Tahmoor Coal Pty Ltd

BIODIVERSITY MANAGEMENT PLAN

Tahmoor North - Western Domain
Longwalls West 3 and West 4

May 2021

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1 Introduction

1.1 Background

Tahmoor Coal Mine (Tahmoor Mine) is an underground coal mine located approximately 80 kilometres (km) south-west of Sydney between the towns of Tahmoor and Bargo, New South Wales (NSW) (refer to **Figure 1-1**). Tahmoor Mine produces up to three million tonnes of Run of Mine coal per annum from the Bulli Coal Seam. Tahmoor Mine produces a primary hard coking coal product and a secondary higher ash coking coal product that are used predominantly for coke manufacture for steel production. Product coal is transported via rail to Port Kembla and Newcastle for Australian domestic customers and export customers.

Tahmoor Mine has been operated by Tahmoor Coal Pty Ltd (Tahmoor Coal) since Tahmoor Mine commenced in 1979 using bord and pillar mining methods, and via longwall mining methods since 1987. Tahmoor Coal is a wholly owned entity within the SIMEC Mining Division of the GFG Alliance group.

Tahmoor Coal has previously mined 33 longwalls to the north and west of Tahmoor Mine's current pit top location. The current mining area, the 'Western Domain', is located north-west of the Main Southern Rail between the townships of Thirlmere and Picton. The Western Domain is within the Tahmoor North mining area and is within Mining Lease (ML) 1376 and ML 1539.

The mine plan for the Western Domain includes four longwalls - Longwalls West 1 to West 4. An Extraction Plan for the first two longwalls in the Western Domain, Longwalls West 1 and West 2 (LW W1-W2), was approved by the NSW Department of Planning, Industry and Environment (DPIE) on 8 November 2019. Longwalls West 1 (LW W1) was the first longwall to be extracted in the Western Domain and was completed on 6 November 2020. The extraction of Longwalls West 2 (LW W2) commenced on 7 December 2020.

The proposed Longwalls West 3 and West 4 (LW W3-W4) are an extension of LW W1-W2 and will be the focus of the current Extraction Plan. LW W3-W4 are illustrated in **Figure 1-2**.

1.2 Purpose

This Biodiversity Management Plan (BMP) has been prepared to support an Extraction Plan for the secondary extraction of coal from LW W3-W4. This BMP has been designed to identify the monitoring and management measures for biodiversity within the Extraction Plan Study Area that are required to be implemented to demonstrate that the relevant performance measures are achieved.

1.3 Scope

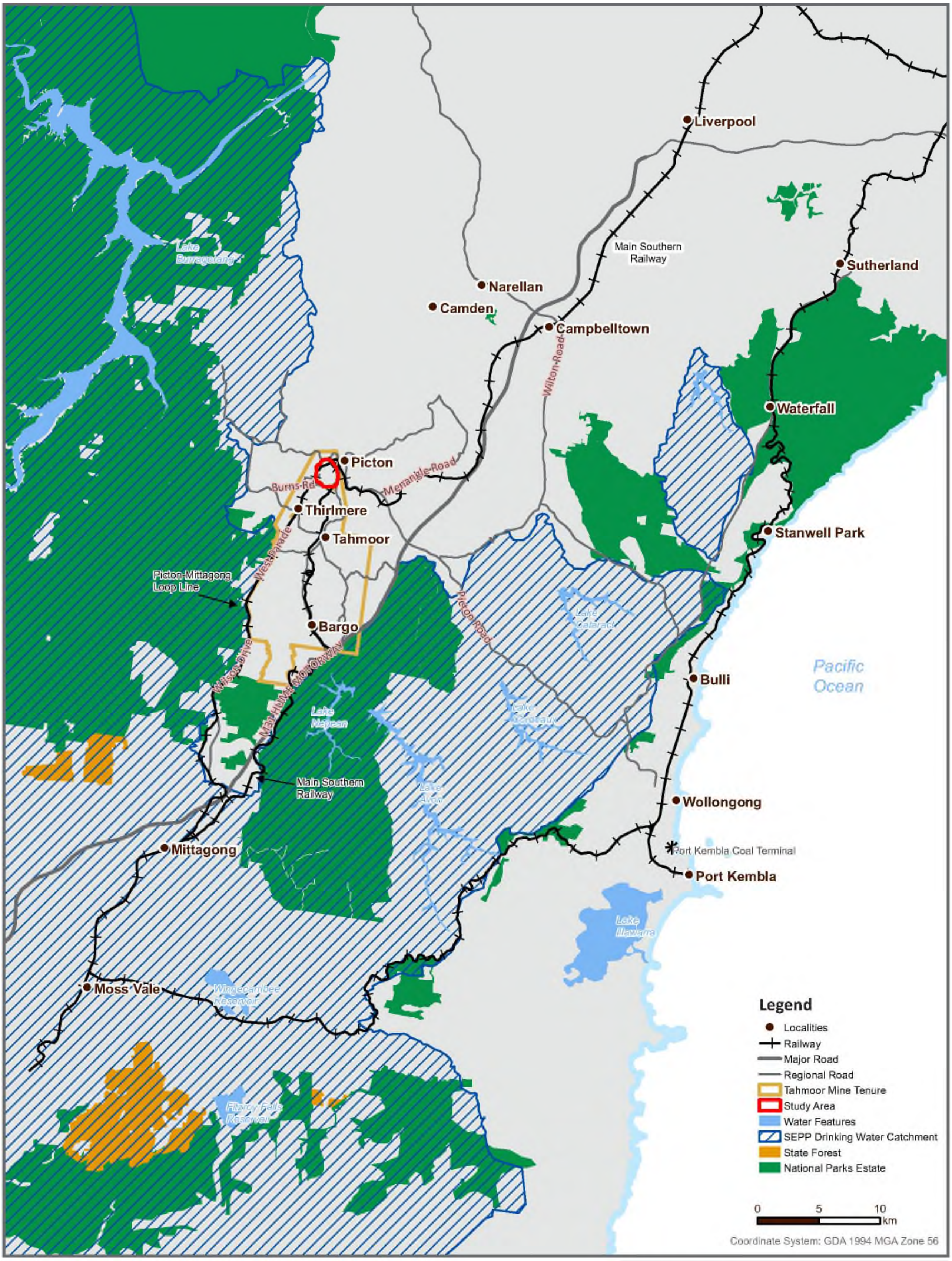
The Study Area applicable to this BMP consists of a combination of the Predicted 20 millimetre (mm) Total Subsidence Contour and the 35° Angle of Draw Line for LW W3-W4 as shown on **Figure 1-2**. Relevant environmental features within a 600 metre (m) buffer from extraction that could be susceptible to far-field or valley related movements have also been included for consideration.

This BMP:

- Addresses specific requirements set by DA 67/98 Condition 13H(vii)(d) (refer to **Section 2.1**);
- Addresses related regulatory requirements (refer to **Section 2.2**);
- Addresses the monitoring and management of potential subsidence-related impacts to biodiversity (refer to **Section 5**); and
- Provides a Trigger Action Response Plan (TARP) to be implemented to manage and protect known biodiversity values within the Study Area (refer to **Appendix A**).

This BMP has been prepared based on the contents of the following technical reports:

- Aquatic Biodiversity Technical Report (ABTR) (Niche, 2021a) (**Appendix B**);
- Terrestrial Biodiversity Technical Report (TBTR) (Niche, 2021b) (**Appendix C**); and
- Subsidence Predictions and Impact Assessment (MSEC, 2021) (**Volume 1**).



REGIONAL CONTEXT

Tahmoor North Western Domain Longwalls West 3 and West 4 Extraction Plan

FIGURE 1-1

Date: 22/12/2020

Data Sources:
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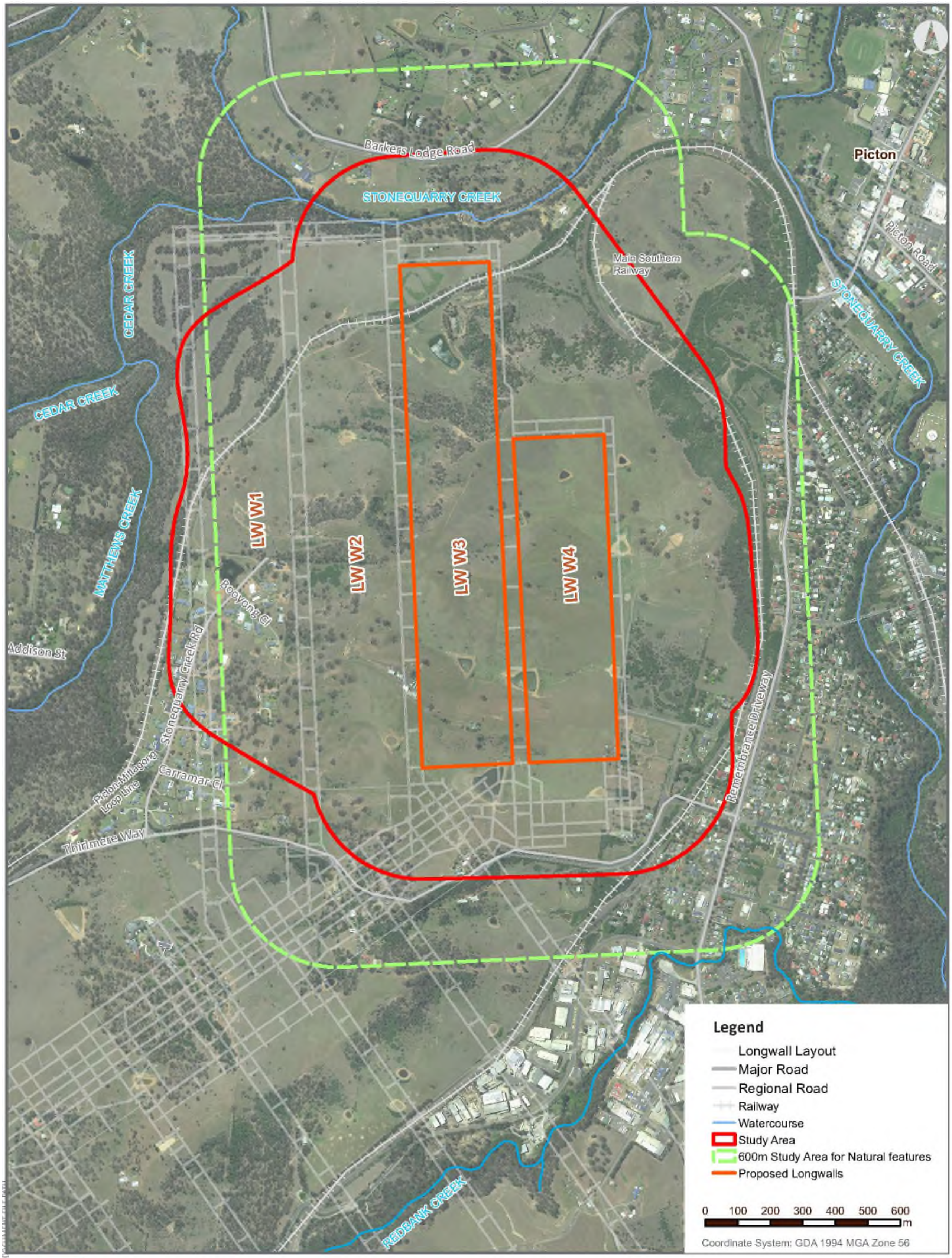

EXTRACTION PLAN STUDY AREA

Tahmoor North Western Domain Longwalls West 3 and West 4 Extraction Plan

FIGURE 1-2

Date: 10/05/2021

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2 Regulatory Requirements

2.1 Project Approval

2.1.1 Development Consent

Tahmoor Coal's operations are conducted in accordance with applicable Commonwealth and State environmental, planning, mining safety, and natural resource legislation. A register of relevant environmental legislative and regulatory requirements is maintained by Tahmoor Coal in a compliance database.

The proposed LW W3-W4 will be operating in the Tahmoor North mining area under Development Consents DA 57/93 and DA 67/93, as discussed further in **Section 3.2.1** of the Extraction Plan Main Document.

DA 67/98 provides the conditional planning approval framework for mining activities in the Western Domain to be addressed within an Extraction Plan and supporting management plans. Conditions relevant to this BMP from DA 67/98 are detailed in **Table 2-1**.

Table 2-1 Key Conditions from DA 67/98 regarding biodiversity

<table>
<tr><th>Condition</th><th colspan="2">Condition Requirement</th><th>Section Addressed</th></tr>
<tr><td colspan="4">SUBSIDENCE
Performance Measures – Natural and Heritage Features etc.</td></tr>
<tr><td>13A</td><td colspan="2">The Applicant must ensure that extraction of Longwall 33 and subsequent longwalls does not cause any exceedances of the performance measures in Table 1.
Note: The Applicant will be required to define more detailed performance indicators (including impact assessment criteria) for each of these performance measures in the various management plans that are required under this consent.</td><td rowspan="4">Section 5, Section 6, Appendix A</td></tr>
<tr><td rowspan="3">Excerpt from Table 1</td><td>Feature</td><td>Performance Measure</td></tr>
<tr><td colspan="2">Biodiversity</td></tr>
<tr><td>Threatened species, threatened populations, or endangered ecological communities</td><td>• Negligible environmental consequences.</td></tr>
<tr><td>13B</td><td colspan="2">Measurement and monitoring of compliance with performance measures and performance indicators in this consent is to be undertaken using generally accepted methods that are appropriate to the environment and circumstances in which the feature or characteristic is located. These methods are to be fully described in the relevant management plans and monitoring programs. In the event of a dispute over the appropriateness of proposed methods, the Secretary will be the final arbiter.</td><td>Section 5, Section 6, Appendix A</td></tr>
</table>

Condition	Condition Requirement	Section Addressed
Additional Offsets		
13C	If the Applicant exceeds the performance measures in Table 1 and the Secretary determines that: • it is not reasonable or feasible to remediate the subsidence impact or environmental consequence; or remediation measures implemented by the Applicant have failed to satisfactorily remediate the subsidence impact or environmental consequence, • then the Applicant must provide a suitable offset to compensate for the subsidence impact or environmental consequence, to the satisfaction of the Secretary.	Noted. Performance measures in Table 1 of DA 67/98 are not anticipated to be exceeded.
13D	The offset must give priority to like-for-like physical environmental offsets, but may also consider payment into any NSW Offset Fund established by EES, or funding or implementation of supplementary measures such as: • actions outlined in threatened species recovery programs; • actions that contribute to threat abatement programs; • biodiversity research and survey programs; and/or • rehabilitating degraded habitat. *Note: Any offset required under this condition must be proportionate with the significance of the impact or environmental consequence*	Noted. Performance measures in Table 1 of DA 67/98 are not anticipated to be exceeded.
Extraction Plan		
13H(vi)	describe in detail the performance indicators to be implemented to ensure compliance with the performance measures in Table 1 and Table 2, and manage or remediate any impacts and/or environmental consequences;	Section 5.1, Section 5.2, and Section 6
13H(vii)(d)	Biodiversity Management Plan which has been prepared in consultation with EES, which establishes a baseline data for the existing habitat on the site, including water table depth, vegetation condition, stream morphology and threatened species habitat, and provides for the management of potential impacts and environmental consequences of the proposed second workings on aquatic and terrestrial flora and fauna, with a specific focus on threatened species, populations and their habitats, EECs and groundwater dependent ecosystems	Consultation detailed in Section 2.3 Monitoring detailed in Section 5 Management Detailed in Section 6 and Appendix A
13H(vii)(h)	Trigger Action Response Plan/s addressing all features in Table 1 and Table 2, which contain:	Section 6.3, Section 6.5, Appendix A
	• appropriate triggers to warn of increased risk of exceedance of any performance measure; and	
	• specific actions to respond to high risk of exceedance of any performance measure to ensure that the measure is not exceeded;	
	• an assessment of remediation measures that may be required if exceedances occur and the capacity to implement the measures; and	
	• adaptive management where monitoring indicates that there has been an exceedance of any performance measure in Table 1 or Table 2, or where any such exceedance appears likely; an	

Condition	Condition Requirement	Section Addressed
13H(vii)(i)	Contingency Plan that expressly provides for:	Section 5.3, Section 6.4, Section 6.5, Appendix A
	• adaptive management where monitoring indicates that there has been an exceedance of any performance measure in Table 1 and Table 2, or where any such exceedance appears likely; and	
	• an assessment of remediation measures that may be required if exceedances occur and the capacity to implement those measures; and	
	• includes a program to collect sufficient baseline data for future Extraction Plans.	

2.1.2 Extraction Plan Guideline

This BMP has been prepared in accordance with the DPIE *Draft Guidelines for the Preparation of Extraction Plans V5* (DPE, 2015), as illustrated in **Table 2-2**.

Table 2-2 Extraction Plan Guideline Requirements for Key Component Plans

Extraction Plan Guideline Content Requirements for Key Component Plans	Section(s) Addressed
An overview of all landscape features, heritage sites, environmental values, built features or other values to be managed under the component plan.	Section 3
Setting out all performance measures included in the development consent relevant to the features or values to be managed under the component plan.	Section 2.1.1, Section 5.1
Setting out clear objectives to ensure the delivery of the performance measures and all other relevant statutory requirements (including relevant safety legislation).	Section 2, Section 5.1, Section 6
Proposing performance indicators to establish compliance with these performance measures and statutory requirements.	Section 5.1
Describe the landscape features, heritage sites and environmental values to be managed under the component plan, and their significance.	Section 3
Describe all currently-predicted subsidence impacts and environmental consequences relevant to the features, sites and values to be managed under the component plan.	Section 4
Describe all measures planned to remediate these impacts and/or consequences, including any measures proposed to ensure that impacts and/or consequences comply with performance measures and/or the Applicant's commitments.	Section 6, Appendix A
Describe the existing baseline monitoring network and the current baseline monitoring results, including pre-subsidence photographic surveys of key landscape features and key heritage sites which may be subject to significant subsidence impacts (such as significant watercourses, swamps and Aboriginal heritage sites).	Section 3, Section 5.2
Fully describing the proposed monitoring of subsidence impacts and environmental consequences.	Section 5.2
Describe the proposed monitoring of the success of remediation measures following implementation.	Section 6.4, Appendix A
Describe adaptive management proposed to avoid repetition of unpredicted subsidence impacts and/or environmental consequences.	Section 6.5
Describe contingency plans proposed to prevent, mitigate or remediate subsidence impacts and/or environmental consequences which substantially exceed predictions or which exceed performance measures.	Section 6.4, Appendix A
Listing responsibilities for implementation of the plan.	Section 7.3

Extraction Plan Guideline Content Requirements for Key Component Plans	Section(s) Addressed
An attached Trigger, Action, Response Plan (effectively a tabular summary of most of the above).	Appendix A

2.2 Relevant Legislation

The relevant Acts and regulations protecting and managing biodiversity in New South Wales are detailed in the sections below.

2.2.1 Biodiversity Conservation Act 2016

The NSW *Biodiversity Conservation Act 2016* (BC Act) provides protection for threatened species native to NSW (excluding fish and marine vegetation). Species, populations and ecological communities listed under Schedule 1 (Endangered) and Schedule 2 (Vulnerable) are considered to be threatened in NSW.

Protection is provided by integrating the conservation of threatened species, endangered populations and Endangered Ecological Communities / Critically Endangered Ecological Communities (EEC/CEECs) into development control processes under the NSW *Environmental Planning and Assessment Act 1979* (EP&A Act).

No significant impacts to threatened biodiversity listed under the BC Act are likely as a result of the extraction of LW W3-W4.

2.2.2 Environment Protection and Biodiversity Conservation Act 1999

Under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act), approval from the Commonwealth Minister for Department of Agriculture, Water and the Environment is required for any action that may have a significant impact on Matters of National Environmental Significance. These matters are:

- Listed threatened species and ecological communities;
- Migratory species protected under international agreements;
- Ramsar wetlands of international importance;
- The Commonwealth marine environment;
- World Heritage properties;
- National Heritage place;
- Great Barrier Reef Marine Park;
- Nuclear actions; and
- A water resource, in relation to coal seam gas development and large coal mining development.

No significant impacts to threatened biodiversity listed under the EPBC Act are likely as a result of the extraction of LW W3-W4.

2.3 Consultation

The DPIE - Environment, Energy and Science (EES) Group and Wollondilly Shire Council were consulted during the preparation of this BMP. A summary of consultation undertaken is provided in **Section 2.1.2** of the Extraction Plan Main Document, and a copy of the incoming correspondence is also provided in **Appendix C** of the Extraction Plan Main Document.

Preliminary comments from EES have been received and Tahmoor Coal will complete further consultation with EES following the submission of the Extraction Plan.

During consultation with Wollondilly Shire Council, it was requested that the following information is included in the Biodiversity Management Plan and other comments relating to ecology:

- A detailed assessment of potential impacts mining operations on the ecological health of waterways in a catchment context that includes aquatic ecology; and
- The terrestrial assessment be based on the most up to date vegetation mapping and the implementation of the Plan involve targeted surveys for flora and fauna species identified as being likely to occur on the site prior to the commencement of works.

A detailed discussion of potential impacts to aquatic ecology (and terrestrial ecology) from the extraction of LW W3-W4 is provided in **Section 4** of this BMP.

Baseline terrestrial monitoring has been completed in the Western Domain since 2017 and includes vegetation mapping and targeted surveys for flora and fauna species. Further details of the terrestrial ecological monitoring program is provided in **Section 3.2**. The ecological monitoring program will be continued during and after LW W3-W4 mining as outlined in **Section 5.2.**

3 Existing Environment

3.1 Aquatic Ecology

The following subsections have been sourced from the ABTR (**Appendix B**). This report should be referred to for further detail regarding baseline conditions of aquatic biodiversity.

3.1.1 Baseline Monitoring Data Sources

The existing environment has been characterised using baseline studies and ongoing aquatic monitoring in the Study Area. These include:

- Tahmoor North Longwalls 31 to 37 Aquatic Ecology Assessment (Niche, 2014a):
  - Riparian Channel and Environment Inventory assessment to rank the relative health of stream condition;
  - AUSRIVAS stream health assessment (including aquatic habitat, macrophytes, in situ water quality and macroinvertebrates);
  - Fish survey;
  - Threatened species and key fish habitat assessment;
- Biannual aquatic ecological monitoring for Spring 2017, Autumn 2018, Spring 2018 and Autumn 2019 (Niche, 2019a):
  - Riparian Channel and Environment Inventory assessment to rank the relative health of stream condition;
  - AUSRIVAS stream health monitoring (including aquatic habitat, macrophytes, in situ water quality and macroinvertebrates);
  - Quantitative macroinvertebrate (Before After Control Impact (BACI)) monitoring;
  - Fish survey;
- Tahmoor Coal Pty Ltd - Tahmoor Colliery Longwall Panels 31 to 37 Streams, Dams & Groundwater Assessment, Tahmoor, NSW (GeoTerra, 2014); and
- Extraction Plan LW W1 – W2 - Surface Water Technical Report (HEC, 2019).

