/06/2024	N/A	N/A
19/06/2024	N/A	N/A
20/06/2024	N/A	N/A
21/06/2024	N/A	N/A
22/06/2024	N/A	N/A
23/06/2024	N/A	N/A
24/06/2024	N/A	N/A
25/06/2024	N/A	N/A
26/06/2024	N/A	N/A
27/06/2024	N/A	N/A
28/06/2024	N/A	N/A
29/06/2024	N/A	N/A
30/06/2024	N/A	N/A
1/07/2024	N/A	N/A
2/07/2024	N/A	N/A
3/07/2024	N/A	N/A
4/07/2024	N/A	N/A
5/07/2024	N/A	N/A
6/07/2024	N/A	N/A

Date	Number of calls	Roosting indicated
7/07/2024	N/A	N/A
8/07/2024	N/A	N/A
9/07/2024	N/A	N/A
10/07/2024	N/A	N/A
11/07/2024	N/A	N/A
12/07/2024	N/A	N/A
13/07/2024	N/A	N/A
14/07/2024	N/A	N/A
15/07/2024	N/A	N/A
16/07/2024	N/A	N/A
17/07/2024	N/A	N/A
18/07/2024	N/A	N/A
19/07/2024	N/A	N/A
20/07/2024	N/A	N/A
21/07/2024	N/A	N/A
22/07/2024	N/A	N/A
23/07/2024	-	-
24/07/2024	-	-
25/07/2024	-	-
26/07/2024	-	-
27/07/2024	-	-

Date	Number of calls	Roosting indicated
28/07/2024	-	-
29/07/2024	-	-
30/07/2024	-	-
31/07/2024	-	-
1/08/2024	-	-
2/08/2024	-	-
3/08/2024	-	-
4/08/2024	-	-
5/08/2024	-	-
6/08/2024	-	-
7/08/2024	-	-
8/08/2024	3,705	Yes
9/08/2024	-	-
10/08/2024	-	-
11/08/2024	-	-
12/08/2024	-	-
13/08/2024	-	-
14/08/2024	-	-
15/08/2024	-	-
16/08/2024	-	-
17/08/2024	335	Yes

Date	Number of calls	Roosting indicated
18/08/2024	349	Yes
19/08/2024	399	Yes
20/08/2024	570	Yes
21/08/2024	551	Yes
22/08/2024	545	Yes
23/08/2024	595	Yes
24/08/2024	713	Yes
25/08/2024	610	Yes
26/08/2024	675	Yes
27/08/2024	763	Yes
28/08/2024	620	Yes
29/08/2024	725	Yes
30/08/2024	526	Yes
31/08/2024	460	Yes
1/09/2024	520	Yes
2/09/2024	820	Yes
3/09/2024	528	Yes
4/09/2024	499	Yes
5/09/2024	396	Yes
6/09/2024	453	Yes
7/09/2024	388	Yes

Date	Number of calls	Roosting indicated
8/09/2024	485	Yes
9/09/2024	472	Yes
10/09/2024	402	Yes
11/09/2024	720	Yes
12/09/2024	-	-
13/09/2024	-	-
14/09/2024	-	-
15/09/2024	-	-
16/09/2024	-	-
17/09/2024	-	-
18/09/2024	-	-
19/09/2024	-	-
20/09/2024	-	-
21/09/2024	-	-
22/09/2024	-	-
23/09/2024	-	-
24/09/2024	-	-
25/09/2024	-	-
26/09/2024	-	-
27/09/2024	-	-
28/09/2024	-	-

Date	Number of calls	Roosting indicated
29/09/2024	-	-
30/09/2024	-	-
1/10/2024	-	-
2/10/2024	-	-
3/10/2024	-	-
4/10/2024	1,096	Yes
5/10/2024	841	Yes
6/10/2024	635	Yes
7/10/2024	862	Yes
8/10/2024	1,260	Yes
9/10/2024	1,624	Yes
10/10/2024	671	Yes
11/10/2024	1,378	Yes
12/10/2024	827	Yes
13/10/2024	789	Yes
14/10/2024	719	Yes
15/10/2024	570	Yes
16/10/2024	938	Yes
17/10/2024	499	Yes
18/10/2024	717	Yes
19/10/2024	634	Yes

Date	Number of calls	Roosting indicated
20/10/2024	558	Yes
21/10/2024	760	Yes
22/10/2024	899	Yes
23/10/2024	906	Yes
24/10/2024	1,058	Yes
25/10/2024	771	Yes
26/10/2024	945	Yes
27/10/2024	702	Yes
28/10/2024	486	Yes
29/10/2024	277	Yes
30/10/2024	267	Yes
31/10/2024	389	Yes
1/11/2024	249	Yes
2/11/2024	301	Yes
3/11/2024	199	Yes
4/11/2024	246	Yes
5/11/2024	382	Yes
6/11/2024	404	Yes
7/11/2024	412	Yes
8/11/2024	390	Yes
9/11/2024	336	Yes

Date	Number of calls	Roosting indicated
10/11/2024	225	Yes
11/11/2024	212	Yes
12/11/2024	342	Yes
13/11/2024	299	Yes
14/11/2024	196	Yes
15/11/2024	539	Yes
16/11/2024	442	Yes
17/11/2024	740	Yes
18/11/2024	518	Yes
19/11/2024	1,020	Yes
20/11/2024	677	Yes
21/11/2024	639	Yes
22/11/2024	504	Yes
23/11/2024	785	Yes
24/11/2024	419	Yes
25/11/2024	293	Yes
26/11/2024	425	Yes
27/11/2024	427	Yes
28/11/2024	320	Yes
29/11/2024	419	Yes
30/11/2024	209	Yes

