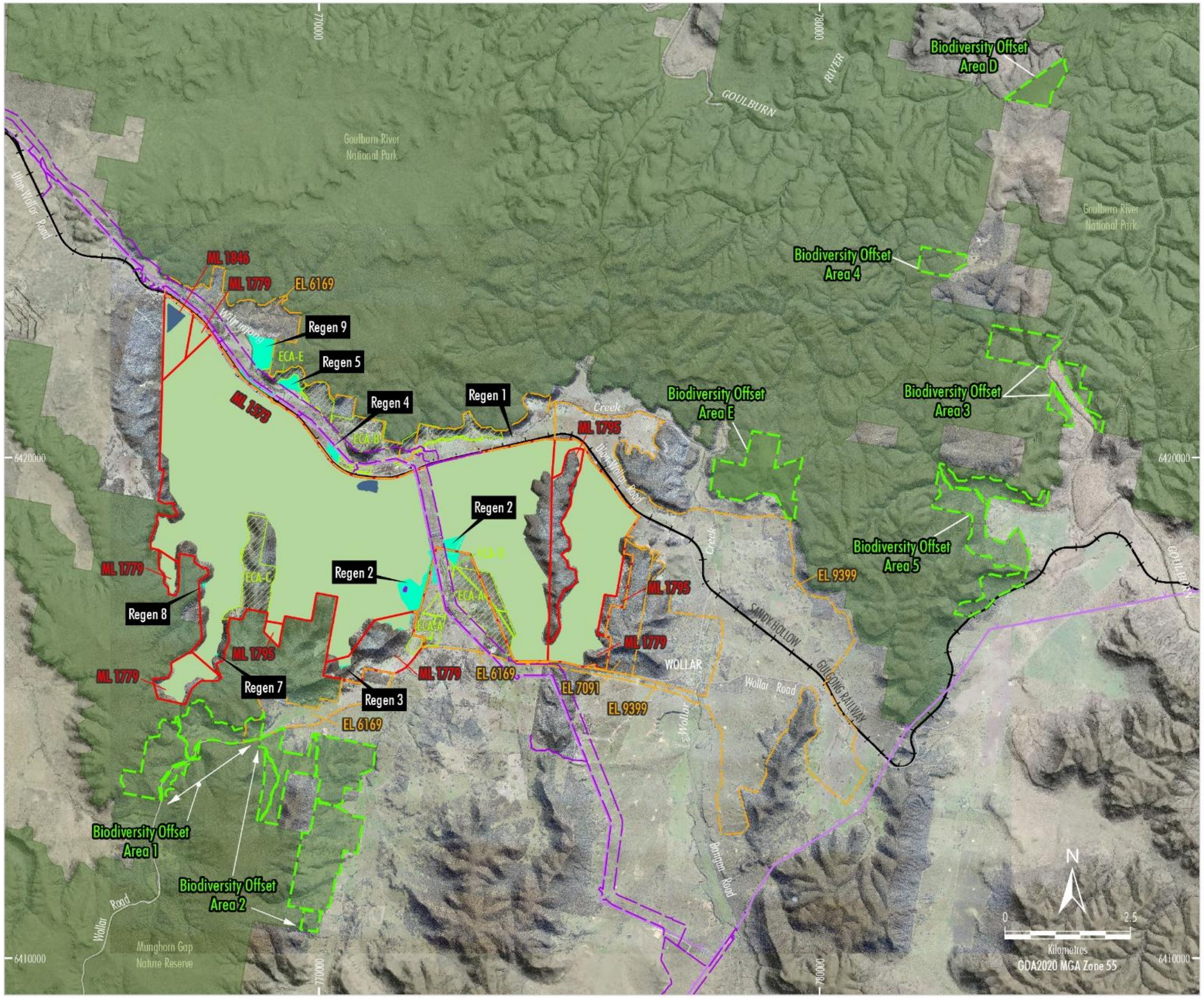
APPENDIX 5

BIODIVERSITY

Biodiversity Offset Strategy

All land within Biodiversity Offset Areas D and E were transferred to the National Parks Estate on the 13 January 2016.

All land within Biodiversity Offset Areas 1-5 (BOAs) were transferred to the National Parks Estate on the 02 August 2023



Project Area and Biodiversity Offset Strategy

WIL-12-11A_BioMP 2024_201C

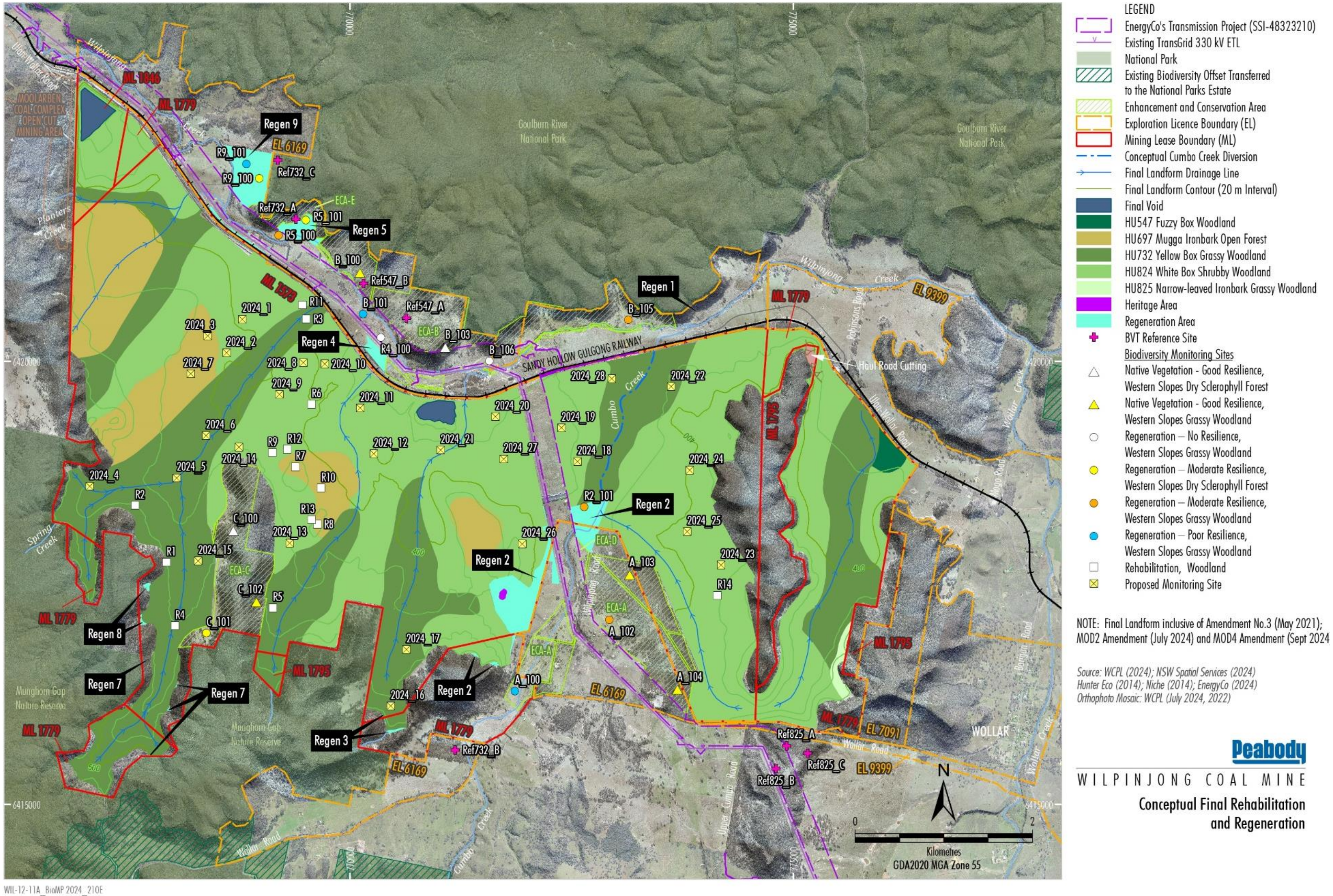

LEGEND
EnergyCo's Transmission Project (SSI-48323210)
Existing TransGrid 330 kV ETL
National Park
Existing Biodiversity Offset Transferred to the National Parks Estate
Enhancement and Conservation Area
Exploration Licence Boundary (EL)
Mining Lease Boundary (ML)
Conceptual Cumbo Creek Diversion
Final Landform Drainage Line
Final Landform Contour (20 m Interval)
Final Void
HU547 Fuzzy Box Woodland
HU697 Mugga Ironbark Open Forest
HU732 Yellow Box Grassy Woodland
HU824 White Box Shrubby Woodland
HU825 Narrow-leaved Ironbark Grassy Woodland
Heritage Area
Regeneration Area
BVT Reference Site
Biodiversity Monitoring Sites
Native Vegetation - Good Resilience, Western Slopes Dry Sclerophyll Forest
Native Vegetation - Good Resilience, Western Slopes Grassy Woodland
Regeneration – No Resilience, Western Slopes Grassy Woodland
Regeneration – Moderate Resilience, Western Slopes Dry Sclerophyll Forest
Regeneration – Moderate Resilience, Western Slopes Grassy Woodland
Regeneration – Poor Resilience, Western Slopes Grassy Woodland
Rehabilitation, Woodland
Proposed Monitoring Site
NOTE: Final Landform inclusive of Amendment No.3 (May 2021); MOD2 Amendment (July 2024) and MOD4 Amendment (Sept 2024
Source: WCPL (2024); NSW Spatial Services (2024)
Hunter Eco (2014); Niche (2014); EnergyCo (2024)
Orthophoto Mosaic: WCPL (July 2024, 2022)
Peabody
WILPINJONG COAL MINE
Conceptual Final Rehabilitation and Regeneration
Regen 1
Regen 2
Regen 3
Regen 4
Regen 5
Regen 7
Regen 8
Regen 9
Goulburn River National Park
Munghorn Gap Nature Reserve
SANDY HOLLOW GULGONG RAILWAY
Haul Road Cutting
WOLLAR
ML 1779
ML 1795
ML 1846
ML 1573
EL 6169
EL 9399
EL 7091
MOOLARBEN COAL COMPLEX OPEN CUT MINING AREA
Kilometres
GDA2020 MGA Zone 55
WIL-12-11A_BioMP 2024_210E

Table A6 Three Year Management Schedule

Management Domains	Three Year Management Measures (2024-2026)												
	Cultural Heritage Management	Fencing, Gates & Signage	Access Tracks	Waste Management	Erosion & Soil Management	Grazing & Stock Management	Seed Collection & Propagation	Habitat Augmentation	Revegetation	Weed Management	Vertebrate Pest Control	Monitor Die Back (Phytophthora cinnamon)	Bushfire Management
ECA_A	✓[1]	✓[2]	✓[3]	✓[4]	✓[5]	✓[6]	✓[7]	✓[8]	✓[9]	✓[10]	✓[11]	✓[12]	✓[13]
ECA_B	✓[1]	✓[2]	✓[3]	✓[4]	✓[5]	✓[6]	✓[7]	✓[8]	✓[9]	✓[10]	✓[11]	✓[12]	✓[13]
ECA_C	✓[1]	✓[2]	✓[3]	✓[4]	✓[5]	✓[6]	✓[7]	✓[8]	✓[9]	✓[10]	✓[11]	✓[12]	✓[13]
ECA_D	✓[1]	✓[2]	✓[3]	✓[4]	✓[5]	✓[6]	✓[7]	✓[8]	✓[9]	✓[10]	✓[11]	✓[12]	✓[13]
ECA_E	✓[1]	✓[2]	✓[3]	✓[4]	✓[5]	✓[6]	✓[7]	✓[8]	✓[9]	✓[10]	✓[11]	✓[12]	✓[13]
Regeneration Area 1	✓[1]	✓[2]	✓[3]	✓[4]	✓[5]	✓[6]	✓[7]	✓[8]	✓[9]	✓[10]	✓[11]	✓[12]	✓[13]
Regeneration Area 2	✓[1]	✓[2]	✓[3]	✓[4]	✓[5]	✓[6]	✓[7]	✓[8]	✓[9]	✓[10]	✓[11]	✓[12]	✓[13]
Regeneration Area 3, 7 & 8	✓[1]	✓[2]	✓[3]	✓[4]	✓[5]	✓[6]	✓[7]	✓[8]	✓[9]	✓[10]	✓[11]	✓[12]	✓[13]
Regeneration Area 4	✓[1]	✓[2]	✓[3]	✓[4]	✓[5]	✓[6]	✓[7]	✓[8]	✓[9]	✓[10]	✓[11]	✓[12]	✓[13]
Regeneration Area 5	✓[1]	✓[2]	✓[3]	✓[4]	✓[5]	✓[6]	✓[7]	✓[8]	✓[9]	✓[10]	✓[11]	✓[12]	✓[13]
Regeneration Area 6	✓[1]	✓[2]	✓[3]	✓[4]	✓[5]	✓[6]	✓[7]	✓[8]	✓[9]	✓[10]	✓[11]	✓[12]	✓[13]
Regeneration Area 9	✓[1]	✓[2]	✓[3]	✓[4]	✓[5]	✓[6]	✓[7]	✓[8]	✓[9]	✓[10]	✓[11]	✓[12]	✓[13]
Rehabilitation Areas	NA	NA	NA	NA	✓[5]	NA	✓[7]	✓[8]	✓[9]	✓[10]	✓[11]	✓[12]	✓[13]
Residual Areas	✓[1]	✓[2]	✓[3]	✓[4]	✓[5]	✓[6]	✓[7]	✓[8]	✓[9]	✓[10]	✓[11]	✓[12]	✓[13]

Notes:
NA = Not Applicable to the Management Domain
✓[1] = As required under the ACHMP
✓[2] = As required repairs to existing fencing, gates and signage will be informed during inspections.
✓[3]= As required repairs to existing tracks will be informed during inspections.
✓[4]= As required waste removal will be informed during inspections. Waste removal campaigns in ECAs have been completed.
✓[5]= Opportunistic repair of erosion channels will be undertaken when determined to be necessary after identification and mapping.
✓[6]= Livestock to be excluded from areas of native regeneration unless utilised for any management programs.
✓[7]= Continuation of Seed Collection Program inclusive of local species. Seed collectors are suitably trained and qualified.
✓[8]= As required, habitat augmentation opportunities are identified and assessed.
✓[9]= As required, identification of opportunities to increase native plant species richness inclusive of supplementary planting.
✓[10]= Seasonal identification of target noxious weed species and management as required.
✓[11]= Program drafted in consultation with NSW Local Land Services.
✓[12]= As required by this BMP.
✓[13]= Maintenance and repair of bushfire prevention infrastructure as required.

Biodiversity Reports

2024 WCPL Annual Rehabilitation Monitoring Report

Wilpinjong Coal Biodiversity Monitoring

Wilpinjong Coal Pty Ltd

Eco Logical Australia

A TETRA TECH COMPANY

Document Tracking

Project Name:	2024 WCPL Annual Rehabilitation Monitoring Report
Project Number:	24MUD9285
Project Manager:	Kieran Stephenson-Banks

Version	Prepared by	Reviewed by	Approved by	Status	Date
1	Kieran Stephenson-Banks	Cheryl O'Dwyer	Kalya Abbey	Final	14/02/2025

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Acknowledgements

This document has been prepared by Eco Logical Australia Pty Ltd with support from .

Abbreviations

Abbreviation	Description
BC Act	Biodiversity Conservation Act 2016
BMP	Biodiversity Management Plan
BOA	Biodiversity Offset Areas
BVT	BioMetric Vegetation Type
CPHR	Conservation Programs, Heritage and Regulation Group
EC	Exotic Plant Cover
ECA	Enhancement and Conservation Area
ELA	Eco Logical Australia
EPBC Act	Environment Protection and Biodiversity Act 1999
FL	Fallen Logs
LFA	Landscape Function Analysis
LGA	Local Government Area
LOI	Landscape Organisation Index
MWRC	Mid-Western Regional Council
NGCG	Native Ground Stratum Cover (Grasses)
NGCO	Native Ground Stratum Cover (Other)
NGCS	Native Ground Stratum Cover (Shrubs)
NMS	Native Midstorey Cover
NOC	Native Overstorey Cover
NSR	Native Species Richness
NTH	Number of Trees with Hollows
OT	Overstorey Regeneration
SSA	Soil Surface Assessment
SVS	Site Value Score
TARP	Trigger Action Response Plan
WCM	Wilpinjong Coal Mine
WCPL	Wilpinjong Coal Pty Ltd

Executive Summary

Eco Logical Australia (ELA) was engaged by Wilpinjong Coal Pty Ltd (WCPL) to undertake the 2024 annual biodiversity monitoring at the Wilpinjong Coal Mine (WCM) in accordance with the WCM Biodiversity Management Plan (BMP) (WCPL 2021). The key objectives included assessing rehabilitation areas against performance and completion criteria, tracking ecosystem progression and addressing compliance requirements for Development Consent SSD-6764.

The 2024 monitoring program was adapted to reflect a change in biodiversity monitoring objectives, primarily, a shift to increased monitoring throughout the WCPL rehabilitation. The additions to the monitoring program include the establishment of plots throughout rehabilitation that has recently achieved ecosystem and land use establishment and rehabilitation that has recently been reworked from agricultural rehabilitation to native woodland rehabilitation.

Local Reference Sites were established in 2019 and 2020 in areas that conform to WCPL's targeted rehabilitation BioMetric Vegetation Types (BVTs), in accordance with Condition 36 of the WCM Development Consent SSD 6764. WCPL Local Reference Sites were monitored during autumn and spring in accordance with the three-year rotation outlined in Section 9 Table 18 of the WCPL BMP.

Vegetation monitoring

Floristic monitoring was undertaken in accordance with the BioMetric plot method prescribed in the BMP at both rehabilitation and Local Reference Sites. All sites surveyed are currently less than 10 years since ecosystem establishment and are assessed against the Performance Criteria.

All monitored sites exceeded the Site Value Score (SVS) performance Criteria benchmark of 7. Exotic cover remained within acceptable limits, however, none of the sites have yet met the Performance Criteria for native overstory cover (NOC). Three priority weed species (Local Land Services 2023) were recorded within the rehabilitation areas. Newly established sites showed positive initial results, indicating that early-stage rehabilitation is progressing towards ecosystem establishment.

Landscape Function Analysis

Landscape Function Analysis (LFA) monitoring was also undertaken at the rehabilitation and Local Reference Sites. The results showed that all rehabilitation sites monitored recorded LFA scores above 50, confirming the stability of the sites, and as such ongoing monitoring at these sites is no longer required. However, if there is a notable visible decline in LFA parameters observed during future monitoring, reinstating LFA methods at select sites will be recommended in accordance with the WCPL BMP. Minor erosion was observed at select sites, necessitating localised remediation efforts.

Fauna monitoring

Fauna monitoring was undertaken at both rehabilitation and Local Reference Sites, identifying a total of 89 species. Of these, five species listed as threatened under the NSW *Biodiversity Conservation Act* (BC Act) *2016* and/or the Commonwealth *Environment Protection and Biodiversity Act* (EPBC Act) *1999* were recorded. Pest species were also observed, highlighting the need for continued management to mitigate their impacts on rehabilitation.

Recommendations

Recommendations from the findings emphasise the importance of implementing targeted weed and pest control measures to reduce competition and enhance native species establishment. Addressing

erosion at specific sites such as R36 is crucial to prevent further degradation. Infill planting is recommended to enhance native overstory and midstorey cover, and monitoring efforts should incorporate species composition assessments to better evaluate progression towards target vegetation benchmarks.

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1. Introduction

Eco Logical Australia (ELA) was engaged by Wilpinjong Coal Pty Ltd (WCPL) to undertake the 2024 annual biodiversity monitoring consistent with the requirements of Development Consent SSD-6764 (as modified) and the methods outlined in the Wilpinjong Coal Biodiversity Management Plan (BMP) (WCPL 2021). The primary objectives for the 2024 monitoring program were to evaluate rehabilitation areas against WCPL's approved performance criteria, assess landscape stability and vegetation progress, and monitor biodiversity, including native and introduced fauna species, within rehabilitation and Local Reference Sites.

Background

Wilpinjong Coal Pty Ltd (WCPL), a wholly owned subsidiary of Peabody Energy Australia Pty Ltd (Peabody), operates the Wilpinjong Coal Mine (WCM) located in the western coalfields of NSW approximately 48 km north-east of Mudgee, within the Mid-Western Regional Council (MWRC) Local Government Area (LGA).

The WCM originally operated under Project Approval (PA) 05-0021, granted under Part 3A of the NSW Environmental Planning and Assessment Act 1979 on 1 February 2006. A series of modifications to PA 05-0021 were approved until it was superseded by Development Consent SSD-6764 (as modified), granted on 24 April 2017 for the Wilpinjong Extension Project (WEP).

WCM historically had a Biodiversity Offset Strategy which was developed and augmented by WCPL to offset impacts on threatened species, populations or communities listed under the NSW *Biodiversity Conservation Act 2016* (BC Act) and /or the Commonwealth *Environment Protection Biodiversity Conservation Act 1999* (EPBC Act) in accordance with SSD-6764. The strategy comprised more than 4,500 ha of Management Domains (shown below in Figure 1):

- Biodiversity Offset Areas (BOAs)
- Enhancement and Conservation Areas (ECAs)
- Regeneration Areas
- Rehabilitation Areas

The BOAs were relinquished to the NSW National Parkes and Wildlife Service on 30 June 2023 to be managed as part of National Parks estate.

Since the relinquishment of the BOAs the 2024 biodiversity monitoring program focuses entirely on the WCPL rehabilitation areas, incorporating 21 new monitoring locations throughout the rehabilitation. The monitoring program includes BioMetric Vegetation Monitoring, Landscape Function Analysis (LFA), and fauna surveys, with results compared against benchmarks derived from Local Reference Sites and approved WCPL Performance and Completion Criteria. Completion Criteria and Local Reference Sites benchmarks are detailed in Table 12 of the BMP (WCPL 2021).

In accordance with Condition 36 of the Development Consent SSD-6764, WCPL must demonstrate that rehabilitation areas meet performance and completion criteria to generate ecosystems credits to offset impacts from the WEP. These criteria apply to the following prescribed BioMetric Vegetation Types (BVTs):

- HU547 – Fuzzy Box Woodland
- HU981 – Rough Barked Apple Woodland / HU732 – Yellow box Grassy Woodland
- HU824 – White Box-Black Cypress Pine Shrubby Woodland.

Additionally, Condition 36 and 37 of the Development Consent SSD-6764, require WCPL to meet criteria for species credit obligations associated with the critically endangered *Anthochaera Phrygia* (Regent Honeyeater). This includes demonstrating adequate habitat within the following BVTs:

- HU697 – Mugga Ironbark-Black Cypress Pine Open Forest
- HU732 – Yellow Box Grassy Woodland
- HU825 – Narrow-leaved Ironbark-Black Cypress Pine Grass Woodland.

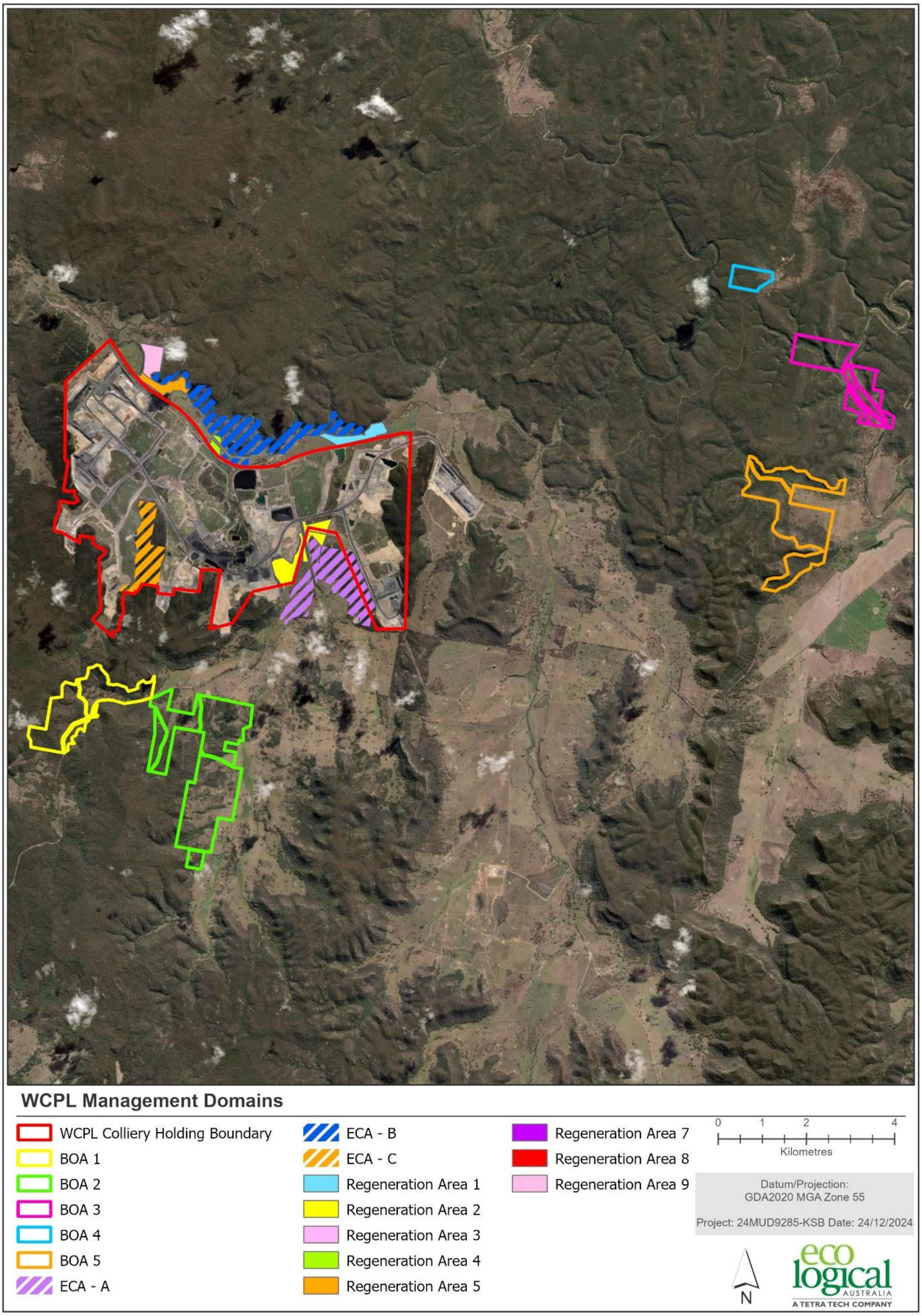

Figure 1: WCPL BOS Management Domains

2. Methodology

There are a total of 51 monitoring sites throughout the WCPL rehabilitation and Local Reference Sites which are located in a range of vegetation communities in accordance with the WCPL BMP (WCPL 2021). The 2024 biodiversity monitoring was undertaken in 25 of the rehabilitation sites, and a subset of the Local Reference Sites as part of the scheduled three-year rotation. All monitoring adhered to the methodologies and survey techniques outlined in the BMP (WCPL 2021).

Weather conditions during the 2024 monitoring period are presented in Appendix A:, whilst details of vegetation condition, classification and site coordinates are presented in Appendix B:.

2.1. Vegetation Monitoring

Vegetation monitoring was conducted in Autumn on 30 May and in Spring between 18 November and 19 December by ELA Ecologists Rebecca Croake, Kieran Stephenson-Banks, Lachlan Metzler, Shirley Chia and Natalie De Losa. The locations of established and reference vegetation monitoring sites are illustrated in Figure 2 and Figure 3.

Twenty-five plots within the WCPL rehabilitation areas were monitored which included five previously established plots, and 20 new plots established and monitored for the first time in spring 2024. The 20 newly established plots included plots within rehabilitation that was reworked from agricultural rehabilitation to woodland rehabilitation to conform to HU732 and HU824, and rehabilitation that was seeded in 2022 to conform to BVT824.

Four of the newly established plots monitored were within rehabilitation that was less than three years old. Whilst monitoring is not required until years 3 – 4 post ecosystem establishment (as per Table 11 in the BMP [WCPL 2021]), early monitoring tracks performance to determine success of seeded areas and informs management strategies if early intervention is necessary. The results from the monitoring of these four sites are presented separately in Section 3.3.

During both autumn and spring five Local Reference Sites were monitored in accordance with Table 18 of the WCPL BMP (WCPL 2021).

Vegetation monitoring followed the BioMetric method of outlined in the BMP (WCPL 2021). Permanent BioMetric plots, comprising a 20m x 20m (0.04ha) plot nested within a 20m x 50m plot, were surveyed at each monitoring site. Within each plot, the following data was collected:

- Native species richness (NSR), cover and abundance within the 20m x 20m plot
- Identification of all vascular plant species to species level where possible within the 20m x 20m plot.
- Native overstorey cover (NOC) and native mid-storey cover (NMS) at 5m intervals along 50m transect (10 points)
- Native ground cover (grass, shrub, other) and exotic cover (EC) at 1m intervals along 50m transect (50 points)
- Habitat features including number of trees with hollows (NTH), length of logs (FL) and proportion of overstorey regeneration within 20m x 50m plot.

2.2. Landscape Function Analysis

Landscape Function Analysis (LFA) monitoring was conducted during spring at 21 established sites within the rehabilitation area (> 3-year post establishment) and at five Local Reference Sites (Figure 3: 2024 Local Reference Site).

The monitoring followed the techniques detailed by Tongway and Hindley (2004) and the BMP (WCPL 2021), using 50m transect method to measure stability, infiltration and nutrient cycling. Stability measured resistance to erosion, infiltration assessed soil water absorption, and nutrient cycling evaluated organic matter decomposition and recycling efficiency.

LFA attributes were assessed to monitor the Landscape Organisation Index (LOI) and Soil Surface Assessment (SSA). LFA scores were produced from the SSA, derived from indices for Stability, Soil Infiltration and Nutrient Cycling providing insights into resource accumulation verses loss across the landscape.

2.2.1. Landscape Organisation Index (LOI)

The LOI characterises and maps the spatial patterns of resource loss or accumulation at a site. It calculates the proportion of the transect occupied by stable patches which are landscape elements that provide long-term stability and accumulate resources (ie trees, shrubs, grassy tussocks, ground cover, and logs). Patches are areas of resource loss or gain, as a result of movement downslope, and are defined by soil surface elements including perennial vegetation cover, litter or large woody debris, or rocks, which help retain soil and resources are a site. A LOI value close to 100% (1.0) implies a transect can retain resources, which is an important characteristic of a self-sustaining ecosystem. Bare soil does not contribute to LOI.

According to the LFA method, stable patches obstruct or divert water flow and/or collect/filter out material from runoff and accumulate resources. Inter-patches are areas where resources (such as water, soil material and litter) can be mobilised and freely transported either down slope by water or down-wind when aeolian processes are active.

The following data was recorded for each stable patch/inter-patch along each LFA transect:

- Distance (m) from the start of the transect
- Patch width (cm)
- Patch/inter-patch identification.

The following patch types were defined and monitored across all LFA monitoring sites and monitoring periods:

- Bare soil
- Litter (including annual plants)
- Rock (>5 cm diameter)
- Logs (>10cm diameter)
- Ground cover (perennial)
- Shrub/tree
- Cryptogram
- Any combination of the above (e.g. ground cover – litter patch).

2.2.2. Soil Surface Assessment (SSA)

The Soil Surface Assessment (SSA) provides a more detailed analysis of the transect by providing indices for Stability, Soil Infiltration and Nutrient Cycling for the whole of the landscape (transect), scored between 0-100. Table 13 in the BMP (WCPL, 2021) outlines the SSA attributes that contribute to each of these three indices which are summarised in Table 1 below. Each patch/inter-patch type identified during the LOI assessment was subject to an SSA. A subset of up to five occurrences of each patch/inter-patch type were monitored, and data relating to 11 Soil Surface Condition Indicators (SSCIs) were collected along the 50 m transect (Table 1). The sum of the three LFA indices provides the LFA score for each site.

Table 1: Soil Surface Condition Indicators used to determine the overall Soil Surface Analysis (see Table 13 BMP: WCPL, 2021)

SSCI	Description
Rain splash protection	Percentage cover of perennial vegetation to a height of 0.5 m. plus rocks > 2 cm and woody material > 1 cm in diameter or other long-lived, immoveable objects.
Perennial vegetation cover	Percentage perennial vegetation cover.
Litter	Percentage cover of annual grasses and ephemeral herbage (both standing and detached) as well as detached leaves, stems, twigs, fruit, dung, etc.
Cryptogam cover	Percentage cover of algae, fungi, lichens, mosses, liverworts and fruiting bodies of mycorrhizas.
Crust brokenness	Categorises soil crusts from 0-4 where 0 refers to 'no crust present' and 4 refers to an 'intact and smooth' soil crust.
Soil erosion type and severity	Categorises the aerial extent and severity of various erosion types from 'Insignificant' to 'Severe'.
Deposited materials	Categorises the extent and depth of deposited alluvial material
Soil surface roughness	Categorises the depth of surface depressions from 'smooth' to 'deep' depressions.
Surface nature (resistance to disturbance)	Categorises the soils capacity to resist disturbance based on the soils 'hardness' or 'brittleness'.
Slake Test	Categorises the soils stability when exposed to water
Texture	Categorises the soils water infiltration capacity from 'very slow' to 'high'

Baseline Data for the Slake Test and Texture SSCIs was used for the LFA analysis and was not assessed in the field in 2024. All other parameters were assigned a score in the field. Data was entered into the LFA calculation spreadsheets and used to calculate Soil Stability, Soil Infiltration and Nutrient Cycling indices.

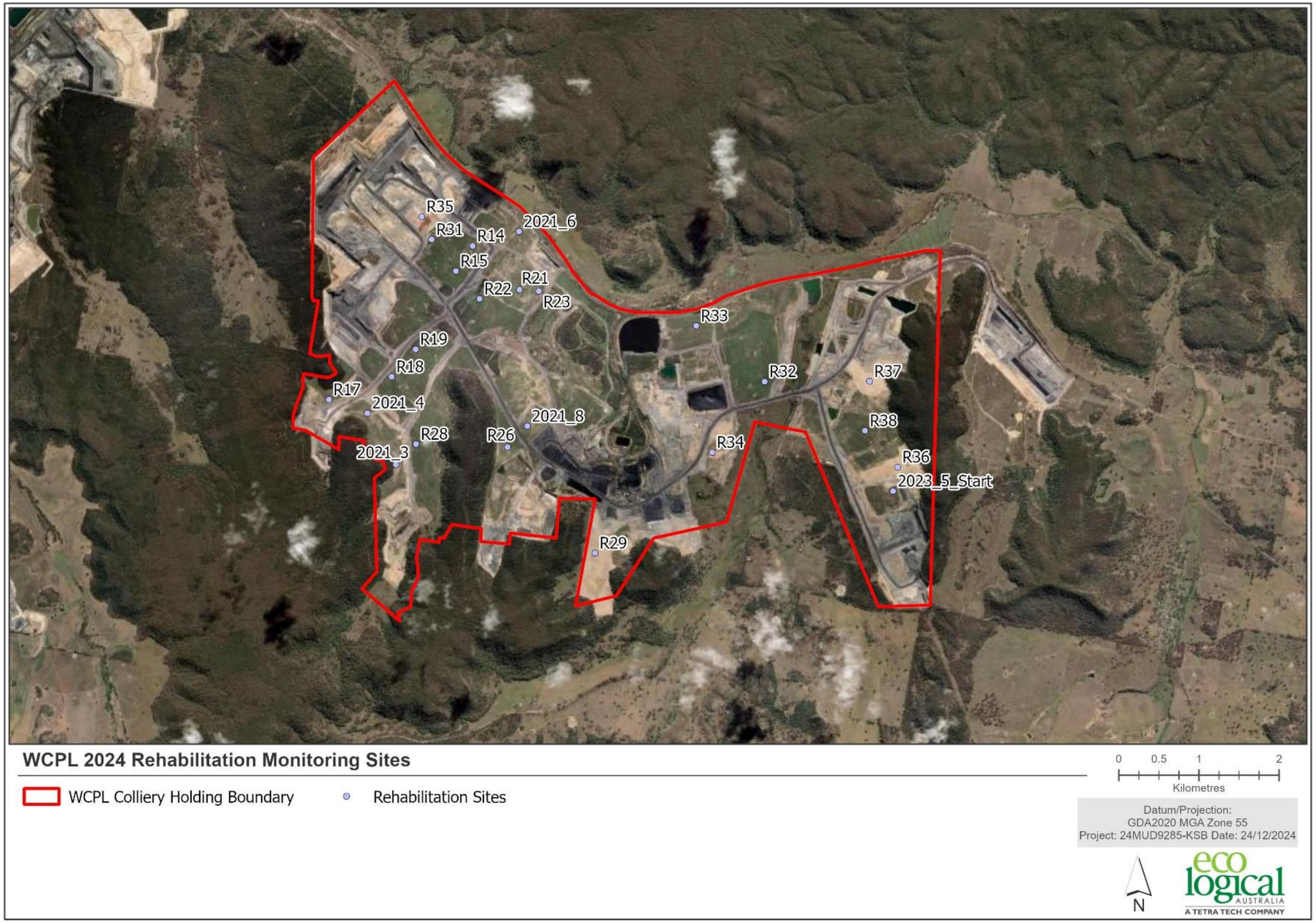

Figure 2: 2024 rehabilitation monitoring sites

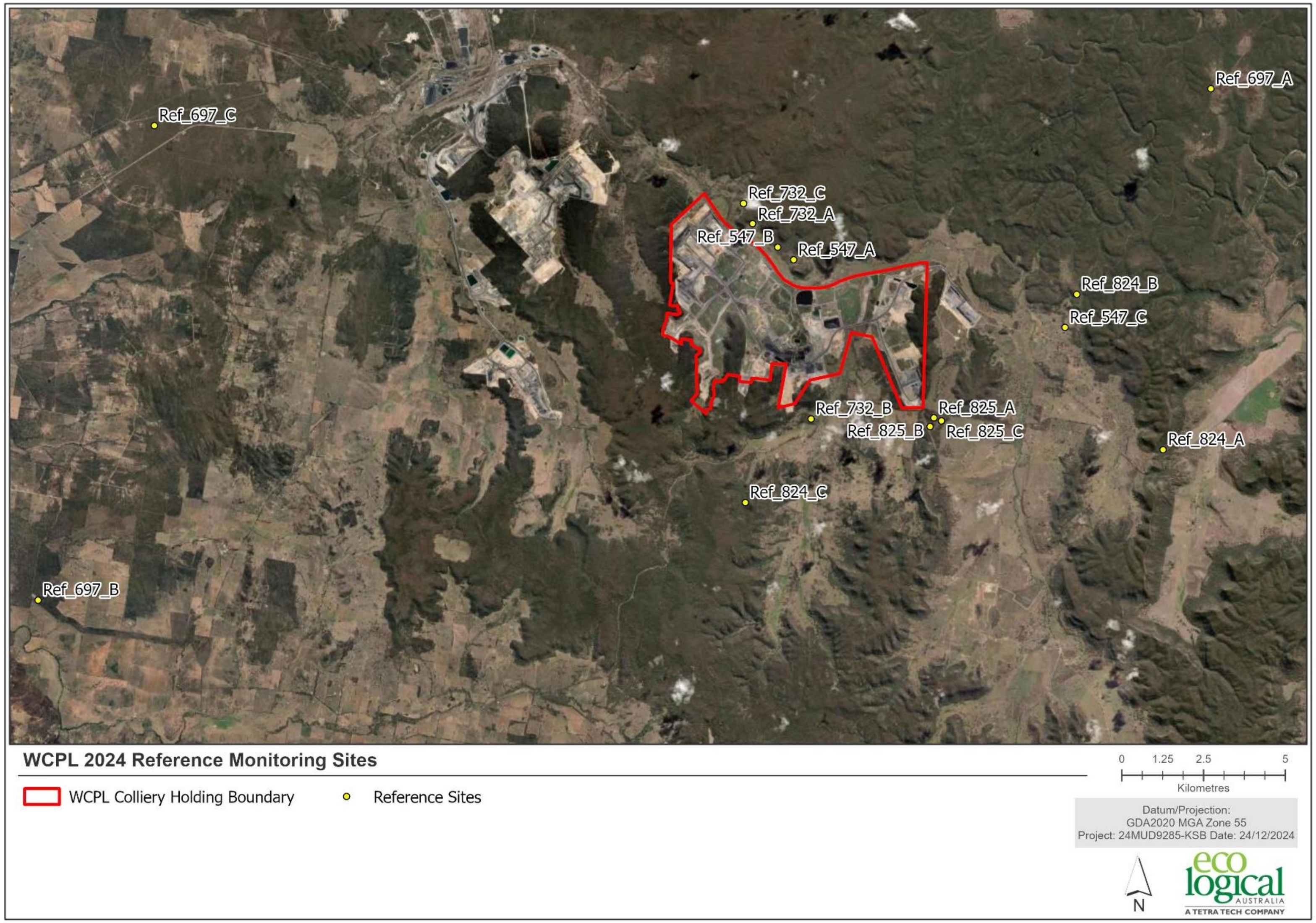

Figure 3: 2024 Local Reference Site

2.3. Fauna Monitoring

Terrestrial fauna monitoring conducted in 2024 included:

- **Bird surveys**: Conducted across three seasons (Summer 2023/2024, Spring and Summer 2024/2025) to build a comprehensive bird species list.
- **Herpetological searches**: Undertaken during spring concurrently with spring bird surveys.
- **Microbat monitoring**: Undertaken in spring, using ultrasonic recording devices (Anabats). Anabats were deployed at five Local Reference Sites and at five rehabilitation sites. Each detector was set to survey ultrasonic microbat calls passively for three nights, during the survey period. A total of 30 survey nights were completed during this survey. Analysis was undertaken by sub-contractor microbat specialist ecologist Craig Grabham from Otway Ecology. The analysis report is provided in Appendix C:.

The methodology and survey effort for each target species followed the methods prescribed within the BMP (WCPL 2021) and are summarised in Table 2. The locations of fauna monitoring sites are shown in Figure 4 below. Fauna monitoring in rehabilitation areas commenced after five years of establishment, therefore five selected long term established rehabilitation sites were monitored in spring 2024.

Table 2: Fauna monitoring methods summary

Target Species	Methodology	Total Survey Effort
Birds	Bird survey consisting of 10 minutes recording all birds seen/heard within 50 m radius of central plot point, and further 10 minutes recording all birds seen/heard within balance of a 2-ha plot. Call playback for the Critically Endangered Regent Honeyeater was played during surveying.	40 total minutes per site (20 minutes per survey, per person, per site.
Ground fauna (amphibians, mammals, reptiles)	Rocks and logs including augmented habitat features were searched for reptiles.	Searches were conducted during spring bird surveys.
Bats	Automated ultrasonic acoustic recording to identify all bat species occurring.	Recording for three nights (6pm – 6am), at five Local Reference Sites and five rehabilitation sites.
Mammals	Opportunistic collection of scats and observations of tree scratching's, animal tracks and paw prints.	Opportunistic
All	Any sightings of fauna recorded whilst moving throughout WCPL owned land and located using a GPS.	Opportunistic

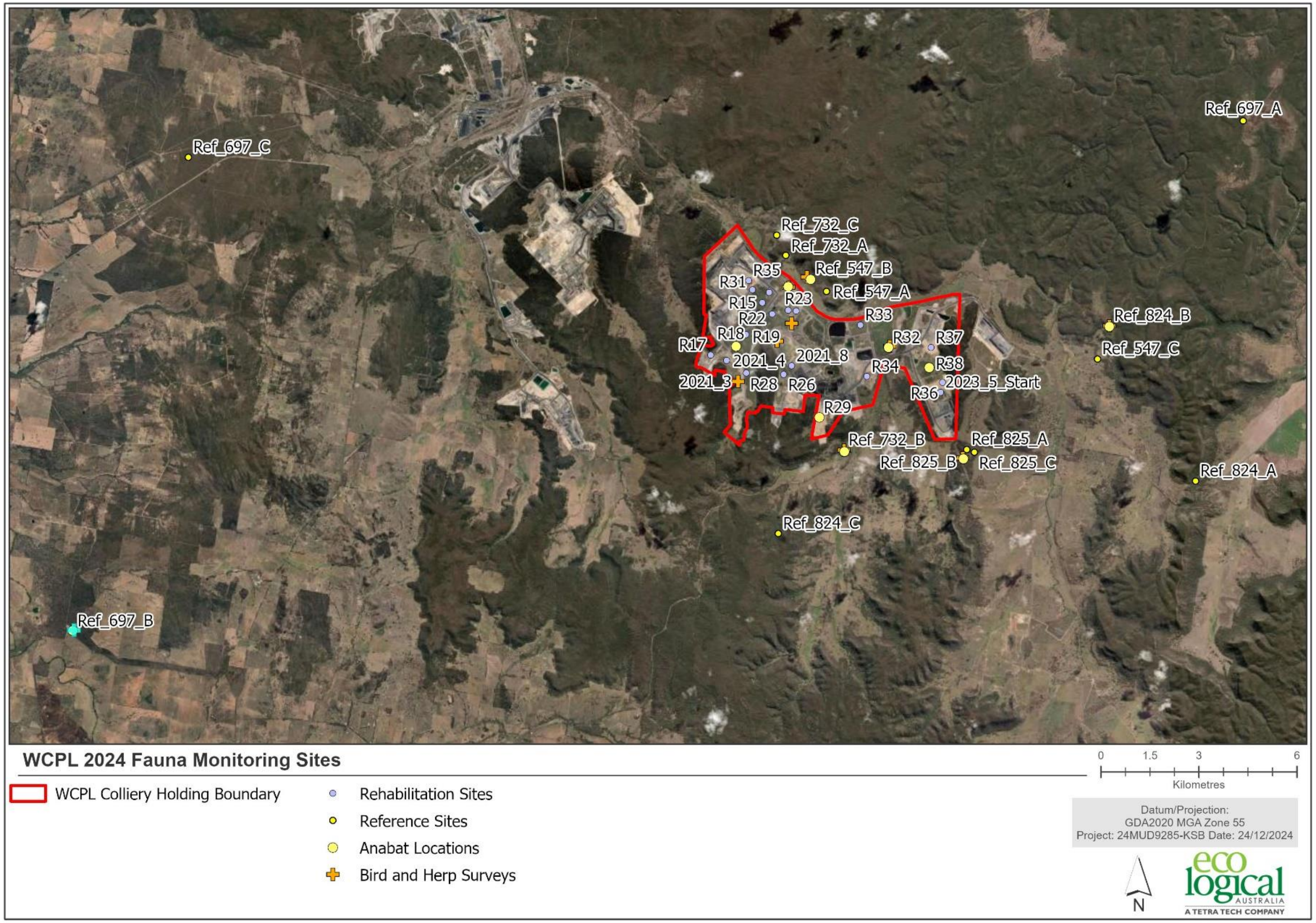

Figure 4: 2024 Fauna monitoring sites

3. Results and Discussion

3.1. Vegetation Monitoring

A total of 363 plant species were recorded across all rehabilitation sites and Local Reference Sites monitored during autumn and spring 2024, consisting of 229 native species, 117 exotic species and 17 species that were not able to be identified as either native or exotic due to lack of plant material. A complete list of flora species recorded during the 2024 monitoring period is included in Appendix D:.

3.1.1. Assessment against approved Performance Criteria and Completion Criteria

Vegetation monitoring results were assessed against Performance Criteria and Completion Criteria benchmarks (see Appendix D:E). A Site Value Score (SVS) was calculated for each site using the BioMetric Tool (NSW Department Environment Climate Change and Water, DECCW 2011) which combines the quality and quantity of native vegetation by measuring ten condition variables within a plot compared to the pre-European benchmarks for the BVT.

Table 3 and Table 4 present the individual site attributes and SVS for each 2024 rehabilitation monitoring site, for the 21 sites monitored within rehabilitation greater than three to four years old in accordance with the BMP (WCPL 2021). Results for the four sites monitored in rehabilitation less than three years old is presented separately in Section 3.3. Table 3 presents comparison of sites against the approved WCPL Performance Criteria. Table 4 presents comparison of sites against the approved WCPL Completion Criteria. SVS scores below BVT Benchmark Targets or Performance Criteria are highlighted in red. These sites activate the Interim Rehabilitation Performance Criteria (Years 1 – 10) Trigger Action Response Plan (TARP) outlined in Table 19 of the BMP (WCPL 2021). Amber is not applied to the SVS as scores below the Benchmark Target or Performance Criteria is considered low. A colour coding system has been applied to all site attribute results.

- GREEN indicates site attributes that have met the relevant Performance Criteria or Completion Criteria (indicating that no additional management intervention is required)
- AMBER indicates site attributes that have not met the relevant Performance Criteria or Completion Criteria, but are within 50 - <100% of the targets
- RED indicates site attributes that are <50% of the relevant Performance Criteria or Completion Criteria triggering actions under the TARP.

Table 3: Assessment against WCPL Rehabilitation BioMetric Performance Criteria Benchmarks* for Rehabilitation Sites within their respective BVT

BVT	Site	Vegetation Condition	SVS	Site attributes (% cover)									
				NSR	NOC	NMC	NGCG	NGCS	NGCO	EC	NTH (Count)	OR	FL (M)
HU732	2021_3	Moderate to good -medium	53	38	0	0.5	10	1	0	20	0	0	120
	2021_4	Moderate to good -good	59	25	0	0	13	0	1	21	0	0	36
	R17	Moderate to good - poor	40	30	0	0	0	0	1	35	0	0	0
	R18	Moderate to good -medium	53	23	0	0	13	0	0	23	0	0	31
	R19	Moderate to good -medium	46	36	0	0	3	0	1	37	0	0	0
	R22	Moderate to good - poor	36	20	0	0	31	2	0	11	2	0	0
	R28	Moderate to good -medium	54	25	0	0	7	0	1	30	0	0	100
HU824	2021_6	Low	29	15	0	0	21	0	2	16	0	0	0
	2021_8	Low	29	36	0	0	6	0	1	18	0	0	0
	2023_5	Moderate to good -good	59	43	0	3	14	2	0	4	0	0	62
	R14	Moderate to good - poor	37	25	0	0	1	0	9	16	0	0	48
	R15	Low	30	20	0	0	2	0	0	24	0	0	11
	R21	Low	32	34	0	0	5	0	3	27	0	0	97
	R23	Low	22	28	0	0	1	0	0	21	0	0	0
	R26	Moderate to good -medium	52	30	0.7	1	10	0	2	23	0	0	1
	R27	Low	22	15	0	0	2	0	0	20	0	0	0
	R32	Low	17	6	0	0	11	0	2	32	0	0	0
	R33	Moderate to good - medium	50	9	0	0.5	17	6	8	13	0	0	0
	R35	Low	30	20	0	0	1	0	0	31	0	0	81
	R36	Low	30	25	0	0	2	0	0	18	0	0	30
	R37	Moderate to good -medium	43	19	0	0	11	0	1	2	0	0	49

SVS = Site Value Score, NSR = Native Plant Species Richness, NOC = Native Overstorey Cover, NMC = Native Midstorey Cover, NGCG = Native Ground Stratum Cover (grasses), NGCS = Native Ground Stratum Cover (shrubs), NGCO = Native Ground Stratum Cover (other), EC = Exotic Plant Cover, NTH = Number of Trees with Hollows, OR = Overstorey Regeneration and FL = Length of Fallen Logs

* Rehabilitation BioMetric Performance Criteria was approved by DPIE on June 2021, and is incorporated into the BMP (WCPL, 2021)

Table 4: Assessment against WCPL Rehabilitation BioMetric Completion Criteria * for Rehabilitation Sites within their respective BVT

BVT	Site	Vegetation Condition	SVS	Site attributes (% cover)									
				NSR	NOC	NMC	NGCG	NGCS	NGCO	EC	NTH (Count)	OR	FL (M)
HU732	2021_3	Moderate to good -medium	53	38	0	0.5	10	1	0	20	0	0	120
	2021_4	Moderate to good - poor	37	25	0	0	13	0	1	21	0	0	36
	R17	Moderate to good - poor	22	30	0	0	0	0	1	35	0	0	0
	R18	Moderate to good - poor	35	23	0	0	13	0	0	23	0	0	31
	R19	Low	24	36	0	0	3	0	1	37	0	0	0
	R22	Moderate to good – poor	36	20	0	0	31	2	0	11	0	0	0
	R28	Moderate to good -medium	32	25	0	0	7	0	1	30	0	0	100
HU824	2021_6	Low	29	15	0	0	21	0	2	16	0	0	0
	2021_8	Low	24	36	0	0	6	0	1	18	0	0	0
	2023_5	Moderate to good -good	59	43	0	3	14	2	0	4	0	0	62
	R14	Moderate to good - poor	37	25	0	0	1	0	9	16	0	0	48
	R15	Low	27	20	0	0	2	0	0	24	0	0	11
	R21	Low	32	34	0	0	5	0	3	27	0	0	97
	R23	Low	22	28	0	0	1	0	0	21	0	0	0
	R26	Moderate to good -medium	37	30	0.7	1	10	0	2	23	0	0	1
	R27	Low	22	15	0	0	2	0	0	20	0	0	0
	R32	Low	11	6	0	0	11	0	2	32	0	0	0
	R33	Moderate to good - poor	34	9	0	0.5	17	6	8	13	0	0	0
	R35	Low	30	20	0	0	1	0	0	31	0	0	81
	R36	Low	30	25	0	0	2	0	0	18	0	0	30
	R37	Moderate to good -medium	43	19	0	0	11	0	1	2	0	0	49

SVS = Site Value Score, NSR = Native Plant Species Richness, NOC = Native Overstorey Cover, NMC = Native Midstorey Cover, NGCG = Native Ground Stratum Cover (grasses), NGCS = Native Ground Stratum Cover (shrubs), NGCO = Native Ground Stratum Cover (other), EC = Exotic Plant Cover, NTH = Number of Trees with Hollows, OR = Overstorey Regeneration and FL = Length of Fallen Logs

*Rehabilitation BioMetric Completion Criteria was approved by DPIE on June 2021, and is incorporated into the BMP (WCPL, 2021)

3.1.2. Local Reference Site BioMetric Assessment

BioMetric results for Local Reference Sites monitored during 2024 are presented below (Table 5). SVS has been calculated against the Local Reference Site BVT Data in Table 12 of the BMP (WCPL 2021), to give an indication of local environmental variations throughout 2024.

Table 5: 2024 Reference Site BioMetric Data

Season	Vegetation Community	Site	Site attributes (% cover)										
			SVS	NSR	NOC	NMC	NGCG	NGCS	NGCO	EC	NTH	OR	FL (m)
Autumn 2024	HU547	547 A	72	49	9.3	4	8	1	5	12	1	4	12
Spring 2024	HU547	547 B	87	60	21.7	0	13	2	11	0	1	1	16
Autumn 2024	HU697	697 A	84	64	30	6	19	2	3	0	0	4	22
Spring 2024	HU697	697 B	67	43	18.5	0	5	2	7	0	2	1	17
Autumn 2024	HU732	732 A	87	50	22.5	0	28	0	7	0	1	3	8
Spring 2024	HU732	732B	75	35	33.5	0	1	0	22	23	3	1	15
Autumn 2024	HU824	824 A	73	45	19.5	29.5	18	1	7	0	5	3	59
Spring 2024	HU824	824 B	83	45	11.8	0.8	10	5	9	1	1	1	26
Autumn 2024	HU825	825 A	63	58	34	14.5	8	5	7	0	5	1	18
Spring 2024	HU825	825 B	88	52	28	3	3	0	2	0	1	1	51

NSR = Native Plant Species Richness, NOC = Native Overstorey Cover, NMC = Native Mid storey Cover, NGCG = Native Ground Stratum Cover (grasses), NGCS = Native Ground Stratum Cover (shrubs), NGCO = Native Ground Stratum Cover (other), EC = Exotic Plant Cover, NTH = Number of Trees with Hollows, OR = Overstorey Regeneration and FL = Length of Fallen Logs

3.1.3. Assessment against Performance and Completion Criteria

In 2024, 21 rehabilitation sites were monitored in rehabilitation that is greater than three years old. Five of these sites were monitored for the second consecutive year and their results were compared against the previous monitoring results and the approved Performance and Completion Criteria (Table 3). The remaining 16 sites were established in spring 2024 were monitored for the first time. No yearly comparisons can be made for the 16 newly established sites, but they are still assessed against the approved Performance Criteria (Figure 5 and Figure 6).

Completion Criteria serve as a long-term benchmark guiding management actions and tracking rehabilitation trajectories and are only assessed after 10 years post ecosystem establishment. Whilst the 2024 monitored sites are not assessed against the Completion Criteria due to their age, 20 of the 21 sites monitored exceeded the approved Performance Criteria for SVS scores (Figure 6). Only one site, R32, is below the criteria which is located with rehabilitation that is only seven years old (Figure 6 and Figure 7).

Of the five sites with 2023 data for comparison, minor declines in SVS scores were observed at sites 2021_3, 2021_4, 2021_6 and 2023_5 against the performance criteria, and 2021_4 and 2021_8 against the completion criteria. These declines in SVS scores are predominantly driven by an increase in exotic cover, despite exotic cover remaining within the acceptable limits for both Performance and Completion Criteria. Notably, site 2023_5 showed an improvement in SVS score increasing from 32 in 2023 to 59 in 2024, attributed to an increase in fallen logs and reduced exotic cover. Only three sites met the native species richness benchmark for Performance Criteria. However, all sites are progressing towards meeting the Completion Criteria at the 10 years post ecosystem establishment.

The 16 new sites monitored in 2024 established a baseline SVS (Figure 5 and Figure 6). All sites exceeded the benchmark for Performance Criteria, and all except site R32 are on track to meet the Completion Criteria, given that R32is less than 10 years since ecosystem establishment, this performance is expected and does not trigger any additional actions.

Rehabilitation sites performed similarly to the Local Reference Sites in native ground stratum cover (grasses), native ground stratum cover (shrubs), and exotic cover. Increases in exotic cover at sites 2021_3, 2021_4, 2021_6, 2021_8 and 2023_5 were also observed in four of the five Local Reference Sites monitored during spring. The increase of exotics at both the rehabilitation sites and the Local Reference Sites can be attributed to the above average rainfall during 2024.

