

Metropolitan Coal Vegetation Monitoring

Longwalls 23-27 – Spring 2022

Prepared for

Metropolitan Coal

2 FEBRUARY 2024



DOCUMENT TRACKING

Project Name	Metropolitan Coal Vegetation Monitoring Longwalls 23-27 Spring 2022
Project Number	22SUT-1419
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Status	Final
Version Number	V2
Last saved on	2 February 2024
Cover photo	Clockwise from top left: <i>Leionema diosmeum</i> , Woronora River 1, <i>Hibbertia riparia</i> , Upland Swamp vegetation, <i>Genoplesium fimbriatum</i> – Brian Towle and Elizabeth Norris

This report should be cited as ‘Eco Logical Australia, 2024. *Metropolitan Coal Vegetation Monitoring, Longwalls 23-27 – Spring 2022*. Prepared for Metropolitan Coal Pty Ltd.’

ACKNOWLEDGEMENTS

This document has been prepared by Eco Logical Australia Pty Ltd with support from Metropolitan Coal Pty Ltd and Resource Strategies.

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Abbreviations

Abbreviation	Description
ANOSIM	Analysis of Similarity
ANOVA	Analysis of Variation
BBS	Bangalay Botanical Surveys
BL	Baseline
BMP	Biodiversity Management Plan
BOM	Bureau of Meteorology
BT	Banksia Thicket
ELA	Eco Logical Australia Pty Ltd
GPS	Global Positioning System
LW	Longwall
mm	millimetres
NPWS	National Parks and Wildlife Service
RH	Restioid Heath
TTT	Tea Tree Thicket

1. Introduction

Metropolitan Coal is located near Helensburgh, approximately 30 km south of Sydney and 30 km north of Wollongong (Figure 1). Metropolitan Coal is a wholly owned subsidiary of Peabody Energy Australia Pty Ltd.

Metropolitan Coal was granted Project Approval (08_0149) for the Metropolitan Coal Project ('the Project') in accordance with section 75J of the *Environmental Planning and Assessment Act 1979* on 22 June 2009. In accordance with Project Approval Condition 6, Schedule 3, a Biodiversity Management Plan (BMP) was prepared as a component of the Metropolitan Coal Longwalls 23-27 Extraction Plan to manage the potential environmental consequences of the Extraction Plan on aquatic and terrestrial flora and fauna, with a specific focus on swamps (Metropolitan Coal 2015).

The Metropolitan Coal Longwalls 23-27 BMP has been superseded by the Metropolitan Coal Longwalls 308-310 BMP (Metropolitan Coal 2022). In accordance with the Longwalls 308-310 BMP, the Longwalls 23-27 vegetation monitoring program has continued to be implemented to monitor the potential impacts of Longwalls 23-27 on terrestrial flora, with a specific focus on upland swamp and riparian vegetation.

Mining of Longwalls 23-27 commenced in May 2014 and was completed in March 2017. This spring 2022 report presents the eleventh dataset collected post the completion of Longwalls 23-27, with data also collected in spring 2017, and autumn and spring from 2018 to 2022 (Eco Logical Australia 2018b – 2023). Previous data collection and reporting has occurred during the mining of Longwalls 23-27 in autumn and spring 2014, autumn and spring 2015, autumn and spring 2016 and autumn 2017 (Eco Logical Australia 2014a – 2018a). Prior to the commencement of mining, baseline data was collected during spring 2010, autumn and spring 2011, autumn and spring 2012, and autumn and spring 2013 (Eco Logical Australia 2013).

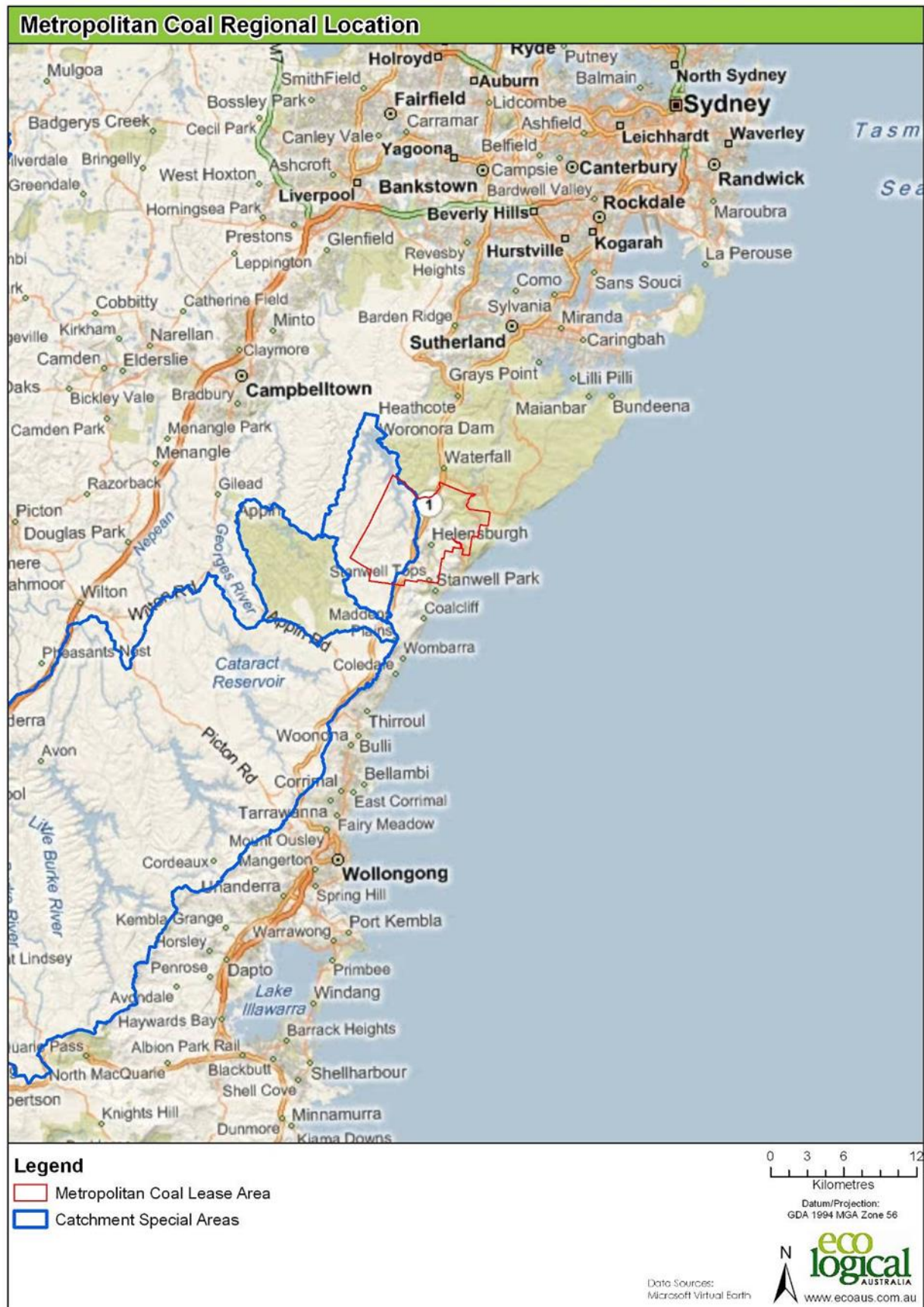


Figure 1: Metropolitan Coal regional location

2. Vegetation mapping

A baseline flora survey of the Metropolitan Coal longwall mining area was undertaken by Bangalay Botanical Surveys (Bangalay Botanical Surveys (BBS) 2008) for the Metropolitan Coal Project Environmental Assessment (Helensburgh Coal Pty Ltd 2008). This baseline flora survey identified and mapped vegetation communities for a large area of the Metropolitan Coal lease boundary including the area overlying Longwalls 23-27 and surrounds (Figure 2). The identification of vegetation communities in the baseline flora survey (BBS 2008) largely followed the vegetation mapping of the Woronora, O'Hares and Metropolitan Catchments by NSW National Parks and Wildlife Services (NPWS 2003).

A number of distinct vegetation communities have been identified as comprising the Upland Swamps Complex within the Woronora, O'Hares and Metropolitan Catchments (NPWS 2003), with four distinct upland swamp vegetation communities identified by Bangalay Botanical Surveys (2008) namely:

- Tea Tree Thicket
- Banksia Thicket
- Sedgeland–heath Complex (an amalgamation of the Sedgeland, Restioid Heath and Cyperoid Heath vegetation associations identified by Keith & Myerscough (1993) but condensed by NPWS (2003) on the basis that they could not be readily distinguished by air photo interpretation for community mapping).
- Fringing Eucalypt Woodland.

The Bangalay Botanical Surveys (2008) mapping shows 17 upland swamps located above or immediately adjacent to Longwalls 23-27, namely Swamps 19, 27, 28, 29, 30, 31, 32, 33, 34, 35, 36, 93, 94, 95, 96, 97, 98 (Figure 2 and Figure 3). The vegetation in these 17 swamps was classified as 'Banksia Thicket' (Swamps 94 and 33) and 'Sedgeland-heath Complex' (Swamps 19, 27, 28, 29, 30, 31, 32, 34, 35, 36, 93, 95, 96, 97 and 98).

Subsequent field inspections were undertaken by Eco Logical Australia to validate the vegetation classification of BBS (2008). The swamps over Longwalls 23-27 are relatively small and comprise either Banksia Thicket or Restioid Heath or a combination of the two with the following exceptions:

- Swamp 28, mapped as 'Sedgeland-heath Complex' (BBS 2008), contained elements of the vegetation communities 'Banksia Thicket' and 'Tea Tree Thicket' consistent with descriptions of this community by BBS (2008) and NPWS (2003).
- Swamp 29, mapped as 'Sedgeland-heath Complex' (BBS 2008), contained vegetation which was more characteristic of 'Sandstone-Heath Woodland' consistent with descriptions of this community by BBS (2008) and NPWS (2003).
- Swamp 32 and Swamp 34, mapped as 'Sedgeland-heath Complex' (BBS 2008), was considered to include elements of the 'Sandstone-Heath Woodland' consistent with descriptions of this community by BBS (2008) and NPWS (2003).

Riparian vegetation occurs along streams which flow to the Woronora Reservoir including the Waratah Rivulet and the Eastern Tributary and some of their tributaries. Riparian vegetation includes vegetation mapped as community 4a (Sandstone Riparian Scrub; BBS 2008) (Figure 2).

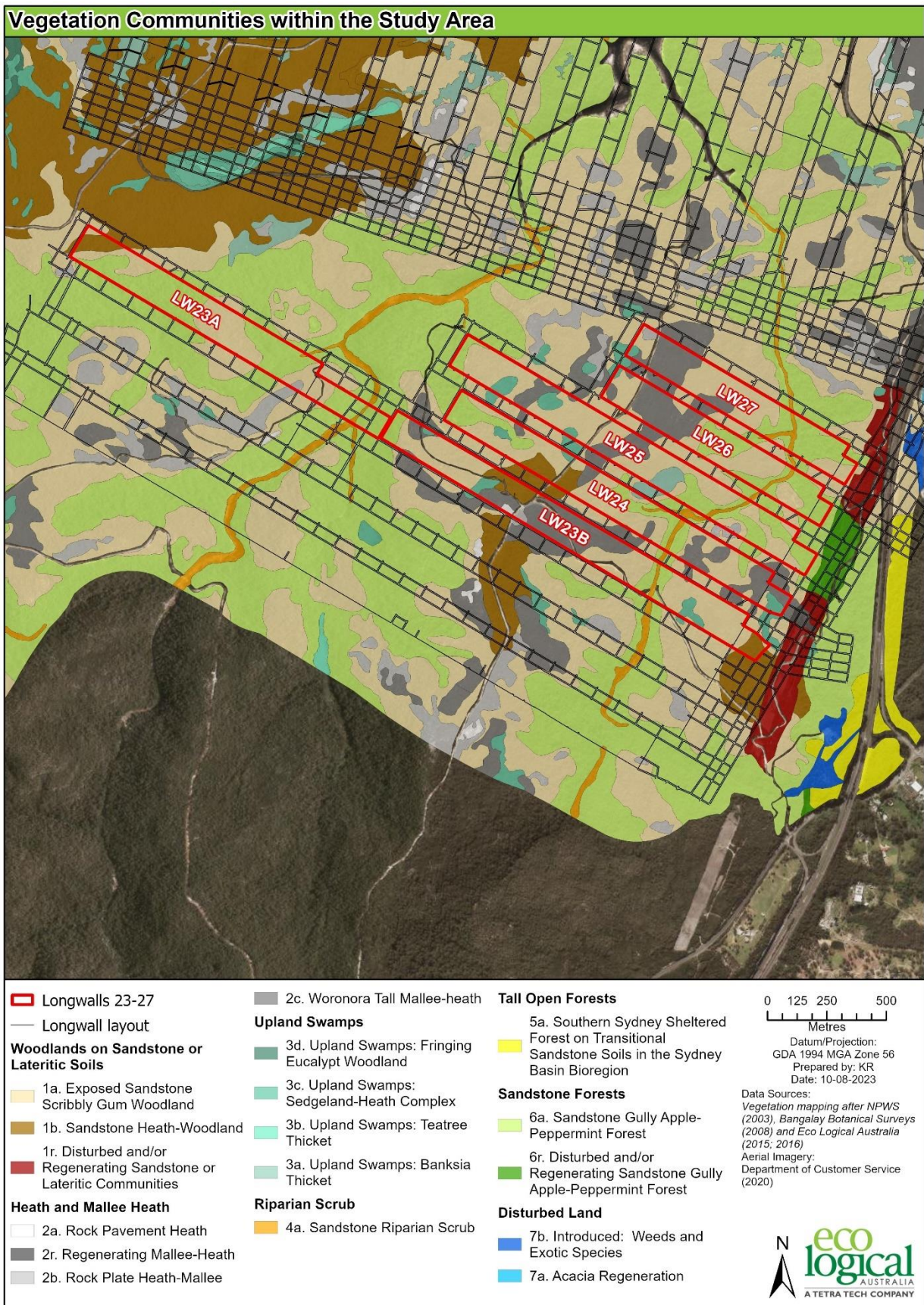


Figure 2: Vegetation communities overlying Longwalls 23 to 27 and surrounds.



Figure 3: Upland swamps overlying and adjacent to Longwalls 23 to 27.

3. Methods

The vegetation monitoring program for Longwalls 23-27 comprises two main components:

- Monitoring of upland swamp vegetation
- Monitoring of riparian vegetation.

Upland swamp and riparian vegetation surveys are conducted bi-annually in autumn and spring.

Copies of data sheets used for all the monitoring surveys are provided in Appendix A.

3.1 Upland swamp monitoring

3.1.1 Visual inspections

Visual inspections were conducted during spring 2022 in Swamps 19, 28, 30, 31, 32, 33, 34, 35, 36 and 94 overlying and / or immediately adjacent to Longwalls 23-27 (Figure 3) and in control Swamps 101, 111a, 125, 135, 136, 137a, 137b, 138, Bee Creek Swamp, Dahlia Swamp, Woronora River 1, and Woronora River south arm (Figure 4) to record evidence of potential subsidence impacts.

Traverses over the swamps were conducted in spring 2022 to record:

- Cracking of exposed bedrock areas and / or swamp substrate
- Areas of increased erosion, particularly along any existing drainage lines
- Any changes in water colour, particularly evidence of iron precipitation
- Changes in vegetation condition, including areas of stressed vegetation (i.e. plants that demonstrate symptoms of stress) and dead / dying plants that appear unusual
- Whether the amount of seepage (at the terminal step / over exposed surfaces of the swamp) at the time of inspection appears unusual (relative to recent rainfall).

In addition to traverses aimed at covering the majority of the extent of each swamp, established photo points distributed throughout each swamp were visited to ensure consistent recording of observations between survey seasons.

Photographs of any cracking, erosion, water colour changes and stressed vegetation were recorded, concurrently with a description of the nature and extent of these observations, and appropriate global positioning system (GPS) readings. Seepage areas were documented by photographs of flow over exposed surfaces, e.g. terminal step and exposed sandstone areas.

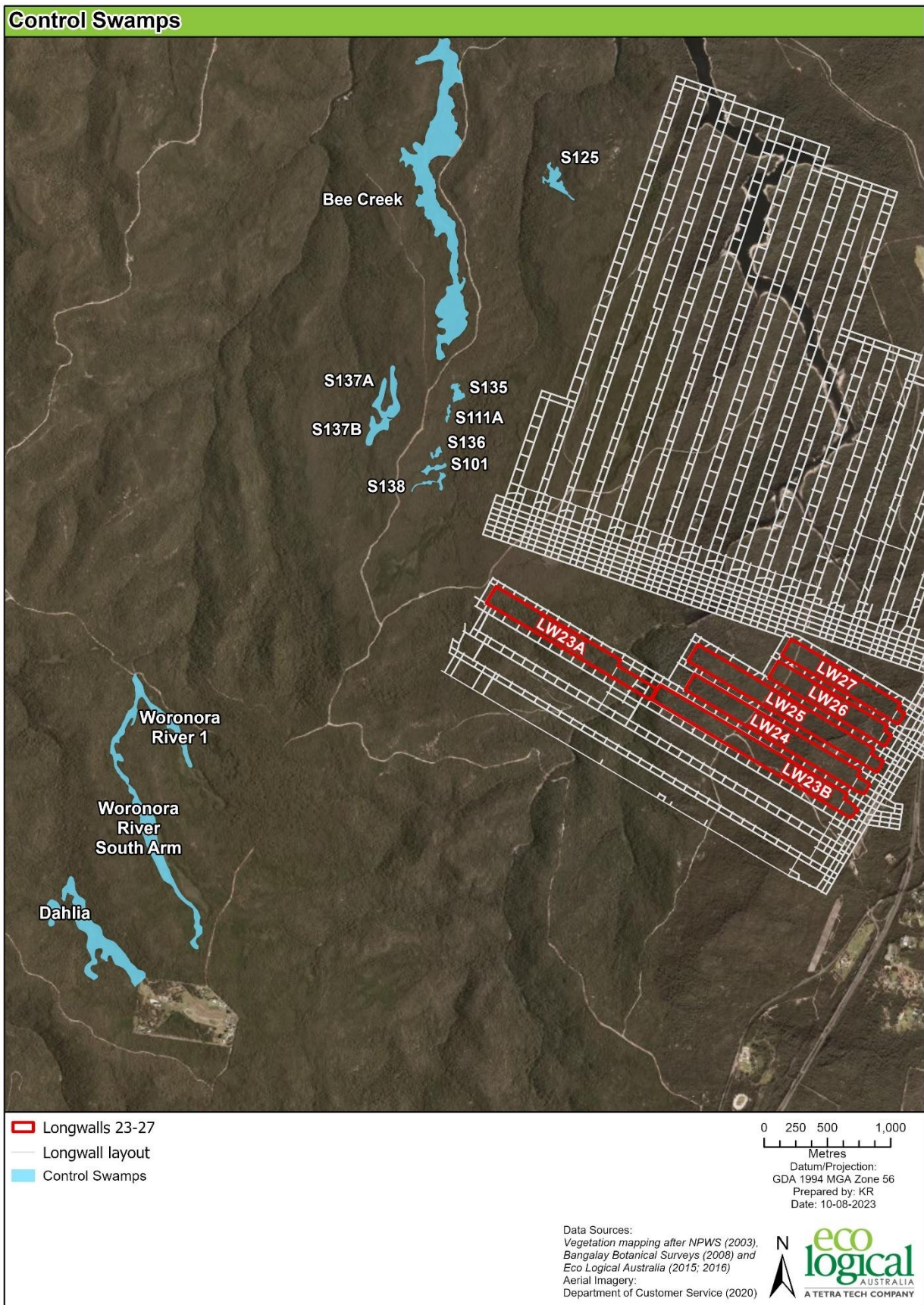


Figure 4: Control swamps in which vegetation monitoring is undertaken.

3.1.2 Transect / quadrat monitoring

Transect / quadrat monitoring was conducted during spring 2022 in Swamps 28, 30, 33, 35 and 94 overlying or immediately adjacent to Longwalls 23-27 and in control Swamps 101, 111a, 125, 135, 136, 137a, 137b, 138, Bee Creek Swamp, Dahlia Swamp, Woronora River 1, and Woronora River south arm.

With the exception of Swamp 28, which supports Tea Tree Thicket in the lower portion of the swamp, all the swamps over Longwalls 23-27 comprise either Banksia Thicket or Restioid Heath, or a combination of the two.

Swamps considered suitable as controls for the Banksia Thicket / Restioid Heath vegetation were Swamps 135, 136, 137a, 137b, 138 and Bee Creek Swamp, as well as control swamps monitored as a component of the Longwalls 20-22 vegetation monitoring program, namely Swamps 101, 111a and 125. Swamps considered suitable as controls for the Tea Tree Thicket vegetation were swamps Woronora River 1, Woronora River south arm and Dahlia Swamp monitored as a component of the Longwalls 20-22 vegetation monitoring program.

Swamps 30, 33, 35, 94 and control Swamps 135, 136, 137a, 137b and 138 are valley side swamps and tend to have their longest axis extending horizontally around the slope perpendicular to the gradient and are often rather narrow. Three transects have been established in each of these swamps extending downslope perpendicular to the horizontal long axis and approximately evenly distributed along the long axis.

Swamp 28 is also a valley side swamp which supports Banksia Thicket in the upper portion of the swamp and Tea Tree Thicket in the lower portion of the swamp. No similar swamps in terms of their geomorphic characteristics are known from elsewhere in the study area to provide a control for Swamp 28. Patches of Tea Tree Thicket in three much larger swamps (Woronora River 1, Woronora River south arm and Dahlia Swamp) have been selected as controls for the Tea Tree Thicket in Swamp 28 with the proviso that the condition and floristics of the vegetation in all swamps is similar.

Swamp 28 and the corresponding control swamps Bee Creek Swamp, Woronora River 1, Woronora River south arm and Dahlia Swamp have their long axis extending downslope. In these swamps, transects have been established across the slope perpendicular to the long axis. Two approximately evenly spaced transects have been established in Swamp 28, one within Banksia Thicket and the other in Tea Tree Thicket vegetation. As the control swamps are much larger in area, only a single transect has been established in Woronora River 1, Woronora River south arm, and Dahlia Swamp, with three transects established in Bee Creek Swamp.

Transects have been marked with a star picket at each end and at regular intervals (20 m) to ensure that the same line is sampled each monitoring season. Vegetation has also been flagged along this line (every 5 m) to further aid re-locating the transect line and quadrat positions. For the valley side swamps, vegetation assessment is made on 1 m² quadrats centred on the transect line at 5 m intervals starting from 0 m. Exceptions to this include Swamps 30 and 137b where the vegetation is dense. In Swamps 30 and 137b, the placement of quadrats is as for Tea Tree Thicket swamps, with the quadrats placed upslope of the transect line with one quadrat edge located on the line. For Swamp 28 and the associated Tea Tree Thicket control swamps, vegetation assessment is made on 1 m² quadrats placed upslope of the transect line with one quadrat edge located on the line. Quadrats are placed upslope to

avoid surveying trampled vegetation along the transect, with trampling more pronounced in these swamps due to the thick vegetation cover.

The transect length varies within each swamp and between swamps, however, the statistical analyses to be performed on the quadrat data do not require the transect lengths to be the same between swamps.

The data collected for each quadrat included:

- Vegetation structure
- Dominant species
- Estimated cover and height for each stratum
- Full floristics
- Estimated cover / abundance for each species in the quadrat using the following seven-point modified Braun-Blanquet scale:

Modified Braun-Blanquet Scale:

- 1 = cover less than 5% of site and rare
- 2 = cover less than 5% of site and uncommon
- 3 = cover less than 5% of site and common
- 4 = cover 5% – 20% of site
- 5 = cover 21% – 50% of site
- 6 = cover 51% – 75% of site
- 7 = cover 76% – 100%

- Condition / health rating for each species in the quadrat using the following scale:

Condition Scale:

- 1 = severe damage / dieback
- 2 = many dead stems
- 3 = some dead branches
- 4 = minor damage
- 5 = healthy

Photographs of each quadrat and permanent photo points along each transect were taken.

3.1.3 Indicator species

Due to the minimal number of swamps and variation in floristics across the swamps, it has not been possible to select indicator species common to all swamps. Overall, five indicator species have been selected, three for the Banksia Thicket / Restioid Heath swamps and two for the Tea Tree Thicket swamps across both longwall and control sites. Twenty tagged individuals of each species were established at each site in spring 2010 as follows:

- *Epacris obtusifolia* – monitored in Swamps 19, 30, 33, 35, 94, 101, 111a, 125, 135, 136, 137a, 137b and 138

- *Pultenaea aristata* – monitored in Swamps 19, 30, 33, 35, 94, 101, 111a, 135, 136, 137a and 138
- *Sprengelia incarnata* – monitored in Swamps 19, 33, 35, 94, 101, 125, 135, 136, 137a and 138
- *Banksia robur* – monitored in Swamp 28, Woronora River 1, Woronora River south arm, and Dahlia Swamp
- *Callistemon citrinus* – monitored in Swamp 28, Woronora River 1, Woronora River south arm, and Dahlia Swamp.

Population monitoring data collected includes:

- Condition / health rating for each plant, based on the following scale:

Condition Scale:

- 1 = severe damage / dieback
- 2 = many dead stems
- 3 = some dead branches
- 4 = minor damage
- 5 = healthy

- Reproductive rating for each plant, based on the following scale:

Reproductive Status

- 1 = nil
- 2 = sparse (occasional flowers only)
- 3 = low (under 25% of potential flowering)
- 4 = moderate (25% to 75% of potential flowering)
- 5 = high (over 75% of potential flowering)

All locations of tagged individuals were recorded using a differential GPS providing sub-metre accuracy to enable accurate re-location during future surveys. Tagged individuals were also flagged in the upper branches providing a rapid visual reference point.

3.2 Riparian vegetation monitoring

Riparian vegetation is monitored along the Waratah Rivulet (longwall sites MRIP01 and MRIP02 and control sites MRIP03, MRIP04 and MRIP10) and the Eastern Tributary (longwall sites MRIP05, MRIP06, MRIP09, MRIP11 and MRIP12 and control (compromised) sites MRIP07 and MRIP08) (Figure 5).

Riparian vegetation monitoring sites MRIP07 and MRIP08 were used as control sites for comparison against the longwall riparian monitoring sites prior to subsidence impacts occurring to pools on the Eastern Tributary at these sites post spring 2016 and before autumn 2017. Analyses from autumn 2017 onwards no longer considers these sites as control sites.

Quadrat / transect surveys for longwall sites MRIP01, MRIP02, MRIP05 and MRIP06, control sites MRIP03 and MRIP04, and control (compromised) sites MRIP07 and MRIP08 commenced in spring 2008 as part of the Longwalls 20-22 monitoring program. Visual inspections and indicator species monitoring were introduced at these sites and at longwall site MRIP09 and control site MRIP10 in spring 2009.

Quadrat / transect surveys, visual inspections and indicator species monitoring at sites over Longwalls 23-27 (sites MRIP11 and MRIP12) commenced in spring 2010.

3.2.1 Visual Inspections

Visual inspections of riparian areas were undertaken in locations adjacent to the riparian vegetation monitoring sites (MRIP01 – MRIP12, Figure 5), together with areas traversed whilst accessing the monitoring sites to record evidence of subsidence impacts including:

- Areas of new water ponding
- Any cracking or rock displacement
- Changes in vegetation condition, including areas of stressed vegetation that appear unusual.

Photographs of any new water ponding, cracking / rock displacement and stressed vegetation were taken, concurrently with a description of the observations, and appropriate GPS readings.

3.2.2 Quadrat monitoring

Permanent quadrats (20 m x 2 m) were established for monitoring riparian vegetation at the following sites:

- MRIP01, MRIP02, MRIP05 and MRIP06 overlying Longwalls 20-22
- MRIP11 and MRIP12 overlying Longwalls 23-27
- MRIP03, MRIP04, MRIP07 and MRIP08, downstream of Longwalls 20-22 and Longwalls 23-27.

The data collected for each quadrat included:

- Vegetation structure
- Dominant species
- Estimated cover and height for each stratum
- Full floristics
- Estimated cover / abundance for each species using the seven-point modified Braun-Blanquet scale (as per upland swamps, Section 3.1.2)
- Condition / health rating for each species in the quadrat (as per upland swamps, Section 3.1.2).

Permanent photo points have been established for each quadrat.