3.1.2 Watercourses and Stream Morphology

The Study Area is located in the Stonequarry Creek catchment with the natural waterway features comprising Matthews Creek, Cedar Creek and Stonequarry Creek (refer **Figure 1-2**).

Redbank Creek flows from west to east adjacent to, though outside of, the southern boundary of the Study Area. A topographic ridgeline straddles the Study Area, with the south-east portion of the area discharging via tributaries to Redbank Creek. The south-west portion of the area discharges to Matthews Creek, while the north-northwest portion of the area discharges to Cedar Creek and Stonequarry Creek. A portion of Stonequarry Creek traverses the northern boundary of the Study Area, while Matthews Creek, Cedar Creek and Redbank Creek are located outside of the Study Area (Niche, 2021a).

Baseline pool water level and surface water quality data has been collected within and surrounding the Study Area by HEC (2019), which has been incorporated throughout this section.

Matthews Creek

The headwaters of Matthews Creek lie within the residential area of Thirlmere, with residential development significantly affecting the vegetation and weed growth along the upper reaches of the creek. The catchment comprises mainly rural properties. The creek flows to the north-east on the northern side of Thirlmere (**Figure 3-1**). The creek then flows to the north, downstream of Thirlmere, through a rural area with sparse residential development, along with poultry farms, commercial vegetable gardens and a shale quarry. The riparian zone of the creek contains thick native vegetation in this region. The creek in the vicinity of Thirlmere is generally in a poor state, with a high content of weeds and rubbish dumped or washed into it. Downstream of the residential area the creek significantly improves to a more natural state, down to the junction with Cedar Creek. To date, the creek has not been mined beneath, and the headwaters of the creek are located outside of the Study Areas of the previous and current longwalls.

Matthews Creek is relatively incised in Hawkesbury Sandstone, with a steep V-shaped valley and isolated vertical scarps predominating adjacent. Just upstream and at the junction with Cedar Creek, the valley becomes more incised and steeper with more predominant vertical scarps in the basal exposed sandstone of the valley. Overhangs of undercut sandstone are also prevalent in this section. The stream bed and banks of Matthews Creek are well vegetated and do not show significant erosion or bank instability, principally as it is developed on, or just above, exposed Hawkesbury Sandstone basement.

Water level baseline data for Matthew Creek has been detailed in HEC (2019), which described Matthews Creek as exhibiting ‘flashy’ responses to rainfall events, and indicates that pools in Matthews Creek within the Study Area experience natural periods of no flow.

The eastern tributaries of Matthews Creek within the Study Area are first and second order, ephemeral streams. The first and second order tributaries flow beneath Stonequarry Creek Road and a residential area along this road known as “Stonequarry Estate” located to the east of the Picton Mittagong Loop Line. Surface water runoff from these tributaries has been partially diverted by urban drainage associated with “Stonequarry Estate” and flows through stormwater detention basins / dams and culverts under the rail line, with runoff from the tributaries likely to contribute to flow in Matthews Creek during periods of extended or significant rainfall only. The tributaries of Matthews Creek traverse LW W1 and LW W2 though do not traverse LW W3 or LW W4 (HEC, 2021).

Cedar Creek

Cedar Creek flows from south-west to north-east adjacent to the western boundary of the Study Area Cedar Creek joins with Stonequarry Creek approximately 370 m north-west of LW W3 and has an estimated catchment area of 27 km^2. At the confluence with Stonequarry Creek, Cedar Creek is a fifth order stream. The catchment area of Cedar Creek contains rural properties including a number of poultry farms, while the upper reaches are timbered and the head of the catchment lies within the Nattai National Park.

The minor tributary of Cedar Creek within the Study Area is a first order, ephemeral stream and likely only flows during periods of extended or high rainfall. Surface water runoff from the headwater of this tributary is predominately captured by a farm dam with runoff from the tributary likely to contribute to flow in Cedar Creek during periods of extended or significant rainfall only. Flow in the tributary passes through a culvert under the Picton Mittagong Loop Line before flowing to Cedar Creek. The tributary of Cedar Creek traverses LW W1 and LW W2 though does not traverse LW W3 or LW W4 (HEC, 2021).

Adjacent to the Study Area, the channel of Cedar Creek is incised in Hawkesbury Sandstone, with a steep sided valley and exposed sandstone base in some parts. Rockbar, boulder and rock shelf constrained pools are prominent in the portion of creek traversing the Study Area. The bed and banks are well vegetated and show little evidence of erosion or bank instability (GeoTerra, 2014). Groundwater seepage has been observed to occur at the junction of Cedar Creek and Matthews Creek based on high iron hydroxide precipitation within this reach (Niche, 2019b).

As described by HEC (2019), Cedar Creek monitoring sites were fairly consistent during the baseline monitoring period with subdued small peaks in water level recorded during rainfall periods. Sharp increases in water level were recorded at the most upstream monitoring sites following rainfall events followed by steep recessions.

Stonequarry Creek

Stonequarry Creek flows within the northern boundary of the Study Area and has an estimated catchment area of 44 km^2 to the downstream boundary of the Study Area. Within the Study Area, the creek is a fifth order stream (**Figure 3-1**). A minor tributary of Stonequarry Creek flows from south-east to north-west across the northern section of LW W3. Stonequarry Creek then flows eastwards outside boundary of the Study Area, through the town of Picton, joining the Nepean River near Maldon. The catchment area of Stonequarry Creek upstream of the Study Area comprises mainly rural properties and farmland with localised housing development.

The minor tributary of Stonequarry Creek within the Study Area is a first order, ephemeral stream which likely only flows during periods of extended or high rainfall. Surface water runoff from the headwater of the tributary is predominately captured by a farm dam with runoff from the tributary likely to contribute to flow in Stonequarry Creek during periods of extended or significant rainfall only. Flow in the tributary passes through a culvert under the Picton Mittagong Loop Line before flowing to Stonequarry Creek.

In the Study Area, the creek bed has a low gradient and predominately consists of a long pool (SR17), which extends from monitoring Site 4 to monitoring Site 15 (refer **Figure 3-1**). The pool is approximately 670 m long and is perennial in nature, with trickle flow observed over the rockbar during the period of prolonged low rainfall in 2019. Downstream of the SR17 rockbar (see Site 15, **Figure 3-1**) lies a series of connected pools, located on a large sandstone rock shelf and constrained by rockbars. The bed and banks within the section of Stonequarry Creek traversing the Study Area are well vegetated and show little evidence of erosion or bank instability (GeoTerra, 2014).

The catchment area of Stonequarry Creek upstream of the Study Area comprises mainly rural properties and farmland with localised housing development (HEC, 2019). The headwaters of Stonequarry Creek lie to the north and west of Cedar Creek. Stonequarry Creek flows in a southerly direction immediately upstream of its junction with Cedar Creek, then to the east downstream of the junction through a rural area with sparse residential development, along with poultry farms, commercial vegetable gardens and a shale quarry. The riparian zone of the creek contains thick native vegetation and high weed growth in the Study Area. LW W3 – W4 do not mine beneath the creek and the headwaters are located outside of the Study Areas of the previous and current longwalls.

Baseline data by HEC (2019) has indicated that water level at Stonequarry Creek remained above the cease to flow (CTF) level for the duration of the monitoring period, while the water level at downstream sites regularly fell below the CTF level, exhibiting ‘flashy’ responses to rainfall events followed by steeper recessions (HEC, 2019).

3.1.3 Aquatic Biodiversity

Aquatic baseline monitoring includes an initial stream health assessment conducted in 2014 (Niche, 2014a) and monitoring primarily based on AUSRIVAS and quantitative macroinvertebrate sampling biannually since Spring 2017 (Niche, 2019a). The baseline monitoring program was conducted in November 2017, April 2018, November 2018 and May 2019 and employed the following survey methods:

- Aquatic habitat assessment comprising:
  - AUSRIVAS;
  - Riparian Channel and Environment (RCE) Inventory;
- Macroinvertebrate survey comprising:
  - AUSRIVAS macroinvertebrate sampling;
  - A quantitative benthic macroinvertebrate monitoring program (to be updated when samples have been identified and analysed);
- Water quality sampling; and
- Fish sampling.

The baseline monitoring is primarily focused on macroinvertebrate monitoring regimes including AUSRIVAS and quantitative BACI design. In AUSRIVAS, macroinvertebrate samples are compared to modelled reference sites and is a rapid assessment based on presence/absence of invertebrates is completed. This provides of before/after impact monitoring of the sites through time.

The quantitative macroinvertebrate program compares potential impacts sites with upstream control sites and contains community assemblage data, which can be used to determine quantitative changes in fauna abundance, richness and structure that may be otherwise be missed by a rapid assessment approach. This approach takes into account the natural variability of the stream through the comparison to upstream control sites through time.

Collected habitat and water quality data is used to aid the interpretation of macroinvertebrate monitoring; to determine the likely drivers behind any changes in stream health indicators.

Fish sampling is no longer conducted due to the few individuals and species caught not considered to be a suitable indicator to measure impacts.

The monitoring locations for the current monitoring program are shown in **Figure 3-1**, summarised below in **Table 3-1**. The major results and conclusions from the baseline aquatic monitoring are provided in **Table 3-2**, and more detailed analysis of baseline results are provided in the report by Niche (2021a).

Table 3-1 Monitoring Site Summary

Site number	Site code	Watercourse	Sampling method
Impact sites (potentially impacted by LW W1-W4)			
Site 4	SQC4	Stonequarry Creek	• Aquatic habitat assessment; • AUSRIVAS and Quantitative macroinvertebrate sampling; and • Water quality sampling.
Site 5	CC5	Cedar Creek	
Site 6	CC6	Cedar Creek	
Site 7	MC7	Matthews Creek	
Site 8	MC8	Matthews Creek	
Site 15	SQC15	Stonequarry Creek	• Quantitative macroinvertebrate sampling; and • Water quality sampling.
Site 18	SQC18	Stonequarry Creek	

Control sites			
Site 9	CC9	Cedar Creek	• Quantitative macroinvertebrate sampling; and • Water quality sampling.
Site 10	CC10	Cedar Creek	
Site 11	CC11	Cedar Creek	
Site 12	CC12	Cedar Creek	
Site 13	SQC13	Stonequarry Creek	
Site 14	SQC14	Stonequarry Creek	
Site 16	CC 16	Cedar Creek	
Site 17	MC17	Matthews Creek	

Table 3-2 Summary of results and conclusions of baseline studies

Indicator	Parameter	Results	Conclusion
Stream condition/ aquatic habitat	Stream condition	Matthews Creek, Stonequarry Creek and Cedar Creek were found to be in moderate to good stream/riparian condition with the best habitat located within the gorge along Matthews/Cedar Creek above Stonequarry Creek.	Streams are generally in moderate to good condition however low flows places natural stress on the aquatic environment and the availability and quality of aquatic habitat. Iron floc occurring in CC6 is natural and may indicate groundwater influencing benthic habitat at the location.
	Aquatic habitat	Habitat availability varied among seasons, particularly at MC8 (Site 8), which was dry on two occasions and could not be sampled. Macrophyte diversity was low with in the gorge and greatest downstream (CC5, SQC4, SC15) (Site 5, Site 4, and Site 15). Iron staining was observed at CC6 (Site 6) and CC12 (Site 12), however was reduced considerably after surveys after high rainfall.	
Water quality	Electrical conductivity	The water quality results showed high salinity (approximately 1000 µS/cm) within and upstream the Study Area. Salinity was generally lower in times of higher water levels and flow.	Electrical conductivity is naturally elevated above ANZECC guidelines in and upstream of the Study Area and resident fauna are likely to be adapted to these relatively high concentrations.
	Dissolved oxygen	Low dissolved oxygen was characteristic of all sites	Low dissolved oxygen is considered normal for stream pools exhibiting low- to no-flow conditions.
	pH	The pH from 2017-spring 2019 was variable. Most exceedences were below ANZECC guidelines however there were sites and seasons that were above. This occurred in both potential impact sites and control sites.	Reduction in pH may be related to low rainfall, less surface water flow and increase in groundwater water influence.
	Alkalinity	Alkalinity was generally low in all streams.	Low alkalinity indicates a low buffering capacity against changes in pH.

Indicator	Parameter	Results	Conclusion
Macroinvertebrates	AUSRIVAS	Most sites on all sampling occasions were different to modelled reference sites scoring in Band B and Band C. However, a site on Matthews Creek (MC8, Site 8) and Stonequarry Creek (SQC4, Site 4) scored in Band A on one occasion.	Low stream health scores and indices that were observed in the baseline study can be considered natural characteristics of drying intermittent/low flow streams.
	SIGNAL	Most sites had low signal score (<4).	
	EPT	EPT scores were generally low with Cedar Creek CC5 having the highest score. Most common pollution sensitive EPT taxa included Calamoceridae, Leptoceridae and Leptophlebiidae.	
	Assemblage data	The results showed that assemblages were temporally and spatially variable.	Temporal variability between surveys is likely related to change in flow/habitat quality. Spatial differences are likely to be related to morphological and hydrological differences in streams. Site 11 was an outlier and has been discontinued from monitoring.
Fish	Fish identification and counts	Few fish were observed. Most common in the Study Area and upstream sites was introduced *Gambusia Holbrooki*. One native fish was identified within the Study Area *Gobiomorphus coxii*. *Galaxias olidus* was found in Cedar Creek upstream of the Study Area.	Fish are unlikely to be a good indicator of environmental impact. Fish surveys have been discontinued from the monitoring program.

3.1.4 Threatened species

As discussed in the ABTR (Niche, 2021a), there are no aquatic threatened species considered likely to occur in the Study Area, and therefore aquatic threatened species are unlikely to be impacted by longwall mining as part of the extraction of LW W3-W4. No threatened species have been identified as part of the baseline monitoring.

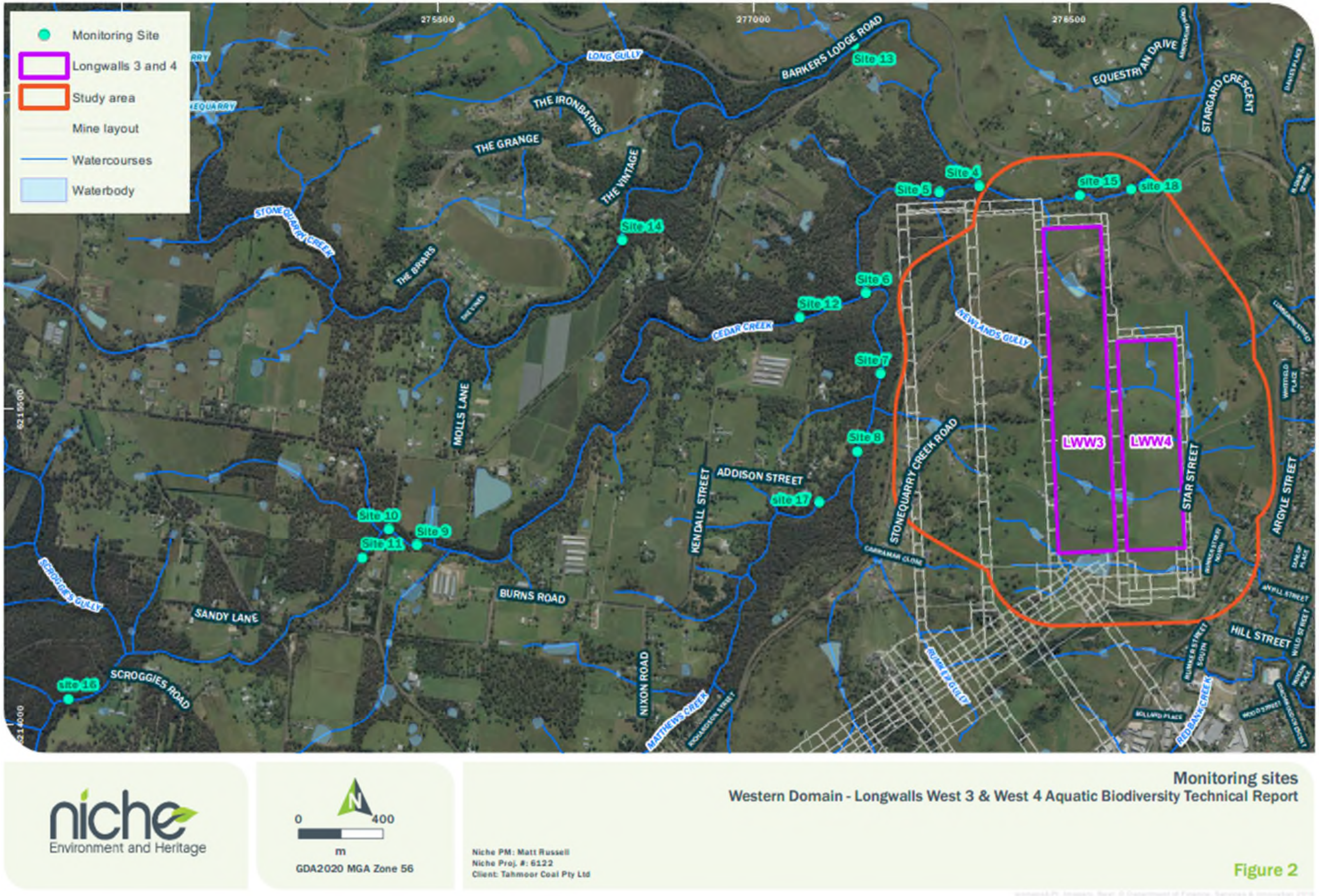

Figure 3-1 Aquatic Ecology Monitoring Sites (Niche, 2021a)

3.2 Terrestrial Ecology

The following subsections have been sourced from the TBTR (**Appendix C**). This report should be referred to for further detail regarding baseline conditions of terrestrial biodiversity.

3.2.1 Previous Assessments and Baseline Monitoring

The existing environment is characterised by baseline studies and on-going terrestrial ecology monitoring (amphibians and riparian monitoring) in the Study Area. Relevant studies include the following:

- Tahmoor North Longwalls 31 to 37 Terrestrial Ecology Assessment (Niche, 2014b):
  - Validated vegetation mapping;
  - Threatened flora surveys;
  - Habitat survey for threatened fauna;
  - Amphibian survey;
  - Impact assessment under both State and Commonwealth legislation;
- Biannual terrestrial ecological monitoring for Spring 2017, Autumn 2018, Spring 2018 and Autumn 2019 (Niche, 2019b; Niche, 2021b):
  - Riparian vegetation monitoring;
  - Collection of flora plots/transects; and
  - Amphibian transects.

The riparian monitoring program has been designed as a BACI study, such that a sufficient amount of data is collected over time in order to be able to compare any changes towards ecology indicators as a result of subsidence. Riparian vegetation monitoring sites have been set up along Matthews Creek, Cedar Creek, and Stonequarry Creek which include three impact sites (sites 3, 4 and 5) and five control sites (sites 6, 7, 8, 9, and 10) as illustrated in **Figure 3-2**.

3.2.2 Vegetation Mapping and Riparian Vegetation Baseline Data

Vegetation in the Study Area has been mapped as part of NPWS (2002) Cumberland Plain Vegetation Mapping Project and Tozer (2010) Native vegetation of southeast NSW, which was confirmed during the field survey completed by Niche (2014b).

Three vegetation communities have been mapped within the Study Area by Tozer et al (2010) and Niche (Niche, 2021b), which included the following:

- Cumberland Shale Sandstone Transition Forest;
- Cumberland River Flat Forest; and
- Sydney Hinterland Transition Woodland.

Vegetation along the upper banks of Stonequarry Creek has been mapped as Cumberland Shale Sandstone Transition Forest (Plant Community Type (PCT) 1395) with a small section of Cumberland River-flat Forest (PCT835) occurring to the north of the longwalls. The condition of the vegetation communities varied depending on grazing, historic clearing and invasion of introduced species. A small patch of vegetation along the upper banks of Matthews Creek and Cedar Creek within the Study Area has been mapped as Hinterland Sandstone Gully Forest (PCT1181) (Niche, 2021b).

A total of 201 and 328 flora species were detected within the riparian monitoring sites during the 2020 Autumn and Spring monitoring seasons, respectively. Of these, there were 150 and 284 native species, and 51 and 44 exotic species for the 2020 Autumn and Spring monitoring seasons. This differed from previous years where fewer species were detected overall. Changes in species diversity across years it likely attributed to seasonality, given some species flower at differing times of the year/season (Niche, 2021b).

Species richness across monitoring sites ranged from 18 to 65 species, with species richness generally greater in Spring compared with Autumn. Floristic composition and vegetation cover at each site were relatively consistent over all monitoring events. Impact sites had a slightly lower mean species richness and percentage vegetation cover than control sites.

Based on the three years of baseline monitoring, natural variation in the riparian vegetation has been observed. Given the riparian nature, a higher degree of variation in diversity, abundance and structure is expected. Over the three years of monitoring, differences in some of the key attributes between the two seasons were observed. This is predicted given changes in foliage cover between seasons, vegetation growth, branch loss and natural die back of species such as annuals.

Control sites for all monitoring events showed higher mean vegetation cover compared with the impact sites. Exotic species, which typically made up only a small percentage of the site's foliage cover, remained relatively constant throughout all monitoring events. Native cover fluctuated much more, which is likely the result of the overall higher levels of native cover at all sites.

Sites which occurred in a more protected environment, such as deep gullies or cannons, tended to have less fluctuation in species richness and cover. This could reflect the sheltered environment which may provide a buffer to the seasonal conditions. However, these sites also tend to have poorer soils and are less suited to the establishment and persistence of annual species.

Flooding, which may have occurred as a result of heavy rain events, may have also contributed towards influencing species richness and vegetation cover. This may occur when vegetation such are trees or growth medium is washed away or deposited within the riparian zone.

3.2.3 Threatened Ecological Communities

A list of Threatened Ecological Communities (TECs) occurring or potentially occurring within the locality was determined from database searches (the NSW Bionet Database Search tool and EPBC Act Protected Matters Search tool) and a literature review. Based on the results of the database searches, nine TECs have been identified as potentially occurring within the locality as outlined in Appendix 1 of the TBTR. Two TECs are likely to occur in the Study Area, as listed below:

- Cumberland Shale Sandstone Transition Forest – Listed as Critically Endangered under the BC Act and EPBC Act;
- Cumberland River-Flat Eucalyptus Forest – Listed as Endangered under the BC Act.