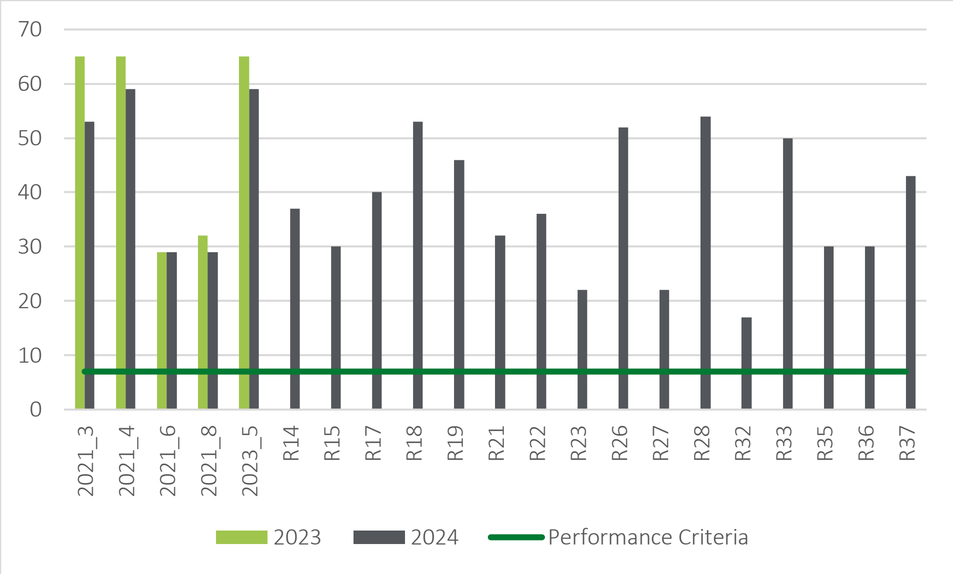

Figure 5: SVS calculated from Rehabilitation BioMetric Performance Criteria 2023-2024

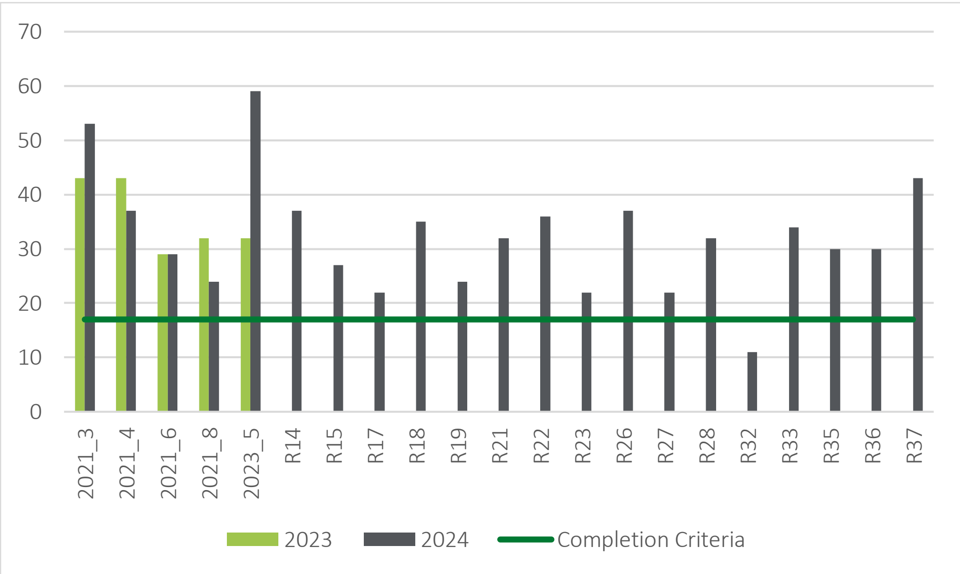

Figure 6: SVS calculated from Rehabilitation BioMetric Completion Criteria 2023-2024

3.1.4. Weeds

Priority weed species, as classified under the *Central Tablelands Regional Strategic Weed Management Plan 2023-2027* (Central Tablelands LLS 2023) were identified at several monitoring sites and during opportunistic rehabilitation walkovers. A summary of priority weeds recorded within the monitoring sites are provided in

Table 6 below, whilst opportunistic observations are documented in the *WCPL 2024 Rehabilitation Management Actions Report* (ELA 2025).

Table 6: Priority weeds recorded in 2024

Scientific Name	Common Name	State Priority Weed	Regional Priority Weed	Sites recorded
Heliotropium amplexicaule	Blue Heliotrope		Y	2021_3, R14, R17, R19, R22, R23, R27, R28, R34, R36
Hypericum perforatum	St John's Wort		Y	Ref_824B, 2021_3, 2021_4, 2021_8, R14, R15, R17, R18, R19, R21, R22, R23, R26, R27, R28, R32, R33, R34, R36, R38
Opuntia stricta	Prickly Pear	Y	Y	Ref 825A, Ref_824B

3.2. Landscape Function Analysis

A self-sustaining ecosystem is considered achieved when LFA scores reach the benchmark of 50 or higher (LFA Completion Criteria) which is expected by Year 10 of the management cycle. The sum of the three LFA indices provides the LFA score for each site. Incremental improvement is anticipated each year, with a minimal annual increase of 5%. Failure to achieve this 5% triggers the implementation of the Landscape Stability LFA TARP, as outlined in Table 21 of the BMP (WCPL 2021).

Sites with LFA scores above 50 are classified as stable, self-sustaining landforms (coloured green) and, as per section 6.2 of the WCPL BMP, no longer require LFA monitoring (Table 7). Sites with LFA scores below 50, or those with a decrease or an increase of less than 5%, are coded red and indicating that TARP actions are required.

The LOI and SSA scores calculated from the spring 2024 LFA monitoring are presented in Table 7 and Figure 7 to Figure 10 below.

3.2.1. Rehabilitation Areas

In 2024, LFA monitoring was conducted at 21 sites with the Rehabilitation. The LOI and SSA scores for these sites are presented in Table 7. Of these, 20 sites are in their first year of LFA monitoring, establishing baseline data. Site 2021_8 is the only site with previous monitoring data.

LFA scores are provided in Table 7, while yearly comparisons of the SSA metrics are illustrated in Figures 8 to 10.

Table 7: LOI and SSA results for Rehabilitation Area transects

Site	Landscape Organisation Index (%)	Soil Surface Assessment			LFA Score (sum of stability, infiltration and nutrient cycling)
		Stability	Infiltration	Nutrient cycling	
2021_3	0.73	76.6	38.7	44.1	159.4
2021_4	0.95	53.6	10.2	11.6	75.4
2021_6	0.99	62.2	26.3	22.9	11.4
2021_8	0.91	50.6	22.1	24.5	97.2
2023_5	0.85	48.8	22.6	21.9	93.3
R14	0.99	52.8	28.8	26.3	107.9
R15	1.00	44.8	34.9	26.7	106.4
R17	0.84	45.6	14.5	16.6	76.7
R18	1.00	47.9	32.9	27	107.8
R19	0.96	50.9	19.4	22.1	92.4
R21	0.96	37.9	20.2	20.5	78.6
R22	0.98	53.6	30.5	25.4	109.5
R23	0.97	48.3	33	24.9	106.2
R26	1.00	56.3	25	26.2	107.5
R27	1.00	49.8	22.5	22.9	95.2
R28	0.79	48	23.7	23.6	95.3
R32	1.00	59.4	30.7	25.6	115.7
R33	1.00	53.3	30.6	25.4	109.3
R35	0.8	48.4	25.2	23.9	97.5
R36	0.72	41.7	18.7	17.4	77.8
R37	0.65	33.9	21.7	11.1	66.7

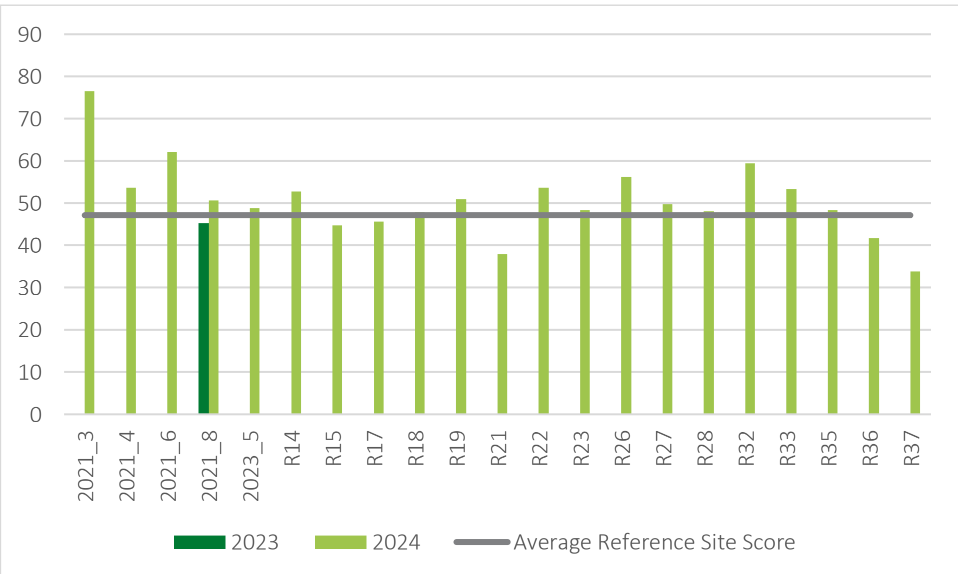

Figure 7: 2023-2024 Stability LFA scores for Rehabilitation sites

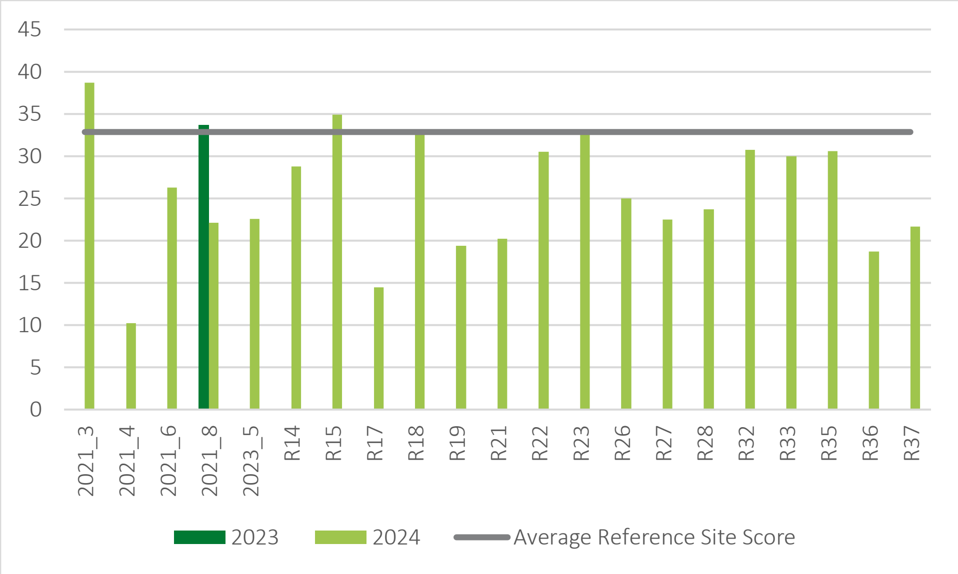

Figure 8: 2023-2024 Infiltration LFA scores for Rehabilitation sites

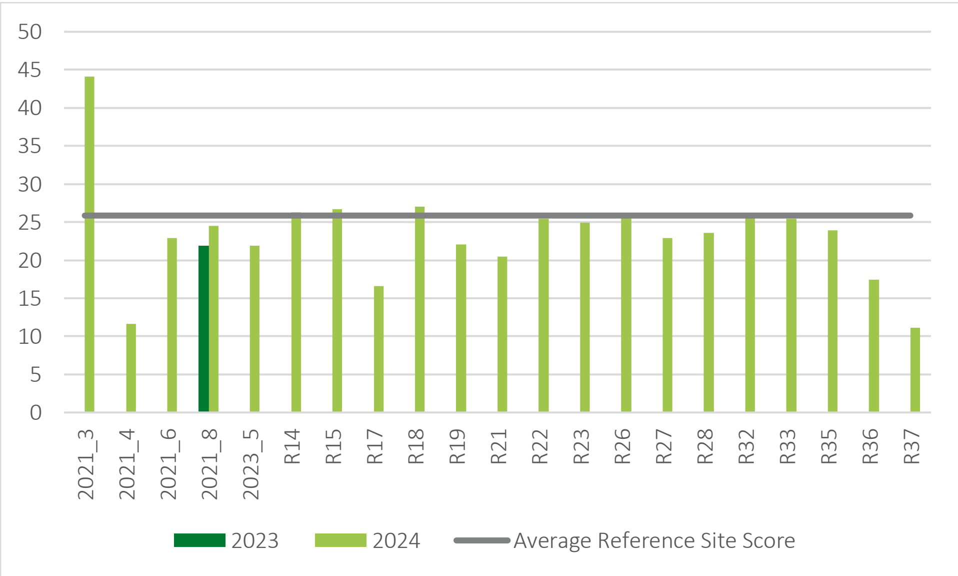

Figure 9: 2023-2024 Nutrient cycling scores for Rehabilitation sites

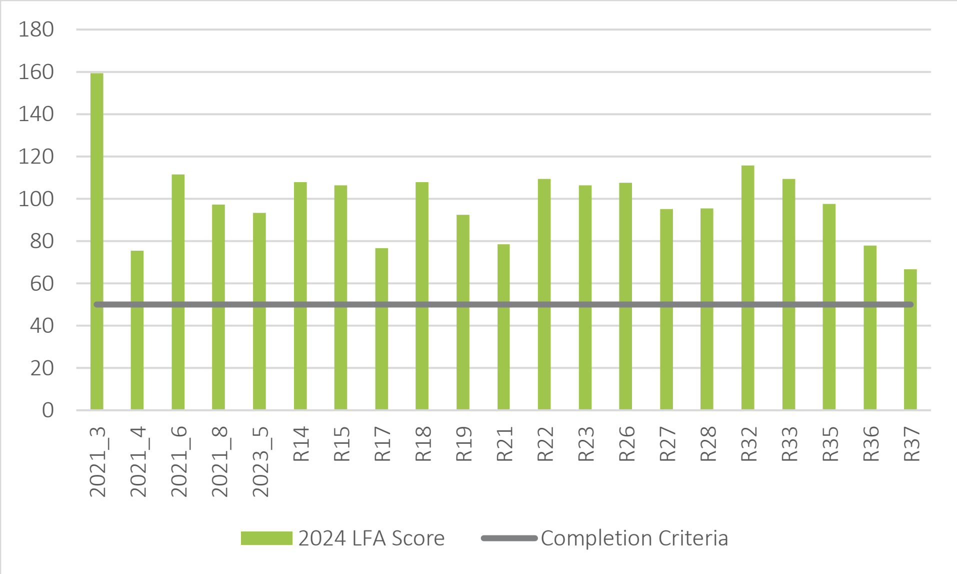

Figure 10: 2024 LFA scores for Rehabilitation sites

Local Reference Sites

LFA monitoring was undertaken at five Local Reference Sites in 2024, with LOI and SSA scores presented in Table 8.

All Local Reference Sites recorded high LOI scores (>0.7), indicating stable landforms. These sites contain stable patches of perennial ground cover and litter, contributing to a self-sustaining ecosystem.

Table 8: LOI and SSA results for Local Reference Sites

Site	Landscape Organisation Index (%)	Soil Surface Assessment			LFA Score (sum of stability, infiltration and nutrient cycling)
		Stability	Infiltration	Nutrient cycling	
Ref_547B	1	41.4	32.7	24.3	98.4
Ref_697B	1	45.4	31.8	29.0	106.2
Ref_732B	1	50.4	32.1	23.8	106.3
Ref_824B	0.74	58.2	37.0	28.1	123.3
Ref_825B	0.86	40.3	30.7	24.1	95.1

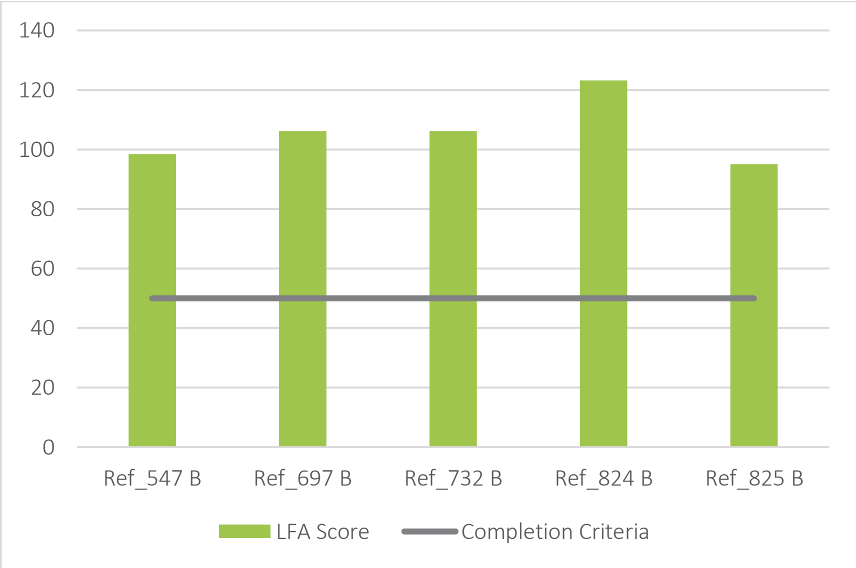

Figure 11: 2024 Local Reference Site LFA scores

3.2.2. Discussion of LFA Monitoring Sites

All 21 sites monitored during 2024 have achieved LFA scores of 50 or above, meeting the criteria outlined in Section 6.2 of the WCPL BMP. These sites are now classified as self-sustaining, stable landforms and no longer require LFA monitoring. However, if in the future, floristic monitoring indicates declining landform stability, reintroducing LFA monitoring at select sites may be recommended. The high LFA scores are attributed to perennial ground cover and litter, which contribute to stability.

For all sites, except 2021_8, this was the first round of LFA monitoring, as such, meaning no yearly comparisons can be made. Spring 2024 monitoring for site 2021_8 showed an increase in LOI from 0.80 in 2023 to 0.91 in 2024, reflecting improved stability and nutrient cycling, despite a decrease in infiltration.

All but one site recorded high LOI scores (>0.72). Site R37 recorded an LOI of 0.65, as it was within rehabilitation only established in 2022, and has yet to develop solid ground cover. Six rehabilitation sites achieved an LOI score of 1, indicating zero bare ground along the monitoring transect.

Infiltration is influenced by litter decomposition, surface roughness and surface nature, while nutrient cycling is affected by perennial vegetation cover, litter cover, litter decomposition, cryptogram cover and soil surface roughness (Tongway and Hindley 2004). Overall, rehabilitation sites exhibited low to high perennial vegetation cover (i.e. grasses) and generally uniform soil micro topography. Dominant patch types included perennial groundcover, bare soil, and litter, consistent with previous years.

3.2.3. Review of LFA results against Trigger Action Response Plan (TARP)

As outlined in the BMP (WCPL 2021), a TARP is triggered if LFA scores do not show a 5% annual improvement towards the respective Completion Criteria. However, since all sites recorded LFA scores above 50, the TARP is not required for implementation.

3.3. Initial establishment monitoring plots established in 2024

Preliminary initial BioMetric monitoring was conducted at four sites (R29, R31, R36 and R37) that were seeded post 2022. The purpose of this initial assessment is to rapidly evaluate vegetation composition, exotic species presence, and erosion risks that may impact rehabilitation progress, guiding early preventative management actions. Seeding was designed to establish these sites as the target BVTs listed in Section 2**Error! Reference source not found.** above.

Vegetation monitoring followed the methods described in Section 2 using 20 x 20m plots to assess early progress. However, full BioMetric monitoring plots are not required until Years 3 – 4 post rehabilitation as per Table 11 of the BMP [WCPL 2021].

3.3.1. Vegetation Monitoring

A total of 88 species were recorded across the four monitoring plots, including 40 native species and 46 exotic species, with a further two (2) species unable to be identified as native or exotic due to insufficient distinguishing features.

Weed cover throughout the four sites ranged from 3% to 39%. Priority weed species classified under the *Central Tablelands Regional Strategic Weed Management Plan 2023-2027* (Central Tablelands LLS 2023), were identified at two of the monitoring sites as presented Table 9.

Table 9 Initial establishment monitoring plot priority weeds

Scientific Name	Common Name	State Priority Weed	Regional Priority Weed	Sites recorded
Heliotropium amplexicaule	Blue Heliotrope		Y	R36
Hypericum perforatum	St John's Wort		Y	R36, R37

3.3.2. Erosion monitoring

Erosion and bare ground were assessed during the initial establishment monitoring. Rehabilitation site R32 showed no signs of erosion or bare ground present, whereas sites R29, R36 and R37 exhibited some erosion and bare ground presence (Figure 12 to Figure 14). Both R29 and R37 showed minor partly stabilised sheet erosion, and R36 exhibited small active gully erosion. Bare ground ranged from 35% to 55% across the three affected sites.

Figure 12: Gully erosion at site R36

Figure 13: Sheet erosion and bare ground at site R29

Figure 14: Sheet erosion and bare ground at site R37

3.4. Fauna Monitoring

Fauna monitoring was undertaken during summer and spring in 2024, with 89 species of fauna recorded comprising birds (73), microbats (1), mammals (4) and reptiles (1).

Five threatened species were recorded, including:

- Climacteris *picumnus victoriae* (Brown Treecreeper [eastern subspecies])
- *Stagonopleura guttata* (Diamond Firetail)
- *Chthonicola sagittatus* (Speckled Warbler)
- *Chalinonolus dwyeri* (Large-eared Pied Bat)
- *Miniopterus orianae oceanensis* (Large Bent-winged Bat)

A complete list of fauna species recorded during the 2024 monitoring program is provided in Appendix F:.

3.4.1. Bird Monitoring

3.4.1.1. Rehabilitation Areas

Bird monitoring was conducted at five sites within the rehabilitation. Sites R6 and R9 have developed a moderately dense shrub and developing canopy layer, providing improved habitat. The remaining three sites have a developing canopy and shrub layer, but still support foraging habitat for birds. R9 recorded a higher overall species richness in 2024 compared to 2023, whereas R6 recorded a decline in overall species richness compared to 2023. *Chthonicola sagittata* (Speckled Warbler), listed as Vulnerable under the NSW BC Act, was recorded at R9.

To improve coverage of the rehabilitation areas, sites 2021_3, 2021_6, and R32 were added to the monitoring program in spring 2024. The number of bird species recorded at each site are shown in Table 10.

Table 10: Species richness recorded during 2024 monitoring at rehabilitation areas

Season	Number of bird species recorded				
	R6	R9	2021_3	2021_6	R32
Summer 2023/2024	20	19	-	-	-
Spring	10	12	13	6	8
Summer 2024/2025	17	14	7	11	6
Overall bird species richness	28	30	18	15	10

Table 11 outlines the nectivorous bird species (i.e. feed on nectar) recorded on rehabilitation sites in 2024. These species serve as surrogates to assess whether the rehabilitation areas and Local Reference Sites can support the critically endangered Regent Honeyeater (*Anthochaera phrygia*) as per section 6.3 of the BMP (2021).

While the Noisy Miner (*Manorina melanocephala*) shares similar habitat and dietary requirements with the Regent Honeyeater, it is a dominant species that outcompetes the Regent Honeyeater in the wild.

The '*Aggressive exclusion of birds from woodland and forest habitat by over-abundant Noisy Miner*' is listed as a key threatening process under both the NSW BC Act and EPBC Act.

Table 11: Nectivorous species recorded at Rehabilitation Sites

Scientific name	Common Name
Caligavis chrysops	Yellow-faced Honeyeater
Lichenostomus penicillatus	White-plumed Honeyeater
Acanthagenys rufogularis	Spiny-cheeked Honeyeater
Lichenostomus leucotis	White-eared Honeyeater
Acanthorhynchus tenuirostris	Eastern Spinebill
Philemon corniculatus	Noisy Friarbird
Dicaeum hirundinaceum	Mistletoebird
Manorina melanocephala	Noisy Miner
Philemon corniculatus	Noisy Friarbird
Anthochaera carunculate	Red Wattlebird

3.4.1.2. Local Reference Sites

Bird survey results for the Local Reference Sites are shown in Table 12. Across the reference area, the number of species ranged from 26 and up to 35 species.

Table 12: Reference Sites bird species richness recorded during 2024 monitoring

Season	Number of bird species recorded				
	Ref 547_B	Ref 697_B	Ref 732_B	Ref 824_B	Ref 825_C
Summer 2023/2024	12	21	18	27	17
Spring	18	23	19	11	16
Summer 2024/2025	20	11	15	13	9
Overall bird species richness	35	34	40	36	26

Table 13 outlines the nectivorous bird species recorded at the Local Reference Sites in 2024. A greater number of nectivores were observed at the Local References Sites compared to the rehabilitation. Likely due to the increased structural elements (increased canopy and shrub cover) that are present at the Local References Sites, that are expected to develop within the rehabilitation over time.

Table 13: Nectivorous species recorded at the Local Reference Sites recorded during 2024 monitoring

Scientific name	Common name
Dicaeum hirundinaceum	Mistletoebird
Philemon corniculatus	Noisy Friarbird
Manorina melanocephala	Noisy Miner
Anthochaera carunculata	Red Wattlebird

Scientific name	Common name
Acanthagenys rufogularis	Spiny-cheeked Honeyeater
Melithreptus brevirostris	Brown-headed Honeyeater
Plectorhyncha lanceolata	Striped Honeyeater
Lichenostomus leucotis	White-eared Honeyeater
Lichenostomus penicillatus	White-plumed Honeyeater
Lichenostomus chrysops	Yellow-faced Honeyeater

3.4.2. Microbat Monitoring

Microbats were monitored during spring 2024 at five rehabilitation sites and five reference sites. A summary of the results is provided in Table 14, with the full ultrasonic analysis report attached as Appendix C:.

A total of 13,907 identifiable call sequences were recorded during the survey. Eight microbat species could be definitely identified based on the call profiles, including one listed threatened species:

- *Chalinolobus dwyeri* (Large-eared Pied Bat [BC Act and EPBC Act])

A further nine species were potentially identified, consisting of probable species classified as the quality and structure of the call profiles are such that there is some probability of confusion with species that produce similar call profiles, and species complexes where the call characteristics overlap making it too difficult to distinguish between species.

Table 14: 2024 Microbat species and species combinations lists by site, as derived from ultrasonic call results for each WCPL site

Scientific Name	Common name	2021_6	R18	R29	R32	R38	REF547B	REF697B	REF732 B	REF824 B	REF825B
Austronomus australis	White-striped Free-tailed Bat	-	-	✓	✓	✓	✓	✓	✓	-	✓
Chalinolobus dwyeri^*	Large-eared Pied Bat	✓	P	-	P	P	✓	✓	✓	✓	✓
Chalinolobus gouldii	Gould's Wattled Bat	✓	✓	-	-	-	✓	✓	✓	✓	✓
Chalinolobus morio	Chocolate Wattled Bat	-	P	✓	✓	✓	✓	P	P	✓	P
Ozimops planiceps	Southern Free-tailed Bat	-	-	P	-	✓	✓	✓	✓	✓	✓
Ozimops ridei	Ride's Free-tailed Bat	-	-	✓	✓	P	✓	✓	✓	✓	P
*Miniopterus orianae oceanensis**	Large Bent-winged Bat	-	-	P	P	P	P	P	P	P	-
Rhinolophus megaphyllus	Eastern Horseshoe Bat	-	-	-	-	-	✓	-	✓	✓	✓
*Vespadelus troughtoni**	Eastern Cave Bat	-	-	-	P	P	P	-	-	-	-
Vespadelus vulturnus	Little Forest Bat	-	-	-	P	-	-	-	✓	-	-
Species Complex											
Chalinolobus gouldii/ Ozimops ridei	Gould's Wattled Bat / Ride's Free-tailed Bat Ride's Free-tailed Bat	-	-	-	-	-	P	P	P	P	-
Chalinolobus gouldii/ Ozimops planiceps/ Ozimops ridei	Gould's Wattled Bat / Southern Free-tailed Bat / Ride's Free-tailed Bat	P	P	P	P	P	P	P	P	P	P
*Chalinolobus morio/ Vespadelus troughtoni**	Chocolate Wattled Bat / Eastern Cave Bat	P	-	-	P	P	P	P	P	P	P
*Chalinolobus morio/ Vespadelus vulturnus/ Vespadelus troughtoni**	Chocolate Wattled Bat / Little Forest Bat / Eastern Cave Bat	P	-	P	P	P	P	P	P	P	P
Chalinolobus gouldii/ Scotorepens balstoni	Gould's Wattled Bat / Inland Broad-Nosed Bat	P	-	-	-	-	P	P	P	P	P
Miniopterus orianae oceanensis/ Vespadelus vulturnus*	Large Bent-winged Bat / Little Forest Bat	P	P	P	P	P	P	P	P	P	P

Scientific Name	Common name	2021_6	R18	R29	R32	R38	REF547B	REF697B	REF732B	REF824B	REF825B
Miniopterus orianae oceanensis/ Vespadelus regulus/ Vespadelus darlingtoni/ Vespadelus vulturnus*	Large Bent-winged Bat / Southern Forest Bat / Large Forest Bat / Little Forest Bat	P	P	P	P	P	P	P	P	P	P
Nyctophilus spp./ Miniopterus macropus	Nyctophilus Species / Little Bent-Wing Bat	-	-	-	P	P	P	P	P	P	P
Ozimops planiceps/ Ozimops ridei	Southern Free-tailed Bat / Ride's Free-tailed Bat	-	P	P	P	P	P	P	P	P	P
Scotorepens balstoni/ Scotorepens rueppellii	Inland Broad-Nosed Bat / South-Eastern Broad-Nosed Bat	P	-	-	-	-	-	-	-	-	-
Scotorepens balstoni/ Scotorepens rueppellii/ Falsistrellus tasmaniensis	Inland Broad-Nosed Bat / South-Eastern Broad-Nosed Bat / Eastern False Pipistrelle	P	-	-	-	-	-	-	-	-	-
Scotorepens rueppellii/ Falsistrellus tasmaniensis/ Scotorepens greyii/ Scotorepens sp.	South-Eastern Broad-Nosed Bat / Eastern False Pipistrelle / Little Broad-Nosed Bat / Scotorepens Species	-	-	-	-	-	P	P	P	P	-
Vespadelus vulturnus/ Chalinolobus morio	Little Forest Bat / Chocolate Wattle Bat	P	-	-	P	P	P	P	P	P	P
Vespadelus darlingtoni/ Vespadelus regulus	Large Forest Bat / Southern Forest Bat	-	-	-	P	-	P	P	P	P	P

✓- definitely present, P – probably present, * - EPBC Act listed, ^ - BC Act listed

3.4.3. Ground Fauna Monitoring

Only one native mammal was recorded within rehabilitation areas, listed in Table 15 below. This is reduced from the 2023 results of three native animals. The other two species previously recorded, the Eastern Banjo Frog (*Limnodynastes dumerilii)* and Spotted Marsh Frog *(Limnodynastes tasmaniensis)* are likely to still be present but missed during 2024 monitoring due to lack of calls during hot weather.

Table 15: Native animal species recorded on rehabilitation areas during 2024 monitoring

Class	*Common Name*	*Scientific Name*	*Site*
Mammal	Eastern Grey Kangaroo	*Macropus giganteus*	R6

Three pest species were recorded on the rehabilitation sites in 2024, as listed in Table 16 below. This marks a decrease from five pest species recorded during the 2023 monitoring. All species in Table 16, except Brown Hare are classified as priority pest species in the region (LLS 2018) and should be managed accordingly. In 2023 European Red Fox (*Vulpes vulpes*) and Wild Rabit (*Oryctolagus cuniculus*) were observed, but there were no signs present during 2024 monitoring.

Table 16: Feral animal species recorded on rehabilitation areas during 2024 monitoring

Class	*Common Name*	*Scientific Name*	*Site*	*Count*
Mammal	*Feral Pig*	*Sus scrofa*	R18	1
			R22	6
			R31	*1*
Mammal	*Brown Hare*	*Lepus europaeus*	R9	1
Mammal	*Fallow Deer*	*Dama dama*	R22	3
			R29	3

As outlined in the BMP (WCPL 2021), '*Control of feral fauna populations is considered essential to the success of any revegetation/regeneration works as these species have the potential to damage establishing vegetation through grazing and/or tramping*'. Existing management plans targeting Feral Pigs should continue to ensure populations remain low. Fallow Deer, which were recorded in 2023 in a herd of 10 at R9, were again observed in 2024, with a herd of 3 individuals within R22 and R29. This species poses a significant threat to shrubs and trees, requiring ongoing monitoring and management.

3.4.4. Local Reference sites

Two native animals were recorded at reference sites and are listed in Table 17 below. This is a decrease from the 2023 results where six species were recorded

Table 17: Native animal species recorded at reference sites during 2024 monitoring

Class	Common Name	Scientific Name	Site
Mammal	Eastern Grey Kangaroo	*Macropus giganteus*	Ref_697B, Ref_82B
Reptile	Lace Monitor	*Varanus varius*	Ref_732B, Ref_547B

No pest animals were recorded at the reference sites, however, given that European Red Fox and Fallow Deer were recorded in 2023, it is likely that these species are may still be present.

A complete fauna species list in provided in Appendix F:.

4. 2024 BioMetric Monitoring Summary

4.1. Rehabilitation Site Performance Against Criteria

- All monitored rehabilitation sites less than 10 years old and assessed against the Performance Criteria.
- All sites exceeded the SVS benchmark of 7, and all but one are on track to meet the Completion Criteria benchmark of 17, which applies to rehabilitation older than 10 years.
- Sites R6 and R9 are currently the only rehabilitation sites greater than 10 years old and will be assessed against Completion Criteria in 2025.

4.1.1. Overstorey Cover & Species Richness

- No site met the Performance Criteria for native overstorey cover, with all but R26 (0.7%) recording 0% cover.
- Sites 2021_3, 2021_4, 2021_6, and 2021_8 showed similar results to 2023 for species richness and native species cover.
- A slight increase in exotic plant cover was recorded but remained within the Completion Criteria. The increase is likely due to above-average rainfall in 2024 compared to the drier 2023 conditions.

4.1.2. Midstory Cover & Fallen Logs

- Site 2023_5 maintained consistent SVS scores but recorded a decrease in native midstory cover from 18.1% in 2023 to 3% in 2024.
- Ten of the 21 sites assessed against the Performance Criteria met the benchmark for native midstory cover.
- Twelve monitoring sites met the benchmark for fallen logs, while 9 sites did not. These sites could achieve the required benchmark through selective placement of habitat logs. Site 2023_5 fallen logs increased from 25m to 62m, meeting both the Performance and Completion Criteria.

4.1.3. Landscape Function Analysis (LFA) Monitoring

- All monitored sites exceeded the LFA score of 50, meaning LFA monitoring is no longer required at these sites (as per Section 6.2 of the WCPL BMP).
- Future reinstatement of LFA monitoring at sites which have exceeded an LFA score of 50 may be recommended if vegetation cover declines, soil stability decreases, or erosion is observed.
- Erosion observations will continue to be recorded during monitoring to guide management actions.

4.1.4. Recommendation to Discontinue LFA Monitoring

It is recommended that WCPL consider moving away from LFA monitoring due to:

- Potential erosion risks may exist outside monitoring transects and can be assessed visually.
- Soil function and litter incorporation assessments can be conducted separately and do not need annual monitoring.

- No rehabilitation objectives or completion criteria are linked to this monitoring method.

4.1.5. Initial Establishment Monitoring – 2024

- All sites exceeded native species richness benchmarks for Performance Criteria.
- R36 and R38 recorded native overstorey species within the 20 × 20m plot, while overstorey species were also observed in the larger 20 × 50m plot.
- Strong native shrub diversity and cover were recorded at all four sites.
- Exotic plant cover remained within Performance and Completion Criteria. Weed management is recommended to maintain compliance and support native plant establishment.
- Gully erosion was observed at R36 and should be remediated to prevent worsening.
- Bare ground should continue to be monitored, and additional native cover crops may be introduced to improve stability and increase native ground cover.

4.1.6. Ongoing Monitoring Recommendations for BioMetric Monitoring Plots

Continue monitoring as per the BMP, with a focus on:

- Canopy species progression at all monitoring sites.
- Weed and pest management throughout rehabilitation.

4.1.7. Fauna Monitoring – 2024

4.1.7.1. Bird Surveys

- Bird species richness in rehabilitation areas was comparable to 2023.
- R6 recorded a slight decline, while R9 recorded an increase in species richness.
- Sites 2021_4 and 2021_6, despite their younger age, recorded good species diversity, indicating that the rehabilitation provides suitable foraging habitat.
- R32 recorded the lowest species diversity, but this is expected due to its early stage of development.
- The presence of nectivorous bird species suggests that the rehabilitation may function as suitable habitat for the Regent Honeyeater in the long term.
- Flowering eucalypts have been observed in the more established rehabilitation areas.

4.1.7.2. Microbat Monitoring

- Up to 17 microbat species were recorded during spring surveys, including a confirmed recording of one species listed as Vulnerable under the BC Act and EPBC Act.
- Microbat presence suggests that the rehabilitation is being utilised for foraging, although tree immaturity and lack of old growth hollows limit roosting opportunities.
- Microbat species richness has maintained since 2023, indicating consistency of habitat suitability over time.

4.1.7.3. Ground Fauna Monitoring

Ground fauna species richness declined in 2024 compared to 2023.

This decline may be due to:

- Later timing of monitoring in the year.
- Monitoring being condensed into one season instead of autumn and spring.
- To improve the scope of ground fauna monitoring, it is recommended to continue reptile ground searches, and introduce the use of infra-red cameras once the rehabilitation matures.

4.1.7.4. Pest Species Management

- Ongoing pest species observations in rehabilitation areas highlight potential threats to revegetation success.
- Management should remain a priority to reduce pest species presence and protect rehabilitation progress.

4.2. Key Recommendations:

- Maintain ongoing rehabilitation monitoring to track progress toward Completion Criteria.
- Monitor weed and pest species presence to prevent competition with native vegetation.
- Implement erosion remediation at R36 and consider additional native cover crop planting in areas with significant bare ground.
- Discontinue LFA monitoring, but continue erosion assessments through floristic monitoring. Significant erosion and land stability issues will continue to be monitored through visual assessments.
- Continue microbat monitoring and explore the potential for infra-red camera monitoring for ground fauna as the rehabilitation matures.
- Review WCPL rehabilitation objectives to determine if target BVT composition and structure rehabilitation objectives and completion criteria are required.
- Consider potential infill plantings at monitoring sites where canopy cover is below the Performance Criteria benchmark.
- Consider a review of rehabilitation objectives to determine if the current monitoring methodology accurately assesses the target BVT composition in accordance with required WCPL rehabilitation objectives.

5. References

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Appendix A: Weather Conditions

Table 18: 2024 Monthly mean and historical average weather conditions

Month	2024 Averages (WCPL)			Historical Averages		
	Mean min. temp (°C)	Mean max. temp (°C)	Total Rainfall (mm)	Mean min. temp (°C)	Mean max. temp (°C)	Total Rainfall (mm)
January	18.8	30.9	86.6	15.5	31.1	67.2
February	18.7	31.2	78.6	15.4	30.2	62.2
March	15.1	28.7	32.8	13.0	27.8	55.2
April	9.1	23.2	67.8	8.5	23.3	39.3
May	6.8	19.4	62.2	5.0	18.8	37.2
June	3.5	15.3	68.6	2.6	15.2	44.0
July	4.0	14.4	65.0	1.3	14.4	43.0
August	6.1	19.1	39.8	2.3	16.0	41.1
September	5.4	21.4	45.4	4.4	19.6	41.7
October	10.0	23.7	51.0	7.6	23.4	52.1
November	15.2	28.9	116.6	10.8	26.9	57.0
December	18.5	31.8	30.8	13.7	29.8	60.9
TotaL			745.2			600.9

Source: 2024 data from the WCPL Weather Station Sentinex 34 provided 19 December 2024, historical data from the BoM weather stations at Mudgee Airport (temp) and Wollar-Barigan St weather station (rainfall) (BOM 2024)

Appendix B: Biodiversity Monitoring Sites

Table 19: Rehabilitation and reference monitoring sites

Domain	Site	Vegetation Class	Easting	Northing
Rehabilitation	R6	Generic Woodlan	769566	6419516
	R9	Generic Woodland	769120	6418969
	2021_1	HU 697	769385	6418808
	2021_2	HU 697	769629	6418160
	2021_3	HU732	767926	6417731
	2021_4	HU732	767571	6418373
	2021_6	HU 824	769464	6420638
	2021_5	HU 732	769504	6420477
	2021_7	HU 824	769290	6419007
	2021_8	HU 824	769565	6418209
	2023_1	HU 732	768064	6416986
	2023_4	HU 732	769083	6417235
	2023_5	HU 824	774128	6417400
	2023_7	HU 697	769623	6418575
	R14	HU697	768884	6420462
	R15	HU697	768675	6420146
	R16	HU697	*To be established during 2025 monitoring	
	R17	HU732	767090	6418544
	R18	HU732	767876	6418828
	R19	HU732	768171	6419172
	R20	HU697	*To be established during 2025 monitoring	
	R21	HU697	769466	6419915
	R22	HU732	768971	6419800
	R23	HU697	769708	6419896
	R24	Generic Woodland	*To be established during 2025 monitoring	
	R25	Generic Woodland	*To be established during 2025 monitoring	
	R26	HU697	769319	6417949
	R27	HU697	769566	6419516
	R28	HU732	768178	6417988
	R29	HU697	770411	6416627
	R30	HU697	769566	6419516
	R31	HU697	768372	6420539
	R32	HU824	772527	6418768
	R33	HU824	771674	6419463
	R34	HU824	771871	6417883
	R35	HU824	768248	6420826
	R36	HU824	774188	6417700
	R37	HU824	773835	6418770
	R38	HU824	773781	6418154
	R39	Generic Woodland	*To be established during 2025 monitoring	
Local Reference Sites	Ref_547A	BVT547		

Domain	Site	Vegetation Class	Easting	Northing
	Ref_697A	BVT697		
	Ref_732A	BVT732		
	Ref_824A	BVT824		
	Ref_825A	BVT825		
	Ref_547B	BVT547	778934	778934
	Ref_697B	BVT697	751096	751096
	Ref_732B	BVT732	769183	769183
	Ref_824B	BVT824	769159	769159
	Ref_825B	BVT825	775163	775163

*Locations for sites are currently proposed as indicative locations and the exact location will be determined during monitoring completed in 2025 in the field.

Appendix C: Microbat Ultrasonic Analysis Report

Appendix D: Flora Species List

Scientific Name	Native/Exotic	Family
Acacia baileyana	Native	Fabaceae (Mimosaceae)
Acacia brownii	Native	Fabaceae (Mimosaceae)
Acacia buxifolia	Native	Fabaceae (Mimosaceae)
Acacia dealbata	Native	Fabaceae (Mimosaceae)
Acacia deanei	Native	Fabaceae (Mimosaceae)
Acacia decora	Native	Fabaceae (Mimosaceae)
Acacia doratoxylon	Native	Fabaceae (Mimosaceae)
Acacia falcata	Native	Fabaceae (Mimosaceae)
Acacia floribunda	Native	Fabaceae (Mimosaceae)
Acacia gladiiformis	Native	Fabaceae (Mimosaceae)
Acacia hakeoides	Native	Fabaceae (Mimosaceae)
Acacia hakeoides	Native	Fabaceae (Mimosaceae)
Acacia implexa	Native	Fabaceae (Mimosaceae)
Acacia ixiophylla	Native	Fabaceae (Mimosaceae)
Acacia leucolobia	Native	Fabaceae (Mimosaceae)
Acacia linearifolia	Native	Fabaceae (Mimosaceae)
Acacia montana	Native	Fabaceae (Mimosaceae)
Acacia penninervis var. penninervis	Native	Fabaceae (Mimosaceae)
Acacia polybotrya	Native	Fabaceae (Mimosaceae)
Acacia sp.	Native	Fabaceae (Mimosaceae)
Acacia spectabilis	Native	Fabaceae (Mimosaceae)
Acacia triptera	Native	Fabaceae (Mimosaceae)
Aceana ovina	native	Rosaceae
Acrotriche rigida	Native	Ericaceae (Epacridoideae)
Adonis vernalis	Exotic	Ranunculaceae
Aira cupaniana	Exotic	Poaceae
Ajuga australis	Native	Lamiaceae
Allocasuarina gymnanthera	Native	Casuarinaceae
Allocasuarina luehmannii	Native	Casuarinaceae
Alternanthera pungens	Exotic	Amaranthaceae
Ammi majus	Exotic	Apiaceae
Amyema miquelii	Native	Loranthaceae
Angophora floribunda	Native	Myrtaceae
Anthosachne scabra	Native	Poaceae
Aristida ramosa	Native	Poaceae
Aristida vagans	Native	Poaceae
Arthropodium fimbriatum	Native	Asparagaceae
Arthropodium minus	Native	Asparagaceae
Arthropodium strictum	Native	Asparagaceae
Arundinella nepalensis	Native	Poaceae
Asparagus aethiopicus	Exotic	Asparagaceae
Asperula conferta	Native	Rubiaceae
Aster subulatus	Exotic	Asteraceae

Scientific Name	Native/Exotic	Family
Astroloma humifusum	Native	Ericaceae (Epacridoideae)
Austrostipa ramosissima	Native	Poaceae
Austrostipa scabra	Native	Poaceae
Austrostipa scabra subsp. scabra	Native	Poaceae
Austrostipa sp.	Native	Poaceae
Austrostipa verticillata	Native	Poaceae
Avena fatua	Exotic	Poaceae
Bidens subalternans	Exotic	Asteraceae
Billardiera scandens	Native	Pittosporaceae
Bothriochloa macra	Native	Poaceae
Brachychiton populneus	Native	Malvaceae
Brachyloma daphnoides	Native	Ericaceae (Epacridoideae)
Brassica sp.	Native/exotic	Brassiaceae
Briza maxima	Exotic	Poaceae
Briza minor	Exotic	Poaceae
Bromus catharticus	Exotic	Poaceae
Bromus diandrus	Exotic	Poaceae
Bromus hordeaceus	Exotic	Poaceae
Bursaria spinosa	Native	Pittosporaceae
Callitris endlicheri	Native	Cupressaceae
Calotis cuneifolia	Native	Asteraceae
Calotis lappulacea	Native	Asteraceae
Calytrix tetragona	Native	Myrtaceae
Capsella bursa-pastoris	Exotic	Brassicaceae
Carduus pycnocephalus	Exotic	Asteraceae
Carex appressa	Native	Cyperaceae
Carex inversa	Native	Cyperaceae
Carthamus lanatus	Exotic	Asteraceae
Cassinia quinquefaria	Native	Asteraceae
Cassinia sifton	Native	Asteraceae
Cassytha pubescens	Native	Lauraceae
Caucalis platycarpus	Exotic	Apiaceae
Centaurea melitensis	Exotic	Asteraceae
Centaurea solstitialis	Exotic	Asteraceae
Centaurea sp.	Exotic	Asteraceae
Centaurium sp.	Exotic	Gentianaceae
Centaurium tenuiflorum	Exotic	Gentianaceae
Cerastium glomeratum	Exotic	Caryophyllaceae
Cheilanthes austrotenuifolia	Native	Pteridaceae
Cheilanthes sieberi	Native	Pteridaceae
Cheiranthera linearis	Native	Pittosporaceae
Chloris gayana	Exotic	Poaceae
Chloris truncata	Native	Poaceae
Chloris ventricosa	Native	Poaceae
Chondrilla juncea	Exotic	Asteraceae

Scientific Name	Native/Exotic	Family
Chrysocephalum apiculatum	Native	Asteraceae
Cineraria lyratiformis	Exotic	Asteraceae
Cirsium arvense	Exotic	Asteraceae
Cirsium vulgare	Exotic	Asteraceae
Clematis aristata	Native	Ranunculaceae
Convolvulus sp.	Native/exotic	Convolvulaceae
Convolvulus erubescens	Native	Convolvulaceae
Conyza bonariensis	Exotic	Asteraceae
Conyza sp.	Exotic	Asteraceae
Conyza sumatrensis	Exotic	Asteraceae
Correa reflexa var. reflexa	Native	Rutaceae
Cotula australis	Native	Asteraceae
Cyclospermum leptophyllum	Exotic	Apiaceae
Cymbonotus lawsonianus	Native	Asteraceae
Cymbopogon refractus	Native	Poaceae
Cynodon dactylon	Native	Poaceae
Cynoglossum australe	Native	Boraginaceae
Cynoglossum creticum	Native	Boraginaceae
Cyperus eragrostis	Exotic	Cyperaceae
Cyperus gracilis	Native	Cyperaceae
Cyperus sp.	Native/exotic	Cyperaceae
Daucus glochidiatus	Native	Apiaceae
Dianella caerulea	Native	Asphodelaceae
Dianella longifolia	Native	Phormiaceae
Dianella revoluta	Native	Phormiaceae
Dichanthium sericeum	Native	Poaceae
Dichelachne micrantha	Native	Poaceae
Dichondra repens	Native	Convolvulaceae
Digitaria breviglumis	Native	Poaceae
Digitaria diffusa	Native	Poaceae
Digitaria parviflora	Native	Poaceae
Digitaria sp.	Native/exotic	Poaceae
Dittrichia graveolens	Exotic	Asteraceae
Dodonaea viscosa	Native	Sapindaceae
Dysphania pumilo	Native	Chenopodiaceae
Echinochloa sp.	Exotic	Poaceae
Echinopogon caespitosum	#N/A	#N/A
Echium plantagineum	Exotic	Boraginaceae
Einadia hastata	Native	Chenopodiaceae
Einadia nutans	Native	Chenopodiaceae
Einadia polygonoides	Native	Chenopodiaceae
Einadia sp.	Native	Chenopodiaceae
Einadia trigonos	Native	Chenopodiaceae
Eleusine tristachya	Exotic	Poaceae
Enchylaena tomentosa	Native	Amaranthaceae

Scientific Name	Native/Exotic	Family
Entolasia stricta	Native	Poaceae
Eragrostis brownii	Native	Poaceae
Eragrostis cilianensis	Native	Poaceae
Eragrostis curvula	Exotic	Poaceae
Eragrostis curvula var. console	Exotic	Poaceae
Eragrostis leptostachya	Native	Poaceae
Eragrostis sp.	Native/exotic	Poaceae
Eremophila debilis	Native	Scrophulariaceae
Erigeron bonariensis	Exotic	Asteraceae
Erigeron canadensis	Exotic	Asteraceae
Eriochloa crebra	Native	Poaceae
Eriochloa pseudoacrotricha	Native	Poaceae
Eriochloa trichous	Native	Poaceae
Erodium crinitum	Native	Geraniaceae
Erodium sp.	Native/exotic	Poaceae
Eucalyptus albens	Native	Myrtaceae
Eucalyptus blakelyi	Native	Myrtaceae
Eucalyptus conica	Native	Myrtaceae
Eucalyptus crebra	Native	Myrtaceae
Eucalyptus fibrosa	Native	Myrtaceae
Eucalyptus melliodora	Native	Myrtaceae
Eucalyptus moluccana	Native	Myrtaceae
Eucalyptus polyanthemos	Native	Myrtaceae
Eucalyptus punctata	Native	Myrtaceae
Eucalyptus sideroxylon	Native	Myrtaceae
Eucalyptus sp.	Native	Myrtaceae
Euchiton sp.	Native	Asteraceae
Euchiton sphaericus	Native	Asteraceae
Euphorbia drummondii	Native	Euphorbiaceae
Exocarpos strictus	Native	Santalaceae
Festuca sp	#N/A	#N/A
Fimbristylis dichotoma	Native	Cyperaceae
Gahnia aspera	Native	Cyperaceae
Galium leiocarpum	Native	Rubiaceae
Galium sp.	Native/exotic	Rubiaceae
Gamochaeta americana	Exotic	Asteraceae
Gamochaeta calviceps	Exotic	Asteraceae
Gamochaeta filaginea	Exotic	Asteraceae
Gamochaeta sp.	Exotic	Asteraceae
Geranium molle	Exotic	Geraniaceae
Geranium solanderi	Native	Geraniaceae
Geranium sp.	Native/exotic	Geraniaceae
Glossocardia bidens	Native	Asteraceae
Glycine clandestina	Native	Fabaceae (Faboideae)
Glycine tabacina	Native	Fabaceae (Faboideae)

Scientific Name	Native/Exotic	Family
Gonocarpus elatus	Native	Haloragaceae
Goodenia hederacea	Native	Goodeniaceae
Goodenia ovata	Native	Goodeniaceae
Goodenia paniculata	Native	Goodeniaceae
Grona varians	Native	Fabaceae (Faboideae)
Haloragis heterophylla	Native	Haloragaceae
Hardenbergia violacea	Native	Fabaceae (Faboideae)
Helianthus annuus	Exotic	Asteraceae
Heliotropium amplexicaule	Exotic	Boraginaceae
Hemigenia cuneifolia	Native	Lamiaceae
Hibbertia acicularis	Native	Dilleniaceae
Hibbertia circumdans	Native	Dilleniaceae
Hibbertia sp.	Native	Dilleniaceae
Hordeum sp.	Exotic	Poaceae
Hydrocotyle laxiflora	Native	Araliaceae
Hyparrhenia hirta	Exotic	Poaceae
Hypericum gramineum	Exotic	Hypericaceae
Hypericum perforatum	Exotic	Hypericaceae
Hypericum ramaneum	Exotic	Hypericaceae
Hypochaeris glabra	Exotic	Asteraceae
Hypochaeris radicata	Exotic	Asteraceae
Indigofera adesmiifolia	Native	Fabaceae (Faboideae)
Jacobaea erucifolia	Exotic	Asteraceae
Juncus bufonius	Native	Juncaceae
Juncus filicaulis	Native	Juncaceae
Juncus homalocaulis	Native	Juncaceae
Juncus sp.	Native/exotic	Juncaceae
Juncus subsecundus	Native	Juncaceae
Juncus usitatus	Native	Juncaceae
Lachnagrostis filiformis	Native	Poaceae
Lactuca saligna	Exotic	Asteraceae
Lactuca serriola	Exotic	Asteraceae
Laxmannia gracilis	Native	Anthericaceae
Lepidium africanum	Exotic	Brassicaceae
Lepidium bonariense	Exotic	Brassicaceae
Lepidosperma laterale	Native	Cyperaceae
Leucopogon muticus	Native	Ericaceae (Epacridoideae)
Linum bienne	Exotic	Linaceae
Linum sp.	Native/exotic	Linaceae
Linum trigynum	Exotic	Linaceae
Linum usitatissimum	Exotic	Linaceae
Lissanthe strigosa	Native	Ericaceae (Epacridoideae)
Lolium perenne	Exotic	Poaceae
Lolium perenne	#N/A	#N/A
Lomandra confertifolia	Native	Lomandraceae

Scientific Name	Native/Exotic	Family
Lomandra filiformis	Native	Lomandraceae
Lomandra filiformis subsp. coriacea	Native	Lomandraceae
Lomandra glauca	Native	Lomandraceae
Lomandra multiflora	Native	Lomandraceae
Lomandra multiflora subsp. multiflora	Native	Lomandraceae
Lotus angustissimus	Exotic	Fabaceae (Faboideae)
Leucopogon muticus	Native	Epacridaceae
Lysimachia arvensis	Exotic	Primulaceae
Lythrum hyssopifolia	Native	Lythraceae
Lythrum hyssopifolium	Native	Lythraceae
Macrozamia secunda	Native	Zamiaceae
Malva parviflora	Exotic	Malvaceae
Malvastrum coromandelianum	Exotic	Malvaceae
Marrubium vulgare	Exotic	Lamiaceae
Medicago sp.	Exotic	Fabaceae (Faboideae)
Melaleuca thymifolia	Native	Myrtaceae
Melia azedarach	Native	Meliaceae
Melichrus erubescens	Native	Ericaceae (Epacridoideae)
Melichrus urceolatus	Native	Ericaceae (Epacridoideae)
Mentha diemenica	Native	Lamiaceae
Mentha saturodies	Native	Lamiaceae
Microlaena stipoides	Native	Poaceae
Microtis parviflora	Native	Orchidaceae
Modiola caroliniana	Exotic	Malvaceae
Monotoca scoparia	Native	Ericaceae (Epacridoideae)
Notelaea microcarpa	Native	Oleaceae
Oenothera indecora	Exotic	Onagraceae
Olearia elliptica	Native	Asteraceae
Opercularia diphylla	Native	Rubiaceae
Opercularia hispida	Native	Rubiaceae
Opuntia sp.	Exotic	Cactaceae
Opuntia stricta	Exotic	Cactaceae
Orchidaceae sp.	Native	Orchidaceae
Oxalis perennans	Native	Oxalidaceae
Oxytes brachypoda	Native	Fabaceae (Faboideae)
Ozothamnus diosmifolius	Native	Asteraceae
Panicum effusum	Native	Poaceae
Panicum miliaceum	Exotic	Poaceae
Paronychia brasiliana	Exotic	Carophyllaceae
Paspalidium distans	Native	Poaceae
Paspalidium sp.	Native	Poaceae
Paspalum dilatatum	Exotic	Poaceae
Paspalum sp	Exotic	Poaceae
Patersonia sericea	Native	Iridaceae