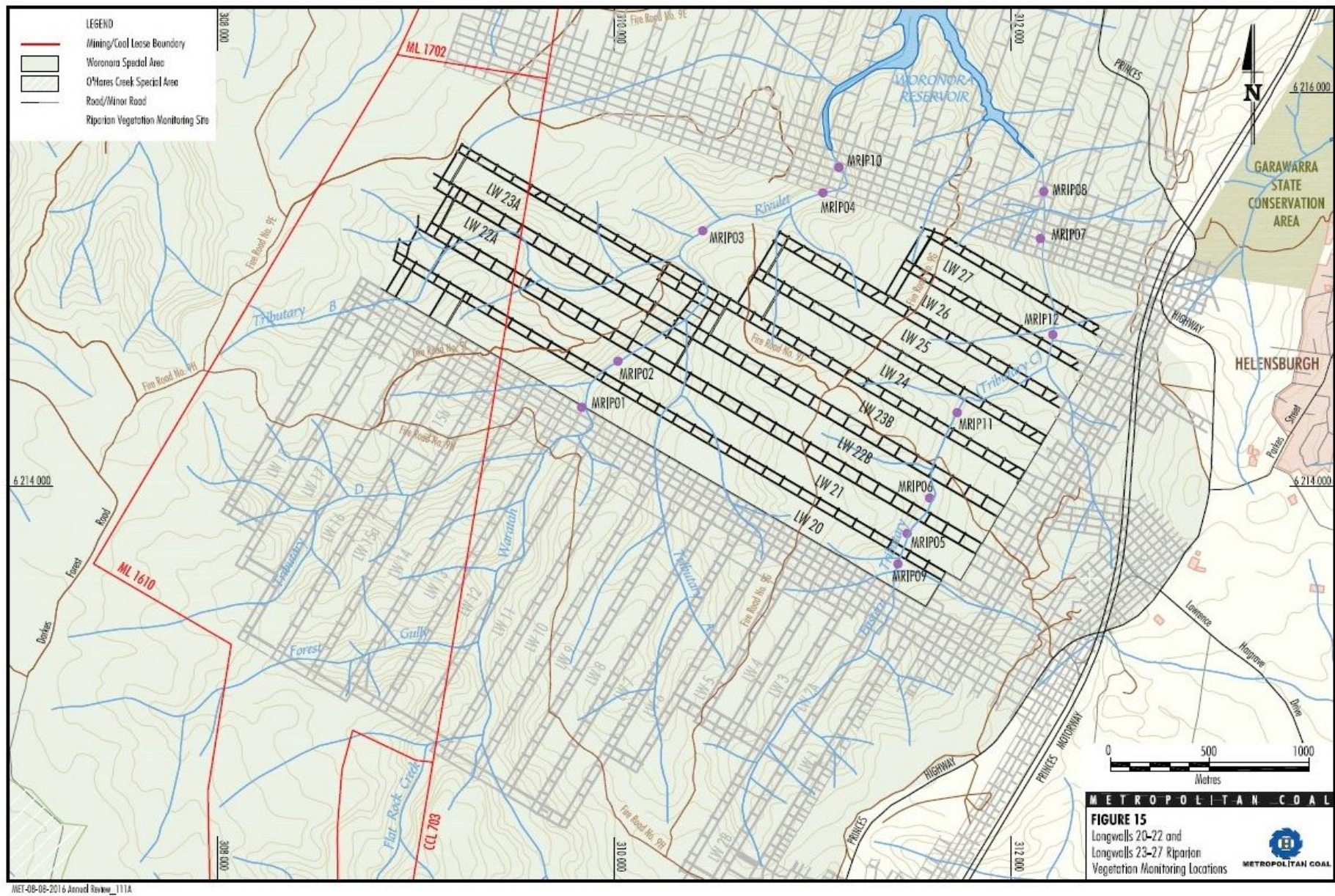


Figure 5: Riparian monitoring locations

3.2.3 Indicator species

Three indicator species were selected for population monitoring along Waratah Rivulet and the Eastern Tributary, namely *Prostanthera linearis*, *Lomatia myricoides* and *Schoenus melanostachys*. Twenty tagged individuals of each species are monitored at each of the following sites, with the exception of MRIP08, where only 10 individuals of *Prostanthera linearis* were able to be found and tagged:

- MRIP01, MRIP02, MRIP05, MRIP06 and MRIP09 overlying Longwalls 20-22
- MRIP11 and MRIP12 overlying Longwalls 23-27
- MRIP03, MRIP04, MRIP07, MRIP08 and MRIP10 downstream of Longwalls 20-22 and Longwalls 23-27.

Monitoring of indicator species commenced in spring 2009 for longwall sites MRIP01, MRIP02, MRIP05, MRIP06 and MRIP09 and control sites MRIP03, MRIP04, MRIP07, MRIP08 and MRIP10, as part of Longwall 20-22 vegetation monitoring, and in spring 2010 for longwall sites MRIP11 and MRIP12.

Population monitoring data collected includes:

- Condition / health rating for each plant (as per upland swamps, Section 3.1.3)
- Reproductive rating (as per upland swamps, Section 3.1.3).

All locations of tagged individuals were recorded using a differential GPS providing sub-metre accuracy to enable accurate re-location during future surveys. Tagged individuals were also flagged in the upper branches providing a rapid visual reference point.

3.3 Summary of Monitoring Program

All upland swamp and riparian site details, including GPS waypoints and transect details, are provided in Appendix B. A summary of the monitoring sites and details on vegetation community, monitoring type (longwall or control) and monitoring components (visual observation, transect / quadrat and population monitoring of indicator species) is provided below (Table 1).

Table 1: Summary of monitoring program for LW 23-27; tick = monitoring method is applied to site

Swamp	Type	Vegetation Community	Visual Inspections	Transect / Quadrat (Floristics)	Population monitoring of Indicator species
UPLAND SWAMP MONITORING					
S19	Longwall	Restioid Heath	✓	✗	✓
S28	Longwall	Banksia Thicket / Tea Tree Thicket	✓	✓	✓
S30	Longwall	Restioid Heath	✓	✓	✓
S31	Longwall	Restioid Heath	✓	✗	✗
S32	Longwall	Restioid Heath	✓	✗	✗
S33	Longwall	Banksia Thicket	✓	✓	✓
S34	Longwall	Restioid Heath	✓	✗	✗
S35	Longwall	Restioid Heath	✓	✓	✓
S36	Longwall	Banksia Thicket / Restioid Heath	✓	✗	✗
S94	Longwall	Banksia Thicket	✓	✓	✓
S101	Control	Restioid Heath	✓	✓	✓
S111a	Control	Restioid Heath	✓	✓	✓
S125	Control	Restioid Heath	✓	✓	✓
S135	Control	Banksia Thicket	✓	✓	✓
S136	Control	Banksia Thicket	✓	✓	✓
S137a	Control	Restioid Heath	✓	✓	✓
S137b	Control	Banksia Thicket	✓	✓	✓
S138	Control	Restioid Heath	✓	✓	✓
Bee Creek	Control	Banksia Thicket	✓	✓	✗
Dahlia	Control	Tea Tree Thicket	✓	✓	✓
Woronora River 1	Control	Tea Tree Thicket	✓	✓	✓
Woronora River south arm	Control	Tea Tree Thicket	✓	✓	✓
RIPARIAN VEGETATION MONITORING					
MRIP01	Longwall	Riparian Scrub	✓	✓	✓
MRIP02	Longwall	Riparian Scrub	✓	✓	✓
MRIP03	Control	Riparian Scrub	✓	✓	✓
MRIP04	Control	Riparian Scrub	✓	✓	✓
MRIP05	Longwall	Riparian Scrub	✓	✓	✓
MRIP06	Longwall	Riparian Scrub	✓	✓	✓
MRIP07	Control (Compromised)	Riparian Scrub	✓	✓	✓
MRIP08	Control (Compromised)	Riparian Scrub	✓	✓	✓
MRIP09	Longwall	Riparian Scrub	✓	✗	✓
MRIP10	Control	Riparian Scrub	✓	✗	✓
MRIP11	Longwall	Riparian Scrub	✓	✓	✓
MRIP12	Longwall	Riparian Scrub	✓	✓	✓

3.4 Species identification and nomenclature

Field guides and standard texts used for the identification of plant species, included:

- Bishop (2000)
- Brooker & Kleinig (2006)
- Fairley & Moore (2010)
- Harden (1992-2002)
- Jacobs, Whalley, & Wheeler (2008)
- Jones (2006)
- Klaphake (2004)
- Pellow, Henwood, & Carolin (2009)
- Robinson (2003).

The naming of plant species recorded during the surveys follows the nomenclature presented in Harden (1992-2002), with subsequent taxonomic updates from NSW Flora Online on PlantNET (the NSW Plant Information Network System) (Royal Botanic Gardens and Domain Trust, Sydney 2023).

3.5 Survey timing

A summary of the timing of vegetation monitoring conducted in spring 2022 is outlined in Table 2.

Table 2: Survey timing spring 2022

Date	Upland Swamp sites	Riparian monitoring sites
1 September 2022	Swamp 111a	
7 September 2022	Swamp 125	
18 October 2022	Swamp 136	
19 October 2022	Swamp 135	
26 October 2022		MRIP07, MRIP08
1 November 2022		MRIP12
4 November 2022		MRIP05 (in part), MRIP09
7 November 2022		MRIP05 (in part), MRIP06, MRIP11
9 November 2022	Swamp 34, Swamp 35 (in part)	
10 November 2022	Swamp 33 (in part), Swamp 35 (in part)	
11 November 2022	Swamp 33 (in part)	
15 November 2022	Swamp 137a (in part), Swamp 137b	
16 November 2022	Swamp 101	
17 November 2022	Swamp 19	MRIP03
18 November 2022	Swamp 28, Swamp 30	
21 November 2022	Swamp 138, Bee Creek Swamp	
22 November 2022	Swamp 36	
1 December 2022	Woronora River south arm, Woronora River 1	

Date	Upland Swamp sites	Riparian monitoring sites
6 December 2022	Swamp 137a (in part)	
7 December 2022	Swamp 94	
8 December 2022	Swamp 137a (in part),	
13 December 2022		MRIP01, MRIP02
14 December 2022	Dahlia Swamp	
15 December 2022		MRIP04, MRIP10
19 December 2022	Swamp 31, Swamp 32	

3.6 Weather conditions

The spring 2022 survey commenced at the start of September and was completed mid-December 2022. Field work was extended into summer due to the catchment being closed for approximately five weeks. This was due to over 500 millimetres of rainfall falling in the catchment across the survey period. The weather conditions throughout the spring 2022 survey period were generally wetter and cooler than previous spring survey periods. Overall, the temperatures in spring 2022, as recorded at Bellambi Meteorological station (Bureau of Meteorology (BOM) station no. 068228), ranged from a minimum of 14.9°C to a maximum of 27.2°C. This being cooler than previous spring seasons, including spring 2021 (15.8°C – 32.1°C) and spring 2020 (15.0°C – 39.7°C).

The total monthly rainfall from September 2008 to December 2022, encompassing the entire survey period (November 2008 to December 2022), taken from the Metropolitan Colliery Meteorological Station Helensburgh 2, is presented with the long term mean monthly rainfall in Table 3 and Figure 6).

Table 3: Monthly rainfall (mm) for entire survey period (spring 2008 to spring 2022) taken from Metropolitan Colliery Meteorological Station Helensburgh 2

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	TOTAL
2008									89.0	53.5	64.5	82.0	
2009	35.5	210.0	102.0	155.5	152.5	80.5	55.5	5.0	26.0	120.5	63.5	63.5	1070
2010	37.0	182.5	118.5	30.5	89.5	169.0	47.5	43.0	173.5	75.0	103.5	90.5	1160
2011	42.0	4.0	164.5	59.5	51.0	167.0	169.5	91.0	75.0	80.0	162.5	76.0	1142
2012	180.5	242.0	235.5	117.5	15.0	129.5	45.5	5.5	22.5	63.5	54.5	28.0	1140
2013	171.0	220.5	67.0	104.5	106.5	283.5	7.0	11.0	80.5	12.0	217.5	54.5	1336
2014	31.5	50.5	218.5	59.0	11.5	28.0	8.0	93.0	25.5	79.5	39.5	182.5	827
2015	113.5	96.0	32.5	445.0	101.5	62.5	53.0	81.5	38.5	30.5	119.0	60.5	1234
2016	275.0	31.0	46.5	55.5	36.0	394.5	92.5	84.0	52.5	15.5	36.0	67.5	1187
2017	63.0	172.0	404.5	70.0	13.5	174.5	12.5	18.5	0.5	37.0	39.0	52.5	1058
2018	38.0	83.0	139.0	19.0	11.5	95.5	1.0	16.0	41.0	175.5	117.0	93.5	830
2019	58.0	44.0	180.5	24.0	6.5	88.5	36.5	48.0	130.0	29.5	40.0	2.5	688
2020	88.5	550.5	132.5	75.5	75.0	48.0	218.0	129.5	32.0	162.0	55.0	104.5	1671
2021	88.0	101.0	391.0	18.5	128.0	55.0	16.5	66.5	34.5	99.0	96.5	130.5	1225
2022	133.5	337.5	734.5	387.0	126.5	11.0	787.0	20.0	150.0	250.5	55.0	45.0	3037

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	TOTAL
Mean*	131.4	159.9	161.5	128	128.9	144.1	101.7	88.1	77.2	93.9	105.1	102.7	

Survey periods are shaded mid-green.

* Mean data taken from Bureau of Meteorology Station Number 068024 (Darkes Forest), established in 1894 (Source: www.bom.gov.au, April 2023). Each monthly long-term mean is calculated using all data obtained since the commencement of monitoring at Station 068024.

The spring 2022 survey was undertaken after a period of extremely high rainfall in July 2022 (787.0 millimetres) with a reasonably dry June (11.0 millimetres) and August 2022 (20.0 millimetres). The preceding autumn 2022 survey period was delayed, and characterised, by particularly high rainfall. Therefore, the end of the autumn 2022 data collection period ran straight into the start of the spring 2022 survey season (Table 3). During the spring 2022 survey period, rainfall in both September (150.0 millimetres) and October (250.5 millimetres) was more than double the mean for those months across all recorded years. In comparison, November and December received approximately half the amount of rainfall than the recorded means for those months.

The rainfall preceding and during vegetation surveys has been discussed in the previous reports (Eco Logical Australia 2014b – 2023) and is summarised in Table 4, below.

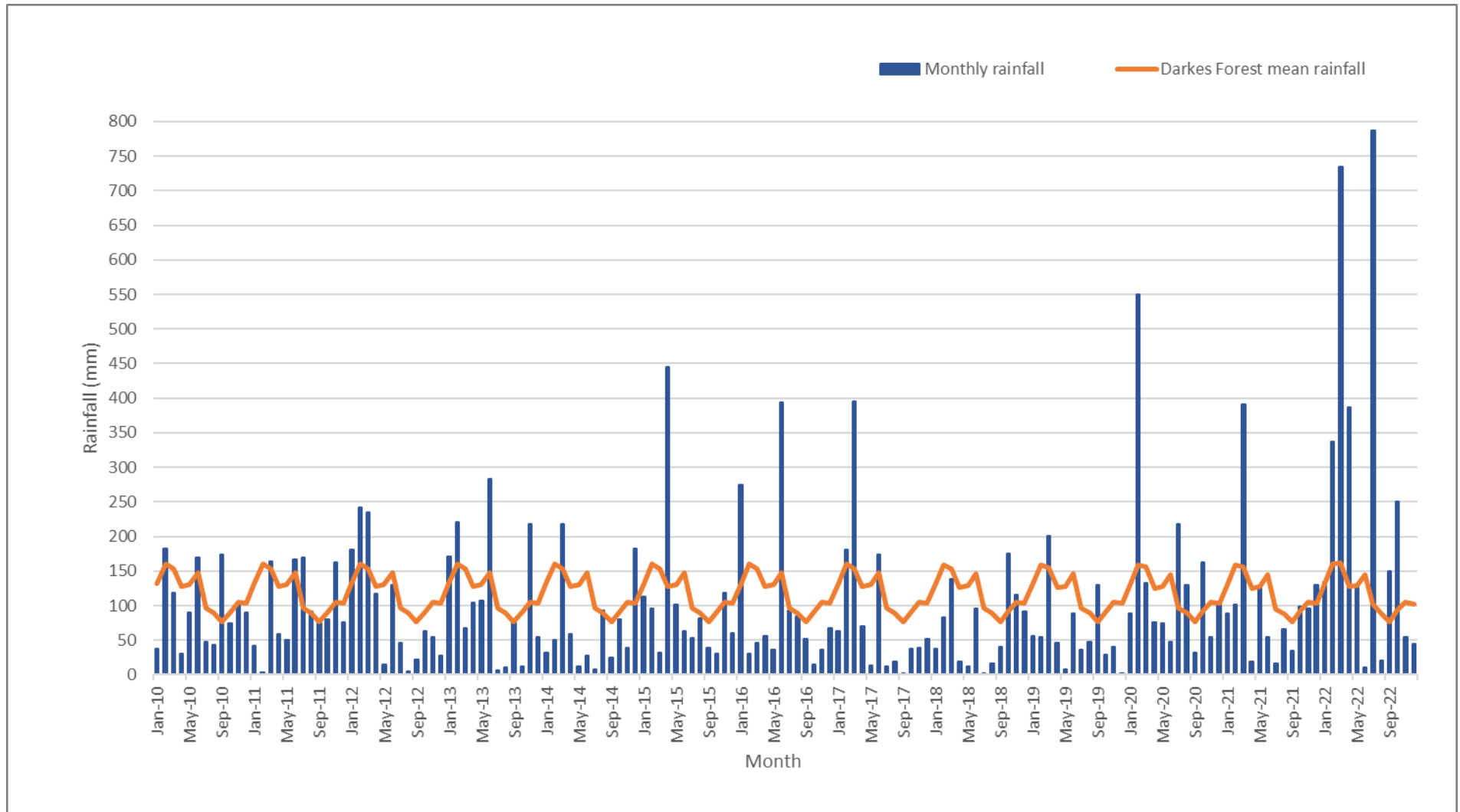


Figure 6: Monthly rainfall for the study area (January 2010 to Spring 2022)

Observational data from HELENSBURGH 2 Metropolitan Coal weather station (Source: Manly Hydraulics Laboratory, <https://wiski.mhl.nsw.gov.au/applications>, April 2023). Mean data taken from Bureau of Meteorology Station Number 68024 (Darkes Forest), established in 1894 (Source: www.bom.gov.au, April 2023).

Table 4: Summary of weather conditions throughout monitoring period (spring 2010 – spring 2022)

Survey Season / Period	Conditions prior to survey/s	Rainfall during survey/s
Autumn 2010 – Autumn 2012	Wet conditions (many months above average during this period)	Moderate to high rainfall
Spring 2012	Dry conditions (all winter months well below average rainfall)	Low rainfall
Autumn 2013	Wetter condition (many months above average rainfall immediately preceding)	Moderate to high rainfall
Spring 2013	Wetter conditions following dry winter	Moderate to high rainfall
Autumn 2014	Average conditions	Low rainfall
Spring 2014	Dry conditions	Low to moderate rainfall
Autumn 2015	Moderately wet conditions	High rainfall (exceptionally high rainfall in April 2015)
Spring 2015	Moderate to dry conditions (all winter months well below average rainfall)	Low to moderate rainfall
Autumn 2016	Wet conditions (above average rain in November 2015 and very heavy rain in January 2016)	Low rainfall (below average rainfall for all survey months)
Spring 2016	Wet conditions (heavy rain in June 2016)	Low rainfall (below average rainfall for all survey months)
Autumn 2017	Wet conditions (heavy rain in March 2017)	Low rainfall (below average rainfall for most of survey period)
Spring 2017 – Spring 2019	Dry conditions (rainfall well below average most months from July 2017 onwards)	Low rainfall (below average rainfall for all survey months except for October and November 2018 and March 2019 only)
Autumn 2020	Moderately wet conditions (rainfall below average for December 2019 and January 2020, but heavy rain February 2020)	Low to moderate rainfall (close to average rainfall March 2020, below average for remaining survey months)
Spring 2020	Wet conditions (heavy rain in July and August 2020)	Moderate rainfall (below average rainfall for September and November, well above average for October)
Autumn 2021	Moderate to dry conditions (rainfall consistent with average in December 2020, but below average for January and February 2021)	Moderate rainfall (well above average rainfall for March 2021, below average in April and June, and close to average for May)
Spring 2021	Dry conditions (rainfall below average from June to August 2021)	Moderate rainfall (low rainfall September, average for October and November, above average for December 2021)
Autumn 2022	Very wet conditions (rainfall close to average December and January, then well above average February, March and April 2022)	Very high rainfall (close to average rainfall in May, below average June and August, then well above average in July 2022)
Spring 2022	Very wet conditions (extremely high rainfall in March, April and July 2022)	High rainfall (well above average rainfall in September and October 2022. Below average rainfall in November and December)

3.7 Assessment against performance indicators

The monitoring results from the spring 2022 survey have been analysed and assessed against the performance indicators developed for upland swamp vegetation monitoring and riparian vegetation monitoring in accordance with the Longwalls 308-310 BMP (Appendix C).

3.7.1 Upland swamp vegetation

Visual observations

The information recorded during these inspections is used to make an assessment of changes in the condition of the swamps over time.

Transect / quadrat monitoring

The data collected from the transect / quadrat monitoring was analysed as follows:

- Analysis of the number of species (i.e. species richness) overtime and relative to control sites using analysis of variance (ANOVA). The purpose of ANOVA is to test for significant differences in floristic diversity over time. The analysis was conducted using the R statistical package v 3.6.2.
- Analysis of species lists using Cluster Analysis (ANOSIM). Cluster Analysis is a method used for combining similar objects into groups or clusters and is used to test for significant differences in species cover / abundance and condition scores overtime and relative to control sites. ANOSIM looks at groups of sites in multidimensional space and compares them with other groups to see if they are different. Data for the ANOSIM analysis were based on the average cover / abundance and average vegetation condition across all quadrats for each transect, whether a species was present or not: i.e. the transect is considered the unit of comparison. The analysis was conducted using the R statistical package v 3.6.2.

Indicator species monitoring

The data collected from indicator species monitoring is quantitatively analysed for the proportions of plants surviving, and differences in health and reproduction ratings over time and relative to control swamps.

Assessment against upland swamp vegetation performance indicator

The visual inspections, transect / quadrat data and population monitoring of indicator species is used to assess the upland swamp vegetation performance indicator:

The vegetation in upland swamps is not expected to experience changes significantly different to vegetation in control swamps.

3.7.2 Riparian vegetation

Visual inspections

The information recorded during these inspections will be used to make an assessment of changes in the condition of the riparian vegetation over time.

Quadrat monitoring

The vegetation structure data, including dominant species, height and estimated cover for each stratum, collected from the quadrat monitoring is assessed for changes between seasons within a site, and for differences between longwall and control sites within the current season. The full floristics and associated cover / abundance and condition data is analysed to provide an assessment of trends between monitoring sites, and over time, in overall species richness as well as the cover / abundance and condition of particular species.

Indicator species monitoring

The data collected from the indicator species monitoring is quantitatively analysed for the proportion of plants surviving overtime and relative to control sites, and differences in health and reproduction ratings over time and relative to control sites.

Assessment against riparian vegetation performance indicator

The vegetation monitoring conducted at locations adjacent to riparian vegetation monitoring sites and areas traversed whilst accessing the monitoring sites is used to assess the extent of riparian dieback against the riparian vegetation performance indicator:

Impacts to riparian vegetation are expected to be localised and limited in extent, similar to the impacts previously experienced at Metropolitan Coal.

The riparian vegetation performance indicator will be exceeded if vegetation monitoring:

- Identifies an increase in the extent of vegetation dieback compared to that observed up to, and including, the autumn 2018 vegetation survey at site MRIP02 on the Waratah Rivulet and between sites MRIP05 and MRIP09 on the Eastern Tributary.
- Identifies vegetation dieback greater than 50 cm from the stream at sites MRIP01, MRIP03, MRIP04, MRIP06, MRIP07, MRIP08, MRIP10, MRIP11 or MRIP12 as a result of mine subsidence.

4. Results and discussion

A list of all flora species recorded during the spring 2022 monitoring survey is presented in Appendix D.

4.1 Upland swamp vegetation monitoring

4.1.1 Visual inspections

Visual inspections were conducted across all upland swamp sites during the spring 2022 survey. Traverses covering the majority of the extent of each swamp were conducted, and the following provides a summary of the visual observations:

- No new areas of cracking of exposed bedrock were observed in either longwall or control swamps in spring 2022, other than the previously reported occurrence of minor surface cracks in exposed bedrock, considered to be a weathering artefact in Swamps 31 and 34. No additional cracks were observed at these sites.
- Areas in which active erosion was observed in spring 2022 were generally minor and limited to minor erosion along existing tracks in control sites only (Swamp 101 and Woronora River south arm). The exception to this is control site Woronora River 1 where severe erosion, including gouging of sediments along flow paths and exposure of roots, was observed first observed at the north-western end of the swamp in autumn 2022 following extremely high rainfall in early 2022. In spring 2022, these flood impacts were still apparent and slightly extended, with deep holes and more exposed roots than the previous season (Plate 1). A similar, although not as extensive, impact was observed in control Swamp 125, along the creekline which runs through the site, where moderate levels of erosion were recorded, with sediment scoured off the banks and plant roots exposed. Swamps previously observed with active erosion but not recorded with any erosion impacts in spring 2022 include Swamps 19, 28, 30, 31, 34, 36, 111a, 137b and 138.
- Swamp surface sediments were generally wet to saturated in most longwall and all control sites, the exceptions being the smaller, rockier swamps (Swamps 31 and 32). In many swamps, areas of saturated sediment had turned into a red-coloured 'sludge', which appears to be a mix of mud and iron bacteria and algae. This was particularly abundant in Swamps 19, 35, 94, 111a, 125, 136, and 137b. Drying and cracking of swamp surface sediments, which had been observed in previous seasons, was not observed in any sites in spring 2022.
- Abundant seepage was recorded in the majority of control sites and two of the longwall sites, Swamps 30 and 94.
 - For Banksia Thicket / Restioid Heath swamps seepage was generally observed on terminal steps, mid-swamp rock plates or along transects (Plate 2). The exceptions tended to be smaller swamps and those without a terminal step, where seepage was found to be:
 - Moderate – Swamps 19, 33, 35, and 138
 - Minor – Swamp 31, 34, 36, 101
 - Absent – Swamps 28 (Transect 1), 32, and Bee Creek Swamp.

- For Tea Tree Thicket swamps, seepage was abundant at two control sites (Woronora River south arm and Dahlia Swamp), particularly around the centre of each transect where it bisected the main drainage line which runs along the middle of these swamps. No standing water or seepage was observed in the remaining control site (Woronora River 1) or in the Tea Tree Thicket vegetation component of the longwall site (Swamp 28). Swamp 28 has consistently been observed with drier swamp sediments and less standing water than the larger control swamps, including during the baseline monitoring period.
- Standing water was commonly observed in most longwall and control sites. In some cases, flowing water was observed within a swamp. This was often associated with access and transect tracks. Whilst there were no observations of changes in water colour, there were many observations of standing water or seepage with a metallic sheen (Plate 3), caused by iron bacteria, on the surface in most longwall (except Swamps 31,32 and 34) and control sites (except Swamp 111a and Bee Creek). In addition, most instances of seepage were observed to be iron-stained, which is caused by an abundance of iron bacteria. As with the metallic sheen, iron-stained seepage was observed in most longwall and control sites.
- For the valley side swamps supporting Restioid Heath and Banksia Thicket, vegetation in spring 2022 at both longwall and control sites was generally found to be in a good condition, similar to that observed from autumn 2020 to autumn 2022. In seasons prior to this, vegetation condition has varied from healthy to stressed, with a number of shrubs and ground layer species recorded with leaf yellowing and dieback. In the current spring 2022 survey, healthy individuals of all species previously noted with dieback were observed within all swamps, with new growth commonly recorded. At the same time minor yellowing of common swamp shrub species was observed across most of the longwall and control sites in spring 2022, in particular *Banksia ericifolia* subsp. *ericifolia* and *Petrophile pulchella* (Plate 4). Visual observations noted the following details regarding vegetation stress of particular species, vegetation layers and swamps:
 - Species with reduced condition across both longwall and control swamps: Stressed individuals with yellowing foliage, or scattered dead individuals, of the shrub species: *Allocasuarina distyla* (Swamps 32, 33, 34 36 and 138), *Banksia ericifolia* subsp. *ericifolia* (all longwall sites except Swamps 30 and 31, and all control sites except Swamp 125), *Banksia serrata* (Swamp 31, 111a, and 135), *Epacris microphylla* (Swamp 30, 94, 125, and 127b), *Hakea teretifolia* (Swamps 19, 94, and all control sites except Swamp 125) and *Petrophile pulchella* (Swamps 32, 34, 101, 111a, 135, 136, 137a, 137b, and 138); and of the ground layer species *Lepidosperma laterale* (Swamp 94, and 137a) *Xanthorrhoea resinosa* (Swamps 31 and 101).
 - Species with reduced condition in control swamps only: Isolated individuals of the shrub species: *Darwinia fascicularis* (Swamp 125, 137a, and 137b), *Kunzea ambigua* (Swamp 137a), *Kunzea capitata* (Swamp 137a), *Leptomeria acida* (Swamp 135), *Leptospermum squarrosum* (Swamp 137a), *Leptospermum trinervium* (Swamp 101), *Leucopogon esquamatus* (Swamp 101, and 125) and *Persoonia pinifolia* (Swamp 138); and of the ground layer species *Chordifex dimorphus* (Swamp 101), *Cyathochaeta diandra* (Swamp 101, and 138).