Date	Number of calls	Roosting indicated
1/12/2024	289	Yes
2/12/2024	390	Yes
3/12/2024	339	Yes
4/12/2024	260	Yes
5/12/2024	301	Yes
6/12/2024	324	Yes
7/12/2024	308	Yes
8/12/2024	414	Yes
9/12/2024	410	Yes
10/12/2024	1,249	Yes
11/12/2024	443	Yes
12/12/2024	831	Yes
13/12/2024	698	Yes
14/12/2024	818	Yes
15/12/2024	486	Yes
16/12/2024	1,257	Yes
17/12/2024	292	Yes
18/12/2024	252	Yes
19/12/2024	251	Yes
20/12/2024	194	Yes
21/12/2024	249	Yes

Date	Number of calls	Roosting indicated
22/12/2024	230	Yes
23/12/2024	259	Yes
24/12/2024	213	Yes
25/12/2024	163	Yes
26/12/2024	271	Yes
27/12/2024	280	Yes
28/12/2024	313	Yes
29/12/2024	244	Yes
30/12/2024	230	Yes
31/12/2024	484	Yes

Note: '-' = no sampling

N/A – data not suitable for analysis

## Appendix D: Summary temporal statistics for Pilbara leaf-nosed bat activity

Site	Previous data analysis (mean number of calls, $\pm$ SE), GAM ) (Biologic, 2024)					Revised data <sup>1</sup> (mean number of calls, $\pm$ SE), GAM, current survey)				
	Baseline (2014-2019)	2020	2021	2022	2023	Baseline (2014-2019)	2020	2021	2022	2023
<b>Impact</b>										
CO-CA-01	3,514	3,089	2,647	2,048	2,565	3,487	3,272	2,712	2,137	2,668
	( $\pm$ 397)	( $\pm$ 378)	( $\pm$ 324)	( $\pm$ 250)	( $\pm$ 314)	( $\pm$ 377)	( $\pm$ 384)	( $\pm$ 319)	( $\pm$ 251)	( $\pm$ 313)
CO-CA-03	11,138	1,421	3,567	759	1,383	11,062	1,503	3,662	791	1,437
	( $\pm$ 1,193)	( $\pm$ 177)	( $\pm$ 436)	( $\pm$ 93)	( $\pm$ 182)	( $\pm$ 1,133)	( $\pm$ 180)	( $\pm$ 430)	( $\pm$ 93)	( $\pm$ 183)
CO-CA-05	695	1,171	391	89	285	696	1,245	402	92	296
	( $\pm$ 169)	( $\pm$ 435)	( $\pm$ 145)	( $\pm$ 33)	( $\pm$ 112)	( $\pm$ 157)	( $\pm$ 454)	( $\pm$ 146)	( $\pm$ 34)	( $\pm$ 115)
CO-CA-10	41	6	11	11	57	41	6	6	12	59
	( $\pm$ 9)	( $\pm$ 2)	( $\pm$ 5)	( $\pm$ 5)	( $\pm$ 23)	( $\pm$ 9)	( $\pm$ 2)	( $\pm$ 3)	( $\pm$ 5)	( $\pm$ 23)
CO-WS-01	42	17	21	11	6	43	18	22	12	6
	( $\pm$ 10)	( $\pm$ 6)	( $\pm$ 8)	( $\pm$ 5)	( $\pm$ 2)	( $\pm$ 9)	( $\pm$ 6)	( $\pm$ 8)	( $\pm$ 5)	( $\pm$ 2)
CO-WS-03	30	8	-	23	9	31	9	-	24	10
	( $\pm$ 7)	( $\pm$ 3)	-	( $\pm$ 9)	( $\pm$ 4)	( $\pm$ 7)	( $\pm$ 3)	-	( $\pm$ 9)	( $\pm$ 4)
<b>Control</b>										
CO-WS-08	44	3	14	14	1	44	3	14	15	2
	( $\pm$ 10)	( $\pm$ 1)	( $\pm$ 5)	( $\pm$ 6)	( $\pm$ 1)	( $\pm$ 9)	( $\pm$ 1)	( $\pm$ 5)	( $\pm$ 6)	( $\pm$ 1)
CO-WS-13	79	-	-	-	4	79	10	15	5	4
	( $\pm$ 18)	-	-	-	( $\pm$ 2)	( $\pm$ 17)	( $\pm$ 4)	( $\pm$ 6)	( $\pm$ 2)	( $\pm$ 2)
CO-CA-18	126	-	-	-	101	126	56	45	71	105
	( $\pm$ 29)	-	-	-	( $\pm$ 38)	( $\pm$ 27)	( $\pm$ 20)	( $\pm$ 16)	( $\pm$ 26)	( $\pm$ 38)
LR-MI-01	4,921	2,849	6,330	723	891	4,964	2,050	10,011	1,274	925
	( $\pm$ 1,055)	( $\pm$ 103)	( $\pm$ 418)	( $\pm$ 183)	( $\pm$ 286)	( $\pm$ 991)	( $\pm$ 747)	( $\pm$ 3,273)	( $\pm$ 398)	( $\pm$ 291)
MW-CA-02	37,069	25,282	54,769	8,813	8,813	37,173	26,866	56,309	-	9,152
	( $\pm$ 7,845)	( $\pm$ 8,490)	( $\pm$ 20,315)	( $\pm$ 2,831)	( $\pm$ 2,831)	( $\pm$ 7,341)	( $\pm$ 8,846)	( $\pm$ 20,434)	-	( $\pm$ 2,880)

<sup>1</sup>Data has been reanalysed during current survey . Revised average number of calls has been derived from GAM (update from GAM modelled data calculated in 2023) and represent estimated marginal means (which are observed means corrected for differences in the timing of sampling via the model)

Note: '-' = no sampling