River-flat Eucalypt Forest, which is listed as an Endangered Ecological Community under the BC Act, occurs at control site 9. It occurs here in a highly disturbed state, with high exotic plant abundance.

3.2.4 Threatened Flora

A total of 36 threatened flora listed on the BC Act and/or EPBC Act were identified as subject species during the Terrestrial Ecology Assessment (Niche, 2014b) which was obtained during database searches of Bionet and the EPBC Act Protected Matter Search tool, and field surveys.

As detailed by Niche (2014b), no threatened flora listed on the BC and/or EPBC Act were recorded in the Study Area. Furthermore, no threatened flora have been recorded during the riparian monitoring program to date (Niche, 2021b).

The following threatened flora which have been attributed a moderate to high likelihood of occurrence in the Terrestrial Ecology Assessment (Niche, 2014b) where are relevant to this TBTR are listed below:

- *Acacia pubescens;*
- *Epacris purpurascens* var*. purpurascens;*
- *Grevillea parviflora* subsp*. Parviflora;*
- *Leucopogon exolasius*;
- *Persoonia bargoensis;*
- *Pomaderris brunnea;*
- *Pterostylis Saxicola;*
- *Pimelea spicata;* and
- *Tetratheca glandulosa.*

3.2.5 Threatened Fauna

A total of 61 threatened fauna listed on the BC Act and/or EPBC Act were identified as subject species during the Terrestrial Ecology Assessment (Niche, 2014b) which was obtained during database searches of Bionet and the EPBC Act Protected Matter Search tool, and field surveys.

No threatened fauna species have been recorded within the Study Area during the ongoing biodiversity monitoring program which commenced in Spring 2017. Two threatened fauna species listed on the BC Act (the Varied Sittella and the Cumberland Plain Land Snail) were recorded just outside the Study Area during the surveys conducted in 2012 and 2014.

After considering the habitat present in the Study Area and the results of the Terrestrial Ecology Assessment and survey (Niche, 2014b), 32 of these threatened fauna were considered to have a moderate to high likelihood of occurrence Study Area. These species include:

- Amphibians: Red-crowned Toadlet;
- Birds: Regent Honeyeater, Great Egret, Bush Stone-curlew, Gang-gang Cockatoo, Glossy Black-Cockatoo, Brown Treecreeper (eastern subspecies), Varied Sittella, Little Eagle, White-throated Needletail, Swift Parrot, Hooded Robin (south-eastern form), Black-chinned Honeyeater (eastern subspecies), Rainbow Bee-eater, Black-faced Monarch, Satin Flycatcher, Turquoise Parrot, Barking Owl, Powerful Owl, Scarlet Robin, Speckled Warbler, Rufous Fantail, Masked Owl;
- Invertebrates: Cumberland Plain Land Snail; and
- Mammals: Large-eared Pied Bat, Little Bentwing-bat, Eastern Bentwing-bat, Eastern Freetail-bat, Southern Myotis, Koala, Grey-headed Flying-fox, Greater Broad-nosed Bat.

3.2.6 Amphibians

No threatened amphibians were recorded during the Terrestrial Ecology Assessment (Niche, 2014b), nor have any threatened amphibians been detected during the baseline monitoring (Niche 2020, Niche 2021b). Despite the non-detection, potential habitat for the Red-crowned Toadlet exists across the riparian areas within the Study Area.

The baseline monitoring (Niche 2020, Niche 2021b) has confirmed that no threatened amphibian species were detected either as frogs or tadpoles. While the Study Area contains superficially suitable habitat, it is possible that the species would no longer be able to survive in the area due to predation pressures from two introduced predators: the Plague Minnow (*Gambusia holbrooki*) and the Yabbie (*Cherax destructor*), both of which were detected at all monitoring sites.

During the Niche (2020) amphibian baseline monitoring, amphibian detection was relatively inconsistent due to the relatively dry conditions across seasons. However, subsequent monitoring events have not detected the presence of threatened amphibians (Niche 2021b). All amphibians identified during monitoring represent an otherwise normal array of 'predator aware' species for the quality of habitat throughout the Study Area.

The amphibian baseline monitoring concluded the following findings in relation to the Study Area:

- There were 663 detections of individual amphibians recorded during the Autumn monitoring and 1,133 detections recorded during the Spring monitoring, totalling 1,796 detections over the seven amphibian surveys.
- There were nine species of amphibian recorded across the monitoring sites during the Autumn monitoring. A total of 12 species of amphibian were recorded during the Spring monitoring. One additional species was noted nearby during the survey periods Orange-groined Toadlet (*Uperoleia laevigata*).
- All sites had at least one species of amphibian recorded during each survey, however, one site (Site 6) recorded no amphibians during the Autumn 2020 survey.
- The most widespread and abundant amphibian species during these surveys was the Clicking Froglet (*Crinia signifera*), which was detected on all sites during the Spring survey and seven of the eight sites during the Autumn 2020 survey period.
- The low amphibian counts observed during some survey events are almost certainly due to the dry conditions experienced prior to and during those surveys. Generally greater amphibian numbers were detected when there was significant rain prior to the survey or light rain with warm conditions during the survey. In at least one instance rainfall inhibited amphibian detection due to the extreme water noise from a rapidly flowing creek in a canyon.

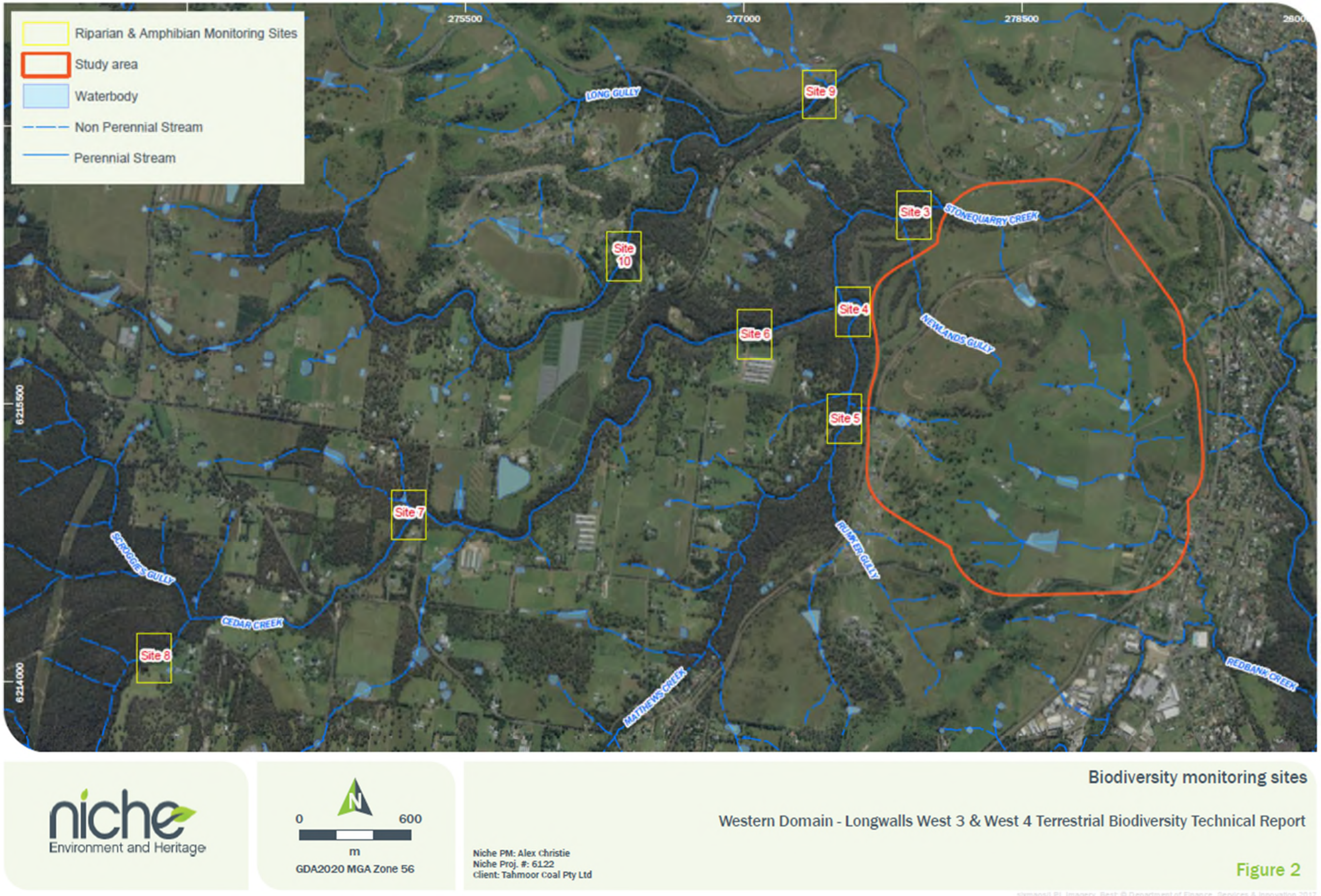

Figure 3-2 Terrestrial Ecology Monitoring Sites (Niche, 2021b)

4 Predicted Subsidence Impacts and Environmental Consequences

4.1 Aquatic Ecology

4.1.1 LW W3-W4 Predicted Impacts to Aquatic Ecology

The following subsections have been sourced from the ABTR (**Appendix B**), and this report should be referred to for further detail regarding predicted subsidence impacts and environmental consequences to aquatic biodiversity.

Table 4-1 outlines the potential environmental consequences to aquatic biodiversity.

Table 4-1 Environmental Consequences to Aquatic Biodiversity

Aquatic Value	Creek System	Environmental Consequence
Aquatic Habitat	Matthews Creek	Potential reduction in pool habitat near LW W1, less than 10% reduction in overall pool habitat and increase in iron floc smothering the benthos at Cedar/Matthews Creek junction.
	Cedar Creek	Potential reduction in pool habitat near LW W1, less than 10% reduction in overall pool habitat and increase in iron floc smothering the benthos at Cedar/Matthews Creek junction.
	Stonequarry Creek	Minor/negligible reduction in pool habitat.
Riparian Vegetation	Matthews Creek	Potential localised impacts from gas emissions, low likelihood.
	Cedar Creek	Potential localised impacts from gas emissions, low likelihood.
	Stonequarry Creek	Potential localised impacts from gas emissions, low likelihood.
Macrophytes	Matthews Creek	Potential localised reduction in available wetted habitat, low likelihood.
	Cedar Creek-	Potential localised reduction in available wetted habitat.
	Stonequarry Creek	Potential minor reduction in wetted habitat.
Macroinvertebrates	Matthews Creek	Potential reduction in available habitat and macroinvertebrate biomass. Reduction of sensitive macroinvertebrate species at Cedar Creek/Matthews Creek junction. Potential localised temporal change in community composition from episodic changes in water quality.
	Cedar Creek	Potential localised reduction in available habit and macroinvertebrate biomass. Reduction of sensitive macroinvertebrate species at Cedar Creek/Matthews Creek junction. Potential localised temporal change in community composition from episodic changes in water quality.

Aquatic Value	Creek System	Environmental Consequence
	Stonequarry Creek	Potential localised temporal change in community composition from episodic changes in water quality. Low likelihood.
Fish	Matthews Creek	Potential localised temporal reduction in fish passage in low flows when there is naturally limited fish passage.
	Cedar Creek-	Potential localised temporal reduction in fish passage in low flows when there is naturally limited fish passage.
	Stonequarry Creek	Unlikely.
Threatened Species	Matthews Creek	Unlikely.
	Cedar Creek	
	Stonequarry Creek	

4.1.2 LW W1 and LW W2 aquatic ecology monitoring results

Two monitoring sampling events have occurred during mining of LW W1 and one event after LW W2 commenced in December 2020. The monitoring results assess potential impacts of LW1 using quantitative and AURIVAS results. At the time of the report only AUSRIVAS sampling data had been analysed for LW W2.

During and post LW1 mining

Autumn 2020 monitoring (Niche 2020) had the following results:

- Autumn 2020 was considerably wetter than previous years with one high rainfall event and one moderate rainfall event occurring before sampling;
- All sites had similar riparian and channel condition prior to sampling, however there was more aquatic habitat available in autumn 2020 and less iron floc at Cedar Creek CC6. CC5 had a changed flow path however provided similar habitat types compared to previous surveys. In general, there were less macrophytes present at CC6, SQC4 and SQC17, however similar species were present;
- Water quality appeared to have improved, with EC within ANZECC guidelines. The pH exceeded guidelines however was more alkaline and above DTV compared to previous surveys which were below;
- AUSRIVAS scores in autumn 2020 were either comparable to previous results or higher than any scores observed pre-mining;
- Signal scores in autumn 2020 for CC5, MC7 and MC8 were marginally lower than any pre-mining scores. Cedar Creek CC5 had the lowest EPT scores in autumn 2020 compared to previous surveys of this location; and
- Number of taxa were above or within the range of pre-mining results.

Spring 2020 monitoring (Niche 2021c) had the following results:

- No change in stream morphology and condition;
- Overall, despite some minor water quality exceedance in EC and pH, the water quality was comparable to control sites;
- AUSRIVAS scores in spring 2020 were either comparable to or higher than scores observed pre-mining;
- Signal scores in spring 2020 for sites SQ4, CC5, CC6 and MC8 were marginally lower than any pre-mining spring 2019 scores with MC7 marginally higher;

- EPT scores at all sites where the same or higher compared to pre-mining spring 2019 survey; and
- Number of taxa were above or within the range of pre-mining results.

It was concluded in both the spring 2020 and autumn 2020 aquatic monitoring reports that the waterways were within TARP Level 1 (normal condition) according to the LW W1-W2 Biodiversity Management Plan TARPs for aquatic ecology, and that mining of LW1 was having no measurable impact to aquatic ecology in autumn and spring 2020.

During LW W2

The preliminary AUSRIVAS results from the autumn 2021 monitoring event (Niche, 2021c) shows the following:

- No indication of any impact to aquatic ecology or water quality particularly as AUSRIVAS scores were within the range of, or above, pre-mining AURIVAS scores and natural variability.
- No water quality or stream morphological changes observed that can be related to any potential subsidence impact from LW W1 and LW W2.

The preliminary autumn 2021 monitoring results confirm that all sites are considered to be within TARP Level 1 (normal condition) according to the LW W1-W2 Biodiversity Management Plan TARPs for aquatic ecology (macroinvertebrate indicators and aquatic habitat) and no TARP triggers have been exceeded (Niche, 2021c).

4.2 Terrestrial Ecology

The following subsections have been sourced from the TBTR (**Appendix C**), and this report should be referred to for further detail regarding predicted subsidence impacts and environmental consequences to terrestrial biodiversity.

The following sections outline the potential subsidence impacts and environmental consequences to key areas of terrestrial biodiversity.

4.2.1 Vegetation

As detailed by Niche (2014b), the majority of vegetation within the Study Area would not be impacted by subsidence due to underground mining but impacts may potentially occur for riparian vegetation. Riparian vegetation potentially impacted by subsidence is generally not mapped as discrete vegetation communities, rather these areas display structural and floristic variation within their composite community in response to more frequent contact with the local water table. As such, it would be hard to distinguish impacts to truly riparian vegetation and the intergrade between riparian and woodland communities.

Vegetation which occurs on undulating lands or on ridgelines is unlikely to be impacted by subsidence. It is possible that cracking may occur within these communities, however cracking is unlikely to result in vegetation change as these communities occur in drier soils and are not ultimately reliant upon groundwater for their floristic make up or distribution.

Riparian vegetation may be impacted by subsidence through water diversion, cracking of bedrock or the release of strata gas. The overall stability of the bed and banks of overlying creeks could be indirectly affected by subsidence induced fracturing and enhanced drainage of groundwater from the banks and bed of creeks leading to loss of riparian vegetation. However, based on previous observations within the Southern Coalfields and Tahmoor North to date, such incidents have generally not occurred.

MSEC (2021) states that gas emissions may occur as a result of subsidence however are rare. In the Southern Coalfield, impacts to vegetation as a result of subsidence are minor in occurrence. Previous examples of impacts include: dieback of riparian vegetation as a result of subsidence which occurred nearby Cataract River during the 1990s (Eco Logical Australia, 2004). Strata gas emissions association with subsidence are temporary, and therefore are unlikely to cause long-term adverse changes to the habitat of threatened riparian species (FloraSearch, 2009).

As detailed by Niche (2014b), impacts to vegetation associated with subsidence are unlikely, and if occurred, are likely to result in minor localised floristic changes. Given MSEC (2021) reports that gas releases resulting in observable vegetation die back are not common, and in the instance where it has occurred at Tower Colliery the impacts were limited to small areas that were successfully revegetated (Niche 2014b), it is expected that any impacts to the PCTs as a result of gas emissions from the extraction of LW W3-W4 would be limited in extent and temporal in nature. In addition, as demonstrated by the sites previously affected by gas emissions, if vegetation die back was to occur, the vegetation would regenerate once the gas emissions ceased. As such, it is considered unlikely that gas emissions from subsidence would result in a decrease in the extent of the PCTs and habitat within the Study Area.

4.2.2 Destruction of Vegetation/Tree Fall by Rock Falls and Earth Slippages

The steep slopes on the sides of valleys are predominantly found in Hawkesbury Sandstone, however, natural steep slopes are also located on the sides of ridges above the proposed longwalls, where the near surface lithology is part of the Wianamatta Shale group (MSEC, 2021). Cliffs, pagodas or escarpments have not been identified as occurring within the Study Area.

Subsidence may result in the downslope movement of soils, causing tension cracks to appear at the tops of the slopes, and compression ridges to form at the bottoms of the slopes, which in turn has the potential to cause erosion (MSEC, 2021). However, as indicated by MSEC (2021), there would be no impact to cliffs as the nearest identified cliffs are a minimum of 700 m from the Study Area. As such, as assessed by Niche (2014b), it is considered unlikely that any large-scale impacts to native vegetation due to earth and rock-face instability would occur. If such an event was to occur, the impacts would be localised.

Slippage of earth and rocks down steep slopes and rock falls have the potential to directly impact (destroy/smother) vegetation, flora and fauna habitat as well as directly injure or kill native fauna.

4.2.3 Threatened Ecological Communities

Subsidence is unlikely to result in impacts to native vegetation that do not occur within the creeklines or immediately adjacent. This has been discussed in detailed by Niche (2014b) which has concluded that the TECs observed in the Study Area are predominately located toward the top portions of the creek valleys and therefore are unlikely to be exposed to any gas emissions from subsidence.

All the TECs that occur within the Study Area are associated with shale, alluvial and shale/sandstone transition soils which are unlikely to be subject to any biologically significant effects. As only minor changes in groundwater are predicted (SLR, 2021), it is unlikely significant impacts to native vegetation will occur as a result of the proposal.

4.2.4 Flora

A detailed in the Terrestrial Ecology Assessment (Niche, 2014b), threatened flora species reliant upon watercourses, and riparian zones may be potentially impacted by subsidence. Within the Study Area, potential subsidence induced impacts may impact habitat for *Epacris purpurascens* var*. purpurascens,* and *Pomaderris brunnea*. Impacts may occur as a result of the following:

- Gas emissions from sandstone fracturing above extracted longwalls may cause die back and changes in potential habitat within riparian vegetation;
- Changes in hydrology from creek bed cracking, causing localised vegetation structure and composition changes to potential habitat; and
- Loss of individuals due to changes in hydrology, and groundwater changes.

The remainder of affected species are not likely to be reliant on any landscape feature that may be significantly affected by subsidence.

As discussed in relation to native vegetation, die-back of plants from gas emissions is a rare event. If such an event was to happen, it would be very localised, and unlikely to result in large scale die back of native flora. The likelihood for threatened flora to be located immediately adjacent to the edge of a watercourse, that may have foliage exposed to a gas emission event is considered low. Furthermore, the subject threatened flora generally occurs on the high elevations in woodland or swamp habitats that are positioned away from the watercourse bed. As such, the chances of a gas emission event affecting any potential population is considered low.

In relation to changes to water flow and standing pools, this is unlikely to affect the subject threatened flora as these species do not occur submerged, immersed or directly connected via roots to the water within pools. The drying of pools or predicted changes to the hydrological regime to watercourses within the Study Area are therefore unlikely to result in impacts to these threatened flora species.

As discussed in relation to native vegetation, the likelihood for any large-scale impacts associated with potential rock falls/slipping of rock are low. The chances of threatened flora to be present directly in the locality of such events is considered low. As such, it is unlikely that any large-scale impacts to threatened flora due to earth and rock-face instability would occur.

As discussed in detail by Niche (2014b), based on previous experience at Dendrobium, Appin and Tower Mines within the Southern Coalfields, potential subsidence impacts are likely to have a minimal effect on vegetation composition, dispersal mechanisms, or isolation of potential populations where those vegetation communities are not dependent on surface water flows of groundwater levels. As such the Terrestrial Ecology Assessment (Niche, 2014b) concluded that subsidence impacts from the proposal are not considered likely to have a significant impact on threatened flora.

4.2.5 Fauna

As detailed in the Terrestrial Ecology Assessment (Niche, 2014b), no significant impacts to threatened fauna are expected. Given that MSEC (2021) reports that impacts are less than that provided in the Terrestrial Ecology Assessment (Niche, 2014b), it is reasonable to assume that similar impact conclusion would be reached.

As discussed by Niche (2014b) a number of threatened species are generally highly mobile and/or potential habitat is unlikely to be impacted by subsidence. These species include:

- Birds: Regent Honeyeater, Great Egret, Bush Stone-curlew, Gang-gang Cockatoo, Glossy Black-Cockatoo, Brown Treecreeper (eastern subspecies), Varied Sittella, Little Eagle, White-throated Needletail, Swift Parrot, Hooded Robin (south-eastern form), Black-chinned Honeyeater (eastern subspecies), Rainbow Bee-eater, Black-faced Monarch, Satin Flycatcher, Turquoise Parrot, Barking Owl, Powerful Owl, Scarlet Robin, Speckled Warbler, Rufous Fantail, Masked Owl;
- Invertebrates: Cumberland Plain Land Snail; and
- Mammals: Koala and Grey-headed Flying Fox.

Assessments of Significance under the BC and/or EPBC Acts were carried out by Niche (2014b) for the following species:

- Amphibians: Red-crowned Toadlet; and
- Mammals: Large-eared Pied Bat, Little Bentwing-bat, Eastern Bentwing-bat, Eastern Freetail-bat, Southern Myotis, Greater Broad-nosed Bat.