- Species with reduced condition in longwall swamps only: Isolated individuals of the shrub species: *Acacia ulicifolia* (Swamp 19) *Angophora hispida* (Swamp 32), *Baeckea imbricata* (Swamp 30), *Dillwynia floribunda* (Swamp 32, and 94), and *Isopogon anemonifolius* (Swamp 32); and the ground layer species *Caustis flexuosa* (Swamp 32), and *Lepidosperma filiforme* (Swamp 31).
- Ground Layer: Standing litter of sedge species was observed in most longwall and control sites, however new growth of these and other ground layer species was commonly recorded, including *Chordifex fastigiatus*, *Cyathochaeta diandra*, *Lepidosperma filiformis*, *Lepyrodia scariosa*, *Schoenus brevifolius* and *Xanthorrhoea resinosa*.
- Swamp 19: In autumn and spring 2019 large patches of vegetation in Swamp 19 were recorded to be in a declined condition, with many dead individuals of *Hakea teretifolia*, *Leptospermum arachnoides* and *L. squarrosum*, particularly around the rock plates (Eco Logical Australia 2020a and b). In the previous five surveys (autumn 2020 to autumn 2022), vegetation appeared in an improved condition, with new growth in both the shrub and ground layers. In the current spring 2022 survey, vegetation was generally in a good condition with continued recovery of sedge and shrub species. Minor yellowing of isolated *Banksia ericifolia* subsp. *ericifolia* and *Hakea teretifolia* individuals was recorded, however healthy individuals of these species were also observed.
- Swamps 30 – 33: In spring 2017, it was first reported that large areas of senescing vegetation were observed in Swamps 30, 31 and 33. In addition, individuals of the shrub species *Banksia ericifolia* subsp. *ericifolia* and *Hakea teretifolia* were consistently observed scattered throughout these sites, and Swamp 32, as yellowing or dead (Eco Logical Australia 2018b). This situation continued throughout the following four monitoring seasons (Eco Logical Australia 2019a – 2020b), until autumn and spring 2020, when improvement in the vegetation condition was observed along with new growth in affected areas. In the current spring 2022 survey, regrowth of both shrub and ground layer species was commonly recorded across all these swamps (Plate 5). Very minor yellowing of scattered *Allocasuarina distyla* (Swamps 32 and 33), *Banksia ericifolia* subsp. *ericifolia* individuals (Swamps 32 and 33) and *Petrophile pulchella* individuals (Swamps 32) were observed in spring 2022, however healthy individuals of these species were also recorded.
- Swamp 94: In spring 2019, individuals with reduced condition (yellowing foliage or senescing) were observed for *Banksia ericifolia* subsp. *ericifolia* (throughout the swamp) and *Leptospermum squarrosum* (common only at Photo Point 3). In subsequent surveys these species generally appeared in an improved condition, with isolated exceptions (e.g. autumn 2021). In the current spring 2022 survey, vegetation was generally similar to the previous autumn 2022 survey, although minor yellowing of *Banksia ericifolia* subsp. *ericifolia* individuals was observed to be common and widespread across the swamp, especially within areas of standing water (Plate 6). In addition, a few individuals of other common swamp shrub species, *Petrophile pulchella* and *Hakea teretifolia*, were observed to be yellowing scattered throughout the swamp. Healthy individuals of these species were commonly observed throughout the swamp.
- 2021 Hazard reduction burn: Swamp 33 was subject to a hazard reduction burn in May 2021, following the autumn 2021 survey. Burnt areas varied from severe (all ground and

mid-layer plants consumed), to moderate (dead leaves remained attached to standing shrubs) to unburnt. In subsequent surveys, the extent of vegetation recovery within burnt areas was likewise variable, with some areas observed with many new seedlings and abundant sedge growth, while minimal new growth was observed in others. In spring 2022, the ground layer is recovering very well across most burnt areas (Plate 7), with high covers of common ground layer species, including *Empodisma minus* and *Xanthorrhoea resinosa*. Seedlings of common swamp shrub species, such as *Banksia ericifolia* subsp. *ericifolia* and *Petrophile pulchella*, are beginning to appear, although at relatively low densities. Unburnt vegetation at this site was generally in a healthy condition in spring 2022, with new growth observed on both shrub and ground layer species.

- For the Tea Tree Thicket swamps, vegetation condition of both longwall (lower portion of Swamp 28) and control sites was found to be similar to Banksia Thicket / Restioid Heath sites in spring 2022, with most vegetation found to be in good condition. In Swamp 28, previously senesced large shrubs have continued to collapse in spring 2022, particularly along Transect 2, resulting in an opening up of the vegetation canopy (Plate 8). In spring 2022 new growth in the form of resprouting *Callistemon citrinus* was observed in this patch. Recovery of ground layer species has been slow in this area, likely due to the dense layer of debris. Overall, vegetation condition improved for a number of species within both longwall and control sites, including:
 - Old areas of dieback of the understorey species *Empodisma minus* have mostly collapsed within the lower portion of longwall Swamp 28. Minor regrowth of *Empodisma minus* continues to be observed within this site and no additional areas of dieback were recorded in spring 2022. In control swamps this species remained in a healthy condition in spring 2022.
 - Abundant regrowth of *Gleichenia microphylla* was observed within all Tea Tree Thicket longwall and control swamps, and no additional areas of *Gleichenia microphylla* dieback were recorded within Swamp 28 in spring 2022.
 - Consistent with all prior surveys, no standing water or seepage was observed within Swamp 28, however soils were damp to wet at the site in spring 2022. Swamp 28 has been observed to be a much drier swamp, compared to the control swamps, since monitoring began in spring 2010¹. This may have contributed to the previous noted dieback within Swamp 28, particularly for *Empodisma minus* and *Gleichenia microphylla*.
 - Exceptions to the generally good condition of vegetation were limited to dieback of isolated or scattered individuals in the control sites only: *Banksia ericifolia* subsp. *ericifolia* (Woronora River 1 and Woronora River south arm), *B. robur* (Woronora River south arm), *Hakea teretifolia* (Woronora River 1 and Woronora River south arm).
- One weed species was observed during the spring 2022 visual inspections, namely *Hypochaeris radicata* (Catsear), within control site Dahlia Swamp. Weeds have previously been recorded in low densities within this site.

¹ It is noted that while Dahlia Swamp and Woronora River 1 swamps are used as controls for the Tea Tree Thicket vegetation in Swamp 28, these large headwater swamps are not comparable from a hydrogeological perspective as Swamp 28 is located in a valley-side position. Being large head-water swamps, the control swamps remain moist most of the time. For groundwater monitoring, the valley-side Swamps 137a and 137b are used as control sites for Swamp 28.



Plate 1: Woronora River 1, near Photo Point 1, showing heavy flood impacts, with gouging of sediment in bottom left, partially hidden by vegetation and debris – spring 2022



Plate 2: Swamp 30, Photo Point 3, showing seepage across terminal step – spring 2022



Plate 3: Swamp 94, along Transect 1, showing metallic sheen on standing water – spring 2022



Plate 4: Widespread yellowing of vegetation, Photo Point 2, Swamp 137b, spring 2022



Plate 5: Swamp 31, Photo Point 5, showing overall improved condition of vegetation – spring 2022



Plate 6: Swamp 94, Photo Point 4, showing minor yellowing of scattered *Banksia ericifolia* subsp. *ericifolia* – spring 2022



Plate 7: Swamp 33, Transect 1, showing vegetation impacted by May 2021 hazard reduction burn, with recovery of ground layer – spring 2022



Plate 8: Swamp 28 – Photo Point 2 (end of Transect 2), showing collapse of old senesced shrubs and subsequent opening of the vegetation canopy – spring 2022

4.1.2 Transect / quadrat monitoring

Vegetation structure, dominant species, and estimated cover for each stratum

The vegetation structure, dominant species and estimated cover for each stratum at upland swamp monitoring sites is provided in Appendices E, F and G.

The vegetation structure, dominant species and estimated cover for each stratum has been variable across all seasons with variations recorded between sites, seasons and strata. This variability is considered to reflect both the natural variations in the height and cover of vegetation structural layers through time, as well as the subjective nature of the data collection. Within the variability of this dataset, a general trend towards increasing height and cover of the mid layer vegetation and reduction in cover of the ground layer continues to occur across all longwall and control sites. The increase in height and foliage cover of the mid-storey and subsequent decrease in groundcover is a recognised pattern which typically occurs within upland swamps with increased time since fire (Keith & Bradstock 1994). With increased time since fire, upland swamps commonly form dense thickets dominated by obligate seeders such as *Banksia ericifolia* subsp. *ericifolia*, *Hakea teretifolia* and *Leptospermum squarrosum* with smaller shrubs and sedges tending to become sparser and less diverse. It is likely the shorter species get shaded and outcompeted by the taller species. The formation of these dense thickets is mediated by fire, which reduces the cover of these obligate seeders.

Species richness

A summary of species richness within swamp sites since spring 2010 is provided in Figure 7, Figure 8 and Table 5. The raw data for each swamp is presented in Appendices E, F and G.

As observed for the baseline monitoring period (spring 2010 to spring 2013), species richness in spring 2022 was generally higher in valley side swamps supporting Banksia Thicket / Restioid Heath than in swamps supporting Tea Tree Thicket (Figure 7, Figure 8 and Table 5).

Species richness within individual Banksia Thicket / Restioid Heath sites in spring 2022 was within the range recorded for all previous seasons for all longwall sites and most control sites, the exception being Swamp 136, which declined below previously recorded levels (Figure 7). Two other control sites, Bee Creek Swamp and Swamp 137a, recorded their equal lowest species richness. When compared to the previous season, a small to moderate decrease in species richness was recorded at two longwall sites (Swamps 33 and 94). The remaining longwall sites all recorded an increase in species richness from the previous season, ranging from large (Swamp 35 and Swamp 28 – Transect 1), to moderate (Swamp 30). Species richness declined in the majority of control sites, with decreases in species richness ranging from moderate (Swamps 136, 137a and 138) to small (Bee Creek Swamp and Swamp 137b), compared to autumn 2022. A large increase in species richness compared to autumn 2022 was recorded at one control site (Swamp 135), whilst a small increase was observed at another (Swamp 101). No change in species richness was recorded at the remaining control site (Swamp 111a) in spring 2022.

Swamp 33 was subject to a hazard reduction burn in May 2021, following the autumn 2021 survey. Burnt areas varied from severe (all ground and mid-layer species killed), to moderate (dead leaves remained attached to standing shrubs) to unburnt, with 44% of quadrats within this site impacted. The effects of this burn can be seen in the large decrease (eight species) in species richness observed within Swamp 33 in the initial survey following the fire (spring 2021) when compared to the previous season

(autumn 2021). In spring 2022, species richness in Swamp 33 decreased slightly, compared to autumn 2022, but remains at a similar level to that observed pre-fire.

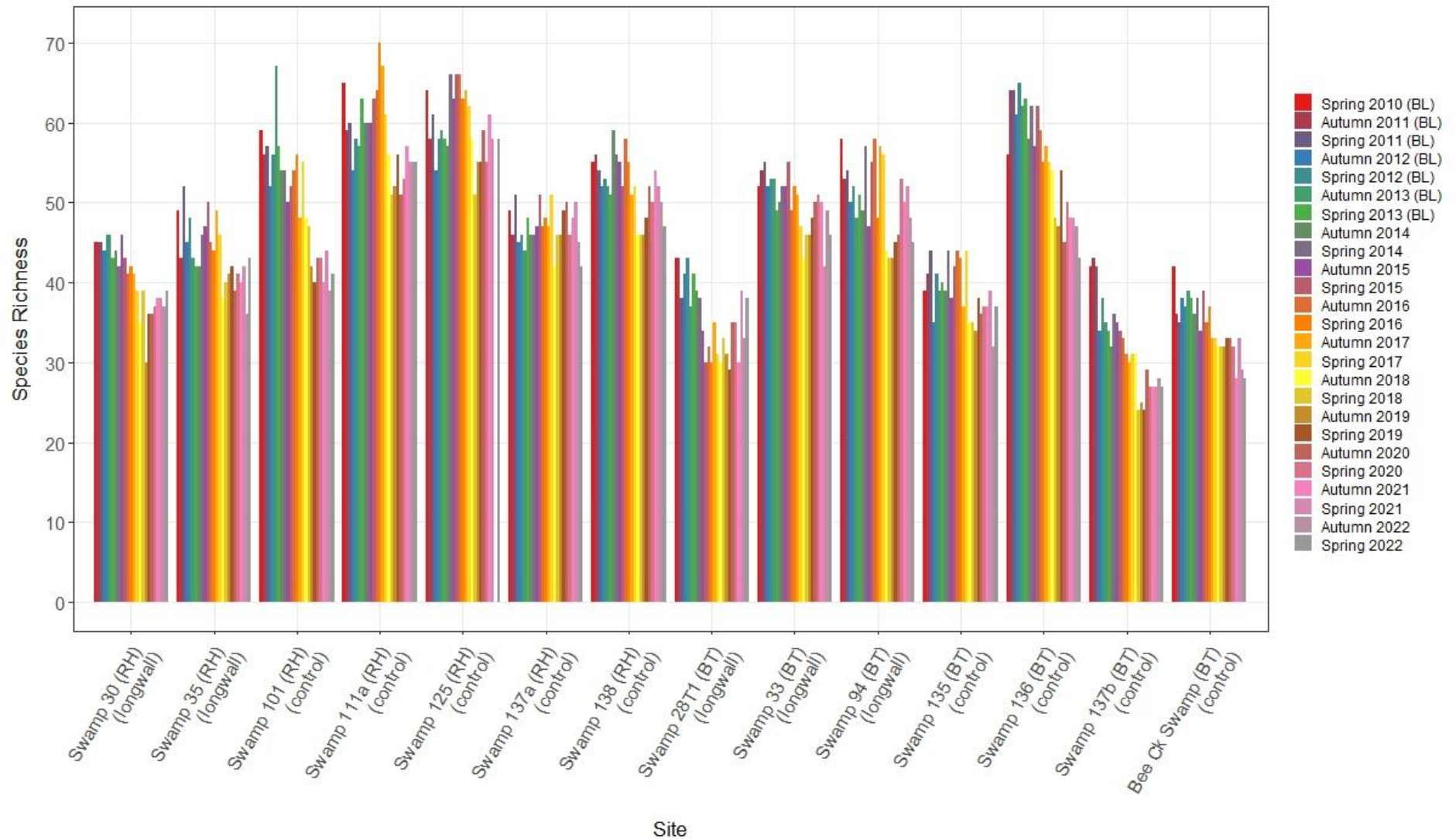


Figure 7: Native species richness within upland swamp sites supporting Restioid Heath (RH) and Banksia Thicket (BT), spring 2010 to spring 2022², BL = baseline

² NB missing data point for Swamp125 in autumn 2022 due to weather related survey disruptions in the first half of 2022

Table 5: Number of native species recorded in upland swamps (spring 2010 to spring 2022)

Site	Spring 2010	Autumn 2011	Spring 2011	Autumn 2012	Spring 2012	Autumn 2013	Spring 2013	Autumn 2014	Spring 2014	Autumn 2015	Spring 2015	Autumn 2016	Spring 2016	Autumn 2017	Spring 2017	Autumn 2018	Spring 2018	Autumn 2019	Spring 2019	Autumn 2020	Spring 2020	Autumn 2021	Spring 2021	Autumn 2022	Spring 2022
Swamp 30 (RH)	45	45	45	44	46	46	43	44	42	46	43	41	42	41	39	35	39	30	36	36	37	38	38	36	39
Swamp 35 (RH)	49	43	52	45	48	43	42	42	46	47	50	45	44	49	46	38	40	41	42	39	41	40	42	36	43
Swamp 101 (RH)	59	56	57	52	56	67	57	54	54	50	52	54	56	48	55	48	47	42	40	43	43	40	44	39	41
Swamp 111a (RH)	65	59	60	54	58	57	63	60	60	60	63	64	70	67	61	56	51	52	56	51	53	57	55	55	55
Swamp 125 (RH)	64	58	61	54	58	59	58	57	66	63	66	66	63	64	62	58	51	55	55	59	55	61	58	-	58
Swamp 137a (RH)	49	46	51	45	46	44	48	47	46	46	51	47	48	47	51	42	46	46	49	50	46	48	50	45	42
Swamp 138 (RH)	55	56	54	52	53	52	51	59	56	55	52	58	55	51	52	46	46	46	48	52	50	54	52	50	47
Swamp 28 – Transect 1 (BT)	43	43	38	41	43	41	41	39	38	34	30	32	30	35	31	30	33	31	29	35	35	30	39	32	38
Swamp 33 (BT)	53	55	55	52	53	53	49	50	52	52	55	49	52	51	47	43	46	46	48	50	51	50	42	49	46
Swamp 94 (BT)	58	53	54	50	52	48	51	49	57	47	55	58	48	57	56	44	43	43	45	46	53	50	52	48	45
Swamp 135 (BT)	39	41	44	35	41	39	40	39	44	38	42	44	43	37	44	35	35	34	38	36	37	37	39	31	37
Swamp 136 (BT)	56	64	64	61	65	62	63	58	62	57	62	59	55	57	55	54	48	47	54	45	50	48	48	47	43
Swamp 137b (BT)	42	43	42	34	38	35	34	32	36	35	34	33	31	30	31	31	24	25	24	29	27	27	27	28	27
Bee Creek (BT)	42	36	35	38	37	39	38	36	38	34	39	35	37	33	33	32	32	32	33	33	32	28	33	29	28
Swamp 28 – Transect 2 (TTT)	25	24	24	22	24	20	21	18	22	18	18	19	16	14	16	16	12	10	14	11	13	13	13	13	14
Woronora River 1 (TTT)	19	20	20	20	20	21	24	19	20	18	19	19	19	19	20	17	17	18	17	15	17	14	14	16	17
Woronora River south arm (TTT)	29	26	28	29	29	29	30	29	30	27	29	24	27	27	24	26	25	24	28	24	30	28	28	28	25
Dahlia Swamp (TTT) ⁵	24	22	23	23	22	23	24	23	23	23	24	21 (2)	23	22	27	26 (1)	26 (2)	25 (1)	28	29 (1)	30	25	30	-	27

BT = Banksia Thicket; RH = Restioid Heath; TTT = Tea Tree Thicket

Numbers in brackets indicate the number of exotic species recorded, additional to native species

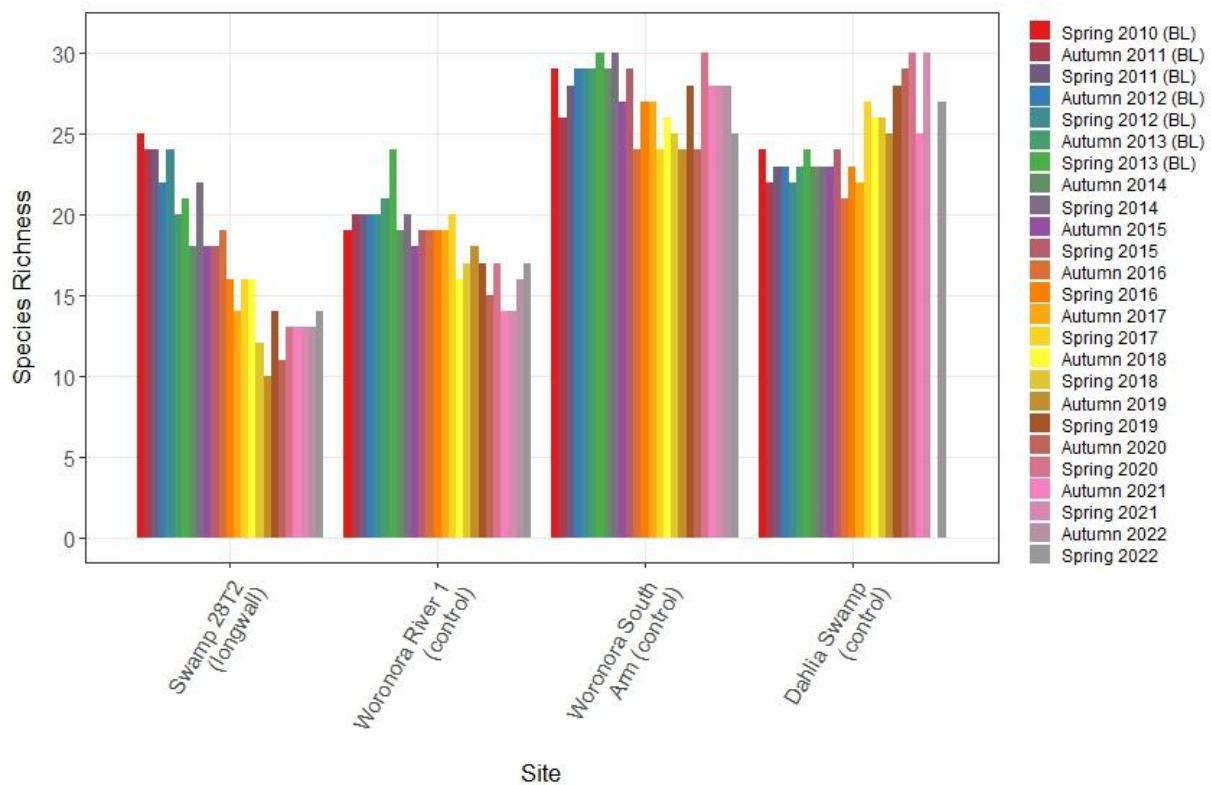


Figure 8: Native species richness within upland swamps supporting Tea Tree Thicket, spring 2010 to spring 2022³, BL = baseline

The overall decreasing trend in species richness across all longwall and control sites observed from autumn 2017 onwards, appears to be reversing across many of the sites. This is particularly apparent in the longwall sites, in which species richness is exhibiting a gradual increasing trend since the deep trough observed between Autumn 2018 and spring 2019, the timing of which corresponds to the prolonged period of low rainfall. The exception to this early stage reversal of the decreasing trend is two control sites, Bee Creek Swamp and Swamp 136, both of which continue to display declining numbers of species. The early stage of species richness increase following two years of very high rainfall (2020 – 2022) provides strong evidence to support the assumption that the decrease in species richness from autumn 2017 – spring 2019 were likely attributable to environmental conditions, including the stress associated with drying out of shallow soils. The effects of successional changes on species composition, which occurs in upland swamps over time since last fire, may continue to effect species richness.

Species richness within individual Tea Tree Thicket sites in spring 2022 was within the range of previous monitoring seasons at the single longwall (Swamp 28 – Transect 2) and all control sites (Figure 8). When compared to the previous season, autumn 2022, a small increase in species richness was observed in spring 2022 for the longwall site (Swamp 28 – Transect 2). Likewise, a small increase in species richness was recorded at one control site (Woronora River 1) when compared to autumn 2022, whilst a moderate decrease was recorded at the remaining control sites (Woronora River south arm and Dahlia Swamp).

³ NB missing data point for Dahlia Swamp in autumn 2022 due to weather related survey disruptions in the first half of 2022

Species richness across Swamp 28 has reduced over time in both the Banksia Thicket and Tea Tree Thicket vegetation during both the baseline and mining period (Figure 7 and Figure 8). Generally, the greatest decline has been occurring in the Tea Tree Thicket component (Transect 2), located at the topographically lower section of the swamp. However, as with the results for the Banksia Thicket / Restioid Heath sites, there are signs of the early stages of recovery of species richness in Swamp 28, following two years of very high rainfall (2020 – 2022), particularly in Transect 1, where the number of species recorded in spring 2021 and 2022 was within the range observed during the baseline period (spring 2010 to spring 2013).

In the current spring 2022 survey, species richness within the Banksia Thicket component of Swamp 28 (Transect 1) increased by six species compared to the previous season, autumn 2022, bringing it back up to near the level observed in spring 2021. In the Tea Tree Thicket component (Transect 2) species richness increase by 1 (Figure 8).

The declines in species richness in Swamp 28 following autumn 2015 may be related to the impacts to the groundwater system of Swamp 28 identified in 2016, based on the incomplete recovery of substrate water levels following rainfall events (Metropolitan Coal 2019). This was likely exacerbated by the prolonged period of low rainfall from 2016 – late 2019.

Overall, a total of 45 species have been recorded within Swamp 28 (Transect 2) over the entire monitoring period:

- A total of eight species recorded during the baseline period were not recorded by the end of the baseline period or during the mining and post-mining periods (Table 6). Of the eight species not recorded by the end of the baseline period, two are considered to be wet heath or swamp species, namely: *Boronia parviflora* and *Selaginella uliginosa*, however these two species were recorded only once during the baseline period.
- An additional 23 species were recorded within the mining or post-mining periods, but were not recorded by the spring 2022 survey. Of these species:
 - Eight species (*Actinotus minor*, *Burchardia umbellata*, *Cryptostylis erecta*, *Hakea salicifolia*⁴, *Leptospermum arachnoides*, *Lomandra gracilis*, *Petrophile pulchella* and *Ptilothrix deusta*) had been recorded in one or two surveys only during the mining and post mining period and were not recorded in the baseline period. All were recorded in only one or two quadrats with low estimated cover / abundance scores (1 or 2, i.e. cover less than 5 % of the quadrat).
 - Two species are considered to be wet heath or swamp species, namely: *Bauera microphylla* and *Monotaxis linifolia*. *Bauera microphylla* was recorded in all baseline surveys prior to, and including, spring 2012 and was then not recorded until autumn 2016. During the baseline period, *Monotaxis linifolia* was recorded in every survey and during the mining period was only recorded in the spring 2014, autumn 2015 and spring 2015 surveys.
- Two species recorded in autumn 2022 were not recorded in spring 2022, namely *Cyathochaeta diandra* and *Leptospermum squarrosum*.

⁴ It is assumed that the *Hakea dactyloides*, only recorded in the spring 2017, and *H. salicifolia*, only recorded in autumn 2018 may have been the same plant and one was a misidentification. Both were recorded with an estimated cover / abundance of 1 (cover less than 5 % of the site and rare) and noted to be overhanging the quadrat area

- Two additional species was recorded within Swamp 28 – Transect 2 in the spring 2022 survey, namely *Baumea* sp. and *Hakea dactyloides*.

In contrast, species richness in control sites (Woronora River 1, Woronora River south arm and Dahlia Swamp) has remained relatively stable throughout the monitoring period, however these large headwater swamps are not comparable from a hydrogeological perspective. Swamp 28 is very small, does not contain any internal drainage lines and free surface water has never been observed at this site since the inception of monitoring. Species richness in Transect 2 of Swamp 28 will continue to be closely monitored.

