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Biodiversity monitoring 2018

Walker Quarry, Wallerawang, NSW

Prepared for: Walker Quarries

05 February 2019 Version: Final

PROJECT NUMBER	**2018-087**		
PROJECT NAME	Biodiversity monitoring 2018		
PROJECT ADDRESS	Walker Quarry, Wallerawang, NSW		
PREPARED FOR	Walker Quarries		
AUTHOR/S	Brian Towle		
REVIEW	Technical	QA	Version
	Bruce Mullins	Bruce Mullins	1.0
VERSION	Version	Date to client	
	Final	05/02/2019	

This report should be cited as: 'Ecoplanning (2019). Biodiversity monitoring 2018– Walker Quarry, Wallerawang, NSW. Prepared for Walker Quarries.'

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1 Introduction

Walker Quarries Pty Ltd (Walker Quarries) currently operates Wallerawang Quarry (the Quarry), located on land adjoining the Great Western Highway to the south of Wallerawang, approximately 8 km northwest of Lithgow (**Figure 1.1**). Original approval (DA 344-11-2001) was granted to Sitegoal Pty Ltd (parent company of Walker Quarries Pty Ltd) in 2004, however, activities were not commenced until late 2014. DA 344-11-2001 was modified on 25 August 2017 and required the preparation of a Biodiversity Management Plan (Condition 3(26)).

Section 5 of the Biodiversity Management Plan (BMP) for the Quarry outlines the ecological and rehabilitation monitoring program for the Quarry. The monitoring is designed to assess the adequacy of the ecological management strategies to be undertaken as part of the BMP.

The specific objectives of the monitoring program are to:

- evaluate the success of flora and fauna management strategies;
- facilitate continuous improvement in rehabilitation and revegetation practices;
- record and document changes in retained vegetation within the Quarry, and allow for comparison with previous records;
- record and document fauna population changes and identify any breeding and critical habitat; and
- ensure the ecological significance of the remnant vegetation or rehabilitated areas are maintained or improved as a result of ongoing management practices.

The BMP includes specific monitoring procedures in relation to the Purple Copper Butterfly (*Paralucia spinifera;* PCB) and local flora and fauna which represent a continuation of monitoring techniques undertaken at the Quarry in 2016 and 2017 (Lesryk Environmental 2016a; 2016b; 2017a; 2017b).

This report presents the method and results of monitoring for the PCB and local flora and fauna undertaken in spring 2018 and in accordance with the BMP. A brief comparison with the results of previous vegetation monitoring in 2016 and 2017 is included to assess changes in quality, integrity and habitat value of retained vegetation.

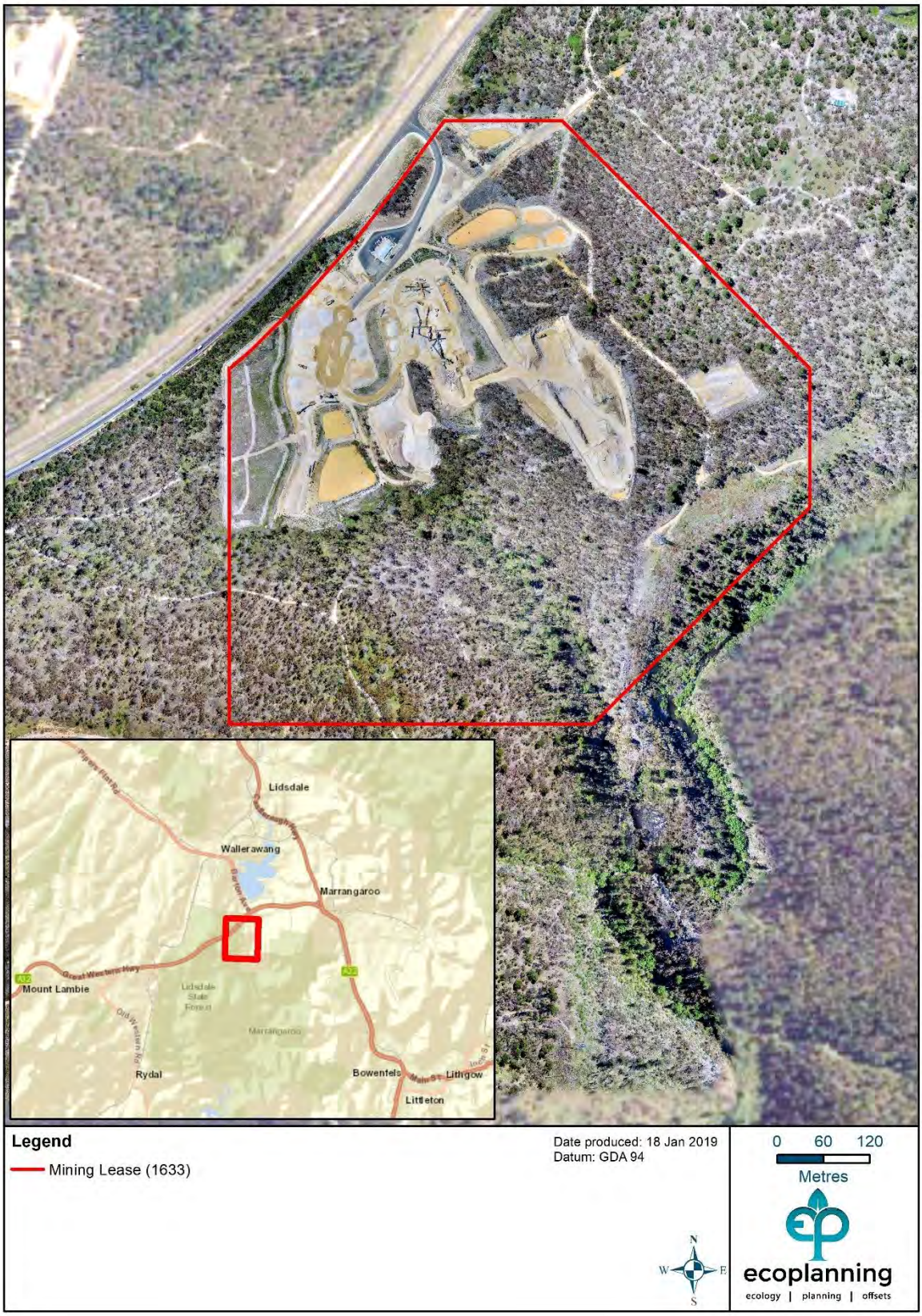

Figure 1.1: Site location

2 Methods

2.1 Local flora and fauna

Monitoring surveys for local flora and fauna were undertaken by Brian Towle (Senior Ecologist) and Thomas Hickman (Ecologist) on the 1 November 2018.