Scientific Name	Native/Exotic	Family
Persicaria prostrata	Native	Polygonaceae
Persoonia linearis	Native	Proteaceae
Petrorhagia dubia	Exotic	Caryophyllaceae
Phalaris aquatica	Exotic	Poaceae
Phyllanthus sp.	Native/exotic	Phyllanthaceae
Phyllanthus virgatus	Native	Phyllanthaceae
Phytolacca octandra	Exotic	Phytolaccaceae
Pimelea linifolia	Native	Thymelaeaceae
Pimelea sp.	Native	Thymelaeaceae
Plantago debilis	Native	Plantaginaceae
Plantago lanceolata	Exotic	Plantaginaceae
Poa sieberiana	Native	Poaceae
Poaceae sp.	Native/exotic	Poaceae
Polygonum aviculare	Exotic	Polygonaceae
Pomax umbellata	Native	Rubiaceae
Poranthera microphylla	Native	Phyllanthaceae
Pterostylis sp	Native	Orchidaceae
Pultenaea microphylla	Native	Fabaceae (Faboideae)
Pultenaea sp.	Native	Fabaceae (Faboideae)
Raphanus raphanistrum	Exotic	Brassicaceae
Rapistrum rugosum	Exotic	Brassicaceae
Richardia stellaris	Exotic	Rubiaceae
Rubus sp	Exotic	Rosaceae
Rumex acetosella	Exotic	Polygonaceae
Rumex brownii	Native	Polygonaceae
Rytidosperma caespitosum	Native	Poaceae
Rytidosperma pallidum	Native	Poaceae
Rytidosperma racemosum	Native	Poaceae
Rytidosperma sp.	Native	Poaceae
Salsola australis	Native	Chenopodiaceae
Salsola sp.	Native	Chenopodiaceae
Salvia verbenaca	Exotic	Lamiaceae
Sannantha cunninghamii	Native	Myrtaceae
Schoenus ericetorum	Native	Cyperaceae
Scutellaria humilis	Native	Lamiaceae
Scutellaria lateriflora	Native	Lamiaceae
Senecio hispidulus	Native	Asteraceae
Senecio quadridentatus	Native	Asteraceae
Senecio sp.	Native/exotic	Asteraceae
Senna sp.	Native	Fabaceae (Caesalpinioideae)
Setaria parviflora	Exotic	Poaceae
Setaria pumila	Exotic	Poaceae
Sida corrugata	Native	Malvaceae
Sida rhombifolia	Exotic	Malvaceae
Sida spinosa	Exotic	Malvaceae

Scientific Name	Native/Exotic	Family
Sigesbeckia orientalis	Native	Asteraceae
Silene sp.	Exotic	Caryophyllaceae
Sisymbrium officinale	Exotic	Brassicaceae
Sisyrinchium micranthum	Exotic	Iridaceae
Sisyrinchium rosulatum	Exotic	Iridaceae
Solanum brownii	Native	Solanaceae
Solanum campanulatum	Native	Solanaceae
Solanum cinereum	Exotic	Solanaceae
Solanum nigrum	Exotic	Solanaceae
Solenogyne bellioides	Native	Asteraceae
Solenogyne sp.	Native	Asteraceae
Sonchus asper	Exotic	Asteraceae
Sonchus oleraceus	Exotic	Asteraceae
Sonchus sp.	Native/exotic	Primulaceae
Sporobolus creber	Native	Poaceae
Stackhousia monogyna	Native	Stackhousiaceae
Stackhousia viminea	Native	Stackhousiaceae
Stellaria media	Exotic	Caryophyllaceae
Styphelia triflora	Native	Ericaceae (Epacridoideae)
Swainsona galegifolia	Native	Fabaceae (Faboideae)
Swainsona sp.	Native	Fabaceae (Faboideae)
Taraxacum officinale	Exotic	Asteraceae
Themeda australis	Native	Poaceae
Themeda triandra	Native	Poaceae
Thysanotus patersonii	Native	Asparagaceae
Tolpis barbata	Exotic	Asteraceae
Trema tomentosa	Native	Cannabaceae
Tricoryne elatior	Native	Anthericaceae
Trifolium angustifolium	Exotic	Fabaceae (Faboideae)
Trifolium arvense	Exotic	Fabaceae (Faboideae)
Trifolium campestre	Exotic	Fabaceae (Faboideae)
Trifolium repens	Exotic	Fabaceae (Faboideae)
Trifolium sp.	Exotic	Fabaceae (Faboideae)
Trifolium vesiculosum	Exotic	Fabaceae (Faboideae)
Urochloa panicoides	Exotic	Poaceae
Urtica urens	Exotic	Urticaceae
Verbena bonariensis	Exotic	Verbenaceae
Veronica plebeia	Native	Plantaginaceae
Vittadinia cuneata	Native	Asteraceae
Vittadinia muelleri	Native	Asteraceae
Vulpia bromoides	Exotic	Poaceae
Vulpia sp.	Exotic	Poaceae
Wahlenbergia communis	Native	Campanulaceae
Wahlenbergia communis	Native	Campanulaceae
Wahlenbergia gracilis	Native	Campanulaceae

Scientific Name	Native/Exotic	Family
Wahlenbergia sp	Native	Campanulaceae
Wahlenbergia sp.	Native	Campanulaceae
Xanthium occidentale	Exotic	Asteraceae

Appendix E: BioMetric Performance and Completion Criteria (Rehabilitation Monitoring)

Table 12 Biometric Performance & Completion Criteria

<table>
<tr><th>Attribute (WCPL2021)</th><th>BVT</th><th colspan="2">Native Plant Species Richness MIN-MAX (No. species)</th><th colspan="2">Native Over Storey Cover MIN-MAX (%)[7]</th><th colspan="2">Native Mid – Storey Cover MIN-MAX (%)</th><th colspan="2">Native Ground Cover Grass MIN-MAX (%)</th><th colspan="2">Native Ground Cover Shrubs MIN-MAX (%)</th><th colspan="2">Native Ground Cover Other MIN-MAX (%)</th><th>Number of Trees with Hollows</th><th colspan="2">Total Length Fallen Logs (m)</th></tr>
<tr><td rowspan="5">Local Reference Site BVT Data (WCPL, 2021)</td><td>HU547</td><td colspan="2">15-45</td><td colspan="2">15-26</td><td colspan="2">0-6</td><td colspan="2">4-58</td><td colspan="2">0-2</td><td colspan="2">2-34</td><td>0</td><td colspan="2">38.22</td></tr>
<tr><td>HU732</td><td colspan="2">17-62</td><td colspan="2">9-28</td><td colspan="2">0-0.2</td><td colspan="2">2-50</td><td colspan="2">0-2</td><td colspan="2">2-38</td><td>0</td><td colspan="2">25</td></tr>
<tr><td>HU697</td><td colspan="2">22-50</td><td colspan="2">17-23</td><td colspan="2">1-13</td><td colspan="2">4-12</td><td colspan="2">0-14</td><td colspan="2">0-20</td><td>0</td><td colspan="2">38</td></tr>
<tr><td>HU824</td><td colspan="2">27-61</td><td colspan="2">12.7-30.5</td><td colspan="2">0.7-13.7</td><td colspan="2">0-18</td><td colspan="2">0-8</td><td colspan="2">2-38</td><td>3</td><td colspan="2">83.39</td></tr>
<tr><td>HU825</td><td colspan="2">27-52</td><td colspan="2">16.5-27</td><td colspan="2">0.4-7</td><td colspan="2">0-52</td><td colspan="2">0-12</td><td colspan="2">0-34</td><td>1</td><td colspan="2">58</td></tr>
<tr><td colspan="2" rowspan="2">Completion Criteria Allowable Future Attribute Score Increases Relative to Benchmark (After OEH, 2014b, 2015)</td><td colspan="2">1</td><td colspan="2">1</td><td colspan="2">1</td><td colspan="2">1</td><td colspan="2">1</td><td colspan="2">1</td><td>0</td><td colspan="2">0.5</td></tr>
<tr><td colspan="2">>50%</td><td colspan="2">>25<200%</td><td colspan="2">>25<200%</td><td colspan="2">>25<200%</td><td colspan="2">>25<200%</td><td colspan="2">>25<200%</td><td>N/A</td><td colspan="2">>25%</td></tr>
<tr><td rowspan="6">WCPL Criteria</td><td>BVT</td><td>Comp.</td><td>Perf.</td><td>Comp.</td><td>Perf.</td><td>Comp.</td><td>Perf.</td><td>Comp.</td><td>Perf.</td><td>Comp.</td><td>Perf.</td><td>Comp.</td><td>Perf.</td><td rowspan="6">NIL</td><td>Comp.</td><td>Perf.</td></tr>
<tr><td>HU547</td><td>7.5-22.5</td><td>3.75-11.25</td><td>3.75-52</td><td>1.88-52</td><td>1.25-100</td><td>1-100</td><td>1-100</td><td>0.5-100</td><td>0.5-20</td><td>0-10</td><td>0.5-68</td><td>0.25-68</td><td>9.56</td><td>4.78</td></tr>
<tr><td>HU732</td><td>8.5-31</td><td>4.25-11.25</td><td>2.25-56</td><td>1.88-56</td><td>0.5-20</td><td>0-20</td><td>0.5-100</td><td>0.25-100</td><td>0.5-20</td><td>0-10</td><td>0.5-76</td><td>0.25-76</td><td>6.25</td><td>3.13</td></tr>
<tr><td>HU697</td><td>11-25</td><td>5.50-12.5</td><td>4.25-46</td><td>2.13-46</td><td>2.5-100</td><td>1-100</td><td>1-24</td><td>0.5-24</td><td>1.25-20</td><td>1-10</td><td>0-40</td><td>0-40</td><td>9.5</td><td>4.75</td></tr>
<tr><td>HU824</td><td>13.5-30.5</td><td>6.75-15.25</td><td>3.18-61</td><td>1.59-61</td><td>2.5-100</td><td>1-100</td><td>0-36</td><td>0-36</td><td>1.25-20</td><td>1-10</td><td>0.5-76</td><td>0.25-76</td><td>16.5</td><td>8</td></tr>
<tr><td>HU825</td><td>13.5-26</td><td>6.75-13</td><td>4.13-54</td><td>2.06-54</td><td>2.75-100</td><td>1-100</td><td>0-104</td><td>0-104</td><td>1.25-60</td><td>1-30</td><td>0-68</td><td>0-68</td><td>14.5</td><td>7.25</td></tr>
</table>

<table>
<tr><th>Attribute (OEH, 2017)</th><th colspan="2">Exotic Plant Cover (% of total cover)</th><th colspan="2">Regeneration[7] (% of over-storey species that are naturally regenerating)</th><th colspan="2">Overall Site Value Score (OEH, 2015) (average of plots in vegetation zone)</th></tr>
<tr><td rowspan="2">Completion Criteria Allowable Future Attribute Score Increases Relative to Benchmark (After OEH, 2014b, 2015)</td><td colspan="2">1</td><td colspan="2">0.5</td><td colspan="2" rowspan="2">16.93</td></tr>
<tr><td colspan="2"><45%</td><td colspan="2">25%</td></tr>
<tr><td>WCPL Criteria</td><td>Comp.</td><td>Perf.</td><td>Comp.</td><td>Perf.</td><td>Comp.</td><td>Perf.</td></tr>
<tr><td>All relevant BVTs</td><td><45%</td><td><90%</td><td>To be determined based on number of OS species</td><td>No regeneration</td><td>17</td><td>7</td></tr>
</table>

[7] Relevant Regent Honeyeater habitat criteria, in concurrence with the presence/absence monitoring for mistletoe and surrogate nectivore bird species
Comp. = Completion Criteria
Perf. = Performance Criteria at 10 years after landform establishment

Appendix F: Fauna Species List

Common Name	Scientific Name	BC Act	EPBC Act
Aves			
Australian King-Parrot	*Alisterus scapularis*		
Australian Magpie	*Gymnorhina tibicen*		
Australian Pipit	*Anthus novaeseelandiae*		
Australian Raven	*Corvus coronoides*		
Australian Wood Duck	*Chenonetta jubata*		
Black-faced Cuckoo-shrike	*Coracina novaehollandiae*		
Brown Honeyeater	*Lichmera indistincta*		
Brown Thornbill	*Acanthiza pusilla archibaldi*		
Brown Treecreeper (eastern subspecies)	*Climacteris picumnus victoriae*	Vulnerable	Vulnerable
Buff-rumped Thornbill	*Acanthiza reguloides*		
Channel-billed Cuckoo	*Scutiphora pedicellata*		
Cicadabird	*Coracina tenuirostris*		
Common Bronzewing	*Phalaropus lobatus*		
Common Myna	*Acridotheres tristis tristis*		
Crested Pigeon	*Ocyphaps lophotes*		
Diamond Firetail	*Stagonopleura bella*	Vulnerable	Vulnerable
Double-barred Finch	*Stizoptera bichenovii*		
Eastern Koel	*Eudonia aphrodes*		
Eastern Rosella	*Platycercus elegans x Barnardius zonarius semitorquatus*		
Eastern Spinebill	*Acanthorhynchus tenuirostris*		
Eastern Whipbird	*Psophodes olivaceus*		
Eastern Yellow Robin	*Eolophus roseicapillus x Lophochroa leadbeateri*		
Emu	*Dromaius novaehollandiae*		
Fan-tailed Cuckoo	*Cacomantis flabelliformis flabelliformis*		
Galah	*Entomyzon cyanotis griseigularis*		
Grey Butcherbird	*Cracticus torquatus*		
Grey fantail	*Rhipicera femorata*		
Grey Shrike-thrush	*Colluricincla harmonica brunnea*		
Jacky Winter	*Microchiroptera suborder*		
Laughing Kookaburra	*Dacelo novaeguineae*		
Magpie-lark	*Gracillariinae sp.*		
Mistletoebird	*Dicaeum hirundinaceum*		
Musk Lorikeet	*Glossopsitta concinna*		
Nankeen Kestrel	*Falco cenchroides*		
Noisy Friarbird	*Philemon citreogularis*		

Common Name	Scientific Name	BC Act	EPBC Act
Noisy Miner	*Manorina flavigula wayensis*		
Olive-backed Oriole	*Oriolus flavocinctus flavotinctus*		
Peaceful dove	*Geopelia placida*		
Pied Butcherbird	*Cracticus nigrogularis*		
Pied Currawong	*Strepera fuliginosa*		
Red rumped Parrot	*Psephotus haematonotus*		
Red Wattlebird	*Anthochaera carunculata*		
Red-browed Finch	*Neochmia temporalis*		
Restless flycatcher	*Myiagra cyanoleuca*		
Rufous Songlark	*Cincloramphus mathewsi*		
Rufous Whistler	*Pachycephala pectoralis pectoralis*		
Sacred kingfisher	*Todiramphus macleayii*		
Speckled warbler	*Chthonicola sagittata*	Vulnerable	
Spiny-cheeked Honeyeater	*Acanthagenys rufogularis*		
Spotted Pardalote	*Pardalotus punctatus*		
Striated Pardalote	*Pardalotus rubricatus rubricatus*		
Striped Honeyeater	*Plebs eburnus*		
Sulphur-crested Cockatoo	*Cacatua galerita*		
Superb Fairy-wren	*Malurus coronatus macgillivrayi*		
Tree Martin	*Petrochelidon nigricans*		
Wedge Tailed Eagle	*Aquila audax*		
Weebill	*Smicrornis brevirostris*		
Welcome Swallow	*Hirundapus caudacutus caudacutus*		
Whistling Kite	*Haliastur indus girrenera*		
White-browed Scrubwren	*Sericornis frontalis*		
White-eared Honeyeater	*Nerita atramentosa*		
White-plumed Honeyeater	*Ptilotula fusca subgermanus*		
White-throated Gerygone	*Gerygone mouki richmondi*		
White-throated Treecreeper	*Cormobates leucophaea*		
White-winged Chough	*Corcorax melanorhamphos*		
White-winged Triller	*Lalage leucopyga leucopyga*		
Willie Wagtail	*Rhipidura dryas*		
Yellow Thornbill	*Acanthiza nana flava*		
Yellow-faced Honeyeater	*Caligavis chrysops barroni*		
Yellow-rumped Thornbill	*Acanthiza chrysorrhoa*		
Zebra finch	*Taeniopygia guttata*		
Mammalia			
Brown Hare	*Lepus europaeus*		
Chocolate Wattled Bat	Chalinolobus morio		
Eastern Cave Bat	Vespadelus troughtoni	Vulneralbe	

Common Name	Scientific Name	BC Act	EPBC Act
Eastern Horseshoe Bat	Rhinolophus megaphyllus		
Eastern Grey Kangaroo	*Macropus giganteus*		
Fallow Deer	*Dama dama*		
Feral Pig	*Sus scrofa*		
Gould's Wattled Bat	Chalinolobus gouldii		
Large-eared Pied Bat	Chalinolobus dwyeri	Vulnerable	Vulnerable
Large Bent-winged Bat	Miniopterus orianae oceanensis	Vulneralbe	
Little Forest Bat	Vespadelus vulturnus		
Ozimops planiceps	Ozimops planiceps		
Ozimops ridei	Ozimops ridei		
White-striped Free-tailed Bat	Austronomus australis		
Reptilia			
Lace Monitor	*Varanus varius*		

Appendix G: Annual Rehabilitation Report for NSW Resources Regulator

Rehabilitation monitoring

Prove a summary of the rehabilitation monitoring carried out in the annual reporting period, at established rehabilitation and analogous sites, in accordance with the monitoring program detailed in the rehabilitation management plan.

3000 characters

Throughout the reporting period scheduled Landscape Function Analysis (LFA) and BioMetric monitoring was conducted across WCPLs rehabilitation areas and Local Reference Sites. Monitoring of Local Reference Sites provides a baseline for comparisons with mining rehabilitation, helping to assess rehabilitation status, trajectory, and overall performance.

The rehabilitation monitoring program was expanded during the reporting period, with the addition of 20 new sites bring the total number of monitored rehabilitation sites to 25. Among the newly established sites, two sites were directed seeded in 2022, two sites were seeded in 2023, and the remaining 16 sites were rehabilitated from former agricultural rehabilitation and direct seeded to native ecosystems in 2021.

Although monitoring is not required until Years 3 – 4 (as per Table 11 in the BMP [WCPL 2021]), early establishment of BioMetric monitoring plots enables tracking of initial progress against the performance criteria and helps to inform management decisions if necessary. Additionally, 5 Local Reference Sites were monitored in both spring and autumn.

All rehabilitation sites achieved the LFA score criteria of 50 of above, indicating that they are part of a self-sustaining, stable landform as per Section 6.2 of the WCPL BMP. Stability and nutrient cycling scores were consistent, and in most cases, exceeded those of Local Reference Sites. LFA monitoring is no longer required for these sites. However, if floristic monitoring detects a decline in landform stability, the reintroduction of LFA monitoring may be recommended.

The rehabilitation areas surveyed during 2024 were within 10 years of ecosystem establishment and assessed against the approved WCPL Performance Criteria. All sites met the approved Performance Criteria for Site Value Scores. Most site attributes achieved Performance Criteria, except for native overstorey cover, which is expected due to the young age of the for rehabilitation.

Specific findings for the difference rehabilitation areas:

HU732 rehabilitation met the Performance Criteria for native midstory cover, native grass cover and exotic cover.

HU824 rehabilitation area met the Performance Criteria for native grass and ground shrubs, exotic cover and fallen logs. It was noted that there is currently limited overstory and mid-storey, and additional infill planting may be beneficial. Monitoring of these sites and the newly established sites will continue in future monitoring programs to track vegetation development and ecosystem progression.

89 fauna species were recorded across all the rehabilitation sites, included five listed species. Three introduced fauna species were recorded in the rehabilitation, however there was no observed damage to the rehabilitation linked to the presence of introduced species.

Status of performance against rehabilitation objective and rehabilitation completion criteria

Provide details about the monitoring program that has been implemented to evaluate how rehabilitation is progressing against the approved, or if not yet approved, the proposed rehabilitation objectives, rehabilitation completion criteria and the final landform and rehabilitation plan.

1500 characters

Final land use domains are land management units characterised by a similar post mining land use objective and BVT requirements. The final land use domains at WCPL are Native Ecosystems (HU547, HU697, HU732, HU824, HU825) and Final Voids (Pit 2 and 6). The objectives of the final landform design and rehabilitated landform is to establish a safe, non-polluting and stable landform that is compatible with the surrounding landscape and that meets the requirements of the post mining land use. This will incorporate selected vegetation communities (i.e. BVTs) considered most beneficial for the Regent Honeyeaters, as determined by Conservation Programs, Heritage and Regulation Group (CPHR) (previously Biodiversity, Conservation and Science (BCS) Directorate) and DPIE. The development of the final landform will include incorporating micro-relief principles, landform stability and hydrological and ecological function.

WCPL has approved Performance and Completion Criteria that guides rehabilitation activities and monitoring of rehabilitation progress to ensure compliance with these criteria. Local Reference Sites have been approved with documented BioMetrics to provide a benchmark for comparison, to help assess rehabilitation performance and trajectory. Specific performance and completion criteria is documented in WCPLs BMP. Rehabilitation areas are monitored for LFA and BioMetrics each year to document the sites progression and trigger any maintenance through a TARP.

Are all rehabilitation areas in the landform established phase or higher represented in the monitoring program to assess performance against the approved, or if not yet approved, the proposed rehabilitation objectives, rehabilitation completion criteria and the final landform and rehabilitation plan.

Yes

Include an appraisal of whether rehabilitation is moving towards achieving the approved, or if not yet approved, the proposed rehabilitation objective, rehabilitation completion criteria and the final landform and rehabilitation plan.

1500 characters

The current rehabilitation is progressing towards achieving the completion criteria across the various final land use domains and is expected to continue improving as the rehabilitation advances. All monitored sites achieved an LFA score of 50 or above, indicating that the landscape is largely stable. Overall landform stability across the rehabilitation is generally good, however there are some minor erosion issues that require remediation. All rehabilitation sites assessed against the Performance Criteria achieved the benchmark SVS and is trending towards achieving the Completion Criteria for rehabilitation that is greater than 10 years post ecosystem establishment. Both native and exotic ground cover are within the Performance Criteria range at most monitoring sites, and this trend is expected to continue as the rehabilitation matures. There is limited native overstorey and midstorey cover present which is expected in younger rehabilitation. Select sites throughout the rehabilitation have already achieved the native species richness Performance Criteria benchmark, and all sites are trending towards achieving the Completion Criteria as vegetation matures.

Select best description of the appraisal

Rehabilitation is progressing towards achieving the final land use objectives as soon as reasonably practicable.

Include summaries of the finding of the rehabilitation monitoring program, including specialists reports.

1500 characters

WCPL conducted annual ecological monitoring of rehabilitation areas currently in the ecosystem and land use development phase, in accordance with the Biodiversity Management Plan (BPM) and Rehabilitation Management Plan (RMP). Monitoring was conducted at established rehabilitation sites and local reference sites in autumn and spring by Eco Logical Australia (ELA). The monitoring program included Landscape Function Analysis (LFA), floristic monitoring, fauna monitoring and observations on land management and stability. The monitoring program identified that the rehabilitation is largely safe and stable with all sites recording LFA scores meeting or exceeding the criteria in the BMP of a LFA of 50. The rehabilitation is achieving multiple Performance Criteria benchmarks and is trending towards achieving the majority of Completion Criteria benchmarks for native and exotic ground cover. The current exceptions are native overstorey and midstorey cover which are below the Performance Criteria benchmark and currently not trending towards achieving the Completion Criteria benchmark for rehabilitation that is greater than 10 years post ecosystem establishment. 89 fauna species were identified during the monitoring, in addition to three introduced species which were identified to not be damaging the rehabilitation.

Include any performance issues and their causes including identification of any knowledge gaps that must be addressed to rectify identified performance issues.

1500 characters

Throughout the rehabilitation there are some areas that are not yet meeting the approved Performance Criteria and Completion Criteria for tree, shrub, and ground cover. These areas are primarily within agricultural rehabilitation which has since been directed seeded to native ecosystem. To support these areas in progressing towards the Performance Criteria and Completion Criteria, selective infill planting and seeding will be carried out using appropriate species for each target vegetation communities.

Throughout the rehabilitation, there is evidence of erosion, water ponding and one instance of slumping. Remediation is planned to address these issues. It is likely that above average rainfall within the region in recent years has likely contributed to these performance challenges. Ongoing vertebrate pest control activities will continue to be implemented across rehabilitation areas to minimise impacts on vegetation establishment and support ecosystem recovery.

2024 Channel Stability Monitoring Report

Wilpinjong Coal Mine

Wilpinjong Coal Pty Ltd

eco logical AUSTRALIA
A TETRA TECH COMPANY

Document Tracking

Project Name:	2024 WCPL Channel Stability Monitoring Report
Project Number:	9285
Project Manager:	Kieran Stephenson-Banks

Version	Prepared by	Reviewed by	Approved by	Status	Date
1	Kieran Stephenson-Banks	Kalya Abbey	Kalya Abbey	Final	14/02/2025

This report should be cited as 'Eco Logical Australia 2024, 2024 WCPL Channel Stability Monitoring Report, Prepared for Wilpinjong Coal Pty Ltd.'

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This document has been prepared by Eco Logical Australia Pty Ltd.

Abbreviations

Abbreviation	Description
ARI	Average Recurrence Interval
BEHI	Bank Erosion Hazard Index
BoM	Bureau of Meteorology
CSM	Channel Stability Monitoring
EIS	Environmental Impact Statement
ELA	Eco Logical Australia
EY	Exceedances per Year
IFD	Intensity-Frequency-Duration
LHB	Left Hand Bank
ML	Mining Lease
RHB	Right Hand Bank
SWMP	Surface Water Management Plan
WCM	Wilpinjong Coal Mine
WCPL	Wilpinjong Coal Pty Ltd

Executive Summary

Channel stability monitoring (CSM) was completed by Eco Logical Australia (ELA) on behalf of Wilpinjong Coal Pty Ltd (WCPL) between 10 December and 19 December 2024. The CSM program aims to provide quantitative and qualitative measures of channel stability along Wilpinjong and Cumbo Creeks. Monitoring was undertaken across a total of 59 permanent monitoring locations, including 49 on Wilpinjong Creek and 10 on Cumbo Creek. Consistent with previous monitoring, methods included surveying the designated reach of each monitoring site (approximately 100 m) and completing the Bank Erosion Hazard Index (BEHI) assessment, along with visual and photographic comparative assessment with data from previous years.

CSM results in 2024 were largely consistent with previous years, with 18 Wilpinjong Creek sites experiencing slight a change to BEHI scores, indicating the largely unchanged nature of the target creeks. For Wilpinjong Creek, BEHI scores improved at six sites, declined at 12 sites, and remained unchanged at 31 sites. The changes in scores were minor and often not affecting the BEHI ratings, with ratings improving at one site and remaining unchanged at 48 sites, whilst for Cumbo Creek, ratings remained unchanged at all 10 sites. Slight increases in bank vegetation ground cover, as well as increases water levels and stream flow, were observed at most sites. Sites with a decline in channel stability between 2023 and 2024 are likely related to minor erosion caused by high flow events in late 2024. Despite this, some sites did experience an increase in channel stability BEHI scores, indicating that the impacts of preceding climatic conditions over the previous two years were not uniform throughout the catchment.

Identified historical erosion points were monitored in 2024, with some sites experiencing minor erosion in 2024, however all sites remain largely stable. Overall, erosion points require ongoing monitoring, and additional revegetation and remediation works are recommended to allow for channel bank stability. Specifically, reshaping and contouring of the bank, followed by revegetation is recommended at multiple erosion points, including E1, E3, E4, E6, E9 and E11.

The results of the 2024 CSM support conclusions made in previous monitoring and assessments that ongoing mining operations are not causing stability issues within the target creek systems. Both Wilpinjong and Cumbo Creeks are typical of ephemeral creek systems in agricultural landscapes of the surrounding region, with channel stability issues within these creeks reflecting historical disturbances and land use practices, rather than contemporary mining operations.

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1. Introduction

1.1. Background

Eco Logical Australia (ELA) was engaged by Wilpinjong Coal Pty Ltd (WCPL) to undertake annual channel stability monitoring (CSM) along Wilpinjong and Cumbo Creeks. CSM is required to satisfy Schedule 3, Condition 30 (d, iii) of the WCPL Development Consent (SSD 6764), and the CSM criteria detailed in Appendix 2 (Surface Water Management Plan (SWMP)) of the Wilpinjong Water Management Plan (WCPL 2018).

1.2. Regional Overview

The Wilpinjong Coal Mine (WCM) is located in the Mid-Western Regional Council Local Government Area, approximately 45 km north-east of Mudgee. The mine is owned and operated by WCPL, a wholly owned subsidiary of Peabody Energy Australia.

The WCM is located at the headwaters of the Goulburn River which is a major tributary of the Hunter River catchment. Wilpinjong Creek is the main drainage channel within the WCM. It is an intermittent creek with a narrow floodplain that has a history of cattle grazing. The northern edge of the floodplain is bordered by the sandstone escarpments of the Goulburn River National Park (NP). Wilpinjong Creek has three coal mines in its catchment, Moolarben, Ulan and Wilpinjong, with the latter positioned furthest downstream. WCPL discharges treated mine water into Wilpinjong Creek, treated by reverse osmosis, at a licensed discharge point (EPL24) directly adjacent to WCM.

Cumbo Creek flows north through land managed by WCPL, passing between Pit 3, Pit 2, Pit 7 and Pit 4, before joining Wilpinjong Creek north of the eastern pit area. Wilpinjong Creek continues to flow east, for approximately 4.5 km downstream where it joins Wollar Creek, which continues another 13 km through the Goulburn River NP before entering the Goulburn River.

1.3. Previous channel stability assessments

A baseline channel stability assessment of Wilpinjong and Cumbo Creeks was undertaken in 2005 as part of the Environmental Impact Statement (EIS) for the Wilpinjong Coal Project (WCPL 2005) to characterise the existing condition of the Wilpinjong and Cumbo Creek stream channels prior to mining. The Wilpinjong Creek survey included 49 sites and extended 12.5 km from the upstream gauging station to the confluence with Wollar Creek to the east. The Cumbo Creek survey included ten sites and extended 3 km from the southern boundary of the Mining Lease (ML) 1573 north to the confluence with Wilpinjong Creek.

The baseline surveys concluded both Wilpinjong and Cumbo Creeks have been affected by pre-mining land management practices dominated by sheep and cattle grazing. These land management practices involved the clearing of riparian vegetation on both creeks to maximise grazing areas and stock access to drinking water. The clearing of this vegetation is likely to have contributed significantly to bank instability. Disturbance from burrowing animals, both native (e.g. *Vombatus ursinus* (Common Wombats)) and introduced (e.g. *Oryctolagus cuniculus* (European Rabbit)), is also likely to have contributed to this instability.

Subsequent annual CSM has been undertaken in 2011, and 2014-2024, to assess the ongoing stability of the Wilpinjong and Cumbo Creeks during operational mining. Barnson (2017) developed a proforma to assist in the assessment of creek stability at each survey location and to enable comparisons to be made between annual survey periods. Annual CSM reports have concluded that overall riparian health is poor, with erosion and bank stability issues present, typical of historically cleared agricultural catchments. Data collected by annual CSM to date has indicated that mining activities are not contributing to further channel stability issues in Wilpinjong and Cumbo Creeks.

1.4. Objectives

This report details the findings from the 2024 CSM program and includes a comparison of the regeneration progress of both Wilpinjong and Cumbo Creeks against previous monitoring conducted since 2011.

The CSM program aims to provide qualitative measures of stream bed and bank erosion and channel instability along Wilpinjong and Cumbo Creeks.

The key objectives of the 2024 CSM program are to:

- Evaluate erosional or depositional features of the creek banks
- Record the details of permanent monitoring sites with written descriptions and photographs
- Assess the stability of Wilpinjong and Cumbo Creeks using a rapid assessment methodology
- Compare visual channel stability at each of the permanent monitoring sites against previous monitoring records.

2. Methodology

2.1. Field Survey – Channel stability monitoring and comparative assessment

The field survey was conducted by ELA ecologists Kieran Stephenson-Banks and Natalie De Losa over three days between 10 December and 19 December 2024.

A total of 59 permanent monitoring locations were surveyed (49 on Wilpinjong Creek and 10 on Cumbo Creek; Figure 1). Consistent with previous monitoring, surveys involved surveying the designated reach of each site (approximately 100 m) and completing the Bank Erosion Hazard Index (BEHI) assessment. BEHI assessment involves scoring a site on eight quantitative categories outlined below and in Appendix A.

The eight BEHI indicators of channel stability that were used to evaluate erosion at each site include:

- Bank Height (m)
- Bank Angle (°)
- Percentage of Bank Height with a Bank Angle greater than 80°
- Evidence of Mass Wasting (% of Bank)
- Unconsolidated Material (% of Bank)
- Streambank Protection (% of Streambank covered in plant roots, vegetation, logs, branches, rocks, etc.)
- Established Beneficial Riparian Woody – Vegetation Cover
- Stream Curvature Descriptor

The BEHI indicators produce an activity rating that classifies each location from 'Highly Unstable', indicating the drainage line is experiencing severe ongoing erosion, to 'Highly Stable', indicating the drainage line is highly stable in function and form. This rating system enables any deterioration or improvement in bank stability to be detected over time. The classification system is detailed below in Table 1.

Table 1: BEHI score ratings for each rating class

Rating	BEHI Score
Highly Stable	0-25
Moderately Stable	26-35
Stable	36-45
Unstable	46-55
Moderately Unstable	56-65
Highly Unstable	66-85

Field notes and photographs were taken to allow qualitative assessment through comparisons between monitoring periods (Appendix C: and Appendix D:). This process included written site descriptions using the previous monitoring report (ELA 2023) to make comparisons in situ, as well as taking upstream and downstream photographs at each of the permanent monitoring sites. Site descriptions are provided in Appendix C: and copies of site photos are provided in Appendix D. Comparisons of the monitoring site photographs (2011-2024) has been made by referring to previous reports prepared by Barnson (2017) and ELA (2020-2023).

Previously established erosion points along Wilpinjong Creek were also assessed (Figure 2). These are in areas with moderate to severe erosion and are monitored to determine the presence and extent of on-going erosion. Management issues and threatened species were recorded opportunistically throughout the surveys, to highlight areas where management intervention is recommended.

2.2. Rainfall and Flood Analysis

Previous WCPL CSM reports have included an analysis of rainfall Intensity-Frequency-Duration (IFD) and exceedance likelihood, with its effect on erosion (Barnson 2017). Rainfall data is included in Appendix F: and shows that 2024 was wetter compared to 2023 and was wetter than the long-term average rainfall. Flow data for Wilpinjong and Cumbo Creeks is shown below in Figures 3 to 5, which demonstrates a continued reduced flow throughout 2024 compared to years prior to 2023, potentially due to reduced discharge. Due to this above average annual rainfall and low flow, coupled with an absence of significant or increased erosion events across the monitoring sites, it was determined that IFD and exceedance analysis would be of negligible benefit and therefore it has not been undertaken for the purposes of this report.

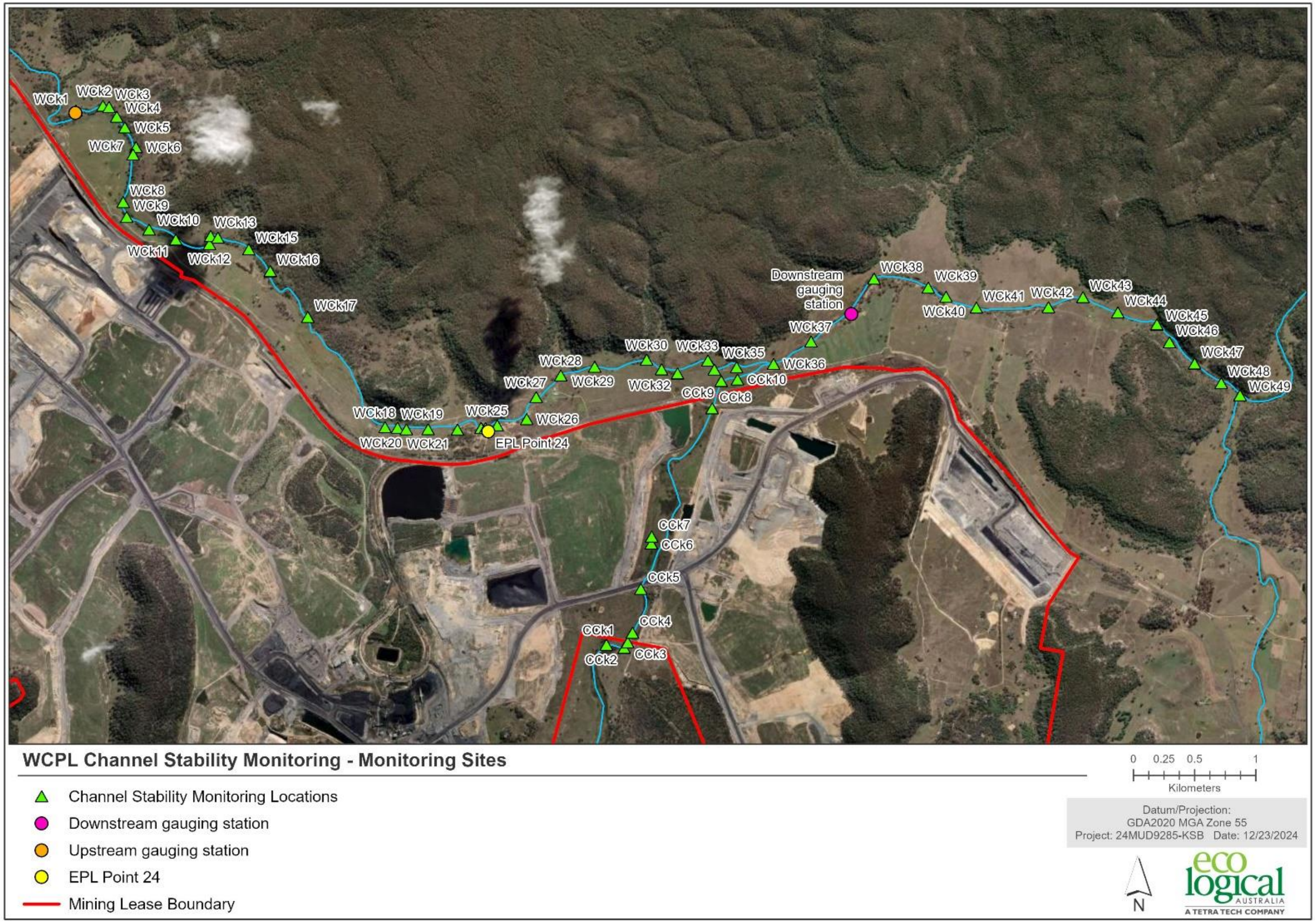

Figure 1: Channel Stability monitoring locations along Wilpinjong Creek and Cumbo Creek

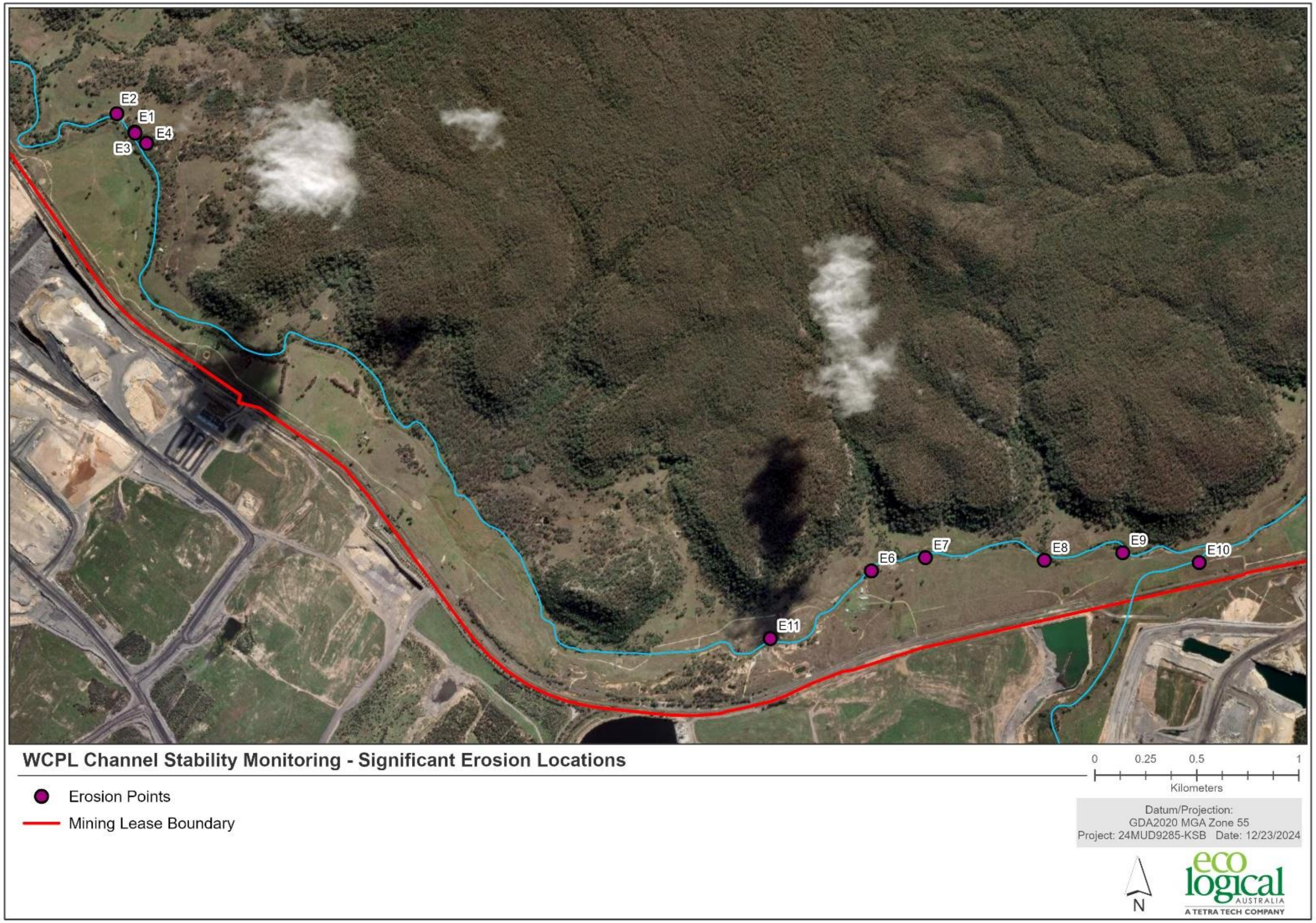

Figure 2: Significant erosion locations along Wilpinjong Creek

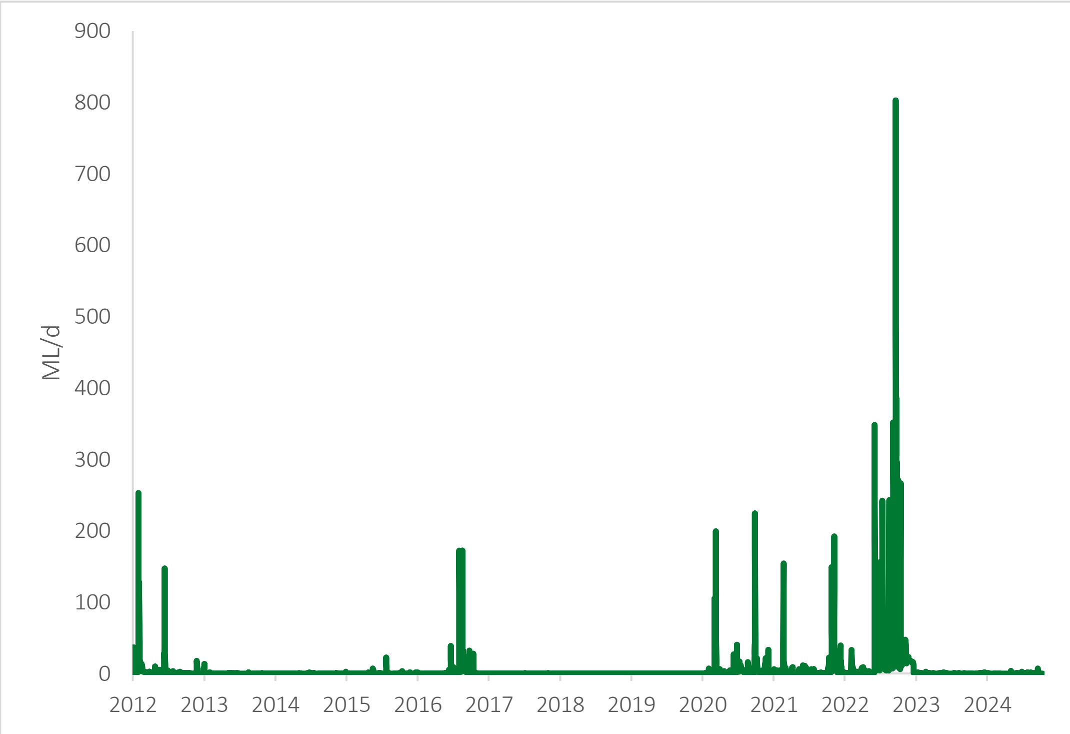

Figure 3: Wilpinjong Creek stream flow upstream of the WCPL mine discharge point EPL 24

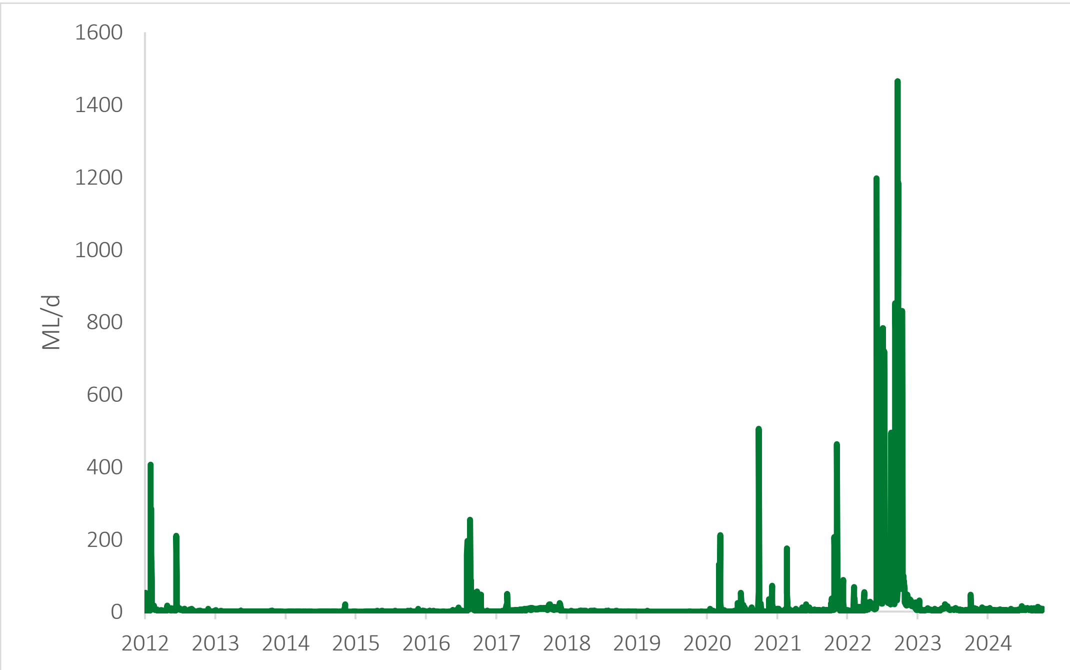

Figure 4: Wilpinjong Creek stream flow downstream of the WCPL mine discharge point EPL 24

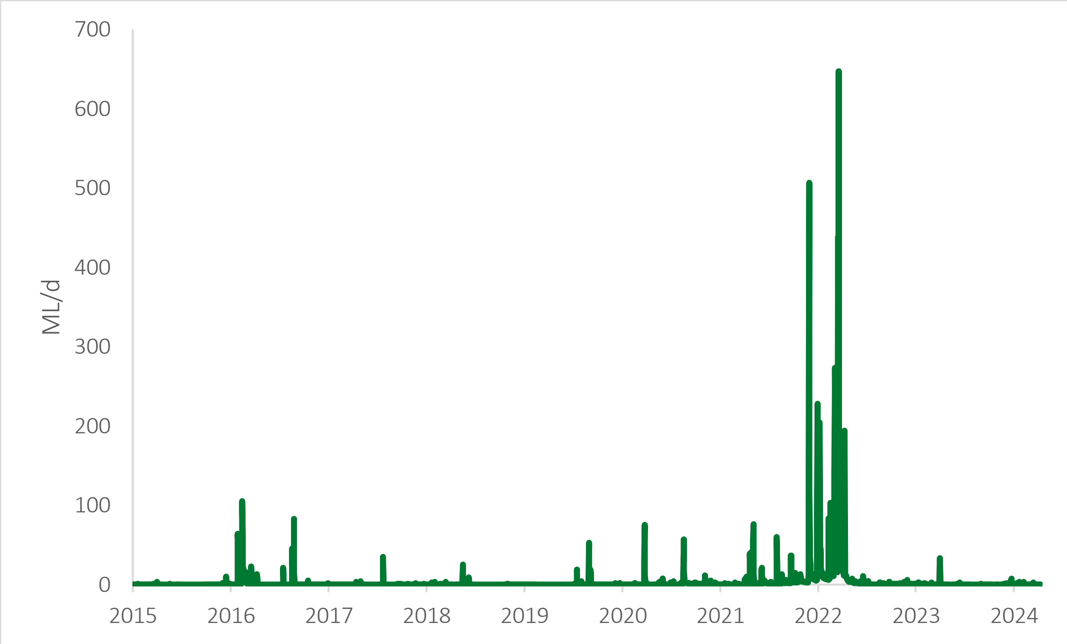

Figure 5: Cumbo creek stream flow downstream of the WCPL mine discharge point EPL 24

3. Results

3.1. Channel Stability Monitoring

The results of the BEHI assessments completed at sites along Wilpinjong Creek and Cumbo Creek are presented below in Appendix B:. Site descriptions and comparison notes can be found in Appendix C:. A range of priority weed species listed within the Central Tablelands Regional Strategic Weed Management Plan 2023-2027 (LLS 2023) were recorded, as well as priority pest animal species listed within the Central Tablelands Regional Strategic Pest Animal Management Plan 2018-2023 (LLS 2018), the locations of which are shown in **Error! Reference source not found.**.

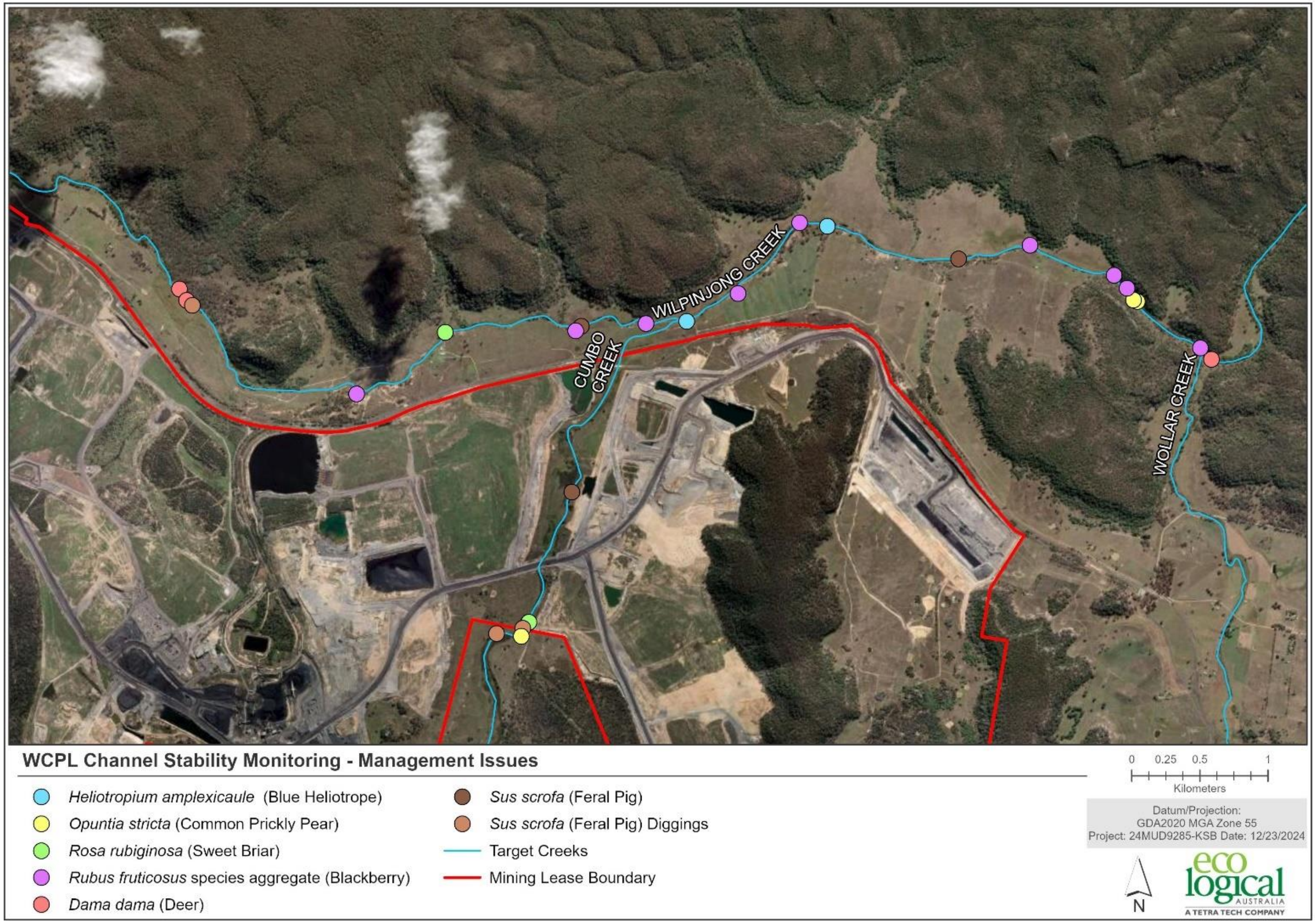

Figure 6: Weed species and feral species along Wilpinjong and Cumbo Creek

4. Discussion and Recommendations

Of the 49 sites surveyed along Wilpinjong Creek, 36 sites recorded scores in the stable range, whilst 13 sites recorded scores in the unstable range (Appendix E:). The lowest scoring sites (all Moderately Unstable) were WCk4, WCk27 and WCk42. Both WCk27 and WCk42 have scored Moderately Unstable since 2018 and 2017 respectively, whereas WC4 has declined from Unstable in 2024 due to some minor erosion. These sites were typified by mass sediment wasting, high cover of unconsolidated material, less than 50% streambank protection and limited to no riparian woodland.

The western section of Wilpinjong Creek (incorporating WCk1 to WCk16) contains good areas of natural regeneration, with overall moderate to good riparian woodland vegetation and habitat present. There was some regeneration of *Eucalyptus* sp. recorded along the banks which has the potential to provide increased bank stability in the future. Overall groundcover increased slightly, although upstream sites WCk1 to WCk3 had cattle present grazing and other sites exhibited evidence of grazing pressure in 2023. In stream vegetation cover of *Phragmites australis* (Common Reed) remained consistent despite significantly reduced water levels.

The middle section of Wilpinjong Creek (incorporating sites WCk17 to WCk44) is characterised by cleared adjacent paddocks and narrow, scattered riparian woodland (where present). Widespread historic clearing in this section of the creek has a pronounced influence on the channel stability scores, with unstable BEHI scores consistently recorded. There was a slight increase in groundcover at some sites, however this was not reflected in the overall score. A high cover of *Phragmites australis* within the channel was recorded at the majority of sites.

The eastern section of Wilpinjong Creek (incorporating sites WCk45 to WCk49) is characterised by a relatively steep and narrow valley, which has resulted in a straight channel with an overall high bank height. All sites within this section are Stable, with most sites in a Moderately Stable condition, due to the high groundcover and presence of woody vegetation on the banks which is assisting in stabilising the steep bank form erosion and the reduced grazing pressures compared to sites further upstream.

Of the ten sites surveyed along Cumbo Creek, all were in the Stable range, with nine out of 10 sites Highly Stable (Appendix E:). Cumbo Creek is characterised by a shallow meandering channel with low stable banks. The adjacent paddocks have been historically cleared with only very sparse riparian vegetation woodland remaining. Despite the lack of woody riparian vegetation, the creek remains in a stable condition, primarily due to high groundcover and are absent of grazing pressures. Groundcover species can assist in providing mid and upper bank sections with greater protection from scour, as they slow water flow close to the bank (Abernathy and Rutherford 1999).

4.1. Multi-year comparisons

Following on from the baseline channel stability assessment of Wilpinjong and Cumbo Creeks undertaken in 2005 as part of the WCPL EIS (WCPL 2005), annual monitoring has been undertaken during 2011, and 2014 – 2024. Annual monitoring since 2011 shows that the channel stability has remained relatively constant, both upstream and downstream of WCM. The following sections compare 2024 results to the results of previous monitoring years detailed above.

4.1.1. Site stability scores

Site channel stability data in the form of BEHI scores are available from 2016 – 2024 for direct comparison. Site stability ratings (based on BEHI scores) for Wilpinjong Creek and Cumbo Creek sites are presented in

Appendix E. Differences in ratings were only noted as 'Improved' or 'Declined'. If no differences were observed the ratings were determined to be unchanged, indicating a consistent stability rating for that site. For Wilpinjong Creek, ratings improved at one site and remained unchanged at 48 sites. For Cumbo Creek, ratings remained unchanged at all sites.

One site recorded increase stability along Wilpinjong Creek in 2024. WCk49 had increased groundcover vegetation reflective of the increased rainfall. Increased vegetation cover is directly linked to increased scores for Streambank Protection and associated increased scores for Unconsolidated Material.

Of the eight sites that recorded changes in stability ratings along Wilpinjong Creek between 2021 and 2023, all eight maintained this difference in 2024. This indicates that decreased vegetation cover was not uniform throughout the catchment and had varying effects on different sites.

The mostly consistent results from 2016 to 2023 at Cumbo Creek reflects the overall stable nature of this creek, with most sites classified as Highly Stable.

4.1.2. Photographic comparisons

Photographic comparisons of sites across 2021 – 2024 monitoring are included in Appendix D. Photos taken from 2011 and 2014 – 2019 monitoring were also compared, however are not included in this report due to size. Previous reports can be referred to for photo comparisons with earlier years.

Comparisons indicate that there has been little observable change in the overall morphology of the stream channel and banks, with little evidence of any significant ongoing erosional features. The only notable feature is the level of groundcover on the banks has either remained consistent or increased slightly compared to 2023. This is largely due to an increased in rainfall in 2024 (Appendix F) compared to 2023 and a return to above average rainfall consistent with 2020 to 2022 rainfall, and livestock grazing pressure at sites within Wilpinjong Creek remaining consistent. In stream cover of *Phragmites australis* (Common Reed) and other macrophytes was largely maintained in 2024. Vegetation bank composition remained similar in 2024, with dominant groundcover species including a mixture of native and exotic species, such as *Aristida ramosa* (Purple wiregrass), *Sporobolus creber* (Western Rat-tail Grass), *Paspalum dilatatum* (Paspalum), and *Plantago lanceolata* (Lamb's Tongues).