Table 6: Species richness for Swamp 28 (Transect 2) – Baseline, Mining and Post-mining Periods (values are number of quadrats in which the species was recorded along Transect 2, maximum = 5)

		Baseline period							Mining period							Post-mining										
Family	Scientific Name	Spr 2010	Aut 2011	Spr 2011	Aut 2012	Spr 2012	Aut 2013	Spr 2013	Aut 2014	Spr 2014	Aut 2015	Spr 2015	Aut 2016	Spr 2016	Aut 2017	Spr 2017	Aut 2018	Spr 2018	Aut 2019	Spr 2019	Aut 2020	Spr 2020	Aut 2021	Spr 2021	Aut 2022	Spr 2022
Apiaceae	<i>Actinotus minor</i>								1																	
Apiaceae	<i>Xanthosia pilosa</i>	1																								
Blandfordiaceae	<i>Blandfordia nobilis</i>																							1	1	
Colchicaceae	<i>Burchardia umbellata</i>																						1			
Cunoniaceae	<i>Bauera microphylla</i>	1	1	1	1	2							1													
Cunoniaceae	<i>Bauera rubioides</i>											1				1	1		1	1	1		1		1	2
Cyperaceae	<i>Baumea</i> sp.																									2
Cyperaceae	<i>Cyathochaeta diandra</i>																			2		1			1	
Cyperaceae	<i>Lepidosperma filiforme</i>					2																				
Cyperaceae	<i>Ptilothrix deusta</i>												1													
Cyperaceae	<i>Schoenus brevifolius</i>	4	4	4	4	4	4	4	3	4	4	3	3	3	2	1	3			1						
Droseraceae	<i>Drosera binata</i>	2		1		3		2		4		3	1			1						1	1	3	5	4
Ericaceae	<i>Epacris obtusifolia</i>	3	4	2	4	4	4	5	4	4	5	4	5	4	3	3	4	3	2	2	3	3	3	3	2	3
Euphorbiaceae	<i>Monotaxis linifolia</i>	2	1	2	1	1	1	1		1	1	1														
Fabaceae (Faboideae)	<i>Dillwynia floribunda</i>	5	3	4	4	4	3	3	3	3	3	1	3	1												
Fabaceae (Mimosoideae)	<i>Acacia linifolia</i>						1			1																
Fabaceae (Mimosoideae)	<i>Acacia terminalis</i>	1	1	1		1		1	1	1																
Gleicheniaceae	<i>Gleichenia microphylla</i>	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5					1				
Goodeniaceae	<i>Dampiera stricta</i>		2	1	1	1	1																			
Lauraceae	<i>Cassytha glabella</i>	3	3	2		3	2	1	2	1	1						1									
Lomandraceae	<i>Lomandra gracilis</i>																							1		
Myrtaceae	<i>Callistemon citrinus</i>	5	5	4	4	5	4	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
Myrtaceae	<i>Leptospermum arachnoides</i>												1													
Myrtaceae	<i>Leptospermum grandifolium</i>	2	2	2	1	2	2	1	2	2	2	2	2	2	2	2	3	2	2	1	2	2	2	3	3	3
Myrtaceae	<i>Leptospermum squarrosum</i>	1	1		1			1		1								1							1	
Orchidaceae	<i>Cryptostylis erecta</i>																		1	1						
Orchidaceae	<i>Cryptostylis subulata</i>		1	1							1		1	1	1						1	1	1	1	1	1
Poaceae	<i>Entolasia stricta</i>					1																				
Poaceae	<i>Tetrarrhena turfosa</i>	2	3	1	2	1	3	3	2	1	1	1	2	1	1	1										
Proteaceae	<i>Banksia ericifolia</i> subsp. <i>ericifolia</i>	5	4	4	5	5	5	5	5	5	5	5	4	5	5	5	4	4	4	5	5	5	5	5	5	4
Proteaceae	<i>Banksia robur</i>	3	3	3	2	3	2	2	2	2	2	2	2	2	2	2	2	1								
Proteaceae	<i>Grevillea patulifolia</i>				1																					
Proteaceae	<i>Hakea dactyloides</i>															1										1
Proteaceae	<i>Hakea salicifolia</i>																1									
Proteaceae	<i>Hakea teretifolia</i>	2	2	2	2	2	2	1	2	2	2	2	2	2	2	2	2	1	3	3	3	3	3	3	2	2
Proteaceae	<i>Persoonia pinifolia</i>	2	2	2	1	2	2	3	2	3	3	2	4	4	4	4	4	3	4	2	3	3	4	4	4	4
Proteaceae	<i>Petrophile pulchella</i>																	1								
Proteaceae	<i>Symphionema paludosum</i>	3	3	2	2	2	2	3	1	1	1	1	1	1												
Restionaceae	<i>Empodisma minus</i>	5	5	5	5	5	5	5	5	5	5	5	5	4	5	5	5	3	3	4	2	3	4	3	4	3
Restionaceae	<i>Leptocarpus tenax</i>	2	2	1	1	2	2	1	1	1							1	1		1						
Rutaceae	<i>Boronia parviflora</i>			1																						
Santalaceae	<i>Leptomeria acida</i>	1	1		1		1	1		1	1	1		1	1	1	1			1	1	1	1	1		
Selaginellaceae	<i>Selaginella uliginosa</i>	1																								
Thymelaeaceae	<i>Pimelea linifolia</i> subsp. <i>linifolia</i>	1	1	1	1	1																				
Xanthorrhoeaceae	<i>Xanthorrhoea resinosa</i>	1	2	1	1	2	2	2	1	1	1		1	1	1	2	1	2	1	2	2	2	1	2		1
Total species per survey		25	24	24	22	24	20	21	18	22	18	18	19	16	14	16	16	12	10	14	11	13	13	12	13	14
Total species recorded in baseline, mining and post mining periods		32							28							28										
	species no longer recorded since baseline period																									
	species no longer recorded since mining or post mining period																									
	additional species recorded post baseline period																									

Transect / quadrat monitoring analysis – species richness

Upland swamp sites were split into two groups for analysis based on their floristic differences: Banksia Thicket / Restioid Heath and Tea Tree Thicket swamps.

For the Banksia Thicket / Restioid Heath sites, species richness data were analysed for each season using analysis of variance (ANOVA). No significant differences were detected between longwall and control sites in any season including the current spring 2022 season ($p = 0.968$; Figure 9).

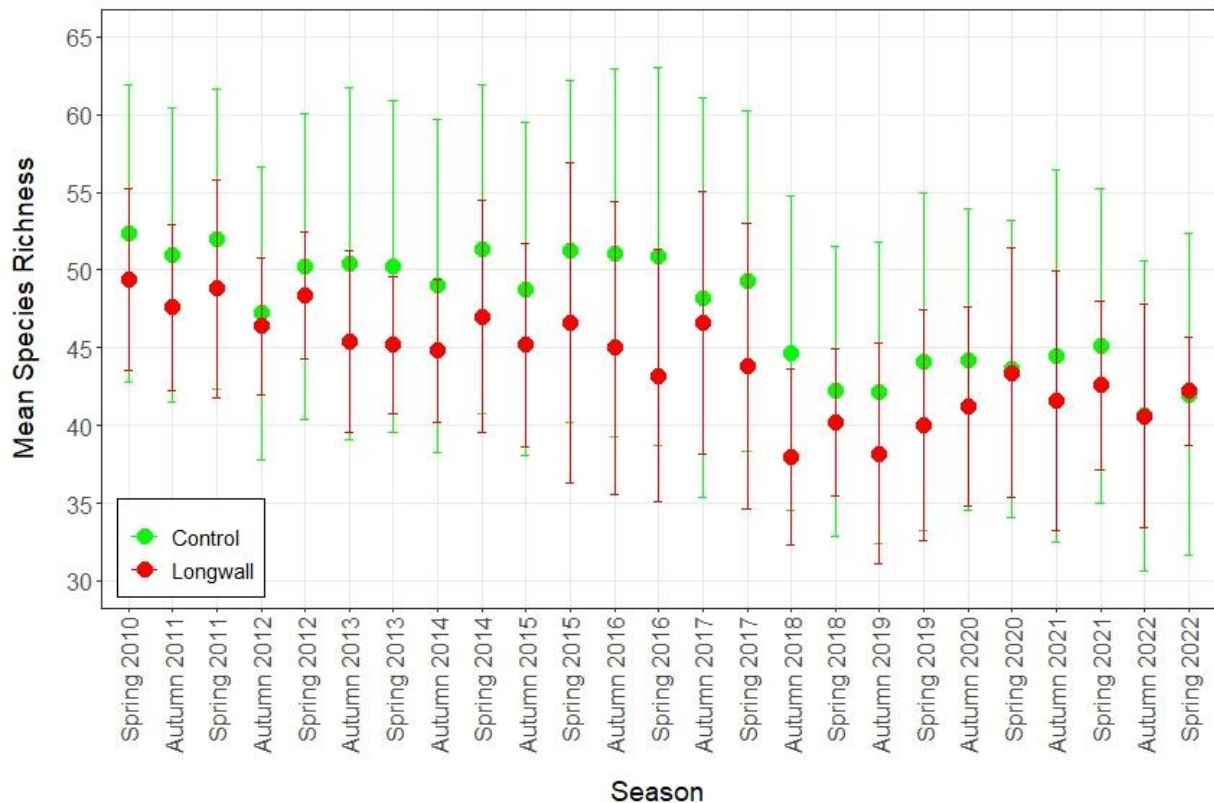


Figure 9: Mean species richness in upland swamps supporting Banksia Thicket / Restioid Heath, spring 2010 to spring 2022

As there is only one Tea Tree Thicket longwall site, the species richness data was not analysed using ANOVA. Instead, a graphical representation of the data is presented in Figure 10. Mean species richness in control sites remains higher than the species richness recorded for the single longwall site (Swamp 28 – Transect 2), a trend that has been consistent since autumn 2013, during the baseline monitoring period. As discussed above, species richness within the single longwall swamp (Swamp 28 – Transect 2) has shown an overall decline across the monitoring period. In the spring 2022 survey, species richness in Swamp 28 – Transect 2 increased slightly from the previous autumn 2022 season. Mean species richness in Tea Tree Thicket control sites also increased slightly compared to autumn 2022, remaining within the range previously measured across all seasons (Figure 10).

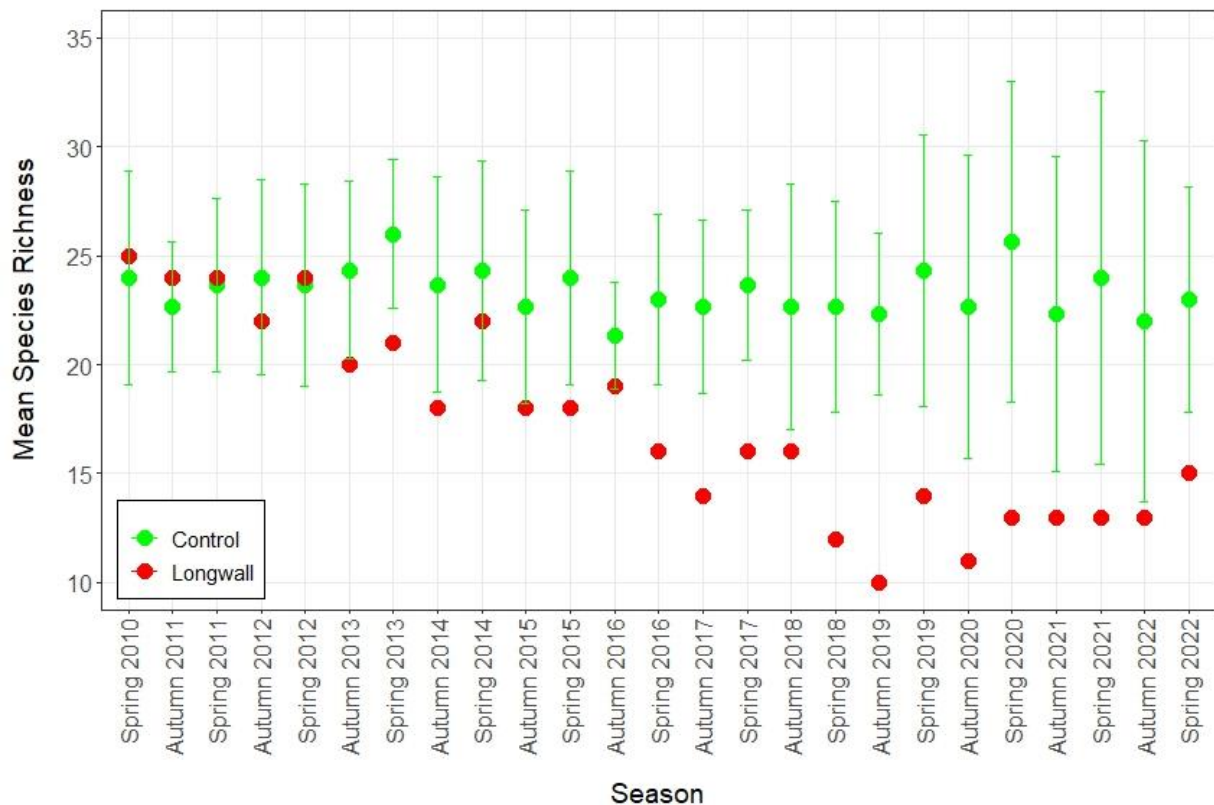


Figure 10: Mean species richness in upland swamps supporting Tea Tree Thicket, spring 2010 to spring 2022

Cover / abundance and condition

The cover / abundance and condition ratings for each species are provided in Appendices E, F and G.

As for the baseline monitoring period, fluctuations in species cover / abundance were recorded across all sites in spring 2022. No patterns of increasing or decreasing cover / abundance were identified in relation to individual species across sites or groups of species (i.e. swamp indicator species, generalist species, shrubs, groundcovers) within sites.

Fluctuations in vegetation condition were also recorded across all sites in spring 2022. Generally, vegetation within both Banksia Thicket / Restioid Heath and Tea Tree Thicket swamps was in a healthy condition throughout the survey period and observations of increased stress were limited to scattered individuals of a small number of species within most swamps.

Within the Banksia Thicket / Restioid Heath sites, a number of species were observed with dieback in both longwall and control sites, having condition ratings ranging from minor damage / dieback (Condition 4) to 'many dead stems' (Condition 2). Species commonly observed with some dieback in both longwall and control swamps include: *Baeckea imbricata*, *Banksia ericifolia* subsp. *ericifolia*, *Epacris microphylla*, *Hakea teretifolia*, *Leptospermum squarrosum*, and *Petrophile pulchella*.

Thirteen species which were observed with dieback (i.e. Condition <5) within longwall swamps in spring 2022 that were also observed with dieback within control swamps (Table 7). Seven species were observed with dieback in longwall swamps and not observed with dieback within control swamps (where the species occurred in both longwall and control swamps). Observations of dieback were

predominantly individual plants with minor dieback (Condition 4) or some dead branches (Condition 3) with very few observations of many dead branches (Condition 2) or severe damage / dieback (Condition 1). Fourteen species were observed with dieback within control swamps and were not observed with dieback within longwall swamps (where the species occurred in both longwall and control swamps) (Table 7). A full list of species and their condition scores, including those observed with dieback, within longwall and control swamps supporting Banksia Thicket / Restioid Heath in spring 2022 is provided in Appendix E and F.

Table 7: Species with dieback (Condition score <5) in longwall and control sites supporting Banksia Thicket / Restioid Heath, spring 2022

LONGWALL Sites only	CONTROL Sites only	LONGWALL & CONTROL Sites
<i>Allocasuarina distyla</i>	<i>Actinotus minor</i>	<i>Baeckea imbricata</i>
<i>Chorizandra cymbaria</i>	<i>Banksia oblongifolia</i>	<i>Banksia ericifolia</i> subsp. <i>ericifolia</i>
<i>Darwinia fascicularis</i>	<i>Cassytha glabella</i>	<i>Chordifex fastigiatus</i>
<i>Drosera peltata</i>	<i>Chordifex dimorphus</i>	<i>Dillwynia floribunda</i>
<i>Empodisma minus</i>	<i>Cyathochaeta diandra</i>	<i>Epacris microphylla</i>
<i>Eucalyptus luehmanniana</i>	<i>Eucalyptus haemastoma</i> **	<i>Epacris obtusifolia</i>
<i>Kunzea capitata</i> *	<i>Hakea gibbosa</i>	<i>Hakea teretifolia</i>
<i>Lambertia formosa</i> *	<i>Hibbertia riparia</i>	<i>Isopogon anethifolius</i>
<i>Lepyrodia scariosa</i>	<i>Lepidosperma neesii</i>	<i>Lepidosperma filiforme</i>
<i>Persoonia lanceolata</i> *	<i>Leucopogon esquamatus</i>	<i>Leptospermum squarrosum</i>
	<i>Lindsaea linearis</i>	<i>Petrophile pulchella</i>
	<i>Mirbelia rubiifolia</i> **	<i>Schoenus brevifolius</i>
	<i>Persoonia levis</i>	<i>Xanthorrhoea resinosa</i>
	<i>Petrophile sessilis</i>	
	<i>Platysace linearifolia</i>	
	<i>Xanthosia tridentata</i>	

* species not found in control sites in autumn 2022

** species not found in longwall sites in autumn 2022

The average vegetation condition for each species, that is the mean of the vegetation condition scores recorded for each species across an individual swamp, was calculated from the spring 2022 data and compared to previous seasons. In spring 2022, the number of species that had an average vegetation condition less than 5 increased at all longwall sites, however all sites were within the range previously recorded. Within control sites, the number of species with an average vegetation condition less than 5 was generally similar to longwall sites, with all sites within or below the range previously recorded. When compared to the previous season, three control site saw a decrease in the number of species with an average vegetation condition less than 5 (Bee Creek Swamp, S101, and S137b), whilst an increase was observed at all other sites.

Swamp 33 was subject to a hazard reduction burn in May 2021, following the autumn 2021 survey. Burnt areas varied from severe (all ground and mid-layer species killed), to moderate (dead leaves remained attached to standing shrubs) to unburnt, with 44% of quadrats within this site impacted. In spring 2022 the number of species with an average vegetation condition less than 5 in Swamp 33 was within the range observed in other longwall site and the control sites.

Within the Tea Tree Thicket longwall site (Swamp 28 – Transect 2), all species were recorded in a healthy condition in spring 2022. In contrast, isolated individuals of seven species were recorded with dieback (ranging from Condition 1 to 4) within the control swamps (*Banksia ericifolia* subsp. *ericifolia*, *Banksia oblongifolia*, *Banksia robur*, *Chorizandra cymbaria*, *Empodisma minus*, *Gleichenia microphylla*, *Schoenus brevifolius*). Healthy individuals of these species were also recorded within these sites.

Transect / quadrat monitoring analysis – vegetation cover / abundance

Upland swamp sites were split into two groups for analysis based on their floristic differences: Banksia Thicket / Restioid Heath and Tea Tree Thicket swamps. Analysis of similarities (ANOSIM) was used to examine the differences in vegetation composition, as measured by species cover / abundance, of Banksia Thicket / Restioid Heath swamps between the longwall and control sites for each season. The results of the ANOSIM are presented in Table 8. As there is only one Tea Tree Thicket longwall site, differences in vegetation cover / abundance were not analysed using ANOSIM.

Significant differences in vegetation composition between longwall and control sites, as measured by species cover / abundance, were observed in all seasons from spring 2010 to autumn 2014 (except autumn 2012 where a marginal difference was detected), and again from autumn 2018 to spring 2022. No significant difference was observed for the period between spring 2014 to spring 2017 survey. As significant differences between longwall and control sites based on the vegetation cover / abundance have been observed during the baseline period and at various time since longwall mining commenced and was completed, these are considered attributable to seasonal variations and pre-existing natural differences and in vegetation composition between individual swamps.

Table 8: Analysis of Similarities (ANOSIM) of vegetation cover / abundance in control versus longwall upland swamp sites supporting Banksia Thicket / Restioid Heath (spring 2010 to spring 2022)

Season	R statistic	p-value
Spring 2010	0.173	0.039
Autumn 2011	0.167	0.038
Spring 2011	0.206	0.015
Autumn 2012	0.132	0.057
Spring 2012	0.142	0.04
Autumn 2013	0.154	0.044
Spring 2013	0.152	0.032
Autumn 2014	0.175	0.021
Spring 2014	0.099	0.109
Autumn 2015	0.125	0.068
Spring 2015	0.102	0.121
Autumn 2016	0.108	0.083
Spring 2016	0.0917	0.106
Autumn 2017	0.1156	0.063
Spring 2017	-0.104	0.599
Autumn 2018	0.277	0.005
Spring 2018	0.276	0.004
Autumn 2019	0.269	0.007

Season	R statistic	p-value
Spring 2019	0.258	0.009
Autumn 2020	0.237	0.011
Spring 2020	0.255	0.007
Autumn 2021	0.265	0.006
Spring 2021	0.292	0.004
Autumn 2022	0.305	0.002
Spring 2022	0.272	0.005

Baseline period highlighted light green; seasons where significant differences were recorded (p-value <0.05) are bold.

To further explore if there have been changes in species cover / abundance at individual sites, an investigation of vegetation cover / abundance change from the previous autumn 2022 survey to the current spring 2022 survey was carried out by tallying the number of species that had decreased in average vegetation cover / abundance since autumn 2022 at each site, along with the number of species that had increased in average vegetation cover / abundance (Table 9). This showed very little trend in the vegetation cover / abundance data between longwall and control sites for spring 2022. The number of species that had an increase in average cover / abundance was higher than the number of species that had a decrease in average cover / abundance at over half of the longwall and three of the control sites. Species showing a change in average cover / abundance in spring 2022 from autumn 2022 in longwall and control sites are listed in Appendix I.

Table 9: Number of species found to have an increase or decrease in the average cover / abundance score in spring 2022, compared to autumn 2022.

	Increased Cover / Abundance	Decreased Cover / Abundance
Longwall Sites		
Swamp 28 – Transect 1	11 (1)	9 (1)
Swamp 30	17 (2)	9 (1)
Swamp 33	12 (1)	17 (1)
Swamp 35	14 (2)	16 (0)
Swamp 94	14 (0)	11 (0)
<i>Total number of species</i>	<i>37 (5)</i>	<i>38 (3)</i>
Control Sites		
Swamp 101	10 (1)	14 (0)
Swamp 111a	27 (3)	13 (2)
Swamp 125*	26 (3)	20 (3)
Swamp 135	11 (1)	11 (0)
Swamp 136	17 (0)	16 (2)
Swamp 137a	12 (1)	18 (1)
Swamp 137b	10 (0)	11 (0)
Swamp 138	10 (1)	22 (4)
Bee Creek Swamp	8 (1)	11 (2)
<i>Total number of species</i>	<i>59 (10)</i>	<i>51 (10)</i>

Numbers in brackets () indicate species only recorded in either longwall or control sites, in spring 2022.

* increases / decreases for S125 are compared with spring 2021, as no data was collected in this swamp in autumn 2022

Transect / quadrat monitoring analysis – vegetation condition

Analysis of similarities (ANOSIM) was also used to examine differences in the vegetation composition, as measured by the condition of their species assemblages, of Banksia Thicket / Restioid Heath swamps between the longwall and control sites for each season, and the results are presented in Table 10. As with vegetation cover / abundance, differences in vegetation condition for Tea Tree Thickets were not analysed using ANOSIM, due to there being only one Tea Tree Thicket longwall site.

A significant difference in vegetation condition between longwall and control sites was observed in the current autumn 2022 survey, as has occurred since autumn 2018 and in select seasons during, and following, the baseline period (spring 2010 – spring 2011, spring 2012, and autumn 2014) (Table 10). As with the vegetation composition results, this indicates that the vegetation communities vary significantly between control and longwall sites based on the condition of their species assemblages. However, as these significant differences have been observed during the baseline period and at various time since longwall mining commenced and was completed, these are considered attributable to seasonal variations and pre-existing natural differences and in vegetation composition between individual swamps.

Table 10: Analysis of Similarities (ANOSIM) of vegetation condition in control versus longwall upland swamp sites supporting Banksia Thicket / Restioid Heath (spring 2010 to spring 2022)

Season	R statistic	p-value
Spring 2010	0.173	0.021
Autumn 2011	0.177	0.022
Spring 2011	0.179	0.02
Autumn 2012	0.113	0.071
Spring 2012	0.150	0.042
Autumn 2013	0.134	0.053
Spring 2013	0.132	0.061
Autumn 2014	0.142	0.044
Spring 2014	0.103	0.092
Autumn 2015	0.116	0.083
Spring 2015	0.096	0.125
Autumn 2016	0.116	0.072
Spring 2016	0.0795	0.148
Autumn 2017	0.105	0.097
Spring 2017	0.077	0.517
Autumn 2018	0.258	0.007
Spring 2018	0.264	0.006
Autumn 2019	0.279	0.004
Spring 2019	0.256	0.008
Autumn 2020	0.201	0.019
Spring 2020	0.229	0.009
Autumn 2021	0.227	0.009
Spring 2021	0.247	0.01

Season	R statistic	p-value
Autumn 2022	0.262	0.003
Spring 2022	0.271	0.006

Baseline period highlighted light green; seasons where significant differences were recorded (p-value <0.05) are bold.

To further explore if there have been changes in species condition at individual sites, an investigation of vegetation condition change from the previous autumn 2022 survey to the current spring 2022 survey was carried out by tallying the number of species that had decreased in average vegetation condition since autumn 2022 at each site, along with the number of species that had increased in average vegetation condition (Table 11). The number of species that had a decrease in average condition was higher than the number of species that had an increase in average vegetation condition at all longwalls, in spring 2022. In contrast, this was the case in only two of the control sites. However, the number of species recording a decline in vegetation condition was generally similar between longwall and control sites in spring 2022. Overall, nine species declined in condition across longwall sites but did not decline at any control sites, where a change was recorded, between autumn 2022 and spring 2022. Thirteen species declined in condition in control sites but did not decline at any longwall sites, where a change was recorded and where species occurred in both longwall and control site, between autumn 2022 and spring 2022. Species showing a change in average condition in spring 2022 from autumn 2022 in longwall and control sites are listed in Appendix I.

Table 11: Number of species found to have an increase or decrease in the average condition score in spring 2022, compared to autumn 2022

	Increased Condition	Decreased Condition
Longwall Sites		
Swamp 28 – Transect 1	1 (0)	2 (0)
Swamp 30	1 (0)	4 (0)
Swamp 33	1 (0)	13 (1)
Swamp 35	3 (0)	11 (1)
Swamp 94	3 (0)	7 (0)
<i>Total number of species</i>	<i>7 (0)</i>	<i>22 (2)</i>
Control Sites		
Swamp 101	4 (0)	3 (0)
Swamp 111a	0	11 (1)
Swamp 125*	6 (0)	10 (0)
Swamp 135	4 (0)	3 (0)
Swamp 136	0	13 (0)
Swamp 137a	3 (0)	9 (0)
Swamp 137b	2 (0)	2 (0)
Swamp 138	6 (0)	6 (1)
Bee Creek Swamp	6 (1)	0
<i>Total number of species</i>	<i>20 (1)</i>	<i>26 (2)</i>

Numbers in brackets () indicate species only recorded in either longwall or control sites, in spring 2022.

* increases / decreases for S125 are compared with spring 2021, as no data was collected in this swamp in autumn 2022

As significant differences between longwall and control sites, as measured by both vegetation composition and vegetation condition, were recorded across baseline monitoring seasons and survey seasons following the commencement of mining Longwalls 23-27, the observed differences are attributed to pre-existing differences and natural fluctuations in vegetation cover / abundance and condition between these swamps, driven by factors other than longwall mining.

4.1.3 Indicator species monitoring

Indicator species monitoring data, including a condition / health rating and reproductive rating for each plant, are provided in Appendices E, F and G.

Prior to population monitoring being undertaken in autumn 2021, Swamp 33 was subject to a hazard reduction burn in May 2021. Impacts to indicator species monitoring at this site were minor, with the majority of tagged individuals which were burnt having previously been recorded as dead or with severe dieback (Condition 1) for a number of seasons. One *Epacris obtusifolia* individual recorded with some dead branches (Condition 3) in spring 2020, was killed during the hazard reduction burn.

Condition scale

Over the entire survey period, including the baseline monitoring period (i.e. all surveys up to and including spring 2013), and across all valley side swamps supporting Banksia Thicket / Restioid Heath, there has been a general decrease in the mean vegetation condition of the tagged indicator species, particularly from autumn 2017 to the current spring 2022 survey (Figure 11, Figure 12 and Figure 13). This decrease has occurred at both longwall and control swamps and is considered to reflect the natural fluctuations in plant health associated with herbivory, resource competition, ageing plants, shading from adjacent vegetation, and, in particular drought conditions following an extended period of below-average rainfall from July 2017 to February 2020.

In spring 2022, mean vegetation condition for *Epacris obtusifolia* was greater at control sites than longwall sites, as indicated by the non-overlapping error bars (Figure 11). The mean vegetation condition for *Pultenaea aristata* and *Sprengelia incarnata* individuals was similar, and minimal, between control and longwall sites (Figure 12 and Figure 13). In spring 2022, the mean vegetation condition for tagged individuals of *Epacris obtusifolia* within longwall sites and *Sprengelia incarnata* and *Pultenaea aristata* within both longwall and control sites remained at the lowest recorded condition for these species across all seasons.

The mean vegetation condition of tagged indicator species in swamps supporting Tea Tree Thicket vegetation has varied between longwall and control sites for individual species over the monitoring period (Figure 14 and Figure 15). The mean vegetation condition of tagged *Banksia robur* individuals has been greater in control sites than longwall sites throughout the entire monitoring period, including during the baseline seasons (Figure 14). In spring 2022, the vegetation condition for this species in the longwall Swamp 28 remains at the lowest recorded mean across all seasons. This is because every tagged individual of this species (20) in this swamp has been recorded as Condition 1 (dead) since autumn 2019. Vegetation condition of *Banksia robur* in control swamps has gradually declined since autumn 2011 (baseline) but remained relatively constant between spring 2014 and autumn 2018.