In accordance with the requirements of the BMP, monitoring of local flora involves annual monitoring of vegetation within six monitoring plots (10 m x 10 m). As rehabilitation of the Quarry is completed, additional quadrats will be established to allow for comparison of the vegetation of rehabilitated landform to the surrounding landforms.

The locations of the six monitoring plots are shown in **Figure 2.1** with site details summarised in **Table 2.1**. Each plot is marked with a star picket in its north-western corner (where GPS coordinates for the plot have been recorded) and a photo of each plot was taken from this location.

The monitoring within the six monitoring plots follows the methods of previous monitoring surveys (Lesryk Environmental 2016a; 2017a) and the methods outlined within the BMP. Within each plot the abundance of all vascular plants present was recorded using the following modified Braun-Blanquet scale:

1. <5% cover & 3 or less individuals
2. <5% cover & More than 3 individuals sparsely scattered
3. <5% cover common and consistent

4a. <5% cover & very abundant many individuals

4b. 5 – 25% cover

5. 25 – 50% cover
6. 50 – 75% cover
7. 75% - 100% cover

The dominant species and foliage cover for each stratum (e.g. canopy, shrub, groundcover) was also recorded for each monitoring plot.

Two Levy Pole transects were also conducted for each monitoring plot. Each Levy Pole transect involves a 5 m transect extending into the quadrat at 90 degrees to the quadrat perimeter tape. The starting points for each transect were determined by a random number generator excluding the sides of the quadrat (0, 10, 20, 30 and 40 metres). This meant that numbers from the following number sets were selected (1-9, 11-19, 21-29, 31-39). If the two transect locations determined by the random number generator intersected each other, the second transect was moved based upon another randomly generated number (provided the second number was 1 m or more apart from the first transect).

At 0.5 m increments along the Levy Pole transect (starting at 0.5 m and finishing at 5.0 m) all vegetation that made contact with a pole (approximately 18 mm diameter) held vertically was recorded. Vegetation which made contact with the pole was identified to species level and the height of the vegetation was assigned to one of the following height categories:

- 0 - 0.1 m

- >0.1 - 0.5 m
- >0.5 - 1 m
- >1.0 – 2.0 m
- >2.0 – 4.0 m.

Observations of local fauna, including species identified from call recognition, indirect observations (including scats, tracks, chewed cones etc.) or observed visually were recorded concurrently with surveys for the PCB and the vegetation monitoring plots. These fauna observations were not confined to any specific plot and included areas of retained bushland within the Quarry which were traversed to access monitoring plots.

Table 2.1: Floristic monitoring plot details

Monitoring plot	GPS co-ords (GDA94)		Aspect (°)	Slope (°)	Location
	Easting	Northing			
WALLQ1	227942	6296438	140	20	East of the supplementary stockpile area
WALLQ2	227859	6296349	310	5	South of creek below main storage dam
WALLQ3	227992	6296455	225	30	South of extraction area
WALLQ4	228201	6296456	80	10	East of extraction area
WALLQ5	228117	6296843	10	8	North-east of the top working dam
WALLQ6	228269	6296610	320	15	NE of the extraction area

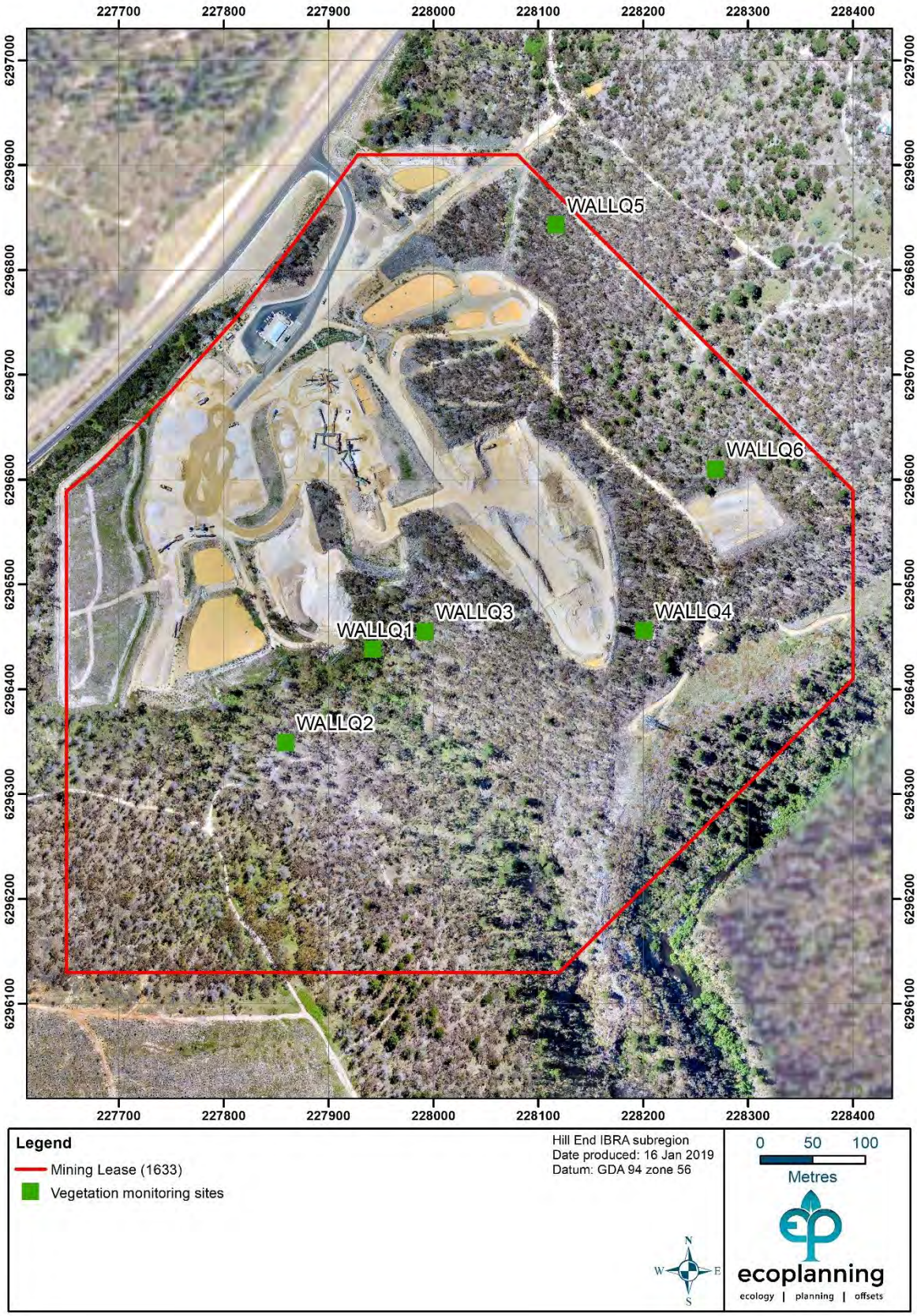

Figure 2.1: Vegetation monitoring locations

2.2 Purple Copper Butterfly

Monitoring surveys for the PCB at the Quarry and control site were undertaken on the 23 October 2018 by Brian Towle. In accordance with the BMP, five patches of *Bursaria spinosa* subsp. *lasiophylla* (Blackthorn) within the Quarry were monitored. The locations of the five monitoring sites are shown in **Figure 2.2** with site details summarised in **Table 2.2**. At each of the monitoring sites the following methods were employed:

- Surveyors positioned themselves to survey the site and conduct visual inspections to observe any butterfly activity for at least 10 minutes per site.
- Random plants were searched for PCB caterpillars.
- Random plants were selected and searched for the ant species *Anonychomyrma itinerans*, as this ant has a mutualistic relationship with PCB.
- Selected *Bursaria spinosa* subsp. *lasiophylla* plants were gently shaken to trigger a flight response from any butterflies present.
- Any butterflies observed were captured using a butterfly net and identified using Braby (2016). All animals captured were released at their point of capture.
- The age of plants (large plants and seedlings present), health (any new shoots present) and evidence of grazing (chewed leaves) were recorded.

The BMP identifies that this survey methodology is also to be undertaken at two control sites, with control sites located at Cox's Creek Wallerawang and Eusdale Road Yetholme surveyed in previous seasons. In consultation with OEH, an alternative control site was identified at the Cheetham Flats TSR (Hampton Road, Rydal) located approximately 13 km south-west of the Quarry. In 2018 surveys for PCB at control sites were limited to the single site at Cheetham Flat TSR. Where PCB were observed flying at the control site no further searches for caterpillars or ants were undertaken.

Weather conditions during the survey period (23 October 2018), as recorded onsite, were warm with temperatures between 28-30ºC, cloud cover of between 5-10% and with moderate humidity recorded (30 – 50 %). Winds were generally light although increased in the late afternoon (after surveys were completed). Weather conditions as recorded at the nearest meteorological station at Marrangaroo (station 063308), located approximately 5 km east of the Quarry, are presented in **Table 2.3**.

Table 2.2: PCB monitoring site details

Monitoring plot	GPS co-ords (GDA94)		Elevation (masl), aspect & slope (°)	Approx. stand size
	Easting	Northing		
17	227716	6295941	~922 m ASL. North facing slope, ~10°	100 x 30 m
18	227887	6295945	~917 m ASL. North facing slope, ~5°	20 x 20 m
19	227948	6296046	~915 m ASL. East facing slope, ~30°	20 x 20 m
20/21	228005	6296045	~910 m ASL. South facing slope, ~30°	30 x 20 m
24	228244	6295945	~955 m ASL. North-east facing slope, ~20°	20 x 20 m

ASL – Above Sea Level

Table 2.3: Weather conditions during Purple Copper Butterfly surveys, as recorded at Marrangaroo meteorological station

Date	Temperature (°C)		Rainfall (mm)	Wind - 9am		Wind – 3 pm	
	Min	Max		Direction	speed	Direction	speed
23/10/2018	6.7	25.4	0	WNW	4	WNW	13

Figure 2.2: Purple Copper Butterfly monitoring locations

3 Results and Discussion

3.1 Local flora and fauna

The photos and floristic data recorded within each monitoring plot and the Levy Pole transect results are presented within **Appendix A**.

3.1.1 Photo-point monitoring

Photos taken from the north-west corner of each vegetation monitoring plot are included within **Appendix A** of this report. No disturbance to vegetation or soils including vegetation clearing, widespread dieback, erosion or excavations associated with the Quarry operations were recorded within monitoring plots as shown in site photographs. Additionally, no detectable change in vegetation integrity or condition can be observed from comparison of photographs from monitoring plots across seasons.

3.1.2 Floristic monitoring

A summary of native and exotic species richness within each monitoring site is presented in **Table 3.1**. Across all monitoring locations, native species richness has increased in 2018 compared to previous monitoring seasons (**Figure 3.1**). It is unknown whether the observed increase represents natural fluctuations in species richness in response to climatic conditions including rainfall or if the observed increase is related to the change in observers or survey effort. Nonetheless, the recorded increase in native species richness in 2018 suggests that the retained woodland within monitoring sites is not being impacted by the Quarry operations in a manner which is impacting native species richness.

Exotic species richness has remained relatively stable at individual monitoring plots across seasons (**Table 3.1**). One monitoring plot (WALLQ1) recorded an increase in exotic species richness in 2018 with seven exotic species recorded at this site in 2018 compared with five and two species within 2016 and 2017, respectively. The increase in exotic species richness at WALLQ1 occurred in conjunction with an increase in native species richness and may be related to natural fluctuations in species richness or the change in observers in 2018. The additional weed species observed at WALLQ1 in 2018 were all present at low densities and are species which have been observed within the Quarry in previous years. One of the additional weed species recorded at WALLQ1, *Hypericum perforatum* (St Johns Wort), is a high threat exotic weed, as defined under the Biodiversity Assessment Method.

The percent cover of individual species and structural layers within monitoring plots was generally similar across seasons. Increases and decreases in cover of individual species at individual sites were observed, although no overall trends suggesting increases or decreases in individual species, or groups of species, were observed.