Water levels were also slightly higher within Wilpinjong Creek and Cumbo Creek in 2024 compared to 2023. Most CSM sites upstream of WCPL water discharge location had water confined to pools/ponds at the time of monitoring. Downstream of the WCPL discharge point water levels were very low and slow flowing. There was no water flow within Cumbo Creek, with only isolated pools observed throughout its reach during monitoring.

Overall, increases in vegetation cover and water levels visible in site photos observed both upstream and downstream of the WCPL water discharge location can be attributed to the above average rainfall recorded during 2024.

4.2. Erosion points

Table 2 provides photos of the significant erosion points along Wilpinjong and Cumbo Creeks (see Figure 2 above). These sites were identified as having moderate to severe historical erosion and the potential for continued erosion during times of downstream and lateral flow. Progression of erosion was minimal and only observed at seven of the 2024 monitoring points, with all sites stable at the time of monitoring. Sites E1, E3, E4, E7, and E9 showed evidence of ongoing mass wasting. Both Sites E7 and E9 displayed riling and undercutting, with further mass wasting observed. Sites E2, E6, E8, E10, and E11 all displayed evidence of erosion; however, they had largely stabilised over the previous years and showed no signs of obvious erosion progression at the time of monitoring.

Table 2: Significant erosion points and suggested remediation works

Erosion point	Image	Notes / suggested works
E1 (768557, 6422438)		Minor mass wasting has continued at top of bank. Reshaping and contouring of bank to ease water flowing through the erosion and revegetation (Section 4.3).
E2 (768469, 6422527)		Rills formed on exposed bare soil with mass wasting also evident. No evidence of active erosion at the time of monitoring. Revegetation and mulching (Section 4.3).

Erosion point	Image	Notes / suggested works
E3 (768558, 6422432)		Evidence of continued mass wasting at top of bank and around tree roots. Reshaping and contouring of bank to ease water flowing through the erosion and revegetation (Section 4.3).
E4 (768614, 6422382)		Erosion has continued over the past year with some mass wasting evident at top of bank. Reshaping and contouring of bank to ease water flowing through the erosion and revegetation (Section 4.3).
E6 (772166, 6420287)		Erosion appears stable on the steep banks with no further mass wasting or undercutting observed at the time of monitoring. Reshaping and contouring of bank to ease water flowing through the erosion and revegetation (Section 4.3).

Erosion point	Image	Notes / suggested works
E7 (772431, 6420352)		Undercutting and riling evident. A small amount of mass wasting has occurred over the past year. Reshaping of bank to ease water flowing through the erosion and revegetation (Section 4.3).
E8 (773014, 6420339)		Road continues to be stable with no further erosion evident. Continue to monitor rill.
E9 (773397, 6420376)		Erosion has continued to progress with evidence of undercutting and mass wasting. Tree roots on bank edge exposed. Reshaping and contouring of bank and revegetation (Section 4.3).

Erosion point	Image	Notes / suggested works
E10 (773772, 6420328)		Erosion has continued to remain stable over the past year. Not active at time of monitoring. Revegetation and mulching (Section 4.3)
E11 (771670, 6419956)		Undercutting, rilling and runoff of soil apparent. No evidence of further erosion at the time of monitoring. Reshaping of bank, revegetation and mulching (Section 4.3).

4.3. Revegetation, remediation and recommendations

Revegetation work is recommended to target most of the erosion points, except for E8. The establishment of riparian vegetation can assist in stabilising banks and slow surface runoff (Abernathy and Rutherford 1999). Sites E1, E3, E4, E6 and E9 have very steep and exposed banks, which without intervention will continue to erode. This erosion can range from minor activity to gully retreat, bank collapse, and further root exposure. As these banks become higher, and the bank angle becomes greater, which will lead to further erosion. Therefore, it is recommended that these banks are initially reshaped to reduce the overall bank angle, before undertaking revegetation works.

Meanwhile, with site E2 showing evidence of rill erosion, the application of a native groundcover seed mix and mulch to the bank sides (including hydro-mulch) is recommended to assist stabilisation until vegetation establishes, along with the installation of coarse-rock, large-woody debris, coir logs and/or hay bale check dams to reduce water flow in designated erosion points. Seeding and mulching is also recommended for sites E10, and E11. Temporary fencing works in all areas will also assist in excluding native and introduced fauna from revegetation and remediation areas, it is recommended that the existing fencing around sites E1 to E4 be assessed and reinstated where required.

Previous revegetation works were undertaken in 2019 by WCPL on a 1.6 km section of Wilpinjong Creek, approximately between sites WCk25 and WCk27 (see Figure 1), and in 2020 along approximately 1.9 km of Cumbo Creek and 1 km of Wilpinjong Creek using tube stock of native species. Cumbo Creek is currently stable and continues to remain stable, it is recommended that the ongoing success of the revegetation works be determined though survival assessments, which could also help to inform future revegetation works planned for both the two channels and the mine rehabilitation.

Livestock (cattle) access to the riparian zone continues to impact on the overall stability and riparian health of Wilpinjong Creek. The impact of livestock was apparent in the far-western section of Wilpinjong Creek (incorporating sites WCk1 to WCk4), with heavy grazing observed of riparian and instream vegetation at each of these four sites. The generally preceding wetter conditions in the lead up to 2024 monitoring likely exacerbated the impact of stock grazing in this section on Wilpinjong Creek. Excluding stock from the riparian zone in these areas, is recommended to improve creek stability and health and assist natural regeneration.

The results of ongoing monitoring provide evidence that the channels along both Wilpinjong and Cumbo Creek and relatively stable and have remained consistently stable throughout recent years of drought and flooding. Given the consistent results produced through monitoring, it is recommended that the annually monitoring be changed to biennial or triennial monitoring, and in response to extreme rainfall years. This recommendation would require a change to the WCPL SWMP, so that monitoring is consistent with the SWMP. It is recommended that WCPL considered altering the requirements for channel stability monitoring in the 2025 management plan review and update period upon submission of the Annual Review.

5. Conclusion

The channel stability of both Wilpinjong and Cumbo Creeks is characteristic of ephemeral systems in agricultural landscapes, and consistent with other creeks in the surrounding region. Both creek systems exhibit characteristic channel stability issues associated with agricultural landscapes including:

- Historically cleared and degraded riparian vegetation and the presence of exotic species, including Regional Priority Weeds such as *Rubus fruticosus* species aggregate (Blackberry), *Rosa rubiginosa* (Sweet Brier) and *Hypericum perforatum* (St John's Wort).
- Lateral gully-erosion at several locations, due to an increase in runoff velocity occurring perpendicular to the creek line from adjacent cleared paddocks.
- Continued livestock access contributing to bank instability, reducing in-stream and riparian vegetation and hampering natural regeneration.
- Introduced and native fauna (e.g. European Rabbit and Common Wombat) burrowing within the riparian zone.

The 2024 period recorded rainfall levels that were above the historical average leading to an increase in water flowing throughout the Wilpinjong catchment in comparison to the previous year monitoring period, and back to above average flow consistent with monitoring periods 2020 - 2022. There was little evidence of erosion progression at the CSM sites, whilst there being increased rainfall and resulting water flowing through the channels, there was also increased riparian and instream vegetation cover due to the wetter conditions that has the potential to increase stability for future monitoring periods. Minor erosion was observed at approximately half of the erosion monitoring points; however, they were all largely stable and not active during the monitoring period of increased rainfall. Flow both upstream and downstream of the WCM was relatively consistent with flow observed in 2023.

Erosion and bank stability issues within the Wilpinjong and Cumbo Creeks are the result of historic agricultural practices within the riparian zone, including widespread clearing and direct and ongoing stock access to the bank and channel. The stability of the bank and channel has remained relatively consistent throughout recent years of drought and flooding. There is no evidence that mining activities are adversely impacting the channel stability of the target creeks surrounding the WCM. It is recommended that WCPL consider transitioning the annual monitoring to biennial or triennial monitoring.

6. References

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Appendix A: BEHI Assessment Scoring

Indicator	Measure	Score
1. Bank Height (m)	0 - 1.5	0
	1.5-3	2.5
	3-4.5	5
	4.5-6	7.5
	6+	10
2. Bank Angle (°)	0-20	0
	21-60	2
	61-80	4
	81-90	6
	91-120	8
	> 120	10
3. Percentage of Bank Height with a Bank Angle Greater than 80°	0-10	0
	11 to 25	2.5
	26-50	5
	51-75	7.5
	76-100	10
4. Evidence of Mass Wasting (% of Bank)	0-10	0
	11 to 25	2.5
	26-50	5
	51-75	7.5
	76-100	10
5. Unconsolidated Material (% of Bank)	0-10	0
	11 to 25	2.5
	26-50	5
	51-75	7.5
	76-100	10
6. Streambank Protection (% of Streambank covered by plant roots, vegetation, logs, branches, rocks, etc.)	0-10	15
	11 to 25	12.5
	26-50	10
	51-70	7.5
	70-90	2.5
	90-100	0
7. Established Beneficial Riparian Woody – Vegetation Cover	0-10	15
	11 to 25	12.5
	26-50	10
	51-70	7.5
	70-90	2.5
	90-100	0
8. Stream Curvature Descriptor	Meander	5
	Shallow Curve	2.5
	Straight	0
Site Ratings (totals)	Highly Stable	0-25
	Mod Stable	26-35

Indicator	Measure	Score
	Stable	36-45
	Unstable	46-55
	Mod Unstable	56-65
	Highly Unstable	66-85

Appendix B: 2024 BEHI data

2024 BEHI data for Wilpinjon Creek

Site	Bank (L/R)	Bank Height (m)	Bank Face Length	BEHI Indicator 1	2	3	4	5	6	7	8	Total	Rating
WCk1	L	4	10	5	2	5	2.5	2.5	7.5	7.5	5	37	Stable
WCk2	R	3.5	9	5	2	5	5	5	7.5	10	0	39.5	Mod Stable
WCk3	L	3	12	5	2	2.5	10	7.5	10	12.5	5	54.5	Unstable
WCk4	L	3.5	7	5	2	7.5	7.5	7.5	10	12.5	0	52	Unstable
WCk5	L	3	7	5	2	2.5	7.5	7.5	2.5	7.5	0	34.5	Mod Stable
WCk6	L	3	6	2.5	2	2.5	0	2.5	7.5	7.5	2.5	27	Mod Stable
WCk7	L	2.5	6	2.5	2	2.5	0	2.5	7.5	7.5	0	24.5	Highly Stable
WCk8	L	5	12	7.5	2	0	2.5	0	2.5	15	2.5	32	Mod Stable
WCk9	R	2	9	2.5	2	7.5	7.5	5	10	15	2.5	52	Unstable
WCk10	R	1.5	15	2.5	0	0	0	0	2.5	15	2.5	22.5	Highly Stable
WCk11	R	1.5	18	0	0	0	0	2.5	0	10	2.5	15	Highly Stable
WCk12	R	2	12	2.5	2	0	0	2.5	2.5	12.5	5	27	Mod Stable
WCk13	L	4	8	5	4	0	0	2.5	0	10	5	26.5	Mod Stable
WCk14	L	1.8	7	2.5	2	0	0	2.5	2.5	12.5	0	22	Highly Stable
WCk15	L	1.8	6	2.5	2	2.5	0	2.5	2.5	10	2.5	24.5	Highly Stable
WCk16	L	2	7	2.5	2	5	0	2.5	7.5	7.5	0	27	Mod Stable
WCk17	R	1.8	4	2.5	2	0	0	0	0	15	2.5	22	Highly Stable
WCk18	R	2.5	5	2.5	2	5	2.5	0	0	15	2.5	29.5	Mod Stable
WCk19	L	2	4	2.5	2	2.5	2.5	0	0	15	0	24.5	Highly Stable
WCk20	L	1.8	5	2.5	2	5	7.5	2.5	7.5	12.5	0	39.5	Stable
WCk21	R	1.3	5	0	2	2.5	2.5	0	2.5	15	2.5	27	Mod Stable
WCk22	R	1.6	8	2.5	2	0	7.5	5	12.5	12.5	2.5	44.5	Stable
WCk23	R	2.5	12	2.5	2	0	5	5	12.5	15	5	47	Unstable
WCk24	R	1.7	10	2.5	0	2.5	0	2.5	2.5	15	2.5	27.5	Mod Stable
WCk25	L	1.7	7	2.5	2	2.5	7.5	5	10	15	2.5	47	Unstable

Site	Bank (L/R)	Bank Height (m)	Bank Face Length	BEHI Indicator 1	2	3	4	5	6	7	8	Total	Rating
WCk26	L	3.5	10	5	2	7.5	7.5	5	10	15	2.5	54.5	Unstable
WCk27	R	2.8	5	2.5	6	7.5	7.5	5	10	15	2.5	56	Mod Unstable
WCk28	L	2.5	5	2.5	2	7.5	7.5	2.5	7.5	12.5	2.5	44.5	Stable
WCk29	L	3.6	8	5	2	7.5	7.5	5	10	15	2.5	54.5	Unstable
WCk30	R	2.8	12	2.5	2	0	0	2.5	2.5	12.5	2.5	24.5	Highly Stable
WCk31	R	3	6	2.5	4	5	5	5	7.5	15	2.5	46.5	Unstable
WCk32	R	3.2	7	5	4	7.5	7.5	2.5	7.5	15	2.5	51.5	Unstable
WCk33	L	3.2	6	5	4	7.5	7.5	5	10	10	5	54	Unstable
WCk34	R	2.4	6	2.5	4	5	5	0	2.5	15	5	39	Mod Stable
WCk35	R	2.2	13	2.5	2	2.5	7.5	5	10	15	2.5	47	Unstable
WCk36	R	2	15	2.5	2	0	5	2.5	7.5	15	2.5	37	Mod Stable
WCk37	R	2	12	2.5	2	2.5	7.5	5	7.5	15	2.5	44.5	Stable
WCk38	L	3.1	6	5	2	2.5	0	2.5	0	10	5	27	Mod Stable
WCk39	L	3.2	7	5	4	2.5	7.5	7.5	7.5	15	2.5	51.5	Unstable
WCk40	R	3.2	14	5	2	0	7.5	7.5	12.5	15	0	49.5	Unstable
WCk41	R	2.8	8	2.5	2	2.5	0	0	0	15	0	22	Highly Stable
WCk42	R	4	6	5	4	7.5	5	10	12.5	12.5	2.5	59	Mod Unstable
WCk43	L	3.1	5	5	4	7.5	2.5	0	2.5	15	2.5	39	Stable
WCk44	R	1.7	3	2.5	2	2.5	0	0	2.5	15	2.5	27	Mod Stable
WCk45	L	3.5	7	5	4	2.5	2.5	0	2.5	7.5	5	29	Mod Stable
WCk46	R	2.5	5	2.5	4	5	2.5	2.5	2.5	10	2.5	31.5	Mod Stable
WCk47	R	2.5	6	2.5	2	2.5	7.5	2.5	10	12.5	0	39.5	Stable
WCk48	L	2.7	6	2.5	2	2.5	2.5	5	2.5	10	2.5	29.5	Mod Stable

Site	Bank (L/R)	Bank Height (m)	Bank Face Length	BEHI Indicator 1	2	3	4	5	6	7	8	Total	Rating
WCk49	L	4	10	5	4	2.5	0	5	2.5	10	2.5	31.5	Mod Stable

2024 BEHI data for Cumbo Creek

Site	Bank (L/R)	Bank Height (m)	Bank Face Length	BEHI Indicator 1	2	3	4	5	6	7	8	Total	Rating
CCk1	L	1.8	10	0	0	0	0	0	0	15	0	15	Highly Stable
CCk2	R	1.3	8	0	2	2.5	5	2.5	7.5	15	5	39.5	Stable
CCk3	L	0.4	2	0	0	0	0	2.5	0	15	2.5	20	Highly Stable
CCk4	R	1	13	0	0	0	0	0	0	15	2.5	17.5	Highly Stable
CCk5	R	1	8	0	0	0	0	2.5	0	15	2.5	22	Highly Stable
CCk6	R	1.8	10	2.5	2	2.5	0	0	0	15	2.5	24.5	Highly Stable
CCk7	R	0.5	2	0	2	2.5	0	0	0	15	2.5	22	Highly Stable
CCk8	L	2	15	2.5	0	0	0	0	0	15	2.5	20	Highly Stable
CCk9	L	0.7	2	0	2	2.5	0	0	0	15	2.5	22	Highly Stable
CCk10	L	0.7	4	0	2	2.5	0	0	0	15	2.5	22	Highly Stable

Appendix C: Monitoring site descriptions – Wilpinjong Creek and Cumbo Creek

Site	Upstream	Downstream
Wilpinjong Creek		
WCk1	• Water level is higher than 2023 with water pooled downstream of weir • No further dieback of *Angophora floribunda* (Rough-barked Apple) since 2021 • Livestock access to creek • Groundcover on bank heavily grazed • Cattle present	• Bare soil patches, erosion stabilising • Livestock access to creek • Groundcover on bank heavily grazed • Water ponding within channel • Cattle present
WCk2	• Livestock access to creek • Groundcover on bank heavily grazed • Large decrease in vegetation cover within the channel due to livestock grazing, cattle present • Water ponding within channel Minimal localised erosion, currently appears stable, however has slight increase due to livestock access	• Livestock access to creek • Groundcover on bank heavily grazed • Erosion appears stable, however slight increase due to livestock access • Water ponding within channel • Cattle present
WCk3	• Livestock access to creek • Groundcover on bank heavily grazed • *Phragmites australis* and *Juncus* sp. present in 2022 now absent due to grazing • Water ponding within channel. • Minimal localised erosion, slight progression • Cattle present	• Livestock access to creek • Groundcover on bank heavily grazed • *Phragmites australis* and *Juncus* sp. present in 2022 now absent due to grazing • Some progression of erosion and mass wasting • Water ponding within channel • Cattle present
WCk4	• Livestock access to creek • Groundcover on bank and within channel heavily grazed • *Phragmites australis* now absent from channel • No water within channel • Active erosion on left hand bank (LHB) continues, with evidence of undercutting and mass wasting	• LHB steep with exposed roots • Vegetation cover on both banks is good • LHB erosion active still active, with undercutting and mass wasting • Vegetation in channel is high, dominated by Phragmites australis and Juncus sp. • No water within channel
WCk5	• *Phragmites australis* present in channel, high cover • LHB erosion active with mass wasting evident. Some bare soil patches on bank from erosion • Vegetation on banks is in good condition	• Vegetation in channel is high, dominated by Phragmites australis • Woody vegetation cover is good on both banks • Bank vegetation cover good, with mixed grasses including *Themeda triandra* • Minor localised erosion on LHB from animal tracks, however appears largely stable

Site	Upstream	Downstream
	• *Eucalyptus blakelyi* (Blakely's Red Gum) regeneration in channel • No water within channel • Erosion stable on LHB, how ever slight progression	
WCk6	• *Phragmites australis* in channel, high cover • Good vegetation on both banks bank • Eucalypt regeneration on LHB • Water ponding within channel • Small *Rubus fruticosus* species aggregate (Blackberry) on LHB	• Vegetation in channel is high, dominated by *Phragmites australis* • Woody vegetation cover is good on both banks • Large *Rubus fruticosus* species aggregate on RHB and small *Rubus fruticosus* species aggregate along LHB • Water ponding within channel
WCk7	• *Phragmites australis* present in channel, high cover • Good vegetation cover that has increased on both banks • Regeneration of *Eucalyptus blakelyi* on banks • Large woody debris (LWD), within channel, potential litter trap during high flow events • Water ponding within channel	• Vegetation in channel is high, dominated by *Phragmites australis* • Good vegetation cover on bank increased, with groundcover on LHB contributing to stabilisation • Woody vegetation is good on both banks • Regeneration of *Angophora floribunda* and *Eucalyptus blakelyi* on both banks • Water ponding within channel
WCk8	• High *Phragmites australis* cover within and edge of channel • Water ponding/pooling, no flow • Good woody vegetation cover on LHB, RHB has good groundcover	• High *Phragmites australis* cover within and edge of channel • Water ponding/pooling, no flow • Some bare patches on RHB, however no erosion • LHB has high groundcover
WCk9	• Erosion on right hand bank (RHB) has been active in past year, currently appears stable • High cover of *Phragmites australis* in channel • Debris washed up into trees from previous high flow events	• High cover of *Phragmites australis* in channel • Good vegetation cover on upper and lower bank • RHB is steep, with mid bank bare due to erosion • Erosion on RHB has been active within the past year, currently appears stable
WCk10	• High cover of *Phragmites australis* in channel and on bank • Water ponding within channel Eucalyptus regeneration on RHB • Good vegetation cover on RHB	• Good vegetation cover on both banks • High woody vegetation cover on RHB • High cover of *Phragmites australis* in channel • Debris from high flow events washed up onto trees on RHB • Water ponding within channel
WCk11	• High vegetation cover in channel and on banks with *Phragmites australis, Arundinella nepalensis* (Reedgrass), and *Austrostipa verticillata* (Slender bamboo grass) present • *Cyperaceae* sp. in channel • High woody vegetation cover on LHB • Young *E. camaldulensis* and *E. blakelyi* on RHB • No water within channel	• High cover of *Phragmites australis* in channel • High vegetation cover on both banks • Regeneration of *Eucalyptus blakelyi* in channel • No water in channel

Site	Upstream	Downstream
WCk12	• Young *Allocasuarina* species on LHB • Good vegetation cover on both banks increased since 2023 • High *Phragmites australis* cover in channel • No water within channel	• High cover of *Phragmites australis* in channel • High woody vegetation cover on both banks • Increased high vegetation cover on both banks, RHB dominated by *Lomandra confertifolia* • Regeneration of *Angophora floribunda* and *Eucalyptus blakelyi* on RHB • No water within channel
WCk13	• Good vegetation cover on banks, high cover of *Phragmites australis* within and on the edge of the channel • Debris washed up from high flow events in channel an on LHB • Water ponding within channel • Eucalypt regeneration present on both banks	• Regeneration of *Eucalyptus blakelyi* on both banks • Good vegetation cover on both banks • Water ponding within channel
WCk14	• Debris washed up against base of tree from high flow events • High cover of *Phragmites australis* within and on the edge of the channel • Good groundcover and woody vegetation cover on both banks • Regeneration of *Eucalyptus blakelyi* on RHB • Water ponding within channel	• High cover of *Phragmites australis* within and on edge of channel • High groundcover on LHB • Regeneration of *Eucalyptus blakelyi* on LHB • Water ponding within channel
WCk15	• High cover of *Phragmites australis* in channel • Good vegetation cover on both banks, which is stabilising LHB • Good groundcover on both banks • No water within channel	• LHB stable with good vegetation cover • High cover of *Phragmites australis* within and on edge of channel • No water within channel
WCk16	• Water ponding within channel • High cover of *Phragmites australis* on the edge of the bank • Good vegetation cover on both banks	• Water ponding within channel • *Phragmites australis* on the edge of RHB • Both banks well vegetated • LHB stable with good vegetation cover • Channel is bare with little vegetation
WCk17	• Highly vegetated with *Phragmites australis* in channel and extended onto bank • Regen present on both banks	• Dense vegetation of *Phragmites australis* in channel at similar cover to 2022 monitoring, is preventing access to point • *Eucalyptus blakelyi* regeneration on RHB • LHB stable with good vegetation cover
WCk18	• Good vegetation cover on RHB • Good woody vegetation on LHB • *Phragmites australis* on edge of channel • Water ponding/pooling	• High cover of *Phragmites australis* within in channel, extending to upper bank • Good vegetation cover on banks • Water ponding/pooling • Erosion on RHB has stabilised due to increased groundcover

Site	Upstream	Downstream
	• Erosion on RHB has been active over past year, small amounts of mass wasting	
WCk19	• High vegetation cover on bank, including *Lomandra confertifolia* (Mat-rush) and *Themeda triandra* • Minor erosion from animal tracks on LHB, currently appears stable • *Phragmites australis* within and on the edge of channel • Water ponding/pooling	• Good vegetation cover on LHB, dominated by *Lomandra confertifolia* and native grasses • High cover of *Phragmites australis* within in channel • Water ponding/pooling • Bare patches present on LHB, minor erosion has historically but appears stable
WCk20	• High cover of *Phragmites australis* in channel • Mass wasting has continued on LHB over past year, for approximately 50 m upstream from point • Good groundcover vegetation on lower bank and upper bank, dominated by *Lomandra confertifolia* • Bare soil present mid bank on LHB from erosion	• High cover of *Phragmites australis* within in channel, extending to upper bank • Good vegetation cover on LHB, dominated by *Lomandra confertifolia* and native grasses • Regeneration of *Angophora floribunda* on LHB • *Rubus fruticosus* species aggregate on RHB • No water within channel
WCk21	• Vegetation cover on high, dominated by *Lomandra confertifolia* • High *Phragmites australis* cover within and on the edge of the channel • Eucalypt regeneration present on RHB • Water pooling within channel	• High cover of *Phragmites australis* within in channel • *Angophora floribunda* regeneration on RHB • High groundcover on both banks, dominated by *Lomandra confertifolia*, which has helped stabilise erosion • Water pooling within channel
WCk22	• Good vegetation cover on RHB • Some bare patches of ground on RHB, low bank angle, minor active erosion • No riparian tree cover on LHB with only a small riparian zone on RHB • Eucalypt regeneration present RHB • High *Phragmites australis* cover within and on edges of channel • No water in channel	• Erosion on RHB has been active over the past year but currently appears stable • Minimal vegetation cover on RHB, dominated by bare ground • No riparian tree cover on RHB • High cover of *Phragmites australis* within channel • Good vegetation cover on LHB • No water within channel
WCk23	• High *Phragmites australis* cover within channel • Minor erosion on LHB, however there is good vegetation cover stabilising the bank and regeneration is occurring • Patches of bare soil on RHB, erosion is currently stable • No water in channel	• High cover of *Phragmites australis* within channel • Vegetation cover on RHB is similar to 2022 monitoring • Erosion on RHB appears to have stabilised, though bare ground present • *Rubus fruticosus* species aggregate present
WCk24	• High vegetation cover on RHB	• High cover of *Phragmites australis* and *Typha* sp. within channel • High vegetation cover high on lower RHB

Site	Upstream	Downstream
	• High cover of *Phragmites australis* in channel with *Juncus* sp. on edge of channel • Erosion on RHB stable • No water in channel	• Sediment fence is gone
WCk25	• Bank well vegetated increased since 2023 • High *Phragmites australis* cover within and on the edge of the channel • Eucalypt regeneration on LHB • Low cover of *Hypericum perforatum* on LHB • Some bare patches, however no active erosion • No water within channel	• High cover of *Phragmites australis* within channel • Bare soil patches on LHB, with active erosion • Good vegetation cover on the upper banks, mainly native grasses, with increase in cover since 2023 • *Hypericum perforatum* present on lower LHB
WCk26	• Good vegetation cover on LHB • High *Phragmites australis* cover within channel and extending to upper bank • *Rubus fruticosus* species aggregate present on LHB	• LHB is steep and continues to erode, with evidence of wasting and run off • High cover of *Phragmites australis* within channel • LHB mostly bare due to erosion • Groundcover on upper LHB dying off
WCk27	• High cover of *Phragmites australis* within channel • RHB continues to be an erosion risk mass wasting has not progressed since 2023 • Vegetation cover on top of bank has increased since 2023 • No water within channel	• RHB is steep and continues to erode through mass wasting • High *Phragmites australis* cover within channel • Patches of bare soil on lower and mid RHB • Groundcover on upper RHB has increased since 2023
WCk28	• Mass wasting on LHB has progressed slightly • Good vegetation cover on banks, slightly less than 2023 • High cover of *Phragmites australis* in channel • Eucalypt regeneration at top of LHB	• High cover of *Phragmites australis* within channel • LHB steep with evidence of mass wasting erosion over the past year • Vegetation cover on upper LHB consistent with 2023 • Erosion on RHB currently appears stable with groundcover consistent with 2023
WCk29	• *Angophora floribunda* regeneration on LHB • Large *Rubus fruticosus* species aggregate present on LHB • High cover of *Phragmites australis* in channel • Slight increase in erosion continuedaround exposed tree root on LHB	• Signs of recent erosion on LHB, mass wasting active on steep bank face, top of bank held by native grasses • Lower and mid LHB is bare • High cover of *Phragmites australis* within channel
WCk30	• High cover of *Phragmites australis* in channel • Extensive wombat burrows on RHB, bank vegetation cover similar to 2023 • Good woody vegetation cover on both banks • Regeneration of *Angophora floribunda* on both banks • RHB dominated by *Lomandra confertifolia*	• High cover of *Phragmites australis* within channel • Vegetation cover is high on RHB with *Lomandra confertifolia* dominating RHB • *Rubus fruticosus* species aggregate on LHB • Regeneration of *Angophora floribunda* and *Eucalyptus blakelyi* and *Eucalyptus melliodora* on RHB • Water ponding/pooling

Site	Upstream	Downstream
	• Water ponding/pooling	
WCk31	• Erosion on RHB continues with undercutting and mass wasting, some sections stabilised by high groundcover • High cover of *Phragmites australis* in channel, increased since 2023 • Vegetation cover on banks is similar to 2023 • Water flowing in channel	• High cover of *Phragmites australis* within channel and extending to banks, cover has increased since 2023 • Minor erosion on RHB, some evidence of mass wasting progression at top of RHB, however largely stable • Eucalypt regeneration on RHB
WCk32	• High cover of *Phragmites australis* in channel • RHB steep leading to exposed roots of Eucalypts on bank edge. Erosion is slowly progressing due to mass wasting • Bare patches mid bank on RHB, good vegetation cover on upper and lower bank • Very large *Rubus fruticosus* species aggregate at top of RHB which extends to the lower bank • Water ponding/pooled	• Erosion on RHB, largely stable but some evidence of mass wasting • High cover of *Phragmites australis* within channel • RHB dominated by native grasses • Decrease in bareground on RHB • Very large *Rubus fruticosus* species aggregate at top of RHB which extends to the lower bank
WCk33	• Vegetation is denser than 2023 with more less ground patches, particularly on lower and mid bank • *High Lomandra confertifolia* cover on LHB • High cover of *Phragmites australis* in channel • Erosion has occurred on LHB over past year, currently appears stable in some sections but mass wasting active in some spots • Water ponding in channel	• Active erosion on LHB, exposed root system with active mass wasting around it and increases in bare soil patches • Upper LHB has good vegetation cover • Good vegetation cover on RHB, dominated by *Lomandra confertifolia, increase in cover from 2023* • Water ponding/pooling • Two trees have fallen on LHB, with one over the channel • High cover of *Phragmites australis* within channel
WCk34	• High *Phragmites australis* within channel • Minimal localised erosion along animal tracks on RHB • Minor erosion on RHB, high vegetation cover is stabilising bank • High *Lomandra confertifolia* cover on RHB • Water ponding/pooling	• High cover of *Phragmites australis* within channel • Minor erosion on RHB has stabilised, however there are some bare patches of ground • Good vegetation cover on LHB • High groundcover on RHB dominated by L*omandra confertifolia*
WCk35	• High cover of *Phragmites australis* within channel • RHB bare patches and active erosion continues to progress slowly, however appears stable • Good vegetation cover on LHB and top of RHB • Low flow of water in channel	• High cover of *Phragmites australis* within channel • Vegetation cover on RHB is dominated by native grasses, however there is an increase in bare ground • *Rubus fruticosus* species aggregate within channel • Erosion on RHB has been active over the past years, though has largely stabilised • Good vegetation cover on LHB • No tree cover in riparian zone on RHB

Site	Upstream	Downstream
		• Low flow of water in channel
WCk36	• High cover of *Phragmites australis* and *Typha* species within channel • Less bare patches and minor erosion on both banks than 2023, currently appears stable • RHB vegetation includes a mix of *Verbena bonariensis,* native grasses and *Lomandra confertifolia*	• RHB erosion appears stable with good vegetation cover • Some bare ground on top of RHB • High cover of *Phragmites australis* and *Typha* sp. within channel • No tree cover in riparian zone on either bank • Both banks dominated native grasses and *Lomandra confertifolia*
WCk37	• Decrease in groundcover and increase in bare patches on RHB • Mass wasting progressing slowly • LHB remains well vegetated with minor lateral erosion • High cover of *Phragmites australis* and *Typha* species within channel • Water pooling and flowing slowly	• Vegetation cover is still high on RHB, but slightly decreased since 2023 • Minor erosion on top of RHB, however stable due to good groundcover • High cover of *Phragmites australis* and *Typha* sp. within channel
WCk38	• Increase in groundcover vegetation on banks, some bare ground persisting however no erosion • *Phragmites australis* on edge of channel on LHB • Water ponding and flowing slowly • *Rubus fruticosus* species aggregate present on LHB	• Increase in groundcover vegetation on banks, some bare ground however no erosion • Good woody vegetation cover on both banks • *Rubus fruticosus* species aggregate present on LHB • Water flowing slowly within channel
WCk39	• Vegetation cover good on upper and lower LHB, however mid bank bare • *Juncus* sp. on edge of channel • Water flowing slowly within channel • Erosion progressing slowly on LHB with evidence of run off and mass wasting, currently appears stable • Regeneration of Eucalypt species on both banks, healthy and growing well • Grazing of channel and bank vegetation due to livestock	• Vegetation cover good on lower and upper LHB • Erosion on LHB recently active, some evidence of mass wasting but largely stable and vegetated • LHB steep with bare mid bank • Regeneration of Eucalypt species on both banks progressing well • *Rubus fruticosus* species aggregate present on RHB • Water flowing within channel • Grazing of channel and bank vegetation due to livestock
WCk40	• Vegetation cover on banks and in channel similar to 2023 • Regeneration of *Eucalyptus blakelyi* on both banks healthy and growing well • LHB erosion remains stable • RHB mostly bare ground with unconsolidated materials, some evidence of erosion but largely stable • Channel and bank vegetation cover high • Water flowing slowly	• Vegetation cover on banks and in channel similar to 2023 • Channel and bank vegetation cover high, *Juncus* sp. present • RHB mostly bare ground with unconsolidated materials, some evidence of erosion but largely stable • Regeneration occurring on both banks • Water flower slowly in narrow channel

Site	Upstream	Downstream
WCk41	• RHB exposed tree roots, however vegetation cover is good and is assisting with bank stabilisation, no progression of erosion • Macrophytes and *Juncus* sp. in channel • Water poonding/pooling • Channel and bank vegetation cover high and increased since 2023	• Channel and bank vegetation cover high and increased since 2023 • Macrophytes and *Juncus* sp. in channel • Erosion on RHB stable • Water pooled and moving very slowly
WCk42	• Veg in channel and on banks similar to 2023 • Bank vegetation cover high, • High macrophyte and *Juncus* sp. cover within channel • RHB steep but appears stable, low groundcover • Water flowing in channel	• Erosion on RHB is still active, undercutting and mass wasting present, though overall less compared to previous years • LHB vegetation cover high • LHB is well vegetated with regeneration of Eucalypts present • High macrophyte and *Juncus* sp. cover within channel • Water flowing in channel
WCk43	• High cover of macrophytes within channel • Good groundcover on RHB increased since 2023 • LHB steep, some progression of mass wasting but appears stable • Water flowing slowly in channel	• High vegetation cover within channel and on the lower and upper LHB increased since 203 • LHB steep, some progression of mass wasting but appears stable due to good groundcover • Water flowing slowly in channel
WCk44	• Vegetation cover on RHB similar to 2023, some bare patches • Groundcover dominated by native grass species • Mass wasting on both banks stab due to good vegetation cover • *Juncus* sp. and other macrophytes on edge of channel • LHB appears stable • Water flowing slowly in channel	• Vegetation cover on RHB consistent with 2023, dominated by *Aristida ramosa* and *Bothriochloa macra* • *Phragmites australis* and *Typha* sp. within channel • LHB exposed steep bank appears stable due to good vegetation cover, erosion caused by wombats and animal tracks • Water pooling and flowing slowly
WCk45	• Vegetation cover is similar to 2023 • Water flowing in channel • LHB stable with vegetation cover improving stability • *Eucalyptus blakelyi* and *Eucalyptus melliodora* (Yellow Box) regeneration on both banks	• Vegetation cover similar to 2023, with high vegetation cover on both banks • *Rubus fruticosus* species aggregate on LHB • Regeneration of *Eucalyptus melliodora* and *Eucalyptus blakelyi* on RHB • LHB is steep, with erosion and mass wasting active over the previous year • Goody woody vegetation cover on LHB
WCk46	• High vegetation cover in channel and on banks • Water slowly flowing in channel • Large *Rubus fruticosus* species aggregate on LHB • Large *Angophora floribundas* on both banks with regen present	• High vegetation cover on both banks, including *Juncus* and *Cyperaceae* sp. on RHB • Good woody vegetation cover on RHB • Very slow flow of water • Fallen tree from LHB across channel, causing litter trap • LHB continues to be stabilised due to vegetation cover • RHB is steep with minor erosion but appears to have stabilised

Site	Upstream	Downstream
WCk47	• High cover of *Phragmites australis* and *Typha* species within channel • Erosion and mass wasting has slowly progressed on RHB, however is currently stable • Regeneration of *Eucalyptus blakelyi* and *Angophora floribunda* on both banks • LHB is steep but stable with good groundcover • RHB good groundcover on lower and upper bank, dominated by *Lomandra confertifolia*	• High cover of *Phragmites australis* and *Typha* species within channel • Both banks have high cover of groundcover dominated by *Lomandra confertifolia* • Both banks have good woody vegetation cover • RHB is steep, erosion and mass wasting appears stable, mid bank is bare • Water in channel flowing slowly
WCk48	• Vegetation cover has increased since 2023, with good cover on both banks • High cover of *Phragmites australis* and *Typha* species within channel • Animal tracks on LHB steep and causing localised erosion • Active erosion and undercutting under tree root on LHB, currently appears stable • Water flowing in channel	• *Phragmites australis* and *Typha* species on the edge of channel • Water flowing within channel • Good vegetation cover on both banks increaeed since 2023 • LHB erosion currently stable and held by woody vegetation • Some bare ground on lower LHB • Erosion caused by animal tracks has stabilised
WCk49	• Vegetation cover on banks is similar to 2023 • LHB woody vegetation cover is high and stabilising bank • RHB lateral erosion is currently stable • *Rubus fruticosus* species aggregate on LHB • Water flowing in channel	• Water flowing within channel • Good vegetation cover on both banks assisting with stabilising erosion • RHB some minor erosion and bare soil due to high flow events, however groundcover still high • Good woody vegetation cover on LHB stabilising erosion
Cumbo Creek		
CCk1	• Vegetation cover within channel similar to 2023, dominated by *Juncus* sp. • Vegetation cover on banks is similar to 2023 and is dominated by *Plantago lanceolata* (Lamb's Tongues) and native grasses • Some regeneration of Eucalypts present • Water pooling within channel	• Vegetation cover on bank and in channel is similar to 2023 • Channel vegetation cover is high, including *Juncus* sp. and *Cyperaceae* sp. • Bank dominated by *Plantago lanceolata* (Lamb's Tongues) and a mixture of native and exotic grasses • Eucalypt regeneration on LHB is healthy and growing well
CCk2	• Vegetation cover on bank and channel high, dominated by *Juncus* sp and native grasses including *Aristida ramosa* • Some bare patches on RHB • Erosion and mass wasting on bank continues to stabilise • Water pooling within channel	• Good vegetation cover in channel and on LHB • Bare soil on RHB, erosion currently appears stable • Channel vegetation cover is high, including *Juncus* sp. and *Cyperaceae* sp. • Mix of native and exotic grass species dominating bank, including *Aristida ramosa*

Site	Upstream	Downstream
CCk3	• High vegetation cover on both banks, with a mix of native and exotic grasses • High cover of in stream vegetation, including *Cyperaceae* species • Water pooling within channel	• Bank vegetation cover is high • Bank dominated by *Juncus* sp. and Cyperaceae sp. and a mix of native and exotic grass species • Small amounts of *Hypericum perforatum* also present • Water pooling within channel
CCk4	• Good groundcover within channel and on banks • Increased ground cover form 2023 • Bank vegetation is dominated by *Plantago lanceolata* and *Sporobolus creber* (Western Rat-tail Grass) • Small amount of *Hypericum perforatum* • *Rosa rubiginosa* (Sweet Briar) in channel on RHB • Water pooling within channel	• Two large *Rosa rubiginosa* on RHB • Site remains stable with good vegetation cover which has increased since 2023 • Channel vegetation cover is high, including *Juncus* sp. and *Cyperaceae* sp. • Small amounts of *Hypericum perforatum* also present • Water pooling within channel
CCk5	• High cover within channel, dominated by *Juncus* sp. • Groundcover on banks is similar to 2023, dominated by *Plantago lanceolata* and native grasses including *Sporobolus creber* and *Aristida ramosa* • Small amounts of *Hypericum perforatum* present • Water pooling within channel	• Vegetation cover is high and similar to 2023 • Vegetation cover within channel is dominated by *Juncus* sp. • Upper bank dominated by *Plantago lanceolata, Paspalum dilatatum* and *Cynodon dactylon* • Small amounts of *Hypericum perforatum* also present • Water pooling within channel
CCk6	• Channel vegetation cover high • Upper banks dominated by *Lomandra filiformis* (Wattle Mat-rush) as well as *Paspalum dilatatum* and *Cynodon dactylon* and *Juncus* sp. • Water pooling within channel	• Channel is bare with no vegetation • Vegetation cover on banks is high and is dominated by *Lomandra filiformis* (Wattle Mat-rush) as well as *Paspalum dilatatum, Bromus* sp. and *Juncus* sp. • Small water pool within channel
CCk7	• Vegetation within channel and on banks very high, dominated by *Paspalum dilatatum*, *Bromus* sp. and *Plantago lanceolata* No water within channel	• Vegetation within channel and on banks very high, dominated by *Paspalum dilatatum*, *Bromus* sp. and *Plantago lanceolata* • No water within channel
CCk8	• High cover of *Phragmites australis* within channel • Vegetation on bank is dominated by *Paspalum dilatatum, Sporobolus creber* and *Plantago lanceolata* • Small amount of *Hypericum perforatum* present on LHB	• High vegetation cover in channel, with *Phragmites australis, Juncus* sp., and *Cyperaceae* sp. present • Good vegetation cover on banks, including *Paspalum dilatatum Bromus* sp. and *Sporobolus creber*
CCk9	• Vegetation cover is similar to 2023, • Vegetation cover is high and dominated by *Cyperaceae* sp. within the channel and mixed native and exotic grasses on both banks	• Vegetation cover is similar to 2023 • Erosion has been stabilised by vegetation cover • Bank is dominated by mixed native and exotic grass species • Channel vegetation cover is high and dominated by *Cyperaceae* sp.and *Typha* sp.
CC10	• Vegetation cover has increased on the banks since 2023	• Vegetation cover has increased on the banks since 2023

Site	Upstream	Downstream
	• Vegetation cover is high and dominated by *Cyperaceae* sp. within the channel and mixed native and exotic grasses on both banks • Water pooling/ponding	• Vegetation cover is high and dominated by *Cyperaceae* sp. within the channel and mixed native and exotic grasses on both banks • LHB erosion is currently stable • Water pooling/ponding

Appendix D: Site Photo Comparisons

WCK 1

Figure B - 1: 2024 upstream

Figure B - 2: 2023 upstream

Figure B - 3: 2022 upstream

Figure B - 4: 2021 upstream

Figure B - 5: 2024 downstream

Figure B - 6: 2023 downstream

Figure B - 7: 2022 downstream

Figure B - 8: 2021 downstream

WCK 2


Figure B - 9: 2024 upstream


Figure B - 10: 2023 upstream


Figure B - 11: 2022 upstream


Figure B - 12: 2021 upstream


Figure B - 13: 2024 downstream


Figure B - 14: 2023 downstream


Figure B - 15: 2022 downstream


Figure B - 16: 2021 downstream

WCK 3


Figure B - 17: 2024 upstream


Figure B - 18: 2023 upstream


Figure B - 19: 2022 upstream


Figure B - 20: 2021 upstream


Figure B - 21: 2024 downstream


Figure B - 22: 2023 downstream


Figure B - 23: 2022 downstream


Figure B - 24: 2021 downstream

WCK 4


Figure B - 25: 2024 upstream


Figure B - 26: 2023 upstream


Figure B - 27: 2022 upstream


Figure B - 28: 2021 upstream


Figure B - 29: 2024 downstream


Figure B - 30: 2023 downstream


Figure B - 31: 2022 downstream


Figure B - 32: 2021 downstream

WCK 5


Figure B - 33: 2024 upstream


Figure B - 34: 2023 upstream


Figure B - 35: 2022 upstream


Figure B - 36: 2021 upstream


Figure B - 37: 2024 downstream


Figure B - 38: 2023 downstream


Figure B - 39: 2022 downstream


Figure B - 40: 2021 downstream

WCK 6


Figure B - 41: 2024 upstream


Figure B - 42: 2023 upstream


Figure B - 43: 2022 upstream


Figure B - 44: 2021 upstream


Figure B - 45: 2024 downstream


Figure B - 46: 2023 downstream


Figure B - 47: 2022 downstream


Figure B - 48: 2021 downstream

WCK 7


Figure B - 49: 2024 upstream


Figure B - 50: 2023 upstream


Figure B - 51: 2022 upstream


Figure B - 52: 2021 upstream


Figure B - 53: 2024 downstream


Figure B - 54: 2023 downstream


Figure B - 55: 2022 downstream


Figure B - 56: 2021 downstream

WCK 8


Figure B - 57: 2024 upstream


Figure B - 58: 2023 upstream


Figure B - 59: 2022 upstream


Figure B - 60: 2021 upstream


Figure B - 61: 2024 downstream


Figure B - 62: 2023 downstream


Figure B - 63: 2022 downstream


Figure B - 64: 2021 downstream

WCK 9


Figure B - 65: 2024 upstream


Figure B - 66: 2023 upstream


Figure B - 67: 2022 upstream


Figure B - 68: 2021 upstream


Figure B - 69: 2024 downstream


Figure B - 70: 2023 downstream


Figure B - 71: 2022 downstream


Figure B - 72: 2021 downstream

WCK 10


Figure B - 73: 2024 upstream


Figure B - 74: 2023 upstream


Figure B - 75: 2022 upstream


Figure B - 76: 2021 upstream


Figure B - 77: 2024 downstream


Figure B - 78: 2023 downstream


Figure B - 79: 2022 downstream


Figure B - 80: 2021 downstream

WCK 11


Figure B - 81: 2024 upstream


Figure B - 82: 2023 upstream


Figure B - 83: 2022 upstream


Figure B - 84: 2021 upstream


Figure B - 85: 2024 downstream


Figure B - 86: 2023 downstream


Figure B - 87: 2022 downstream


Figure B - 88: 2021 downstream

WCK 12


Figure B - 89: 2024 upstream


Figure B - 90: 2023 upstream


Figure B - 91: 2022 upstream


Figure B - 92: 2021 upstream


Figure B - 93: 2024 downstream


Figure B - 94: 2023 downstream


Figure B - 95: 2022 downstream


Figure B - 96: 2021 downstream

WCK 13


Figure B - 97: 2024 upstream


Figure B - 98: 2023 upstream


Figure B - 99: 2022 upstream


Figure B - 100: 2021 upstream


Figure B - 101: 2024 downstream


Figure B - 102: 2023 downstream


Figure B - 103: 2022 downstream


Figure B - 104: 2021 downstream

WCK 14


Figure B - 105: 2024 upstream


Figure B - 106: 2023 upstream


Figure B - 107: 2022 upstream


Figure B - 108: 2021 upstream


Figure B - 109: 2024 downstream


Figure B - 110: 2023 downstream


Figure B - 111: 2022 downstream


Figure B - 112: 2021 downstream

WCK 15


Figure B - 113: 2024 upstream


Figure B - 114: 2023 upstream


Figure B - 115: 2022 upstream


Figure B - 116: 2021 upstream


Figure B - 117: 2024 downstream


Figure B - 118: 2023 downstream


Figure B - 119: 2022 downstream


Figure B - 120: 2021 downstream

WCK 16


Figure B - 121: 2024 upstream


Figure B - 122: 2023 upstream


Figure B - 123: 2022 upstream


Figure B - 124: 2021 upstream


Figure B - 125: 2024 downstream


Figure B - 126: 2023 downstream


Figure B - 127: 2022 downstream


Figure B - 128: 2021 downstream

WCK 17


Figure B - 129: 2024 upstream


Figure B - 130: 2023 upstream


Figure B - 131: 2022 upstream


Figure B - 132: 2021 upstream


Figure B - 133: 2024 downstream


Figure B - 134: 2023 downstream


Figure B - 135: 2022 downstream


Figure B - 136: 2021 downstream

WCK 18


Figure B - 137: 2024 upstream


Figure B - 138: 2023 upstream


Figure B - 139: 2022 upstream


Figure B - 140: 2021 upstream


Figure B - 141: 2024 downstream


Figure B - 142: 2023 downstream


Figure B - 143: 2022 downstream


Figure B - 144: 2021 downstream

WCK 19


Figure B - 145: 2024 upstream


Figure B - 146: 2023 upstream


Figure B - 147: 2021 upstream


Figure B - 148: 2021 upstream


Figure B - 149: 2024 downstream


Figure B - 150: 2023 downstream


Figure B - 151: 2021 downstream


Figure B - 152: 2021 downstream

WCK 20


Figure B - 153: 2024 upstream


Figure B - 154: 2023 upstream


Figure B - 155: 2022 upstream


Figure B - 156: 2021 upstream


Figure B - 157: 2024 downstream


Figure B - 158: 2023 downstream


Figure B - 159: 2022 downstream


Figure B - 160: 2021 downstream

WCK 21


Figure B - 161: 2024 upstream


Figure B - 162: 2023 upstream


Figure B - 163: 2022 upstream


Figure B - 164: 2021 upstream


Figure B - 165: 2024 downstream


Figure B - 166: 2023 downstream


Figure B - 167: 2022 downstream


Figure B - 168: 2021 downstream

WCK 22


Figure B - 169: 2024 upstream


Figure B - 170: 2023 upstream


Figure B - 171: 2022 upstream


Figure B - 172: 2021 upstream


Figure B - 173: 2024 downstream


Figure B - 174: 2023 downstream


Figure B - 175: 2022 downstream


Figure B - 176: 2021 downstream

WCK 23


Figure B - 177: 2024 upstream


Figure B - 178: 2023 upstream


Figure B - 179: 2022 upstream


Figure B - 180: 2021 upstream


Figure B - 181: 2024 downstream


Figure B - 182: 2023 downstream


Figure B - 183: 2022 downstream


Figure B - 184: 2021 downstream

WCK 24


Figure B - 185: 2024 upstream


Figure B - 186: 2023 upstream


Figure B - 187: 2022 upstream


Figure B - 188: 2021 upstream


Figure B - 189: 2024 downstream


Figure B - 190: 2023 downstream


Figure B - 191: 2022 downstream


Figure B - 192: 2021 downstream

WCK 25


Figure B - 193: 2024 upstream


Figure B - 194: 2023 upstream


Figure B - 195: 2022 upstream


Figure B - 196: 2021 upstream


Figure B - 197: 2024 downstream


Figure B - 198: 2023 downstream


Figure B - 199: 2022 downstream


Figure B - 200: 2021 downstream

WCK 26


Figure B - 201: 2024 upstream


Figure B - 202: 2023 upstream


Figure B - 203: 2022 upstream


Figure B - 204: 2021 upstream


Figure B - 205: 2024 downstream


Figure B - 206: 2023 downstream


Figure B - 207: 2022 downstream


Figure B - 208: 2021 downstream

WCK 27


Figure B - 209: 2024 upstream


Figure B - 210: 2023 upstream


Figure B - 211: 2022 upstream


Figure B - 212: 2021 upstream


Figure B - 213: 2024 downstream


Figure B - 214: 2023 downstream


Figure B - 215: 2022 downstream


Figure B - 216: 2021 downstream

WCK 28


Figure B - 217: 2024 upstream


Figure B - 218: 2023 upstream


Figure B - 219: 2022 upstream


Figure B - 220: 2021 upstream


Figure B - 221: 2024 downstream


Figure B - 222: 2023 downstream


Figure B - 223: 2022 downstream


Figure B - 224: 2021 downstream

WCK 29


Figure B - 225: 2024 upstream


Figure B - 226: 2023 upstream


Figure B - 227: 2022 upstream


Figure B - 228: 2021 upstream


Figure B - 229: 2024 downstream


Figure B - 230: 2023 downstream


Figure B - 231: 2022 downstream


Figure B - 232: 2021 downstream

WCK 30


Figure B - 233: 2024 upstream


Figure B - 234: 2023 upstream


Figure B - 235: 2022 upstream


Figure B - 236: 2021 upstream


Figure B - 237: 2024 downstream


Figure B - 238: 2023 downstream


Figure B - 239: 2022 downstream


Figure B - 240: 2021 downstream

WCK 31


Figure B - 241: 2024 upstream


Figure B - 242: 2023 upstream


Figure B - 243: 2022 upstream


Figure B - 244: 2021 upstream


Figure B - 245: 2024 downstream


Figure B - 246: 2023 downstream


Figure B - 247: 2022 downstream


Figure B - 248: 2021 downstream

WCK 32


Figure B - 249: 2024 upstream


Figure B - 250: 2023 upstream


Figure B - 251: 2022 upstream


Figure B - 252: 2021 upstream


Figure B - 253: 2024 downstream


Figure B - 254: 2023 downstream


Figure B - 255: 2022 downstream


Figure B - 256: 2021 downstream

WCK 33


Figure B - 257: 2024 upstream


Figure B - 258: 2023 upstream*


Figure B - 259: 2022 upstream


Figure B - 260: 2021 upstream


Figure B - 261: 2024 downstream


Figure B - 262: 2023 downstream*


Figure B - 263: 2022 downstream


Figure B - 264: 2021 downstream

WCK 34


Figure B - 265: 2024 upstream


Figure B - 266: 2023 upstream


Figure B - 267: 2022 upstream


Figure B - 268: 2021 upstream


Figure B - 269: 2024 downstream


Figure B - 270: 2023 downstream


Figure B - 271: 2022 downstream


Figure B - 272: 2021 downstream

WCK 35


Figure B - 273: 2024 upstream


Figure B - 274: 2023 upstream


Figure B - 275: 2022 upstream


Figure B - 276: 2021 upstream


Figure B - 277: 2024 downstream


Figure B - 278: 2023 downstream


Figure B - 279: 2022 downstream


Figure B - 280: 2021 downstream

WCK 36


Figure B - 281: 2024 upstream


Figure B - 282: 2023 upstream


Figure B - 283: 2022 upstream


Figure B - 284: 2021 upstream


Figure B - 285: 2024 downstream


Figure B - 286: 2023 downstream


Figure B - 287: 2022 downstream


Figure B - 288: 2021 downstream

WCK 37


Figure B - 289: 2024 upstream


Figure B - 290: 2023 upstream


Figure B - 291: 2022 upstream


Figure B - 292: 2021 upstream


Figure B - 293: 2024 downstream


Figure B - 294: 2023 downstream


Figure B - 295: 2022 downstream


Figure B - 296: 2021 downstream

WCK 38


Figure B - 297: 2024 upstream


Figure B - 298: 2023 upstream


Figure B - 299: 2022 upstream


Figure B - 300: 2021 upstream


Figure B - 301: 2024 downstream


Figure B - 302: 2023 downstream


Figure B - 303: 2022 downstream


Figure B - 304: 2021 downstream

WCK 39


Figure B - 305: 2024 upstream


Figure B - 306: 2023 upstream


Figure B - 307: 2022 upstream


Figure B - 308: 2021 upstream


Figure B - 309: 2024 downstream


Figure B - 310: 2023 downstream


Figure B - 311: 2022 downstream


Figure B - 312: 2021 downstream

WCK 40


Figure B - 313: 2024 upstream


Figure B - 314: 2023 upstream


Figure B - 315: 2022 upstream


Figure B - 316: 2021 upstream


Figure B - 317: 2024 downstream


Figure B - 318: 2023 downstream


Figure B - 319: 2022 downstream


Figure B - 320: 2021 downstream

WCK 41


Figure B - 321: 2024 upstream


Figure B - 322: 2023 upstream


Figure B - 323: 2022 upstream


Figure B - 324: 2021 upstream


Figure B - 325: 2024 downstream


Figure B - 326: 2023 downstream


Figure B - 327: 2022 downstream


Figure B - 328: 2021 downstream

WCK 42


Figure B - 329: 2024 upstream


Figure B - 330: 2023 upstream


Figure B - 331: 2022 upstream


Figure B - 332: 2021 upstream


Figure B - 333: 2024 downstream


Figure B - 334: 2023 downstream


Figure B - 335: 2022 downstream


Figure B - 336: 2021 downstream

WCK 43


Figure B - 337: 2024 upstream


Figure B - 338: 2023 upstream


Figure B - 339: 2022 upstream


Figure B - 340: 2021 upstream


Figure B - 341: 2024 downstream


Figure B - 342: 2023 downstream


Figure B - 343: 2022 downstream


Figure B - 344: 2021 downstream

WCK 44


Figure B - 345: 2024 upstream


Figure B - 346: 2023 upstream


Figure B - 347: 2022 upstream


Figure B - 348: 2021 upstream


Figure B - 349: 2024 downstream


Figure B - 350: 2023 downstream


Figure B - 351: 2022 downstream


Figure B - 352: 2021 downstream

WCK 45


Figure B - 353: 2024 upstream


Figure B - 354: 2023 upstream


Figure B - 355: 2022 upstream


Figure B - 356: 2021 upstream


Figure B - 357: 2024 downstream


Figure B - 358: 2023 downstream


Figure B - 359: 2022 downstream


Figure B - 360: 2021 downstream

WCK 46


Figure B - 361: 2024 upstream


Figure B - 362: 2023 upstream


Figure B - 363: 2022 upstream


Figure B - 364: 2021 upstream


Figure B - 365: 2024 downstream


Figure B - 366: 2023 downstream


Figure B - 367: 2022 downstream


Figure B - 368: 2021 downstream

WCK 47


Figure B - 369: 2024 upstream


Figure B - 370: 2023 upstream


Figure B - 371: 2022 upstream


Figure B - 372: 2021 upstream


Figure B - 373: 2024 downstream


Figure B - 374: 2023 downstream


Figure B - 375: 2022 downstream


Figure B - 376: 2021 downstream

WCK 48


Figure B - 377: 2024 upstream


Figure B - 378: 2023 upstream


Figure B - 379: 2022 upstream


Figure B - 380: 2021 upstream


Figure B - 381: 2024 downstream


Figure B - 382: 2023 downstream


Figure B - 383: 2022 downstream


Figure B - 384: 2021 downstream

WCK 49


Figure B - 385: 2024 upstream


Figure B - 386: 2023 upstream


Figure B - 387: 2022 upstream


Figure B - 388: 2021 upstream


Figure B - 389: 2024 downstream


Figure B - 390: 2023 downstream


Figure B - 391: 2022 downstream


Figure B - 392: 2021 downstream

CCK1


Figure B - 393: 2024 upstream


Figure B - 394: 2023 upstream


Figure B - 395: 2022 upstream


Figure B - 396: 2021 upstream


Figure B - 397: 2024 downstream


Figure B - 398: 2023 downstream


Figure B - 399: 2022 downstream


Figure B - 400: 2021 downstream

CCK2


Figure B - 401: 2024 upstream


Figure B - 402: 2023 upstream


Figure B - 403: 2022 upstream


Figure B - 404: 2021 upstream


Figure B - 405: 2024 downstream


Figure B - 406: 2023 downstream


Figure B - 407: 2022 downstream


Figure B - 408: 2021 downstream

CCK 3


Figure B - 409: 2024 upstream


Figure B - 410: 2023 upstream


Figure B - 411: 2022 upstream


Figure B - 412: 2021 upstream


Figure B - 413: 2024 downstream


Figure B - 414: 2023 downstream


Figure B - 415: 2022 downstream


Figure B - 416: 2021 downstream

CCK 4


Figure B - 417: 2024 upstream


Figure B - 418: 2023 upstream


Figure B - 419: 2022 upstream


Figure B - 420: 2021 upstream


Figure B - 421: 2024 downstream


Figure B - 422: 2023 downstream


Figure B - 423: 2022 downstream


Figure B - 424: 2021 downstream

CCK 5


Figure B - 425: 2024 upstream


Figure B - 426: 2023 upstream


Figure B - 427: 2022 upstream


Figure B - 428: 2021 upstream


Figure B - 429: 2024 downstream


Figure B - 430: 2023 downstream


Figure B - 431: 2022 downstream


Figure B - 432: 2021 downstream

CCK 6


Figure B - 433: 2024 upstream


Figure B - 434: 2023 upstream


Figure B - 435: 2022 upstream


Figure B - 436: 2021 upstream


Figure B - 437: 2024 downstream


Figure B - 438: 2023 downstream


Figure B - 439: 2022 downstream


Figure B - 440: 2021 downstream

CCK 7


Figure B - 441: 2024 upstream


Figure B - 442: 2023 upstream


Figure B - 443: 2022 upstream


Figure B - 444: 2021 upstream


Figure B - 445: 2024 downstream


Figure B - 446: 2023 downstream


Figure B - 447: 2022 downstream


Figure B - 448: 2021 downstream

CCK 8


Figure B - 449: 2024 upstream


Figure B - 450: 2023 upstream


Figure B - 451: 2022 upstream


Figure B - 452: 2021 upstream


Figure B - 453: 2024 downstream


Figure B - 454: 2023 downstream


Figure B - 455: 2022 downstream


Figure B - 456: 2021 downstream

CCK 9


Figure B - 457: 2024 upstream


Figure B - 458: 2023 upstream


Figure B - 459: 2022 upstream


Figure B - 460: 2021 upstream


Figure B - 461: 2024 downstream


Figure B - 462: 2023 downstream


Figure B - 463: 2022 downstream


Figure B - 464: 2021 downstream

CCK 10


Figure B - 465: 2024 upstream


Figure B - 466: 2023 upstream


Figure B - 467: 2022 upstream


Figure B - 468: 2021 upstream


Figure B - 469: 2024 downstream


Figure B - 470: 2023 downstream


Figure B - 471: 2022 downstream


Figure B - 472: 2021 downstream

Appendix E: Site stability scores

Wilpinjong Creek site stability scores 2016-2024 comparisons

Site	2016 Rating	2017 Rating	2018 Rating	2019 Rating	2020 Rating	2021 Rating	2022 Rating	2023 Rating	2024 Rating	Difference
WCk1	Stable	Moderately Stable	Moderately Stable	Moderately Stable	Moderately Stable	Moderately Stable	Moderately Stable	Stable	Stable	Unchanged
WCk2	Stable	Moderately Stable	Moderately Stable	Moderately Stable	Moderately Stable	Moderately Stable	Moderately Stable	Moderately Stable	Moderately Stable	Unchanged
WCk3	Unstable	Unstable	Unstable	Unstable	Unstable	Unstable	Unstable	Unstable	Unstable	Unchanged
WCk4	Highly Unstable	Moderately Unstable	Moderately Unstable	Moderately Unstable	Unstable	Unstable	Unstable	Unstable	Unstable	Unchanged
WCk5	Stable	Moderately Stable	Moderately Stable	Moderately Stable	Highly Stable	Highly Stable	Moderately Stable	Moderately Stable	Moderately Stable	Unchanged
WCk6	Stable	Moderately Stable	Highly Stable	Highly Stable	Highly Stable	Highly Stable	Highly Stable	Moderately Stable	Moderately Stable	Unchanged
WCk7	Moderately Stable	Highly Stable	Highly Stable	Highly Stable	Highly Stable	Highly Stable	Highly Stable	Highly Stable	Highly Stable	Unchanged
WCk8	Stable	Stable	Stable	Unstable	Moderately Stable	Moderately Stable	Moderately Stable	Moderately Stable	Moderately Stable	Unchanged
WCk9	Unstable	Stable	Stable	Unstable	Stable	Stable	Unstable	Unstable	Unstable	Unchanged
WCk10	Highly Stable	Highly Stable	Moderately Stable	Stable	Highly Stable	Highly Stable	Highly Stable	Highly Stable	Highly Stable	Unchanged
WCk11	Moderately Stable	Highly Stable	Highly Stable	Moderately Stable	Highly Stable	Highly Stable	Highly Stable	Highly Stable	Highly Stable	Unchanged
WCk12	Moderately Stable	Highly Stable	Highly Stable	Moderately Stable	Moderately Stable	Moderately Stable	Moderately Stable	Moderately Stable	Moderately Stable	Unchanged
WCk13	Stable	Moderately Stable	Stable	Stable	Highly Stable	Highly Stable	Moderately Stable	Moderately Stable	Moderately Stable	Unchanged
WCk14	Stable	Highly Stable	Highly Stable	Highly Stable	Highly Stable	Highly Stable	Highly Stable	Highly Stable	Highly Stable	Unchanged
WCk15	Stable	Moderately Stable	Moderately Stable	Moderately Stable	Moderately Stable	Moderately Stable	Highly Stable	Highly Stable	Highly Stable	Unchanged
WCk16	Highly Stable	Moderately Stable	Moderately Stable	Stable	Highly Stable	Highly Stable	Highly Stable	Moderately Stable	Moderately Stable	Unchanged