As detailed by Niche (2014b) no significant impacts to these species were considered likely to occur. Given, the predictions of MSEC (2021) that subsidence impacts from LW W3-W4 are less than those assessed in the Niche (2014b) assessment, the conclusion of no significant impact to these threatened fauna remains current for LW W3-W4.

4.2.6 LW W1 and LW W2 terrestrial ecology monitoring results

It is noted that monitoring completed during the extraction of LW W1-W2 confirmed that all sites are within TARP Level 1 (normal condition) according to the LW W1-W2 Biodiversity Management Plan TARPs for terrestrial ecology, and no TARP trigger have been exceeded (Niche, 2020).

5 Subsidence Monitoring Program

5.1 Performance Measures and Indicators

Performance measures for aquatic and terrestrial ecology are provided in Table 1 of Condition 13A of DA 67/98 and summarised in **Table 5-1**.

Table 5-1 Subsidence Performance Measures and Performance Indicators for Biodiversity

Biodiversity Feature	Subsidence Performance Measures	Subsidence Performance Indicators and Triggers
Threatened species, threatened populations, or endangered ecological communities	Negligible environmental consequences	This performance indicator will be considered to be triggered if: • Declines in macroinvertebrate and stream health indicators are statistically significant; • The subsidence monitoring program identifies changes that exceed performance indicators for surface water or subsidence that may affect aquatic habitat; • Statistically significant changes in amphibian diversity is detected from baseline attributed to mining, as detected during the Annual Amphibian Monitoring program; and/or • Statistically significant changes in riparian vegetation is detected from baseline attributed to mining, as detected during the Annual Riparian Monitoring program.

For the purpose of this Extraction Plan and associated documents, 'negligible' is defined as being 'so small and insignificant as to not be worth considering'. A negligible impact is viewed with regards to a long term context, causing little or no impact. If a short term impact causes a greater than negligible impact, the impact can still be considered negligible if the impacts are of a limited duration and are considered negligible when considered over the long term.

It is anticipated that the above performance measures will be achieved during and after mining of LW W3-W4.

5.2 Monitoring Program

A monitoring program for aquatic and terrestrial biodiversity has been compiled in **Table 5-2**, and the location of monitoring is illustrated in **Figure 3-1** and **Figure 3-2**.

The aim of the monitoring program is to identify where there is a risk of impact to landscape features and agricultural enterprises as a result of mining activities. The monitoring program provides for the opportunity to record the condition of the site during the following three phases:

- Prior to Mining – baseline survey of the condition of the site before the commencement of mining, also referred to as the baseline check;

- During Mining – monitoring of the condition of the site during active subsidence to establish whether there has been any change to the site or if changes have occurred from the effects of subsidence. This monitoring is also referred to as the post mining initial condition check; and
- Post Mining – monitoring of the condition of the site after mining to identify whether there has been any change to the site in the period since mining, and to determine if the ground surface conditions have stabilised. This monitoring is also referred to as the post mining secondary condition check.

If an impact is identified to have occurred or is likely to occur, the TARP (refer to **Appendix A**) should then be referred to for the identification of appropriate mitigation strategies.

Table 5-2 Monitoring Program for Biodiversity Features

Feature	Monitoring Component / Location	Monitoring		
		Prior to Mining	During Mining	Post Mining
Water quality	Physio chemical water quality sampling at all aquatic ecology monitoring sites	Completed as part of baseline monitoring.	Bi-annually (Spring and Autumn)	Bi-annually (Spring and Autumn) for 12 months following the completion of LW W4. This period may be extended as per decision by the Environmental Response Group.
Aquatic habitat	Aquatic habitat observations at aquatic ecology monitoring sites 4-8			
Macroinvertebrates	AUSRIVAS macroinvertebrate sampling at aquatic ecology monitoring sites 4-8			
	Quantitative macroinvertebrate sampling at aquatic ecology monitoring sites 4-18			
Riparian vegetation	Permanent vegetation plots, vegetation condition assessment, photo-point monitoring and plant taxonomy at all riparian vegetation monitoring sites (sites 3-10)	Completed as part of baseline monitoring program	Bi-annually (Spring and Autumn)	Bi-annually (Spring and Autumn) for 12 months following the completion of LW W4. This period may be extended as per decision by the Environmental Response Group.
Amphibians	Amphibian monitoring and photo-point monitoring at all amphibian monitoring sites (sites 3-10)	Completed as part of baseline monitoring program	Bi-annually (Spring and Autumn)	Bi-annually (Spring and Autumn) for 12 months following the completion of LW W4. This period may be extended as per decision by the Environmental Response Group.

5.3 Further Baseline Monitoring

To assist in the preparation of future Extraction Plans, the aquatic and terrestrial ecology monitoring as outlined in **Table 5-2** will provide sufficient baseline data to assist. Monitoring data collected during the mining of LW W3-W4 would be used in the review of observed subsidence impacts for future Extraction Plans.

The monitoring program going forward should aim to be consistent with baseline monitoring conducted in 2017-2019 (Niche, 2021a; Niche, 2021b). The program should also adapt to changing priorities, mine design and/or include improvements to overall design of the monitoring program. This may involve addition or removal of sites and/or indicators as necessary to streamline and detect meaningful ecological change.

6 Subsidence Management Strategies

6.1 Mine Design Considerations

Tahmoor Coal submitted a Subsidence Management Plan Application (SMP Application) for Longwalls 31 to 37 in the Bulli Coal Seam in December 2014, which included longwalls in the Western Domain. The current mine plan has been modified since the 2014 SMP Application to consider feedback received following submission of the SMP Application in 2014, and additional information gathered from underground conditions. The revision of the mine plan has been redesigned specifically to avoid significant impact to the sensitive surface features of the environment, particularly avoiding mining directly under streams of third order or above. The revision of the mine plan also resulted in the re-orientation of longwalls in the Western Domain. Further discussion of mine design considerations is provided in **Section 3.6.1** of the Extraction Plan Main Document.

The current mine plan proposes to continue underground mining operations through the extraction of LW W3-W4 in the Western Domain, which will continue on from the active longwall series (LW W1-W2). The proposed LW W3-W4 are located to the west of the township of Picton, between Matthews, Cedar and Stonequarry Creeks, the Main Southern Railway and the previous longwall series (refer to **Figure 1-2**).

6.2 General Management Measures

There are no general management measures identified for biodiversity in relation to the extraction of LW W3-W4.

6.3 Trigger Action Response Plan

A TARP has been developed using the performance indicators for management of biodiversity as a result of LW W3-W4 mining (refer to **Appendix A**). Level 1 of the TARP indicates that, based on monitoring results, the environment is performing within normal levels. Where performance indicators indicate that a level of risk has been triggered greater than a normal level (Levels 2 or higher with escalating corresponding risk), a response in the form of management / corrective actions is required to be implemented as outlined in the TARP.

6.4 Contingency Plan

In the event that performance measures are considered to have been exceeded or are likely to be exceeded, a response will be undertaken in accordance with the TARP provided in **Appendix A**. This response is a contingency plan that describes the management / corrective actions which can be implemented where required to remedy the exceedance.

If a Corrective Action Management Plan is required in accordance with the TARP, this plan will be prepared in accordance with **Section 3.6.3** of the Extraction Plan Main Document. The success of remediation measures that has been implemented for any TARP exceedance would be reviewed as part of any Corrective Action Management Plan, the Annual Review and Six Monthly Subsidence Impact Reports (refer to **Section 6.1** of the Extraction Plan Main Document).

6.5 Adaptive Management

An Adaptive Management Strategy has been proposed to review mining-induced ground movement and impacts on the streams in proximity to LW W2 (Cedar Creek and Stonequarry Creek, particularly focusing on Pool SR17) to inform considerations for the amendment of the commencing position of LW W3. This strategy is discussed in more detail in **Section 3.6.4** and **Section 3.6.5** of the Extraction Plan Main Document.

While impacts to biodiversity will be considered as part of the overall Adaptive Management Strategy, there are no adaptive management strategies proposed specifically to manage impacts to biodiversity.

7 Review and Improvement

This section of the BMP describes the key elements of implementation relevant to biodiversity. A description of general reporting requirements, reviews and key responsibilities that are applicable to extraction of LW W3-W4 are discussed in the Extraction Plan Main Document.

7.1 Reporting Requirements

Generic reporting requirements for the LW W3-W4 Extraction Plan are discussed in **Section 6.1** of the Extraction Plan Main Document. There are no reporting requirements (other than those identified in the TARPs) specific to biodiversity identified for the extraction of LW W3-W4.

7.2 Review and Auditing

Generic review and auditing requirements for the LW W3-W4 Extraction Plan are discussed in **Section 6.2** of the Extraction Plan Main Document. There are no review or auditing requirements specific to biodiversity identified for the extraction of LW W3-W4.

7.3 Roles and Responsibilities

Generic roles and responsibilities applicable for the implementation of the LW W3-W4 Extraction Plan are discussed in **Section 6.3** of the Extraction Plan Main Document. There are no roles and responsibilities specific to the implementation of biodiversity management measures identified for the extraction of LW W3-W4.

8 Document Information

This section provides a compiled list of references, related documents, terms, and abbreviations used in this document. In addition, this section provides the change information for this document.

8.1 References

Eco Logical Australia (2004), The Impacts of Longwall Mining on the Upper Georges River Catchment: Report to Total Environment Centre, 2004.

FloraSearch (2009), Illawarra Coal Bulli Seam Operations Project Terrestrial Flora Assessment, prepared for BHP Billiton Illawarra Coal.

GeoTerra (2014), Tahmoor Coal Pty Ltd - Tahmoor colliery Longwall Panels 31 to 37 Streams, Dams & Groundwater Assessment Tahmoor, NSW.

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Niche (2014a), Aquatic assessment – Tahmoor North - Longwalls 31-37. Prepared for Tahmoor Coal.

Niche (2014b), Tahmoor North - Longwalls 31 to 37 - Terrestrial Ecology Assessment. Prepared for Tahmoor Coal.

Niche (2019a), Tahmoor North – Western Domain, Aquatic Ecology Baseline Monitoring Report, prepared for Tahmoor Coal.

Niche (2019b), Tahmoor North – Western Domain, Terrestrial Ecology Baseline Monitoring Report, prepared for Tahmoor Coal.

Niche (2020), Tahmoor Mine Western Domain Terrestrial Ecology Monitoring Report - Riparian vegetation and amphibian monitoring Autumn 2018-2020. Prepared for Tahmoor Coal. Dated May 2020.

Niche (2021a), Tahmoor North – Western Domain Longwalls West 3 and West 4, Aquatic Biodiversity Technical Report, prepared for Tahmoor Coal, May 2021.

Niche (2021b), Tahmoor North – Western Domain Longwalls West 3 and West 4, Terrestrial Biodiversity Technical Report, prepared for Tahmoor Coal, May 2021.

Niche (2021c), Re: Western domain AUSRIVAS report – Survey results - autumn 2021. Prepared for Tahmoor Coal.

SLR (2021), Tahmoor Mine LW W3-W4 Extraction Plan: Groundwater Technical Report, prepared for Tahmoor Coal, May 2021, document 665.10010.00006-R01-v3.0.

Tozer et al. (2010), Native vegetation of southeast NSW: a revised classification and map for the coast and eastern tablelands. Cunninghamia (2010) 11(3): 359–406.

8.2 Glossary of Terms

The Extraction Plan Main Document provides a compiles Glossary of Terms in **Section 8.3**.

8.3 Abbreviations

Abbreviations used in this document are provided below in **Table 8-1**.

Table 8-1 Abbreviations

Abbreviation	Definition
ABTR	Aquatic Biodiversity Technical Report
AUSRIVAS	Australian River Assessment System
BACI	Before After Control Impact
BC Act	*Biodiversity Conservation Act 2016*
BMP	Biodiversity Management Plan
CEEC	Critically Endangered Ecological Communities
CTF	Cease to flow
DPE	NSW Department of Planning and Environment (now DPIE)
DPIE	NSW Department of Planning, Industry and Environment (formerly DPE)
EEC	Endangered Ecological Communities
EES	NSW Department of Planning, Industry and Environment - Environment, Energy and Science Group
EP&A Act	NSW *Environmental Planning and Assessment Act 1979*
EPBC Act	Commonwealth *Environment Protection and Biodiversity Conservation Act 1999*
EPT	Ephemeroptera, Plecoptera, Trichoptera – a macroinvertebrate index of stream health.
HEC	Hydro Engineering & Consulting
km	Kilometre/s
LW	Longwall
LW W1	Longwall West 1
LW W1-W2	Longwalls West 1 to West 2
LW W2	Longwall West 2
LW W3-W4	Longwalls West 3 to West 4
LW W4	Longwall West 4
m	Metre/s
mm	Millimetre/s
ML	Mining Lease
Macrophytes	Aquatic vegetation
MSEC	Mine Subsidence Engineering Consultants
NSW	New South Wales
PCT	Plant Community Type
RCE	Riparian Channel and Environment Inventory;

Abbreviation	Definition
Resources Regulator	Department of Regional NSW – Resources Regulator
SIGNAL	'Stream Invertebrate Grade Number – Average Level' is a simple biotic index for macroinvertebrates that uses the pollution tolerance levels of different macroinvertebrate types to create a site score and water quality rating for the river, creek or pond being studied.
SMP Application	Subsidence Management Plan Application for Longwalls 31 to 37 in the Bulli Coal Seam in December 2014
Tahmoor Coal	Tahmoor Coal Pty Ltd
Tahmoor Mine	Tahmoor Coal Mine
TARP	Trigger Action Response Plan
TBTR	Terrestrial Biodiversity Technical Report
TECs	Threatened Ecological Communities

8.4 Change Information

Table 8-2 provides the details of document history of this BMP.

Table 8-2 Document History

Version	Date Reviewed	Reviewed By	Change Summary
1.0	May 2021	Zina Ainsworth, David Talbert, Malcolm Waterfall	New document

Appendix A – Trigger Action Response Plan

Trigger Action Response Plan – Biodiversity Management Plan

Feature	Management		
	Trigger	Action	Response
Decline or significant negative change in macroinvertebrate indicators. These indicators include: • Density • Family richness • Community assemblages • EPT index • SIGNAL score • AUSRIVAS score	Level 1		
	• Monitoring macroinvertebrate indicators are within range of baseline data as supported by statistical analysis.	• Continue monitoring as per monitoring program.	• No action required.
	Level 2		
	• One or more macroinvertebrate indicators are not within range of baseline data as supported by statistical analysis. AND ONE OR BOTH OF THE FOLLOWING: • Subsidence monitoring program identifies potential for impact to watercourse parameters associated with aquatic habitat areas compared to baseline (e.g. cracking). • Surface monitoring program identifies potential impacts to hydrology/water quality parameters compared to baseline.	• Continue monitoring as per monitoring program. • Convene Tahmoor Coal Environmental Response Group to review possible cause and response. • Review and confirm monitoring data, cross check aquatic biodiversity monitoring data against other related environmental data (e.g. control sites and benchmark data) and subsidence monitoring upon identification of the potential trigger. • Undertake further investigations as appropriate to confirm the potential issue and analyse data with the aim of determining whether the exceedance is likely to be mining related.	• As defined by Environmental Response Group. • Assess need for any increase to monitoring frequency or additional monitoring where relevant.
	Level 3		
	• Monitoring indicates that three or more macroinvertebrate indicators are not within range of baseline data as supported by statistical analysis. AND ONE OR BOTH OF THE FOLLOWING: • Subsidence monitoring identifies mining induced impacts compared to baseline watercourse parameters associated with aquatic habitat (e.g. cracking).	• Continue monitoring as per monitoring program. • Convene Tahmoor Coal Environmental Response Group to review possible cause and response. • Review and confirm monitoring data, cross check aquatic biodiversity monitoring data against other related environmental data (e.g. control sites and benchmark data) and subsidence monitoring upon identification of the potential trigger.	• Notify DPIE and relevant stakeholders within 7 days of investigation completion. • Investigate and implement any additional management measures as recommended and contingency plan as required in consultation with DPIE.

	• Subsidence monitoring identifies significant impacts to hydrology/water quality that exceed predictions compared to baseline.	• Undertake further investigations as appropriate to confirm the potential issue and analyse data with the aim of determining whether the exceedance is likely to be mining related.	

Feature	Management		
	Trigger	Action	Response
Reduction in aquatic habitat though loss of pools or associated reduction in water quality (AUSRIVAS habitat assessment).	Level 1		
	• Visual monitoring indicates aquatic habitat parameters are similar to baseline observations at aquatic ecology monitoring sites.	• Continue monitoring as per monitoring program.	• No action required.
	Level 2		
	• Visual monitoring indicates potential change in aquatic habitat compared to baseline observations at aquatic ecology monitoring sites. AND ONE OR BOTH OF THE FOLLOWING: • Subsidence monitoring identifies potential for impact to watercourse parameters associated with macroinvertebrate indicators compared to baseline. • Surface monitoring program identifies potential for impact to hydrology/water quality parameters compared to baseline.	• Continue monitoring as per monitoring program. • Convene Tahmoor Coal Environmental Response Group to review possible cause and response. • Review and confirm monitoring data, cross check aquatic biodiversity monitoring data against other related environmental data (e.g. control sites and benchmark data) and subsidence monitoring upon identification of the potential trigger. • Undertake further investigations as appropriate to confirm the potential issue and analyse data with the aim of determining whether the exceedance is likely to be mining related.	• As defined by Environmental Response Group. • Assess need for any increase to monitoring frequency or additional monitoring where relevant.
	Level 3		

SIMEC

	• Visual monitoring indicates a significance change in aquatic habitat compared to baseline observations at aquatic ecology monitoring sites. AND ONE OR BOTH OF THE FOLLOWING: • Subsidence monitoring identifies potential for impact to watercourse parameters associated with macroinvertebrate indicators compared to baseline. • Subsidence monitoring identifies significant impacts to hydrology/water quality that exceed predictions.	• Continue monitoring as per monitoring program. • Convene Tahmoor Coal Environmental Response Group to review possible cause and response. • Review and confirm monitoring data, cross check aquatic biodiversity monitoring data against other related environmental data (e.g. control sites and benchmark data) and subsidence monitoring upon identification of the potential trigger. • Undertake further investigations as appropriate to confirm the potential issue and analyse data with the aim of determining whether the exceedance is likely to be mining related.	• Notify DPIE and relevant stakeholders within 7 days of investigation completion. • Investigate and implement any additional management measures as recommended and contingency plan as required in consultation with DPIE.

Feature	Management		
	Trigger	Action	Response
Decline in amphibian populations within watercourses of the Study Area	Level 1		
	• Monitoring indicates amphibian population parameters are predominantly within a reasonable range of baseline data as supported by statistical analysis.	• Continue monitoring as per monitoring program.	• No response required.
	Level 2		
	• Monitoring indicates amphibian population parameters are predominantly not within a reasonable range of baseline data as supported by statistical analysis. AND • Subsidence monitoring program identifies potential for impact of watercourse parameters associated with sensitive amphibian habitat areas (within prediction compared to baseline).	• Continue monitoring as per monitoring program. • Convene Tahmoor Coal Environmental Response Group to review possible cause and response. • Review and confirm monitoring data, cross check biodiversity monitoring data against other related environmental data (e.g. control sites and benchmark data) and subsidence monitoring upon identification of the potential trigger. • Undertake further investigations as appropriate to confirm the potential issue and analyse data with the aim of determining whether the exceedance is likely to be mining related.	• As defined by Environmental Response Group. • Consider increasing monitoring frequency or additional monitoring where relevant.
	Level 3		
	• Monitoring indicates amphibian population parameters are significantly not within a reasonable range of baseline data as supported by statistical analysis. AND • Mining induced impacts (exceeds predicted compared to baseline) for watercourse parameters associated with sensitive amphibian habitat are identified by environmental monitoring.	• Continue monitoring as per monitoring program. • Convene Tahmoor Coal Environmental Response Group to review possible cause and response. • Review and confirm monitoring data, cross check biodiversity monitoring data against other related environmental data (e.g. control sites and benchmark data) and subsidence monitoring upon identification of the potential trigger. • Undertake further investigations as appropriate to confirm the potential issue and analyse data with the aim of determining whether the exceedance is likely to be mining related.	• Notify DPIE and relevant stakeholders within 7 days of investigation completion. • Investigate and implement any additional management measures as recommended and contingency plan as required in consultation with DPIE.

<table>
<tr><th rowspan="2">Feature</th><th colspan="3">Management</th></tr>
<tr><th>Trigger</th><th>Action</th><th>Response</th></tr>
<tr><td rowspan="6">Dieback of riparian vegetation within watercourses of the Study Area</td><td colspan="3">Level 1</td></tr>
<tr><td>Monitoring indicates riparian vegetation parameters are predominantly within a reasonable range of baseline data as supported by statistical analysis.</td><td>Continue monitoring as per monitoring program.</td><td>No response required.</td></tr>
<tr><td colspan="3">Level 2</td></tr>
<tr><td>Monitoring indicates riparian vegetation parameters are predominantly not within a reasonable range of baseline data as supported by statistical analysis.
AND
Subsidence monitoring program identifies potential for impact of watercourse parameters associated with sensitive riparian habitat areas (within prediction compared to baseline).</td><td>Continue monitoring as per monitoring program.
Convene Tahmoor Coal Environmental Response Group to review cause and response.
Review and confirm monitoring data, cross check Biodiversity monitoring data against other related environmental data (e.g. control sites and benchmark data) and subsidence monitoring upon identification of the potential trigger.
Undertake further investigations as appropriate to confirm the potential issue and analyse data with the aim of determining whether the exceedance is likely to be mining related.</td><td>As defined by Environmental Response Group.
Consider increasing monitoring frequency or additional monitoring where relevant.</td></tr>
<tr><td colspan="3">Level 3</td></tr>
<tr><td>Monitoring indicates riparian vegetation parameters are significantly not within a reasonable range of baseline data as supported by statistical analysis.
AND
Mining induced impacts (exceeds prediction compared to baseline) for watercourse parameters associated with riparian vegetation are identified by environmental monitoring.</td><td>Continue monitoring as per monitoring program.
Convene Tahmoor Coal Environmental Response Group to review cause and response.
Review and confirm monitoring data, cross check biodiversity monitoring data against other related environmental data (e.g. control sites and benchmark data) and subsidence monitoring upon identification of the potential trigger.
Undertake further investigations as appropriate to confirm the potential issue and analyse data with the aim of determining whether the exceedance is likely to be mining related.</td><td>Notify DPIE and relevant stakeholders within 7 days of investigation completion.
Investigate and implement any additional management measures as recommended and contingency plan as required in consultation with DPIE.</td></tr>
</table>

Appendix B – Aquatic Biodiversity Technical Report

Excellence in your environment

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Aquatic Biodiversity Technical Report
Tahmoor North – Western Domain
Longwalls West 3 and West 4

Prepared for Tahmoor Coal | 5 May 2021

Document control

Project number	Client	Project manager	LGA
6122	Tahmoor Coal	Matthew Russell	Wollondilly Shire

Version	Author	Review	Status	Date
D1	Matthew Russell	Sian Griffiths	Draft	29 April 2021
Rev0	Matthew Russell		Final	5 May 2021

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Glossary and list of abbreviations

Term or abbreviation	Definition
ABTR	Aquatic Biodiversity Technical Report
Aquatic macroinvertebrates	Small animals without a backbone that live for all, or part, of their lives in water. They are a useful indicator of stream health.
AUSRIVAS	Australian River Assessment System
BACI	Before After Control Impact
BC Act	*Biodiversity Conservation Act 2016*
CEEC	Critically Endangered Ecological Communities
CMA	Corrective Management Action
CTF	Cease to Flow
DoE	Department of Environment
DPIE	NSW Department of Planning, Industry and Environment (formerly Office of Environment and Heritage (OEH))
DPI	Department of Primary Industries
DRE	Division of Resources and Energy
EEC	Endangered Ecological Communities
EPT	Ephemeroptera, Plecoptera, Trichoptera – a macroinvertebrate index of stream health.
ha	Hectare/s
km	Kilometre/s
LW W1-W2	Longwalls West 1 and West 2
LW W1-W4	Longwalls West 1 to West 4
LW W3-W4	Longwalls West 3 and West 4
LW W3	Longwall West 3
LW W4	Longwall West 4
m	Metre/s
mm	Millimetre/s
Macrophytes	Aquatic vegetation
Niche	Niche Environment and Heritage
NSW	New South Wales
RCE Inventory	Riparian Channel and Environment Inventory assessment
SIGNAL	'Stream Invertebrate Grade Number – Average Level' is a simple biotic index for macroinvertebrates that uses the pollution tolerance levels of different macroinvertebrate types to create a site score and water quality rating for the river, creek or pond being studied.
Subsidence	The gradual caving in or sinking of an area of land.
TARP	Trigger Action Response Plan

TILs	Trigger Investigation Levels
Upsidence	Is defined as the difference between observed subsidence profiles within valleys and conventional subsidence profiles that would have otherwise been expected in flat terrain.