Table 3.1: Species richness within monitoring plots

Factor	WALLQ1			WALLQ2			WALLQ3			WALLQ4			WALLQ5			WALLQ6		
	2016	2017	2018	2016	2017	2018	2016	2017	2018	2016	2017	2018	2016	2017	2018	2016	2017	2018
No. native species	28	30	35	17	21	27	29	27	42	19	19	24	16	17	23	16	16	21
No. exotic species	5	2	7	2	2	2	2	2	2	1	2	1	1	1	1	0	0	0
Total Species richness	33	32	42	19	23	29	31	29	44	20	21	25	17	18	24	16	16	21

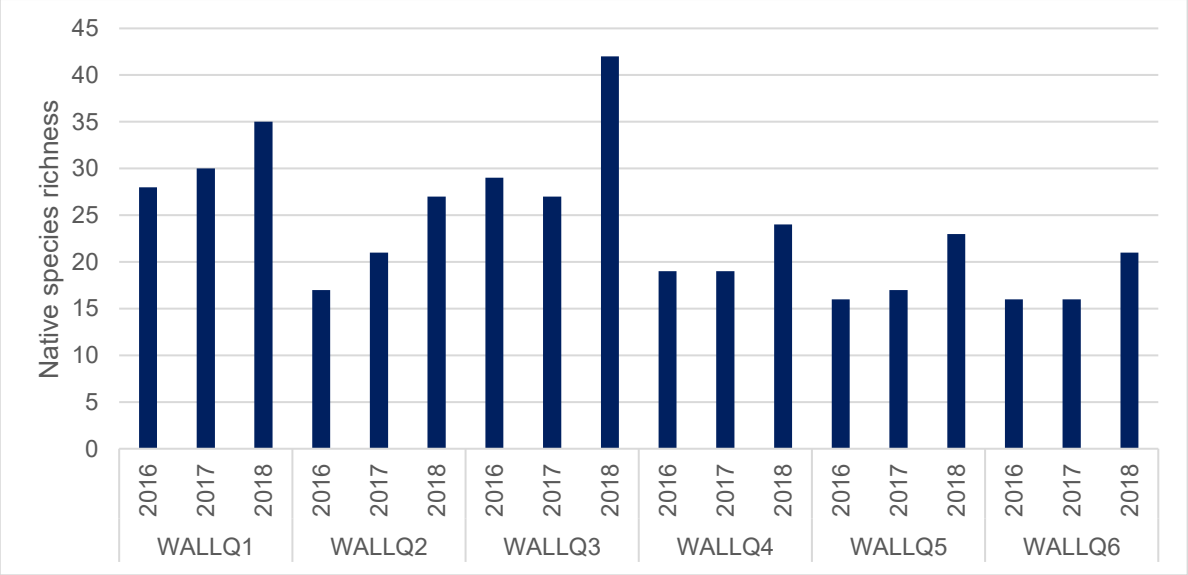

Figure 3.1: Native species richness within monitoring plots

3.1.3 Vegetation structure

The height, cover and dominant species within each structural layer at each monitoring location is presented in **Table 3.2**. Data from Levv Pole transects is presented in **Appendix A**. Across all monitoring plots, native dominated woodland and forest remain present including structural layers which are typical of the woodland and forest types present within the Quarry. The cover and composition of structural layers in 2018 was generally similar to the results from previous monitoring seasons (Lesryk Environmental 2017a). The generally small fluctuations observed in cover of individual structural layers are thought to be related to the subjective nature of this data, rather than indicating changes in overall cover of vegetation structural layers.

Only one monitoring location (WALLQ1) included exotic species as one of the dominant species, although this result is consistent with previous monitoring results (Lesryk Environmental 2017a).

Table 3.2 Vegetation structural data

Monitoring plot	Stratum	Height (m)	Cover (%)	Dominant species
WALL-Q1	Tree	17	20	*Eucalyptus viminalis, Eucalyptus bridgesiana, Eucalyptus mannifera*
	Shrub	2	10	*Bursaria spinosa* subsp. *lasiophylla*
	Ground	0.5	70	*Lomandra filiformis, Anthoxanthum odoratum*, Hypochaeris radicata**
WALL-Q2	Tree	18	20	*Eucalyptus mannifera, Eucalyptus melliodora*
	Shrub	6	5	*Acacia dealbata*
	Ground	0.5	60	*Lomandra filiformis, Poa sieberiana, Gonocarpus tetragynus, Viola betonicifolia*
WALL-Q3	Tree	18	30	*Eucalyptus dives, Eucalyptus viminalis, Eucalyptus bridgesiana*
	Shrub	2	5	*Bursaria spinosa* subsp. *lasiophylla*
	Ground	1	60	*Rytidosperma pallida, Poa sieberiana, Dianella revoluta, Lomandra filiformis*
WALL-Q4	Tree	12	10	*Eucalyptus dives, Eucalyptus mannifera*
	Ground	0.8	30	*Rytidosperma pallida, Goodenia bellidifolia, Dillwynia phylicoides*
WALL-Q5	Tree	12	15	*Eucalyptus mannifera, Eucalyptus rossii*
	Ground	0.75	20	*Lomandra longifolia, Poa sieberiana, Rytidosperma pallida*
WALL-Q6	Tree	16	25	*Eucalyptus mannifera, Eucalyptus rossii*
	Shrub	1.5	1	*Hakea laevipes*
	Ground	0.5	15	*Rytidosperma pallida, Lomandra longifolia, Lomandra gunnii*

* denotes an exotic species.

3.1.4 Local fauna

Two native mammals, 18 birds, one amphibian and one reptile species were opportunistically observed during the monitoring surveys (**Appendix B**). No threatened species listed under the NSW *Biodiversity Conservation Act 2016* (BC Act) were observed.

Observations of local fauna made during the monitoring indicate that the vegetated areas of the Quarry continue to provide habitat for an array of native fauna species.

3.2 Purple Copper Butterfly

At least three PCB were observed flying above and between patches of *Bursaria spinosa* subsp. *lasiophylla* at the control site at Cheetham Flat TSR within the first 10 minutes of observation (**Plate 3.1**). These observations confirmed that the timing and weather conditions were appropriate for PCB surveys. As the control site represents a known site for the species and which is subject to ongoing monitoring by OEH, no further assessment of *Bursaria spinosa* subsp. *lasiophylla*, ant species was undertaken to avoid any further disturbance to PCB individuals.

No PCBs were observed within any of the monitoring sites at the Quarry. One butterfly species, Australian Painted Lady (*Vanessa kershawi*), was recorded in addition to a number of moths, beetles, bees and dragonflies. Data recorded from each monitoring site is included in **Appendix C**.

Ant species were observed at all monitoring sites, with the exception of site 24, although the ant species present was identified as a *Crematogaster* sp. and not the species *Anonychomyrma itinerans* with which PCB has mutualistic relationship.

Bursaria spinosa subsp. *lasiophylla* within each of the monitoring sites was observed to be in a healthy condition with mature fruiting individuals and seedlings present. All sites included *Bursaria spinosa* subsp. *lasiophylla* with new growth (**Plate 3.1**) and some evidence of grazing, although it was not possible to determine whether the grazing was recent.

These monitoring results are largely consistent with monitoring results from 2017, where no PCB or *Anonychomyrma itinerans* were recorded within the Quarry, although *Bursaria spinosa* subsp. *lasiophylla* remained in good health with new growth evident.