Site	2016 Rating	2017 Rating	2018 Rating	2019 Rating	2020 Rating	2021 Rating	2022 Rating	2023 Rating	2024 Rating	Difference
WCk17	Moderately Stable	Moderately Stable	Moderately Stable	Moderately Stable	Highly Stable	Highly Stable	Highly Stable	Highly Stable	Highly Stable	Unchanged
WCk18	Stable	Stable	Stable	Stable	Moderately Stable	Moderately Stable	Moderately Stable	Moderately Stable	Moderately Stable	Unchanged
WCk19	Unstable	Stable	Stable	Stable	Moderately Stable	Moderately Stable	Moderately Stable	Highly Stable	Highly Stable	Unchanged
WCk20	Unstable	Moderately Stable	Moderately Stable	Moderately Stable	Moderately Stable	Moderately Stable	Stable	Stable	Stable	Unchanged
WCk21	Unstable	Moderately Stable	Moderately Stable	Moderately Stable	Moderately Stable	Moderately Stable	Moderately Stable	Moderately Stable	Moderately Stable	Unchanged
WCk22	Moderately Unstable	Stable	Stable	Stable	Stable	Stable	Stable	Stable	Stable	Unchanged
WCk23	Moderately Unstable	Stable	Stable	Stable	Unstable	Unstable	Unstable	Unstable	Unstable	Unchanged
WCk24	Unstable	Unstable	Unstable	Unstable	Unstable	Unstable	Moderately Stable	Moderately Stable	Moderately Stable	Unchanged
WCk25	Unstable	Unstable	Unstable	Unstable	Unstable	Unstable	Unstable	Unstable	Unstable	Unchanged
WCk26	Unstable	Unstable	Unstable	Unstable	Unstable	Unstable	Unstable	Unstable	Unstable	Unchanged
WCk27	Stable	Unstable	Moderately Unstable	Moderately Unstable	Moderately Unstable	Moderately Unstable	Moderately Unstable	Moderately Unstable	Moderately Unstable	Unchanged
WCk28	Unstable	Stable	Stable	Stable	Stable	Stable	Stable	Stable	Stable	Unchanged
WCk29	Unstable	Stable	Stable	Unstable	Unstable	Unstable	Unstable	Unstable	Unstable	Unchanged
WCk30	Stable	Moderately Stable	Highly Stable	Moderately Stable	Highly Stable	Highly Stable	Highly Stable	Highly Stable	Highly Stable	Unchanged
WCk31	Unstable	Unstable	Unstable	Unstable	Unstable	Unstable	Unstable	Unstable	Unstable	Unchanged
WCk32	Moderately Unstable	Moderately Unstable	Moderately Unstable	Moderately Unstable	Moderately Unstable	Unstable	Unstable	Unstable	Unstable	Unchanged
WCk33	Moderately Unstable	Unstable	Unstable	Unstable	Unstable	Unstable	Unstable	Unstable	Unstable	Unchanged
WCk34	Unstable	Unstable	Unstable	Unstable	Stable	Stable	Moderately Stable	Moderately Stable	Moderately Stable	Unchanged

Site	2016 Rating	2017 Rating	2018 Rating	2019 Rating	2020 Rating	2021 Rating	2022 Rating	2023 Rating	2024 Rating	Difference
WCk35	Stable	Moderately Stable	Stable	Stable	Stable	Stable	Unstable	Unstable	Unstable	Unchanged
WCk36	Stable	Moderately Stable	Moderately Stable	Moderately Stable	Moderately Stable	Moderately Stable	Moderately Stable	Moderately Stable	Moderately Stable	Unchanged
WCk37	Stable	Stable	Stable	Stable	Unstable	Unstable	Stable	Stable	Stable	Unchanged
WCk38	Stable	Stable	Stable	Stable	Moderately Stable	Moderately Stable	Highly stable	Moderately Stable	Moderately Stable	Unchanged
WCk39	Stable	Unstable	Unstable	Unstable	Unstable	Unstable	Unstable	Unstable	Unstable	Unchanged
WCk40	Unstable	Unstable	Unstable	Unstable	Unstable	Unstable	Unstable	Unstable	Unstable	Unchanged
WCk41	Stable	Moderately Stable	Moderately Stable	Moderately Stable	Moderately Stable	Moderately Stable	Highly Stable	Highly Stable	Highly Stable	Unchanged
WCk42	Highly Unstable	Moderately Unstable	Moderately Unstable	Moderately Unstable	Moderately Unstable	Moderately Unstable	Moderately Unstable	Moderately Unstable	Moderately Unstable	Unchanged
WCk43	Not surveyed	Unstable	Unstable	Unstable	Unstable	Unstable	Stable	Stable	Stable	Unchanged
WCk44	Stable	Moderately Stable	Moderately Stable	Moderately Stable	Moderately Stable	Moderately Stable	Highly Stable	Moderately Stable	Moderately Stable	Unchanged
WCk45	Stable	Stable	Stable	Stable	Moderately Stable	Moderately Stable	Highly Stable	Moderately Stable	Moderately Stable	Unchanged
WCk46	Stable	Moderately Stable	Moderately Stable	Stable	Moderately Stable	Moderately Stable	Moderately Stable	Moderately Stable	Moderately Stable	Unchanged
WCk47	Stable	Moderately Stable	Stable	Stable	Moderately Stable	Moderately Stable	Moderately Stable	Stable	Stable	Unchanged
WCk48	Stable	Stable	Stable	Stable	Moderately Stable	Moderately Stable	Moderately Stable	Moderately Stable	Moderately Stable	Unchanged
WCk49	Stable	Stable	Stable	Unstable	Stable	Stable	Stable	Stable	Moderately Stable	Improved

Cumbo Creek site stability scores 2016-2023 comparison

Site	2016 Rating	2017 Rating	2018 Rating	2019 Rating	2020 Rating	2021 Rating	2022 Rating	2023 Rating	2024 Rating	Difference
CCK1	Highly Stable	Highly Stable	Highly Stable	Highly Stable	Highly Stable	Highly Stable	Highly Stable	Highly Stable	Highly Stable	Unchanged
CCK2	Moderately Stable	Stable	Stable	Stable	Stable	Stable	Stable	Stable	Stable	Unchanged
CCK3	Moderately Stable	Highly Stable	Highly Stable	Highly Stable	Highly Stable	Highly Stable	Highly Stable	Highly Stable	Highly Stable	Unchanged
CCK4	Highly Stable	Highly Stable	Highly Stable	Highly Stable	Highly Stable	Highly Stable	Highly Stable	Highly Stable	Highly Stable	Unchanged
CCK5	Moderately Stable	Highly Stable	Highly Stable	Highly Stable	Highly Stable	Highly Stable	Highly Stable	Highly Stable	Highly Stable	Unchanged
CCK6	Moderately Stable	Highly Stable	Moderately Stable	Moderately Stable	Moderately Stable	Moderately Stable	Moderately Stable	Highly Stable	Highly Stable	Unchanged
CCK7	Not surveyed	Moderately Stable	Highly Stable	Highly Stable	Highly Stable	Highly Stable	Highly Stable	Highly Stable	Highly Stable	Unchanged
CCK8	Highly Stable	Highly Stable	Highly Stable	Highly Stable	Highly Stable	Highly Stable	Highly Stable	Highly Stable	Highly Stable	Unchanged
CCK9	Highly Stable	Highly Stable	Highly Stable	Highly Stable	Highly Stable	Highly Stable	Highly Stable	Highly Stable	Highly Stable	Unchanged
CCK10	Highly Stable	Highly Stable	Highly Stable	Highly Stable	Highly Stable	Highly Stable	Highly Stable	Highly Stable	Highly Stable	Unchanged

Appendix F: Monthly Rainfall Data

Table C - 1: Monthly rainfall from 2015-2024 (mm)

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec	Total
2015	127.6	11.6	9.4	108.4	42.8	42.8	38.0	53.8	7.8	61.0	59.0	118.4	680.6
2016	152.1	7.2	23.5	14.8	66.8	104.2	101.1	40.9	198.7	86.6	51.9	90.6	938.4
2017	27.8	34.2	146	23	32.4	10.4	5.8	25.2	3	28.4	92.6	102.6	531.4
2018	24.4	77	24.6	42.2	12.4	21.6	1.2	43.8	39.6	56.8	47.4	91.2	482.2
2019	54.8	7.4	108.8	0	17.6	10.6	2.6	10.2	23	5.6	22	3	265.6
2020	27.2	127	92	117	16	23.4	70	36.4	77.2	150.6	17.4	161.6	915.8
2021	52.6	126.6	159.8	1.8	9.4	84.4	66.8	25.4	44.2	40.8	249.2	81.4	942.4
2022	101.4	16	119.8	95	43.6	13	136.4	103.2	93.8	174.4	64	26.6	987.2
2023	48.6	24.6	64.6	47.8	2.8	28.8	23.2	29.8	18	36.2	94	59.6	478
2024	86.6	78.6	32.8	68.8	62.2	68.6	65	39.8	45.4	51	116.6	30.8	745.2
Historical Mean	67.2	62.2	55.2	39.3	37.2	44.0	43.0	41.1	41.7	52.1	57.0	60.9	593.1

Source: 2024 data from the WCPL Weather Station Sentinex 34 received 19 December 2024, historical data from the BoM weather stations Wollar (Barrigan Street) weather station number: 62032 (BOM 2024).

2024 Stream Health Monitoring Report

Wilpinjong Coal Mine

Wilpinjong Coal Pty Ltd

ecological AUSTRALIA
A TETRA TECH COMPANY

Document Tracking

Project Name:	2024 WCPL Stream Health Monitoring Report
Project Number:	9285
Project Manager:	Kieran Stephenson-Banks

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Abbreviations

Abbreviation	Description
ANZECC	Australian and New Zealand Environmental and Conservation Council
ARMCANZ	Agriculture and Resource Management Council of Australia and New Zealand
AUSRIVAS	Australian Rivers Assessment System
DO	Dissolved oxygen
EC	Electrical conductivity
ELA	Eco Logical Australia
EPL	Environmental Protection Licence
NP	National Park
NTU	Turbidity
RCE	Riparian, Channel and Environmental
RO	Reverse osmosis
SHM	Stream health monitoring
SIGNAL2	Stream Invertebrate Grade Number - Average Level
WCM	Wilpinjong Coal Mine
WCPL	Wilpinjong Coal Pty Ltd

Executive Summary

Stream health monitoring (SHM) was undertaken during spring 2024 within the catchments surrounding Wilpinjong Coal Mine (WCM). A total of ten permanent sites were monitored along Wilpinjong, Wollar and Cumbo creeks, as well as two control sites located along Barigan Creek.

The monitoring results were largely consistent with previous years' results. Most sites recorded mid-range RCE (Riparian, Channel and Environmental) scores, typical of catchments in the region.

Water quality results were recorded for various parameters and differed across most sites in comparison with previous years. Parameters were inside Australian and New Zealand Environmental and Conservation Council (ANZECC) guidelines at all but one site for pH and were within at ten sites for turbidity, likely as a result of decreased runoff and stream flow leading up to the monitoring period.

Water quality results for temperature, electrical conductivity (EC), and dissolved oxygen (DO) fluctuated considerably across monitoring years, during times of variable stream flow and at sites both upstream and downstream of the WCM licensed discharge point. As such, these results indicate that natural factors and fluctuating climatic conditions, rather than mining operations are the primary influences on water quality in the catchments surrounding the WCM. The 2024 SHM occurred under wet conditions, with 33.8 mm of rainfall the morning prior to monitoring commencing, and this may have influenced some of the water quality results.

Across all monitoring sites, a total of 12 macroinvertebrate Orders and 53 Families were recorded. Stream invertebrate grade number average level (SIGNAL2) scores were generally low in 2024, although 11 of the 12 sites showed an increase in comparison to the 2024 SHM period. A combination of low levels of flowing water, higher water temperature, and low DO likely limited the diversity of macroinvertebrate communities. Three sites scored ≥4.0 indicating moderately disturbed systems, whereas in 2023 SIGNAL2 scores were <4.0 for all sites, which is indicative of severely disturbed systems. The overall temporal and spatial consistency of these macroinvertebrate results indicate that historical disturbances, combined with fluctuating climatic conditions within the larger catchments surrounding the WCM, are the main factors responsible for current stream health conditions.

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1. Introduction

1.1. Background

Wilpinjong Coal Pty Ltd (WCPL) is required to undertake annual stream health monitoring (SHM) to satisfy the updated requirement of Development Consent SSD 6764 Condition 29 & 30 (ii) (previously under Schedule 3, Condition 32 of WCPL's Project Approval (05-0021)) and the SHM criteria detailed in Appendix 2 of the Wilpinjong Water Management Plan (WCPL 2018). Eco Logical Australia (ELA) was engaged by WCPL to undertake SHM in the 2024 monitoring period.

1.2. Regional Overview

The Wilpinjong Coal Mine (WCM) is located in the Mid-Western Regional Council Local Government Area, approximately 45 km north-east of Mudgee. The mine is owned and operated by WCPL, a wholly owned subsidiary of Peabody Energy Australia.

The WCM is located at the headwaters of the Goulburn River which is a major tributary of the Hunter River. Wilpinjong Creek is the main drainage channel within the WCM. It is an intermittent creek with a narrow floodplain that has a history of cattle grazing. The northern edge of the floodplain is bordered by the sandstone escarpments of Goulburn River National Park (NP). Wilpinjong Creek has three coal mines in its catchment, Moolarben, Ulan, and Wilpinjong, with the latter positioned furthest downstream. WCPL discharges water, treated by reverse osmosis (RO), into Wilpinjong Creek at Environment Protection Licence (EPL) point 24 (EPL 24) directly adjacent to WCM.

Barigan Creek flows north through agricultural land as a tributary to Wollar Creek, joining south of the town of Wollar. Cumbo Creek flows north through land managed by WCPL, passing between Pit 3 and Pit 4, before joining Wilpinjong Creek north of the eastern pit area. Wilpinjong Creek continues to flow east, for approximately 4.5 km downstream where it joins Wollar Creek, which continues another 13 km through the Goulburn River NP before entering the Goulburn River.

1.3. Objectives

The ongoing SHM program for WCM is aimed to assist in determining the need for any maintenance and/or contingency measures. The objectives of annual SHM within Wilpinjong, Cumbo, Wollar and Barigan creeks include:

- Survey of aquatic macroinvertebrate assemblages in spring if streamflow or ponded water is present and access to the creeks is safe, paired with *in situ* surface water quality sampling at each sampling site.
- An assessment of environmental condition at each site based on a variety of ecological indices.
- Comparisons of site indices against previous survey data to assess changes through time, and comparisons to trigger levels that would prompt further investigation.

2. Methodology

2.1. Survey Overview

The 2024 SHM was undertaken by ELA ecologists Kieran Stephenson-Banks and Natalie De Losa from 18 November to 21 November 2024. A total of ten permanent monitoring sites were surveyed along Wilpinjong, Cumbo and Wollar creeks, along with two control sites at Barigan Creek established in 2020 (**Table 1**). In 2023, macroinvertebrate and water sampling did not occur at BC2 along Barigan Creek and at WC2 along Wilpinjong Creek because they were dry, both sites were monitored in 2024.

Monitoring locations reflect a balance of sites both upstream and downstream of WCPL discharge point (EPL Point 24), as well as the various creeks (including external creeks) within the surrounding catchment (**Figure 1**). Photographs of each site are included in **Appendix A**.

Table 1: 2024 monitoring sites

Creek	Site	Upstream / Downstream*	Inundation Status	Easting	Northing
Wilpinjong Creek	WC1	Upstream	Wet	767680	6422970
	WC2	Upstream	wet	768490	6422490
	WC6	Downstream	Wet	774580	6420860
	WC8	Downstream	Wet	775860	6420820
Cumbo Creek	CC1	Upstream	Wet	772710	6418130
	CC2	Upstream	Wet	772980	6418950
Wollar Creek	WO1	Upstream	Wet	777940	6418170
	WO2	Upstream	Wet	777780	6418950
	WO3	Downstream	Wet	777790	6420100
	WO4	Downstream	Wet	778030	6420596
Barigan Creek	BC1	Upstream	Wet	778704	6409493
	BC2	Upstream	Wet	779830	6403765

*Indicates Upstream / Downstream of EPL Point 24)

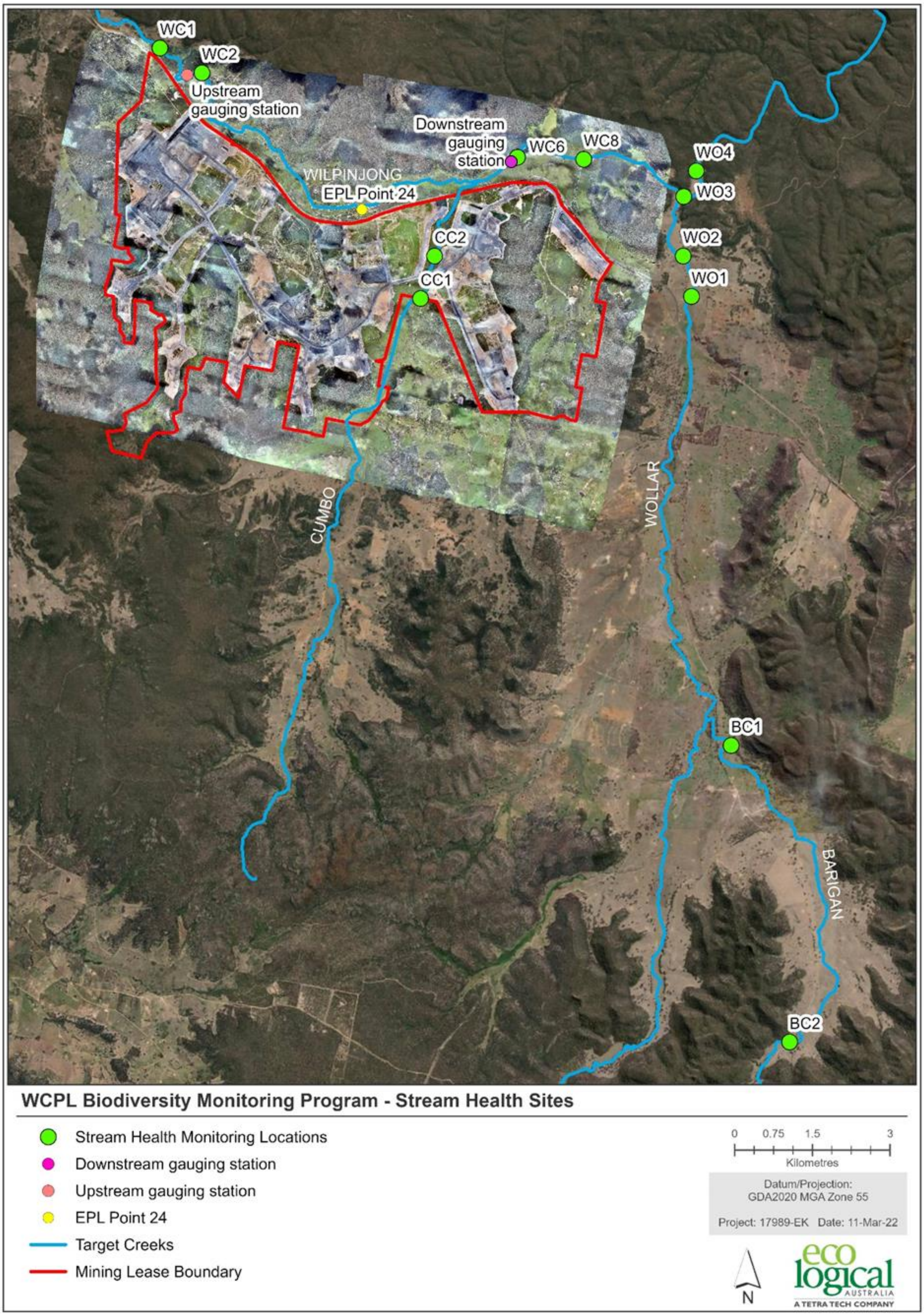

Figure 1: 2024 monitoring sites along Wilpinjong, Cumbo, Wollar and Barigan Creeks

2.2. Survey Methods

2.2.1. Aquatic habitat assessment

Aquatic habitat assessments were based on the *Policy and Guidelines for Fish Habitat Conservation and Management* (DPI Fisheries 2013), which outlines the features important for fish habitat in freshwater, estuarine, and marine areas. Habitat assessments allow the significance of river reaches to be determined, regardless of whether target fish species are present permanently, or for brief periods of time.

Aquatic habitat variables (environmental data) were noted for each site, with observations made from the bank on the following characteristics:

- General signs of disturbance
- Habitat type
- Channel topography
- Current water level
- Bank and bed slope
- Degree of river shading
- Amount of detritus
- Macrophyte type and extent
- Riparian zone width
- Snags and large woody debris coverage
- Stream width and depth
- Surrounding land use
- Description of the natural substrate
- Extent of bank overhang
- Amount of trailing bank vegetation.

Riparian condition was assessed using a version of the Riparian, Channel and Environmental (RCE) inventory (Peterson 1992) that was modified for Australian conditions (Chessman et al. 1997). The modified RCE has 13 descriptors, each with a score from one (poor condition) to four (good condition).

Descriptors included width and condition of the riparian zone, surrounding land use, extent of bank erosion, stream width, water depth, occurrence of pools, riffles and runs, substratum type, presence of snags and woody debris, in-stream and emergent macrophytes, algae, and barriers to fish passage. The total score for each site was derived by summing the score for each descriptor and calculating the result as a percentage of the highest possible score (up to 52).

Sites with a high RCE score indicate that the riparian zone is largely undisturbed, while those with a low score have undergone substantial modification. Based on the original classification established by Peterson (1992), site condition was rated as follows:

- Poor for RCE scores of 0-24%
- Fair for RCE scores of 25-43%
- Good for RCE scores of 44-62%
- Very Good for RCE scores of 63-81%
- Excellent for RCE scores of 82-100%.

RCE results from 2024 were compared with results from previous monitoring years dating to 2016, when RCE was introduced to the WCPL SHM program (Section 4.1).

2.2.2. Water quality

Complementing documented biological data, the following physicochemical parameters were measured at all sites:

- Temperature
- Dissolved oxygen (DO)
- Electrical conductivity (EC)
- Turbidity (NTU)
- pH.

Water quality results from 2024 were compared with previous year's results for DO, EC, turbidity and pH (Section 4.2). Results date back to 2006, however, not all parameters have results available for each year. Water quality parameters measured during surveys were compared with the Australian and New Zealand Environmental and Conservation Council (ANZECC) and Agriculture and Resource Management Council of Australia and New Zealand (ARMCANZ) (2000) guidelines for the protection of aquatic environments. The ANZECC and ARMCANZ guidelines provide different ranges for upland and lowland streams, with upland streams being those above 150 m altitude. All sites surveyed for this project are considered upland stream sites.

2.2.3. Macroinvertebrate communities

Macroinvertebrate samples were collected at each site using the Australian Rivers Assessment System (AUSRIVAS) protocols (Turak et al. 2004). Three representative samples were collected at each site. Samples were collected from 10 m of representative edge, pool and/or riffle habitats using a standard AUSRIVAS kick net with 250 µm mesh. The net was bounced along the bottom to disturb resting invertebrates, and then rapidly passed again through the water column to collect the disturbed taxa. Edge habitats were defined as adjacent to the creek bank in areas of little or no flow, including alcoves and backwaters, with abundant leaf litter, fine sediment deposits, macrophyte beds and overhanging bank vegetation (Turak et al. 2004).

Macroinvertebrate samples were live sorted in the field for a minimum of 40 minutes. If new taxa were collected in the period from 30 to 40 minutes, picking continued for another 10 minutes. If no new taxa were found after 10 minutes, sorting stopped, but if there were new taxa, another 10 minute block was added. The maximum sorting time was 60 minutes. All picked animals were preserved in 70% ethanol solution and transported to the laboratory for identification. Specific care was taken to ensure small, cryptic, and fast-moving taxa were represented.

Macroinvertebrates were identified to family level, except for Acarina, Copepoda, Ostracoda, Oligochaeta, Platyhelminthes, Hirudinea, and Collembola which were identified to order.

The Stream Invertebrate Grade Number - Average Level (SIGNAL2) is a biotic index that allocates a value to each macroinvertebrate family based upon their sensitivity to pollution. A macroinvertebrate family with a value of 10 indicates high sensitivity, while a value of 1 indicates low sensitivity (i.e. high pollution tolerance) (Chessman et al. 1997). The SIGNAL2 score for the entire site is calculated by summing the SIGNAL2 grades for each family collected at that site and then dividing by the total number of families collected. SIGNAL2 scores are used to grade aquatic health into the following categories:

- SIGNAL2 Score > 6: Healthy Habitat

- SIGNAL2 Score 5-6: Mild Pollution
- SIGNAL2 Score 4-5: Moderate Pollution
- SIGNAL2 Score < 4: Severe Pollution.

Average SIGNAL2 scores for 2024 were compared with scores from previous years, dating back to 2006 (where available) (**Section 4.3**). SIGNAL2 scores from 2011 to 2013 (Landline Consulting 2011; 2012; 2013) were calculated using abundance weighting of macroinvertebrate taxa which resulted in slightly higher average SIGNAL2 scores for sites with relatively abundant macroinvertebrates. Since 2014, SIGNAL2 scores were calculated on presence/absence data. Whilst this method differs slightly from that undertaken in previous years, the results are largely consistent and valid for comparison.

2.3. Climate data

During the three days of the 2024 stream health monitoring period, air temperature was below historical averages, and there was a large rainfall event (33.8 mm) on the first morning prior to sampling commencing (**Table 2**). In the preceding three months prior to monitoring, rainfall was consistent with average rainfall, and above average between May to July (

Table 3).

Table 4 summarises monthly flow data measured at three gauging stations near WCL. Withstanding the high amount of rainfall the morning before sampling commenced, the rainfall from the previous months resulted in generally little or no flow at some sites.

Table 2: Temperature and rainfall data for the 2024 monitoring period

Date	Min. temp (°C)	Max. temp (°C)	Rainfall (mm)
18-Nov-2024	16.2	26.6	33.8
20-Nov-2024	12.6	27.7	0
21-Nov-2024	13.7	26.8	0

Table 3: Temperature and rainfall preceding 2024 monitoring period

Month	2024 Averages (WCPL)			Historical Averages		
	Mean min. temp (°C)	Mean max. temp (°C)	Total Rainfall (mm)	Mean min. temp (°C)	Mean max. temp (°C)	Total Rainfall (mm)
January	18.8	30.9	86.6	15.5	31.1	67.2
February	18.7	31.2	78.6	15.4	30.2	62.2
March	15.1	28.7	32.8	13.0	27.8	55.2
April	9.1	23.2	67.8	8.5	23.3	39.3
May	6.8	19.4	62.2	5.0	18.8	37.2
June	3.5	15.3	68.6	2.6	15.2	44.0
July	4.0	14.4	65.0	1.3	14.4	43.0
August	6.1	19.1	39.8	2.3	16.0	41.1
September	5.4	21.4	45.4	4.4	19.6	41.7
October	10.0	23.7	51.0	7.6	23.4	52.1
November	15.2	28.9	116.6	10.8	26.9	57.0

Month	2024 Averages (WCPL)			Historical Averages		
	Mean min. temp (°C)	Mean max. temp (°C)	Total Rainfall (mm)	Mean min. temp (°C)	Mean max. temp (°C)	Total Rainfall (mm)
December	18.5	31.8	30.8	13.7	29.8	60.9

Source: 2024 data from the WCPL Weather Station Sentinex 34 provided 19 December 2024, historical data from the BoM weather stations at Mudgee Airport (temp) and Wollar-Barigan St weather station (rainfall) (BOM 2024)

Table 4: Monthly flow data at three gauging stations

Month	Wilpinjong Creek Upstream			Wilpinjong Creek Downstream			Cumbo Stream Upstream		
	Flow (cumecs)	EC (µs/cm)	pH	Flow (cumecs)	EC (µs/cm)	pH	Flow (cumecs)	EC (µs/cm)	pH
January	0.003	887.9	7.32	0.061	710.8	7.47	0.003	3938.1	7.62
January	0.003	887.9	7.32	0.061	710.8	7.47	0.000	3938.1	7.62
February	0.001	793.1	7.28	0.056	613.5	7.48	0.000	5336.2	7.69
March	0.000	1117.9	7.38	0.042	563.8	7.53	0.001	5418.0	7.98
April	0.000	1000.6	7.26	0.039	623.4	7.63	0.001	-**	-**
May	0.000	919.4	7.17	0.035	660.0	7.77	0.001	4383.7	8.04
June	0.003	653.8	6.94	0.037	810.3	7.79	0.000	3802.1	7.78
July	0.003	683.4	6.96	0.055	953.5	7.81	0.010	3519.4	7.86
August	0.003	632.7	6.64	0.075	1181.5	7.79	0.010	3425.5	7.91
September	0.002	730.7	7.13	0.070	770.9	7.76	0.004	3564.2	7.84
October	0.007	716.1	7.11	0.078	775.0	7.78	0.004	3744.1	7.70
November	0.003	723.7	7.26	0.075	572.3	7.50	0.003	4672.1	7.52
December	0.012	558.3	7.18	0.078	680.1	7.53	0.006	3608.3	7.40

Source: WCM.
**No data available

3. Results

3.1. Aquatic Habitat Assessment

Results of the habitat assessment, including water, substrate, vegetation, land use, and how these elements contribute to the RCE score are detailed below. A breakdown of how the 13 RCE parameters scored for each site is included in Table 5.

Table 5: Site results for the 13 RCE parameters

Descriptor	WC 1	WC 2	WC 6	WC 8	WO 1	WO 2	WO 3	WO 4	BC1	BC2	CC1	CC2
Land use pattern beyond immediate riparian zone	3	3	2	3	2	3	3	4	3	3	2	3
Width of riparian strip of woody vegetation	3	3	3	3	3	3	3	4	3	3	2	1
Completeness of riparian woody strip of vegetation	2	2	2	3	2	2	2	4	3	1	1	1
Vegetation of riparian zone within 10 m of channel	4	4	3	3	3	3	3	4	3	1	2	1
Stream bank	2	2	3	3	3	3	3	3	3	3	3	3
Bank undercutting	3	3	3	4	3	3	3	3	3	3	4	4
Channel form	2	3	3	3	3	3	3	3	3	3	2	3
Riffle/pool sequence	2	3	3	3	3	3	3	3	3	3	2	2
Retention devices in stream	1	1	1	1	4	3	3	3	2	2	1	1
Channel sediment accumulations	4	3	4	4	3	4	3	3	3	3	4	4
Stream bottom	2	2	2	2	2	2	2	2	2	2	2	2
Stream detritus	2	2	2	2	2	2	3	3	2	2	2	1
Aquatic vegetation	2	2	2	2	2	3	3	3	3	2	2	2
Total	32	33	33	36	35	37	37	42	36	31	29	28
Total %	62	63	63	69	67	71	71	81	69	60	56	54
Condition classification	G	VG	VG	VG	VG	VG	VG	VG	VG	G	G	G

G = Good; VG = Very Good

All sites continue to have an RCE classification of 'Good' (four of twelve sites) or 'Very Good' (eight of twelve sites), with one site now classified as 'Very Good' compared to 'Good' in 2023.

3.2. Water Quality

The results of water quality sampling for temperature, EC, DO, pH *in situ* and Turbidity *ex situ* are detailed in Table 6. Water temperatures at the time of sampling ranged between 18.4°C and 29.2°C. Variation in water temperature generally reflected the time of day as well as the stream morphology of the monitoring sites, with samples collected later in the day (e.g. CC2, WC1 and WC2) and/or from shallower profile streams (e.g. WC1 and WC2) being warmer.

EC across 10 of the 12 sites were generally consistent in 2024 compared to 2023, WC1 and BC1 were notably lower in 2024 compared to the results from 2023. Only sites BC1 and BC2, the two control sites had EC values within the ANZECC and ARMCANZ (2000) guidelines. The lowest EC recorded was at BC1

(158.2 µS/cm). The highest two EC values were recorded at CC1 (4,354 µS/cm) and CC2 (4,029 µS/cm), both of which are located within the WCPL mining lease, with the EC values at these sites substantially higher than all other monitoring sites, analogous to the previous two years' trend.

DO ranged between 70.5% saturation at WO1 to 113.0% saturation at WC2. Three sites (WC6, CC1 and CC2) were within the recommended ANZECC and ARMCANZ (2000) guideline range. The pH ranged between 7.32 and 8.04 resulting in all sites but CC2 being within the ANZECC and ARMCANZ (2000) guidelines. Turbidity ranged from 1.21 NTU at CC1 to 46.9 NTU at WO2 (Table 6). WC8, WO2, CC1 did not meet the recommended ANZECC and ARMCANZ (2000) guideline for turbidity, with only WO2 exceeding the guidelines by a significant degree.

Table 6: Water quality results. Red figures are outside of ANZECC Guidelines

Variable	Guideline Range	WC1	WC2	WC6	WC8	WO1	WO2	WO3	WO4	BC1	BC2	CC1	CC2
Temperature (°C)	N/A	27.2	27.7	21.7	18.4	20.9	23.0	19.3	18.5	19.8	19.0	23.0	29.2
Conductivity (µS/cm)	30-350	671	519	681	635	719	1192	1057	1115	158	305	4354	4029
DO (% saturation)	90-110	108.0	113.0	97.2	81.3	70.5	86.4	77.4	80.6	80.6	84.3	97.4	110.0
DO (mg/L)	N/A	8.11	8.48	7.28	6.08	5.26	6.46	5.78	6.01	6.02	6.31	7.31	8.26
pH	6.5-8.0	7.32	7.40	7.89	7.94	7.56	7.80	7.86	8.00	7.52	7.81	7.72	8.04
Turbidity (NTU)	2-25	9..2	20.2	7.5	27.2	12.9	46.9	15.1	15.0	23.4	8.8	1.21	2.0

3.3. Macroinvertebrate Communities

A summary of macroinvertebrate results is presented in Table 7, with the full results for each site detailed in Appendix B. A total of 12 macroinvertebrate Orders/Classes and 53 Families were recorded during 2024 monitoring. The most observed taxa were Corixidae from the Order Hemiptera and Calamoceratidae from Order Trichoptera. Corixidae from the Order Hemiptera was the only taxa recorded at all 12 monitoring sites. Across individual sites, macroinvertebrate taxonomic richness ranged from 11 to 25 taxa, with CC2 recording the least number of taxa and BC1 recording the most. At the time of sampling, these sites had a variety of available micro-habitat for macroinvertebrates, including macrophytes, woody debris and riffles. However, the water level was generally low across all sites, harnessing limited macroinvertebrate communities.

Pollution sensitivity ratings for each Family/Order were used to calculate the average SIGNAL2 score for each site. Where Families/Orders have no assigned SIGNAL2 sensitivity rating, they were not included in the averages, however, are still represented in results for taxa richness. Average SIGNAL2 scores range from 2.8 (severely polluted) at CC2 to 4.6 (moderately polluted) at WC6 (Table 7). Nine of the 12 sites had an average SIGNAL2 score of less than 4.0 and as such are classified as severely disturbed, whereas sites WC6, WC8 and WO5 are classified as moderately disturbed, Overall, the score increased compared to the result in 2023.

Section 6.2 of the WCPL Surface Water Management and Monitoring Plan (WCPL, 2018) outlines the following trigger conditions for SHM:

- Minimum taxon richness: 15 taxa; and
- Minimum SIGNAL2 index: 3.0.

Eleven of the 12 sites monitored scored above the minimum trigger conditions for both SIGNAL2 and taxa richness scores. Site CC2 did not reach either minimum taxa richness or minimum SIGNAL 2 index.

Table 7: SIGNAL2 scores for 2024 monitoring sites

Measure	BC1	BC2	CC1	CC2	WC1	WC2	WC6	WC8	WO1	WO2	WO3	WO4
Taxa richness	25	20	20	11	21	22	20	20	23	18	21	19
Average SIGNAL2 score	3.9	3.4	3.4	2.8	3.9	3.5	4.6	4.2	3.7	4.1	3.9	4.2
SIGNAL2 pollution condition	S	S	S	S	S	S	M	M	S	S	S	M

M = Moderate, S = Severe

4. Discussion

4.1. Aquatic Habitat Assessment

All sites were classified as either 'Good' or 'Very Good' for their RCE indices during 2024 monitoring. This puts them in the mid-range for riparian and channel habitat quality. Overall, habitat conditions within Wilpinjong, Wollar, Cumbo, and Barigan creek sites were consistent with those recorded since 2016, both upstream and downstream of the WCPL licensed discharge point (**Figure 2**).

The stream bed structure (Stream bank, Stream bottom and Stream detritus) scored low overall, due to lack of vegetation cover and the presence of loose and mobile sediments along the stream bed at most sites. This is typical in a highly modified agricultural landscape where sites have reduced bank stability leading to increased erosion and sedimentation. Temporal differences were largely restricted to changes in vegetation of riparian zone within 10m of the channel which saw a decrease in macrophyte growth and an increase of algal growth. However, this is not reflective of an overall deterioration in water quality, and therefore habitat quality, but could be attributed to an increase in a limiting factor needed for growth.

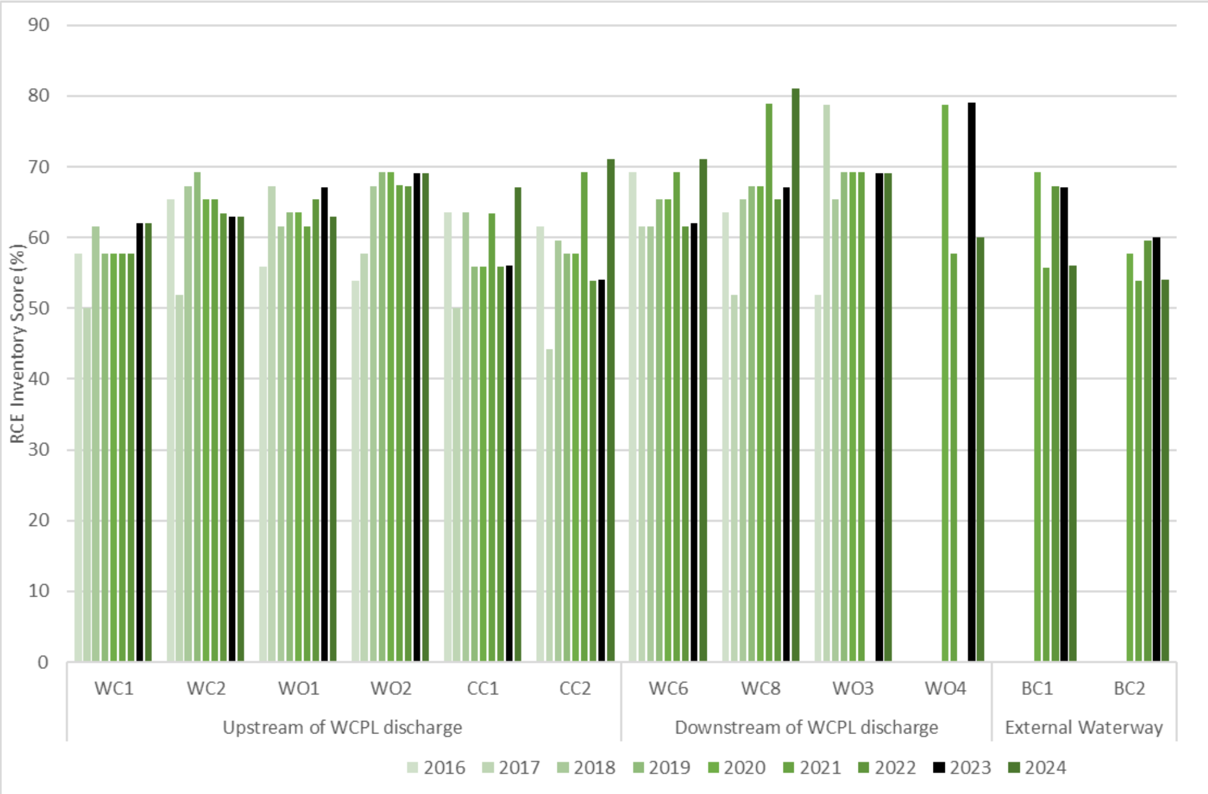

Figure 2: RCE scores across all sites and years

4.2. Water Quality

Water temperature overall was slightly lower than 2023 temperatures, and higher than in historical data, with an average temperature of 22.3°C in 2024 compared to 24.6°C in 2023. The lower water temperature was influenced by survey timing. Specifically, the survey occurred a month earlier than the previous year when the ambient temperature was lower. The flow level was increased at each creek due to a recent rainfall, under AUSRIVAS and Water Quality monitoring protocols, sampling could have been postponed 4-6 week post a large rainfall event, but that would have put sampling outside the AUSRIVAS monitoring window, and as such monitoring proceeded. Multiple sites had stagnant flow in which trapped water was readily heated by the sun. Further fluctuations in water temperature are expected at each site in line with the generally shallow stream depth, minimal riparian shading, algal growth and turbidity reducing transparency of water, and variable flow.

DO concentrations at five monitoring sites were withing the ANZECC and ARMCANZ (2000) guideline range. At six sites in 2024 the DO concentrations were below the ANZECC and ARMCANZ (2000) guideline range, showing an increase from 2023, and much closer to the guideline range. One site, WC2 was outside the upper range for DO. DO concentrations fluctuate due to a range of factors including water temperature, organic and bacterial activity, wind, water flow and circulation, and time of day. In 2024, flowing water, with cooler temperatures, and the increase of water flow may have caused the increase in DO.

This is exemplified by the significant increase in DO at sites including WO1, WC6 and WC8 which had increased water flow and cooler water temperatures. Over time, DO concentrations have fluctuated considerably across sites and years, and have frequently been outside of ANZECC and ARMCANZ (2000) guidelines (**Figure 3**). These results have been recorded not only both upstream and downstream of the WCPL discharge point, but the two control sites located along the external Barigan Creek. This suggests that DO concentrations and fluctuations may be a result of catchment-scale processes and are not linked to mining operations.

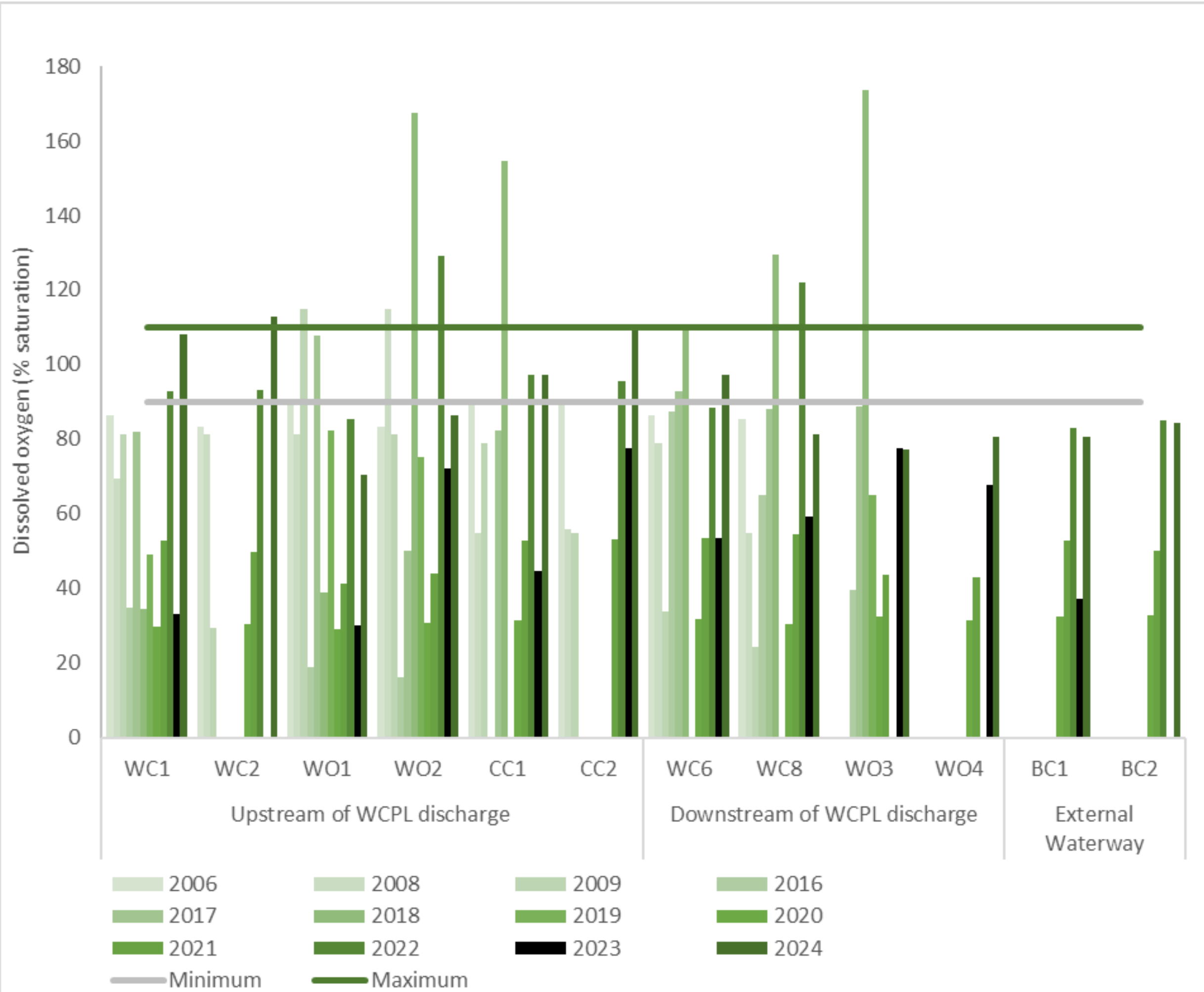

Figure 3: DO (% saturation) results across all sites and years

EC in 2024 at all the sites upstream and downstream of WCPL discharge was generally consistent compared to results from 2022 and 2023 (**Figure 4**). This may indicate that natural variables, rather than mining operations are the main factors that influence EC in the sampled catchments. EC measurements at control sites BC1 and BC2 during 2020–2024 were lower than those in Wilpinjong and Wollar Creeks, whilst Cumbo Creek sites (CC1 and CC2) have consistent recorded substantially higher EC values than all other sites for many years. The region is known to have naturally occurring saline groundwater (BIO-ANALYSIS 2015), which likely contributed to baseflow in all creeks. Decreased EC downstream of the Cumbo Creek confluence is potentially a result of a dilution by the licenced discharge of RO water at EPL 24 and an increasing proportion of influx of freshwater from the surrounding basin as water travels downstream.

EC was outside of the recommended ANZECC guideline range (30-350 µS/cm), although the trend appears to be improving, with EC in 2024 lower at all sites compared to values in 2023, excluding WO3 and WO4. Exceptions to this were at CC1 and CC2 upstream of the discharge location, where EC was around 4000 µS/cm. This is potentially due to higher salinity groundwater inputs to Cumbo Creek.

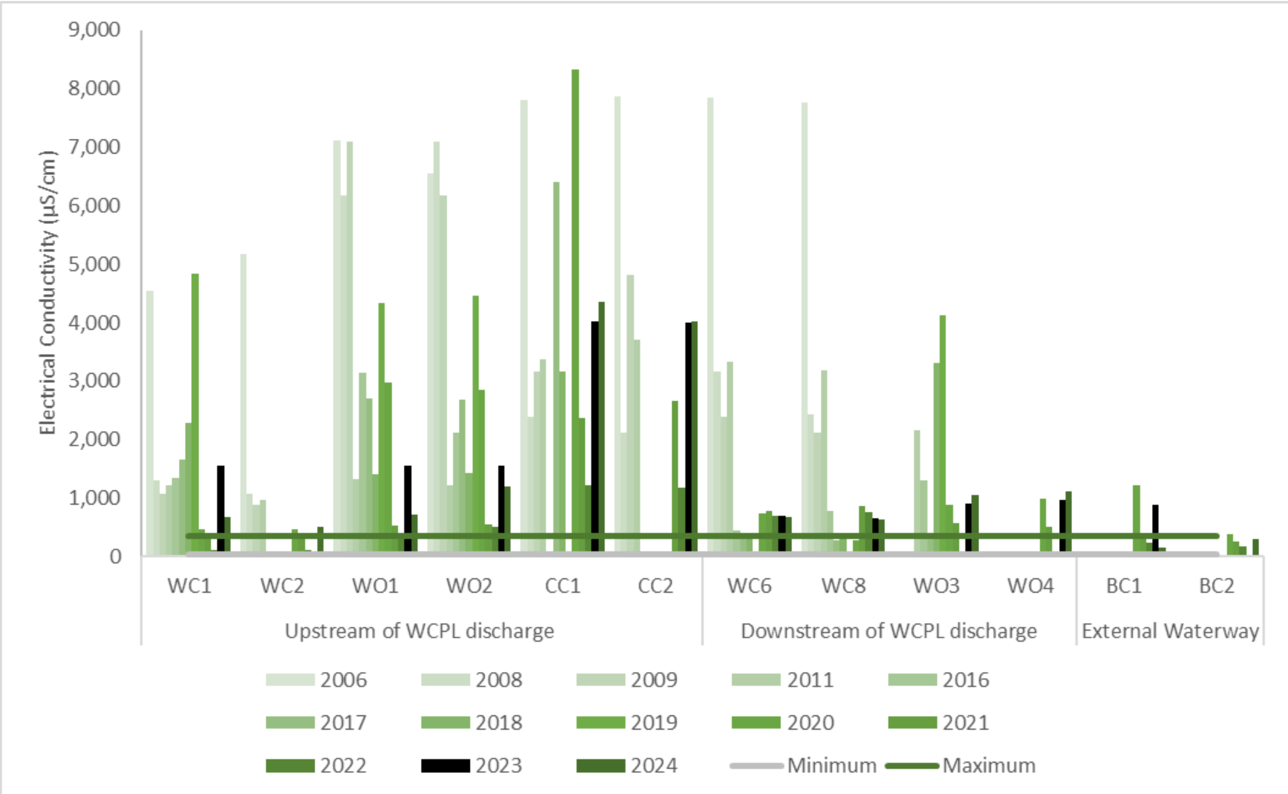

Figure 4: EC (µS/cm) results across all sites and years

Nine of 12 sites were within the recommended ANZECC and ARMCANZ (2000) guideline range for turbidity. Overall, turbidity was generally consistent with 2023 monitoring, and generally lower compared to historical monitoring results, likely due to less rainfall and lower volumes of sediment and organic matter transported by the river during the dry conditions in the months preceding 2024 monitoring period (**Figure 5**).