The mean vegetation condition of tagged *Callistemon citrinus* in longwall and control sites has generally remained relatively high and consistent across all seasons, with vegetation condition greater at longwall Swamp 28 up until spring 2016, as indicated by non-overlapping error bars (Figure 15). In spring 2022, mean vegetation condition for *Callistemon citrinus* was similar between control and the longwall site, Swamp 28. The declining trend in the condition of *Callistemon citrinus* individuals within longwall Swamp 28 observed between spring 2019 to autumn 2021, appears to have reversed with the mean condition in spring 2022 being the highest recorded since spring 2017.

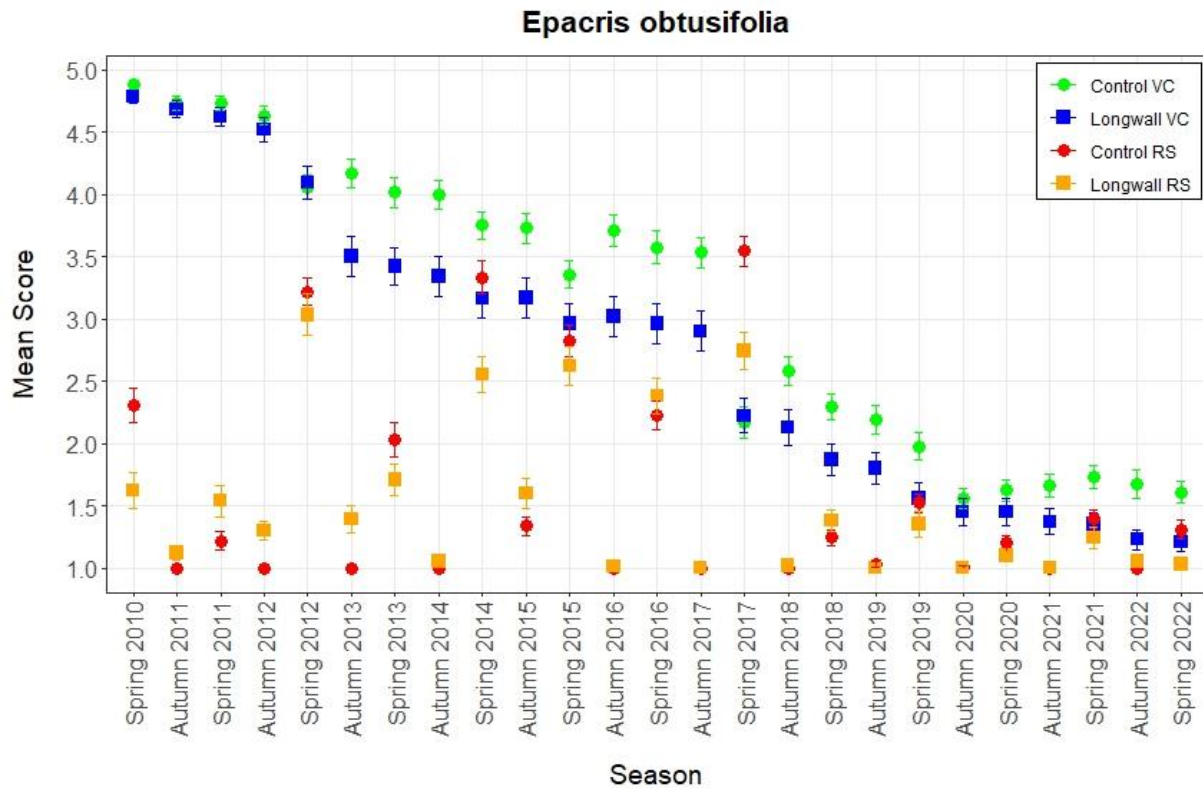


Figure 11: Mean Scores for Vegetation Condition (VC) and Reproductive Status (RS) for the indicator species, *Epacris obtusifolia* (spring 2010 to spring 2022)⁵

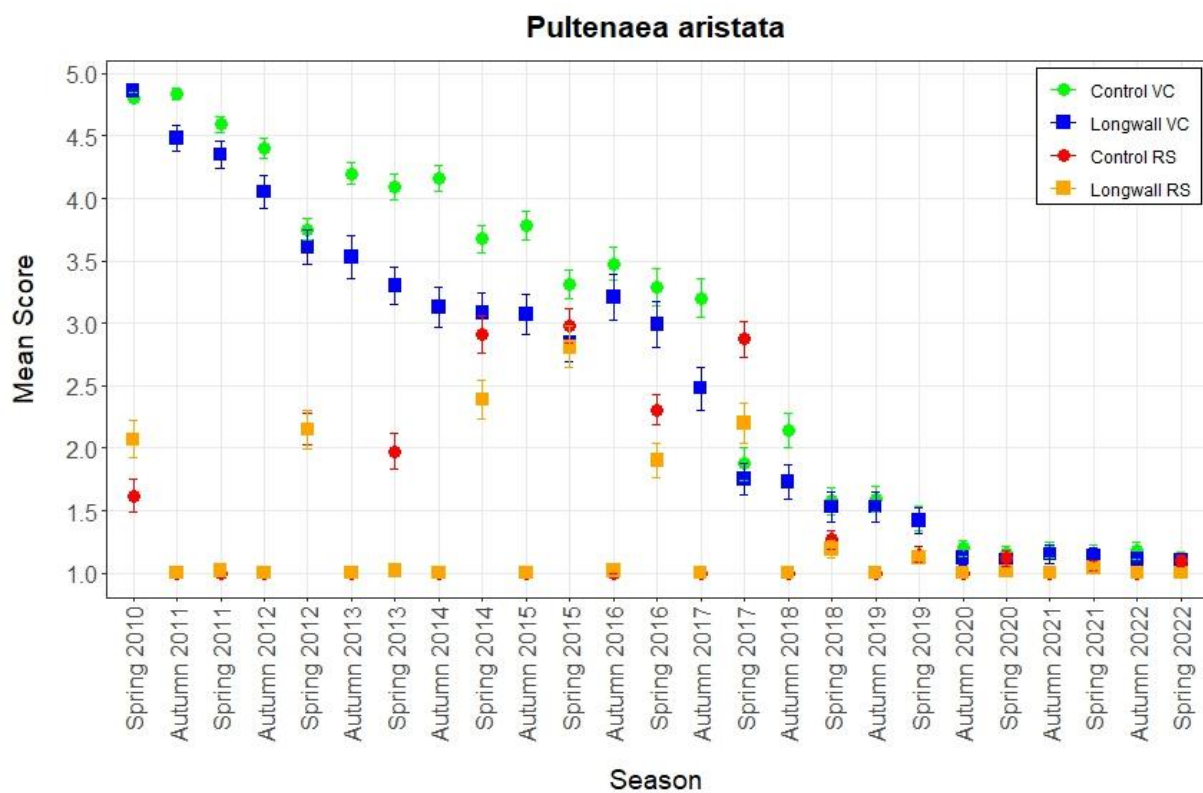


Figure 12: Mean Scores for Vegetation Condition (VC) and Reproductive Status (RS) for the indicator species, *Pultenaea aristata* (spring 2010 to spring 2022)⁵

⁵ Control RS point is often obscured by Longwall RS point where the value is the same, e.g. 1.0

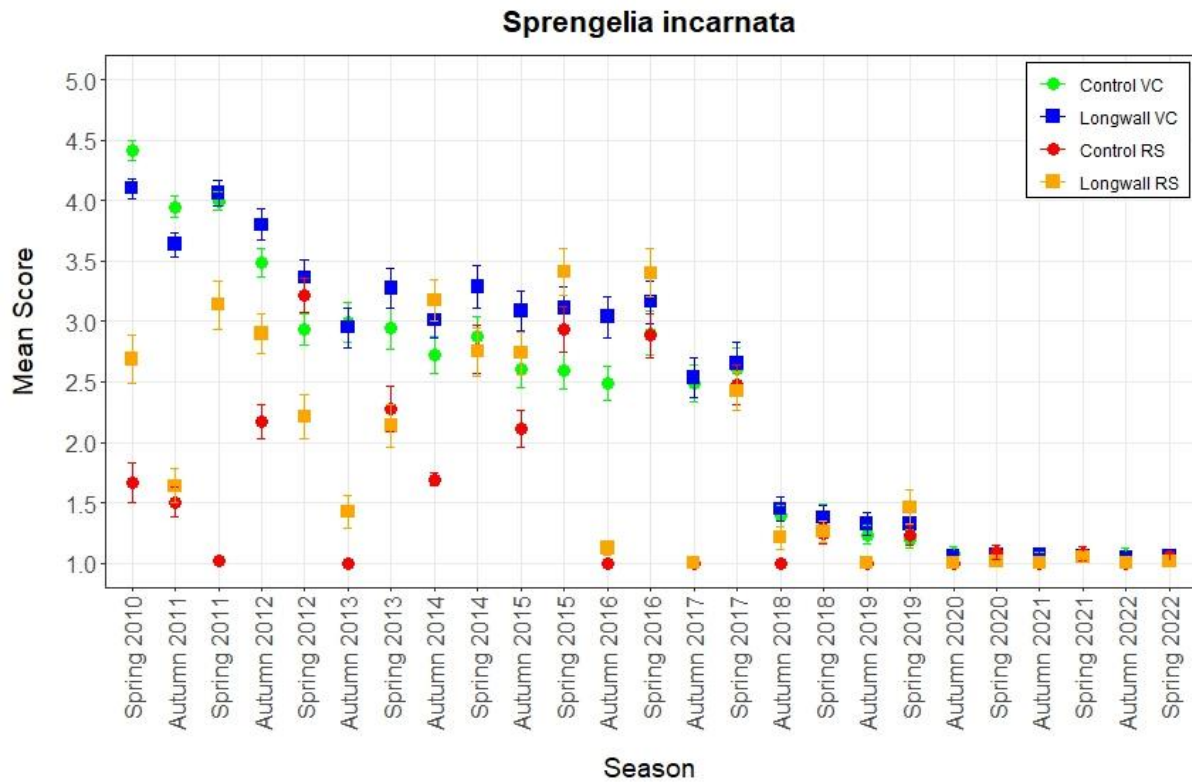


Figure 13: Mean Scores for Vegetation Condition (VC) and Reproductive Status (RS) for the indicator species, *Sprengelia incarnata* (spring 2010 to spring 2022)⁶

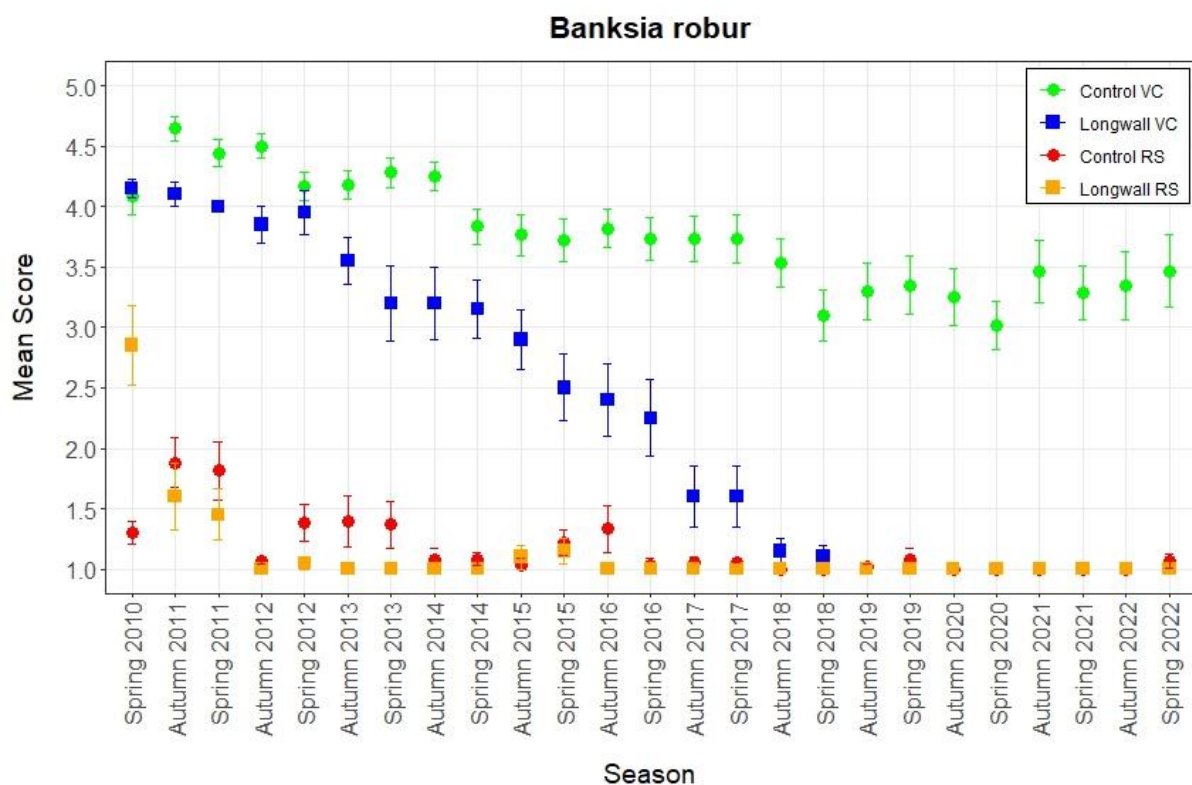


Figure 14: Mean Scores for Vegetation Condition (VC) and Reproductive Status (RS) for the indicator species, *Banksia robur* (spring 2010 to spring 2022)^{6,7}

⁶ Control RS point is often obscured by Longwall RS point where the value is the same, e.g. 1.0

⁷ Longwall VC is obscured by Longwall RS for autumn 2019 to spring 2022

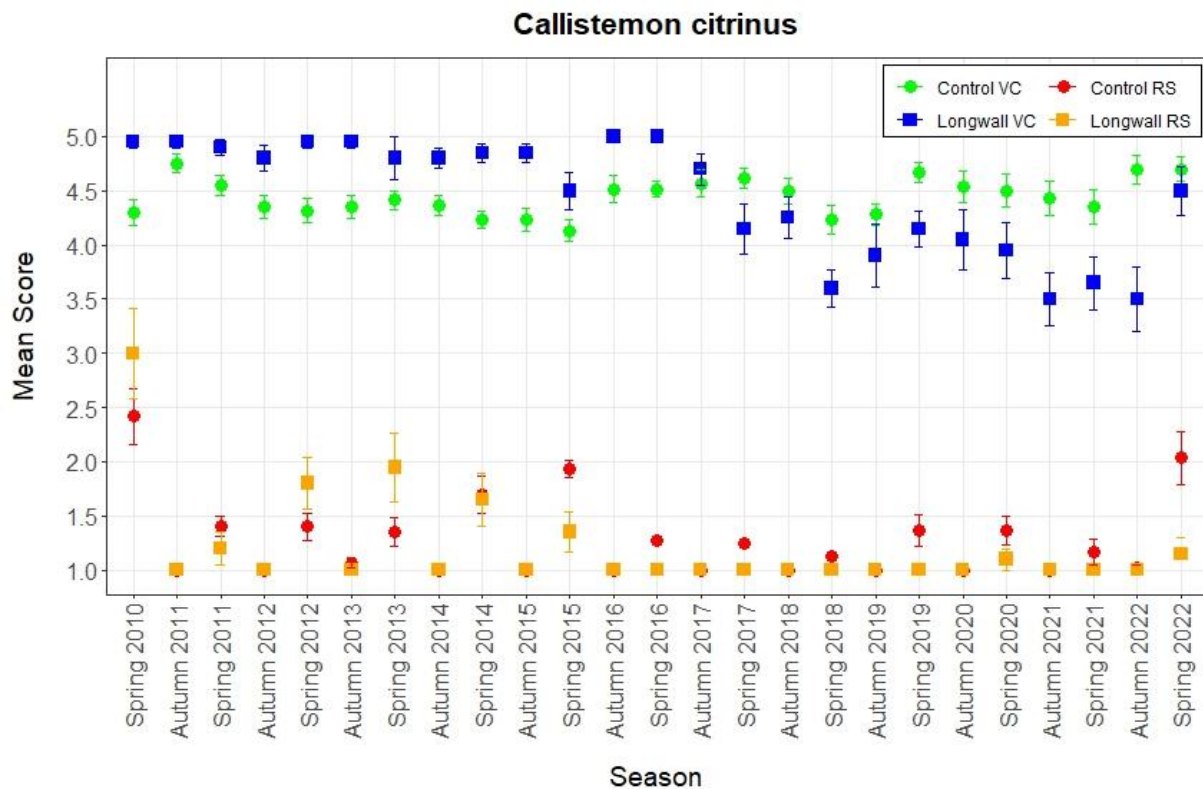


Figure 15: Mean Scores for Vegetation Condition (VC) and Reproductive Status (RS) for the indicator species, *Callistemon citrinus* (spring 2010 to spring 2022)⁸

Reproductive status

The mean reproductive status, as recorded by flowering status, of tagged indicator species, shows that flowering has generally been low to variable across all species within upland swamps and across all seasons including spring 2022 (Figure 11 to Figure 15). The infrequent recording of flowering plants of indicator species across the entire survey period is thought to be related to the timing of surveys not coinciding with peak flowering periods.

Within valley side swamps supporting Banksia Thicket / Restioid Heath, the mean reproductive status of tagged indicator species has been variable between seasons and also between longwall and control swamps in individual seasons (Figure 11 to Figure 13). No clear trends are apparent, apart from a tendency for reproductive status scores to be higher in spring monitoring seasons than autumn for *Epacris obtusifolia* and *Pultenaea aristata*. Where potential differences were observed, as indicated by non-overlapping error bars, the scale of these differences were small (less than 1) although larger differences were observed for individual species in particular seasons. In spring 2022, the mean reproductive status for *Epacris obtusifolia* was higher in control swamps than in longwall sites, although this difference was minimal (<0.5). In spring 2022, the mean reproductive status for *Pultenaea aristata* and *Sprengelia incarnata* was similar between longwall and control sites, with minimal flowering recorded.

⁸ Control RS point is often obscured by Longwall RS point where the value is the same, e.g. 1.0

Within Tea Tree Thicket swamps, mean reproductive status of both *Banksia robur* and *Callistemon citrinus* has been low across all seasons (Figure 14 and Figure 15). Generally, mean reproductive status has been similar between longwall and control swamps, though differences, as indicated by non-overlapping error bars, have been observed in individual seasons. In spring 2022, the mean reproductive status of tagged *Callistemon citrinus* was higher in control sites than in the longwall site, Swamp 28. In spring 2022, the mean reproductive status of tagged *Banksia robur* was similar between the longwall site, Swamp 28, and control sites, with minimal flowering recorded.

Proportion of plants surviving

In spring 2022, 620 of the tagged Banksia Thicket / Restioid Heath swamp indicator species were recorded in Condition 1 (dead or with severe dieback), increasing from 584 individuals recorded in autumn 2022⁹. From autumn 2022 to spring 2022, 10 tagged indicator species individuals declined to Condition 1 after being in a healthier condition in autumn 2022. Six individuals recorded in Condition 1 in autumn 2022 were recorded in an improved condition in spring 2022.

The proportion of the total number of tagged individuals of each indicator species which have been recorded as dead (Condition 1) in each season is presented in Figure 16, Figure 17 and Figure 18. Consistent with previous report findings, in spring 2022 the proportion of individuals which were recorded as dead for *Epacris obtusifolia* and *Pultenaea aristata* was greater in longwall sites than within control sites, whilst the proportion of dead *Sprengelia incarnata* individuals was the same at control sites and longwall sites (0.975).

In spring 2022, there was a higher proportion of dead individuals of *Epacris obtusifolia* at longwall sites (0.96) compared to control sites (0.77), a pattern which has been recorded in all previous seasons since the baseline monitoring period (Figure 16). The difference in proportion dead between longwall and control sites in spring 2022 is similar to the difference observed in previous survey seasons, including the baseline monitoring season, indicating that the observed mortality appears to be driven by natural factors, including extremely dry conditions, herbivory, competition with other vegetation and abiotic factors.

Similarly, the higher proportion of dead individuals of *Pultenaea aristata* at longwall sites (0.96) compared to control sites (0.95) in spring 2022 has been recorded in all previous seasons (Figure 17). The observed trends in mortality for *Pultenaea aristata* across all seasons generally show similar seasonal increases in the proportion dead at both longwall and control sites, however since autumn 2018 there has been an increasing trend in the proportion dead at control sites, which has narrowed the gap between longwall and control sites. In the current spring 2022 survey, there was no change in the proportion dead within longwall sites whilst in control sites a very minor increase was observed, compared to autumn 2022.

The proportion of tagged *Sprengelia incarnata* individuals recorded as dead was the same in control sites and longwall sites (0.975) in spring 2022, with no change in the proportion dead observed at longwall sites since autumn 2020 (Figure 18). A higher proportion of dead *Sprengelia incarnata* individuals within longwall sites has been observed in isolated seasons (autumn and spring 2011, autumn and spring 2020), including the baseline period. Across the monitoring period the proportion

⁹ This large increase is partially due to the absence of population monitoring data from Swamp 125, which was not surveyed in autumn 2022

of dead *Sprengelia incarnata* individuals has generally been greater at control sites, although the difference between longwall and control sites decreased in autumn 2017 and has remained small.

Whilst generally the proportion of plants which have died across all sites continues to increase, and show differences between longwall and control swamps, these changes are consistent with what has been recorded during the baseline monitoring period, indicating that natural factors are contributing to the observed differences in mortality. As discussed in Section 3.6, the survey region experienced an extended dry period from July 2017 through to February 2020. This may account, at least in part, for the increase in the proportion of dead plants observed in all indicator species at both longwall and control sites, particularly from autumn 2018 to autumn 2020.

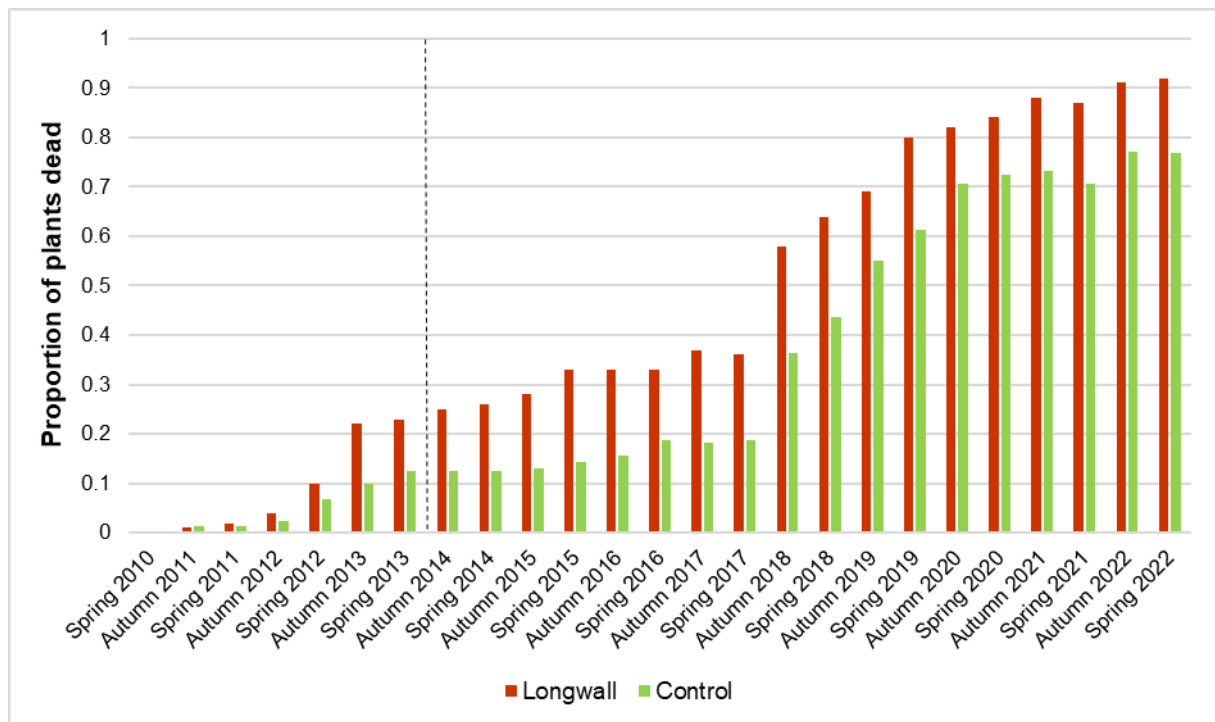


Figure 16: Proportion of tagged *Epacris obtusifolia* which have died at longwall and control Banksia Thicket / Restioid Heath swamps (spring 2010 to spring 2022¹⁰). Dashed line indicates change from baseline monitoring seasons to monitoring undertaken during and post mining of Longwalls 23-27

¹⁰ Figure excludes Swamp 125 from the control data for autumn 2022, as this site was not surveyed during the autumn 2022 season

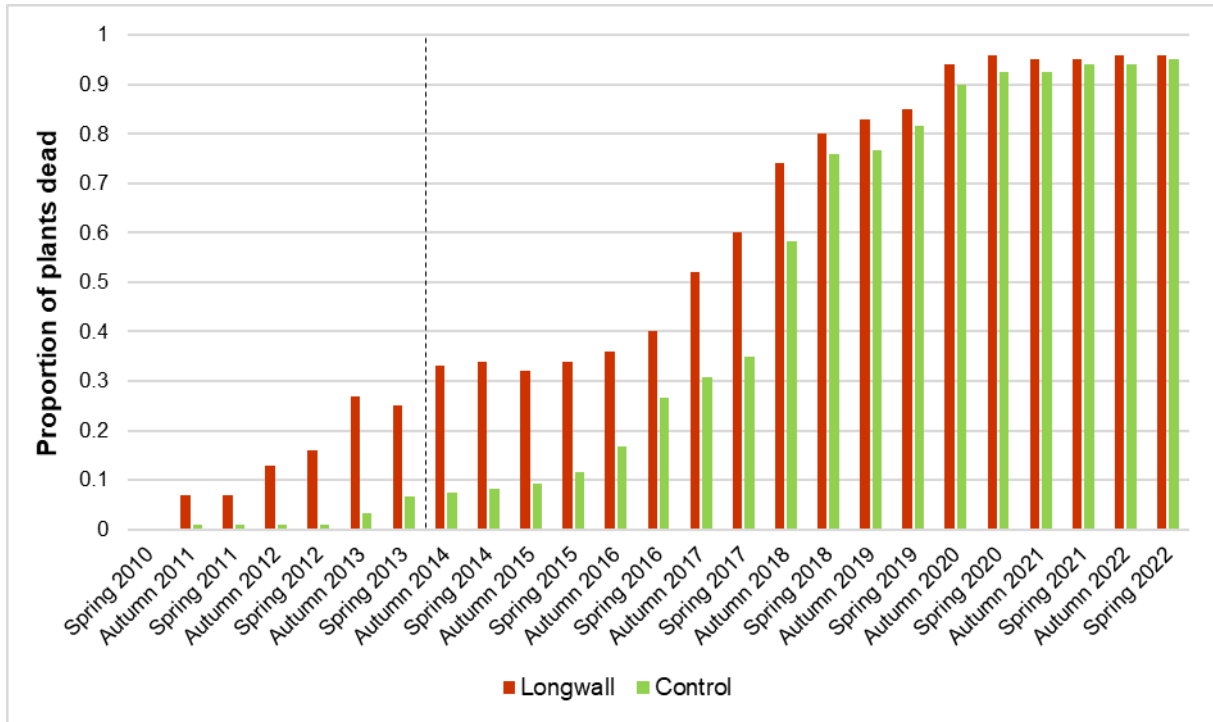


Figure 17: Proportion of tagged *Pultenaea aristata* which have died at longwall and control Banksia Thicket / Restioid Heath swamps (spring 2010 to spring 2022). Dashed line indicates change from baseline monitoring seasons to monitoring undertaken during and post mining of Longwalls 23-27

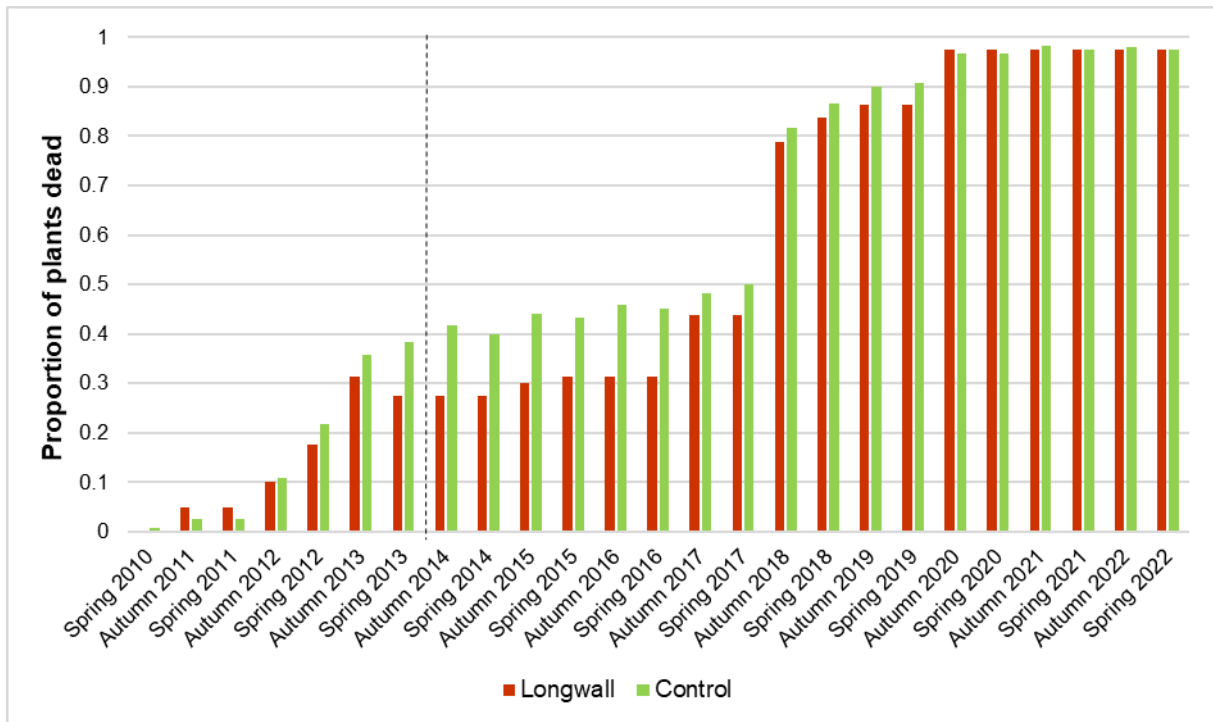


Figure 18: Proportion of tagged *Sprengelia incarnata* which have died at longwall and control Banksia Thicket / Restioid Heath swamps (spring 2010 to spring 2022¹¹). Dashed line indicates change from baseline monitoring seasons to monitoring undertaken during and post mining of Longwalls 23-27

¹¹ Figure excludes Swamp 125 from the control data for autumn 2022, as this site was not surveyed during the autumn 2022 season

In Tea Tree Thicket swamps, observations of dead tagged indicator species have generally been limited to *Banksia robur* individuals, and therefore analysis of the proportion of population monitoring individuals which have died is limited to this species. Individuals of *Callistemon citrinus* have been recorded in Condition 1 in previous seasons in both longwall Swamp 28 and control sites, however, across the whole monitoring period, the previous maximum recorded has been four individuals and in subsequent seasons these individuals have been recorded in an improved condition. In the current spring 2022 season, four *Callistemon citrinus* individual were recorded in Condition 1 across both longwall and control sites.