As the PCB has an annual life-cycle with one generation completed annually, and the species has not been detected within the Quarry during the last three years of monitoring, it is likely that the population(s) which once occurred within the Quarry has become locally extinct. The landscapes surrounding the Quarry, including forestry plantations, cleared agricultural lands and steeply sloping land adjacent to the Cox's River do not represent habitat for the PCB and reduce the chances of habitat on site being recolonised by the species. Another factor reducing the likelihood that habitat at the Quarry may be recolonised by PCB is the weak erratic flight of this species and its extremely low dispersal capability (NPWS 2001).

Plate 3.1: Purple Copper Butterfly observed at the reference site (left) and *Bursaria spinosa* subsp. *lasiophylla* with new growth

4 Conclusions and recommendations

No large-scale disturbance to vegetation or soils which were attributable to the quarry operations were detected within the areas surrounding the Quarry operations. Observations of local fauna made during the monitoring indicate that the vegetated areas of the Quarry continue to provide habitat for an array of native fauna species.

Based upon results from the 2018 monitoring period, no observable or significant trends in the occurrence of specific threatened species or quality / quantity of available habitat has been identified.

Several exotic flora species which have potential to invade native vegetation and outcompete native species were recorded within the Quarry including *Hypericum perforatum** (St Johns Wort), *Pinus radiata** (Radiata Pine) and *Rubus ulmifolius** (Blackberry). These species should be targeted as part of weed control works within the Quarry.

As no PCB or attendant ants (*Anonychomyrma itinerans*) have been recorded within the Quarry during the last three monitoring surveys (Lesryk 2016b; 2017b), with PCB last detected in the Quarry in September 2002, it is likely that the population of PCB which once occurred within the Quarry is now locally extinct. As such, continued monitoring of this species within the Quarry is no longer warranted.

5 References

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Lesryk Environmental (2016b). Purple Copper Butterfly Targeted investigation, Walker Quarry, Wallerawang, NSW. Unpublished report prepared for Walker Quarries Pty Ltd.

Lesryk Environmental (2017a). *Vegetation Monitoring Walker Quarry, Wallerawang, NSW.* Unpublished report prepared for Walker Quarries Pty Ltd.

Lesryk Environmental (2017b). Purple Copper Butterfly Monitoring report #2, Walker Quarry, Wallerawang, NSW. Unpublished report prepared for Walker Quarries Pty Ltd.

NSW National Parks and Wildlife Services (NPWS) (2001). Bathurst Copper Butterfly (*Paralucia spinifera*) Recovery Plan. Threatened Species Unit, NPWS.

Wildthing (1999) Statement of effect on threatened flora and fauna over land proposed for a hard rock quarry within EL4473 near Wallerawang, NSW. Unpublished report prepared for Pacrim Environmental Pty Ltd.

Appendix A Floristic Monitoring data

Site Photos

WALLQ1 – 1 Nov 2018

WALLQ2 – 1 Nov 2018

WALLQ3 – 1 Nov 2018

WALLQ1 – 1 Nov 2018

WALLQ5 – 1 Nov 2018

WALLQ6 – 1 Nov 2018

Vegetation monitoring plot data

Family	Species	Cover abundance																	
		Q1-2016	Q1-2017	Q1-2018	Q2-2016	Q2-2017	Q2-2018	Q3-2016	Q3-2017	Q3-2018	Q4-2016	Q4-2017	Q4-2018	Q5-2016	Q5-2017	Q5-2018	Q6-2016	Q6-2017	Q6-2018
Anthericaceae	*Laxmannia gracilis*											1			2	2			1
Apiaceae	*Platysace lanceolata*																		
Araliaceae	*Hydrocotyle laxiflora*	3	2	2	3	3	3	3	3	2		2	3						3
Aspleniaceae	*Asplenium flabellifolium*		3	2															
Asteraceae	*Arrhenechthites mixtus*	3	3					3	3										
	Brachyscome spathulata									3									
	Cassinia aculeata	1	1																
	Cassinia laevis			1			1												
	Chrysocephalum apiculatum															2			
	*Cirsium vulgare**	1		1															
	Conyza sp.			2															
	Coronidium scorpioides	2	1		2	2			1	2									
	Cymbonotus lawsonianus	2		3			2	3	2	2									
	Euchiton sp.						1												
	Gamochaeta sp.*	1																	
	*Hypochaeris radicata**	3		3	1	1	2	1	1	2	1	1							
	Ozothamnus diosmifolius		1								2	2							
	Senecio hispidulus			1															
	Senecio quadridentatus			1															
	Xerochrysum viscosum	3			3		1	2											
Campanulaceae	*Wahlenbergia sp.*			2			2			2			2						1
Caryophyllaceae	*Stellaria pungens*	4A	4A	3															
Convolvulaceae	*Dichondra repens*		3	2	2	2	2												

Family	Species	Cover abundance																	
		Q1-2016	Q1-2017	Q1-2018	Q2-2016	Q2-2017	Q2-2018	Q3-2016	Q3-2017	Q3-2018	Q4-2016	Q4-2017	Q4-2018	Q5-2016	Q5-2017	Q5-2018	Q6-2016	Q6-2017	Q6-2018
Cyperaceae	*Lepidosperma gunnii*									1			1			1			3
	Lepidosperma urophorum																4A	4A	
Dilleniaceae	*Hibbertia ?riparia*													2	1				
	Hibbertia obtusifolia										4A	4A	2						
Droseraceae	*Drosera hookeri*										4A		2	3					
Ericaceae	*Astroloma humifusum*		1					1	2				1						
	Brachyloma daphnoides							1	1	2			2						1
	Leucopogon ericoides		1					1	1		3	3							
	Leucopogon virgatus									2			2						
	Lissanthe strigosa			1	3	3	2	3	3	2	1	2							
	Monotoca scoparia	1	1																
Fabaceae - Faboideae	*Aotus ericoides*							2	2										
	Bossiaea buxifolia									2									
	Bossiaea prostrata					1													
	Desmodium sp.						1												
	Dillwynia phylicoides					1	1	3	3	1			3	3	3	2	1		1
	Glycine clandestina	1	1	2				2		1									
	Gompholobium uncinatum									2									
	Hardenbergia violacea															1			2
	Hovea heterophylla						1			2			2						2
	Hovea linearis										1	1							
	Mirbelia platylobioides													2	2	2	3	3	2
	Pultenaea subspicata														1	1			
	Pultenaea tuberculata															1			
	Vicia sp.*			2															