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1. Introduction

1.1 Background

The Tahmoor Coal Mine (Tahmoor Mine) is an underground coal mine located approximately 80 kilometres (km) south-west of Sydney between the towns of Tahmoor and Bargo, New South Wales (NSW) (refer to Figure 1). Tahmoor Mine produces up to three million tonnes of Run of Mine coal per annum from the Bulli Coal Seam. Tahmoor Mine produces a primary hard coking coal product and a secondary higher ash coking coal product that are used predominantly for coke manufacture for steel production. Product coal is transported via rail to Port Kembla and Newcastle for Australian domestic customers and export customers.

The Tahmoor Mine has been operated by Tahmoor Coal Pty Ltd (Tahmoor Coal) since Tahmoor Mine commenced in 1979 using bord-and-pillar mining methods, and via longwall mining methods since 1987. Tahmoor Coal is a wholly owned entity within the SIMEC Mining Division of the GFG Alliance group.

An Extraction Plan for Longwalls West 1 and West 2 (LW W1-W2), longwalls located in the Western Domain to the north-west of the Main Southern Railway, was approved by the NSW Department of Planning, Industry and Environment (DPIE) on 8 November 2019. Mining of LW W1 commenced on 15 November 2019 and finished on 6 November 2020. Mining of LW W2 commenced on 7 December 2020.

Tahmoor Coal is proposing to mine a further two longwalls in the Western Domain, Longwalls West 3 and West 4 (LW W3-W4), which will be the focus of this Extraction Plan.

1.2 Context

Niche Environment and Heritage (Niche) were commissioned by Tahmoor Coal to prepare an ABTR associated with LW W3-W4 to address the Approval Conditions in accordance with the Development Consent DA 67/98 (as modified). This assessment details the predicted impacts in relation to aquatic biodiversity and provides relevant Trigger Actions Response Plans (TARPs) associated with aquatic biodiversity.

1.3 Extraction plan Study Area

The proposed LW W3-W4 are located to the west of the township of Picton, and are located between Matthews, Cedar and Stonequarry creeks and the Main Southern Railway. These longwalls sit alongside the eastern side of the previously approved LW W1-W2, which are currently being extracted. The layouts of the completed, active and proposed longwalls at the mine are shown in Drawings Nos. MSEC1112-01 and MSEC1112-02, provided in MSEC (2021) (herein referred to as the Study Area) (Figure 1).

The Study Area (see Figure 1) is defined as the surface area that could be affected by the mining of LW W3-W4 as determined in MSEC (2021). As detailed in MSEC (2021), the extent of the Study Area has been calculated by combining the areas bounded by the following limits:

- A 35° angle of draw from the extents of LW W3-W4; and
- The predicted limit of vertical subsidence, taken as the 20 millimetres (mm) subsidence contour, resulting from the extraction of LW W3-W4.

1.4 Purpose and scope

The purpose of this ABTR is to describe the aquatic biodiversity values and assess the potential significance of the impact of the LW W3-W4 on those values within the Study Area or likely to be impacted by far-field or valley related movements outside the Study Area. This technical report specifically addresses aquatic biodiversity. The document outlines the management strategies, mitigation measures, controls and monitoring programs to be implemented for the management of aquatic flora and fauna from the proposed extraction workings.

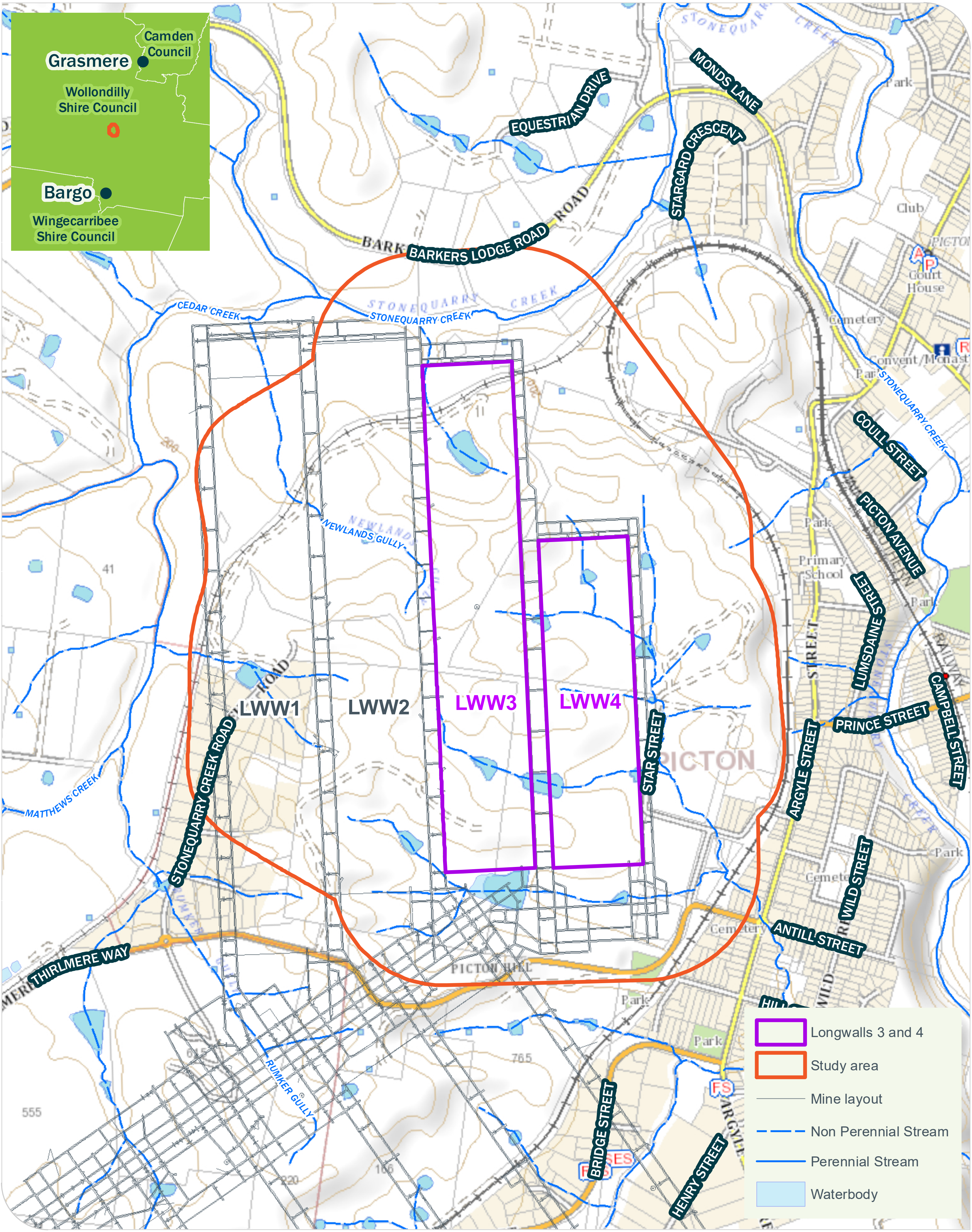
This ABTR includes the following:

- Summary of the baseline data for existing aquatic habitat, aquatic biodiversity, and stream morphology and review of LW W1 and LW W2 monitoring results.
- Provisions for the management of potential impacts and environmental consequences of the proposed second workings on aquatic biota and aquatic habitat.
- Provision of a TARP that includes a description of performance indicators to be implemented to ensure compliance with negligible environmental consequences to threatened species, threatened populations and their habitats, and endangered ecological communities; as well as considerations for the management or remediation of any impacts on and/or environmental consequences for aquatic biodiversity.
- Provisions for the inclusion of the monitoring of aquatic biota and aquatic habitat and a description of any adaptive management practices implemented to guide future mining activities in the event of greater than predicted impacts on aquatic habitat.

1.5 Structure of this document

The main text sections and attachments of this ABTR include the following:

Section 1	Provides an introduction to the ABTR for LW W3-W4, including the purpose and scope of the ABTR and the document structure.
Section 2	Describes the regulatory requirements, the subsidence performance measures relevant to this ABTR for LW W3-W4 and a summary of relevant legislation and stakeholder consultation.
Section 3	Describes the existing environment within the Study Area and the results of baseline monitoring.
Section 4	Summarises the predicted subsidence impacts and environmental consequences resulting from the extraction of LW W3-W4.
Section 5	Describes the management, monitoring and evaluation measures that will be implemented and how monitoring data will be used to assess the relevant performance indicators and performance measures.
Section 6	Provides a Contingency Plan to manage any unpredicted impacts and their consequences and Trigger Action Response Plan (TARP).



niche Environment and Heritage

Niche PM: Matt russell
Niche Proj. #: 6122
Client: Tahmoor Coal Pty Ltd

Location and Study Area
Western Domain - Longwalls West 3 & West 4
Aquatic Biodiversity Technical Report

Figure 1

2. Statuary requirements

2.1 Project approval

The proposed LW W3-W4 (the Project) will be operating in the Tahmoor North mining area under Development Consents DA 57/93 and DA 67/98. DA 67/98 provides the conditional planning approval framework for mining activities in the Western Domain to be addressed within an Extraction Plan and supporting management plans and technical reports.

This ABTR is a component of the Tahmoor North – Western Domain LW W3-W4 Extraction Plan and has been prepared specifically to address Approval Condition 13H (vii)(d) of DA 67/98 (as modified) (Table 1). The biodiversity requirements as stated in Table 1 are addressed in two separate technical reports – an Aquatic Biodiversity Technical Report (this document) and a Terrestrial Biodiversity Technical Report (Niche 2021b).

Table 1: Development consent conditions (extracted from DA 67/98)

<table>
<tr><th>Condition</th><th colspan="2">Condition Requirement</th><th>Section</th></tr>
<tr><td colspan="4">SUBSIDENCE
Performance Measures – Natural and Heritage Features etc.</td></tr>
<tr><td>13A</td><td colspan="2">The Applicant must ensure that extraction of Longwall 33 and subsequent longwalls does not cause any exceedances of the performance measures in Table 1.
Note: The Applicant will be required to define more detailed performance indicators (including impact assessment criteria) for each of these performance measures in the various management plans that are required under this consent.</td><td rowspan="4">Section 5 and Section 6</td></tr>
<tr><td rowspan="3">Excerpt from Table 1</td><td>Feature</td><td>Performance Measure</td></tr>
<tr><td colspan="2">Biodiversity</td></tr>
<tr><td>Threatened species, threatened populations, or endangered ecological communities</td><td>Negligible environmental consequences.</td></tr>
<tr><td>13B</td><td colspan="2">Measurement and monitoring of compliance with performance measures and performance indicators in this consent is to be undertaken using generally accepted methods that are appropriate to the environment and circumstances in which the feature or characteristic is located. These methods are to be fully described in the relevant management plans and monitoring programs. In the event of a dispute over the appropriateness of proposed methods, the Secretary will be the final arbiter.</td><td>Section 5 and Section 6</td></tr>
<tr><td colspan="4">Additional Offsets</td></tr>
<tr><td>13C</td><td colspan="2">If the Applicant exceeds the performance measures in Table 1 and the Secretary determines that:
• It is not reasonable or feasible to remediate the subsidence impact or environmental consequences, or
• Measures implemented by the Applicant have failed to satisfactorily remediate the subsidence impact or environmental consequence.</td><td>Noted.
Performance measures in Table 1 of DA 67/98 are not anticipated to be exceeded.</td></tr>
</table>

Condition	Condition Requirement	Section
	Then the Applicant must provide a suitable offset to compensate for the subsidence impact or environmental consequence, to the satisfaction of the Secretary.	
13D	The offset must give priority to like-for-like physical environmental offsets, but may also consider payment into any NSW Offset Fund established by EES, or funding or implementation of supplementary measures such as: • Actions outlined in threatened species recovery programs • Actions that contribute to threat abatement programs • Biodiversity research and survey programs and/or • Rehabilitating degraded habitat. *Note: Any offset required under this condition must be proportionate with the significance of the impact or environmental consequence*	Noted. Performance measures in Table 1 of DA 67/98 are not anticipated to be exceeded.
Extraction Plan		
13H	The Applicant must prepare an Extraction Plan for all second workings in Longwall 33 and subsequent longwalls to the satisfaction of the Secretary. Each Extraction Plan must:	Extraction Plan main document
13H(vi)	• Describe in detail the performance indicators to be implemented to ensure compliance with the performance measures in Table 1 and Table 2, and manage or remediate any impacts and/or environmental consequences.	Section 5.1, Section 5.2, and Section 6
13H(vii)(d)	• Biodiversity Management Plan which has been prepared in consultation with EES, which establishes baseline data for the existing habitat on the site, including water table depth, vegetation condition, stream morphology and threatened species habitat, and provides for the management of potential impacts and environmental consequences of the proposed second workings on aquatic and terrestrial flora and fauna, with a specific focus on threatened species, populations and their habitats, EECs and groundwater dependent ecosystems.	Consultation detailed in Section 2.3. Monitoring detailed in Section 5. Management detailed in Section 6.
13H(vii)(h)	• Trigger Action Response Plan/s addressing all features in Table 1 and Table 2, which contain: ▪ Appropriate triggers to warn of increased risk of exceedance of any performance measure. ▪ Specific actions to respond to high risk of exceedance of any performance measure to ensure that the measure is not exceeded. ▪ An assessment of remediation measures that may be required if exceedances occur and the capacity to implement the measures. ▪ Adaptive management where monitoring indicates that there has been an exceedance of any performance measure in Table 1 or Table 2, or where any such exceedance appears likely.	Section 6.2 and Section 6.3.
13H(vii)(i)	• Contingency Plan that expressly provides for: ▪ Adaptive management where monitoring indicates that there has been an exceedance of any	Section 6, Section 5.3

Condition	Condition Requirement	Section
	performance measure in Table 1 and Table 2, or where any such exceedance appears likely.	
	▪ An assessment of remediation measures that may be required if exceedances occur and the capacity to implement those measures.	
	▪ Includes a program to collect sufficient baseline data for future Extraction Plans.	

2.2 Relevant Legislation

2.2.1 *Biodiversity Conservation Act 2016*

The NSW *Biodiversity Conservation Act 2016* (BC Act) provides protection for threatened species native to NSW (excluding fish and marine vegetation). Species, populations and ecological communities listed under Schedule 1 (Endangered) and Schedule 2 (Vulnerable) are considered to be threatened in NSW.

Protection is provided by integrating the conservation of threatened species, endangered populations and Endangered Ecological Communities / Critically Endangered Ecological Communities (EEC/CEECs) into development control processes under the EP&A Act.

The Terrestrial Ecology Assessment (Niche 2014b) determined that no significant impacts to threatened biodiversity are likely as a result of the extraction of LW W1-W2. The findings of this assessment, and updates based on the MSEC (2021) predications for the Study Area are provided in Section 4. Given that MSEC (2021) predictions do not exceed those addressed in the Biodiversity Impact Assessment (Niche 2014), similar conclusions regarding non-significant impacts to threatened biodiversity listed under the BC Act are considered likely as a result of the extraction of LW W3-W4.

2.2.2 *Fisheries Management Act 1994*

The objectives of the *Fisheries Management Act 1994* (FM Act) are to conserve, develop and share the fishery resources of NSW for the benefit of present and future generations. In particular, the objectives of the FM Act include to:

- Conserve fish stocks and key fish habitats.
- Conserve threatened species, populations and ecological communities of fish and marine vegetation.
- Promote ecologically sustainable development, including the conservation of biological diversity.

Protection is provided by integrating the conservation of threatened species, endangered populations and EEC/CEECs into development control processes under the EP&A Act. The Aquatic Ecology Impact Assessment (Niche 2014a) concluded there was a very low likelihood of threatened species, populations or ecological communities listed under the FM Act likely to be impacted by the approved disturbance.

2.2.3 *Environment Protection and Biodiversity Conservation Act 1999*

Under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act), approval from the Commonwealth Minister for Department of Agriculture, Water and the Environment is required for any action that may have a significant impact on Matters of National Environmental Significance. These matters are:

- Listed threatened species and ecological communities.
- Migratory species protected under international agreements.
- Ramsar wetlands of international importance.
- The Commonwealth marine environment.

- World Heritage properties.
- National Heritage place.
- Great Barrier Reef Marine Park.
- Nuclear actions.
- A water resource, in relation to coal seam gas development and large coal mining development.

Threatened species, migratory species and threatened ecological communities listed under the provisions of the EPBC Act were considered within the Study Area and an assessment was made to determine if LW W3-W4 would pose a significant impact on Matters of National Environmental Significance.

The Aquatic Ecology Impact Assessment (Niche 2014a) concluded there was a very low likelihood of threatened species, population or ecological communities listed under the EPBC Act to be impacted by the Project's approved disturbance.

2.3 Consultation

A letter was sent to NSW Department of Planning, Industry and Environment (DPIE) – Environment, Energy and Science (EES) Group detailing the Extraction Plan for LW W3-W4. Tahmoor Coal provided a figure of the Extraction Plan Study Area, and an overview of the longwalls. Preliminary comments from EES have been received and Tahmoor Coal will complete further consultation with EES following the submission of the Extraction Plan.

In addition, Tahmoor Coal has undertaken correspondence with Wollondilly Shire Council (WSC) providing a letter (dated 18th September 2020) and figure of the Extraction Plan Study Area, and an overview of the longwalls. With regard to aquatic ecology WSC made the comment provided in Table 2.

Table 2: Summary of consultation

Agency	Comment	Section addressed in document
WSC	A detailed assessment of potential impacts mining operations on the ecological health of waterways in a catchment context that includes aquatic ecology.	Addressed in section 4.3
	An accurate assessment of the extent and nature of impact of LW W3 and LW W4 on aquatic ecology (including downstream waterways).	Addressed in section 4.3.5

3. Existing environment

3.1 Baseline monitoring data sources

The existing environment has been characterised using baseline studies and ongoing aquatic monitoring in the Study Area. These include:

- Tahmoor North Longwalls 31 to 37 Aquatic Ecology Assessment (Niche 2014a):
  - Riparian Channel and Environment Inventory assessment to rank the relative health of stream condition.
  - AUSRIVAS stream health assessment (including aquatic habitat, macrophytes, *in situ* water quality and macroinvertebrates).
  - Fish survey.
  - Threatened species and key fish habitat assessment.
- Biannual aquatic ecological monitoring for spring 2017, autumn 2018, spring 2018 and autumn 2019 (Niche 2019a):
  - Riparian Channel and Environment Inventory assessment to rank the relative health of stream condition.
  - AUSRIVAS stream health monitoring (including aquatic habitat, macrophytes, *in situ* water quality and macroinvertebrates).
  - Quantitative macroinvertebrate (Before After Control Impact (BACI)) monitoring.
  - Fish survey (no longer conducted).
- Tahmoor Coal Pty Ltd - Tahmoor Colliery Longwall Panels 31 to 37 Streams, Dams & Groundwater Assessment, Tahmoor, NSW (GeoTerra, 2014).
- Extraction Plan LW W1 – W2 - Surface Water Technical Report (HEC 2019).

3.2 Watercourses and stream morphology

The Study Area is located in the Stonequarry Creek Catchment with the relevant natural waterway features comprising Matthews Creek, Cedar Creek, Stonequarry Creek and Redbank Creek, as shown in Figure 2. Redbank Creek flows from west to east adjacent to, though outside of, the southern boundary of the Study Area. A topographic ridgeline straddles the Study Area, with the south-east portion of the area discharging via tributaries to Redbank Creek. The south-west portion of the area discharges to Matthews Creek, while the north-northwest portion of the area discharges to Cedar Creek and Stonequarry Creek. A portion of Stonequarry Creek traverses the northern boundary of the Study Area, while Matthews Creek, Cedar Creek and Redbank Creek are located outside of the Study Area.

3.2.1 Matthews Creek

The headwaters of Matthews Creek lie within the residential area of Thirlmere, with residential development significantly affecting the vegetation and weed growth along the upper reaches of the creek. The catchment comprises mainly rural properties. The creek flows to the north-east on the northern side of Thirlmere (Figure 2). The creek then flows to the north, downstream of Thirlmere, through a rural area with sparse residential development, along with poultry farms, commercial vegetable gardens and a shale quarry. The riparian zone of the creek contains thick native vegetation in this region. The creek in the vicinity of Thirlmere is generally in a poor state, with a high content of weeds and rubbish dumped or washed into it. Downstream of the residential area the creek significantly improves to a more natural state, down to the junction with Cedar Creek. To date, the creek has not been mined beneath, and the headwaters of the creek are located outside of the Study Areas of the previous and current longwalls.