In spring 2022, 40 of the tagged *Banksia robur* individuals were recorded as dead, increasing from 33 individuals in autumn 2022. Of the 40 individuals recorded as dead in spring 2022, 20 individuals were located within the single longwall swamp (Swamp 28) and the other 20 individuals were located across the three control swamps. As the total number of tagged *Banksia robur* within the longwall site ($n = 20$) is much less than the total number tagged within control swamps ($n = 60$), the proportion of dead *Banksia robur* individuals in autumn 2022 was three times greater within the longwall swamp (proportion dead = 1) compared to that within control swamps (proportion dead = 0.33) (Figure 19).

It is important to emphasize that all longwall *Banksia robur* individuals occur in one site, Swamp 28. Therefore, in spring 2022, the death of all tagged *Banksia robur* individuals within longwall sites, as demonstrated by a proportion dead of 1 (Figure 19), is entirely attributed to one site, Swamp 28. This was first recorded in the autumn 2019 survey. The higher proportion of dead *Banksia robur* individuals at the single longwall site (Swamp 28), compared with control sites, has been observed since spring 2012 during the baseline monitoring period (prior to the commencement of mining Longwalls 23-27), suggesting that it is attributable to natural factors including herbivory, competition with other vegetation, abiotic factors and / or the soil moisture status of Swamp 28 compared to the larger control swamps. The factors causing an increase in *Banksia robur* mortality are likely to be due to environmental conditions associated with smaller swamp size.

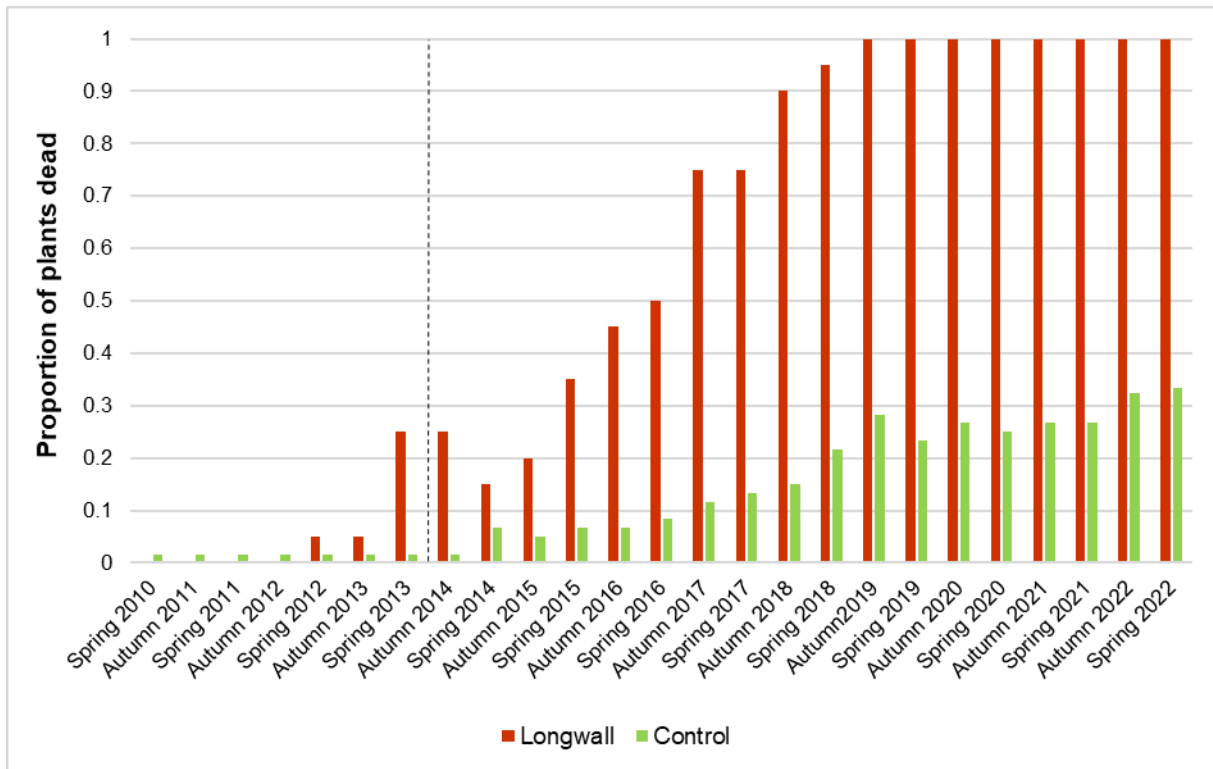


Figure 19: Proportion of tagged *Banksia robur* which have died at longwall and control Banksia Thicket / Restioid Heath swamps (spring 2010 to spring 2022¹²). Dashed line indicates change from baseline monitoring seasons to monitoring undertaken during and post mining of Longwalls 23-27

4.1.4 Assessment against performance indicators

In accordance with the Longwalls 308-310 BMP, the visual observations, transect / quadrat monitoring and indicator species monitoring results are used to assess the upland swamp vegetation performance indicator:

The vegetation in upland swamps is not expected to experience changes significantly different to changes in control swamps.

The Upland Swamp Vegetation Trigger Action Response Plan (TARP) from the Longwalls 308-310 BMP is provided in Appendix C. A summary of the results in relation to the upland swamp vegetation TARP is provided in Table 12.

In previous seasons, the performance indicator has been exceeded for Swamp 28, due to the continual decline in condition of the understorey species, the high mortality rate of *Banksia robur* individuals in comparison to all control sites and the overall declining trend in species richness in the Tea Tree Thicket component (around Transect 2) of this swamp (Table 6). In autumn 2022, there has been an increase in species richness along Transect 2 (Tea Tree Thicket component). These results indicate that in spring 2022, the performance indicator has not been exceeded for this swamp.

¹² Figure excludes Dahlia Swamp data from the control data for autumn 2022, as this site was not surveyed during the autumn 2022 season

Table 12: Summary of Upland Swamp Vegetation Monitoring against Trigger Action Response Plan

Performance Indicator	Monitoring Sites	Baseline	Significance Levels/ Triggers		Spring 2022 Monitoring Results	Action / Response	Comments
<i>The vegetation in upland swamps is not expected to experience changes significantly different to vegetation in control swamps</i>	- Swamps 19, 28, 30, 31, 32, 33, 34, 35, 36 and 94 overlying or adjacent to Longwalls 23-27. - Control Swamps 101, 111a, 125, 135, 136, 137a, 137b, 138, Bee Creek Swamp, Woronora River 1, Woronora River south arm and Dahlia Swamp.	Longwalls 23-27 swamps, as detailed in the LW23-27 vegetation monitoring report for the spring 2010 to spring 2013 surveys¹.	Level 1	Data analysis indicates: - there is not a declining trend in the condition of longwall swamp vegetation; and - there are no significant changes in vegetation between the mined and control swamps.	Swamps 19, 30, 31, 32, 33, 34, 35, 36 and 94	Continue monitoring. Six monthly reporting.	The declining trend in the condition of longwall swamp vegetation previously recorded by vegetation monitoring from spring 2017 to spring 2018 for Swamps 30, 32, 33, 34, 35, 36 and 94 has stabilised, although fluctuations in species richness continue to be observed in spring 2022. In spring 2022, vegetation condition at longwall Swamps 19 and 31 appears to have stabilised, particularly with regards to senescing shrubs, following a declining trend which commenced autumn 2015. Similar trends are apparent in the vegetation of some control sites.
			Level 2	Data analysis indicates: - there is a declining trend in the condition of longwall swamp vegetation over time, however a similar trend is occurring in control swamp vegetation; or - there are significant differences in vegetation between the mined and control swamps, however, the data indicates longwall swamp vegetation is consistent with the baseline monitoring results.	Swamp 28	Consider swamp groundwater monitoring data. Six monthly reporting.	The ongoing decline in the vegetation condition of the Tea Tree Thicket component of Swamp 28 with regards to condition of understorey species and decline in species richness appears to have stabilised and is showing early signs of reversing. Similar trends are apparent in the vegetation of some control sites. Continue close monitoring of trends in vegetation to assess the contribution of climatic condition versus mine subsidence impacts.
			Level 3	Data analysis indicates: - there is a declining trend in the condition of longwall swamp vegetation over time that is not occurring in control swamp vegetation; or - there are significant differences in vegetation between the mined and control swamps, and the data indicates longwall swamp vegetation is not consistent with the baseline monitoring results.	–	Consider swamp groundwater monitoring data. Initiate assessment against the performance measure ² . Consider the need for management measures, in accordance with Sections 8 and 9.	–

¹ Eco Logical Australia (2013) *Metropolitan Coal Vegetation Monitoring, Longwalls 23-27 – Baseline Data*. Report prepared for Metropolitan Coal.

² Threatened species, populations and ecological communities include those listed under the BC Act, EPBC Act or Fisheries Management Act at the time of Project Approval (i.e. the lists current as at 22 June 2009).

4.2 Riparian vegetation monitoring

4.2.1 Visual inspections

Visual inspections of riparian areas have been conducted in locations adjacent to riparian vegetation monitoring sites (i.e. sites MRIP01 to MRIP12) and areas traversed whilst accessing the monitoring sites. The current spring 2022 survey commenced following a period of very high rainfall (Table 3). During the spring 2022 survey, both September (150.0 millimetres) and October (250.5 millimetres) experienced more than double the amount of rainfall compared to the monthly means respectively. November and December 2022 were much drier in comparison, receiving approximately half of the mean rainfall for those months.

Sites MRIP01, MRIP02, MRIP03, MRIP04 and MRIP10 on the Waratah Rivulet were surveyed from mid-November to mid-December. In spring 2022 water was present and flowing at all longwall and control sites on the Waratah Rivulet. Water levels at most Waratah Rivulet monitoring sites (both longwall sites (MRIP01 and MRIP02) and two of the control sites (MRIP03 and MRIP04)) were similar to the previous autumn 2022 survey. The exception was control site MRIP10, where the lower reaches of this site were significantly inundated in autumn 2022. Water levels in spring 2022 were slightly lower than recorded in autumn 2022, which had been observed to be significantly higher than recorded in this site since autumn 2015. At this location, stream side sand banks and vegetation have been swept away, leaving a much larger pool at this section of the Rivulet and inundation of the boulder field and vegetation upstream (Plate 9) and downstream (Plate 10). At both longwall monitoring sites (MRIP01 and MRIP02) water was generally clear with lower levels of iron-oxidising bacteria growth and iron floc observed compared to autumn 2022. At control sites (MRIP03, MRIP04 and MRIP10), water appeared clear and iron floc was absent. Very minor iron-stained seepage was recorded at all longwalls (MRIP01 and MRIP02) and most control monitoring sites (MRIP03 and MRIP10), in spring 2022, and, in contrast to the previous season, seepage did not have a metallic sheen.

Sites MRIP05, MRIP06, MRIP07, MRIP08, MRIP09, MRIP11 and MRIP12 on the Eastern Tributary were surveyed from the end of October to mid-November. Water levels at both longwall (MRIP05, MRIP06, MRIP09, MRIP11 and MRIP12) and control (compromised) (MRIP07 and MRIP08) monitoring sites were generally similar to or slightly higher than the previous autumn 2022 survey period. Locations within MRIP05, MRIP06, MRIP09 and MRIP12 where water was absent and aboveground flow discontinuous in spring 2021, were again observed with water flow in spring 2022. Water levels and associated surface flow between Eastern Tributary monitoring sites MRIP05, MRIP06 and MRIP09 has been variable across the survey period, ranging from very low and discontinuous (e.g. spring 2017) to free flowing (e.g. spring 2018). In particular, water levels in the pool at MRIP05 (ETJ) have varied considerably since first being recorded as dry in spring 2016, however water has been recorded in the pool from spring 2019 to the current survey (Plate 11). At all riparian monitoring sites on Eastern Tributary water was flowing fast and clear to slightly cloudy. Compared to autumn 2022, only minor to moderate levels of iron-oxidising bacteria growth and iron floc were observed at MRIP05 and MRIP06, whilst at longwall site MRIP11 moderate to high levels of iron floc covered all in-stream vegetation and rocks (Plate 12). The remaining Eastern Tributary sites, MRIP07, MRIP08 and MRIP12, were free of iron floc and cloudy only in isolated locations, in spring 2022.

Prior to the autumn 2017 survey, mine subsidence impacts to pool drainage behaviour were recorded by Metropolitan Coal (Metropolitan Coal, 2017) at sites MRIP07 and MRIP08¹³. Since this time water levels and surface flow between sites has been variable, ranging from dry (e.g. MRIP07, autumn 2019), to low levels with minor flow (e.g. autumn 2017), to high levels and continuous flow (e.g. spring 2018). In the current spring 2022 survey, water flow throughout both sites was continuous and levels remain similar to, or slightly higher than, previous seasons (Plate 13 and Plate 14), with the exception of the considerably higher levels downstream of MRIP08, below the waterfall (Plate 15).

Whilst all riparian sites have been subject to high water flows in previous survey years, this was particularly the case immediately prior to, and during, both the previous (autumn 2022) and the current (spring 2022) survey seasons. The impacts of these high water flows and flooding in spring 2022 were only marginally greater than what was observed in Autumn 2022, but included:

- At most riparian sites vegetation was observed to be flood-swept and prone, with loss of individual plants, burial of vegetation by adjacent vegetation, and burial by woody flood debris and sediment. The exception to this was control site MRIP04, which has a more rocky substrate, which had minimal flood impacts to vegetation.
- The erosion, bank scouring and undercutting which was observed at most sites in autumn 2022, was generally only slightly exacerbated in spring 2022. There was little to minor increase of the moderate to severe bank erosion previously observed at a number of longwall (MRIP02, MRIP05 and MRIP06) and control (MRIP03) sites.
- In isolated areas high water flows prior to autumn 2022 resulted in complete removal of sections of bank, most severely at MRIP03 where an extensive section of the eastern bank, around the transect location, has been washed away. This has not extended in spring 2022 (Plate 16).
- In autumn 2022, isolated bank scouring had resulted in changes to stream flow and caused new, or expanded, pooling at MRIP07, MRIP08, MRIP10, MRIP09 and MRIP12. In spring 2022 this pooling was only observed at MRIP09, whilst at MRIP12 it had been extended so that a section of bank had been removed (Plate 17).
- The new inundation of the lower reaches of MRIP10 which was first observed in autumn 2022 was at a similar level in spring 2022 (Plate 18), with no extension of the impacts observed in autumn 2022: swept away / submerged stream-side banks; loss of large mid-stream sand bank near Photo Point 2, which previously supported a dense stand of tall shrubs and *Typha orientalis* (Cumbungi), in spring 2022.
- Areas of increased sediment deposition observed in autumn 2022, along both the Waratah Rivulet and the Eastern Tributary, had not increased considerably in spring 2022. The extensive deposition of sediment observed on the Eastern bank at longwall site MRIP02, along Waratah Rivulet, had a minor extension in spring 2022 (Plate 19), whilst there was no change to the sediment deposition around the control site MRIP04 transect which had buried much of the riparian vegetation and increased the height of the bank in autumn 2022. A moderate increase to the sand bar at MRIP10 was observed in spring 2022 (Plate 20).

¹³ Riparian vegetation monitoring sites MRIP07 and MRIP08 were used as control sites for comparison against the longwall riparian monitoring sites prior to subsidence impacts occurring to pools on the Eastern Tributary at these sites post spring 2016 and before autumn 2017. Analyses from autumn 2017 onwards no longer considers these sites as control sites.

Apart from flood impact, vegetation was generally observed in good condition across, and adjacent to, the riparian monitoring sites. Exceptions to the generally good condition of riparian vegetation in spring 2022 include the following:

- Plants recorded with dieback throughout most riparian sites tended to be isolated to a few individuals scattered throughout the sites; the most common and widespread included *Allocasuarina littoralis*, *Banksia ericifolia* subsp. *ericifolia*, and *Hakea salicifolia*. These were often stream side individuals, which had been impacted by high water flows, and were associated with floodswept / prone vegetation or undercutting of the banks causing shrubs to fall into the water.
- A hazard reduction burn was conducted in the Woronora Catchment in May 2021, which impacted sites along Eastern Tributary, north of Firetrail 9J, i.e. MRIP07, MRIP08, MRIP11 and MRIP12. While this was a very patchy fire, it did burn down to the water edge in places, leaving patches of standing dead shrubs (MRIP11 and MRIP12). Regrowth of burnt areas remained minimal in spring 2022, partially due to flood impacts from recent high water flows (Plate 21).
- At longwall site MRIP01, along Waratah Rivulet, vegetation was generally found to be flood-swept but in good condition with isolated or scattered individuals of the shrub species *Acacia obtusifolia*, *Allocasuarina littoralis*, *Banksia ericifolia* subsp. *ericifolia*, observed with dieback in spring 2022. Post flood recovery was apparent along the transect, particularly in the ground layer with new growth on *Eurychora complanata* and *Gymnoschoenus sphaerocephalus*.
- At longwall site MRIP02, along Waratah Rivulet, vegetation in spring 2022 remained flood-swept, with many patches of prone shrubs. However, recovery in the form of resprouting shrubs and new growth of ground layer species was common (Plate 19). Previously, vegetation dieback at MRIP02 was initially recorded at longwall site MRIP02 in spring 2012, remaining evident up to autumn 2017. Vegetation condition improved until autumn 2018, when extensive areas of vegetation dieback were again recorded. From autumn 2019 to the current spring 2022 survey, vegetation has been observed in an improved condition with new growth within areas of previous dieback, despite impacts of floods. Past and current observations of vegetation dieback and loss at this site were due to both drought and flood events, with areas of prone dead vegetation remaining evident throughout the site.
- At longwall sites MRIP05 and MRIP06, along the Eastern Tributary, dieback of groundcover and shrub layer vegetation has been previously recorded along a discontinuous band, immediately adjacent to the water's edge (i.e. along the top of bank). As detailed in previous reports (Eco Logical 2019b), vegetation condition at MRIP05 has fluctuated between dieback and recovery since spring 2013, particularly affecting both ground layer species, in particular *Bauera rubioides*, *Gleichenia microphylla*, *Schoenus melanostachys* and *Sporadanthus gracilis*. In autumn 2018, dieback was greater than 50 cm from top of bank in some areas at both MRIP05 and MRIP06, whilst from spring 2018 to the current spring 2022 survey vegetation within these patches appeared to improve, with regrowth occurring despite impacts due to high water flow. In the current spring 2022 survey vegetation at both sites were flood-swept with a sparse ground layer often covered by woody flood debris, however where ground layer species did occur they were generally observed in a healthy, recovering, condition, especially *Gahnia sieberiana*, *Gleichenia microphylla*, *Schoenus melanostachys* and *Sporadanthus gracilis* (Plate 22).

- At longwall site MRIP09, along the Eastern Tributary, vegetation was observed to have been extensively impacted by recent high-water flow, with flood swept vegetation and scattered shrubs uprooted or prone. Healthy vegetation was also observed throughout the site in spring 2022, with regrowth of ground layer species commonly recorded (Plate 23). Dieback of shrubs and ground layer plants has been observed in this location since spring 2013, extending throughout 2014, and showing signs of improvement in the condition of ground layer species in autumn 2015 (Eco Logical 2018b). Further dieback of ground layer and shrub layer vegetation was observed in autumn 2018 along a discontinuous band immediately adjacent to the water's edge (i.e. the top of bank) at the lower end of MRIP09 (Photo Point 2) and extending discontinuously downstream to MRIP05. The extent of this dieback did not increase between autumn 2018 and spring 2022.
- At longwall site MRIP11, along the Eastern Tributary, vegetation along the edge of the creek has been observed in a variable condition since autumn 2016. High water flow events, including those immediately prior to and during the previous seasons' (autumn 2022) as well as prior to the current seasons' (spring 2022) survey, have led to inundation of streamside vegetation and undercutting of banks on a number of occasions, resulting in abundant floodswept vegetation throughout (Plate 24). Despite this, patchy recovery of streamside vegetation has been observed from spring 2018 to the current spring 2022 survey, with healthy growth was recorded on a number of ground layer species including *Baumea juncea*, *Gleichenia microphylla*, and *Sporadanthus gracilis*. Scattered dead *Allocasuarina littoralis*, and *Banksia ericifolia* subsp. *ericifolia* individuals were observed along the bank edge often in areas of erosion or sediment loss, although healthy individuals of these species were also observed.
- At longwall site MRIP12, along the Eastern Tributary, vegetation along the edge of the creek has been observed in a variable condition since spring 2017, when widespread dieback of ground layer species and discolouration of shrub species was noted. Vegetation condition continued to decline at this site, and in autumn 2018 large areas of *Gleichenia microphylla* dieback exceeded 50 cm from the top of bank, associated with the increased pooling of water recorded upstream of Photo Point 1. Dieback of *Gleichenia microphylla* has remained similar from autumn 2018 to the current spring 2022 survey, with no additional areas of dieback observed. Impacts to vegetation from recent high-water flows are evident in the current spring 2022 survey, including observations of prone and/or dead individuals of *Allocasuarina littoralis* and *Banksia ericifolia* subsp. *ericifolia*, abundant flood debris and exposure of plant roots due to erosion. Despite this, no new or extended areas of vegetation dieback greater than 50 cm from top of bank were recorded in spring 2022.
- At control sites MRIP03, MRIP04 and MRIP10, along Waratah Rivulet, vegetation in spring 2022 showed signs of high water flow and inundation, with occasional dead individuals of *Allocasuarina littoralis* and *Banksia ericifolia* subsp. *ericifolia*, but was generally in good condition. At MRIP10 large areas of vegetation around the former boulder field (Photo Points 2, 5 and 6) were inundated or swept away as a result of considerable new pooling, as detailed above (Plate 9, Plate 10, and Plate 18). As a result, riparian vegetation in this part of the stream is much more sparse than previous seasons and, where it remains, it is usually prone and / or dying as a result of inundation and high velocity water flow. Upstream of this area, the vegetation was generally in similar condition to other riparian sites, i.e. floodswept, but generally healthy and recovering.

No new areas of bedrock cracking were observed within longwall sites MRIP01, MRIP02, MRIP05, MRIP06, MRIP09, MRIP11 or MRIP12 in spring 2022. Observations of cracking or rock displacement over the monitoring period at the riparian monitoring sites are summarised below:

- Cracking of streamside rocky areas at the downstream end of MRIP01, and further downstream between MRIP01 and MRIP02, was first observed during surveys between autumn 2011 and 2012. Since this time, cracking has been observed to increase and pieces of cracked bedrock at these sites have been transported downstream by higher water flows. Cracking and bedrock movement did not change between the spring 2017 and the current spring 2022 survey.
- Fine hairline cracking of bedrock was observed for the first time at control site MRIP04 in spring 2019, on the eastern bank below a small scarp (Photo Point 6). No changes to these cracks were observed in the current spring 2022 survey.
- Cracking of bedrock was observed for the first time at MRIP05 in autumn 2016, at the pool below Photo Point 5 (between sites MRIP05 and MRIP06). In autumn 2017, further cracking was recorded across the rock bar just upstream of the pool, extending across the width of the rock bar, and a second crack was recorded approximately 1 m upstream. In subsequent surveys, previously recorded cracks at this site generally appeared unchanged, with some extension of cracks over time. No changes to this or other cracks within MRIP05 were observed in the current spring 2022 survey.
- A new area of in-stream bedrock cracking was recorded for the first time in autumn 2017 at site MRIP07 (Photo Point 2c), resulting in little water flow at this site and downstream to MRIP08. At this time, cracking was also observed at Photo Point 4, just upstream of site MRIP08. In autumn 2018 an additional small crack was recorded within MRIP07 at Photo Point 1. Additional hairline cracks were observed for the first time in autumn 2019 in MRIP08 at Photo Point 1 and Photo Point 4. In spring 2019 and spring 2020, sections of cracked rock at Photo Point 4 were missing, presumed to have been washed down stream. Additional cracking observed in autumn 2020 on the western bank adjacent the waterfall and in spring 2021 below the waterfall area appear unchanged in the spring 2022 survey.
- Cracking was first observed at longwall monitoring site MRIP12 during the autumn 2018 survey at Photo Point 1 and Photo Point 2, with fragments of cracked rock at Photo Point 2 beginning to break up and shift in spring 2020. In autumn 2022 the downstream portion of a large rock slab at this Photo Point was observed missing, likely by recent high water flow (Plate 25). Additional instream bedrock cracking observed for the first time in autumn 2021 at PP5a appeared unchanged in the current spring 2022 survey.
- Across all observations, including sites MRIP07 and MRIP08, no impacts to adjacent vegetation were observed in association with any of the observed bedrock cracking.

Two introduced species were observed in riparian monitoring sites: *Gamochaeta* sp. (Cudweed) (MRIP10), and *Hypochaeris radicata* (MRIP02). No introduced aquatic species have been recorded in streams adjacent to the riparian monitoring sites.



Plate 9: Waratah Rivulet, MRIP10, Photo Point 2, upstream, showing inundation of boulder field in spring 2022 (top) compared to spring 2021 (bottom)



Plate 10: Waratah Rivulet, MRIP10, Photo Point 5a, downstream, showing inundation and impact to stream side vegetation in spring 2022 (top) compared to spring 2021 (bottom).