Family	Species	Cover abundance																	
		Q1-2016	Q1-2017	Q1-2018	Q2-2016	Q2-2017	Q2-2018	Q3-2016	Q3-2017	Q3-2018	Q4-2016	Q4-2017	Q4-2018	Q5-2016	Q5-2017	Q5-2018	Q6-2016	Q6-2017	Q6-2018
Fabaceae - Mimosoideae	*Acacia dealbata*	1	2	2	2	4B	2												
	Acacia gunnii										1	2	2						
Geraniaceae	*Geranium homeanum*	4A	2	2	3	1	2												
Goodeniaceae	*Goodenia bellidifolia*										2	2	4a	3	3	3	2	2	
	Goodenia hederacea																		2
Haloragaceae	*Gonocarpus micranthus*		1		3	3		3	3		3	3		3	3				
	Gonocarpus tetragynus			2			3			3			3			3			
Hypericaceae	*Hypericum gramineum*				2	2		2	2	1	2	1	2	3	3	2	1	1	
	*Hypericum perforatum**			1			1												
Iridaceae	*Patersonia sericea*										4A	4A	3	3	3	3	3	3	2
Juncaceae	*Juncus* sp.					1	1												
Lamiaceae	*Ajuga australis*			2			3			2									
Lauraceae	*Cassytha glabella*									2			1						
	Cassytha melantha							2	2										
Liliaceae	*Liliaceae* sp.																		1
Lomandraceae	*Lomandra filiformis*	3	3	4b	4B	4B	4b	4B	4B	4a		1	1	3	3	3	3	3	3
	Lomandra longifolia												1	4B	4B	4b	4B	4B	3
	Lomandra multiflora	3	3	3						1									
Myrtaceae	*Eucalyptus bridgesiana*	4B	4B	1	4B	4B		4B	4B	1									
	Eucalyptus dives									4b	4B	4B	2				1	1	
	Eucalyptus mannifera	4B	4B	1	4B	4B	4b				4B	4B	2	4B	4B	4b	4B	4B	4b
	Eucalyptus melliodora						1												
	Eucalyptus pauciflora			1				1	1	1									
	Eucalyptus rossii													4B	4B	4b	4B	4B	4b
	Eucalyptus viminalis	4B	4B	4B				4B	4B	4b									

Family	Species	Cover abundance																	
		Q1-2016	Q1-2017	Q1-2018	Q2-2016	Q2-2017	Q2-2018	Q3-2016	Q3-2017	Q3-2018	Q4-2016	Q4-2017	Q4-2018	Q5-2016	Q5-2017	Q5-2018	Q6-2016	Q6-2017	Q6-2018
Orchidaceae	*Caladenia fuscata*															1			
	Caladenia moschata									1									
	Caleana sp.										2			3					
Oxalidaceae	*Oxalis perennans*									1									
Phormiaceae	*Dianella revoluta*	3	3	2		2	2	3	3	3									
Phyllanthaceae	*Phyllanthus hirtellus*								1										
	Poranthera ericifolia							1	1										
	Poranthera microphylla									1	1						1	1	
Pinaceae	*Pinus radiata**											1	2	1	1	1			
Pittosporaceae	*Billardiera scandens*			1															
	Bursaria spinosa	4B	4B	4B				4B	4B	2									
Plantaginaceae	*Plantago debilis*	3	3			1		4A	4A										
	Plantago gaudichaudii			3			2			3									
	*Plantago lanceolata**			1															
	Veronica calycina	3		2			2	2		2									
Poaceae	*Anthoxanthum odoratum**	5	5	4b	3	3		4B	4B	3									
	Aristida vagans									1					1	1			
	Dichelachne micrantha												1						
	Echinopogon caespitosus	3	3		3	3			1	1	2	1		3	3	3	3	3	
	Echinopogon ovatus												1						
	Elymus scaber	1	1							1									
	Entolasia marginata						1												
	Microlaena stipoides			3			2			2									
	Poa sieberiana	4B	4B	2	5	5	4a	5	5	4b	4B	4B		4B	4B	4b	4B	4B	2
	Poaceae sp.												1						2

Family	Species	Cover abundance																	
		Q1-2016	Q1-2017	Q1-2018	Q2-2016	Q2-2017	Q2-2018	Q3-2016	Q3-2017	Q3-2018	Q4-2016	Q4-2017	Q4-2018	Q5-2016	Q5-2017	Q5-2018	Q6-2016	Q6-2017	Q6-2018
	Rytidosperma sp.																		2
	Rytidosperma ?monticola					1													
	Rytidosperma pallida	3	3		4A	4B		4B	4B	4b	3	3	4b	3	3	3	3	3	4b
Polygonaceae	*Rumex brownii*			1															
Proteaceae	*Hakea dactyloides*																1	1	
	Hakea laevipes																		3
	Persoonia linearis							1	1	1						1			
Pteridaceae	*Cheilanthes sieberi*										1	1							
Ranunculaceae	*Clematis glycinoides*	3	3	2															
Restionaceae	*Lepyrodia scariosa*							1											
Rosaceae	*Acaena ovina*	3	3	2	2	2	1	1	1										
	Rubus parviflorus			1															
	*Rubus ulmifolius**	1	1	1															
Rubiaceae	*Asperula conferta*			1															
	Galium sp.	1						2		2									
	Opercularia diphylla																	1	
	Pomax umbellata									1						2			
Stackhousiaceae	*Stackhousia monogyna*									2									
Violaceae	*Melicytus dentatus*	1	1																
	Viola betonicifolia			2	4A		3			2									

* indicates an introduced species

Cover abundance:

1. <5% cover & 3 or less individuals
2. <5% cover & More than 3 individuals sparsely scattered
3. <5% cover common and consistent
4a. <5% cover & very abundant many individuals
4b. 5 – 25% cover
5. 25 – 50% cover
6. 50 – 75% cover
7. 75% - 100% cover

Levy Pole transect data

Levy Pole Transect data – Q1a

Height interval recorded	Distance along transect									
	0.5 m	1.0 m	1.5 m	2.0 m	2.5 m	3.0 m	3.5 m	4.0 m	4.5 m	5.0 m
0-0.1 m	*Oxalis perennans*	*Hypochaeris radicata**	*Hypochaeris radicata*; Anthoxanthum odoratum*; Microlaena stipoides*	-	*Stellaria pungens*	*Hypochaeris radicata*; Lomandra filiformis; Anthoxanthum odoratum**	-	*Rytidosperma pallida*	-	*Microlaena stipoides*
0.1-0.5 m	-	-	-	-	-	-	-	-	-	-
0.5-1.0 m	-	-	-	-	-	-	-	-	-	-
1.0-2.0 m	-	-	-	-	-	-	-	-	-	-
2.0 - 4.0 m	-	-	-	-	-	-	-	-	-	-