Within the Study Area, Matthews Creek is relatively incised in Hawkesbury Sandstone, with a steep V-shaped valley and isolated vertical scarps predominating adjacent. Just upstream and at the junction with Cedar Creek, the valley becomes more incised and steeper with more predominant vertical scarps in the basal exposed sandstone of the valley. Overhangs of undercut sandstone are also prevalent in this section. Within the Study Area, Matthews Creek falls approximately 40 m in height over a total length of approximately 1,600 m, with an inferred average gradient of 25 mm/m (MSEC 2014). The stream bed and banks of Matthews Creek are well vegetated and do not show significant erosion or bank instability, principally as it is developed on, or just above, exposed Hawkesbury Sandstone basement.

Water level baseline data for Matthew Creek has been detailed in HEC (2019), which described Matthews Creek as exhibiting ‘flashy’ responses to rainfall events and indicates that pools in Matthews Creek within the Study Area experience natural periods of no flow.

The eastern tributaries of Matthews Creek within the Study Area are first and second order, ephemeral streams. The first and second order tributaries flow beneath Stonequarry Creek Road and a residential area along this road known as “Stonequarry Estate” located to the east of the Picton Mittagong Loop Line. Surface water runoff from these tributaries has been partially diverted by urban drainage associated with “Stonequarry Estate” and flows through stormwater detention basins / dams and culverts under the rail line, with runoff from the tributaries likely to contribute to flow in Matthews Creek during periods of extended or significant rainfall only. The tributaries of Matthews Creek traverse LW W1 and LW W2 though do not traverse LW W3 or LW W4 (HEC 2021).

3.2.2 Cedar Creek

Cedar Creek flows from south-west to north-east adjacent to the western boundary of the Study Area Cedar Creek joins with Stonequarry Creek approximately 370 m north-west of LW W3 and has an estimated catchment area of 27 km^2. At the confluence with Stonequarry Creek, Cedar Creek is a fifth order stream (Figure 2). The catchment area of Cedar Creek contains rural properties including a number of poultry farms, while the upper reaches are timbered and the head of the catchment lies within the Nattai National Park.

The minor tributary of Cedar Creek within the Study Area is a first order, ephemeral stream and likely only flows during periods of extended or high rainfall. Surface water runoff from the headwater of this tributary is predominately captured by a farm dam with runoff from the tributary likely to contribute to flow in Cedar Creek during periods of extended or significant rainfall only. Flow in the tributary passes through a culvert under the Picton Mittagong Loop Line before flowing to Cedar Creek. The tributary of Cedar Creek traverses LW W1 and LW W2 though does not traverse LW W3 or LW W4 (HEC 2021).

Adjacent to the Study Area, the channel of Cedar Creek is incised in Hawkesbury Sandstone, with a steep sided valley and exposed sandstone base in some parts. Rockbar, boulder and rock shelf constrained pools are prominent in the portion of creek traversing the Study Area. The bed and banks are well vegetated and show little evidence of erosion or bank instability (GeoTerra, 2014). Groundwater seepage has been observed to occur at the junction of Cedar Creek and Matthews Creek based on high iron hydroxide precipitation within this reach (Niche, 2019b).

As described by HEC (2019), Cedar Creek monitoring sites were fairly consistent during the baseline monitoring period with subdued small peaks in water level recorded during rainfall periods. Sharp increases in water level were recorded at the most upstream monitoring sites following rainfall events followed by steep recessions.

3.2.3 Stonequarry Creek

Stonequarry Creek flows within the northern boundary of the Study Area and has an estimated catchment area of 44 km^2 to the downstream boundary of the Study Area. Within the Study Area, the creek is a fifth order stream (Figure 2). A minor tributary of Stonequarry Creek flows from south-east to north-west across the northern section of LW W3. Stonequarry Creek then flows eastwards outside boundary of the Study Area, through the town of Picton, joining the Nepean River near Maldon. The catchment area of Stonequarry Creek upstream of the Study Area comprises mainly rural properties and farmland with localised housing development.

The minor tributary of Stonequarry Creek within the Study Area is a first order, ephemeral stream which likely only flows during periods of extended or high rainfall. Surface water runoff from the headwater of the tributary is predominately captured by a farm dam with runoff from the tributary likely to contribute to flow in Stonequarry Creek during periods of extended or significant rainfall only. Flow in the tributary passes through a culvert under the Picton Mittagong Loop Line before flowing to Stonequarry Creek.

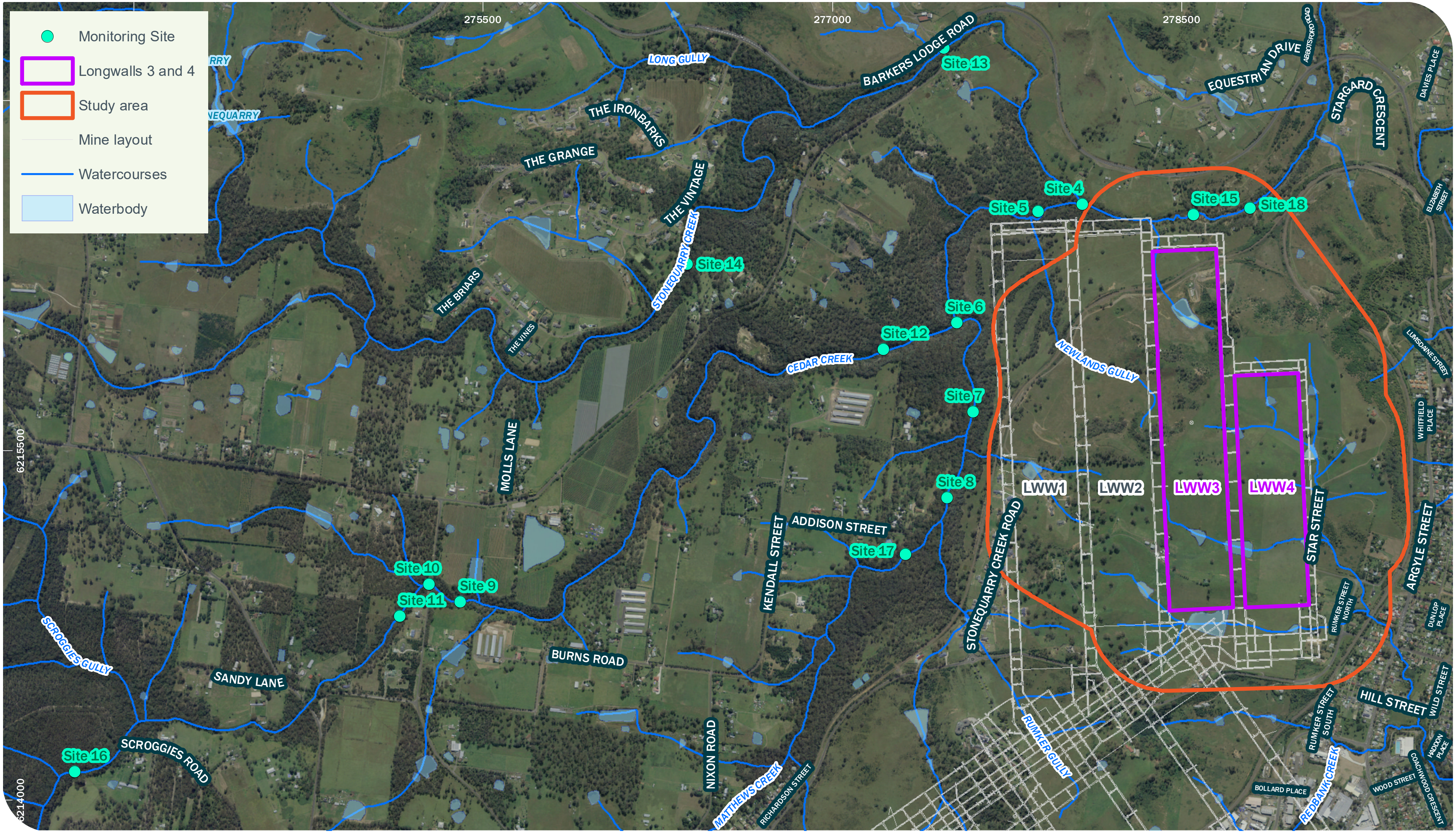
In the Study Area, the creek bed has a low gradient and predominately consists of a long pool (SR17), which extends from monitoring Site 4 to monitoring Site 15 (refer Figure 2). The pool is approximately 670 m long and is perennial in nature, with trickle flow observed over the rockbar during the period of prolonged low rainfall in 2019. Downstream of the SR17 rockbar (see Site 15, Figure 2) lies a series of connected pools, located on a large sandstone rock shelf and constrained by rockbars. The bed and banks within the section of Stonequarry Creek traversing the Study Area are well vegetated and show little evidence of erosion or bank instability (GeoTerra, 2014).

The catchment area of Stonequarry Creek upstream of the Study Area comprises mainly rural properties and farmland with localised housing development (HEC 2019). The headwaters of Stonequarry Creek lie to the north and west of Cedar Creek. Stonequarry Creek flows in a southerly direction immediately upstream of its junction with Cedar Creek, then to the east downstream of the junction through a rural area with sparse residential development, along with poultry farms, commercial vegetable gardens and a shale quarry. The riparian zone of the creek contains thick native vegetation and high weed growth in the Study Area. To date, the creek has not been mined beneath, and the headwaters are located outside of the Study Areas of the previous and current longwalls.

Baseline data by HEC (2019) has indicated that water level at Stonequarry Creek remained above the cease to flow (CTF) level for the duration of the monitoring period, while the water level at downstream sites regularly fell below the CTF level, exhibiting 'flashy' responses to rainfall events followed by steeper recessions (HEC 2019).

3.3 Riparian vegetation

Vegetation along the upper banks of Stonequarry Creek has been mapped as Cumberland Shale Sandstone Transition Forest (PCT1395) with a small section of Cumberland River-flat Forest (PCT835) occurring to the north of the longwalls. The vegetation along the banks of Matthews Creek and Cedar Creek has been mapped as Hinterland Sandstone Gully Forest (PCT1181). The condition of the vegetation communities varied depending on grazing, historic clearing and invasion by introduced species. Cumberland River-flat Forest (PCT835) contained a greater number of introduced species. The headwaters of Matthews Creek lie within the residential area of Thirlmere, with the condition of the creek significantly degraded by residential development.



Environment and Heritage

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m
GDA2020 MGA Zone 56

Monitoring sites

Western Domain - Longwalls West 3 & West 4 Aquatic Biodiversity Technical Report

Niche PM: Matt Russell
Niche Proj. #: 6122
Client: Tahmoor Coal Pty Ltd

Figure 2

3.4 Aquatic biodiversity

3.4.1 Aquatic baseline monitoring

Aquatic baseline monitoring includes an initial stream health assessment conducted in 2014 (Niche 2014) and monitoring primarily based on AUSRIVAS and quantitative macroinvertebrate sampling biannually since spring 2017. The baseline monitoring program was conducted in November 2017, April 2018, November 2018 and May 2019 and employed the following survey methods:

- Aquatic habitat assessment comprising:
  - Australian River Assessment System (AUSRIVAS)
  - Riparian Channel and Environment (RCE) Inventory.
- Macroinvertebrate survey comprising:
  - AUSRIVAS macroinvertebrate sampling
  - A quantitative benthic macroinvertebrate monitoring program.
- Water quality sampling
- Fish sampling.

The baseline monitoring is primarily focused on macroinvertebrate monitoring regimes including AUSRIVAS and quantitative Before After Control Impact (BACI) design. In AUSRIVAS, macroinvertebrate samples are compared to modelled reference sites and a rapid assessment based on presence/absence of invertebrates is completed. This provides of before /after impact monitoring of the sites through time.

The quantitative macroinvertebrate program compares potential impacts sites with upstream control sites and contains community assemblage data, which can be used to determine quantitative changes in fauna abundance, richness and structure that may be otherwise be missed by a rapid assessment approach. This approach takes into account the natural variability of the stream through the comparison to upstream control sites through time.

Collected habitat and water quality data is used to aid the interpretation of macroinvertebrate monitoring; to determine the likely drivers behind any changes in stream health indicators.

Fish sampling is no longer conducted due to the few individuals and species caught was not a suitable indicator to measure impacts.

The monitoring locations for the current monitoring program are shown in Figure 2, summarised below in Table 3 and detailed in Table 13.

Table 3: Monitoring site summary

Site Number	Site Code	Location	Sampling method	Stream	Reason for site selection	Easting	Northing
Potential impact sites – baseline (not yet impacted)							
Site 4	SQC4	Confluence of Stonequarry and Cedar creeks	Aquatic habitat assessment AUSRIVAS and Quantitative macroinvertebrate Water quality sampling	Stonequarry Creek	North of LW W2	278049	6216448
Site 5	CC5	Upstream of Stonequarry Creek confluence		Cedar Creek	North LW W1	277883	6216526

Site Number	Site Code	Location	Sampling method	Stream	Reason for site selection	Easting	Northing
Site 6	CC6	At confluence of Cedar and Matthews creeks		Cedar Creek	West of LW W1	277534	6216048
Site 7	MC7	Upstream of Cedar Creek confluence		Matthews Creek	West of LW W1	277606	6215667
Site 8	MC8	Most upstream site		Matthews Creek	West of LW W1	277494	6215298
Site 15	SQC15	Stonequarry Creek at causeway	Quantitative, water quality	Stonequarry Creek	North of LW W3 and LW 4. Downstream of longwalls. This site was included to have two impact sites on Stonequarry Creek as part of the quantitative monitoring.	278551	6216513
Site 18	SQC18	Stonequarry Creek downstream of causeway	Quantitative, water quality	Stonequarry Creek	North of LW W4. Downstream of longwalls. This site was included to have two impact sites on Stonequarry Creek as part of the quantitative monitoring.	278821	6216476
Control sites							
Site 9	CC9	Cedar Creek at Weir	Quantitative macroinvertebrate Water quality sampling	Cedar Creek	Upstream control	275401	6214851
Site 10	CC10	Cedar Creek at Bridge		Cedar Creek	Upstream control	275268	6214927
Site 11	CC11	Cedar Creek upstream		Cedar Creek	Upstream Control	275140	6214789
Site 12	CC12	Cedar Creek upstream of Matthews Creek		Cedar Creek	Upstream Control was added in autumn 2018 to be closer to Study Area.	276643	6215875
Site 13	SQC13	Stonequarry Creek at bridge		Stonequarry Creek	Upstream Control	277479	6217229
Site 14	SQC14	Stonequarry Creek at Vintage		Stonequarry Creek	Upstream control	276376	6216300

Site Number	Site Code	Location	Sampling method	Stream	Reason for site selection	Easting	Northing
Site 16	CC 16	Cedar Creek at Scroggies Lane		Cedar Creek	Upstream control was added in spring 2018 as other control sites were dry.	273744	6214122
Site 17	MC17	Matthews Creek upstream	Quantitative macroinvertebrate Water quality sampling	Matthews Creek	Upstream control was added in spring 2019 to have a control site on Matthews Creek	277315	6215055

3.4.2 Results and conclusions from aquatic baseline monitoring

The major results and conclusions from the baseline aquatic monitoring are provided in Table 4. This report has been updated to include all aquatic ecology data.

Table 4: Summary of results and conclusions of baseline aquatic monitoring

Indicator	Parameter	Results	Conclusion
Stream condition/ aquatic habitat	Stream condition	Matthews Creek, Stonequarry Creek and Cedar Creek were found to be in moderate to good stream/riparian condition with the best habitat located within the gorge along Matthews/Cedar Creek above Stonequarry Creek.	Streams are generally in moderate to good condition however low flows places natural stress on the aquatic environment and the availability and quality of aquatic habitat. Iron floc occurring in CC6 is natural and may indicate groundwater influencing benthic habitat at the location.
	Aquatic habitat	Habitat availability varied among seasons, particularly at MC8 (Site 8), which was dry on two occasions and could not be sampled. Macrophyte diversity was low with in the gorge and greatest downstream (CC5, SQC4, SC15) (Site 5, Site 4, and Site 15). Iron staining was observed at CC6 (Site 6) and CC12 (Site 12), however was reduced considerably after surveys after high rainfall.	
Water quality	Electrical conductivity	The water quality results showed high salinity (approximately 1000 µS/cm) within and upstream the Study Area. Salinity was generally lower in times of higher water levels and flow.	Electrical conductivity is naturally elevated above ANZECC guidelines in and upstream of the Study Area and resident fauna are likely to be adapted to these relatively high concentrations.

	Dissolved oxygen	Low dissolved oxygen was characteristic of all sites.	Low dissolved oxygen is considered normal for stream pools exhibiting low- to no-flow conditions.
	pH	The pH from 2017-spring 2019 was variable. Most exceedences were below ANZECC guidelines however there were sites and seasons that were above. This occurred in both potential impact sites and control sites.	Reduction in pH may be related to low rainfall, less surface water flow and increase in groundwater water influence.
	Alkalinity	Alkalinity was generally low in all streams.	Low alkalinity indicates a low buffering capacity against changes in pH.
Macroinvertebrates	AUSRIVAS	Most sites on all sampling occasions were different to modelled reference sites scoring in Band B and Band C. However, a site on Matthews Creek (MC8, Site 8) and Stonequarry Creek (SQC4, Site 4) scored in Band A on one occasion.	Low stream health scores and indices that were observed in the baseline study can be considered natural characteristics of drying intermittent/low flow streams.
	SIGNAL	Most sites had low signal score (<4).	
	EPT	EPT scores were generally low with Cedar Creek CC5 having the highest score. Most common pollution sensitive EPT taxa included Calamoceridae, Leptoceridae and Leptophlebiidae.	
	Assemblage data	The results showed that assemblages were temporally and spatially variable.	Temporal variability between surveys is likely related to change in flow/habitat quality. Spatial differences are likely to be related to morphological and hydrological differences in streams. Site 11 was an outlier and has been discontinued from monitoring.
Fish	Fish identification and counts	Few fish were observed. Most common in the Study Area and upstream sites was introduced *Gambusia Holbrooki*. One native fish was identified	Fish are unlikely to be a good indicator of environmental impact. Fish surveys have been

		within the Study Area *Gobiomorphus coxii*. *Galaxias olidus* was found in Cedar Creek upstream of the Study Area.	discontinued from the monitoring program.

3.4.3 Threatened species

No aquatic threatened species are considered likely to occur (Table 5), and therefore aquatic threatened species are unlikely to be impacted by longwall mining as part of the extraction of LW W3-W4. No threatened species have been identified as part of the baseline monitoring.

Table 5: Threatened species likelihood of occurrence

Threatened Species	FM Act	BC Act	EPBC Act	Likelihood of Occurrence
Macquarie Perch (*Macquaria australasica*)	Endangered	-	Endangered	No (Does not occur or have habitat in Study Area, however there are records downstream in the Nepean River).
Sydney Hawk Dragonfly (*Austrocordulia leonardi*)	Endangered	-	-	No (Does not occur or have habitat in Study Area however there are records downstream in the Nepean River).
Adam's Emerald Dragonfly (*Archaeophya adamsi*)	Endangered	-	-	No (Does not occur or have habitat in Study Area).
Giant Dragonfly (*Petalura gigantean*)	-	Endangered	-	No (Does not occur or have habitat in Study Area).

3.5 Aquatic monitoring during mining – assessment of impacts from LW W1 and LW2

Two monitoring sampling events have occurred during mining of LW W1 and one event after LW W2 commenced in December 2020. The monitoring results assess potential impacts of LW1 using quantitative and AURIVAS results. At the time of the report only AUSRIVAS sampling data had been analysed for LW W2.

3.5.1 During and post LW1 mining

Autumn 2020 monitoring (Niche 2020) had the following results:

- Autumn 2020 was considerably wetter than previous years with one high rainfall event and one moderate rainfall event occurring before sampling.
- All sites had similar riparian and channel condition prior to sampling, however there was more aquatic habitat available in autumn 2020 and less iron floc at Cedar Creek CC6. CC5 had a changed flow path however provided similar habitat types compared to previous surveys. In general, there were less macrophytes present at CC6, SQC4 and SQC17, however similar species were present.
- Water quality appeared to have improved, with EC within ANZECC guidelines. The pH exceeded guidelines however was more alkaline and above DTV compared to previous surveys which were below.
- AUSRIVAS scores in autumn 2020 were either comparable to previous results or higher than any scores observed pre-mining.

- Signal scores in autumn 2020 for CC5, MC7 and MC8 were marginally lower than any pre-mining scores. Cedar Creek CC5 had the lowest EPT scores in autumn 2020 compared to previous surveys of this location.
- Number of taxa were above or within the range of pre-mining results.

Spring 2020 monitoring (Niche 2021a) had the following results:

- No change in stream morphology and condition.
- Overall, despite some minor water quality exceedance in EC and pH, the water quality was comparable to control sites.
- AUSRIVAS scores in spring 2020 were either comparable to or higher than scores observed pre-mining.
- Signal scores in spring 2020 for sites SQ4, CC5, CC6 and MC8 were marginally lower than any pre-mining spring 2019 scores with MC7 marginally higher.
- EPT scores at all sites where the same or higher compared to pre-mining spring 2019 survey.
- Number of taxa were above or within the range of pre-mining results.

The Aquatic Biodiversity TARP for LW W1-W2 takes into account changes in aquatic ecology and surface water and visual subsidence monitoring. It was concluded in both the spring 2020 and autumn 2020 aquatic monitoring reports that the waterways were within TARP Level 1 (normal condition) and that mining of LW1 was having no measurable impact to aquatic ecology in autumn and spring 2020.

3.5.2 During LW W2

The preliminary AUSRIVAS results from the autumn 2021 monitoring event shows the following:

- No indication of any impact to aquatic ecology or water quality particularly as AUSRIVAS scores were within the range of, or above, pre-mining AURIVAS scores and natural variability.
- No water quality or stream morphological changes observed that can be related to any potential subsidence impact from LW W1 and LW W2.
- The preliminary autumn 2021 monitoring results confirm that all sites are considered to be ‘normal’ according to the LW W1-W2 Biodiversity Management Plan TARPs for aquatic ecology (macroinvertebrate indicators and aquatic habitat) and no TARP triggers have been exceeded.

3.6 Subsidence monitoring of LW W1 and LW2

Results from the monthly LW W1 and LW W2 monitoring are provided in Table 6.