Plate 11: Eastern Tributary, adjacent to MRIP05, with water in pool ETJ – spring 2022



Plate 12: Eastern Tributary, MRIP11, Photo Point 4, upstream view – spring 2022



Plate 13: Eastern Tributary, MRIP07, Photo Point 2A, upstream view – spring 2022



Plate 14: Eastern Tributary, MRIP08, Photo Point 4, upstream view – spring 2022



Plate 15: Eastern Tributary, MRIP08, Photo Point 8, downstream view – showing much higher water level in spring 2022 (top) compared to spring 2021 (bottom)



Plate 16: Waratah Rivulet, MRIP03, at start of transect where section of bank was washed away in the previous season, showing no extension of removal – spring 2022



Plate 17: Eastern Tributary, MRIP12, Photo Point 1a, erosion beyond stream bank caused altered flow path in the previous season (autumn 2022 – bottom photo), which has extended in the current season (spring 2022 – top photo), causing removal of bank section



Plate 18: Waratah Rivulet, MRIP10, Photo Point 5, west bank, showing inundation of sand bank vegetation and expansion of pool in spring 2022 (top) compared to spring 2021 (bottom)



Plate 19: Waratah Rivulet, MRIP02, Photo Point 1 view of east bank upstream, showing moderate increase of sedimentation – spring 2022



Plate 20: Waratah Rivulet, MRIP10, Photo Point 3, showing increased sediment deposition – spring 2022



Plate 21: Eastern Tributary, MRIP11, limited regrowth following May 2021 hazard reduction burn – spring 2022



Plate 22: Waratah Rivulet, MRIP05, continued recovery of stream side vegetation – spring 2022



Plate 23: Eastern Tributary, MRIP09, Photo Point 3, view upstream – autumn 2022



Plate 24: Eastern Tributary, MRIP11, Photo Point 3, areas of flood swept vegetation – spring 2022



Plate 25: Eastern Tributary, MRIP12, Photo Point 2, showing missing rock sections in spring 2022 (top) compared to spring 2021 (bottom)

4.2.2 Quadrat monitoring

Prior to the autumn 2017 survey, mine subsidence impacts to pool drainage behaviour were recorded by Metropolitan Coal at sites MRIP07 and MRIP08, downstream of Longwall 27 (Metropolitan Coal 2017). Prior to the impacts occurring, sites MRIP07 and MRIP08 were used as control sites for comparison against the longwall riparian monitoring sites. Analyses from autumn 2017 will no longer consider these sites as control sites (consistent with the Longwalls 308-310 BMP (Metropolitan Coal 2022)).

Vegetation structure, dominant species and estimated cover for each stratum

The vegetation structure, dominant species and estimated cover for each stratum at riparian monitoring sites is provided in Appendix H.

In spring 2022, the percent cover and height of the structural layers was generally similar to that recorded for previous seasons. Across all seasons (since the surveys commenced in spring 2010), the vegetation structure, dominant species and estimated cover for each stratum has varied between sites and between seasons within sites. Results have generally fluctuated with no clear trends in vegetation height or cover across sites.

In the current spring 2022 survey, lower-storey foliage cover was variable within both longwall and control sites compared to the previous autumn 2022 survey, with an increase observed at longwall site only (MRIP01, MRIP02, and MRIP06), ranging from 5% to 25%. A decrease in the cover of lower-storey foliage was observed at a similar number of longwall (MRIP05, MRIP11 and MRIP12), ranging from 5% to 25%. No change was observed at two control sites (MRIP03 and MRIP04), whilst increases were observed at the two control (compromised) sites (MRIP07, MRIP08). These trends are considered to reflect both the natural variations in the height and cover of vegetation structural layers through time (including in response to flooding impacts), as well as the subjective nature of the data collection.

At MRIP02, the vegetation cover has revealed some considerable fluctuations over the monitoring period. Season to season detail of changes in cover and dominant species has been provided in previous reports (Eco Logical Australia 2012b – 2023). In summary, the cover of the ground layer declined from being consistently above 60% prior to spring 2012 to below 50%, sometimes as low as 15%, in all seasons following. This is likely attributable to the water loss experienced at this site in spring 2012 and altered water levels observed after this time, including periods where the vegetation at site MRIP02 has been submerged or inundated. In addition, the extended dry period from July 2017 resulted in a decrease in ground layer cover to 20% in autumn 2018 which coincided with observations of extensive areas of dead *Gleichenia microphylla* and *Pteridium esculentum* observed on both sides of the creek. Recent seasons have seen small increases in the cover and recovery of these species, with a slight increase in the cover of the ground layer from 35% in autumn 2022 to 40% in spring 2022. Although previous high water flows have resulted in erosion and sediment loss along the transect (Section 4.2.1), regrowth of dominant ground layer species, such as *Gleichenia microphylla* and *Sticherus flabellatus* var. *flabellatus*, continues to be recorded.

Species richness

A summary of species richness within riparian monitoring sites since spring 2010 is provided in Table 13 and Figure 20. The raw data for each riparian monitoring site is presented in Appendix H.

In spring 2022, species richness within riparian monitoring sites was generally similar to previous seasons, with all values falling within the range observed across previous seasons for individual sites. When comparing species richness in spring 2022 to autumn 2022, a decrease in species richness occurred at only one longwall site, (MRIP06 – 12 species). This is in contrast to the previous reporting period during which species richness fell in all longwall sites. Similarly, at control and control (compromised) riparian monitoring sites, increases in species richness were observed for all sites, in spring 2022. The very large decline in species richness observed across most sites between spring 2021 and autumn 2022, in particular at control sites MRIP03 and MRIP04, was associated with heavy flood impacts following the extremely high rainfall in February 2022.

Across the entire monitoring period (spring 2010 – spring 2022), an overall decrease in species richness was initially observed in both longwall and control monitoring sites. This trend, however, appeared to be reversing for both control and longwall sites, with an overall increase in species richness observed from spring 2017 to autumn 2022. The sharp declines in species richness that were observed across all longwall and control sites in autumn 2022 were attributed to flooding events which caused damage and stress to riparian vegetation through: being undercut by bank erosion; mechanical damage from high volume and velocity water flow; and burial by woody debris and sediment deposition. As these trends were observed across control sites and longwall sites, and appear to be reversing in spring 2022, these changes are likely in response to climate, population dynamics and natural disturbances including flood and drought.

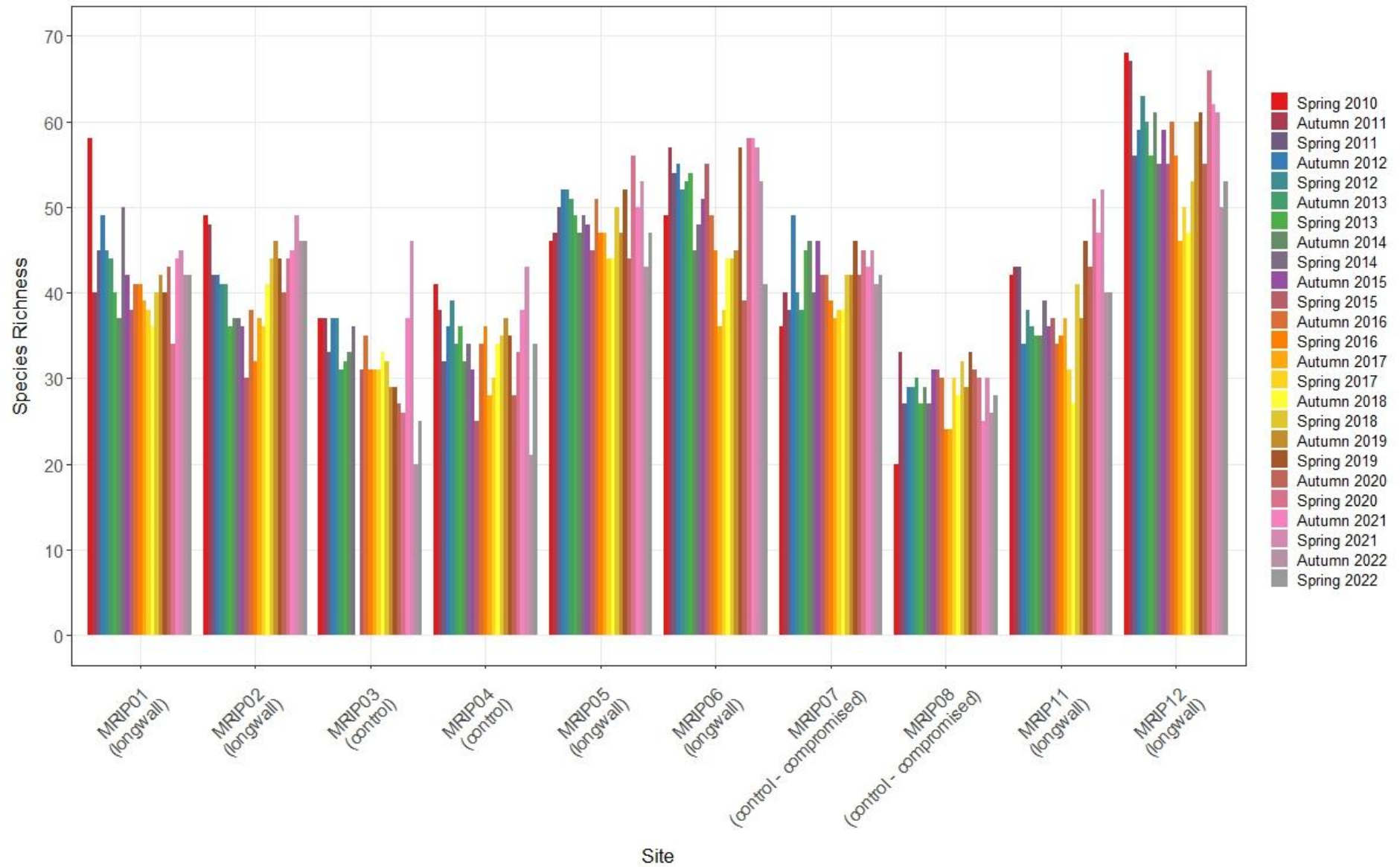


Figure 20: Native species richness within riparian monitoring sites across all seasons, spring 2010 to spring 2022, BL = baseline

Table 13: Number of native species recorded in riparian sites across all seasons (spring 2010 to spring 2022)

Site	Spring 2010	Autumn 2011	Spring 2011	Autumn 2012	Spring 2012	Autumn 2013	Spring 2013	Autumn 2014	Spring 2014	Autumn 2015	Spring 2015	Autumn 2016	Spring 2016	Autumn 2017	Spring 2017	Autumn 2018	Spring 2018	Autumn 2019	Spring 2019	Autumn 2020	Spring 2020	Autumn 2021	Spring 2021	Autumn 2022	Spring 2022
Longwall Sites																									
MRIP01	58 (1)	40	45	49	45	44	40	37	50	42	38	41	41	39	38	36 (2)	40	42	40	43	34	44	45	42	42
MRIP02	49	48	42	42	41	41	36	37	37	36	30	38 (1)	32 (1)	37 (1)	36	41 (1)	44	47 (1)	44 (1)	40 (1)	44	45	49 (1)	46	46
MRIP05	46	47	50	52	52	51	49	47	49	48	45	51	47	47	44	44	50	47	52	44	56	50	53	43	47
MRIP06	49	57	54	55	52	53	54	45	48	51	55	49	45	36	38	44	44	45	57	39	58	58	57	53	41
MRIP07	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	37	38	38	42	42	46	42	45	43	45	41	42
MRIP08	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	24	30	28	32	29	33	31	30	25	30	26	28
MRIP11	42	43	43	34	38	36	35	35	39	36	37	34	35	37	31	27	41	37	46	43	51	46 (1)	52	40	40
MRIP12	68 (3)	67 (5)	56	59	63	60	56	61 (1)	55	59	55 (1)	60	56	46	50	47	53	60 (1)	61 (1)	55	66	62	61	50	53
Control Sites																									
MRIP03	37	37	33	37	37	31	32	33	36	-	31	35	31	31	31	33	32	29	29	27	26	37 (2)	46 (1)	20	25
MRIP04	41	38	32	36	39	34	36	32	34	31	25	34	36	28 (1)	30	34	35	38	35	28	33	38	44 (1)	21	34
MRIP07	36	40	38	49	40	38	45	46	40	46	42	42	39	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
MRIP08	20	33	27	29	29 (1)	30	27	29	27	31	31	30	24	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A

NB: numbers in brackets indicate the number of exotic species recorded in addition to native species

* Riparian vegetation monitoring sites MRIP07 and MRIP08 were used as control sites for comparison against the longwall riparian monitoring sites prior to subsidence impacts occurring to pools on the Eastern Tributary at these sites post spring 2016 and before autumn 2017. Analyses from autumn 2017 onwards no longer considers these sites as control sites.

Cover / abundance and condition

The cover / abundance and condition ratings for each species are provided in Appendix H.

Cover / abundance

Fluctuations in species cover / abundance were recorded across all sites and all seasons. In spring 2022, no patterns of increasing or decreasing cover / abundance were identified in relation to individual species across sites or groups of species (i.e. riparian species, generalist species, shrubs, groundcovers) within sites. For most riparian sites in spring 2022, ground layer species are dominated by *Bauera rubioides*, *Gleichenia microphylla*, *Lomandra fluviatilis*, *Sporadanthus gracilis*, and *Sticherus flabellatus*.

The foliage cover of *Gleichenia microphylla* at site MRIP02 has been recorded under 20% in all seasons since dieback was first recorded in spring 2012, reducing from 21-50% cover for the three seasons prior to dieback being observed (i.e. autumn 2011, spring 2011, autumn 2012). Whilst previous reports provide detail on the season-by-season fluctuations (Eco Logical 2012b – 2023), the overall trend has involved a slow recovery in cover for this species from below 5%, following spring 2012, to 5-20% by spring 2017. This fell again throughout 2018 and the start of 2019 in response to the dry period experienced at this time. Recovery to 5-20% was seen in the intervening seasons, with isolated exceptions (spring 2020) believed to be the result of flooding impacts. In autumn 2022 seasons, *G. microphylla* declined to 5% cover / abundance within MRIP02, however *G. dicarpa* was also recorded within the site, with a cover / abundance of 5%. This remained the case in spring 2022. The cover of *Sticherus flabellatus* var. *flabellatus* at this site has remained high, fluctuating between 5-20% to 21-50% since spring 2021. In spring 2022 it remains in this range, at 5-20%.

The foliage cover of *Gleichenia microphylla* has experienced a similar reduction at four other longwall sites (MRIP05, MRIP06, MRIP11 and MRIP12) since spring 2017. With isolated exceptions (eg. MRIP11 in spring 2014; MRIP12 in autumn 2014), the cover / abundance of this species ranged from less than 5% and common to 21-50% for most seasons up to spring 2017. From autumn 2018 onwards, *G. microphylla* has not been recorded at MRIP05 and MRIP06, including in the current spring 2022 survey. In the current survey, at MRIP11 and MRIP12, both *G. dicarpa* (MRIP11, MRIP12) and *G. microphylla* (MRIP11) were recorded as less than 5% and uncommon, similar to observations in the previous autumn 2022 survey.

Condition

The majority of species within all riparian monitoring quadrats at both longwall and control sites were recorded in a healthy condition (Condition 5) in spring 2022, including species at control (compromised) sites MRIP07 and MRIP08.

Observations of vegetation with dieback included occasional observations of plants with minor dieback (Condition 4), some dead branches (Condition 3) or rarely many dead branches (Condition 2). In spring 2022 three species were observed with dieback at both longwall and control sites (*Banksia ericifolia* subsp. *ericifolia*, and *B. serrata*). While some species were recorded with dieback in longwall sites and in a healthy condition in control sites (e.g. *Baekea linifolia*, *Hakea dactyloides*, *Hakea salicifolia*, *Hibbertia nitida*, *Prostanthera linearis*, *Pseudanthus pimeleoides*, *Schoenus melanostachys* and *Tristania neriifolia*), dieback observed for these species was only minor (Condition 4) or some dead branches (Condition 3). In spring 2022, two species were recorded with dieback in control sites and in a healthy condition in longwall sites (*Caustis pentandra* and *Schoenus brevifolius*).

4.2.3 Indicator species monitoring

Indicator species monitoring data, including a condition / health rating and reproductive rating for each plant, are provided in Appendix H.

As noted in Section 4.2.1 and Section 4.2.2, riparian control sites MRIP07 and MRIP08, located along the Eastern Tributary, were impacted by mine subsidence between spring 2016 and autumn 2017 and can no longer be used as control sites. However, indicator species monitoring at MRIP07 and MRIP08 has continued.

Indicator species monitoring results at longwall sites MRIP01, MRIP02, MRIP05, MRIP06, MRIP09, MRIP11 and MRIP12 have been analysed and assessed against control sites MRIP03, MRIP04 and MRIP10. The results for sites MRIP07 and MRIP08 are discussed separately.

Condition scale

Overall, mean vegetation condition has decreased over the entire survey period for the three riparian indicator species, *Lomatia myricoides*, *Prostanthera linearis* and *Schoenus melanostachys*, within both longwall and control sites, with the extent of decline greatest for *Prostanthera linearis* and only a minor decline observed for *Lomatia myricoides* (Figure 21, Figure 22 and Figure 23).

The mean vegetation condition for tagged riparian indicator species *Lomatia myricoides* was similar between longwall and control sites throughout the baseline period and all seasons until spring 2012, after which the mean vegetation condition at control sites remained relatively high and consistent between seasons, whilst it was more variable for longwall sites but generally lower than control sites (Figure 21). The mean vegetation condition for tagged riparian indicator species *Prostanthera linearis* has generally been higher at longwall than control sites (Figure 22). The mean vegetation condition has been more variable for *Schoenus melanostachys* over the survey period (Figure 23).

In spring 2022, the mean vegetation condition of *Lomatia myricoides* was lower at longwall sites than at control sites, as indicated by the non-overlapping error bars (Figure 21). Very little change in the mean vegetation condition of this species was observed at longwall sites compared to the previous autumn 2022 survey, whilst an increase was observed for control sites.

In spring 2022, the mean vegetation condition of *Prostanthera linearis* was higher at longwall sites than at control sites, as indicated by the non-overlapping error bars (Figure 22). A slight increase in mean vegetation condition was recorded at both longwall and control sites since the previous autumn 2022 survey.

In spring 2022, the mean vegetation condition of *Schoenus melanostachys* was similar at longwall sites and control sites, as indicated by the overlapping error bars (Figure 23). An increase in mean vegetation condition was recorded at both longwall and control sites, compared to the previous autumn 2022 survey.

At control (compromised) sites, MRIP07 and MRIP08, the vegetation condition recorded in autumn 2022 for tagged indicator species of *Lomatia myricoides* and *Prostanthera linearis* was higher than results recorded in autumn 2022 (Table 14).

Reproductive status

In spring 2022, the mean reproductive status for tagged riparian indicator species was similar, and minimal, at longwall and control sites for *Lomatia myricoides* and *Prostanthera linearis* as indicated by overlapping error bars, whilst for *Schoenus melanostachys* it was higher at longwall sites than control sites (Figure 21, Figure 22, and Figure 23). The mean reproductive status for *Prostanthera linearis* and *Schoenus melanostachys* has been considerably more variable between seasons, and between longwall and control sites within seasons, than for *Lomatia myricoides*, preventing any discernible trend from being detected.

At control (compromised) sites MRIP07 and MRIP08, the reproductive status for *Lomatia myricoides* reflected no flowering recorded for any tagged individuals in spring 2022, which is the same result as the previous four seasons. An increase in reproductive status was recorded for *Prostanthera linearis* at MRIP07 in spring 2022, whilst there was no change at MRIP08. A minimal increase was recorded for *Schoenus melanostachys* at MRIP07 and MRIP08 (Table 15).

The limited flowering recorded for each of the riparian indicator species continues to be comparable to results in previous seasons including the baseline monitoring period. The infrequent recording of flowering plants of *Lomatia myricoides* across the entire survey period is thought to be related to the timing of surveys which do not coincide with peak flowering periods.

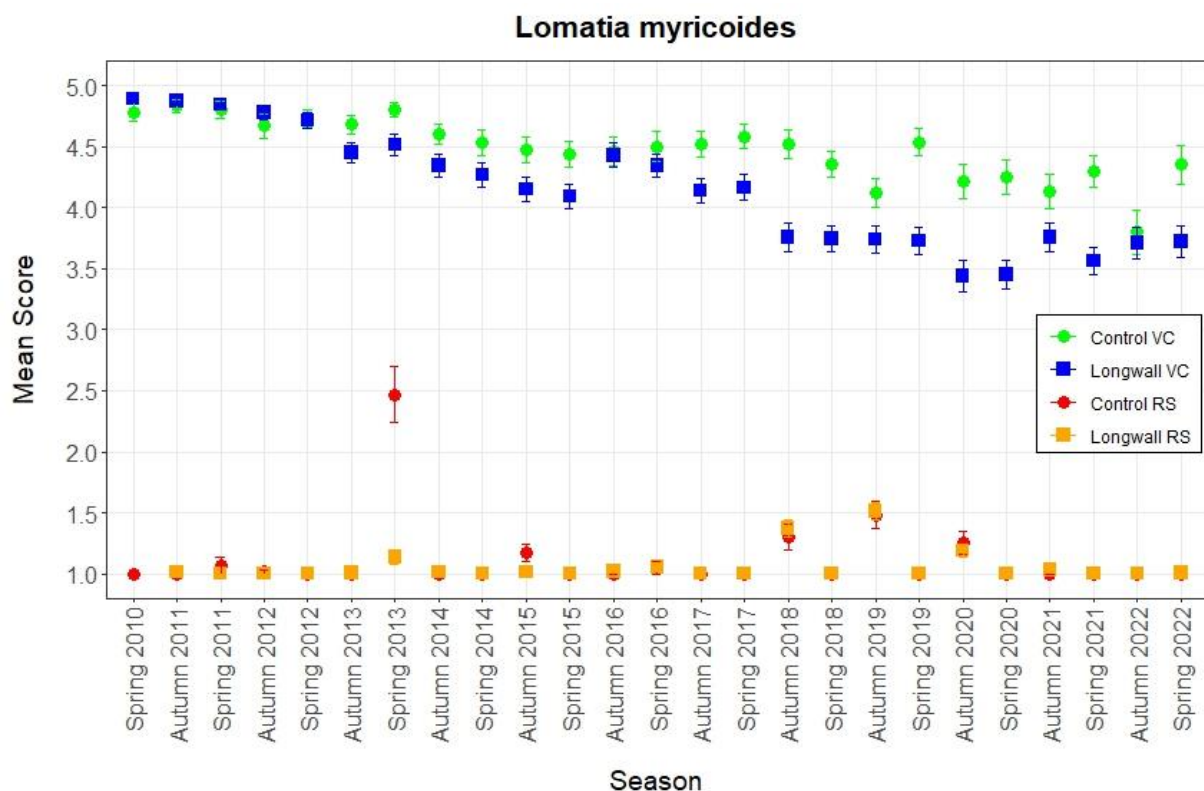


Figure 21: Mean Scores for Vegetation Condition (VC) and Reproductive Status (RS) for the indicator species, *Lomatia myricoides* (spring 2010 to spring 2022)¹⁴

¹⁴ Riparian vegetation monitoring sites MRIP07 and MRIP08 were used as control sites for comparison against the longwall riparian monitoring sites prior to subsidence impacts occurring to pool on the Eastern Tributary at these sites post spring 2016 and before autumn 2017. These sites have been removed from all seasons data analyses

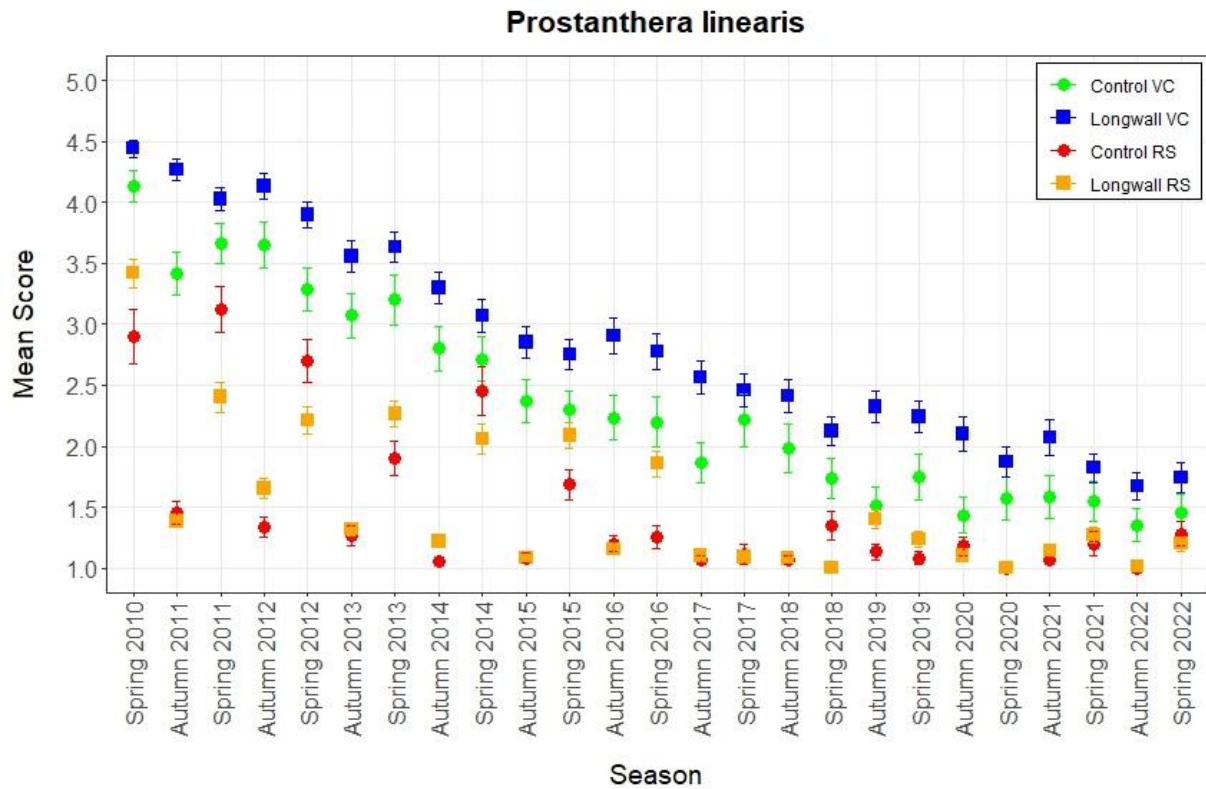


Figure 22: Mean Scores for Vegetation Condition (VC) and Reproductive Status (RS) for the indicator species, *Prostanthera linearis* (spring 2010 to spring 2022)¹⁵

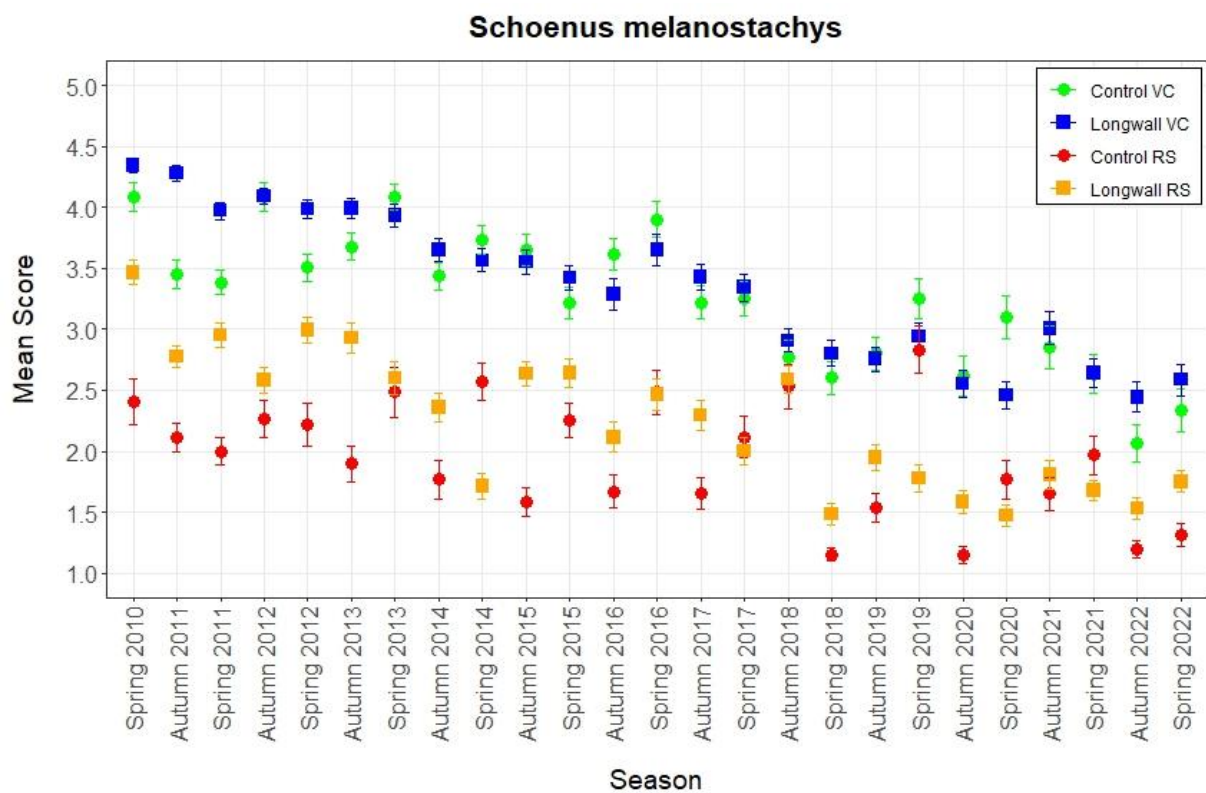


Figure 23: Mean Scores for Vegetation Condition (VC) and Reproductive Status (RS) for the indicator species, *Schoenus melanostachys* (spring 2010 to spring 2022)¹⁵