Levy Pole Transect data – Q1b

Height interval recorded	Distance along transect									
	0.5 m	1.0 m	1.5 m	2.0 m	2.5 m	3.0 m	3.5 m	4.0 m	4.5 m	5.0 m
0-0.1 m	-	-	*Geranium homeanum*	*Microlaena stipoides*	-	*Lomandra filiformis*	*Ajuga australis*	-	*Lomandra filiformis*	-
0.1-0.5 m	*Anthoxanthum odoratum**	-	*Rytidosperma pallida*	*Lomandra filiformis*	-	-	-	*Lomandra filiformis*	-	*Anthoxanthum odoratum**
0.5-1.0 m	-	-	-	-	-	-	-	-	-	-
1.0-2.0 m	-	-	-	-	-	-	-	-	-	-
2.0 - 4.0 m	-	-	-	-	-	-	-	-	-	-

Levy Pole Transect data – Q2a

Height interval recorded	Distance along transect									
	0.5 m	1.0 m	1.5 m	2.0 m	2.5 m	3.0 m	3.5 m	4.0 m	4.5 m	5.0 m
0-0.1 m	*Lomandra filiformis*	*Viola betonicifolia; Lomandra filiformis*	*Viola betonicifolia*	*Poa sieberiana*	*Viola betonicifolia; Lomandra filiformis*	*Microlaena stipoides*		*Anthoxanthum odoratum**	*Viola betonicifolia; Poa sieberiana*	*Lomandra filiformis; Hydrocotyle laxiflora*
0.1-0.5 m	*Dillwynia phylicoides*						*Lomandra filiformis*			
0.5-1.0 m										
1.0-2.0 m										
2.0 - 4.0 m										

Levy Pole Transect data – Q2b

Height interval recorded	Distance along transect									
	0.5 m	1.0 m	1.5 m	2.0 m	2.5 m	3.0 m	3.5 m	4.0 m	4.5 m	5.0 m
0-0.1 m		*Hypericum gramineum*	*Lomandra filiformis*	*Lomandra filiformis*		*Lomandra filiformis; Lissanthe strigosa*	*Lomandra filiformis*			
0.1-0.5 m	*Lomandra filiformis*				*Dianella revoluta*			*Lomandra filiformis*		
0.5-1.0 m										
1.0-2.0 m										
2.0 - 4.0 m										

Levy Pole Transect data – Q3a

Height interval recorded	Distance along transect									
	0.5 m	1.0 m	1.5 m	2.0 m	2.5 m	3.0 m	3.5 m	4.0 m	4.5 m	5.0 m
0-0.1 m	*Anthoxanthum odoratum**		*Cassytha glabella*	*Rytidosperma pallida*	*Rytidosperma pallida*				*Galium sp.*	*Poa sieberiana*
0.1-0.5 m	*Bursaria spinosa*		*Rytidosperma pallida*	*Brachyloma daphnoides*						
0.5-1.0 m										
1.0-2.0 m										
2.0 - 4.0 m										

Levy Pole Transect data – Q3b

Height interval recorded	Distance along transect									
	0.5 m	1.0 m	1.5 m	2.0 m	2.5 m	3.0 m	3.5 m	4.0 m	4.5 m	5.0 m
0-0.1 m										
0.1-0.5 m		*Rytidosperma pallida*	*Rytidosperma pallida*		*Rytidosperma pallida*	*Rytidosperma pallida*	*Rytidosperma pallida*	*Rytidosperma pallida*		*Lomandra filiformis*
0.5-1.0 m										*Brachyloma daphnoides*
1.0-2.0 m										
2.0 - 4.0 m										

Levy Pole Transect data – Q4a

Height interval recorded	Distance along transect									
	0.5 m	1.0 m	1.5 m	2.0 m	2.5 m	3.0 m	3.5 m	4.0 m	4.5 m	5.0 m
0-0.1 m										
0.1-0.5 m		*Rytidosperma pallida*	*Rytidosperma pallida*	*Rytidosperma pallida*			*Rytidosperma pallida*		*Rytidosperma pallida*	
0.5-1.0 m										
1.0-2.0 m										
2.0 - 4.0 m										

Levy Pole Transect data – Q4b

Height interval recorded	Distance along transect									
	0.5 m	1.0 m	1.5 m	2.0 m	2.5 m	3.0 m	3.5 m	4.0 m	4.5 m	5.0 m
0-0.1 m								*Lomandra filiformis*		
0.1-0.5 m		*Acacia gunnii*	*Rytidosperma pallida*		*Rytidosperma pallida*		*Rytidosperma pallida*		*Rytidosperma pallida*	
0.5-1.0 m										
1.0-2.0 m										
2.0 - 4.0 m										

Levy Pole Transect data – Q5a

Height interval recorded	Distance along transect									
	0.5 m	1.0 m	1.5 m	2.0 m	2.5 m	3.0 m	3.5 m	4.0 m	4.5 m	5.0 m
0-0.1 m									*Poa sieberiana*	
0.1-0.5 m	*Lomandra longifolia*			*Lomandra longifolia*			*Poa sieberiana*	*Poa sieberiana*		
0.5-1.0 m		*Lomandra longifolia*	*Lomandra longifolia*							*Lomandra longifolia*
1.0-2.0 m										
2.0 - 4.0 m										

Levy Pole Transect data – Q5b

Height interval recorded	Distance along transect									
	0.5 m	1.0 m	1.5 m	2.0 m	2.5 m	3.0 m	3.5 m	4.0 m	4.5 m	5.0 m
0-0.1 m										
0.1-0.5 m								*Poa sieberiana*		
0.5-1.0 m					*Lomandra longifolia*	*Lomandra longifolia*	*Lomandra longifolia*			
1.0-2.0 m										
2.0 - 4.0 m										

Levy Pole Transect data – Q6a

Height interval recorded	Distance along transect									
	0.5 m	1.0 m	1.5 m	2.0 m	2.5 m	3.0 m	3.5 m	4.0 m	4.5 m	5.0 m
0-0.1 m										
0.1-0.5 m		Rytidosperma pallida		Rytidosperma pallida	Rytidosperma pallida					
0.5-1.0 m									Lomandra longifolia	
1.0-2.0 m										
2.0 - 4.0 m										

Levy Pole Transect data – Q6b

Height interval recorded	Distance along transect									
	0.5 m	1.0 m	1.5 m	2.0 m	2.5 m	3.0 m	3.5 m	4.0 m	4.5 m	5.0 m
0-0.1 m										*Lomandra filiformis*
0.1-0.5 m					*Rytidosperma pallida*					
0.5-1.0 m										
1.0-2.0 m										
2.0 - 4.0 m										