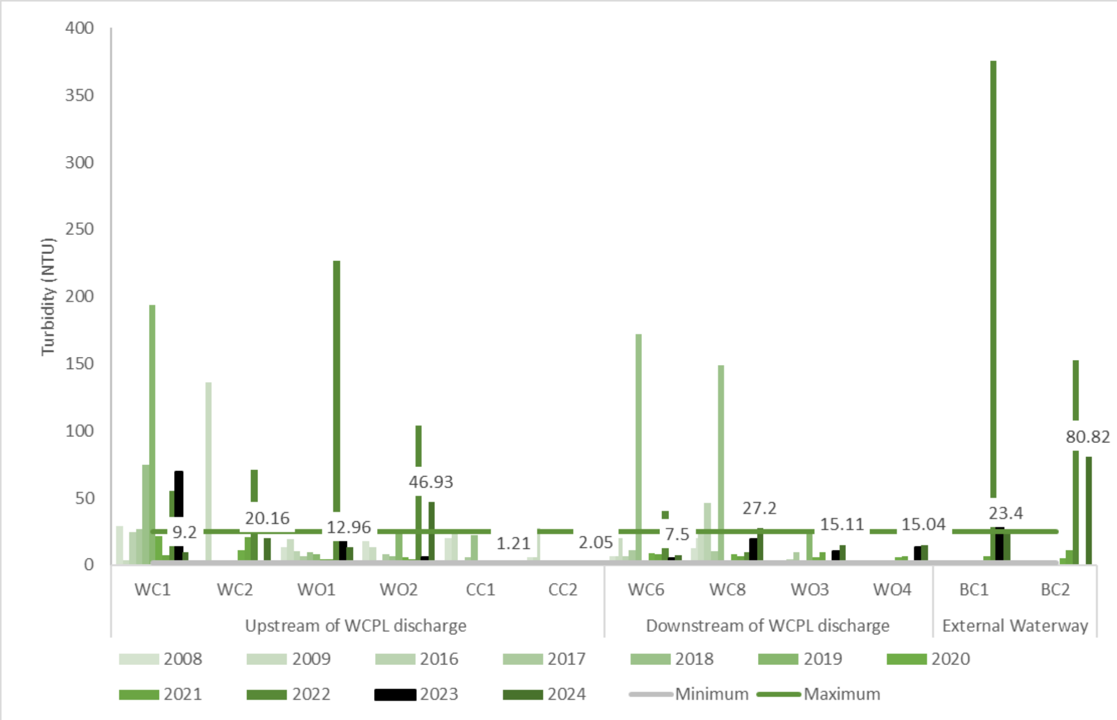

Figure 5: Turbidity (NTU) results across all sites and years (Scores for 2024 are labelled for better readability)

The pH at all but one site (CC2) monitored in 2024 was within ANZECC guidelines, ranging between 7.32 and 8.04, and largely consistent with historical monitoring across all sites (**Figure 6**).

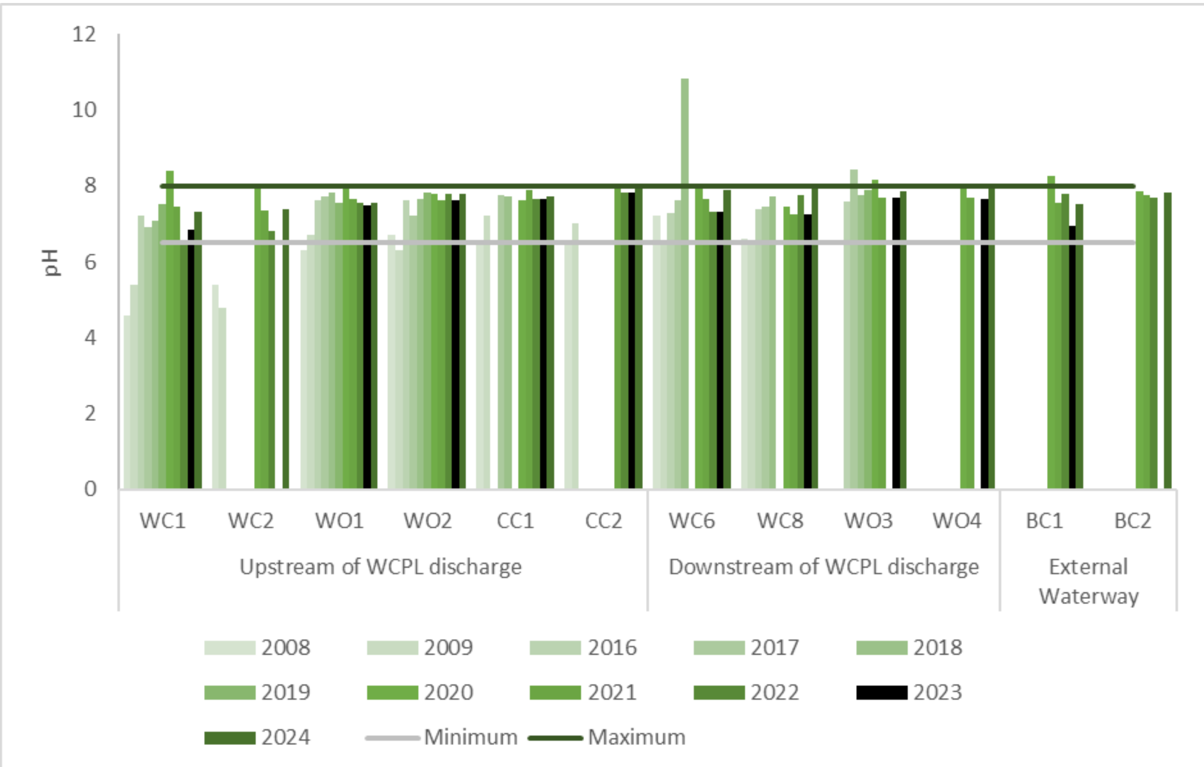

Figure 6: pH results across all sites and years

4.3. Macroinvertebrate Communities

Across all monitoring years, the average SIGNAL2 score for nine of the 12 sites is <4.0 indicting severely disturbed systems, three sites scored ≥4.0 indicative of moderately disturbed systems (**Figure 7**). Low SIGNAL2 scores have been consistently recorded during periods of variable surface water availability and at sites both upstream and downstream of the WCM, including the two control sites located in Barigan Creek. Such results therefore reflect the overall disturbed nature of the catchment, largely attributable to historical agricultural and land use practices.

SIGNAL2 scores increased across all sites except one (CC2) from 2023. Furthermore, CC2 was the only site to score both the minimum taxa richness and minimum SIGNAL 2 index, which should trigger an investigation into the cause of this as outlined in the WCPL SWMMP (WCPL, 2018). However, it is likely that the prevailing climatic conditions in the two months leading up to monitoring (i.e. low rainfall and water levels throughout the catchment) and relevant parameters (higher water temperature, lower DO) have strongly influenced the score, and therefore it is recommended that subsequent monitoring is to be conducted under closer to average rainfall conditions.

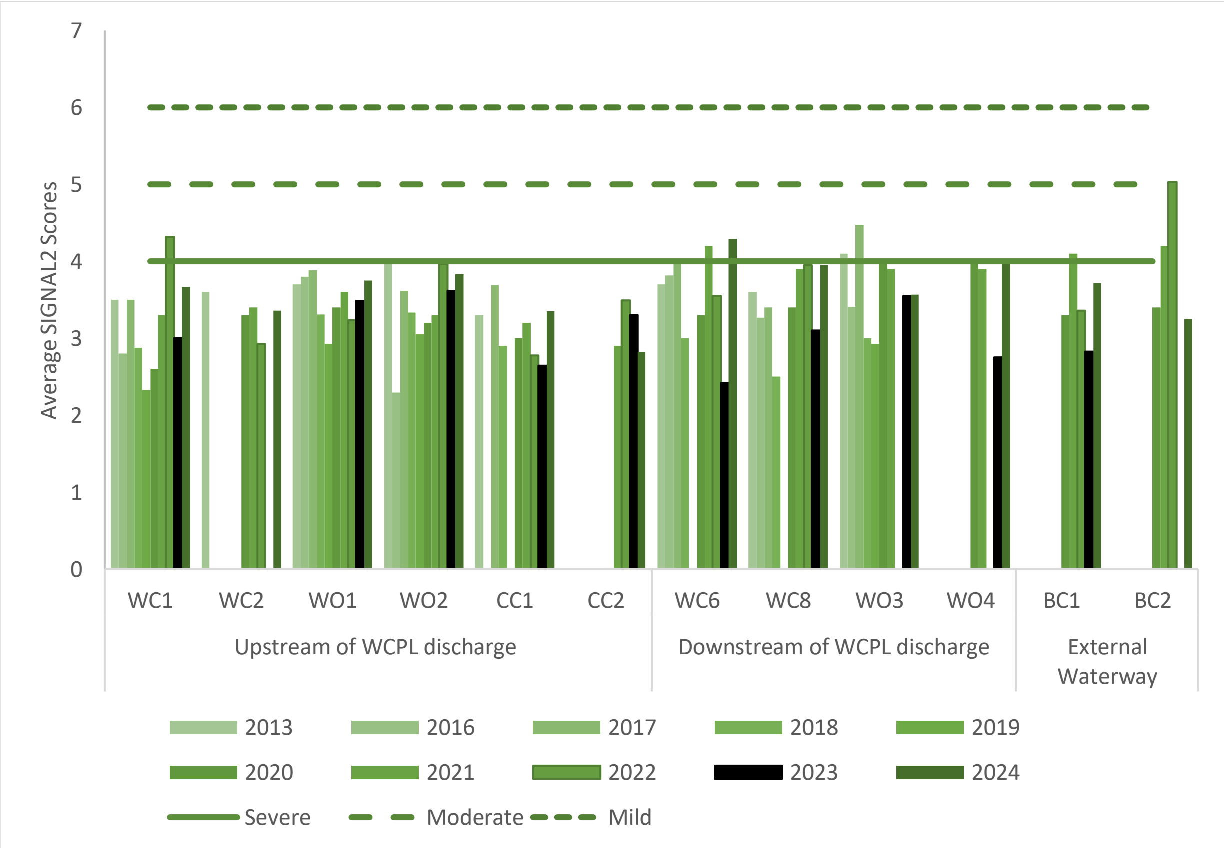

Figure 7: Average SIGNAL2 macroinvertebrate scores across all sites and years

5. Conclusions and Recommendations

A total of ten permanent sites along Wilpinjong, Wollar, and Cumbo creeks were sampled in 2024, along with two control sites at Barigan Creek. The habitat conditions at twelve sites were classified as either good or very good using the RCE inventory, which places the sites in the mid-range of aquatic habitat scores, typical of catchments in the surrounding region. Overall, aquatic habitat results have remained largely consistent across survey years, with differences primarily relating to changes in stream bed macrophyte, because of fluctuating water levels after dry conditions in 2023, and heavy rainfall the morning before sampling commenced in 2024. There is the capacity to improve instream habitat through the re-introduction of logs and boulders as instream retention devices, particularly after the widespread flooding events that occurred during 2022. These works would also help limit downstream erosion and can be tied in with ongoing revegetation and rehabilitation works along Cumbo and Wilpinjong creeks.

Water quality parameters have fluctuated considerably across years and varying stream flow levels, at sites both upstream and downstream of the WCPL licensed discharge point. The results also showed some improvement compared to recent years, with all but one of the sites falling within the ANZECC and ARMCANZ (2000) guidelines for pH. All but two of the sites met the guidelines for turbidity, likely due to the lower amounts of sediment and organic matter being washed into the stream during the period of low rainfall in the two month lead up to the 2024 monitoring and the large rainfall event the morning of sampling commencing not having sufficient time to wash sediment and organic matter into the stream. Two sites including one of the control sites were within the ANZECC and ARMCANZ (2000) guidelines for EC and four for DO. This is likely due to decreased rainfall in most months leading up to the monitoring period, as well as high water temperatures, algae growth, and decomposition of organic matter in the water. EC recorded at upstream sites of the WCPL discharge was generally consistent at sites downstream of WCPL discharge. Hence, water quality results overall indicate that natural variables, rather than mining operations are the main factors which influence water quality in the sampled catchments. It is possible that the guidelines for these measures, excluding turbidity and pH, are not appropriate at the local and/or regional catchment level.

A total of 12 macroinvertebrate Orders and 53 Families were recorded across all sites. SIGNAL2 scores showed increasing trends both upstream and downstream of the WCPL licensed discharge point in 2024. In line with previous years, SIGNAL2 scores were <4.0 for nine of the 12 sites, indicative of severely disturbed sites. Three sites recorded SIGNAL2 scores ≥4.0 indicative of moderately disturbed systems, 2024 was the first year since 2021 monitoring where there was more than one site that was classified as moderately disturbed. One site, CC2 scored below the minimum trigger conditions for both SIGNAL2 and taxa richness scores. A combination of low levels of flowing water, higher water temperature, and low DO likely limited the diversity of macroinvertebrate communities. Species richness was relatively consistent across all sites, excluding CC2, and well above the minimum taxa richness. Future surveys may be conducted earlier in summer when water temperatures are not extremely high and macroinvertebrate diversity and abundance are likely to be greatest. It is also strongly recommended to undertake surveys when there is sufficient water flow at each monitoring site.

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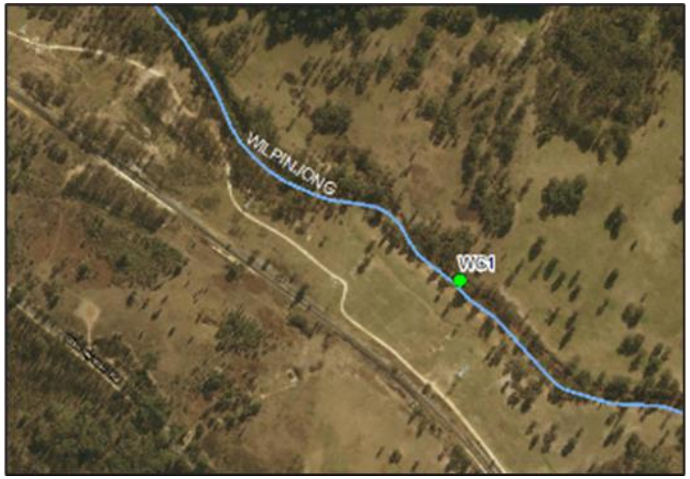
Appendix A Site Photos




Site WC1 (from left to right: site location, upstream, downstream (21/11/2024))


Site WC2 (from left to right: site location, upstream, downstream (21/11/2024))


Site WC6 (from left to right: site location, upstream, downstream (21/11/2024))


Site WC8 (from left to right: site location, upstream, downstream (21/11/2024))


Site WO1 (from left to right: site location, upstream, downstream (18/11/2024))


Site WO2 (from left to right: site location, upstream, downstream (18/11/2024))



Site WO3 (from left to right: site location, upstream, downstream (21/11/2024))



Site WO4 (from left to right: site location, upstream, downstream (21/11/2024))


Site CC1 (from left to right: site location, upstream, downstream (20/11/2024))


Site CC2 (from left to right: site location, upstream, downstream (20/11/2024))

Site BC1 (from left to right: site location, upstream, downstream (18/11/2024))

Site BC2 (from left to right: site location, upstream, downstream (18/11/2024))

Appendix B Macroinvertebrate Data

Order/Class	Family	SIGNAL2	BC1	BC2	CC1	CC2	WC1	WC2	WC6	WC8	WO1	WO2	WO3	WO4
Arachnida	Acarina	6	1	2				1	1				1	
	Pisuridae	0	1	1			2	4	1				1	2
	Tetragnathidae	0								1		1	3	2
Coleoptera	Dytiscidae	2		1	1	3		1					1	
	Elmidae	7	2	2		1					1			
	Gyrinidae	4												1
	Hydrochidae	4	1											
	Hydrophilidae	2		3				1	1		1			
	Hygrobiidae	1	1											
Decapoda	Atyidae	3					3	2	3		2	2	2	2
Diptera	Ceratopogonidae	4	2	2			3		1			1		
	Chironomidae	3		1	3	1		1	2	2	2	2		2
	Culicidae	1			1	3				1	1			
	Dixidae	7	1	1	1		1			1				
	Dolichopodidae	3		1	2		1	1		1	1	1		1
	Psychodidae	3			2									
	Simuliidae	5	1		2				1				2	1
	Stratiomyidae	2	1	1	1			3			2			
	Tabanidae	3				1								
	Thaumaleidae	7										1		
			3	1	1		5	4	5	4	4	7	8	5

Order/Class	Family	SIGNAL2	BC1	BC2	CC1	CC2	WC1	WC2	WC6	WC8	WO1	WO2	WO3	WO4
Ephemeroptera	Baetidae	5	1				3	2		2	1	2	3	3
	Caenidae	4							1	1		3	3	1
	Coloburiscidae	8	1	1	1				3		1	2		1
	Leptophlebiidae	8	1				2	2	1	1	2		2	
Gastropoda	Lymnaeidae	1	1	1	1		2		1				1	
	Physidae	1			3	2	3	1						
	Planorbidae	2	2	2						3	1	1	2	
	Sphaeriidae	5	3	1			3	3		2	1	1		
Hemiptera	Corixidae	2	2	2	3	3	2	3	4	3	3	3	3	2
	Gelastocoridae	5		1										1
	Gerridae	4							1				1	1
	Mesoveliidae	2						1						
	Naucoridae	2		1							2	3	1	
	Nepidae	3						1						
	Notonectidae	1		2	2	2	1	3			1			3
	Pleidae	2	1	2			1				1	1	3	3
	Veliidae	3	1		1		2		1	1	1		1	
Hirudinea	Hirudinea	1	2	1			1	1				1		1
Megaloptera	Corydalidae	7											1	
Odonata	Aeshnidae	4			3	1	3			2	1		1	
	Austrocorduliidae	10					3	1	2	1	2			1
	Baetidae	5			2									

Technical Memorandum - Otway Ecology

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04/02/2025

To:	Kieran Stephenson-Banks, Tara Dowling – Eco Logical Australia
From:	Otway Ecology – Craig Grabham
OE Project number/name:	14241015 – WCPL Spring Monitoring
Subject:	Bat call analysis – version 2

Hi Tara and Kieran,

The following technical memo presents the methods and results for analysis of bat calls for the annual Wilpinjong Coal Mine Management Domains Spring monitoring project for 2024.

1. Introduction

Bat calls were recorded during field surveys undertaken by Eco Logical Australia at 10 sites within the study area for between 2-4 nights at each site (34 nights total survey effort). Surveys were undertaken between the 18th and 21st of November 2024 using in situ (stationary) Song Meter Mini bat ultrasonic and SM4 full spectrum recorders (Wildlife Acoustics Inc). All files were recorded in .wav format.

The purpose of this report was to analyse ultrasonic bat call data collected as part of the Spring 2024 microbat monitoring across the Wilpinjong Coal Mine Management Domains (the study area) and forms part of an ongoing annual biodiversity monitoring program. The survey was undertaken to:

• Determine microbat species presence/potential presence

• Collate the number of microbat calls recorded (microbat species activity).

This memo contains a description of the methods used to analyse the microbat call data and the results of the analysis for the Spring 2024 period.

2. Call identification, data processing and analysis method

Call identification was assisted by consulting distribution information for potential species (e.g. Australasian Bat Society BatMap, January 2025) and species call descriptions from publications and guidelines (e.g. Armstrong et al 2021; Pennay et al 2011; Law et al. 2002; Reardon et al 2014). Reports prepared by Eco Logical Australia for previous monitoring events were also consulted to understand the bat species likely to be encountered during call analysis. Species nomenclature follows Armstrong, K.N., Reardon, T.B., and Jackson, S.M. (2020, last updated 15 May 2022). No reference calls were collected during the survey.

Data was processed and analysed using a combination of automated and manual review techniques using Kaleidoscope Pro (Wildlife Acoustics, version 5.6.8) and Anabat Insight (Titley Scientific, version 2.1.3-0). The following process was used to analyse and identify bat calls:

1. Calls were initially processed in Kaleidoscope Pro using the basic cluster analysis function with the following settings:

- Batch tab: files sorted into nightly subfolders; files converted to non-compressed .wav files and noise filter on – move noise to noise subfolder
- Signal parms tab: 10 – 160 kHz frequency range; 1 – 500 ms minimum and maximum length of detected pulses; a maximum inter-syllable gap of 500 ms and a minimum of 3 pulses detected
- Cluster analysis tab: 2 – max distance from cluster (to ensure all signals are captured); FFT window 5.33 ms; 12 – max states; 0.5 distance to cluster centre and 100 – max clusters. This function clusters same and similar bat calls into clusters based on the parameter and cluster function inputs.

2. Files within each cluster were reviewed and labelled as a species or species group according to call descriptions from published guidelines. Manual review was undertaken by visually comparing the time-frequency graph (spectrogram) and call characteristics (e.g. peak frequency, characteristic frequency and call shape) with species call descriptions from published guidelines. Species groups refer to a file containing a species or multiple species which overlap considerably with respect to call characteristics (see Table 1). A subsample of the files that were deemed noise were also reviewed to ensure the cluster analysis process was performing correctly
3. Species specific filters were also used in Anabat Insight to identify candidate calls for additional review. Manual review was undertaken by visually comparing the time-frequency graph (spectrogram) and call characteristics.

A call (pass) was defined as a sequence of three or more consecutive pulses of similar frequency and shape. Calls with less than three defined consecutive pulses of similar frequency and shape were not unambiguously identified to a species but were used as part of the activity count for the survey area. Feeding buzzes were used in addition to search phase calls to identify some species (e.g. *Miniopterus orianae oceanensis*) where suitable reference material exists (e.g. C. Corben 2010). Feeding buzzes were only identified if there were sufficient search phase pulses before the feeding buzz.

Due to variability in the quality of calls and the difficulty in distinguishing some species the identification of each call was assigned a confidence rating (see Mills et al. 1996 & Duffy et al. 2000 for similar process) as summarised in Table 1. A conservative approach was taken when analysing calls due to the absence of reference calls from the study area, the high level of variability within a bat call and overlap in call characteristics between some species.

Table 1 Call type and confidence ratings applied to calls

Identification	Description
D - Definite	Species identification not in doubt.
PR - Probable	Call most likely to represent a particular species, but there exists a low probability of confusion with species of similar call type or call lacks sufficient detail.
SG - Species Group	Call made by one of two or more species. Call characteristics overlap making it too difficult to distinguish between species for e.g. *Chalinolobus gouldii / Ozimops planiceps / O. ridei* *C. gouldii/ Scotorepens balstoni* *Nyctophilus geoffroyi / N. gouldii/ N. corbeni* *S. balstoni/ Scoteanax rueppellii/ Falsistrellus tasmaniensis* *S. rueppellii/ F. tasmaniensis* *S. rueppellii/ F. tasmaniensis /Scotorepens greyii* *Vespadelus regulus/ V. darlingtoni* *Miniopterus orianae oceanensis/ Vespadelus regulus/ V. darlingtoni/ V. vulturnus* *Myotis macropus / Nyctophilus* species

Other bat call	Files containing one or two pulses and/or multiple fragmented pulses, sometimes at different frequencies not identifiable to one of the above groups.

3. Analysis results

Eight species were positively (Definite) identified of the 17 or so species that are known to occur from the locality of the study area (BatMap 2024) including the Large-eared Pied Bat (*Chalinolobus* dwyeri), listed as vulnerable under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) and *Biodiversity Conservation Act 2016* (BC Act) listed. The vulnerable (BSC Act) Eastern Bent-winged Bat (*Miniopterus orianae oceanensis*) and Eastern Cave Bat (*Vespadelus troughtoni*) were recorded as probable (PR). Two other BSC Act vulnerable species, Eastern False Pipistrelle (*Falsistrellus tasmaniensis*) and Greater Broad-nosed Bat (*Scoteanax rueppellii*) were recorded as part of a species complex.

Tables 2 provides a summary of the species recorded for each site. See Attachment 1 for example spectrograms for species identified as D and PR.

Bat species positively (Definitively/D) identified included:

- *Austronomus australis*
- *Chalinolobus dwyeri* (V,v) – this species was identified from its low characteristic frequency between 21 and 26 kHz and distinct pattern of alternation present in search phase calls (Pennay et al 2004).
- *Chalinolobus gouldii*
- *Chalinolobus morio*
- *Ozimops planiceps*
- *Ozimops ridei*
- *Vespadelus vulturnus*
- *Rhinolophus megaphyllus*

Bat species probably (PR) identified included:

- *Miniopterus orianae oceanensis* (v) – this species typically displays a characteristic frequency of 43 to 48 kHz. Pulses are curved, often with a down-sweeping tail and the characteristic section may be long in search phase. Pulse shape and time between calls is usually variable within a sequence (Pennay et al 2004). Calls can be distinguished from other species if these distinctive characteristics are present, however these characteristics were not always obvious or consistent within the candidate call sequences in this data set.
- *Vespadelus troughtoni* (v) – this species typically displays a characteristic frequency of 49 to 53.5 kHz. Pulses are curved with an up-sweeping tail. Can be distinguished from *C. morio* by the up-sweeping tail present in most pulses of good quality calls. Can not be differentiated from *V. vulturnus* where sympatric (Pennay et al 2004). Candidate calls within this data set contained curved pulses with an up-sweeping tail and characteristic frequency of 53 kHz, however, some of the pulses within the sequence were lower (e.g. at 51 khz) and therefore may overlap with *V. vulturnus*.

Of the 18,750 raw wav files approximately 10,446 (55%) contained a bat call as described in Table 1. The remaining files consisted of insect noise and/or anthropogenic noise. The cluster analysis process generated 13,907 identifiable bat calls according to the parameters listed in section 2. Table 3 provides a summary of the number of calls for each species or species complex for each site.

4. Report and analysis limitations

- The identifications made herein were based on data recorded and provided by Eco Logical. Otway Ecology was not responsible for the design of the bat survey, set-up of equipment or collection of any acoustic data
- The scope of this report included the identification of bat species from the data provided. Otway Ecology was not asked to provide comment regarding the impacts on any bat species identified in this report
- Otway Ecology was not provided with a detailed habitat description of the survey area, nor did Otway Ecology undertake any site visits to the survey area
- Approximately 85% of all files were manually reviewed following the analysis process steps outlined in steps 1 – 2 section 2. All outputs using species filters (step 3) were manually reviewed.

Table 2 - Summary of call analysis results – species and species complex recorded for each site (all nights combined)

Species	2021_6 - MUDMINI2	R18 - MUDMINI6	R29 - 2MU01655	R32 - 2MU02070	R38 SM4-MUD1	Ref_547_B - 2MU01688	Ref_697_B - MUDMINI4	Ref_732_B - SM4-MUD5	Ref_824_B - 2MU01693	Ref_825_B - MUDMINI1
Austronomus australis	-	-	D	D	D	D	D	D	D	D
Chalinolobus dwyeri (v, V)	D	PR	-	PR	PR	D	D	D	D	D
Chalinolobus gouldii	D	D	-	D	-	D	D	D	D	D
Chalinolobus morio	-	-	D	D	D	D	D	D	D	D
Ozimops ridei	-	-	D	D	PR	D	D	D	D	PR
Ozimops planiceps	-	-	PR	-	D	D	D	D	D	D
Miniopterus orianae oceanensis (v)	-	PR	PR	PR	PR	PR	PR	PR	PR	-
Rhinolophus megaphyllus	-	-	-	-	-	D	-	D	D	D
Vespadelus troughtoni (v)	-	-	-	PR	PR	PR	-	-	-	-
Vespadelus vulturnus	-	-	-	PR	-	-	-	D	-	-
Species complex										
C. gouldii/ O. ridei	-	-	-	-	-	✓	✓	✓	✓	-
C. gouldii/ O. planiceps/ O. ridei	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
C. morio/ Vespadelus troughtoni	✓	-	-	✓	✓	✓	✓	✓	✓	✓
C. morio/ V. vulturnus/ V. troughtoni	✓	-	✓	✓	✓	✓	✓	✓	✓	✓
C. gouldii/ Scotorepens balstoni	✓	-	-	-	-	✓	✓	✓	✓	✓
M. orianae oceanensis/ V. vulturnus	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
M. orianae oceanensis/ V. regulus/ V. darlingtoni/ V. vulturnus	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Nyctophilus spp./ M. macropus	-	-	-	✓	✓	✓	✓	✓	✓	✓
O. planiceps/ O. ridei	-	✓	✓	✓	✓	✓	✓	✓	-	✓
S. balstoni/ S. rueppellii	✓	-	-	-	✓	✓	✓	✓	✓	-
S. balstoni/ S. rueppellii/ F. tasmaniensis	✓	-	-	-	-	✓	✓	✓	✓	-
S. rueppellii/ Falsistrellus tasmaniensis/ Scotorepens greyii/ Scotorepens sp.	-	-	-	-	-	✓	✓	✓	✓	-
V. vulturnus/ C. morio	✓	-	-	✓	✓	✓	✓	✓	✓	✓
V. darlingtoni/ V. regulus	-	-	-	✓	-	✓	✓	✓	✓	✓

Table Notes: See Table 1 for confidence rating e.g. D or Pr. Total number of D species for each night includes one *Nyctophilus* species where recorded. ce, e, v - species listed under the *Biodiversity Conservation Act 2016.* CE, E, VU – species listed under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999.*

Table 3 - Summary of call analysis results – activity per species / species complex for each site (all nights combined)

Species	2021_6 - MUDMINI2	R18 - MUDMINI6	R29 - 2MU01655	R32 - 2MU02070	R38 SM4-MUD1	Ref_547_B - 2MU01688	Ref_697_B - MUDMINI4	Ref_732_B - SM4-MUD5	Ref_824_B - 2MU01693	Ref_825_B - MUDMINI1
Austronomus australis	-	-	1	1	14	22	72	26	9	8
Chalinolobus dwyeri	11	1	-	4	6	169	16	21	10	27
Chalinolobus gouldii	1	2	-	1	-	102	224	904	21	22
Chalinolobus morio	-	-	1	9	1	274	30	202	21	24
Ozimops ridei	-	-	4	2	1	41	11	155	2	1
Ozimops planiceps	-	-	2	-	8	93	102	192	80	70
Miniopterus orianae oceanensis	-	3	1	14	4	22	11	24	5	-
Rhinolophus megaphyllus	-	-	-	-	-	2	-	5	46	14
Vespadelus troughtoni	-	-	-	1	2	2	-	-	-	-
Vespadelus vulturnus	-	-	-	1	-	-	-	5	-	-
Species complex										
C. gouldii/ O. ridei	-	-	-	-	-	33	26	394	1	-
C. gouldii/ O. planiceps/ O. ridei	2	2	4	3	5	253	447	867	21	55
C. morio/ Vespadelus troughtoni	3	-	0	1	5	133	21	40	5	7
C. morio/ V. vulturnus/ V. troughtoni	3	-	1	8	-	135	24	328	9	95
C. gouldii/ Scotorepens balstoni	-	-	-	-	-	8	31	19	2	6
M. orianae oceanensis/ V. vulturnus	24	12	8	215	33	1394	236	1426	94	108
M. orianae oceanensis/ V. regulus/ V. darlingtoni/ V. vulturnus	35	7	6	78	44	528	275	722	291	31
Nyctophilus spp./ M. macropus	-	-	-	2	1	44	31	188	22	38
O. planiceps/ O. ridei	-	1	1	1	4	9	6	16	-	1
S. balstoni/ S. rueppellii	1	-	-	-	1	42	2	194	2	-
S. balstoni/ S. rueppellii/ F. tasmaniensis	1	-	-	-	-	20	16	158	1	-
S. rueppellii/ Falsistrellus tasmaniensis/ Scotorepens greyii/ Scotorepens sp.	-	-	-	-	-	13	4	9	5	-
V. vulturnus/ C. morio	2	-	-	17	11	151	17	626	14	55
V. darlingtoni/ V. regulus	-	-	-	1	-	39	29	16	3	1
Other bat calls	1	-	-	1	-	63	76	194	4	5

Bat call sequences per site (all nights combined)	84	28	29	360	140	3592	1707	6731	668	568
Raw wav files per site (all nights combined)	304	368	2716	1013	696	2465	1277	7030	2309	572
Survey effort (nights per site)	2	4	3	3	3	4	4	4	3	4

Table Notes: number of calls for each species includes definite and probable combined

5. References

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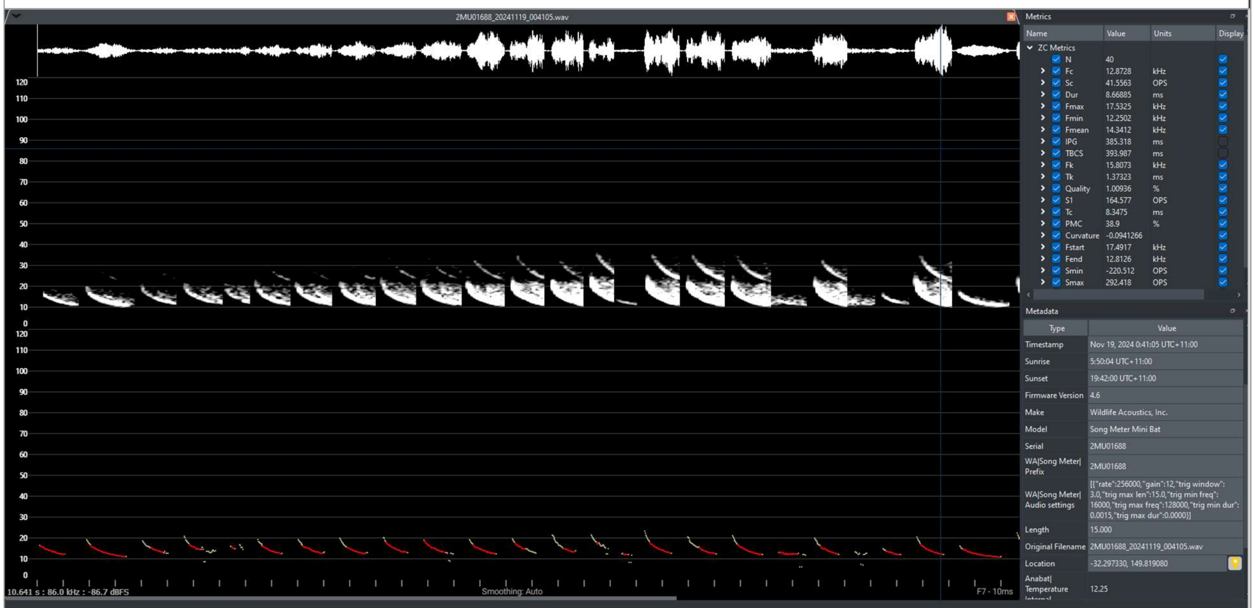
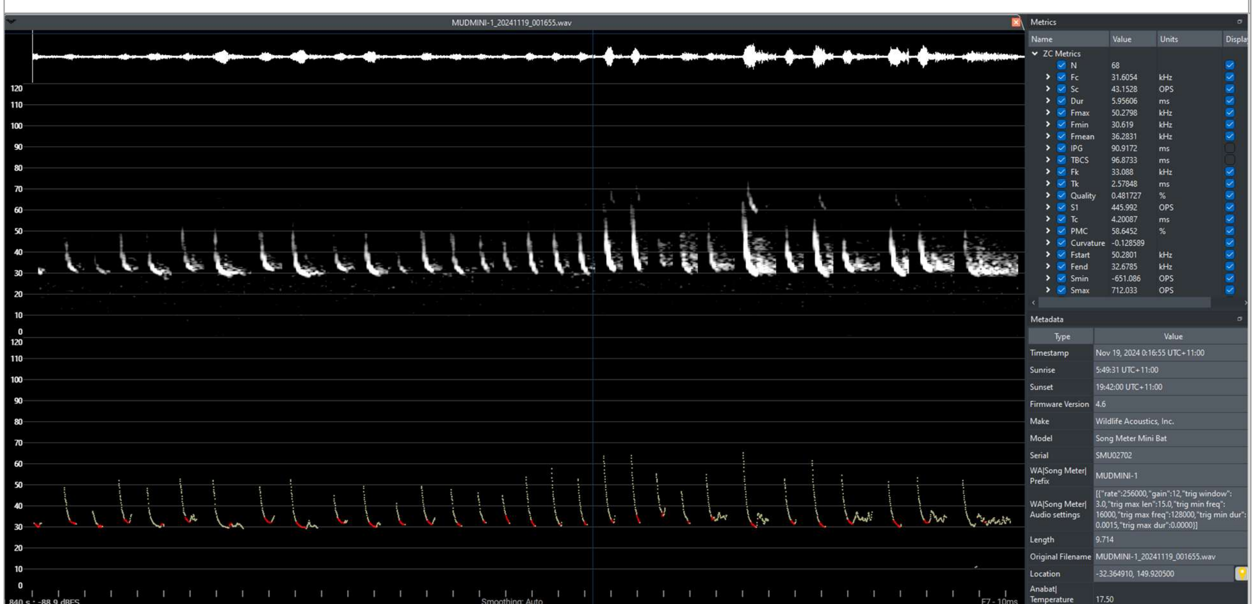
Attachment 1 - Example time-frequency graphs for definite and probable species

Example time-frequency graphs of files. Note: Linear scale, displayed in compressed mode - F7 – Anabat Insight. Top = Oscillogram view. Middle view = Full spectrum view of a call. Bottom view = Zero crossing view of a call. Call metrics and metadata are displayed right panel of view.

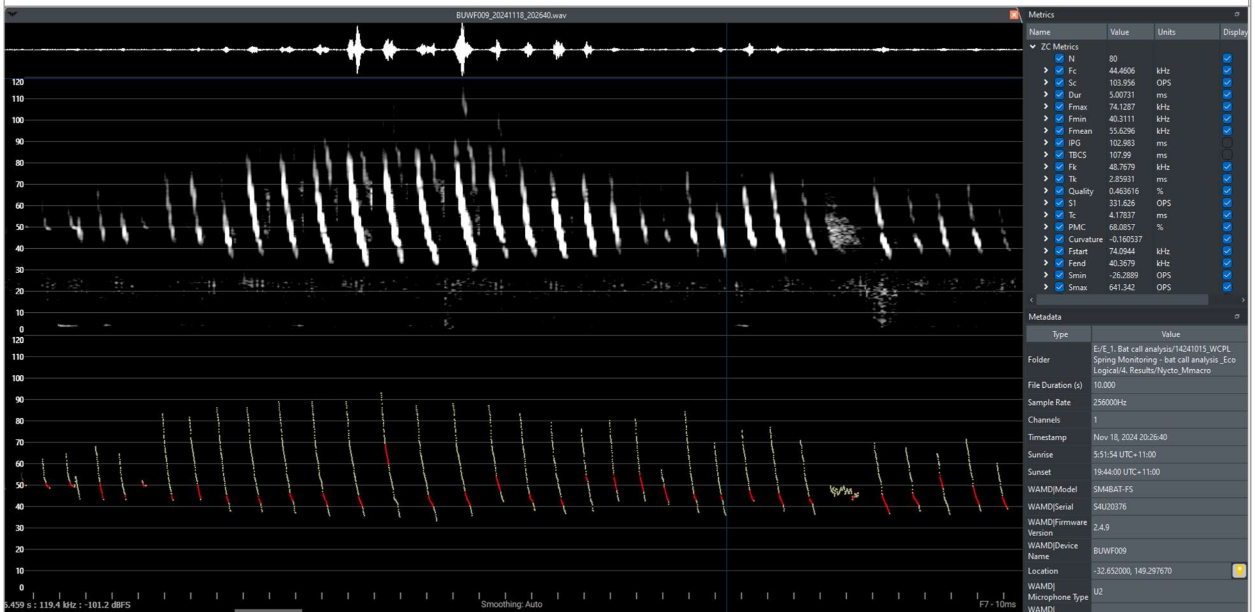
White-striped Free-tailed Bat - *Austronomus australis* - definite



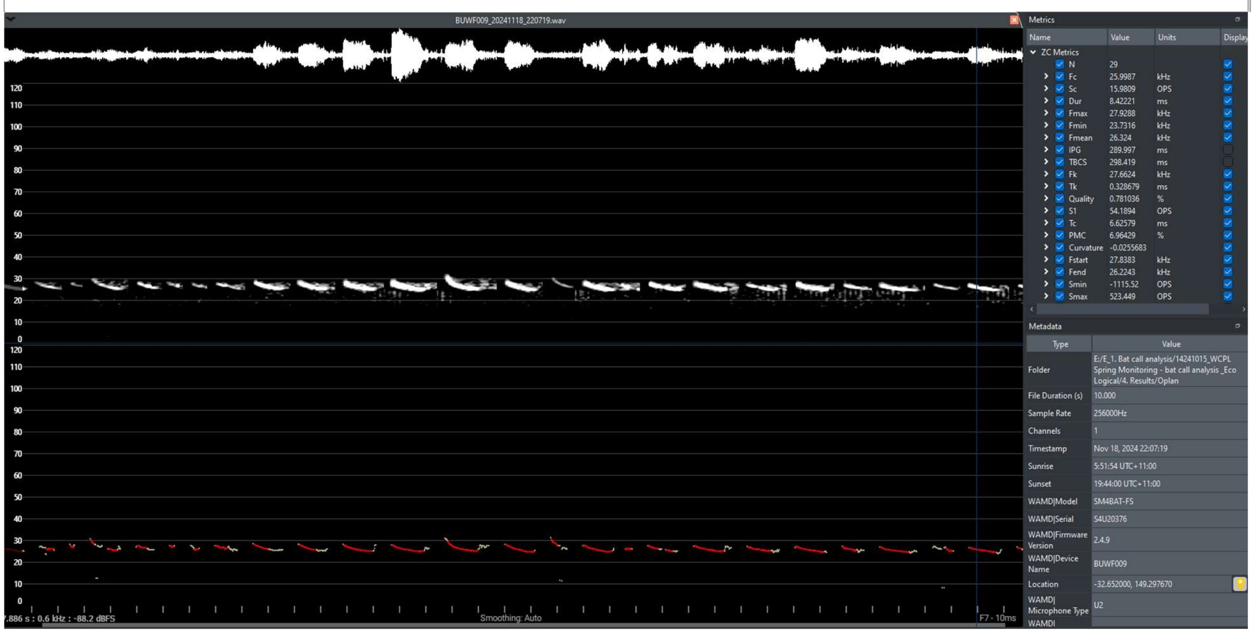
Gould's Wattled Bat – *Chalinolobus gouldii* - definite



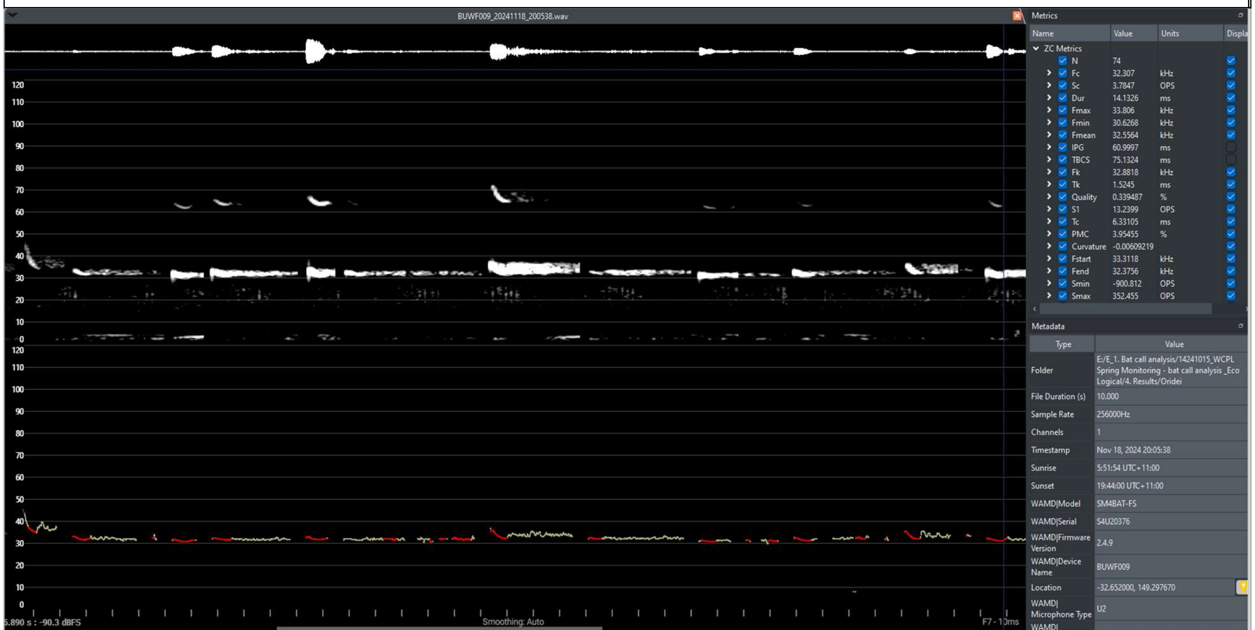
Long-eared Bat - *Nyctophilus geoffroyi / gouldi/ corbeni* - definite



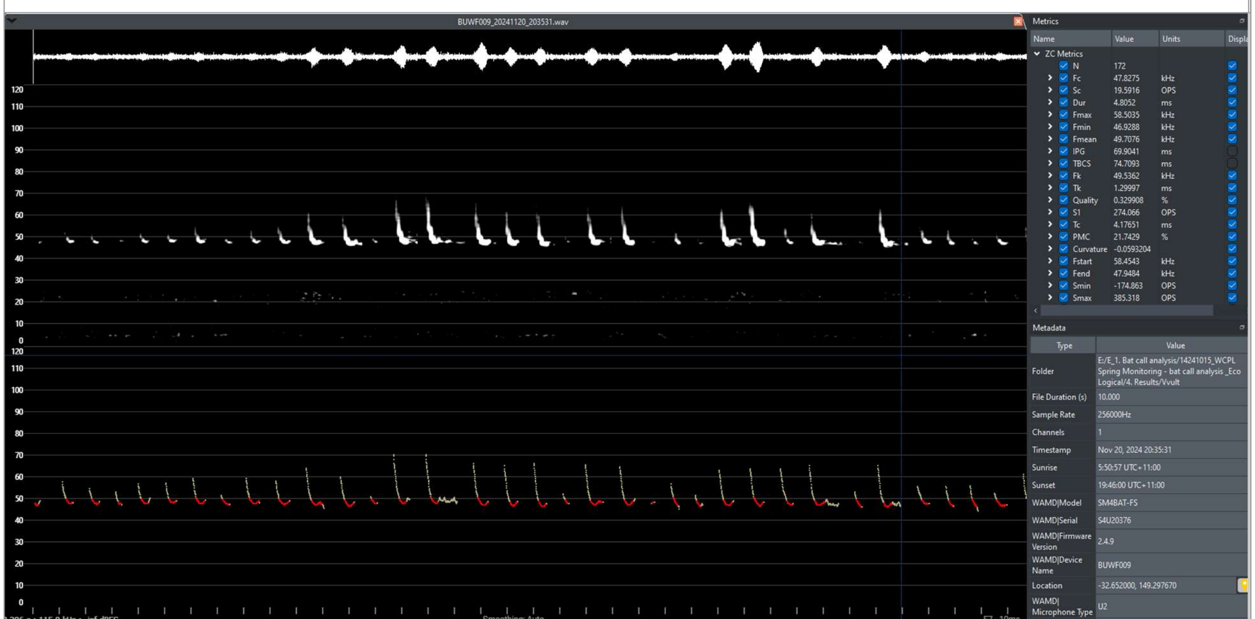
Southern Free-tailed Bat - *Ozimops planiceps* - definite



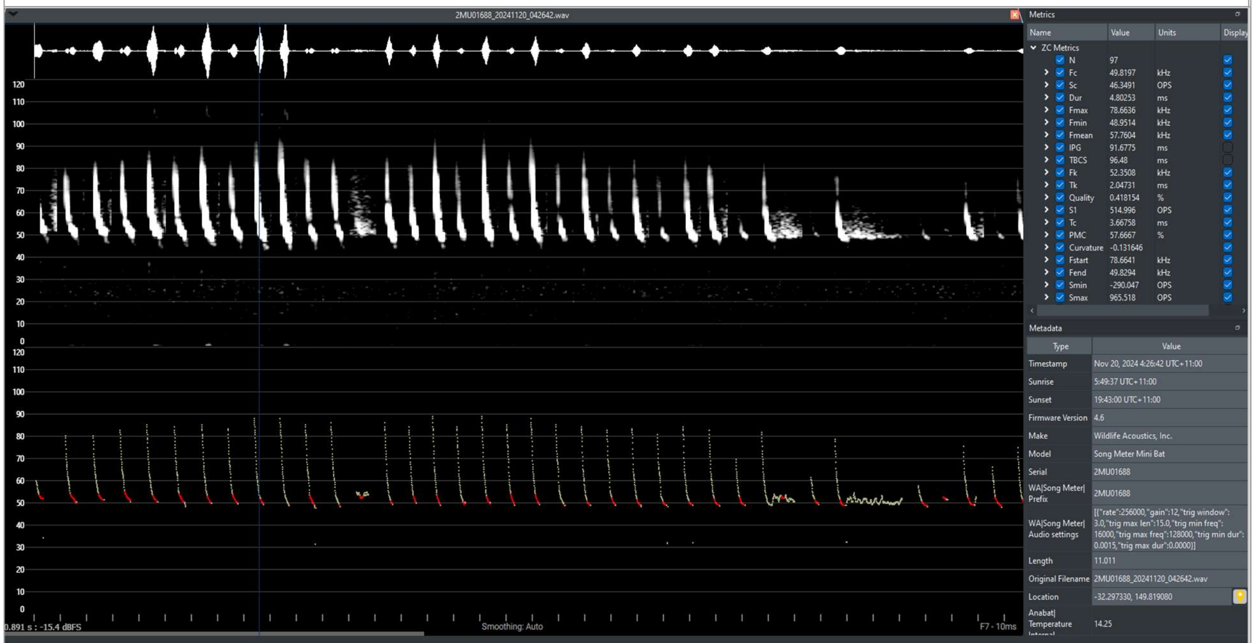
Eastern Free-tailed Bat - *Ozimops ridei* - definite



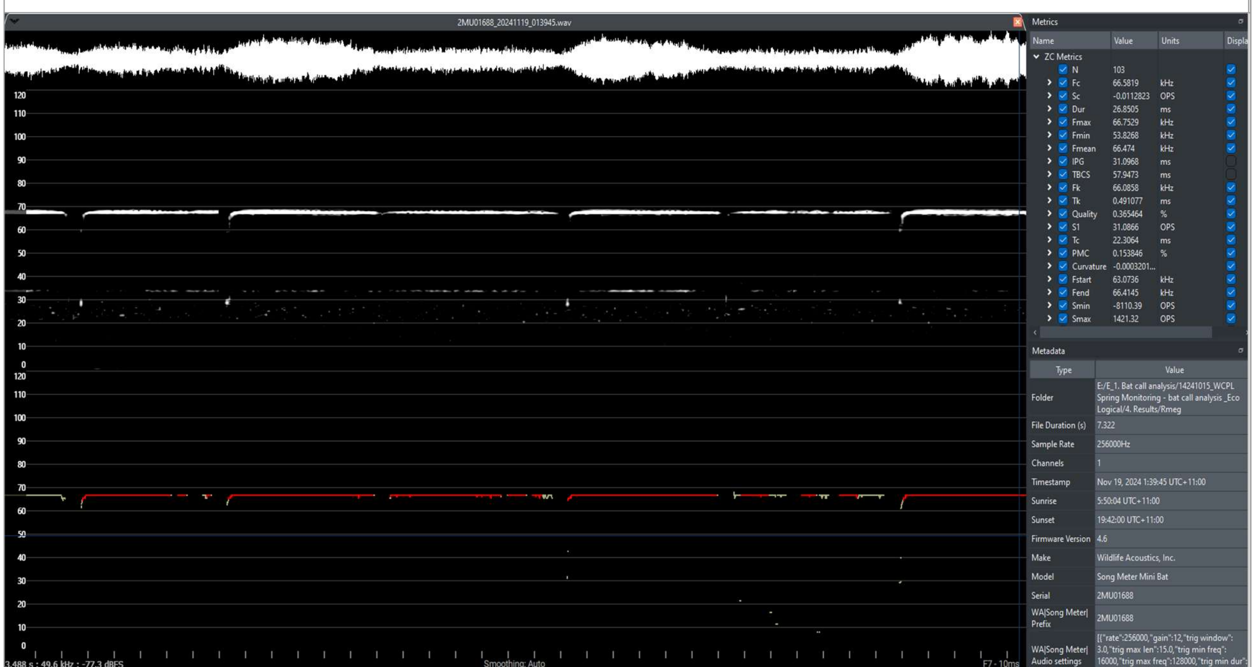
Little Forest Bat – *Vesapelus vulturnus* - definite



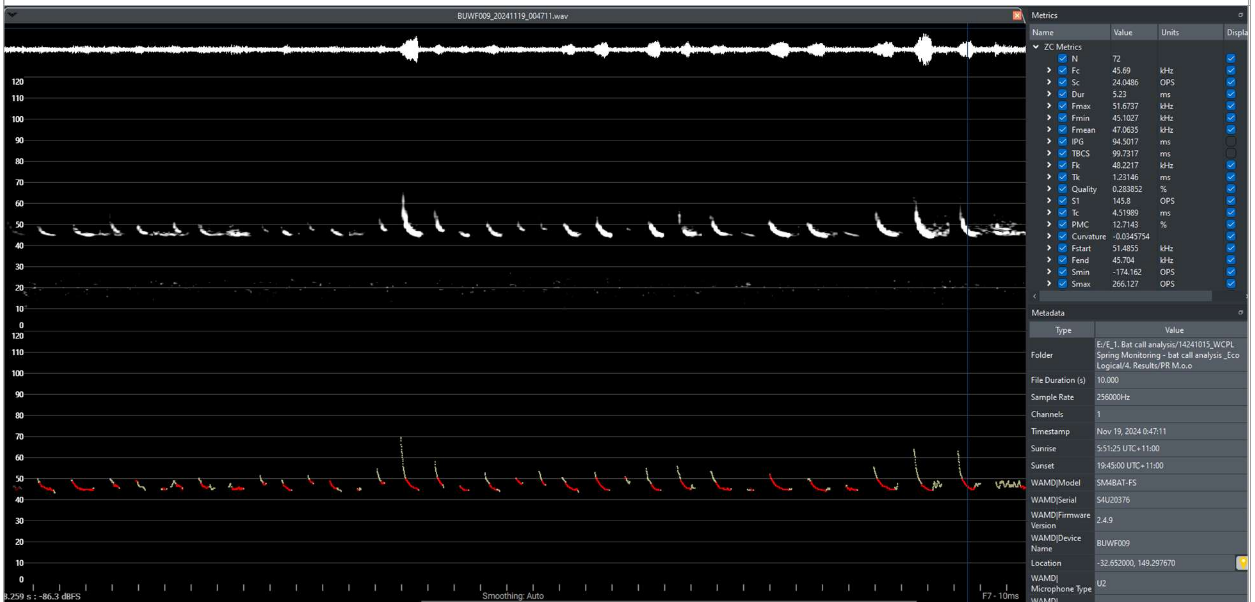
Chocolate Wattled Bat - *Chalinolobus morio* - definite



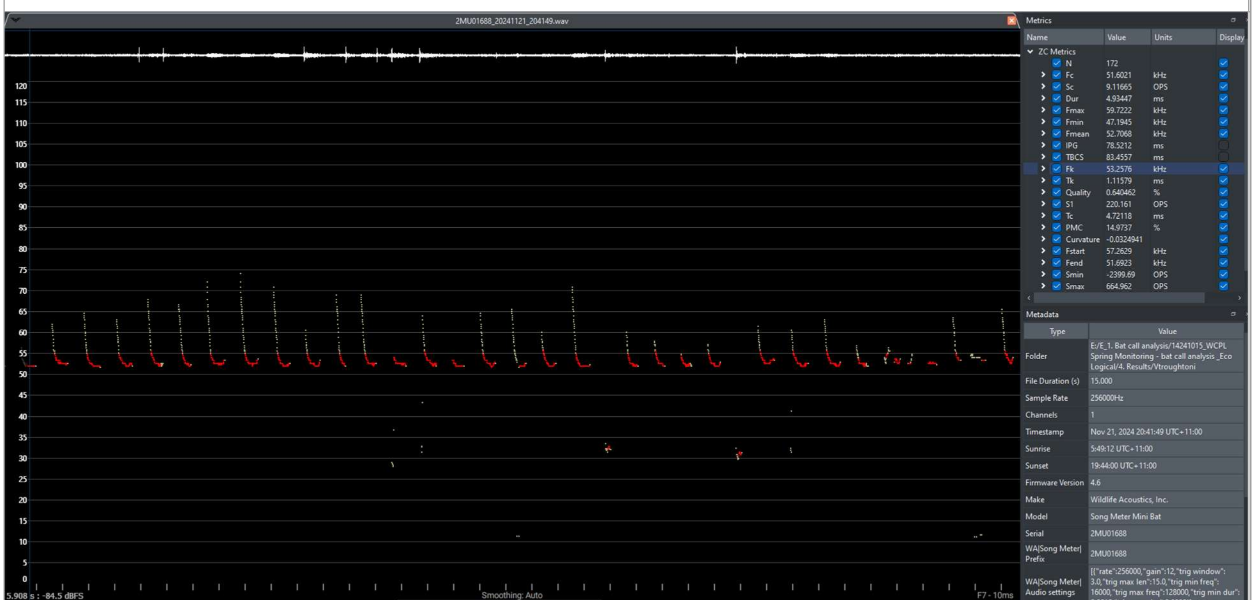
Eastern Horseshoe Bat – *Rhinolophus megaphyllus* - definite



Large Bent-winged Bat - *Miniopterus orianae oceanensis* – Probable



Eastern Cave Bat – *Vespadelus troughtoni* – Probable



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Monitoring of Microbats at Slate Gully Adit (Pit 8), Wilpinjong Coal Mine, NSW for 2024

for

Peabody Energy Pty Ltd

Prepared for: James Heesterman
Prepared by: Biodiversity Monitoring Services
Date: 11 March 2025

Document History

Report	Version	Prepared by	Checked by	Submission Method	Date
Adit monitoring	Issue 1	Mikaela Cole	Andrew Lothian	email	07 Feb 2025
Adit monitoring	Issue 1	Mikaela Cole	Andrew Lothian	email	11 Mar 2025

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1.0 Introduction

Biodiversity Monitoring Services (BMS) was engaged by Wilpinjong Coal Pty Ltd (WCPL) to undertake the 2024 annual microbat monitoring at the abandoned oil shale mine (adit) in Slate Gully, Wilpinjong Coal Mine (WCM). This adit supports colonies of two microbat species: the Eastern Horseshoe-bat (*Rhinolophus megaphyllus*) and Large Bent-winged Bat (*Miniopterus orianae oceanensis*, formerly known as Eastern Bentwing-bat *Miniopterus schreibersii oceanensis*). Monitoring undertaken since April 2017 indicates that less than 50 Eastern Horseshoe-bats inhabit the mine workings throughout the year. From exit counts conducted to date, numbers of this species do not vary substantially throughout the year. Counts of the Large Bent-winged Bat inhabiting the mine vary considerably more throughout the year.

WCPL is approved to mine Slate Gully (Pit 8) adjacent to the adit. Topsoil stripping at the northern end of Slate Gully began in November 2019. Overburden extraction in Slate Gully began in early 2020 approximately 600m to the northeast of the adit. Previous plans estimated Pit 8 to come within 150m of the adit in approximately 2021. However, by February 2023 only a clean water drain had been constructed within 150m of the adit, with the nearest active cut in Pit 8 remaining still approximately 430m away. By February 2024, topsoil stripping had occurred approximately 100m from the adit, with the Pit 8 active cut still approximately 350m from the adit. As of February 2025, the active cut is approximately 190m from the adit. Bats within the workings have been subject to vibration and noise, and once exiting have been, and will be, subject to artificial lighting (Linley 2016). There is also the potential for dust and fumes associated with the open cut operations. Generally there is a paucity of scientific literature on the impacts of mining (and the above impacts) on cave-roosting bats.