¹⁵ Riparian vegetation monitoring sites MRIP07 and MRIP08 were used as control sites for comparison against the longwall riparian monitoring sites prior to subsidence impacts occurring to pool on the Eastern Tributary at these sites post spring 2016 and before autumn 2017. These sites have been removed from all seasons data analyses

Table 14: Vegetation condition of indicator species at control (compromised) sites MRIP07 and MRIP08 for spring 2016 to spring 2022

Condition Score	MRIP07													MRIP08												
	Spring 2016	Autumn 2017	Spring 2017	Autumn 2018	Spring 2018	Autumn 2019	Spring 2019	Autumn 2020	Spring 2020	Autumn 2021	Spring 2021	Autumn 2022	Spring 2022	Spring 2016	Autumn 2017	Spring 2017	Autumn 2018	Spring 2018	Autumn 2019	Spring 2019	Autumn 2020	Spring 2020	Autumn 2021	Spring 2021	Autumn 2022	Spring 2022
<i>Lomatia myricoides</i>																										
C5	13	10	14	8	6	8	6	7	5	10	5	6	8	5	6	7	5	4	5	2	2	5	6	2	8	6
C4	3	3	5	2	6	3	6	3	7	7	7	8	7	8	7	10	7	11	11	11	8	7	6	6	9	11
C3	4	7	1	6	4	5	5	6	4	1	6	4	2	5	5	1	6	3	3	5	8	5	6	8	2	2
C2	-	-	-	2	1	2	1	1	-	-	-	1	1	1	1	1	1	1	-	1	1	1	-	3	-	-
C1	-	-	-	2	3	2	2	3	4	2	2	1	2	1	1	1	1	1	1	1	1	2	2	1	1	1
<i>Prostanthera linearis</i>																										
C5	10	5	7	10	-	7	6	6	3	12	11	5	10	3	1	5	5	3	2	1	2	2	3	2	2	1
C4	3	9	6	1	9	6	5	2	8	2	-	3	2	1	3	-	2	1	2	4	1	1	-	1	1	2
C3	4	2	3	4	6	1	3	5	1	1	2	4	2	2	3	2	-	1	1	-	2	1	1	-	-	-
C2	-	1	-	1	-	2	-	1	1	-	-	-	-	-	-	-	1	-	-	-	-	1	1	-	-	-
C1	3	3	4	4	5	4	6	6	7	5	7	8	6	4	3	3	2	4	5	5	5	5	5	7	7	7
<i>Schoenus melanostachys</i>																										
C5	6	6	1	1	-	1	2	-	1	4	-	8	6	5	2	3	2	2	1	2	4	4	1	-	5	4
C4	3	6	10	5	1	6	3	4	5	7	3	2	6	5	4	5	4	5	4	4	2	2	4	2	2	1
C3	7	6	6	10	12	8	8	9	10	2	7	3	3	5	10	5	8	8	8	6	5	2	3	2	1	1
C2	2	-	1	2	5	3	4	5	1	4	6	4	2	2	3	3	6	5	6	4	1	4	1	6	-	2
C1	2	2	2	2	2	2	3	2	3	3	4	3	3	3	1	3	-	-	1	4	8	8	11	10	12	12

Table 15: Reproductive status of indicator species at control (compromised) sites MRIP07 and MRIP08 for spring 2016 to spring 2022

Reproductive Status	MRIP07													MRIP08												
	Spring 2016	Autumn 2017	Spring 2017	Autumn 2018	Spring 2018	Autumn 2019	Spring 2019	Autumn 2020	Spring 2020	Autumn 2021	Spring 2021	Autumn 2022	Spring 2022	Spring 2016	Autumn 2017	Spring 2017	Autumn 2018	Spring 2018	Autumn 2019	Spring 2019	Autumn 2020	Spring 2020	Autumn 2021	Spring 2021	Autumn 2022	Spring 2022
<i>Lomatia myricoides</i>																										
RS5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
RS4	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-
RS3	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-
RS2	1	-	-	2	-	5	-	3	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-
RS1	19	20	20	18	17 (3)	12 (2)	18 (2)	13 (3)	16 (4)	18 (2)	16 (4)	19 (1)	18 (2)	19 (1)	19 (1)	19 (1)	17 (1)	19 (1)	18 (1)	19 (1)	19 (1)	18 (2)	18 (2)	19 (1)	19 (1)	19 (1)
<i>Prostanthera linearis</i>																										
RS5	2	-	-	-	-	-	-	-	-	-	-	-	1	3	-	-	-	-	-	-	-	-	-	1	-	-
RS4	9	-	1	-	-	-	-	-	-	-	4	-	2	1	-	-	-	-	-	-	-	-	-	1	-	-
RS3	1	-	-	-	-	7	1	-	-	3	8	-	4	1	-	-	-	-	1	2	1	-	2	-	-	-
RS2	4	3	-	-	-	4	1	1	-	4	1	1	-	-	-	-	1	-	3	-	-	-	-	-	-	-
RS1	1 (3)	14 (3)	15 (4)	16 (4)	15 (5)	5 (4)	12 (6)	13 (6)	13 (7)	8 (5)	0 (7)	11 (8)	7 (6)	1 (4)	7 (3)	7 (3)	7 (2)	5 (4)*	1 (5)	3 (5)	4 (5)	5 (5)	3 (5)	1 (7)	3 (7)	3 (7)
<i>Schoenus melanostachys</i>																										
RS5	4	-	1	-	-	-	-	-	-	-	-	-	-	-	1	1	-	-	-	-	-	-	-	-	-	-
RS4	-	10	4	3	1	3	2	4	-	-	-	1	3	4	9	2	8	2	1	1	-	-	-	2	-	-
RS3	1	1	4	6	1	2	2	-	2	-	-	-	1	1	5	3	1	4	1	1	2	3	-	-	-	-
RS2	1	3	4	5	1	5	-	2	6	-	-	1	5	3	3	5	3	4	6	2	2	4	-	5	1	2
RS1	12 (2)	4 (2)	5 (2)	4 (2)	15 (2)	8 (2)	13 (3)	12 (2)	9 (3)	17 (3)	16 (4)	15 (3)	8 (3)	9 (3)	1 (1)	7 (2)	8	10	11 (1)	12 (4)	8 (8)	5 (8)	9 (11)	3 (10)	7 (12)	6 (12)

Numbers in brackets indicate plants which are dead and therefore have a default Reproductive Status of 1

* data for one tagged individual not recorded during survey

Proportion of plants surviving

The assessment of the proportion of plants surviving is limited to riparian sites overlying Longwalls 23-27 (MRIP11 and MRIP12) and control sites downstream (MRIP03, MRIP04 and MRIP10). Sites overlying Longwalls 20-22 (MRIP01, MRIP02, MRIP05, MRIP06 and MRIP09) are not included within this assessment due to the different baseline monitoring periods for these sites (spring 2009 and autumn 2010) compared to sites overlying Longwalls 23-27 (spring 2010 to spring 2013). Up to spring 2016, sites MRIP07 and MRIP08 are included in the control sites data. As a result of subsidence impacts prior to autumn 2017, these sites have been treated separately from the other control sites.

In spring 2022, 121 of the tagged riparian indicator species were recorded as dead or with severe dieback (Condition 1), decreasing from 126 in autumn 2022. In spring 2022 8 tagged indicator species individuals declined to Condition 1 after being in a healthier condition in autumn 2022, while 14 individuals recorded in Condition 1 in autumn 2022 were recorded in an improved condition in spring 2022. In spring 2022, seven tagged *Lomatia myricoides* individuals have been recorded as dead, or Condition 1, within longwall and control sites, which is a decrease from 10 individuals in autumn 2022. Due to the low occurrence of Condition 1 *Lomatia myricoides* individuals within longwall and control sites, no further analysis is conducted.

Since the commencement of mining Longwalls 23-27, the proportion of tagged riparian indicator species that were recorded as dead (Condition 1) has generally been higher within control sites than within longwall sites for both *Prostanthera linearis* and *Schoenus melanostachys*, with isolated exceptions in individual seasons (Figure 24 and Figure 25).

The proportion of tagged *Prostanthera linearis* individuals recorded as dead has generally increased over the entire monitoring period, for both longwall and control monitoring sites (Figure 24). However, the proportion dead has been relatively stable for both longwall and control sites for the past four seasons.

In spring 2022, the proportion of tagged *Schoenus melanostachys* recorded as dead decreased at both longwall and control sites (Figure 25). The proportion of *Schoenus melanostachys* recorded as dead (Condition 1) continues to be greater at control sites (0.45) than at longwall sites (0.28), as has been observed throughout most of the monitoring period.

As the proportion of tagged riparian indicator species that were recorded as dead has generally been greater at control sites than at longwall sites, following the commencement of mining Longwalls 23-27, the observed mortality is attributed to natural factors including the variable impacts of flooding, herbivory, competition with other vegetation and abiotic factors. The riparian vegetation performance indicator has not been exceeded in regard to this analysis.

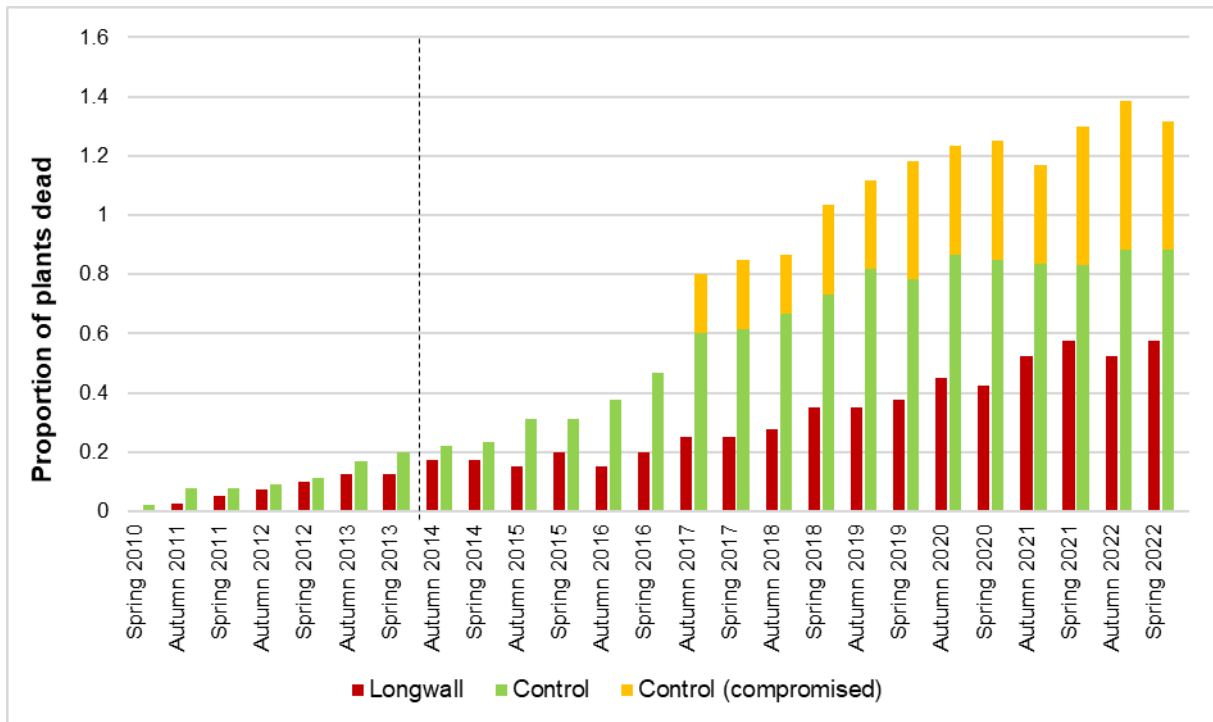


Figure 24: Proportion of tagged *Prostanthera linearis* which have died at longwall and control riparian sites (spring 2010 to spring 2022)¹⁶. Dashed line indicates change from baseline monitoring seasons to monitoring undertaken during and post mining of Longwalls 23- 27

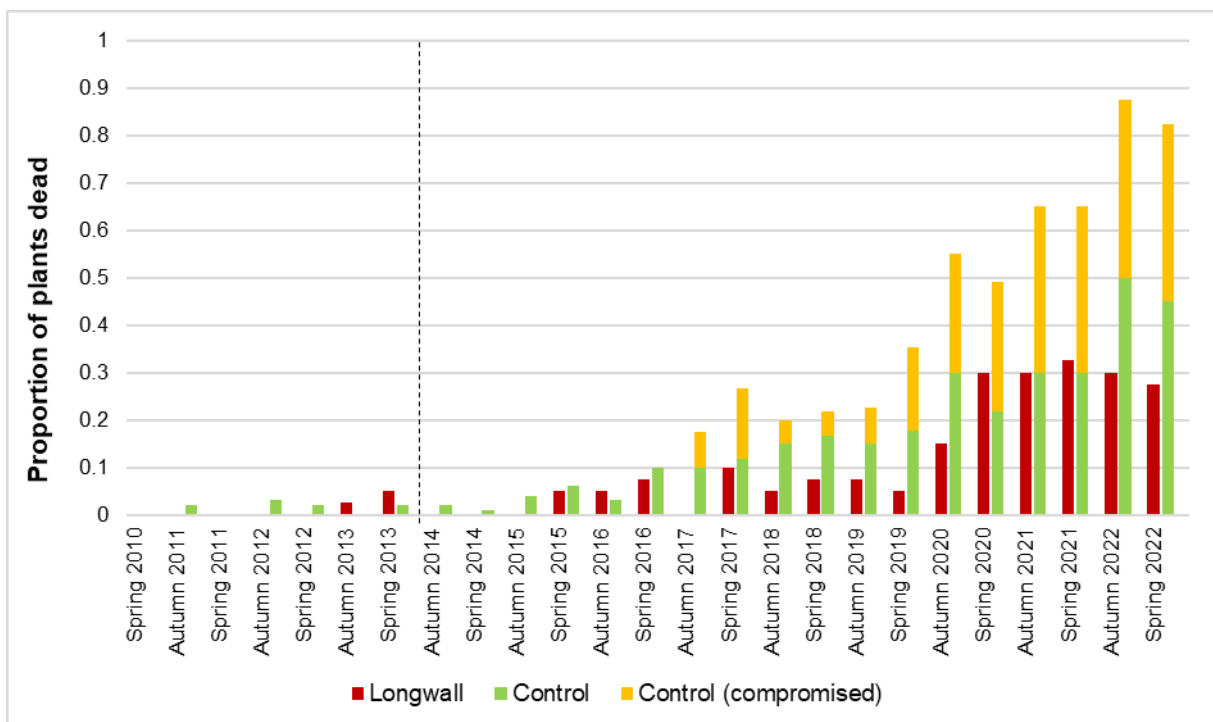


Figure 25: Proportion of tagged *Schoenus melanostachys* which have died at longwall and control riparian sites (spring 2010 to spring 2022)¹⁶. Dashed line indicates change from baseline monitoring seasons to mining undertaken during and post mining of Longwalls 23-27

¹⁶ Data point for Autumn 2018 differs to that reported in Autumn 2018 report due to calculation error

4.2.4 Assessment against performance indicators

In accordance with the Longwalls 308-310 BMP, the visual observations are used to assess the riparian vegetation performance indicator:

Impacts to riparian vegetation are expected to be localised and limited in extent, similar to the impacts previously experienced at Metropolitan Coal

The Riparian Vegetation Trigger Action Response Plan (TARP) from the Longwalls 308-310 BMP is provided in Appendix C.

Results of the visual observations are described in Section 4.2.1 above. A summary of the results in relation to the riparian vegetation TARP is provided in Table 16.

Within longwall sites MRIP02, MRIP05 and MRIP09 the vegetation dieback that has been observed since autumn 2018 had not extended in autumn 2022. No new areas of dieback were observed in spring 2022 and regrowth was observed in the ground layer species, despite recent high water flow events.

Within longwall site MRIP12, areas of vegetation dieback greater than 50 cm from the Waratah Rivulet remain similar to dieback observed in the previous five seasons. Observations of vegetation dieback and loss at this site are associated with areas of bank inundation due to previous and recent flood events. No new areas of dieback were observed in spring 2022.

The performance indicator '*Impacts to riparian vegetation are expected to be localised and limited in extent, similar to the impacts previously experienced at Metropolitan Coal*' has not been exceeded in spring 2022.

Table 16: Summary of Riparian Vegetation monitoring against Trigger Action Response Plan.

Performance Indicator	Baseline	Significance Levels/ Triggers ²		Spring 2022 Monitoring Results	Action / Response	Comments
<i>Impacts to riparian vegetation are expected to be localised and limited in extent, similar to the impacts previously experienced at Metropolitan Coal</i>	No dieback of riparian vegetation prior to the commencement of Longwall 20 as a result of mining. Dieback of riparian vegetation greater than 50 cm from the stream identified at site MRIP02 on the Waratah Rivulet and between sites MRIP05 and MRIP09 on the Eastern Tributary during the mining of Longwalls 20-27.	Level 1	No dieback of riparian vegetation greater than 50 cm from the stream as a result of mine subsidence.	Sites MRIP01, MRIP03, MRIP04, MRIP06, MRIP07, MRIP08, MRIP10 and MRIP11	Continue monitoring. Six monthly reporting. For sites that were previously observed with riparian vegetation dieback greater than 50 cm record the reasons for the reduction in dieback (e.g. vegetation recovery, new stream bank resulting from erosion, other).	None of these sites have previously been observed with riparian vegetation dieback greater than 50 cm from the stream.
		Level 2	Vegetation monitoring: - does not identify an increase in the extent of vegetation dieback compared to that observed at site MRIP02 on the Waratah Rivulet and between sites MRIP05 and MRIP09 on the Eastern Tributary; and - does not identify vegetation dieback greater than 50 cm from the stream at sites MRIP01, MRIP03, MRIP04, MRIP06, MRIP07, MRIP08 or MRIP10, as a result of mine subsidence.	Sites MRIP02, MRIP05, MRIP09 and MRIP12	Consider recent stream features mapping results and pool water level monitoring data. Consider extent of erosion associated with areas of vegetation dieback and whether management measures are required. Six monthly reporting.	Stream conditions at sites MRIP02, MRIP05, MRIP09 and MRIP12 are described in Section 4.2.1 (along with previous observations at these sites). Scouring of the stream bank and erosion resulting from high water flows following heavy rain events described in Section 4.2.1 . The extent of dieback at sites previously observed with riparian vegetation dieback (MRIP02, MRIP05, MRIP09 and MRIP12) had not increased in the current survey and vegetation recovery was apparent.
		Level 3	Vegetation monitoring: - identifies an increase in the extent of vegetation dieback compared to that observed at site MRIP02 on the Waratah Rivulet and between sites MRIP05 and MRIP09 on the Eastern Tributary; and - identifies vegetation dieback greater than 50 cm from the stream at sites MRIP01, MRIP03, MRIP04, MRIP06, MRIP07, MRIP08, MRIP10, MRIP11 or MRIP12, as a result of mine subsidence.	No sites.	Consider recent stream features mapping results and pool water level monitoring data. Initiate assessment against the performance measure ¹ . Consider the need for management measures, in accordance with Sections 8 and 9.	-

1 Threatened species, populations and ecological communities include those listed under the BC Act, EPBC Act or Fisheries Management Act at the time of Project Approval (i.e. the lists current as at 22 June 2009).

2 Note: some sites listed are assessed in the Longwalls 20-22 autumn 2022 Vegetation Monitoring Report.

4.3 Significant species

Five species of conservation significance were recorded during spring 2022 (Appendix D), all of which have been recorded previously (Table 17). Generally, the significant species observed during the transect / quadrat monitoring and visual inspections in spring 2022 were in a healthy condition (Condition 5) at both longwall and control sites. One isolated individuals of *Eucalyptus luehmanniana* were observed with many dead branches (Condition 2), within the longwall site Swamp 33. This species was recorded in good condition (Condition 5) within all other longwall and control sites where it occurred, in spring 2022. Minor dieback of *Eucalyptus luehmanniana* has previously been recorded at both longwall and control sites.

Details regarding the condition of monitored populations of *Pultenaea aristata* are provided in Section 4.1.3.

Two species of conservation significance which have previously been recorded were not observed in the current spring 2022 survey. *Tetratheca neglecta*, which has been recorded in all seasons prior to spring 2016, within one longwall swamp (Swamp 94), has not been recorded since the autumn 2016 survey. Additionally, *Acacia bauera* subsp. *aspera* was not recorded in the current spring 2022 survey. This species is known from one individual within the control site Swamp 111a. In the autumn 2018 survey, this individual was recorded with some dead branches (Condition 3) and has not been recorded since spring 2018.

Hibbertia nitida was recorded in good condition (Condition 5) within all riparian monitoring sites where it occurred, in spring 2022 (Table 17). These observations represent an improvement in the overall condition of this species relative to previous seasons. *Hibbertia nitida* occurs more frequently within longwall riparian sites and is usually found away from the direct top of bank zone. As such, the dieback recorded in previous seasons is not considered to be related to the mining of Longwalls 23-27 and is more likely a result of the impacts of flooding which produce high velocity water flows carrying woody debris.

Table 17: Species of conservation significance recorded across vegetation monitoring sites, spring 2022.

Species	Conservation significance			Location and condition
	EPBC Act	BC Act	RoTAP Code	
<i>Darwinia diminuta</i>	–	–	2RCi	Swamps 35 and 125 – Observed in healthy condition (Condition 5) in all quadrats in which it was recorded, in spring 2022.
<i>Eucalyptus luehmanniana</i>	–	–	2RCa	Swamps 33, 34, 125 and 137a – Observed in a healthy condition (Condition 5) within all swamps, in spring 2022.
<i>Hibbertia nitida</i>	–	–	2RC-	MRIP01, MRIP02, MRIP03, MRIP04, MRIP05, MRIP06, MIP07, MRIP08, MRIP11 and MRIP12 – Recorded in good condition (Condition 5) within all riparian transects, in spring 2022.
<i>Lomandra fluviatilis</i>	–	–	3RCa	MRIP01, MRIP04, MRIP07, MRIP08, MRIP11 and MRIP12 – Recorded in good condition (Condition 5) within all riparian transects, in spring 2022.
<i>Pultenaea aristata</i>	V	V	2V	Swamps 35, 101, 111a, 135, 136, 137a and 138 – Recorded in good condition (Condition 5) within all swamps, in spring 2022. See Section 4.1.3 for details regarding condition of monitored populations of this species.

Legend

- BC Act (NSW *Biodiversity Conservation Act 2016*): V = Vulnerable
- EPBC Act (Commonwealth *Environment Protection & Biodiversity Conservation Act 1999*): V = Vulnerable
- RoTAP (Rare or Threatened Australian Plants) Code:
 - 2 = Geographic range in Australia less than 100 km
 - 3 = Geographic range in Australia more than 100 km
 - R = Rare in Australia but does not have an identifiable threat
 - C = Reserved in that at least one population is found in a national park or other proclaimed conservation reserve
 - V = Vulnerable
 - a: 1000 plants or more are known to occur within a conservation reserve(s)
 - i = less than 1000 plants are known to occur within a conservation reserve(s)
 - = reserved population size is not accurately known

4.4 Introduced species

No weed species were recorded within any of the longwall or control upland swamps, in spring 2022.

Two introduced species were observed in riparian monitoring sites: *Gamochaeta* sp. (Cudweed) (MRIP10), and *Hypochaeris radicata* (Catsear) (MRIP02). No introduced aquatic species have been recorded in streams adjacent to the riparian monitoring sites.

Including the observations in spring 2022, introduced species have been recorded in very low abundance in individual seasons, at all riparian monitoring sites except MRIP07. In addition to those mentioned above, weed species recorded include: *Andropogon virginicus* (Whiskey Grass), *Aster subulatus* (Wild Aster), *Cirsium vulgare* (Spear Thistle), *Cyperus* sp., *Digitaria* sp., *Facelis retusa* (Annual Trampweed), *Gamochaeta coarctata*, *Paspalum dilatatum* (Paspalum), *Solanum nigrum* (Black-berry Nightshade) and *Sonchus oleraceus* (Sowthistle). The low occurrence of introduced species within the riparian monitoring sites is attributed to downstream dispersal from weed sources located in the upper catchment at Darkes Forest, along the Princes Highway and from Flat Rock Crossing where vehicle access may also promote weed spread.

Beyond the monitoring sites, weeds have previously been observed in low densities at Flat Rock Crossing, the area between MRIP03 and MRIP04, the crossing between MRIP11 and MRIP12, as well as scattered occurrences along verges of the main access roads (e.g. Fire trail 9H, Fire trail 9, Fire trail 9J). These include *Ageratina adenophora*, *Andropogon virginicus*, *Conyza* sp., *Gamochaeta* sp., *Paspalum dilatatum* (Paspalum) and *Senecio madagascariensis*. Weed control works have been conducted along portions of Fire Trails 9H and 9J targeting *Ageratina adenophora* and *Andropogon virginicus*. Control of these species within areas upstream of riparian vegetation is likely to reduce the occurrences of these species within the riparian zone.

5. Conclusions

5.1 Upland swamp vegetation monitoring

The key findings of the Longwalls 23–27 spring 2022 upland swamp vegetation survey (since the previous autumn 2022 survey) can be summarised as follows:

- The declining trend in the condition of longwall swamp vegetation previously recorded by vegetation monitoring from spring 2017 to spring 2018 for Swamps 30, 32, 33, 34, 35, 36 and 94 has stabilised for the eighth survey season, and minor recovery in the form of new growth of many of the impacted species was apparent in spring 2022. Swamps 30, 32, 33, 34, 35, 36 and 94 have therefore remained at ‘significance Level 1’, in accordance with the upland swamp vegetation monitoring TARP.
- Vegetation monitoring indicates the declining trend in the condition of longwall Swamps 19 and 31 is stabilising, particularly with regards to senescing shrubs, in spring 2022. Minor yellowing of isolated shrub-species was observed within both sites, however healthy individuals were also recorded. Similar observations were made within control sites for these species. Therefore, Swamps 19 and 31 remain at ‘significance Level 2’, in accordance with the upland swamp vegetation monitoring TARP.
- The ongoing decline in the vegetation condition of the Tea Tree Thicket component of Swamp 28 with regards to condition of understorey species and loss of species richness appears to have stabilised. In spring 2022, a slight increase in species richness along Transect 2 (Tea Tree Thicket component) was recorded, compared to the previous autumn 2022 survey. However, given this single small increase, this does not constitute a recovery phase, and therefore Swamp 28 remains at ‘significance Level 2’, in accordance with the upland swamp vegetation monitoring TARP.

Given the above, the upland swamp vegetation performance indicator, *the vegetation in upland swamps is not expected to experience changes significantly different to changes in control swamps*, has not been exceeded in spring 2022.

5.2 Riparian vegetation monitoring

The key findings of the Longwalls 23–27 spring 2022 riparian vegetation survey (since the previous autumn 2022 survey) can be summarised as follows:

- Dieback of riparian vegetation greater than 50 cm from the stream as a result of mine subsidence has not been observed at sites MRIP01, MRIP03, MRIP04, MRIP06, MRIP07, MRIP08, MRIP10 and MRIP11 to date. These sites remain at ‘significance Level 1’ in accordance with the riparian vegetation monitoring TARP.
- Areas previously observed with riparian vegetation dieback at sites MRIP02, MRIP05, MRIP09 and MRIP12 were not observed with the same extent of dieback in the current spring 2022 survey and vegetation recovery was apparent, despite recent high water flow events. These sites remain at ‘significance Level 2’ in accordance with the riparian vegetation monitoring TARP.

- Compared to autumn 2022, the riparian vegetation condition in control sites, MRIP03, MRIP04 and MRIP10, appears to be initially recovering as evidenced by moderate to large increases in species richness and improved visual observations. This is likely a result of the slightly more stable rain fall experienced prior to the spring 2022 survey compared to the extremely high rainfall prior, and during the autumn 2022 survey, which resulted in flooding impacts such as high velocity water flow, erosion, and sediment and woody debris deposition observed in autumn 2022. Given the resilience of the riparian vegetation community in existing in this dynamic environment, it is likely that vegetation condition will continue to recover if a reasonable number of more stable seasons are experienced. Ongoing monitoring will indicate whether these sites recover and therefore remain suitable comparisons as control sites.

Given the above, the riparian vegetation performance indicator, *impacts to riparian vegetation are expected to be localised and limited in extent, similar to the impacts previously experienced at Metropolitan Coal*, has not been exceeded in spring 2022.

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