Appendix B Fauna species list

Common name	Scientific name	Status (BC Act)	2018 monitoring	Previously recorded[#]
MAMMALS				
Common Wombat	*Vombatus ursinus*			X
Common Ringtail Possum	*Pseudocheirus peregrinus*			X
Eastern Grey Kangaroo	*Macropus giganteus*		X	X
Common Wallaroo	*Macropus robustus*		X	X
Swamp Wallaby	*Wallabia bicolor*			X
Yellow-bellied Sheathtail-bat	***Saccolaimus flaviventris***	**V**		**X**
Large Forest Bat	*Vespadelus darlingtoni*			X
* Fox	*Vulpes vulpes*			X
* Feral Cat	*Felis catus*			X
* Rabbit	*Oryctolagus cuniculus*			X
AVES (BIRDS)				
Yellow-rumped Thornbill	*Acanthiza chrysorrhoa*			X
Striated Thornbill	*Acanthiza lineata*		X	X
Brown Thornbill	*Acanthiza pusilla*			X
Buff-rumped Thornbill	*Acanthiza reguloides*		X	X
Eastern Spinebill	*Acanthorhynchus tenuirostris*			X
Grey Goshawk	*Accipiter novaehollandiae*			X
Australian King Parrot	*Alisterus scapularis*			X
Pacific Black Duck	*Anas superciliosa*			X
Red Wattlebird	*Anthochaera carunculata*			X
Brush Wattlebird	*Anthochaera chrysoptera*			X
Wedge-tailed Eagle	*Aquila audax*			X
Fan-tailed Cuckoo	*Cacomantis flabelliformis*			X
Pallid Cuckoo	*Cacomantis pallidus*			X
Gang-gang Cockatoo	***Callocephalon fimbriatum***	**V**		**X**
Yellow-tailed Black Cockatoo	*Calyptorhynchus funereus*			X
Australian Wood Duck	*Chenonetta jubata*			X
Spotted Quail-thrush	*Cinclosoma punctatum*			X
Red-browed Treecreeper	*Climacteris erythrops*			X
Grey Shrike-thrush	*Colluricincla harmonica*			X
Black-faced Cuckoo-shrike	*Coracina novaehollandiae*		X	X
White-winged Chough	*Corcorax melanorhamphos*			X
White-throated Treecreeper	*Cormobates leucophaea*			X
Australian Raven	*Corvus coronoides*		X	X
Australian Magpie	*Cracticus tibicen*			X
Grey Butcherbird	*Cracticus torquatus*			X
Laughing Kookaburra	*Dacelo novaeguineae*			X
Varied Sittella	***Daphoenositta chrysoptera***	**V**		**X**

Common name	Scientific name	Status (BC Act)	2018 monitoring	Previously recorded#
Eastern Yellow Robin	*Eopsaltria australis*			X
Dollarbird	*Eurystomus orientalis*		X	
White-throated Gerygone	*Gerygone albogularis*		X	X
Welcome Swallow	*Hirundo neoxena*			X
Yellow-faced Honeyeater	*Lichenostomus chrysops*		X	X
White-eared Honeyeater	*Lichenostomus leucotis*			X
Superb Fairy-wren	*Malurus cyaneus*			X
Brown-headed Honeyeater	*Melithreptus brevirostris*			X
White-naped Honeyeater	*Melithreptus lunatus*			X
Restless Flycatcher	*Myiagra inquieta*		X	X
Leaden Flycatcher	*Myiagra rubecula*		X	X
Red-browed Finch	*Neochmia temporalis*			X
Rufous Whistler	*Pachycephala rufiventris*		X	X
Spotted Pardalote	*Pardalotus punctatus*		X	X
Striated Pardalote	*Pardalotus striatus*		X	X
Scarlet Robin	***Petroica boodang***	**V**		**X**
Red-capped Robin	*Petroica goodenovii*			X
Rose Robin	*Petroica rosea*			X
Noisy Friarbird	*Philemon corniculatus*		X	X
New Holland Honeyeater	*Phylidonryis novaehollandiae*			X
Crimson Rosella	*Platycercus elegans*		X	X
Eastern Rosella	*Platycercus eximius*		X	X
Tawny Frogmouth	*Podargus strigoides*			X
Grey Fantail	*Rhipidura albiscapa*		X	X
Willie Wagtail	*Rhipidura leucophrys*			X
White-browed Scrubwren	*Sericornis frontalis*			X
Pied Currawong	*Strepera graculina*		X	X
Grey Currawong	*Strepera versicolor*			X
Sacred Kingfisher	*Todiramphus sanctus*		X	X
Silvereye	*Zosterops lateralis*			X
AMPHIBIANS				
Common Eastern Froglet	*Crinia signifera*			X
Bleating Tree Frog	*Litoria dentata*		X	
REPTILES				
Copper-tailed Skink	*Ctenotus taeniolatus*		X	X
Pale-flecked Garden Sun-skink	*Lampropholis guichenoti*			X
Jacky Lizard	*Amphibolurus muricatus*			X

* denotes an introduced species; V – listed as 'Vulnerable' under the NSW *Biodiversity Conservation Act 2016* (BC Act); # Wildthing Consultants (1999) and Lesryk Environmental (2016; 2017).

Appendix C Purple Copper Butterfly monitoring data

Site	PCB observed	*Anonychomyrma itinerans* (Ants)	*Bursaria spinosa* subsp. *lasiophylla* (Blackthorn)						Other observations
			Number individuals	Height range (m)	Mature individuals	Seedlings	New growth	Grazing	
17	No	No	>200	0-2	Y	Y	Y	Y	Ant species (*Crematogaster* sp.) European Honey Bees (*Apis mellifera*) Moth (species unknown)
18	No	No	~30	0.2-1.4	Y	Y	Y	Y	Ant species (*Crematogaster* sp.) European Honey Bees (*Apis mellifera*) Moths & Grasshoppers (Species unknown)
19	No	No	~60	0.2-1	Y	Y	Y	Y	Ant species (*Crematogaster* sp.) Butterfly (Australian Painted Lady, *Vanessa kershawi*) Jewel Beetle (unknown species)
20/21	No	No	~30	0.2-2	Y	Y	Y	Y	Ant species (*Crematogaster* sp.) Moth and Dragonfly (species unknown)
24	No	No	~30	0.5-2.5	Y	Y	Y	Y	Ant species (*Crematogaster* sp.) present Butterfly (Australian Painted Lady, Vanessa kershawi)