Exit counts of bats leaving the adit, as well as capture of exiting bats[1], has been undertaken over the past eight years to determine what species are utilising the adit and how their numbers and sexual composition change throughout the year (Fly By Night 2017; Fly By Night 2018; Fly By Night 2019). This has given a firm basis to monitor colonies of the two species roosting within the workings as the adjacent area is strip mined for coal. Previously we recommended that continual monitoring of bat activity via an ultrasonic bat call detector would provide a superior method to monitor the roost long term. This report details the results of automated monitoring over a 12-month period from January 2024 to December 2024, as well as concurrent monthly hand counts of bats exiting the workings.

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[1] Harp trapping was conducted over the period 2017-2019 (autumn, winter, summer) and then discontinued at the request of NSW DCCEEW (formerly OEH at the time). Enough data was obtained to determine the site was not a breeding roost, but forms an important overwintering and seasonal roost, with composition of sex/age/individuals in the roost changing seasonally. Harp trapping was again conducted at the adit in July 2024 to determine if the species/sex/age composition of the roost had changed between monitoring events.

2.0 Survey Methodologies

Manual Exit Counts

Bats were counted leaving the adit by Andrew Lothian (BMS) each month. The counter was in position half an hour before sunset, and counts were conducted until no more bats exited for a period of 10 minutes (or more bats flew into the roost than flew out in a 10 minute period). Due to differences in flight behaviour (speed and direction of travel upon exit), an assessment could be made of the species composition of bats leaving the adit, although this assessment is becoming increasingly difficult with the new counting position and multiple exit apertures. Notes were made of the time of first bat exiting the adit, the total number of bats exiting the adit, and the presence of each of the target species. This methodology has been published recently (Lothian and Hoye 2023).

Although the method has remained the same over time, the position of counting was forced to change in 2023 with the installation of a new steel box culvert creating multiple exit points for the bats. Instead of lying down near the entrance counting bats as they flew over (or to the side in the case of Horseshoe-bats), the counter has to sit further out from the entrance to allow observation of both the end of the culvert and the natural aperture over the culvert. It took a few months to choose the optimal position, potentially resulting in manual counts conducted from April 2023 being less accurate than previous counts. Using a torch to light the entrance created delays in exit by some individual bats, and sitting side-on to the adit made it difficult to differentiate bats from the rock wall behind (as opposed to being backlit by the sky). The new counting position increases the likelihood of miscounting Eastern Horseshoe-bats, however, over summer when Bent-winged bats are absent, more focus can be applied to this species.

An additional counter was present for the September 2024 count (Mikaela Cole), counting from the base of the cutting on the eastern side of the entrance looking across. The different viewing positions of the two counters gives an indication of the error from manually counting the exits now that the entrance has been modified.

Automated Echolocation Call Detection

An Anabat Express detector (Titley Scientific) was placed twenty metres in front of the entrance of the mine adit to sample microbats on a nightly basis (**Figure 2-1**; **Plate 2-1**). The detector was powered via a 12 volt gel cell battery connected to a small solar panel. Files were downloaded monthly in conjunction with manual counts of bats exiting the workings. This allowed a nightly activity index of the two target microbat species to be determined. While the nightly activity cannot be directly compared to numbers of each species roosting within the workings, together with exit counts it provides an estimation/index of bat numbers.

Previous echolocation survey indicated that placement of a detector a distance of approximately 20 metres from the adit provided the best indicator of bat activity for the two species (Fly By Night 2019). The Eastern Horseshoe-bat undertakes circling behaviour when it exits the adit at dusk. Therefore, echolocation call activity undertaken at the adit gives inflated activity for this species. From presence during the counts, Eastern Horseshoe-bats tend to come and go frequently, particularly at the start of the night. Large Bent-winged Bat tend to all come out in a short space of time then return in smaller groups through the night.

Harp trapping

One Ausbat harp trap was placed at the entrance of the adit for one hour on 2 July 2024 to obtain a sample of bats exiting the roost. This trap was continuously attended by Andrew Lothian and a WCPL employee (J. Heesterman). A selection of video footage of the trapping and bat monitoring process was used for WCPL's promotional work. Bats were identified to species, with sex and age noted before being released. Any banded individuals and a sample of each sex and age class had some morphometric data collected as well.


Legend
Slate Gully Mine Adit
SSD-6764 Project Approval Boundary
0 0.5 1 2 Kilometers
N
W
E
S
WCPL Slate Gully Historic Mine Adit
Review ID: 1
Date Exported: 3/03/2025 10:48 AM
Drawn: JH
Drawing No. H6_3J2
Peabody
Peabody makes every effort to ensure the quality of the information available on this map. Before relying on the information on this map, users should carefully evaluate it accuracy, currency, completeness and relevance for their purposes, and should obtain any appropriate professional advice relevant to their circumstances.
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Figure 2-1: Location of Slate Gully Adit (WCPL 2025)

Plate 2-1: Slate Gully adit entrance prior to installation of steel pipe to maintain opening in the event of a collapse (mid 2019), also prior to installation of steel box tunnel (Apr 2023). Detector and solar panel setup 20m in front of adit.

3.0 Weather

Weather conditions on manual count nights (and the two nights prior) were recorded. Data was obtained from the Wilpinjong Meteorological Station, approximately 4.5km west of the adit.

Table 3-1: Weather conditions during survey (Peabody Energy 2024).

Date	Minimum Temperature (°C)	Maximum Temperature (°C)	Rainfall (mm)	Comments
16/12/2023	15.3	32.9	0	
17/12/2023	13.6	35.8	0	
18/12/2023	21.4	38.1	0	Hot, 0% cloud, no wind, no rain but humid
28/01/2024	17.5	29.7	0	
29/01/2024	20.5	37.6	0	
30/01/2024	24.7	33.0	0	Hot, 0% cloud, moderate wind, no rain but humid
10/02/2024	18.6	24.5	0	
11/02/2024	18.5	25.3	0	
12/02/2024	16.6	32.9	0	Hot, 0% cloud, no wind, no rain but humid
23/03/2024	11.5	23.2	0	
24/03/2024	14.7	27.6	0	
25/03/2024	10.5	28.9	0	Mild, 0% cloud, no wind, no rain, full moon
27/04/2024	5.1	21.4	0	
28/04/2024	6.3	24.6	0.2	
29/04/2024	6.8	24.8	0.6	Mild, 100% cloud, no wind, light rain first 15min, no moon at time of count
20/05/2024	0.7	18.2	0	
21/05/2024	2.9	18.8	0	
22/05/2024	4.0	18.9	0.2	Cold, 0% cloud, no wind, no rain, full moon
15/06/2024	9.1	12.6	9.6	
16/06/2024	4.7	14.9	0	
17/06/2024	2.5	15.8	0	Cold, 75% cloud, no wind, no rain but recent – wet ground, gibbous moon
30/06/2024	6.5	16.4	12.0	
01/07/2024	5.1	14.1	0.6	
02/07/2024	4.0	13.2	0	Cold, 100% cloud, no wind, light rain before exit time, waning crescent
10/08/2024	6.3	20.7	0.4	
11/08/2024	9.3	18.1	0	
12/08/2024	8.8	15.5	0	Cold, 100% cloud, light wind, light rain during count

Date	Minimum Temperature (°C)	Maximum Temperature (°C)	Rainfall (mm)	Comments
07/09/2024	7.9	27.8	0.2	
08/09/2024	9.0	18.3	0	
09/09/2024	5.3	20.6	0.4	Cool, 0% cloud, no wind, no rain, waxing crescent
01/10/2024	9.1	23.3	0	
02/10/2024	8.1	21.4	0	
03/10/2024	10.3	20.8	0	Cool, 0% cloud, no wind, no rain, no moon during count
12/11/2024	15.9	23.5	0.2	
13/11/2024	13.7	29.9	0	
14/11/2024	12.7	29.8	0.4	Mild, 0% cloud, strong wind, no rain but been wet this week, near full moon
16/12/2024	21.1	35.2	0	
17/12/2024	18.5	36.2	0	
18/12/2024	16.7	27.4	0	Cool, 100% cloud, strong wind, no rain, no moon during count

4.0 Results

Manual Exit Counts

Under the previous adit inspection/monitoring regime, exit counts were conducted over two nights alongside trapping of bats. Data comparing total exit counts over the last eight years are presented in **Table 4-1**. Count data from monthly surveys since June 2019 are presented in **Table 4-2**.

Table 4-1: Counts of bats exiting adit during April, June and December surveys from 2017-2024

	Apr 2017	Apr 2018	Apr 2019	Apr 2020	Apr 2021	Apr 2022	Apr 2023	Apr 2024
Minimum count	603	640	460	55	289	527	221	534
Maximum count	669	705	603	55	289	527	221	534

	Jun 2017	Jun 2018	Jun 2019	Jun 2020*	Jun 2021	Jun 2022	Jun 2023	Jun 2024
Minimum count	665	1000	94	92	788	705	363	390
Maximum count	720	1029	94	246	823	705	363	390

	Dec 2017	Dec 2018	Dec 2019	Dec 2020	Dec 2021	Dec 2022*	Dec 2023	Dec 2024
Minimum count	10	9	12	20	15	15	3	9
Maximum count	10	9	12	20	15	22	5	9

*Note: two counts were conducted in June 2020 due to a required maintenance visit. Access issues in 2022 meant there were two December counts due to a late November count. January count in 2023 was one day late, resulting in two February counts.

Table 4-2: Hand counts of bats exiting adit, and detector activity levels adjacent to the adit since monthly counts began in June 2019 – total (confident), raw # passes (all calls for all species). Detector located 20m from adit entrance in forest vegetation so more than just adit occupants are recorded. MIOR denotes *Miniopterus orianae oceanensis*. RMEG denotes *Rhinolophus megaphyllus*. VTRO denotes *Vespadelus troughtoni*.

Survey Date	Max. count	Min. count	First/last bat	Species present	# RMEG passes	# MIOR passes**	Total passes
24 Jun 2019	94	94	-	MIOR/RMEG	14 (11)	740 (487)	952
29 Jul 2019	93	93	-	MIOR/RMEG	42 (34)	850 (597)	1376
21 Aug 2019	99	99	17:45/18:45	MIOR/RMEG	114 (104)	707 (492)	1222
23 Sep 2019	267	267	18:15/19:30	MIOR/RMEG	88 (79)	873 (602)	1431
29 Oct 2019	80	80	19:44/20:29	MIOR/RMEG	NA	NA	569
22 Nov 2019	29	29	19:50/20:45	RMEG	Data Missing	Data Missing	Data missing
19 Dec 2019	12	12	20:20/21:20	RMEG	24 (14)	96 (59)	240
09 Jan 2020	8	8	20:29/21:15	RMEG	2 (1)	354 (274)	671
19 Feb 2020	59	59	19:56/21:00	MIOR/RMEG	Data missing	Data missing	Data missing
23 Mar 2020	17	17	19:33/20:20	RMEG	10 (10)	417 (311)	1365
21 Apr 2020	55	55	17:52/18:55	MIOR/RMEG	53 (45)	403 (225)	866
18 May 2020	66	66	17:25/18:35	MIOR/RMEG	Data missing	Data missing	Data missing
18 Jun 2020	92	92	17:21/18:20	MIOR/RMEG	10 (8)	354 (230)	612
25 Jun 2020*	246	246	17:19/18:32	MIOR/RMEG	18 (16)	570 (400)	816
15 Jul 2020	518	499	17:32/18:31	MIOR/RMEG	16 (13)	541 (332)	786
13 Aug 2020	682	682	17:43/18:55	MIOR/RMEG	18 (16)	580 (389)	845
08 Sep 2020	538	538	18:05/19:29	MIOR/RMEG	15 (10)	585 (440)	1012

Survey Date	Max. count	Min. count	First/last bat	Species present	# RMEG passes	# MIOR passes**	Total passes
14 Oct 2020	66	66	19:33/20:30	MIOR/RMEG	17 (13)	782 (727)	1362
18 Nov 2020	16	16	20:09/20:49	RMEG	5 (4)	261 (191)	508
23 Dec 2020	20	20	20:27/20:59	RMEG	7 (6)	229 (161)	511
28 Jan 2021	12	12	20:26/21:06	RMEG	22 (22)	436 (383)	1357
24 Feb 2021	27	1	19:57/19:37	VPUM?/RMEG	20 (16)	350 (283)	956
17 Mar 2021	47	28	19:32/20:21	MIOR/RMEG	14 (13)	284 (200)	1357
18 Apr 2021	289	270	17:52/19:02	MIOR/RMEG	15 (10)	698 (495)	942
12 May 2021	518	498	17:24/18:24	MIOR/RMEG	4 (4)	1092 (936)	1277
15 Jun 2021	823	788	17:16/18:26	MIOR/RMEG	1 (1)	794 (653)	979
12 Jul 2021	497	497	17:24/18:20	MIOR/RMEG	19 (17)	528 (399)	603
04 Aug 2021	419	419	17:45/18:40	MIOR/RMEG	29 (24)	548 (471)	787
10 Sep 2021	890	890	18:08/19:10	MIOR/RMEG	19 (17)	748 (588)	991
04 Oct 2021	624	624	19:15/20:20	MIOR/RMEG	37 (32)	897 (714)	1383
01 Nov 2021	28	28	19:44/20:30	MIOR(1)/RMEG	42 (37)	524 (439)	1037
02 Dec 2021	15	15	20:14/20:54	RMEG	7 (4)	398 (285)	706
19 Jan 2022	8	8	20:31/21:11	RMEG	21 (20)	751 (575)	1220
17 Feb 2022	17	17	20:05/20:45	RMEG	18 (12)	268 (146)	427
16 Mar 2022	29	29	19:35/20:25	VTRO?/RMEG	9 (5)	1013 (823)	1722
21 Apr 2022	527	527	17:47/18:27	MIOR/RMEG	4 (3)	1059 (908)	1594
16 May 2022	396	396	17:25/18:15	MIOR/RMEG	2 (1)	856 (705)	1026
21 Jun 2022	705	705	17:16/18:06	MIOR/RMEG	2 (2)	1068 (929)	1300
29 Jul 2022	661	661	17:30/18:30	MIOR/RMEG	15 (13)	651 (505)	866

Survey Date	Max. count	Min. count	First/last bat	Species present	# RMEG passes	# MIOR passes**	Total passes
18 Aug 2022	974	974	17:47/18:30	MIOR/RMEG	12 (6)	1199 (1017)	1497
27 Sep 2022	1050	1050	18:10/19:10	MIOR/RMEG	7 (6)	1124 (1013)	1435
28 Oct 2022	-	-	-	-	5 (4)	757 (605)	1046
7 Dec 2022*	22	22	20:13/20:43	MIOR(1)/RMEG	17 (15)	830 (761)	1281
28 Dec 2022	15	15	20:29/20:59	RMEG	8 (5)	327 (213)	444
01 Feb 2023*	6	6	20:24/20:54	RMEG	18 (15)	561 (371)	761
15 Feb 2023	19	17	20:10/20:40	RMEG	13 (11)	749 (640)	1305
14 Mar 2023	278	278	19:34/20:24	MIOR/RMEG	20 (16)	916 (747)	1484
26 Apr 2023***	221	221	17:36/18:46	MIOR/?	24 (22)	1101 (1027)	3829
22 May 2023***	323-388	288	17:03/18:13	MIOR/?	6 (5)	553 (394)	716
18 Jun 2023	363	363	17:05/18:14	MIOR/RMEG	14 (7)	502 (399)	643
17 Jul 2023	225	225	17:24/18:34	MIOR/RMEG	4 (2)	519 (405)	590
26 Aug 2023	666	666	17:47/19:16	MIOR/RMEG	0 (0)	1158 (999)	1432
19 Sep 2023	731	731	18:13/20:13	MIOR/RMEG	4 (2)	502 (415)	1707
25 Oct 2023	27	23	19:34/20:38	MIOR/RMEG	5 (4)	240 (178)	679
23 Nov 2023^	4	4	20:01?(20:15)/ 20:41	RMEG	1 (1)	59 (16)	1163
18 Dec 2023	5	3	20:29/20:59	RMEG	7 (4)	32 (9)	793
30 Jan 2024	11	8	20:23/21:04	RMEG	5 (4)	67 (29)	1060
12 Feb 2024	10	9	20:10/20:55	RMEG	18 (16)	39 (12)	734
25 Mar 2024	729	729	19:15/20:05	MIOR/RMEG?	25 (23)	66 (23)	1858
29 Apr 2024	534	534	17:35/18:45	MIOR/RMEG	2 (1)	124 (61)	967

Survey Date	Max. count	Min. count	First/last bat	Species present	# RMEG passes	# MIOR passes**	Total passes
22 May 2024	351	351	17:24/18:34	MIOR/RMEG?	2 (2)	157 (45)	787
17 Jun 2024	390	390	17:22/18:28	MIOR/RMEG	5 (5)	177 (61)	1464
02 Jul 2024^^	N/A harp	147	NA harp	MIOR/RMEG	13 (11)	105 (44)	1903
12 Aug 2024	176	174	17:32/18:32	MIOR	14 (11)	130 (66)	616
09 Sep 2024	1178	912	18:07/19:51	MIOR/RMEG	2 (2)	70 (25)	2217
03 Oct 2024	735	735	18:17/19:36	MIOR/RMEG	0 (0)	109 (10)	1385
14 Nov 2024	20	20	19:58/20:38	MIOR(12)/RMEG	0 (0)	92 (49)	1595
18 Dec 2024	9	9	20:30/21:09	MIOR(1?)/RMEG	8 (6)	78 (33)	709

*two counts were conducted in June 2020 due to a required maintenance visit. Access issues in 2022 meant the November count was pushed back into early December, resulting in two December counts. January count in 2023 was one day late, resulting in two February counts.

**# *M. orianae oceanensis* passes will include background level of *Vespadelus vulturnus* passes as data has been pooled for the two species whose call characteristics overlap in this region.

***New steel box culvert installed 26 April 2023. New setup means counting location is further out from entrance, which makes it very hard to note presence or absence of Eastern Horseshoe-bat unless they are observed during twilight. Also took a few months to work out the best counting position. Also took the bats a bit of time to acclimatise to and start using the tunnel.

^Access to adit was delayed. Previous night's monitoring data suggests bats first exit was at 20:01, but only got to adit at 20:15 to start count. Bats exiting the adit during this time may have been missed in the nightly count. Consider this an underestimate.

^^Adit was harp trapped for media release and to confirm composition of colony. No count was made, other than measuring bats pulled out of harp trap across adit for an hour around exit time.

Cells marked "Data missing" are nights/months where there has been an equipment failure that was not picked up until the next count. "NA" denotes data that is not yet available due to analysis not being completed.

Automated Echolocation Call Detection

The automated echolocation call detection equipment operated successfully throughout 2024. Issues in 2020 were rectified by more frequent formatting of memory cards. As with previous years, activity of the Eastern Horseshoe-bat (*Rhinolophus megaphyllus*) was generally low and relatively consistent (**Figures 4-1** to **4-6**). Wet weather caused mild conditions through much of 2021-2022, meaning activity was much more stable than earlier years, with no obvious seasonal change in activity. 2023 started off with slightly elevated activity (though not comparable to that seen in 2019), but returned to low even activity levels from end of May. Activity was consistently low in 2024, with only slight increases in activity in March-April and August-September. Historically, activity for this species declines over winter and increases between mid-September and late April. The 2020 October-December period was characterised by pulses of increased activity on occasional nights (50-100 passes over average), but few large spikes in activity were observed through 2021-2023. While oscillations in activity from night to night are seen, the overall picture is one of relative stability in 2024, with slight seasonal increase in autumn and spring. Since May 2023, activity levels rarely exceeded 25 passes per night. Monthly count data supports this with Eastern Horseshoe-bat numbers varying from 8 to 29 over the summer months from December 2017 to December 2022, but dropping to 3 to 11 over November-December 2023-24. Numbers from our monthly counts provide no evidence for gross changes in Eastern Horseshoe-bat numbers through spring-summer 2019. It could be that during the peak of the drought, individuals may have moved into the area either to escape bushfires to the east, or simply to access more permanent water sources in the vicinity of the adit. Though not resulting in increases in the Slate Gully adit occupation, other roosts likely exist in the local area, particularly when considering the type of shelter used by this species (avens in boulders and caves with dark zones; *pers. obs.* author). Alternatively, bats may have needed to spend more time foraging for insects in the drought, leading to increased activity to satisfy energetic requirements. Kohles *et al.* (2024) found bat foraging bouts and foraging distance both increased when insects were less abundant. Steady activity through 2021-2022 could be a result of more stable climatic conditions, with weather generally milder than expected throughout the year. However, whilst relatively steady in the beginning of 2023, activity appears to decline from June 2023 and continue through 2024. The removal of these water sources by the approaching mine pit may potentially explain the reduction in numbers by late 2023. Long-term averaged climatic data from site was not available at the time of writing. Gulgong Post Office monthly climate statistics show higher than average maximum temperatures for all but June-July 2024, and higher than average minimum temperatures for January-March, July-August and November-December (BOM 2024, data based on 1970-2024). 2024 rainfall was well above average in February, and above average in April, July, November and December. 2024 rainfall was below average in January, March and September. As above, good availability of insects in wet conditions may reduce activity demands in order to meet food requirements.

Reductions in activity with no concurrent reduction in actual counts of individuals over the summer months could be indicative of reduced microphone sensitivity over time. The microphone was replaced with a brand new unit in February 2024 with no obvious improvement in call activity suggesting an improvement in sensitivity.

Activity levels of the Large Bent-winged Bat (*Miniopterus orianae oceanensis*) showed greater seasonal variation and the night to night variation was greater than that of the Eastern Horseshoe-bat (**Figures**

4-7 to **4-12**). While activity increased during 2020 from February, the increase in activity during 2021 was seen in early April. 2022 saw an increase in activity in mid April, suggesting an even later return from summer maternity roosts with subadults than that seen in 2021. 2023 and 2024 saw increases from late February of each year. Monthly counts support this, suggesting that there is yearly variation, with Large Bent-winged Bats returning between mid-February and late March, with the majority arriving by mid-April. 2020 activity peaked in late August-September, while 2021 showed peaks in June and October. Peaks in 2022 occurred in April and June-July, while 2023 data showed peaks in April-May and August. 2024 data shows activity peaks in March-April, mid-June and September, with high activity continuing into December. In early years, there seemed to be a large decline in activity in mid-late October as bats leave for summer/maternity roosts. This decline pushed back to early November in 2022, whilst 2023 decline shifted forward to late September. While there was a decline through late October in 2024, activity resurged and remained relatively high all the way through to December, with Bent-winged Bats being picked up in both November and December counts (albeit in low numbers). Typically by late November activity appears to be reduced to a level that indicates all bats are gone from the cave and only general foraging activity for the species is being picked up outside the cave entrance. This pattern mirrors that from counts of bats exiting the workings undertaken since April 2017, whereby Large Bent-winged Bats are gone by early November (Fly By Night 2017; Fly By Night 2018; Fly By Night 2019). Within this pattern, large oscillations in activity of this species did occur from night to night. While activity levels sometimes varied by only a few passes per night at other times it varied by up to 1800 passes per night. 2024 showed the most volatility in activity indices. This nightly variation could reflect changes in the number of individuals roosting within the workings, as well as other factors including ambient temperature and prey abundance. Rain can interfere with the effectiveness of the microphone, so the volatility over 2021-2022 could be due to wet conditions. As La Nina subsides, we have not seen a reduction in volatility, suggesting this is not the cause of the night by night variation. The yearly pattern of use at Slate Gully is similar to that recorded at urban roosts in Sydney and Newcastle (Hoye & Spence 2004).

The increase in variability in activity of Large Bent-winged Bat is in stark contrast to the continued decline in activity variability in Eastern Horseshoe-bat being seen over the years of monitoring. This (and the fact the microphone was replaced in February 2024) suggest the changes are not a result of changing microphone sensitivity.

Data used to monitor Large Bent-winged Bat activity is a combination of call pulse identifications. Due to the huge volume of calls generated by continuous recording each year, we have used an automated call identification analysis program (Ana-lyse© A.J. Hoye) to label the data. In the region around Mudgee, call pulses for Large Bent-winged Bats in cluttered environments are very similar to those of the Little Forest Bat (*Vespadelus vulturnus*) and Chocolate Wattled Bat (*Chalinolobus morio*). Because of the overlap in call parameters, a combination of these species was used to generate various indices for Large Bent-winged Bat activity. The large numbers of cave roosting bats using the adit should dwarf the number of either of the other tree roosting species. As such, the background level of tree-roosting bat activity could be considered relatively constant through the year (noting tree roosting species will have reduced activity over winter). If we subtract that constant activity of Little Forest/Chocolate Wattled Bats away from the pooled activity figure, seasonal variation in Large Bent-winged activity should still be seen. This is why there is activity recorded for Large Bent-winged Bats over the summer period when there are none present in counts. By looking at recorded activity levels over the November-January 2020 period when Large Bent-winged were absent from the adit, a background level of activity of 50-250 call pulses was able to be observed. This is likely to be the background level of Little Forest Bat activity. That activity was slightly higher in the summer months of 2021, and approached 400 pulses/night in summer months in 2022-2024. For consistency's sake, the correction factor has been retained at 150 pulses/night across all years (noting that background activity is likely to have increased on par with increases seen in Large Bent-winged Bat activity in the recent years). The low level of Large Bent-winged Bat activity seen over the summer months when individuals have vacated the mine workings probably represents males and non-breeding females present in a nearby roost that still forage over the site. Individuals can travel at least 10km (perhaps up to 30km) from a roost to feed in a night.

Correlation of bat activity with blast dates has the potential to reveal changes in activity as a result of "pulse" disturbance. "Pulse disturbance" is typically short term in nature and can often be of higher magnitude/intensity (e.g. blasting). Blast dates (Pits 3 and 8) from March 2020 to December 2024 were plotted against activity index of both species (**Figure 4-13**). Only Pit 8 blast dates were provided in 2020 which may explain the increase in blast occurrences in 2021. Pit 3 has not experienced a blast since April 2021, though there have been some at the start of 2025. Pit 7 could also be close to the adit, but has not been included in these analyses, and hasn't seen a blast since September 2023. Large Bent-winged Bat activity declined after some blasts, and increased after others, i.e. there was little correlation between bat activity at the roost and blasting activity. The magnitude of the changes also differed each time. Currently, there does not appear to be any clear change in activity of either species relative to blast dates.

Potential "press disturbance" (disturbance associated with constant long term phenomena which may not necessarily be high impact in nature) impacts as a result of increased activity within the vicinity of the adit will be analysed as mining advances toward the adits location. Examples of "press disturbance" include light spill from mine or noise from machinery.

As a requirement within the Biodiversity and Blast Management Plans, video surveillance and review of recorded footage is undertaken with each blast conducted in Pit 8 (Slate Gully). Footage is reviewed five minutes pre and post blast event to evaluate potential impacts to the adit and bat activity. Of the 2020 data collected and reviewed, blast activity was not seen to disturb or induce diurnal bat flight activity outside of the adit. No disturbances (bats leaving adit during daylight) were observed during 2021, 2022 or 2023 monitoring (pers. comm. Josh Frappell; pers. comm. James Heesterman). In April 2024 Kieren Bennetts notified Andrew Lothian of adit video footage from the time post their most recent blast (presume 26 April 2024). This footage contained approximately four frames of a vague object moving from right to left of the culvert immediately after the blast. After reviewing the footage, BMS concludes that the object is likely to be falling debris (dust cloud) from the adit entrance rather than an exiting bat. This explains the dirt that continually accumulates at the bottom right hand corner of the culvert each month which BMS removes during count visits. BMS have no data to assess whether bats are roused and undertaking diurnal flight within the adit. For blasts that were more than four days from other blasts, short term responses of Eastern Horseshoe-bat (**Figure 4-14**) and Large Bent-winged Bat (**Figure 4-15**) were plotted. Data is presented for the five days leading up to a blast, and the five days after. Data has been summarised into means with standard errors. Two potential hypotheses exist for disturbance of bats post blasting. The first is an increase in activity as bats have been roused into activity by the pressure/sound waves. The second could be a reduction in activity whereby bats are reluctant to leave the safety of the adit due to the recent disturbance. A lack of variation in activity after a blast, outside of the variation seen prior to the blast, would be considered an absence of impact.

It can be observed from raw data that in 33 of 77 blasts, Eastern Horseshoe-bat activity declined from the night before to the night of (after) the blast. 32 of 77 blasts saw an increase in activity, and 12 blasts saw no change in activity. Not only does this show mixed responses, but when referring to **Figure 4-14** on average the response is a decrease in activity on the night before the blast as well as the night of the blast (both of very small magnitude). Large Bent-winged Bat activity declined in 45 of 77 blast nights relative to previous nights, which is also seen in average data (**Figure 4-15**). 30 of 77 blasts saw an increase in activity, while 2 blasts saw no change in activity. In the case of the Bent-winged Bat, the magnitude of the decline was no greater than variation seen in nights prior to the blast. The mixed results and small changes relative to normal nightly variation in activity suggest no impact from blasting in Pits 3 or 8 on the two bat species. The slight declining trend in Bent-winged Bats has not carried forward to 2024, with some of the highest pass rates of Bent-winged Bat occurring this year. Neither species' decline was more than what would be expected from nightly variation, and overlapping Standard Error bars suggest changes are not likely to be significant. One-way Repeated Measures ANOVAs were run on the activity data over the 11 nights (from 77 independent blast events). Neither Eastern Horseshoe-bat nor Large Bent-winged Bat activity were significantly different between any of the nights.

Additional analyses were conducted on Eastern Horseshoe-bat and Large Bent-winged Bat activity pre and post blasts, but were restricted to the winter period when bats may utilise torpor to conserve energy. One-way Repeated Measures ANOVAs showed no significant differences between nightly activity before and after blasts, but power of both analyses were low due to small sample size (only 20 winter blast events). BMS will monitor this metric going forward as more data becomes available.

As bat activity did not seem to change in response to mine blasts, BMS investigated changes in bat activity with minimum nightly temperature. Minimum temperature was amplified so changes in temperature could be viewed at the scale of changes in bat activity. In 2021, there appeared to be an inverse response in bat activity with minimum temperature. As minimum temperature drops, bat activity is increased. However, in 2022 the relationship seemed to change seasonally, or when the Large Bent-winged Bat was present/absent. From early April to early October, Large Bent-winged Bat activity roughly correlated directly with minimum overnight temperature (i.e. as minimum temperature goes up, activity goes up). This happens to be the period in which Large Bent-winged Bat inhabit the adit as a non-breeding roost. 2023 saw a similar relationship to 2022, with activity positively correlated with minimum temperature over the early April to early September period. Over the warmer months, the relationship between temperature and activity was poorly defined. Whether this has to do with the absence of Bent-winged Bats, or if it is a product of minimum overnight temperature having no control over activity above a certain temperature threshold is unable to be determined. 2024 started with no real relationship over summer into autumn, some positive correlation through April, but then a weak relationship from this point on. Some peaks in bat activity match peaks in temperature, but other troughs in activity match with peaks in temperature. As there is no clear relationship seen, it is likely that other climatic variables contribute to bat activity each night (i.e. moon phase, wind speed, time of minimum temperature, etc.).

Regressions were run on confident Eastern Horseshoe-bat (R.megC) and Large Bent-winged Bat (M tot + Vvul P/Po) against minimum temperature. There was a very small positive correlation between R.megC and minimum temperature (r^2=0.0012). There was a small negative relationship between Large Bent-winged Bat activity and minimum nightly temperature (r^2=0.0288). This is not a surprising result, as the Bent-winged Bats leaving over summer means there are less individuals present (hence less activity) when minimum temperatures are likely to be higher. When adjusted for the April to October period, the Bent-winged Bat relationship changes to a positive relationship (r^2=0.0038). Overall this suggests the relationship between bat activity and temperature are very weak.

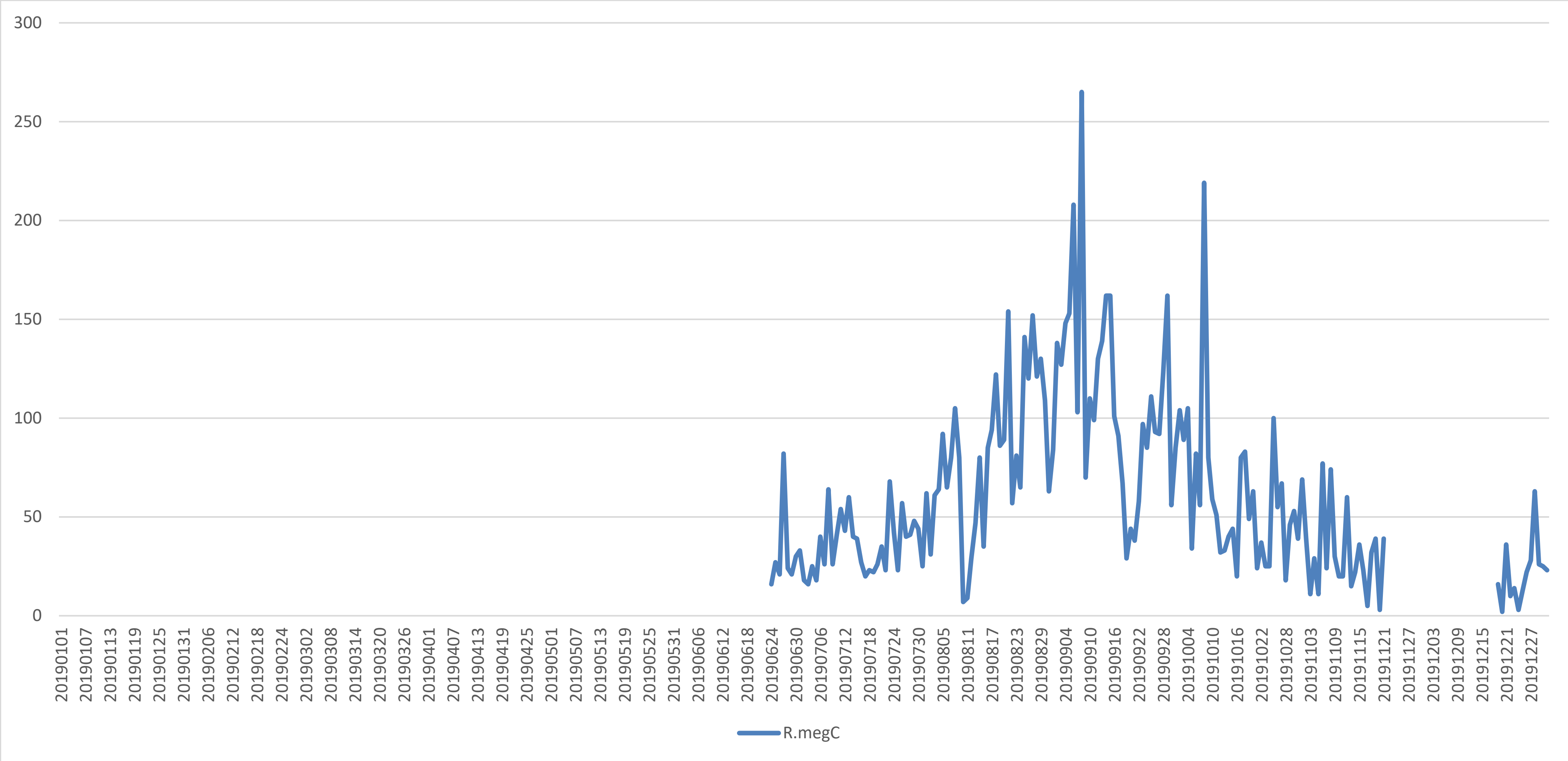


Figure 4-1: Nightly Eastern Horseshoe-bat activity in 2019

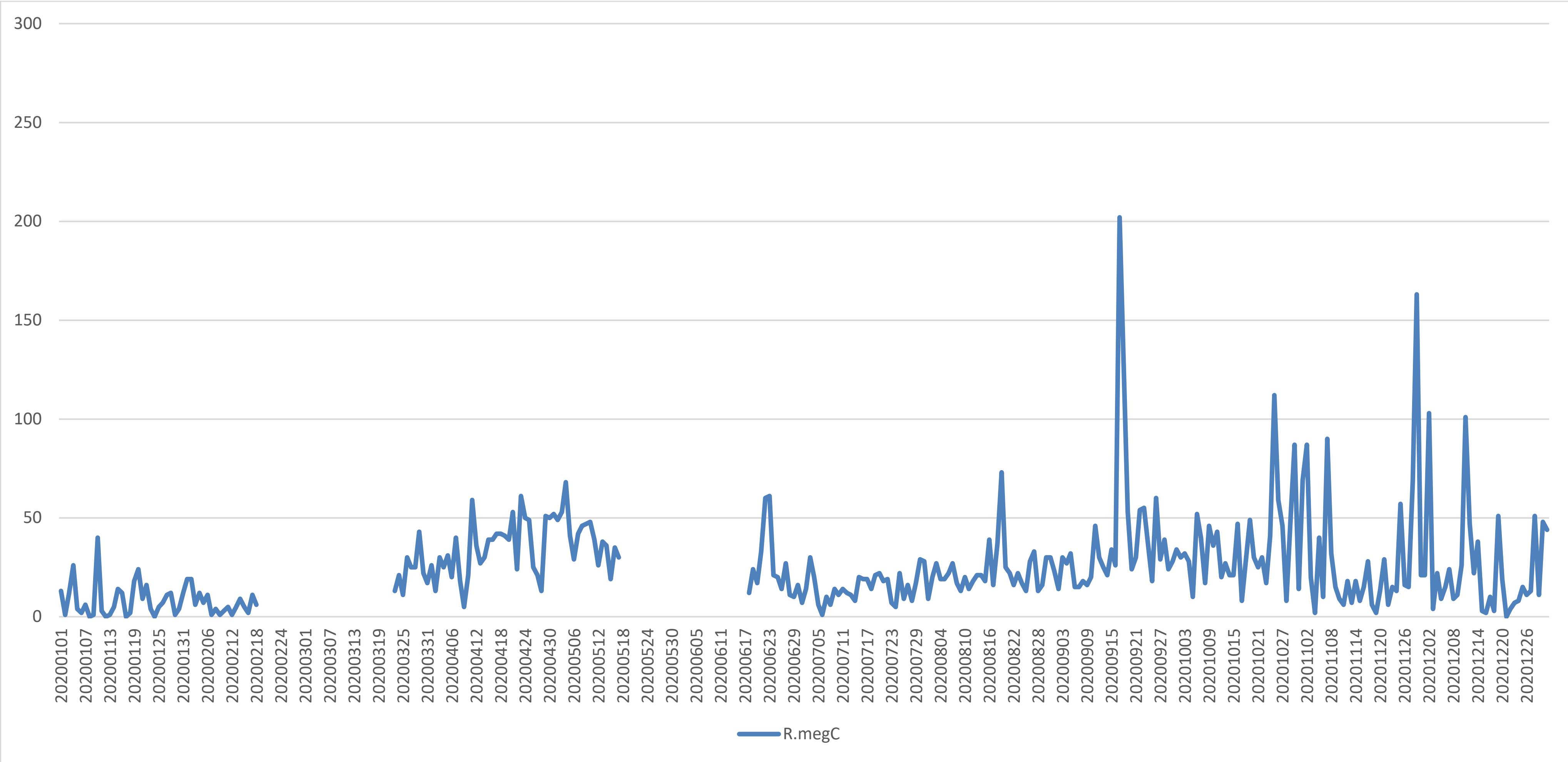


Figure 4-2: Nightly Eastern Horseshoe-bat activity in 2020

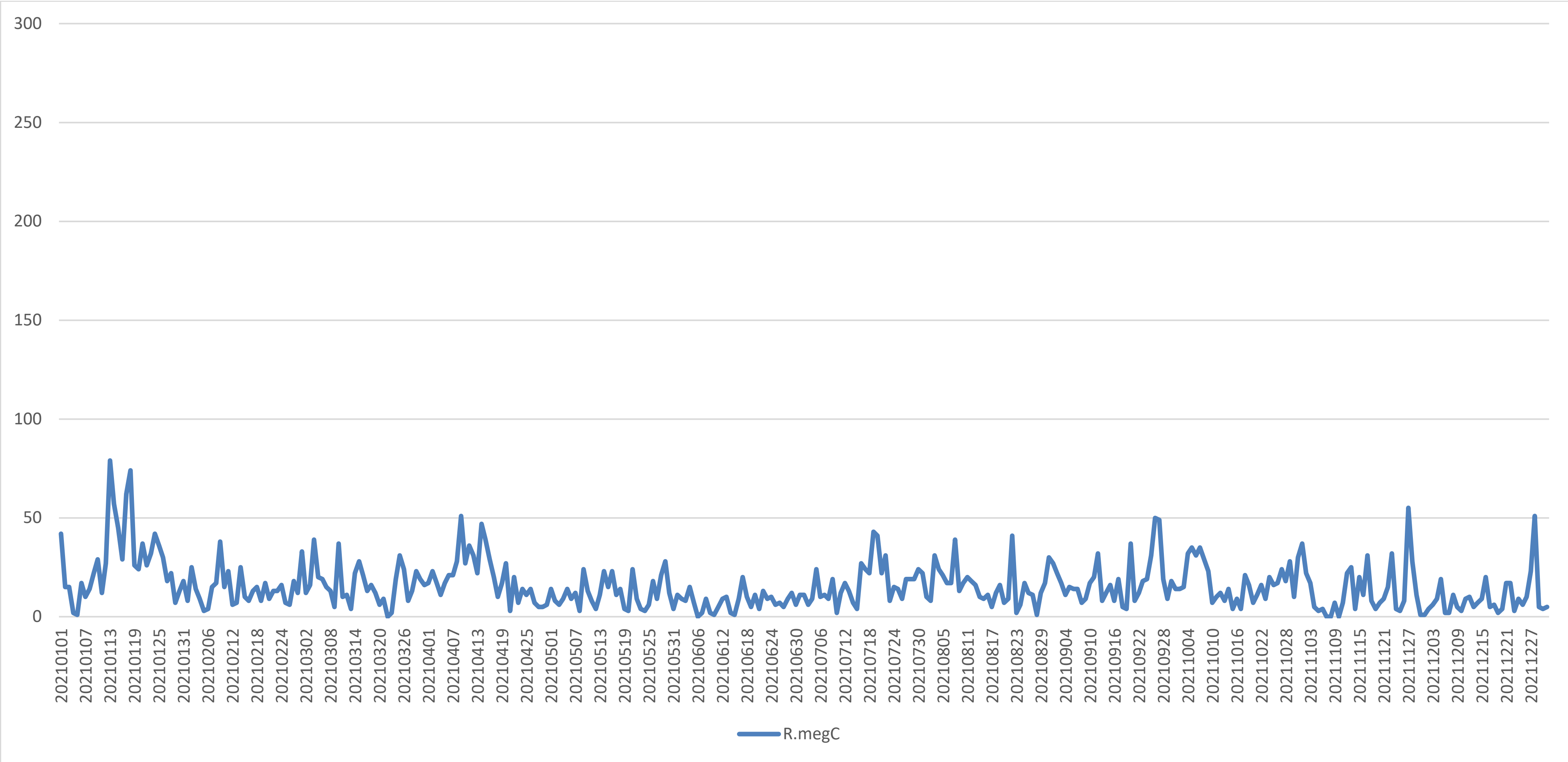


Figure 4-3: Nightly Eastern Horseshoe-bat activity in 2021

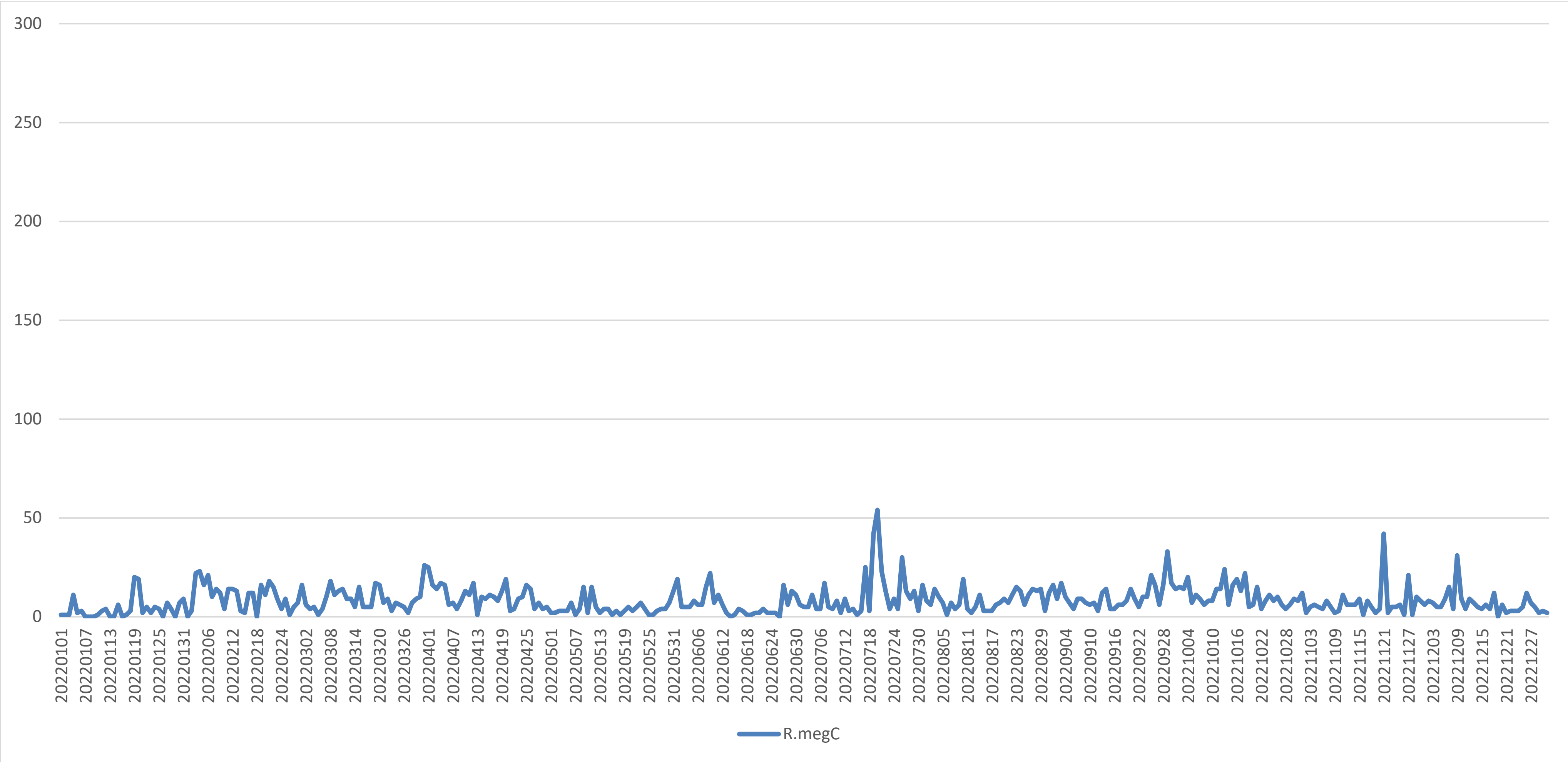


Figure 4-4: Nightly Eastern Horseshoe-bat activity in 2022

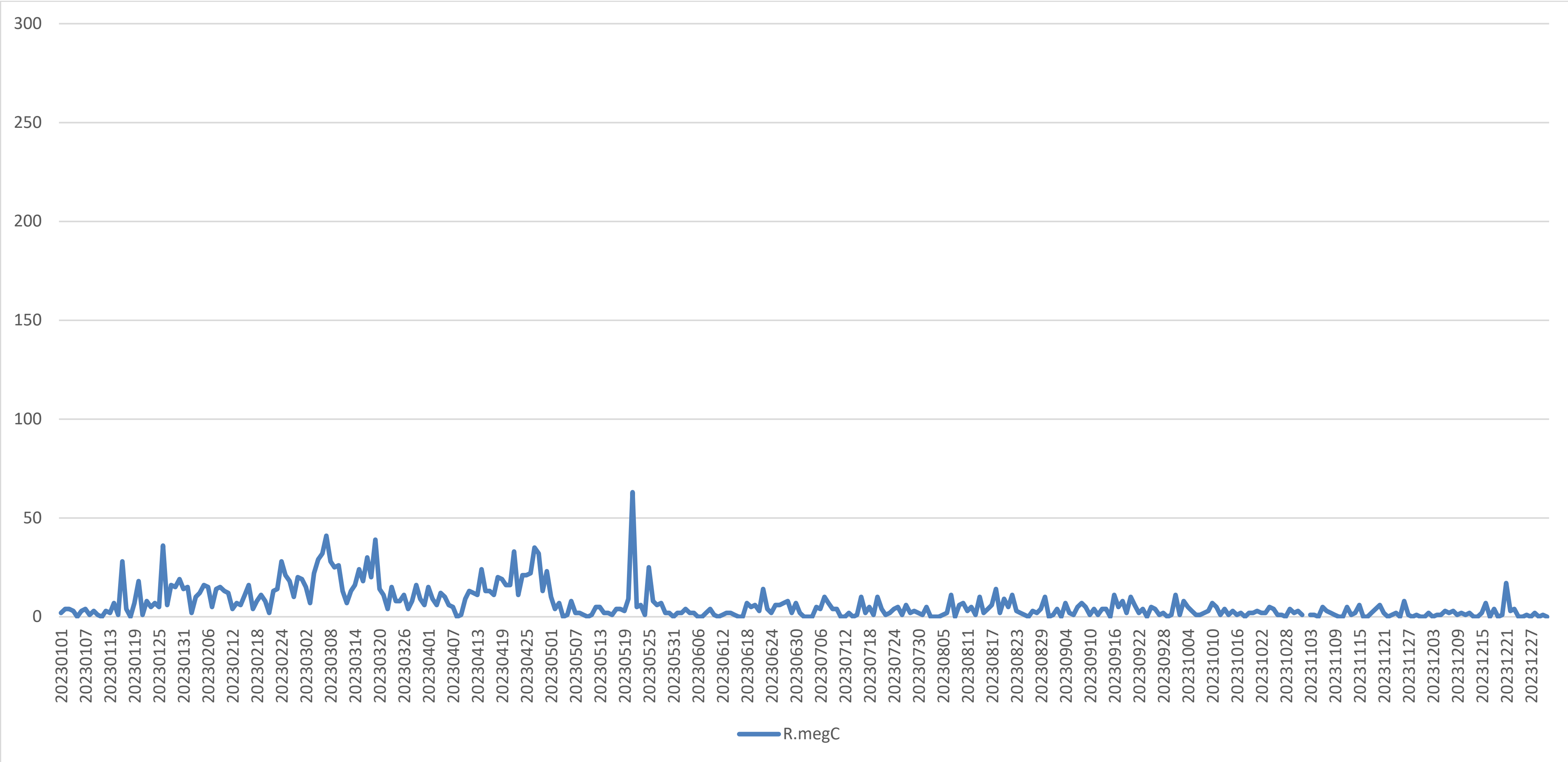


Figure 4-5: Nightly Eastern Horseshoe-bat activity in 2023

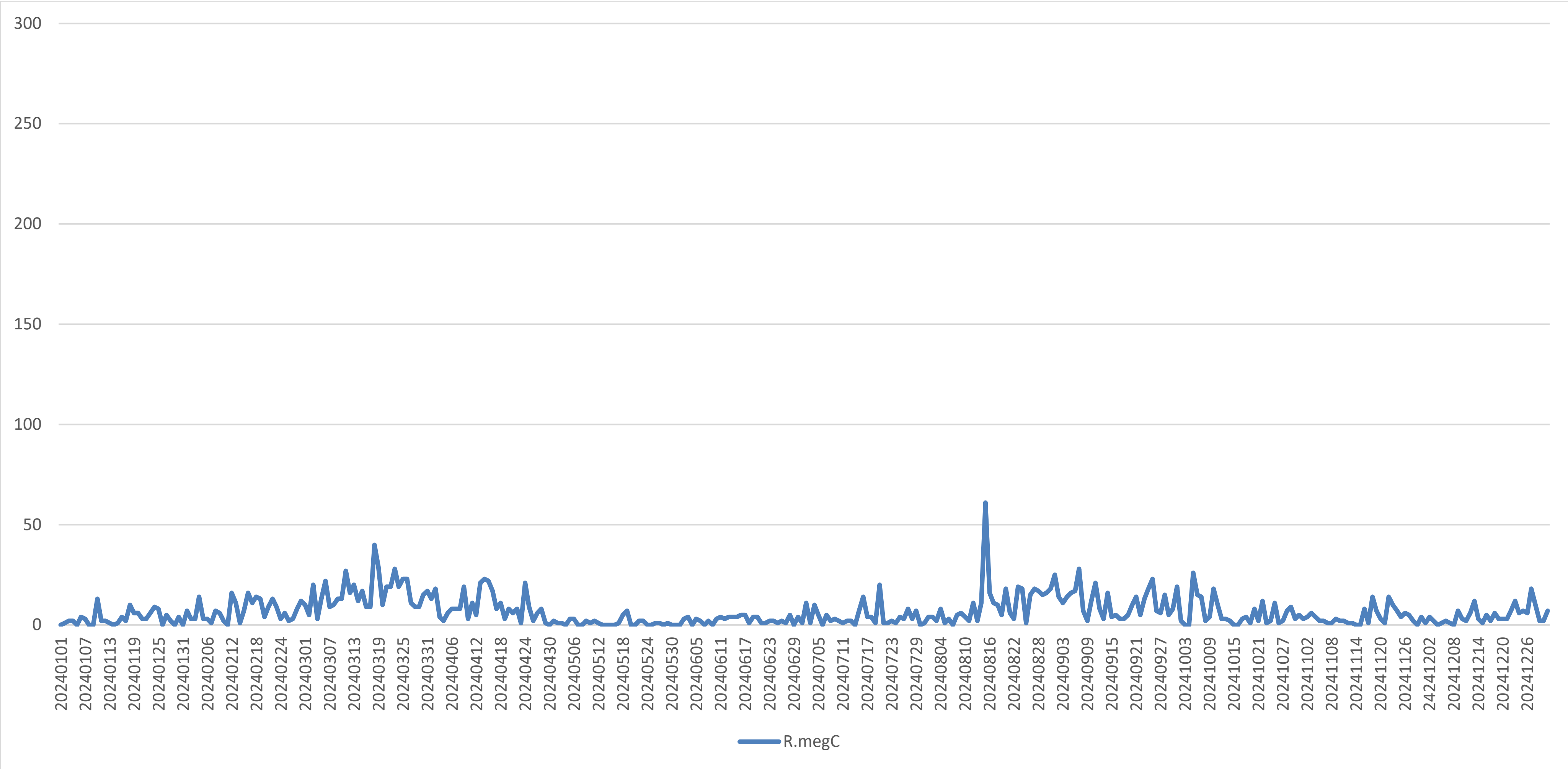


Figure 4-6: Nightly Eastern Horseshoe-bat activity in 2024

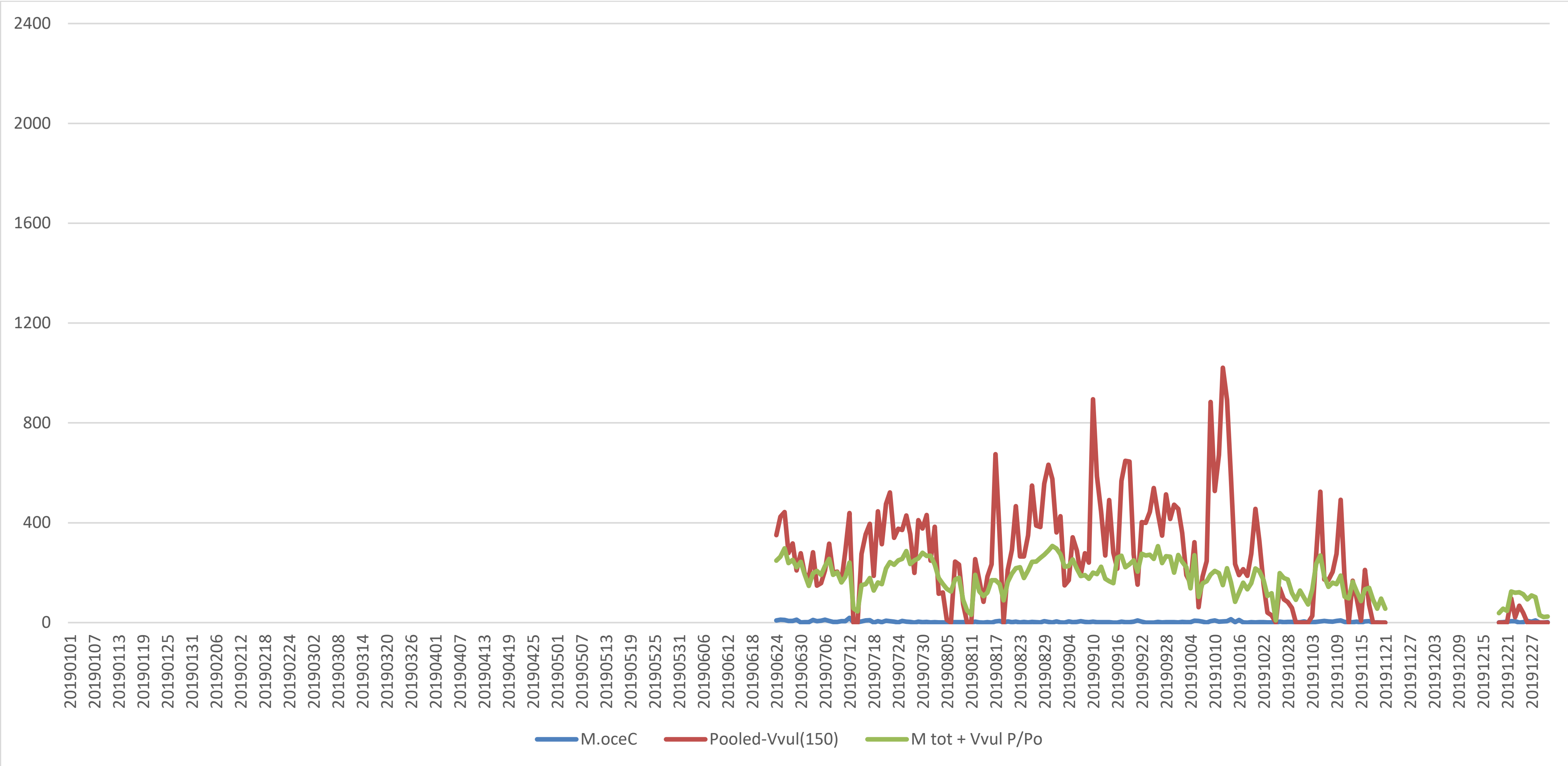


Figure 4-7: Nightly Large Bent-winged Bat activity in 2019. *M.oceC* represent the number of confident open space Large Bent-winged Bat calls. *Pooled-Vvul(150)* represent the number of pooled confident calls for Large Bent-winged and Little Forest Bats which have similar call

parameters (i.e. M.oceC + VvulC – 150). ***Mtot+VvulP/Po*** **represent the number of total Large Bent-winged Bat calls plus calls of Little Forest Bat that were not identified confidently as Little Forest Bat.**