Table 6. Summary of LW W1 and LW W2 monthly subsidence monitoring results

Monitoring type	Monitoring results and conclusions
Subsidence	• Very little to no measurable closure or upsidence was observed during the mining of LW W1. • Very minor valley closure has been measured around the confluence of Cedar and Stonequarry Creeks beyond the commencing ends of LW W1-W2 during the mining of LW W2 (MSEC 2021).
Gas emissions	• Small although reasonably persistent gas bubbles were observed in pool MR45 in Matthews Creek during the creek visual inspections conducted in February to June, October, November and December 2020 (HEC 2021). • This equated to a Level 3 Trigger Action Response Plan (TARP) significance during these periods in accordance with the LW W1 – W2 WMP (SIMEC, 2020). • The results of the gas chromatography analysis were insufficient to provide a direct linkage between mining related influences and the observed gas emissions, although a connection was considered probable (GeoTerra, 2020a).

	• No impact, such as riparian vegetation die back, has been observed in Matthews Creek as part of the biodiversity aquatic and terrestrial monitoring program.
Water quality	• Isolated occurrences of elevated water quality constituents, in excess of baseline conditions, were recorded at some monitoring sites on Matthews Creek, Cedar Creek and Stonequarry Creek following commencement of mining LW W1 (HEC 2021). • The elevated levels of constituents were predominately related to the extended low rainfall period of late 2019 to early 2020, or following the substantial rainfall which occurred in mid-January and February 2020 (HEC 2021). • A water quality TARP significance above Level 2 has not been reported for any sites in Matthews Creek, Cedar Creek or Stonequarry Creek since commencement of mining LW W1 and W2 (HEC 2021).
Water level	• A water level TARP significance above Level 1 has not been reported for any sites in Matthews Creek or Stonequarry Creek since commencement of mining LW W1 and W2 (HEC 2021). • Atypical surface water behaviour was recorded at Cedar Creek monitoring site CB (pool CR14) from 8 October 2020 to late January 2021 and at monitoring site CA (pool CB10), which is located upstream of monitoring site CB (pool CR14) in Cedar Creek, from early December 2020 to late January 2021 (HEC 2021). • This exceeded TARP trigger level 4 and required a detailed investigation (see below).
Water level - detailed investigation (see HEC 2021)	• There is evidence of a change in surface water characteristics in the reach of Cedar Creek within the Study Area (HEC 2021). • Monitoring site CC1A, CA and CB experienced a significant change in recorded water level recessionary behaviour in December 2020 at all sites and in January 2021 at monitoring sites CA and CB (HEC 2021). • The pool water level decline is considered highly likely to be related to regional groundwater level decline associated with mining induced groundwater depressurisation, however further monitoring is required to confirm this (HEC 2021). • Whilst not visible on the surface, it is likely that mining induced subsidence may have mobilised existing fractures resulting in changes in water level recession rates in pools CB3 (monitoring site CC1A), CB10 (monitoring site CA) and CR14 (monitoring site CB). However, these effects have only persisted at pool CB10 and pool CR14 and an additional period of monitoring data is required to confirm the longevity of these effects at these pools (HEC 2021). • The study concluded that (HEC 2021): ▪ Less than 10% of the pools within the Study Area have been impacted and no impacts to pool SR17 on Stonequarry Creek are evident. ▪ Consequently, there is negligible evidence to date of subsidence impacts with environmental consequences greater than minor associated with mining LW W1 and LW W2.
Biannual aquatic ecology	• No TARP exceedances during mining of LW W1 and LW W2 despite reduction in water level observed as part the surface water monitoring (Niche 2020, Niche 2021a).

4. Predicted subsidence impacts and environmental consequences

4.1 Subsidence impacts and environmental consequences

In accordance with the findings of the Southern Coalfield Inquiry (Hebblewhite 2009):

- Subsidence effects are defined as the deformation of ground mass, such as horizontal and vertical movement, curvature and strains.
- Subsidence impacts are the physical changes to the ground that are caused by subsidence effects, such as tensile and sheer cracking and buckling of strata.
- Environmental consequences are then identified, for example, as a loss of surface water flows and standing pools.

The cumulative maximum predicted subsidence, upsidence and closure in mm are provided in Table 7 and total maximum for LW W 3-W4 in Table 8 (MSEC 2021). The predicted subsidence impacts for LW W3-W4 are provided in Section 4.2 and the environmental consequences in Section 4.3.

Table 7: Maximum predicted total vertical subsidence, upsidence and closure for Matthews Creek, Cedar creek and Stonequarry creek (MSEC 2021)

Location	Longwall	Maximum predicted total vertical subsidence (mm)	Maximum predicted total upsidence (mm)	Maximum predicted total closure (mm)
Matthews Creek	After LW W2	90	90	170
	After LW W3	100	100	190
	After LW W4	100	100	200
Cedar creek	After LW W2	60	160	180
	After LW W3	70	170	200
	After LW W4	70	170	200
Stonequarry Creek	After LW W2	50	90	60
	After LW W3	70	120	80
	After LW W4	70	120	80

Table 8: Subsidence, upsidence and closure predictions for Matthews, Cedar and Stonequarry creeks (MSEC 20210)

Site	Subsidence (mm)	Upsidence (mm)	Closure (mm)
Matthews Creek	< 20	< 20	30
Cedar Creek	<20	<20	20
Stonequarry Creek	35	60	45

4.2 Potential subsidence impacts

Tahmoor Coal has designed the layout of LW W3-W4 to avoid mining directly beneath Matthews, Cedar and Stonequarry Creeks. The purpose of the design is to substantially reduce the severity and extent of impacts on surface water flows within these creeks, compared to impacts that would occur if the longwalls were extracted directly beneath them (MSEC 2021). LW W4 has been shortened near Stonequarry Creek to reduce impacts to a significant geomorphological and culturally sensitive rock bar and impacts to ARTC Rail infrastructure.

Potential subsidence impacts are discussed below and summary of potential subsidence impact to each waterway provided in Table 9.

Table 9: Predicted water chemistry and geomorphological impacts of Cedar, Matthews and Stonequarry Creeks and tributaries from the Extraction Plan Layout

Watercourse	Attribute	Predicted impacts (MSEC 20201; HEC 2019)
Cedar Creek	Grade reversal	Grade change negligible (MSEC 2021).
	Ponding	Adverse impacts due to increased levels of ponding unlikely (MSEC 2021).
	Flow	No impacts were observed within the creeks during the extraction of LW W1, taking into account variations due to rainfall and temperature. Impacts have, however, been observed to the side of LW W1 near the confluence of Cedar and Matthews Creeks as at March 2021 during the mining of LW W2. The impact sites are located where valley closure movements are predicted to be the greatest. It is possible that further impacts will be experienced at these sites during the mining of LW W3 (MSEC 2021).
	Reduced baseflow	There is predicted to be negligible apparent effect on flows in Cedar Creek due to baseflow reduction predictions associated with mining LW W3–W4. However cumulative mining impacts may result in effects on flows in Cedar Creek . This level of change would be detectable during normal periods of low flow and would likely be distinguishable from natural variability in catchment conditions (HEC 2021).
	Scour	Adverse impacts due to increased levels of scouring of the banks unlikely (MSEC 2021).
	Pool holding capacity	The predicted rate of impact for the pools along these creeks due to the extraction of the proposed longwalls is less than 10 % (MSEC 2021).
	Water quality changes	Isolated, episodic pulses in salinity, iron, manganese, zinc and nickel may occur. Potential subsidence related impacts to water quality at the junction of Cedar Creek and Matthews Creek (HEC 2021). Existing ferruginous deposition may be exacerbated by subsidence induced emergence of ferruginous springs. To date there has been negligible evidence of an influence of mining LW W1 or LW W2 on surface water quality in Cedar Creek (HEC 2021).
Matthews Creek	Grade reversal	Grade change negligible (MSEC 2021).
	Ponding	Adverse impacts due to increased levels of ponding unlikely (MSEC 2021).
	Flow	MSEC (2021) indicate that fracturing may occur at locations along Stonequarry Creek within the Study Area due to valley-related compressive strains. MSEC (2021) have assessed the potential for 'fracturing in a rock bar or upstream pool resulting in reduction in standing water level based on current rainfall and surface water flow' (MSEC, 2021). The proportion of rock bars within Matthews Creek and Cedar Creek that may experience fracturing is predicted as less than 10% based on a maximum predicted total closure of 200 mm due to the extraction of LW W1 – W4. Although there may be some temporary loss of flow (diversion) from the surface water systems in the event of cracking, connectivity between the groundwater and surface water systems is not predicted (HEC 2021).

Watercourse	Attribute	Predicted impacts (MSEC 20201; HEC 2019)
	Baseflow	HEC (2021) predict that there is no apparent effect on flows in Matthews Creek associated with mining LW W3 – W4 and the level of change would be low compared to natural variability in catchment conditions. Cumulative impacts however may be detectable during normal periods of low flow and distinguishable from natural variability in catchment conditions.
	Scour	Adverse impacts due to increased levels of scouring of the banks unlikely (MSEC 2021).
	Pool holding capacity	The predicted rate of impact for the pools along these creeks due to the extraction of the proposed longwalls is less than 10 % (MSEC 2021).
	Water quality changes	Isolated, episodic pulses in salinity, iron, manganese, zinc and nickel may occur. Potential subsidence related impacts to water quality at the junction of Cedar Creek and Matthews Creek (HEC 2021). Existing ferruginous deposition may be exacerbated by subsidence induced emergence of ferruginous springs. To date there has been negligible evidence of an influence of mining LW W1 or LW W2 on surface water quality in Matthews Creek. Gas emissions observed in Matthews Creek if related to subsidence may increase during LW W3, however no water quality impacts are predicted (MSEC 2021).
Stonequarry Creek	Grade reversal	Grade change negligible (MSEC 2021).
	Ponding	The pool extent and overall pool length is expected to change only slightly due to the extraction of LW W3–W4, although the central portion of pool SR17 is predicted to experience slightly more subsidence than rock bar SR17 resulting in this section of the pool increasing in depth by approximately 40 mm. Minor increases are considered to have a negligible impact on ponding (MSEC 2021).
	Flow	The predicted rate of impact for rock bar SR17 is assessed to be less than 5% based on a maximum total closure of 80 mm predicted for Stonequarry Creek and total closure of 60 mm at rock bar SR17 following extraction of LW W1 – W4 (MSEC, 2021). It is possible that mining-induced fractures could occur at rockbar SR17 due to the extraction of LW W3. As the rock bar is thinly bedded in places and natural fractures are present at isolated locations, it is possible that subsidence induced fracturing could result in surface water flow diversion within the rock bar. However, the likelihood of this occurring is assessed to be less than 5% (MSEC, 2021).
	Baseflow	Mining of LW W3 and W4 as well as cumulative impacts will have a level of change that would be detectable during normal periods of low flow and would likely be distinguishable from natural variability in catchment conditions (HEC 2021).
	Scour	Adverse impacts due to increased levels of scouring of the banks unlikely (MSEC 2021).
	Pool holding capacity	It is possible that subsidence induced fracturing could result in surface water flow diversion within the rock bar. However, the likelihood of this occurring is assessed to be less than 5% (MSEC 2021).
	Water quality changes	Isolated, episodic pulses in salinity, iron, manganese, zinc and nickel may occur. Existing ferruginous deposition may be exacerbated by subsidence induced emergence of ferruginous springs (HEC 2021). To date there has been negligible evidence of an influence of mining LW W1 or LW W2 on surface water quality in Stonequarry Creek (HEC 2021).

Watercourse	Attribute	Predicted impacts (MSEC 20201; HEC 2019)
Tributaries	Grade reversal	Predicted mining-induced changes in grade are small compared with the natural grades of the tributaries. It is unlikely that the tributaries would experience adverse impacts due to changes in stream alignment (MSEC 2021).
	Ponding	It is unlikely that the tributaries would experience adverse impacts due to increased levels of ponding (MSEC 2021).
	Flow	Fracturing could develop along the tributaries located within the Study Area. The fracturing will predominately occur where the tributaries are located directly above LW W1-W4, however can also occur at distances up to approximately 400 m outside the longwalls (MSEC 2021). Surface water flow diversions could occur along the tributaries that are located directly above LW W1-W4 (MSEC 2021). In times of heavy rainfall, the majority of the runoff would flow over the fractured bedrock and soil beds and would not be diverted into the dilated strata below. In times of low flow, however, surface water flows can be diverted into the dilated strata below the beds. The tributaries are ephemeral and, therefore, surface water flows only occur during and for short periods after rain events (HEC 2021).
	Baseflow	Modelling data shows that there is no apparent effect on flows in Redbank Creek tributary with the level of change predicted to be low compared to natural variability in catchment conditions (HEC 2021).
	Scour	It is unlikely that the tributaries would experience adverse impacts due to increased levels of scouring of the banks (MSEC 2021).
	Pool holding capacity	The tributaries are ephemeral and, therefore, surface water flows only occur during, and for short periods after, rain events (MSEC 2021). The main tributary, including the third order reach, is not known to contain any noteworthy surface water features (i.e. rockbars, pools and aquatic habitat). As such, potential impacts of mining on Tributary 1 of Redbank Creek are unlikely to have discernible impact with respect to surface water resources and ecosystems (HEC 2021).
	Water quality changes	None expected (HEC 2021).

4.3 Environmental consequences

Potential environmental consequences have been assessed through the consideration of predicted subsidence, hydrology (flow and quality) and hydrogeology impacts to aquatic ecology. Additionally, assessment of potential impacts have been informed through review of monitoring results from LW W1 and LW W2. To date there has been no measurable evidence of impact to aquatic ecology from the mining of LW W1 and LW W2 (Niche 2020, 2021a).

4.3.1 Ponding and scour

Increased ponding is likely to provide localised increase in available habitat for aquatic macroinvertebrates and if there is stream connectivity in the area of ponding, it may also provide additional habitat for fish and macrophytes. However, increase in water levels predicted in Stonequarry Creek is small and considered negligible. Scouring is not predicted to occur, therefore it is unlikely that aquatic ecology will be impacted by changes to this stream process.

4.3.2 Flow regime and pool holding capacity

Drainage of pools resulting from mine subsidence will impact aquatic biota inhabiting affected pools, including macroinvertebrates and native fish, with high mortalities likely in areas of complete pool drainage.

For invertebrates, there will be loss of habitat in sections of streams, and changes to invertebrate composition, density and family richness where these impacts occur. However, it is unlikely that at a sub-catchment to catchment scale changes to overall assemblage and family richness will be measurable, however total biomass is likely to be reduced if these impacts occur.

The sudden drainage of pools or rapid drop in stream flow due to subsidence are likely to have localised impacts to aquatic biota, particularly on organisms that are unable to move to areas that are damp or submerged. Aquatic plants and sessile animals are particularly vulnerable to desiccation, because of their inability to move elsewhere to other available habitat. The survival of mobile organisms is difficult to predict, as it depends on a number of factors such as their tolerance and response to desiccation and rapid changes in water level, their ability to move, weather conditions, the underlying substratum and duration of exposure (Larned et al. 2010). Streams with soft sediment banks are likely to contain moisture with interstices which may prolong the survival of stranded animals. In the streams with a bedrock substrate where there are few natural refugia, with the exception of cracks and cavities, few organisms may survive complete pool drainage. The majority of freshwater fish species recorded in the Study Area are likely to asphyxiate when exposed to air. Subsidence impacts are predicated to occur in less <10% of pools. Affected pools may experience these extremes as a result of reduction in habitat.

Recovery potential of stream biota

There is capacity for recovery of some stream biota, particularly macroinvertebrate fauna. Temporary rivers function as meta-communities (i.e. part of a larger community), with variable hydrological connectivity and multiple dispersal pathways (water, air, dry river bed) (Larned et al. 2010). Aquatic insects with aerial stages may be the most common migrants to and from disconnected aquatic habits. As well as those invertebrates that can persist for years as cysts, eggs, copodites, cocoons and dehydrated larvae and adults, and crayfish (*Cherax destructor* and *Euastacus spinifer*) which retreat to their burrows or disperse overland. Most taxa identified are able to adapt to drying conditions and have the potential to recruit back to pools once and if pool holding capacity is re-established. Animals with long larval stages and limited distribution, are obligates to a particular habitat, or are poor dispersers will be most impacted. Fish may be limited in their capacity to re-establish if river connectivity is reduced. However, surface flow will remain connected in higher flow periods (GeoTerra 2014) enabling movement of fish. Submerged and floating macrophytes generally require permanent water however they can, in time, recolonise dry areas if and when water levels return.

Although there is potential for recovery, long term impacts may persist. Some pools may not selfheal; either remaining permanently dry; or have a permanently reduced holding capacity (of both volume and retention); and thus contribute to reduced stream connectivity. This could lead to permanent changes to stream biota within the affected pools and restrict recovery of animals that require stream connectivity e.g. fish.

4.3.3 Water quality

The potential impacts of subsidence on water quality in overlying waterways include the liberation of contaminants from subsidence induced fracturing in watercourses. This causes localised and transient increases in iron concentrations and other constituents due to flushing of freshly exposed fractures in the sandstone rocks which contain iron and other minerals. Changes to chemical characteristics of surface flows can also occur as a result of changes to baseflow. One of the effects of longwall subsidence on watercourses commonly reported is the emergence of ferruginous springs (DoP 2008), often accompanied by iron flocs, staining of the bed, increased turbidity and the build-up of iron rich slimes. This ferruginous deposition occurs within sandstone streams in the Sydney Basin and was particularly prevalent at Cedar Creek near confluence of Matthew Creek as well as control sites.

Studies have shown considerable impact to flora and fauna from iron depositional related impacts (Wellnitz et al.1994; Johnson and Ritchie 2003). Invertebrate communities are impacted through a reduction in abundance, richness and changes to community composition (Johnson and Ritchie 2003; Wellnitz et al.1994; Rassmussan and Lindegaard 1988; Peters et al. 2011). It is thought that invertebrates are impacted through a reduction of habitat complexity, interference of holdfast mechanisms, affecting food supply, coating of respiratory surfaces, and inhibiting ion exchange (Johnson and Ritchie 2003; Wellnitz et al. 1994). A commonly affected insect order is mayflies, in particular the family Leptophlebiidae (SIGNAL 8) (Johnson and Ritchie 2003; Wellnitz et al.1994; Rassmussan and Lindegaard 1988; Peters et al 2011). The sensitivity of mayflies is likely to be related to the exposure of gills and the dependence on periphytic algae (Johnson and Richie 2003).

Iron is known to precipitate on the gills of fish and eggs, prevent oxygen uptake (Peuranen et al. 1994) and also affect the food supply (Wellnitz et al.1994). Scouring of iron flocculent increases turbidity and suspended solids and may inhibit fish feeding (Peuranen et al.1994).

The degree of impact will be related to the alkalinity of the stream. Streams that are acidic (low pH) and have low total alkalinity are more likely to be impacted than acidic streams with high total alkalinity (Johnson and Ritchie 2003; Wellnitz et al.1994; Peters et al. 2011) as they have a greater buffering capacity against changes to pH.

The impact of metals (iron, manganese, and zinc) is also expected to be localised and transient (GeoTerra 2014). The impacts to stream fauna similarly are expected to be localised, and fauna are likely be able to recover from transient spikes in concentration. Localised long term changes to fauna may occur if metal concentration is elevated for extended periods of time.

Increases in electrical conductivity has also been raised as an impact from subsidence that could potentially affect aquatic flora and fauna (DoP 2008); aquatic fauna such as Leptophlebiidae are likely to be affected if increases in electrical conductivity occurs. However, it must noted that high salinities can occur naturally in streams in the area. No changes in water quality have been observed to during monitoring of LW W1 and LW W2 however locations near confluence of Cedar Creek and Matthews Creek may experience change in water quality during mining LW W3.

Gas emissions have been known to occur in the Southern Coalfields (DoP 2008). In areas where gas releases occur into the water column there is insufficient time for any substantial amount of gas to dissolve into the water to change water quality (MSEC 2014). Gas emissions have caused rare and isolated dieback of riparian vegetation in the Southern Coalfields (DoP 2008). Minor gas emissions have been observed in Matthews Creek though the origin of the gas emissions is unclear. Regardless, gas emissions are unlikely to impact aquatic ecology and no resulting vegetative die back has been observed. If gas bubbles were discharged due to mine subsidence movements, it is likely that further emissions will occur during the mining of LW W2 and further emissions could possibly occur during the mining of LW W3. Monitoring of gas bubbling will continue in accordance with the LW W3-W4 Water Management Plan.

Where these gas releases occur into the water column there is insufficient time for any substantial amount of gas to dissolve into the water. The majority of the gas is released into the atmosphere and is unlikely to have an adverse impact on water quality or aquatic ecology.

4.3.4 Cumulative impacts to aquatic ecology

Aquatic ecology is affected by the combined influence of water quality, stream connectivity and habitat loss and is therefore susceptible to cumulative impacts to these environmental variables. The cumulative impacts on ecology are difficult to predict and are likely to be spatially and temporally variable. Impacts may be localised (e.g. to a pool), transient (e.g. occur in prolonged low flow condition only), gradational (e.g. downstream from a point source) and may be triggered when one or more environmental thresholds are met. Impacts to stream and biological processes may alter aquatic communities through: localised reduced abundances of sensitive flora and fauna, increased abundances of tolerant flora and fauna, reduced abundances of all aquatic flora and fauna, and/or a reduction of fauna richness. However, there is potential for partial recovery of stream fauna with re-establishment of aquatic communities following natural repair of pool habitat.

The environmental consequences of potential subsidence impacts in consideration of the physical, and surface water impacts are summarised in Table 10.

4.3.5 Downstream impacts

In consideration of the predicted surface water impacts, there are unlikely to be measurable change to aquatic ecology as a result of direct or indirect impact to the waterways. The main risk is potential cracking of Rock bar SR17 which could potentially lead to localised water quality changes in downstream locations where any diverted water resurfaces. However, the longwall layout has been designed with setbacks specifically to limit any impact to this sensitive location. In the event of unpredicted cracking and stream diversion, contingency measures will be implemented (such as grouting) to rehabilitate the rock bar and stream flow (MSEC 2021).

Table 10: Potential environmental consequences of changing aquatic values

Aquatic value	Waterway	Potential environmental consequence
Aquatic habitat	Matthews Creek	Potential reduction in pool habitat near LW W1, less than 10% reduction in overall pool habitat and increase in iron floc smothering the benthos at Cedar/Matthews Creek junction.
	Cedar Creek	Potential reduction in pool habitat near LW W1, less than 10% reduction in overall pool habitat and increase in iron floc smothering the benthos at Cedar/Matthews Creek junction.
	Stonequarry Creek	Minor/negligible reduction in pool habitat.
Riparian Vegetation	Matthews Creek	Potential localised impacts from gas emissions, low likelihood.