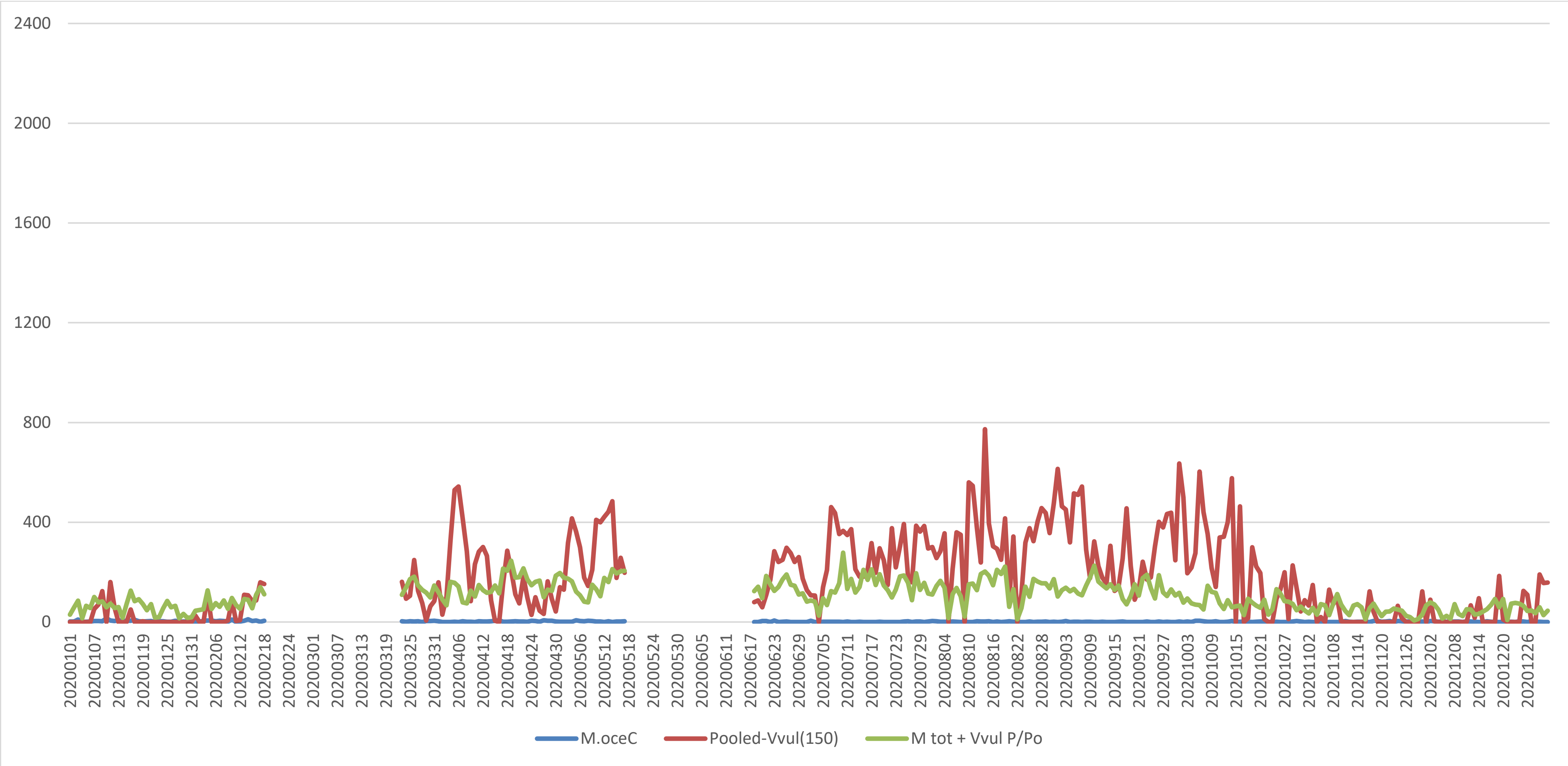


Figure 4-8: Nightly Large Bent-winged Bat activity in 2020. *M.oceC* represent the number of confident open space Large Bent-winged Bat calls. *Pooled-Vvul(150)* represent the number of pooled confident calls for Large Bent-winged and Little Forest Bats which have similar call

parameters (i.e. M.oceC + VvulC – 150). ***Mtot+VvulP/Po*** **represent the number of total Large Bent-winged Bat calls plus calls of Little Forest Bat that were not identified confidently as Little Forest Bat.**

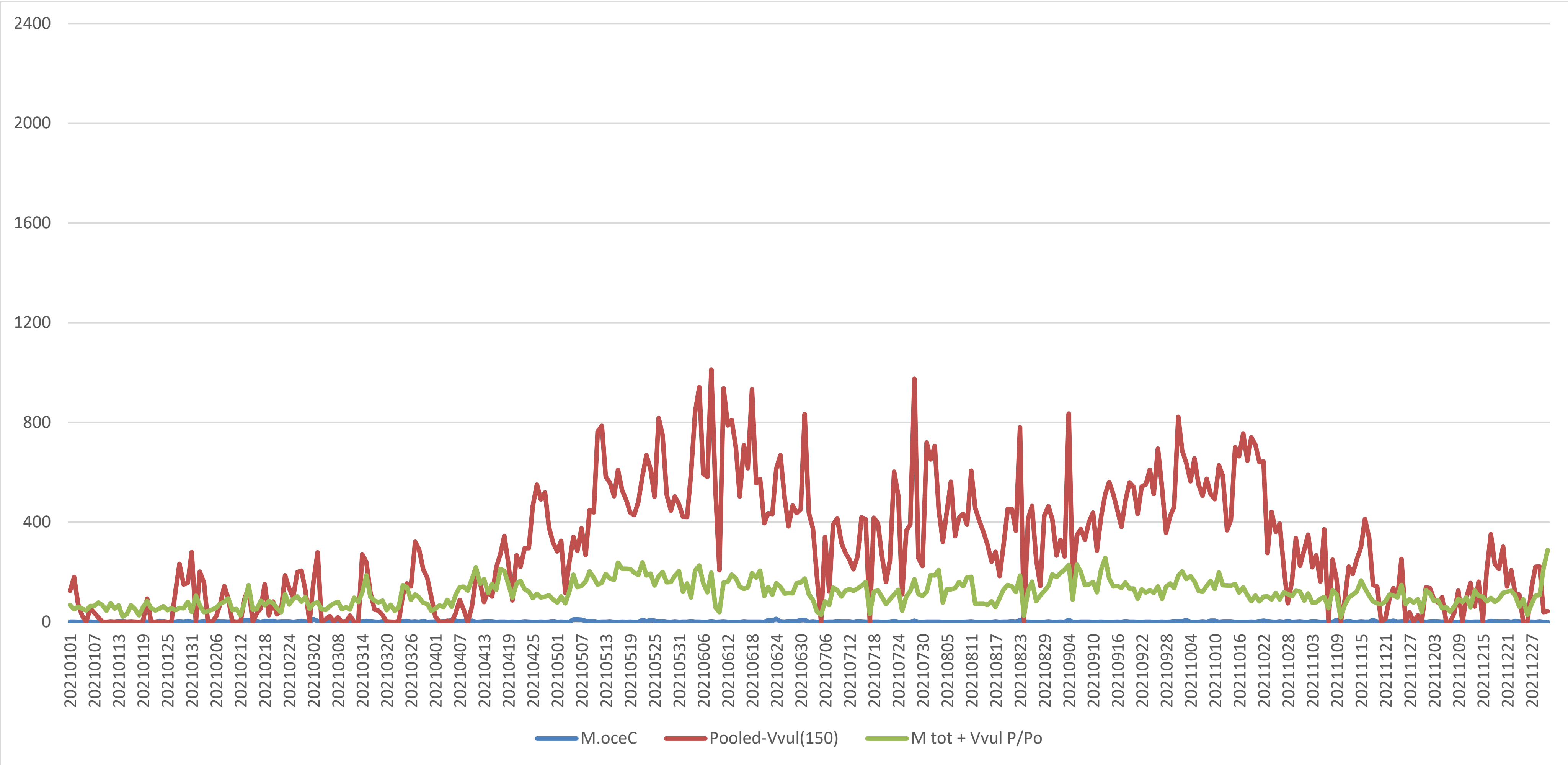


Figure 4-9: Nightly Large Bent-winged Bat activity in 2021. *M.oceC* represent the number of confident open space Large Bent-winged Bat calls. *Pooled-Vvul(150)* represent the number of pooled confident calls for Large Bent-winged and Little Forest Bats which have similar call

parameters (i.e. M.oceC + VvulC – 150). ***Mtot+VvulP/Po*** **represent the number of total Large Bent-winged Bat calls plus calls of Little Forest Bat that were not identified confidently as Little Forest Bat.**

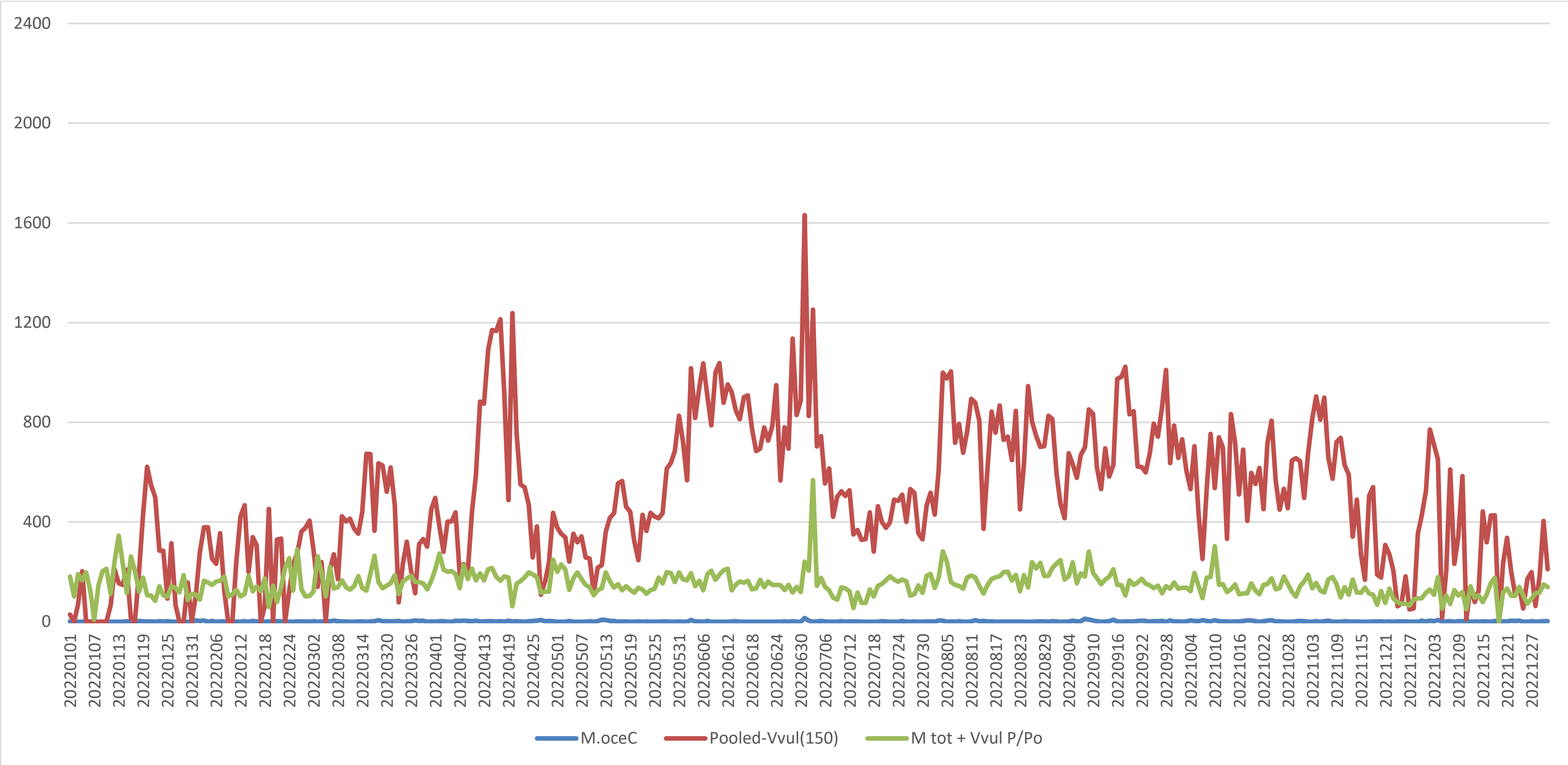


Figure 4-10: Nightly Large Bent-winged Bat activity in 2022. *M.oceC* represent the number of confident open space Large Bent-winged Bat calls. *Pooled-Vvul(150)* represent the number of pooled confident calls for Large Bent-winged and Little Forest Bats which have

similar call parameters (i.e. M.oceC + VvulC – 150). ***Mtot+VvulP/Po*** **represent the number of total Large Bent-winged Bat calls plus calls of Little Forest Bat that were not identified confidently as Little Forest Bat.**

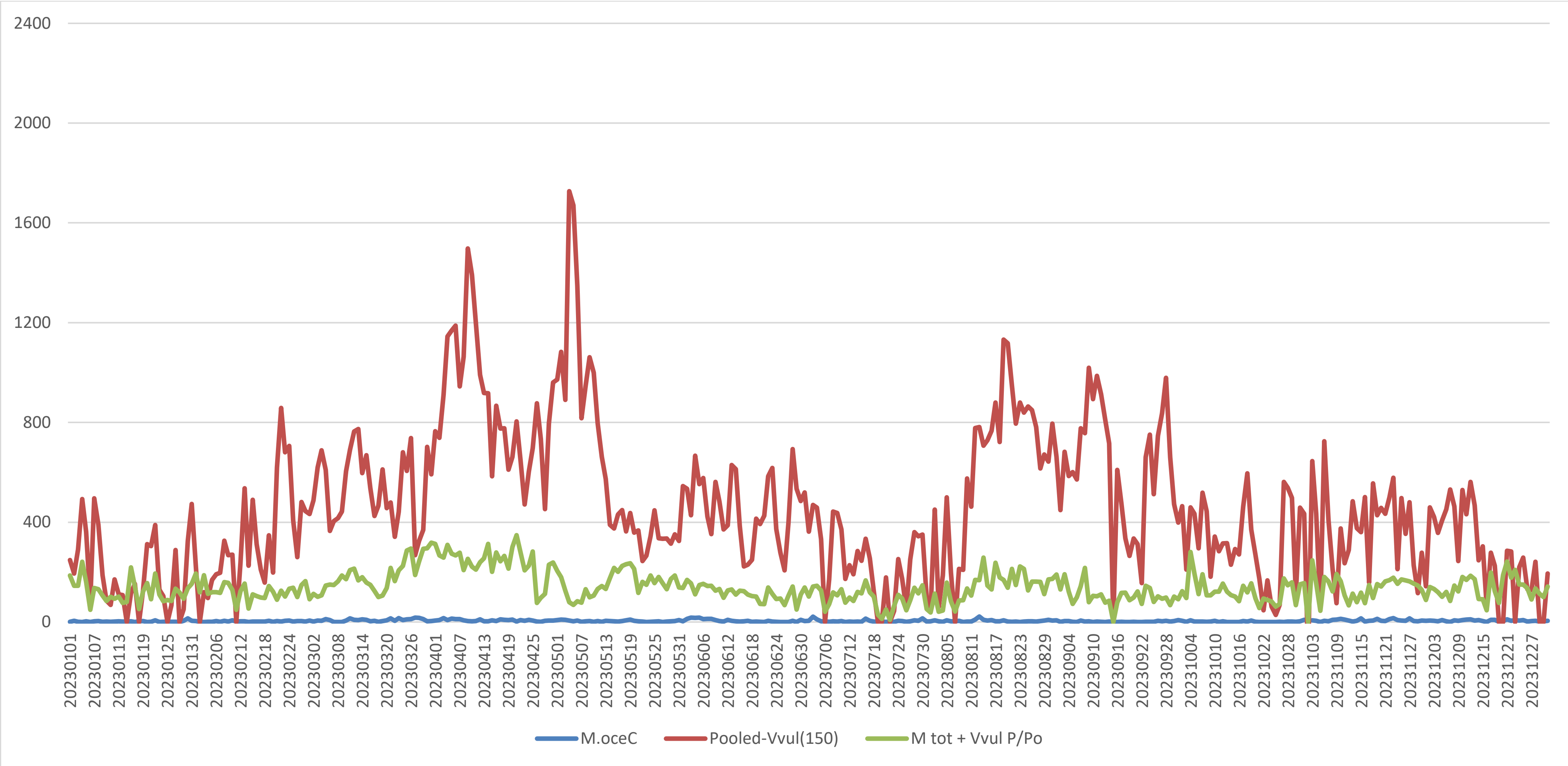


Figure 4-11: Nightly Large Bent-winged Bat activity in 2023. *M.oceC* represent the number of confident open space Large Bent-winged Bat calls. *Pooled-Vvul(150)* represent the number of pooled confident calls for Large Bent-winged and Little Forest Bats which have similar call parameters (i.e. M.oceC + VvulC – 150). *Mtot+VvulP/Po* represent the number of total Large Bent-winged Bat calls plus calls of Little Forest Bat that were not identified confidently as Little Forest Bat.

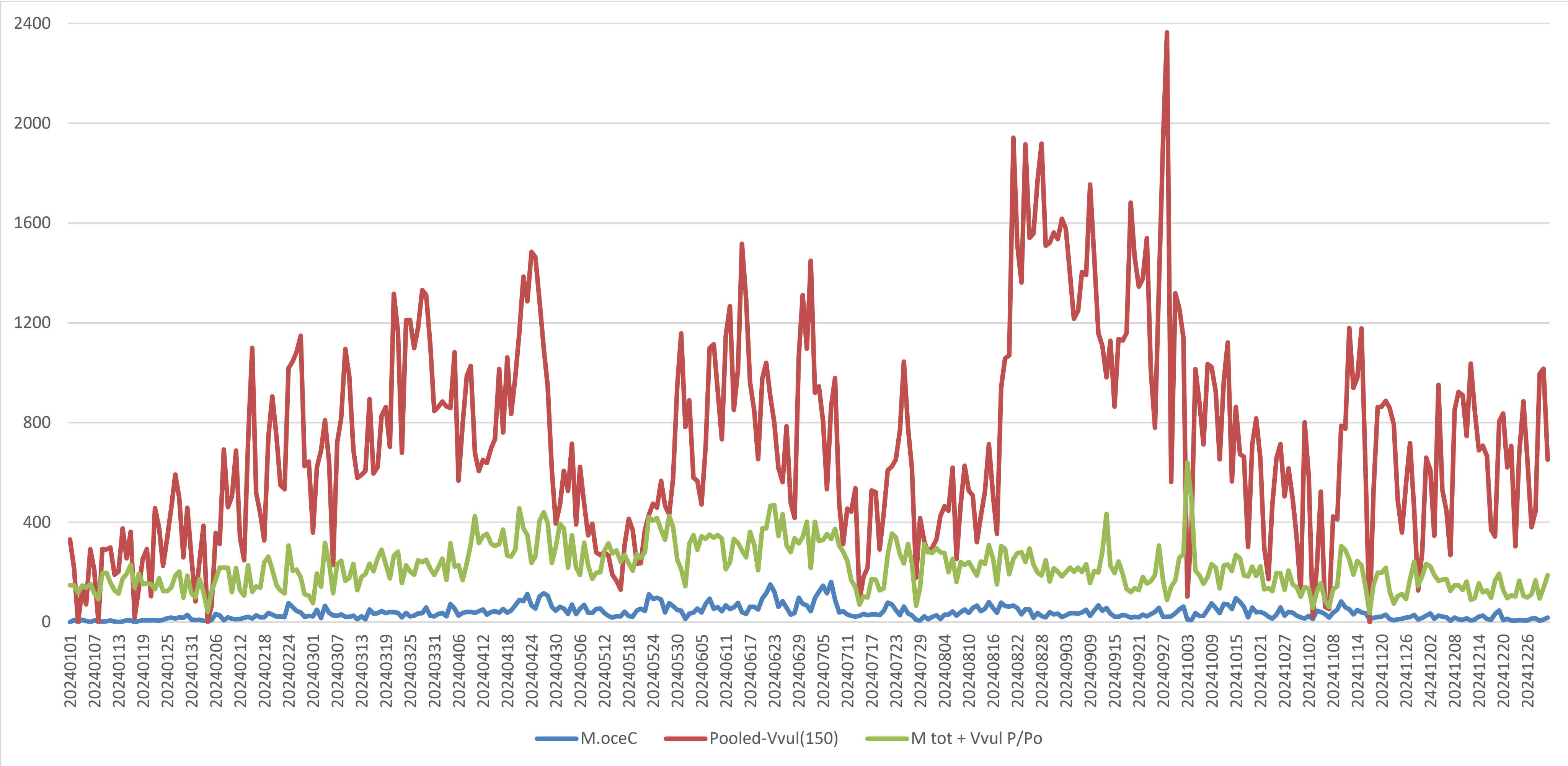
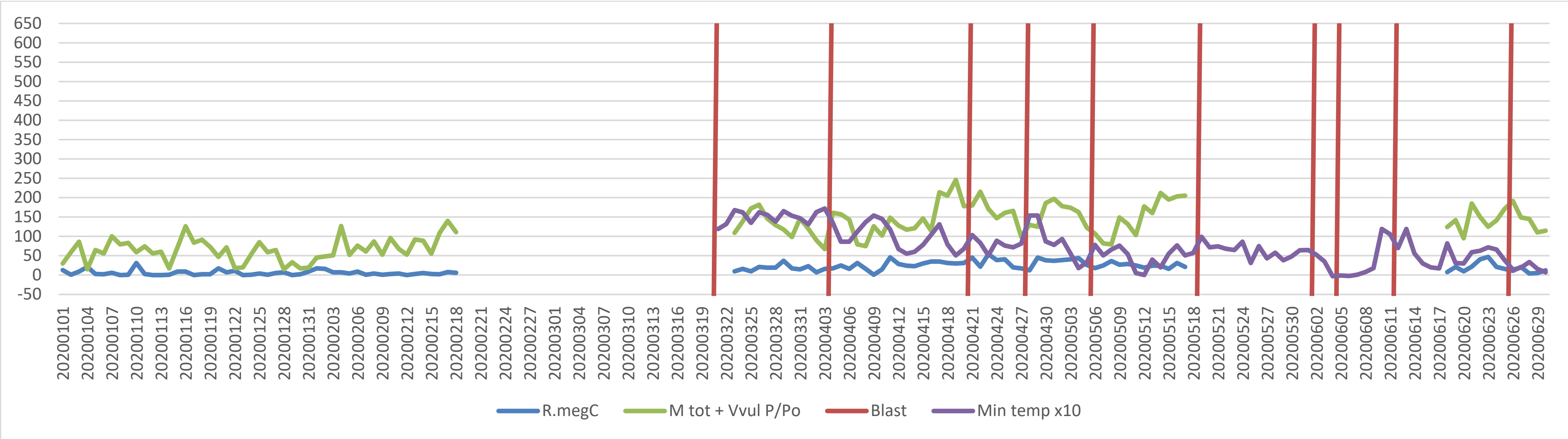


Figure 4-12: Nightly Large Bent-winged Bat activity in 2024. *M.oceC* represent the number of confident open space Large Bent-winged Bat calls. *Pooled-Vvul(150)* represent the number of pooled confident calls for Large Bent-winged and Little Forest Bats which have

similar call parameters (i.e. M.oceC + VvulC – 150). ***Mtot+VvulP/Po*** **represent the number of total Large Bent-winged Bat calls plus calls of Little Forest Bat that were not identified confidently as Little Forest Bat.**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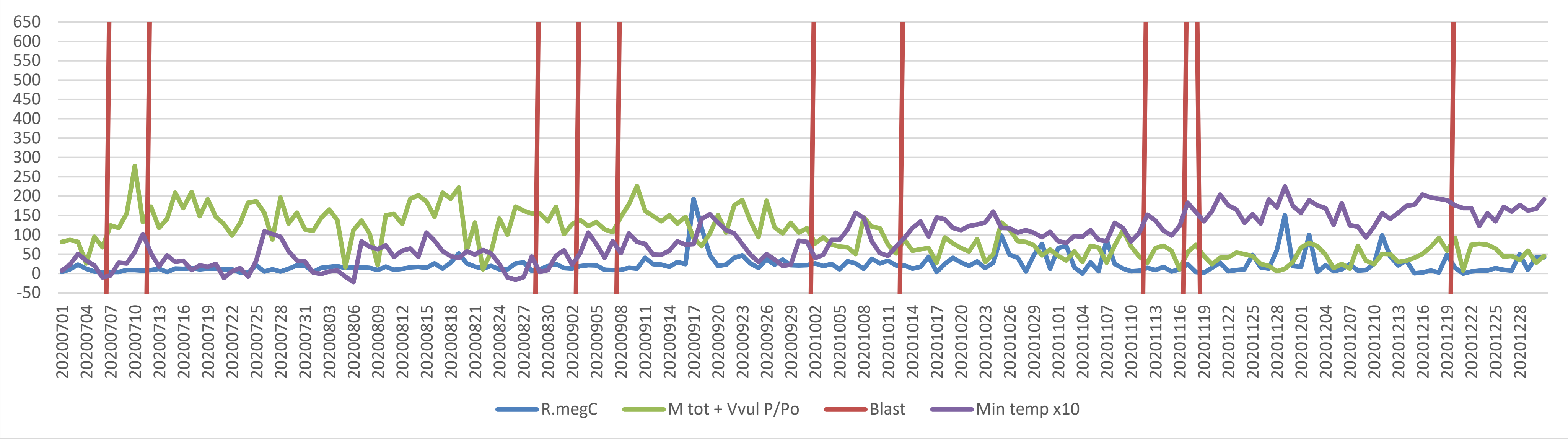
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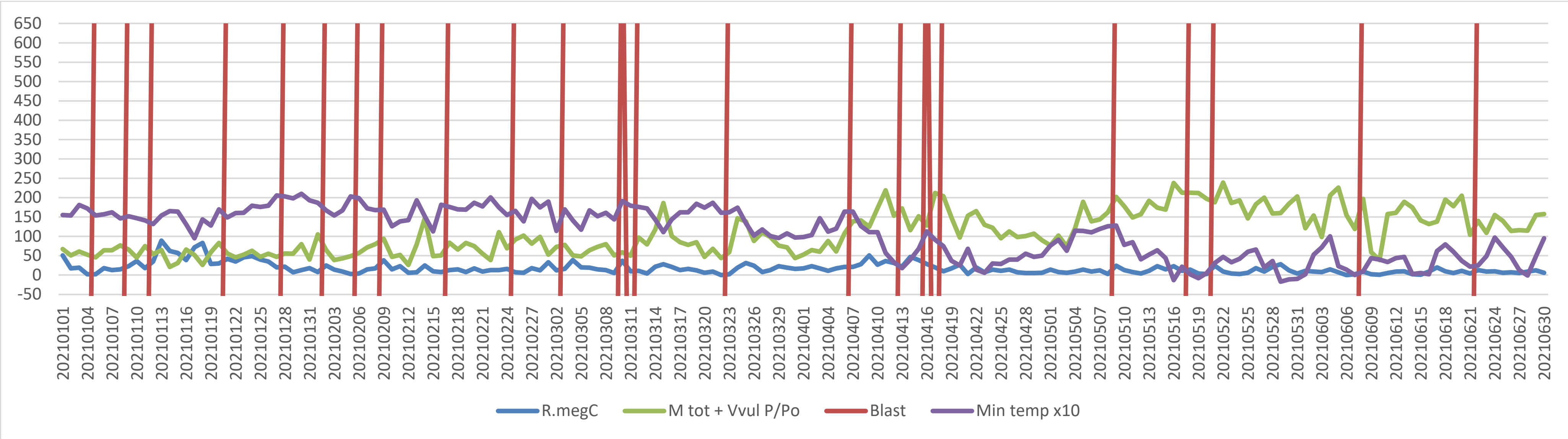
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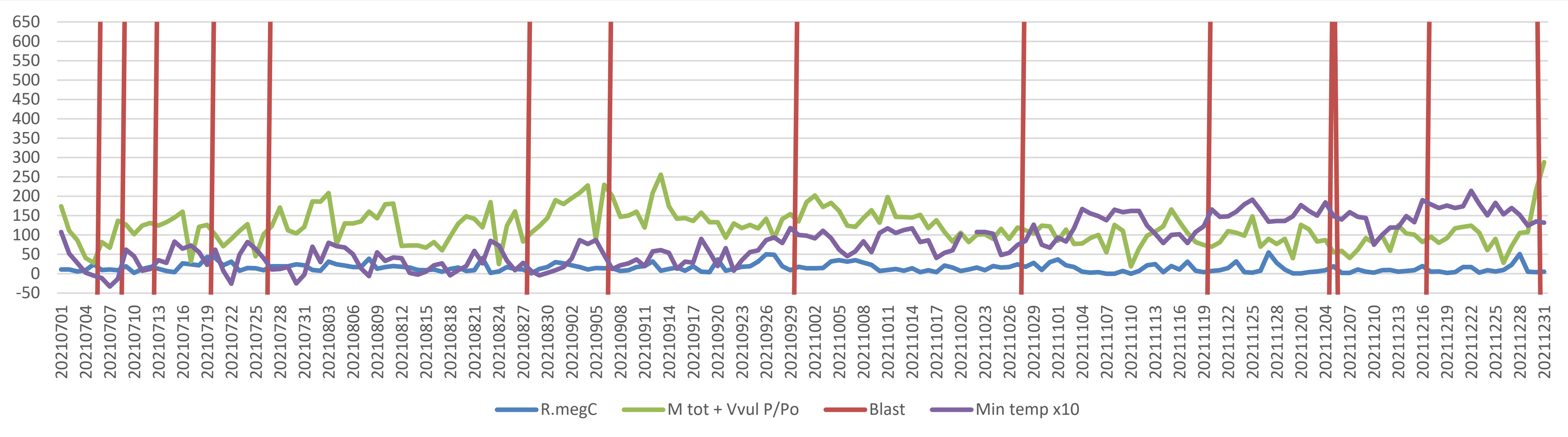
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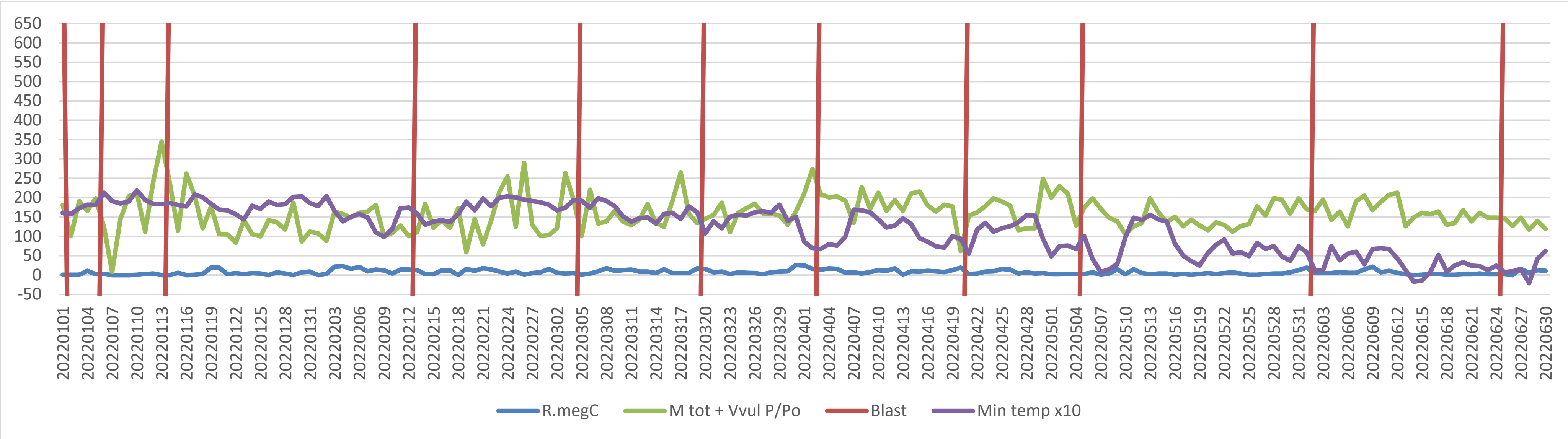
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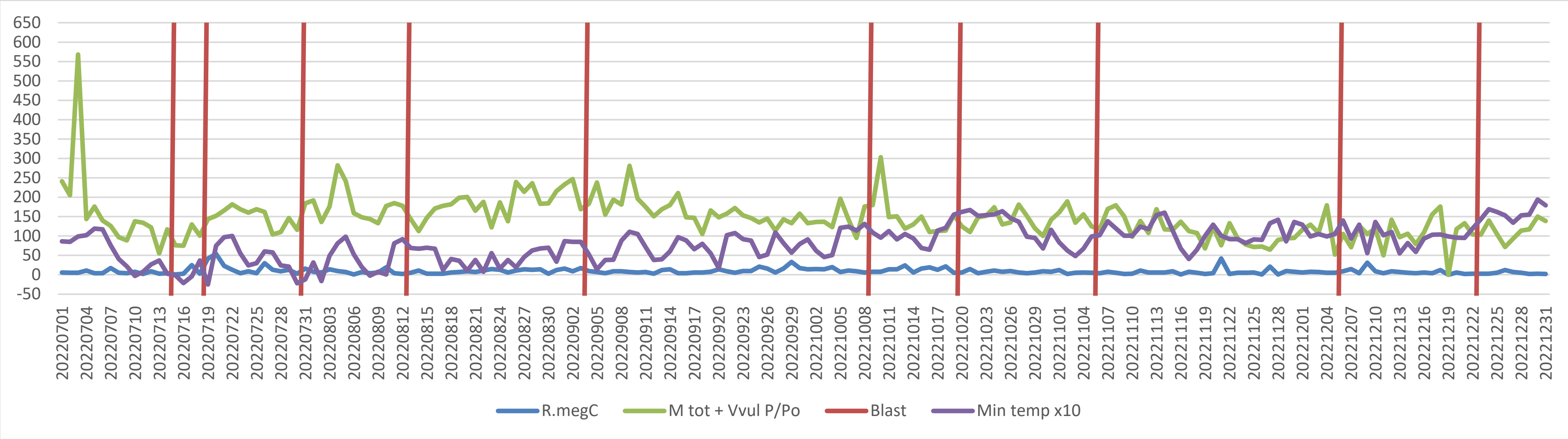
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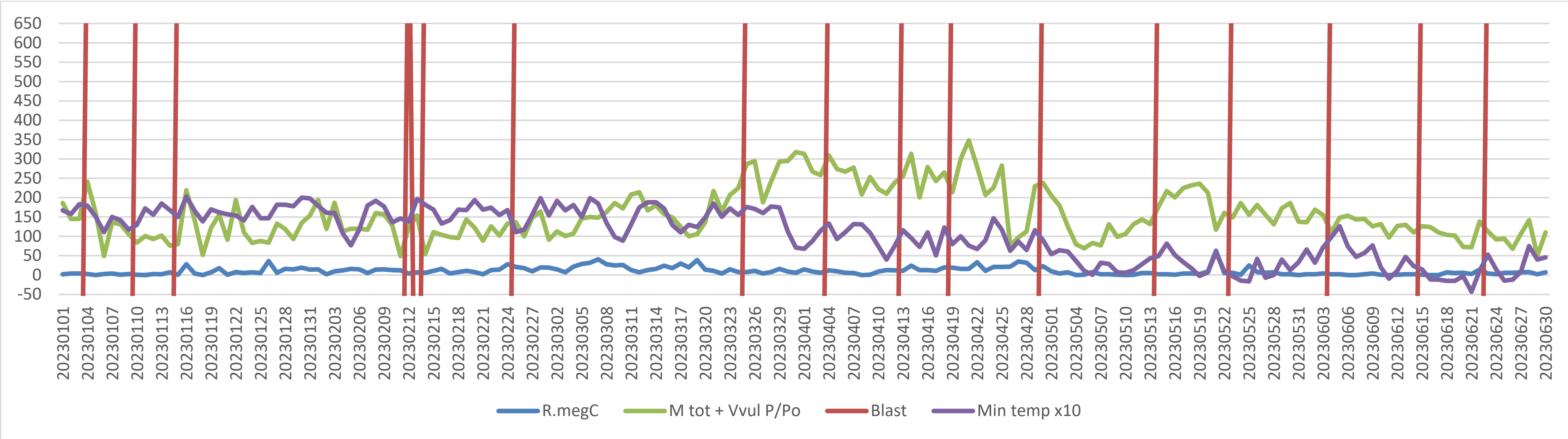
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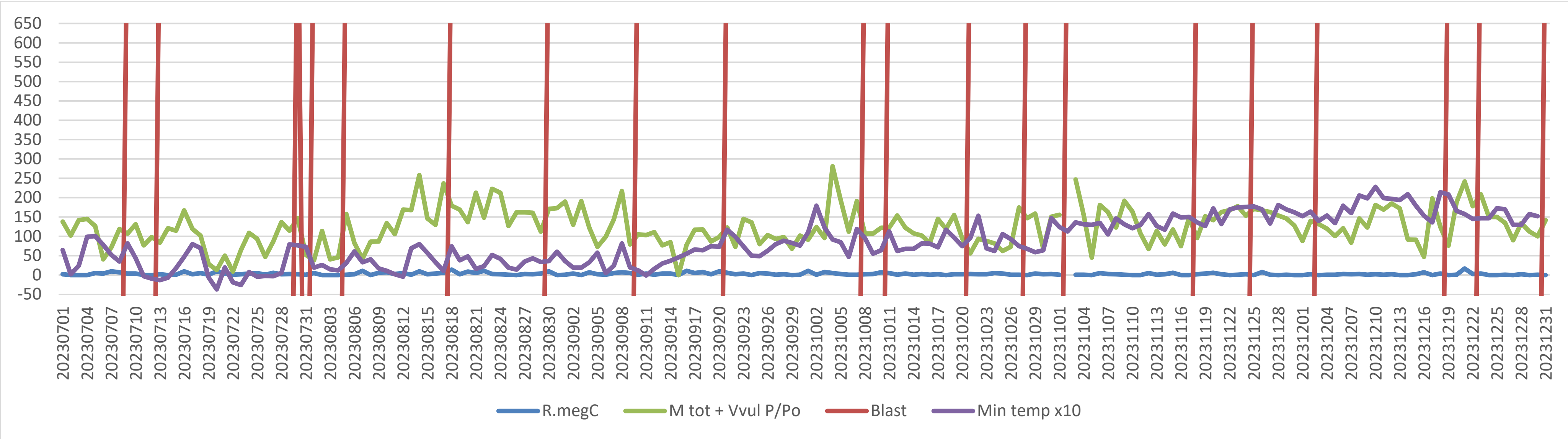
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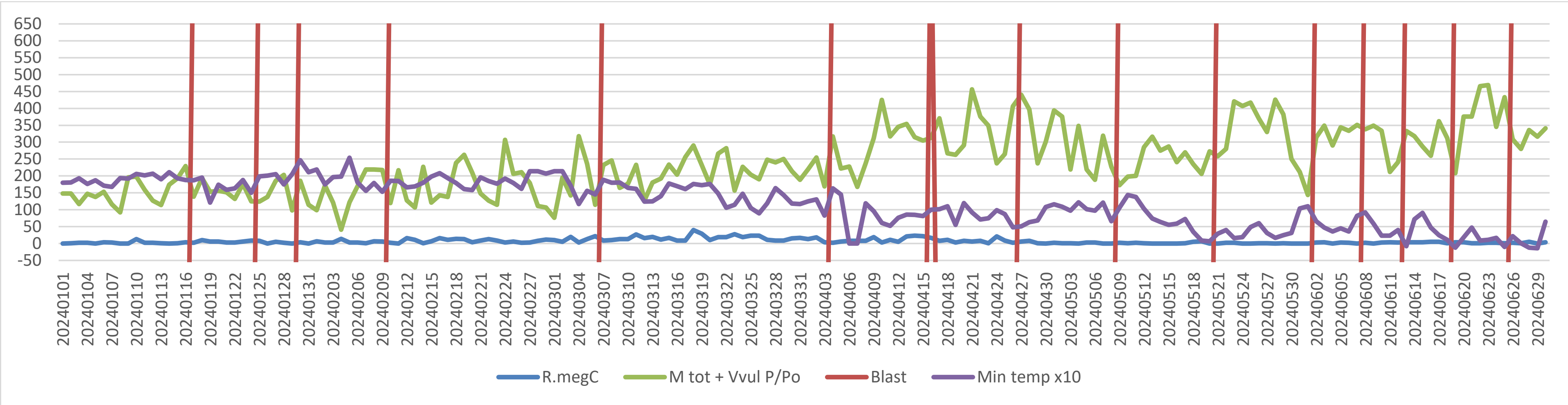
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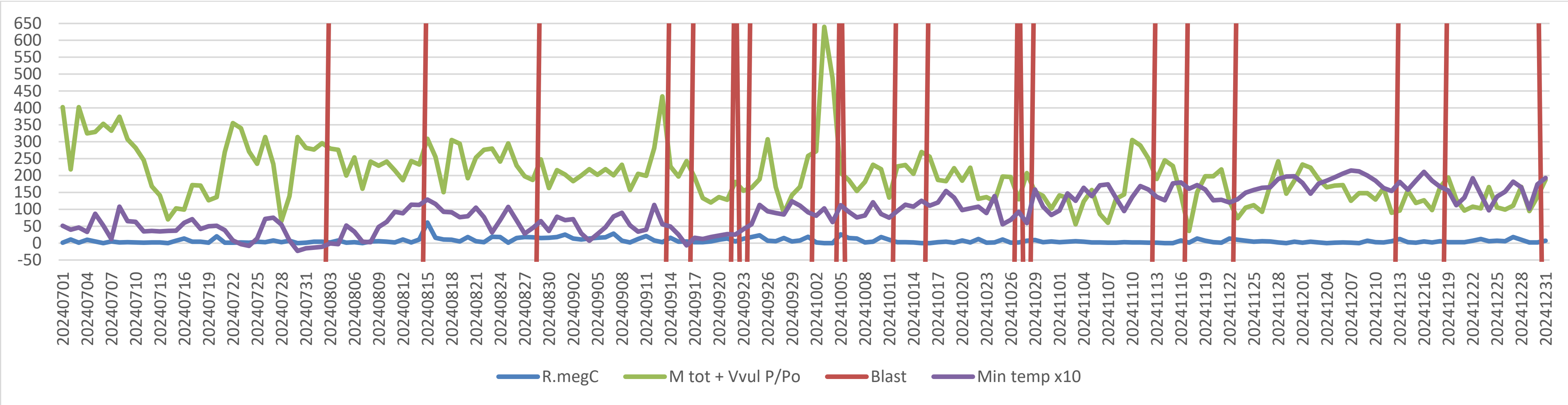

Figure 4-13: Eastern Horseshoe-bat and Large Bent-winged Bat numbers through time with blast dates marked as vertical lines

Minimum temperatures presented as degree Celsius x10 so change in temperature is visible against change in bat activity

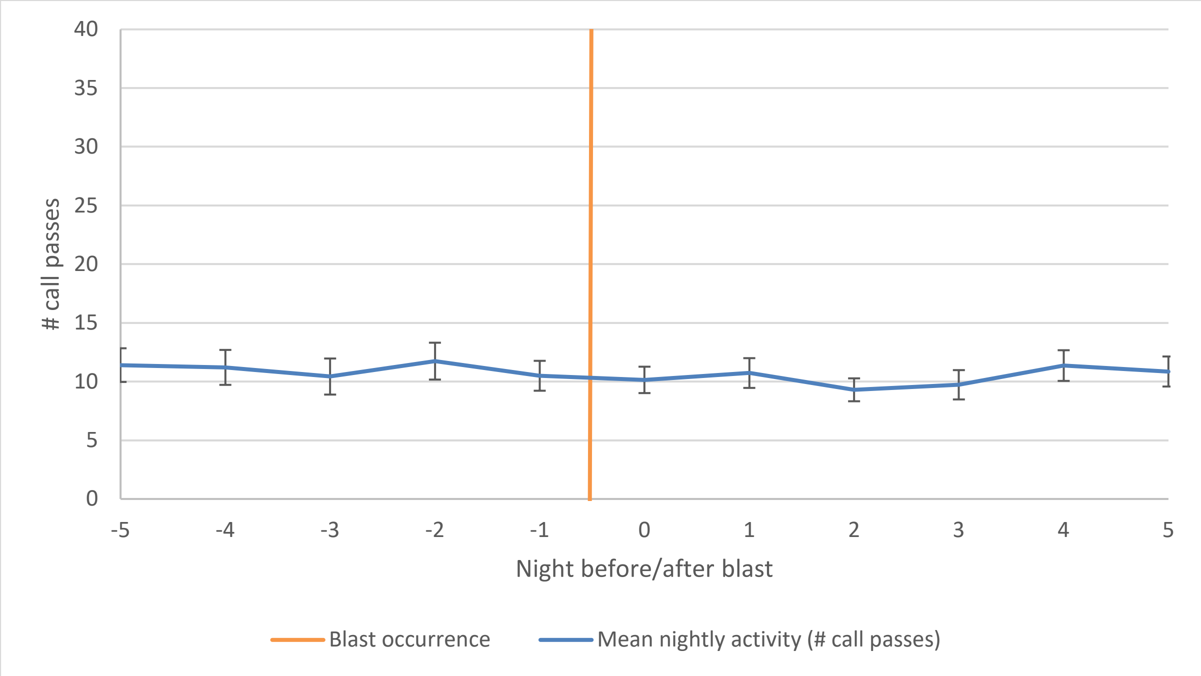

Figure 4-14: Mean short term response by Eastern Horseshoe-bat (R.megC) 2020-2024

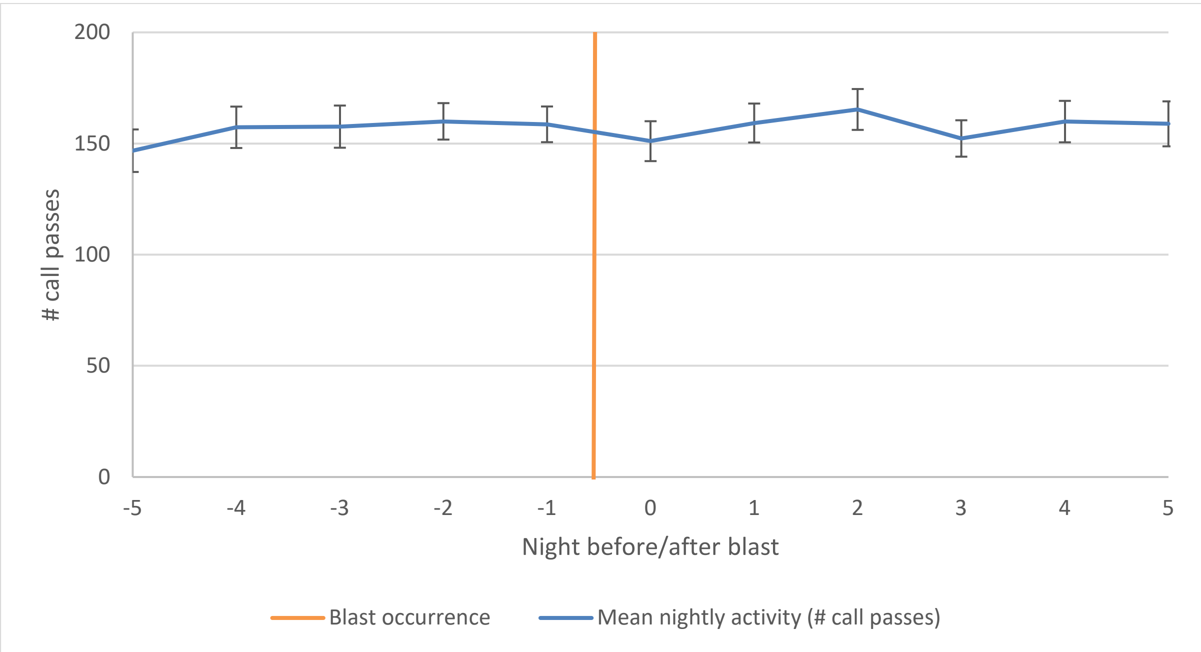

Figure 4-15: Mean short term blast response by Large Bent-winged Bat (M tot + Vvul P/Po) 2020-2024

5.0 Discussion

November 2019 saw the installation of a 900mm diameter steel pipe in the entrance of the adit. Collapsed material was removed, a 20m section of pipe pushed into the entrance, and material back filled around the pipe. The aim of this was to ensure an opening is maintained in the event of an entrance collapse. Modifications to this work were conducted in April 2020 in response to concerns raised via email in March 2020, regarding the height of the backfill material reducing the size of the adit opening. Low numbers of Large Bent-winged Bats were recorded in March 2020, after individuals were found to have returned in February. While the extreme drought and heat conditions experienced through 2019 could explain the large reduction in bat numbers, the fact that numbers had declined since the February count indicated there could be a localised issue. It was postulated that this reduction could be due to the small gap left after material was back filled over the pipe. This material was reduced, increasing the opening to approximately 1.0m in height. By June 2020 numbers were back to where they were in June 2019, and by August 2020 the number of Large Bent-winged Bats counted indicated numbers were back to levels seen in winter 2017.

On 26 April 2023, the steel pipe was removed from the adit and replaced with a larger aperture square steel box tunnel (see **Plate 5-2**). This was in response to the beginning of signs of rock fracture around the adit entrance. The rock around the adit entrance was sprayed with marking paint in September 2022 to facilitate identification of rock that had dislodged from the adit entrance. Minor rock falls (football sized) were observed in December 2022, February 2023, August 2023 and September 2023. A larger block (esky sized) was observed to have dislodged from the right hand side of entrance in March 2023. The new tunnel (measuring 1.1m high x 1.3m wide) was constructed of steel plate with the inner surface a combination of painted and bare steel. The old pipe had a sectional area of approximately 0.64m^2, while the new tunnel had a sectional area of 1.43m^2. This better suits the requirements of Large Bent-winged Bat flight, with few (if any) bats ever observed using the round pipe. The April 2023 count was conducted on the night of the tunnel installation. Dirt had been piled up on top of the tunnel in an attempt to stabilise the tunnel and close the adit in (forcing bats to use the tunnel). On counting the exit, a small aperture was obviously present in the top of the dirt pile, as approximately 90% of the bats exiting the adit that night used the top rather than the tunnel. Forcing large numbers through a small aperture also meant the exit took longer than it had previously. The author proposed that the mine remove some of the dirt on top of the pipe to allow bats to use their preferred flight path, and reduce the risk of predation by a cat or fox standing in front of the small aperture. In May 2023, the space above the tunnel had been expanded to avoid funnelling bats through a tiny aperture.

From June 2023, a few different observation setups were trialled. Shining a torch out and up from the end of the tunnel allowed counting of the bats exiting the tunnel, but made it hard to pick up bats exiting via the top (or out to the side where Horseshoe-bats prefer to come and go). Lowering the light intensity still allowed counting without preventing the bats from exiting (assessed by turning the light off at the end and listening for bats exiting). This method seems to work the best. Though we miss some of the non-target species, we still pick up most of the target species over most months, and can concentrate on the non-target species over summer.

The smaller aperture of the tunnel has still resulted in slowing the emergence of the bats. Exit counts previously peaked in the 10 minute period 10-30 minutes after first exit, and most bats had exited by 40-50 minutes after first exit. With the new tunnel installed, exits were observed as a steadier stream but a peak at about 20-30 (Mar, Apr, Jun) or 30-40 (Sep, Oct) minutes after the first exit. It now takes 70-100 minutes for the colony to exit with the new setup.

Some very small rocks were observed dislodged from the roof in October 2024, but the main concern in 2024 was the widening of the crack in the wall on the right hand side (western side) of the entrance (**Plates 5-2** and **5-3**). A large acacia fell across the entrance in February 2024, but small branches were pruned so it did not obstruct exiting bats.

Looking at December counts from 2017-2023, the number of Eastern Horseshoe-bats was the lowest on record in 2023. 2024 has shown an increase, but numbers are still relatively low. The nine counted in December 2024 match the nine individuals harp trapped in July 2024 (five male, four female). The dry conditions experienced in 2023 may be partly responsible for the drop in numbers, but the removal of farm dams for the mine may also explain the reduction in counts/activity. Blast data does not indicate any obvious impact.

April 2024 counts (both species) were similar to those seen in 2022, but slightly lower than those seen between 2017 and 2019. June counts were on par with the lower years, with the higher numbers not building until September 2024. Numbers peaked for 2024 in September at 912 (or 1178 if you take the second observers count). This is either the highest or second highest count on record, depending on which observers count you take. Though not entirely absent from the adit in November/December 2024, the low numbers of Large Bent-winged Bat at the adit (12 in Nov, one in Dec) are not indicative of breeding activity. These numbers are more indicative of non-breeding individuals remaining in the area over summer, and reconfirms the absence of maternity roost in the adit.

Automated echolocation call detection worked successfully at Slate Gully for estimating the activity of the two microbat species roosting within the disused oil shale mine workings. A fault in the detector caused loss of data over several weeks in March and June 2020, but the equipment has functioned without fail throughout 2021-24. One night in 2023 (2 November) recorded no call passes, but it is impossible to tell if this was a glitch in the detector or a genuine absence of activity over one night. The pattern of activity broadly mirrored numbers of bats recorded leaving the adit from hand counts undertaken over several years (Fly By Night 2017; Fly By Night 2018; Fly By Night 2019), with the absence of Large Bent-winged Bats in March 2020 counts the only anomaly. There are some complications with separating Large Bent-winged Bat calls from Little Forest Bat calls in the area, though the overall trends seen in the pooled data make ecological sense. With such large amounts of data to analyse from nights call recording, this is considered sufficient to monitor changes in the two cave-dwelling species utilising the adit.

The activity of the Large Bent-winged Bat recorded at the detector was broadly comparable with the hand counts undertaken simultaneously at the adit. Activity of the Eastern Horseshoe-bat recorded at the detector correlated much more poorly with the hand counts. This can be attributed to the small population of Eastern Horseshoe-bats resident in the workings throughout the year compared with that of the Large Bent-winged Bat. The activity patterns of the Eastern Horseshoe-bat (lots of coming and going) also impacts the suitability of the index for this species. From all the data collected, we estimate the population of Eastern Horseshoe-bats within the adit to be stable at 5-30 individuals. Early years have shown activity of the Eastern Horseshoe-bat peaking during the autumn and spring months, with minor activity declines over winter and summer. This species' activity was relatively consistent over 2021 and 2022. 2023 saw consistent activity over the first half of the year and very low activity since May. 2024 saw a return to the pattern of peak activity in autumn and spring. Conversely, Large Bent-winged Bat activity fluctuated more in 2024 than during previous years. Activity peaked in April, June and August-September 2024 (April and July in 2022 and April-May and August-September in 2023). Though the usual decline in activity over summer as females migrate to select maternity roosts to give birth (Hoye & Hall 2008) was seen in January 2024, activity remained relatively high through October-December 2024. Patterns of activity do not appear to coincide with noted blasts (data March 2020 to December 2024). The index tracking the number of total Large Bent-winged Bat calls added to those attributed to Little Forest Bat with low confidence (*M tot + Vvul P/Po*, **Figures 4-7** to **4-12**) give the best representation of Large Bent-winged Bat numbers in the adit. Looking at bat activity before and after blasts showed mixed (increase/decrease) results. The small changes relative to normal nightly variation in activity suggest no impact from blasting in Pits 3 or 8 on the two bat species.

Results suggest that monitoring of the colony at Slate Gully through nightly recording of echolocation calls provides a feasible means of monitoring use of the disused workings by the two microbat species. Mean monthly activity for the two species can be compared prior to mining taking place in adjacent areas with that post mining. As of February 2025, mining activity is approximately 190m from the adit (350m in February 2024). As the mine moves past in 2025, we should be able to detect any potential impacts to occupation/activity of the two cave dwelling microbat species. Images from monthly monitoring (**Plates 5-1, 5-2** and **5-3**) show the adit entrance has maintained integrity despite the nearby blasting in Pits 3 and 8 (and potentially Pit 7). However, some football sized rocks were dislodged from the entrance in the last half of 2022. One larger rock fell from the eastern side of the entrance in 2023. A crack opened up on the right hand side in 2024. Things to look out for in 2025 will be collapse of the western wall of the entrance, and getting an access road secured to the site for ongoing monitoring.

Plate 5-1: Periodic monitoring photo of adit entrance from February 2021 (top), January 2022 (middle) and December 2022 (bottom) showing lack of substantial change

Plate 5-2: Monitoring photos of adit entrance pre culvert installation (March 2023 – top left), afternoon of installation (April 2023 – top right), nine months after installation (January 2024 – bottom left), and 20 months after installation (December 2024 – bottom right). This shows progression of pipe to tunnel with

small aperture, tunnel with large aperture. Large crack forming on western side shown with red arrow.

Plate 5-3: Monitoring photos of adit entrance 15 months after installation (July 2024). Harp trapping was conducted to get an update on roost status (species

present, sex ratios and recapture of banded individuals). Large crack forming on western side shown with red arrow.

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Mikaela Cole — BSc (Hons), MECANSW

11 March 2025

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