Aquatic value	Waterway	Potential environmental consequence
	Cedar Creek	Potential localised impacts from gas emissions, low likelihood.
	Stonequarry Creek	Potential localised impacts from gas emissions, low likelihood.
Macrophytes	Matthews Creek	Potential localised reduction in available wetted habitat, low likelihood.
	Cedar Creek-	Potential localised reduction in available wetted habitat.
	Stonequarry Creek	Potential minor reduction in wetted habitat.
Macroinvertebrates	Matthews Creek	Potential reduction in available habitat and macroinvertebrate biomass. Reduction of sensitive macroinvertebrate species at Cedar Creek/Matthews Creek junction. Potential localised temporal change in community composition from episodic changes in water quality.
	Cedar Creek	Potential localised reduction in available habit and macroinvertebrate biomass. Reduction of sensitive macroinvertebrate species at Cedar Creek/Matthews Creek junction. Potential localised temporal change in community composition from episodic changes in water quality.
	Stonequarry Creek	Potential localised temporal change in community composition from episodic changes in water quality. Low likelihood.
Fish	Matthew Creeks-	Potential localised temporal reduction in fish passage in low flows when there is naturally limited fish passage.
	Cedar Creek-	Potential localised temporal reduction in fish passage in low flows when there is naturally limited fish passage.
	Stonequarry Creek	Unlikely.
Threatened species	Matthew Creeks	Unlikely.
	Cedar Creek	Unlikely.
	Stonequarry Creek	Unlikely.

5. Management monitoring and evaluation

5.1 Subsidence performance measures and indicators

This ABTR outlines the management strategies, controls and monitoring programs to be implemented for the management of aquatic flora and fauna regarding potential environmental impacts from the proposed LW W3-W4 extraction workings.

Biodiversity performance measures were defined in DA 67/98 Condition 13A Table 1, and are repeated in Table 11 below. Tahmoor Coal must ensure that there is no exceedance of the subsidence impact performance measures for biodiversity as provided in Table 11, and have contingencies if these performance measures are exceeded.

The monitoring program will continue to be implemented to measure any impacts to aquatic biodiversity, as described in Section 5.2 and Table 12.

TARPs have been developed to:

- Establish compliance with the performance measures outlined in Table 11.
- Inform if the performance measures are likely to be exceeded during secondary extraction within the Study Area.
- Provide management/corrective actions for implementation if a risk is triggered.

The TARPs are described in Section 6.2 and provided in Table 14 of this ABTR.

Table 11: Biodiversity subsidence performance measures and performance indicators

Biodiversity feature	Subsidence performance measure	Adopted subsidence performance indicators
Threatened species, threatened populations, or endangered ecological communities	Negligible environmental consequences	This performance indicator will be considered to be triggered if: • Declines in macroinvertebrate and stream health indicators are statistically significant; and • The subsidence monitoring program identifies changes that exceed performance indicators for surface water or subsidence that may affect aquatic habitat.

5.2 Monitoring

5.2.1 Subsidence monitoring program

The monitoring program outlined below will be implemented to monitor subsidence impacts on aquatic biodiversity within the Study Area and surrounding areas likely to be impacted by far-field movements. As subsidence impacts are predicted to be small in magnitude, the monitoring program outlined below reflects the magnitude of these expected impacts.

5.2.2 Aquatic biodiversity monitoring program

Aquatic biodiversity monitoring would address stream health indicators and measure relevant water quality variables at appropriate spatial and temporal scales at both impact and control sites. This will enable changes to water quality, aquatic habitats and biota resulting from mining related subsidence to be distinguished from natural variability and other catchment influences.

Monitoring will be conducted in an adaptive management framework and be in accordance with the current monitoring program methods and protocols (see baseline monitoring report for details - Niche 2019).

Sampling has been conducted in spring and autumn for two years prior to the commencement of mining in order to establish a baseline condition. Monitoring will continue to be conducted in spring and autumn every year during and for a period of 12 months after mining to detect any changes to the aquatic environment and its biota that could be attributed to mining activities. Monitoring will employ a range of techniques including:

- Physiochemical water quality sampling
- Aquatic habitat observations
- AUSRIVAS macroinvertebrate sampling
- Quantitative macroinvertebrate sampling.

Detailed recommendations for monitoring including laboratory methods and data analysis are provided in Niche (2019a). The sampling regime and monitoring locations are provided in Table 12, Table 13 and Figure 2.

AUSRIVAS monitoring will allow monitoring of the sites through time with a before/after comparison. Quantitative sampling of macroinvertebrates will allow statistical testing of any change to family richness, density and macroinvertebrate assemblages in a BACI experimental design through temporal comparison of impact sites to upstream controls.

Reporting will be completed annually or as required by the TARPs.

5.3 Baseline monitoring for future extraction plans

The monitoring program going forward should aim to be consistent with previous monitoring conducted as part of the subsidence monitoring program (Table 12, Table 13). The monitoring program should also adapt to changing priorities, mine design and/or include improvements to overall design of the monitoring program. This may involve the addition or removal of sites and/or indicators as necessary to streamline and detect meaningful ecological change. The monitoring program should be reviewed, particularly after the completion of the LW W3, to ascertain whether survey effort is effectively monitoring stream health and anthropogenic induced changes and results of monitoring should inform future mine layouts.

Table 12: Monitoring program for aquatic biodiversity values

Feature	Monitoring component / location	Monitoring		
		Prior to mining	During mining	Post mining
Water quality	Physio chemical water quality sampling at all sites	Completed as part of baseline monitoring.	Bi-annually	Bi-annually (spring and autumn) for 12 months following the completion of LW W2. This period may be extended as per the decision by the Environmental Response Group.
Aquatic habitat	Aquatic habitat observations at Sites 4-8 (SQC4, CC5, CC6, MC7, MC8, SQC 15)			
Macroinvertebrates	AUSRIVAS macroinvertebrate sampling at Sites 4-8 (SQC4, CC5, CC6, MC7, MC8, SQC15)			
	Quantitative macroinvertebrate sampling at Sites 4-18 (Table 13).			

Table 13: Location of monitoring sites (refer also figure 2)

Site number	Site code	Location	Sampling method	Stream	Longwall	Easting	Northing
Potential impact sites – baseline (not yet impacted)							
Site 4	SQC4	Confluence of Stonequarry and Cedar creeks	Aquatic habitat assessment AUSRIVAS and Quantitative macroinvertebrate sampling Water quality sampling	Stonequarry Creek	North of Longwall W2	278049	6216448
Site 5	CC5	Upstream of Stonequarry Creek confluence		Cedar Creek	North LW W1	277883	6216526
Site 6	CC6	At confluence of Cedar and Matthews creeks		Cedar Creek	West of LW W1	277534	6216048
Site 7	MC7	Upstream of Cedar Creek confluence		Matthews Creek	West of LW W1	277606	6215667
Site 8	MC8	Most upstream site		Matthews Creek	West of LW W1	277494	6215298
Site 15	SQC15	Stonequarry Creek downstream	Quantitative macroinvertebrate sampling Water quality sampling.	Stonequarry Creek	Downstream of longwalls	278551	6216513
Site 18	SQC18	Stonequarry Creek downstream of causeway	Quantitative, water quality	Stonequarry Creek	Downstream of longwalls. This site was included to have two	278821	6216476

Site number	Site code	Location	Sampling method	Stream	Longwall	Easting	Northing
					impact sites on Stonequarry Creek as part of the quantitative monitoring.		
Control sites							
Site 9**	CC9	Cedar Creek at Weir	Quantitative macroinvertebrate sampling Water quality sampling.	Cedar creek	Upstream control	275401	6214851
Site 10**	CC10	Cedar Creek at Bridge		Cedar Creek	Upstream control	275268	6214927
Site 11*	CC11	Cedar Creek upstream		Cedar Creek	Upstream Control	275140	6214789
Site 12	CC12	Cedar Creek upstream of Matthews Creek		Cedar Creek	Upstream Control	276643	6215875
Site 13	SQC13	Stonequarry creek at bridge		Stonequarry Creek	Upstream Control	277479	6217229
Site 14	SQC14	Stonequarry Creek at Vintage		Stonequarry creek	Upstream control	276376	6216300
Site 16	CC 16	Cedar Creek at Scroggies Lane		Cedar Creek	Upstream control	273744	6214122
Site 17	MC17	Matthews Creek upstream		Matthew Creek	Site 17	MC17	Matthews Creek upstream

*no longer sampled

** Site 9 and 10 are considered the same site as they close together and joined in wet periods.

6. Contingency plan

6.1 Adaptive management

As part of the aquatic biodiversity management, Tahmoor Coal recognises the need to adapt to unforeseeable impacts or changes associated with the Project. Tahmoor Coal will implement the contingencies outlined in Section 6.2 and the TARPs (Table 14).

An Adaptive Management Framework provides for flexible decision making, adjusted to consider uncertainties as management outcomes are understood. Through feedback to the management process, the management procedures are changed in steps until monitoring shows that the desired outcome is obtained. The monitoring program has been developed so that there is statistical confidence in the outcome.

Adaptive management involves:

- Planning – identifying performance measures and indicators, developing management strategies to meet performance measures and establishing programs to monitor against the performance measures.
- Implementation – implementing monitoring programs and management strategies.
- Review – reviewing and evaluating the effectiveness of monitoring and management strategies.
- Contingency response – implementing the contingency plan in the event that a subsidence impact performance measure in relation to surface water resources has been exceeded.
- Adjustment – adjusting management strategies to improve performance.

An adaptive management response would be detailed in an Investigation Report prepared as a response to issues identified in the monitoring program. An Investigation Report will be written, which will determine any adaptive management responses based on the monitoring data and additional expert advice (if sought).

6.2 Trigger Action Response Plans (TARPs)

TARPs are used to set out response measures for unpredicted subsidence impacts and have been developed for potential impacts to sensitive biodiversity features, such as aquatic habitat and macroinvertebrates.

The monitoring results will be used to assess the impacts of mining in the Western Domain against the performance indicators and performance measures using the TARPs.

The frequency of assessment against the TARPs and the proposed method of analysis is summarised in Table 12 and Table 13 for each potential impact to aquatic biodiversity. The impact assessment triggers and proposed response/action plans are detailed in Table 14.

Table 14. TARPs associated with aquatic biodiversity

<table>
<tr><th>Potential impact</th><th>Trigger</th><th>Action</th><th>Response</th></tr>
<tr><td rowspan="6">Decline or significant negative change in macroinvertebrate indicators. These indicators include:
Density
Family richness
Community assemblages
EPT index
SIGNAL score
AUSRIVAS score</td><td colspan="3">Level 1</td></tr>
<tr><td>Monitoring macroinvertebrate indicators are within range of baseline data as supported by statistical analysis.</td><td>Continue monitoring as per monitoring program.</td><td>No action required.</td></tr>
<tr><td colspan="3">Level 2</td></tr>
<tr><td>One or more macroinvertebrate indicators are not within range of baseline data as supported by statistical analysis.

AND ONE OR BOTH OF THE FOLLOWING:
Subsidence monitoring program identifies potential for impact to watercourse parameters associated with aquatic habitat areas compared to baseline e.g. cracking.
Subsidence monitoring program identifies potential impacts to hydrology/water quality parameters compared to baseline.</td><td>Continue monitoring as per monitoring program.
Convene Tahmoor Coal Environmental Response Group to review possible cause and response.
Review and confirm monitoring data, cross check aquatic biodiversity monitoring data against other related environmental data (e.g. control sites and benchmark data) and subsidence monitoring upon identification of the potential trigger.
Undertake further investigations as appropriate to confirm the potential issue and analyse data with the aim of determining whether the exceedance is likely to be mining related.</td><td>As defined by Environmental Response Group.
Assess need for any increase to monitoring frequency or additional monitoring where relevant.</td></tr>
<tr><td colspan="3">Level 3</td></tr>
<tr><td>Monitoring indicates that three or more macroinvertebrate indicators are not within range of baseline data as supported by statistical analysis.

AND ONE OR BOTH OF THE FOLLOWING:</td><td>Continue monitoring as per monitoring program.
Convene Tahmoor Coal Environmental Response Group to review possible cause and response.</td><td>Notify DPIE and relevant stakeholders within 7 days of investigation completion.
Complete an investigation report including the identification of potential remediation measures, and implement remediation measures in consultation with DPIE.</td></tr>
</table>

	• Subsidence monitoring identifies mining induced impacts compared to baseline watercourse parameters associated with aquatic habitat e.g. cracking. • Subsidence monitoring identifies significant impacts to hydrology/water quality that exceed predictions compared to baseline.	• Review and confirm monitoring data, cross check aquatic biodiversity monitoring data against other related environmental data (e.g. control sites and benchmark data) and subsidence monitoring upon identification of the potential trigger. • Undertake further investigations as appropriate to confirm the potential issue and analyse data with the aim of determining whether the exceedance is likely to be mining related.	

Potential impact	Trigger	Action	Response
Reduction in aquatic habitat though loss of pools or associated reduction in water quality (AUSRIVAS habitat assessment).	Level 1		
	Visual monitoring indicates aquatic habitat parameters are similar to baseline observations at aquatic ecology monitoring sites.	• Continue monitoring as per monitoring program.	• No action required.
	Level 2		
	Visual monitoring indicates potential change in aquatic habitat compared to baseline observations at aquatic ecology monitoring sites. AND ONE OR BOTH OF THE FOLLOWING: • Subsidence monitoring identifies potential for impact to watercourse parameters associated with macroinvertebrate indicators compared to baseline. Subsidence monitoring program identifies potential for impact to hydrology/water quality parameters compares to baseline.	• Continue monitoring as per monitoring program. • Convene Tahmoor Coal Environmental Response Group to review possible cause and response. • Review and confirm monitoring data, cross check aquatic biodiversity monitoring data against other related environmental data (e.g. control sites and benchmark data) and subsidence monitoring	• As defined by Environmental Response Group. • Assess need for any increase to monitoring frequency or additional monitoring where relevant.

		upon identification of the potential trigger. • Undertake further investigations as appropriate to confirm the potential issue and analyse data with the aim of determining whether the exceedance is likely to be mining related.	
	Level 3		
	Visual monitoring indicates a significant change in aquatic habitat compared to baseline observations at aquatic ecology monitoring sites. AND ONE OR BOTH OF THE FOLLOWING: • Subsidence monitoring identifies that macroinvertebrate indicators exceed prediction compared to baseline. • Subsidence monitoring identifies significant impacts to hydrology/water quality that exceed predictions.	• Continue monitoring as per monitoring program. • Convene Tahmoor Coal Environmental Response Group to review possible cause and response. • Review and confirm monitoring data, cross check aquatic biodiversity monitoring data against other related environmental data (e.g. control sites and benchmark data) and subsidence monitoring upon identification of the potential trigger. • Undertake further investigations as appropriate to confirm the potential issue and analyse data with the aim of determining whether the exceedance is likely to be mining related.	• Notify DPIE and relevant stakeholders within 7 days of investigation completion. • Complete an investigation report including the identification of potential remediation measures, and implement remediation measures in consultation with DPIE.

6.3 Contingency measures

As subsidence predictions for the study area as a result of the mining of LW W3 and W4 are minimal and mine design has been altered to avoid direct mining beneath creeks, potential impacts are considered unlikely. However, if required, Tahmoor Coal will undertake remediation in consultation with the relevant landholders and NSW Government Agencies. A Response Strategy will be adopted if a significant impact is detected as a result of mining activities within the Study Area.

Standard management measures will be implemented for negligible impacts to aquatic biodiversity where those impacts occur as a result of mining. These measures include continuation of the approved monitoring program and reporting.

Management measures for aquatic biodiversity will be employed where more than negligible impacts resulting from subsidence occur (e.g. Level 2 and Level 3 as described in the TARPs). Management measures include implementation of the standard management measures as well as the involvement of the Tahmoor Coal Environmental Response Group, relevant stakeholders, agencies and specialists to investigate and report on the changes that are identified.

If a Level 3 TARP is triggered, assessment of biodiversity impacts by a qualified Ecologist would be undertaken once the impact is confirmed to be related to mining. Additional monitoring would be undertaken with specialists providing updates on the investigation process and the relevant stakeholders and agencies would be provided with investigation results. In the event that the impacts of mine subsidence on aquatic habitats are greater than predicted, the following mitigation measures would also be considered, in consultation with key stakeholders:

- Should significant impacts on aquatic biodiversity occur that are considered to be outside of the Performance Measures of the approval conditions, Tahmoor Coal would review future longwalls configurations;
- Implementing stream remediation measures, such as backfilling or grouting in areas where fracturing of controlling rock bars and/or stream bed leads to diversion of stream flow and drainage of pools; and
- Implementing appropriate erosion/sedimentation control measures to limit the potential for deposition of eroded sediment into affected streams.

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Rehabilitation
Stakeholder consultation and facilitation
Project management

Environmental offsetting
Offset strategy and assessment (NSW, QLD, Commonwealth)
Accredited BAM assessors (NSW)
Biodiversity Stewardship Site Agreements (NSW)
Offset site establishment and management
Offset brokerage
Advanced Offset establishment (QLD)

Appendix C – Terrestrial Biodiversity Technical Report

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Terrestrial Biodiversity Technical Report
Tahmoor North – Western Domain
Longwalls West 3 & West 4

Prepared for SIMEC Mining - Tahmoor Coal | 4 May 2021

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Document control

Project number	Client	Project manager	LGA
6122	SIMEC Mining - Tahmoor Coal	Luke Baker	Wollondilly Shire

Version	Author	Review	Status	Date
D1	Alex Christie	Luke Baker	Draft	12 October 2020
D2	Alex Christie	Sian Griffiths	Draft	17 December 2020
Rev0	Alex Christie	-	Final	23 December 2020
Rev1	Alex Christie	April Hudson and David Talbert	Final	2 March 2021
Rev1	Alex Christie	April Hudson and David Talbert	Final	4 May 2021

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Glossary and list of abbreviations

Term or abbreviation	Definition
BACI	Before After Control Impact
BAM	Biodiversity Assessment Method
BC Act	*Biodiversity Conservation Act 2016*
CEEC	Critically Endangered Ecological Community
CTF	Cease to Flow
DPIE	NSW Department of Planning, Industry and Environment (formerly Office of Environment and Heritage (OEH))
EEC	Endangered Ecological Community
EPBC Act	*Environment Protection and Biodiversity Conservation Act 1999*
ha	Hectare/s
km	Kilometre/s
LW	Longwalls
LW W1-W2	Longwalls West 1 and West 2
LW W1-W4	Longwalls West 1 to West 4
LW W3-W4	Longwalls West 3 and West 4
LW W3	Longwall West 3
LW W4	Longwall West 4
m	Meters
mm	Millimetres
MNES	Matters of National Environmental Significance
Niche	Niche Environment and Heritage
NSW	New South Wales
PCT	Plant Community Type
SMP	Subsidence Management Plan
Tahmoor Coal	Tahmoor Coal Pty Ltd
TBTR	Terrestrial Biodiversity Technical Report for LW W3-W4
TECs	Threatened Ecological Communities
TARPs	Trigger Actions Response Plans

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1. Introduction

1.1 Background

The Tahmoor Coal Mine (Tahmoor Mine) is an underground coal mine located approximately 80 kilometres (km) south-west of Sydney between the towns of Tahmoor and Bargo, New South Wales (NSW). Tahmoor Mine produces up to three million tonnes of Run of Mine coal per annum from the Bulli Coal Seam. Tahmoor Mine produces a primary hard coking coal product and a secondary higher ash coking coal product that are used predominantly for coke manufacture for steel production. Product coal is transported via rail to Port Kembla and Newcastle for Australian domestic customers and export customers.

The Tahmoor Mine has been operated by Tahmoor Coal Pty Ltd (Tahmoor Coal) since Tahmoor Mine commenced in 1979 using bord and pillar mining methods, and via longwall mining methods since 1987. Tahmoor Coal is a wholly owned entity within the SIMEC Mining Division of the GFG Alliance group.

An Extraction Plan for Longwalls West 1 and West 2 (LW W1-W2), longwalls located in the Western Domain to the north-west of the Main Southern Railway, was approved by the NSW Department of Planning, Industry and Environment (DPIE) on 8 November 2019. Mining of LW W1 commenced on 15 November 2019 and finished on 6 November 2020. Mining of LW W2 commenced on 7 December 2020.

Tahmoor Coal is proposing to mine a further two longwalls in the Western Domain, Longwalls West 3 and West 4 (LW W3-W4), which will be the focus of this Extraction Plan.

1.2 Context

Niche Environment and Heritage (Niche) were commissioned by Tahmoor Coal to prepare a Terrestrial Biodiversity Technical Report (TBTR) associated with LW W3-W4 to address the Approval Conditions in accordance with DA 67/98. This assessment details the predicted impacts in relation to biodiversity and provides relevant Trigger Actions Response Plans (TARPs) associated with terrestrial biodiversity.

1.3 Extraction plan Study Area

The proposed LW W3-W4 are located to the west of the township of Picton, and are located between Matthews, Cedar and Stonequarry creeks and the Main Southern Railway. These longwalls sit alongside the eastern side of the previously approved LW W1-W2, which are currently being extracted. The layouts of the completed, active and proposed longwalls at the mine are shown in Drawings Nos. MSEC1112-01 and MSEC1112-02, provided in MSEC (2021) (herein referred to as the Study Area).

The Study Area (see Figure 1) is defined as the surface area that could be affected by the mining of LW W3-W4 as determined in MSEC (2021). As detailed in MSEC (2021), the extent of the Study Area has been calculated by combining the areas bounded by the following limits:

- A 35° angle of draw from the extents of LW W3-W4; and
- The predicted limit of vertical subsidence, taken as the 20 millimetres (mm) subsidence contour, resulting from the extraction of LW W3-W4.

Features that could experience far-field or valley related movements and could be sensitive to such movements are also discussed in this TBTR.

The Study Area includes a number of natural features and items of surface infrastructure. Of relevance to this TBTR, the natural features include creeks (Matthews, Cedar and Stonequarry creeks) and steep slopes.

1.4 Purpose and scope

The purpose of this TBTR is to describe the biodiversity values and predicted impacts of LW W3-W4 on biodiversity values within the Study Area or likely to be impacted by far-field or valley related movements outside of the Study Area. Niche (2014) included a detailed assessment of greater subsidence impact predictions, the findings of which are incorporated in this TBTR.

This TBTR specifies management strategies, mitigation measures, controls and monitoring programs to be implemented to minimise potential impacts of the proposed extraction workings on terrestrial flora and fauna.

This TBTR includes the following:

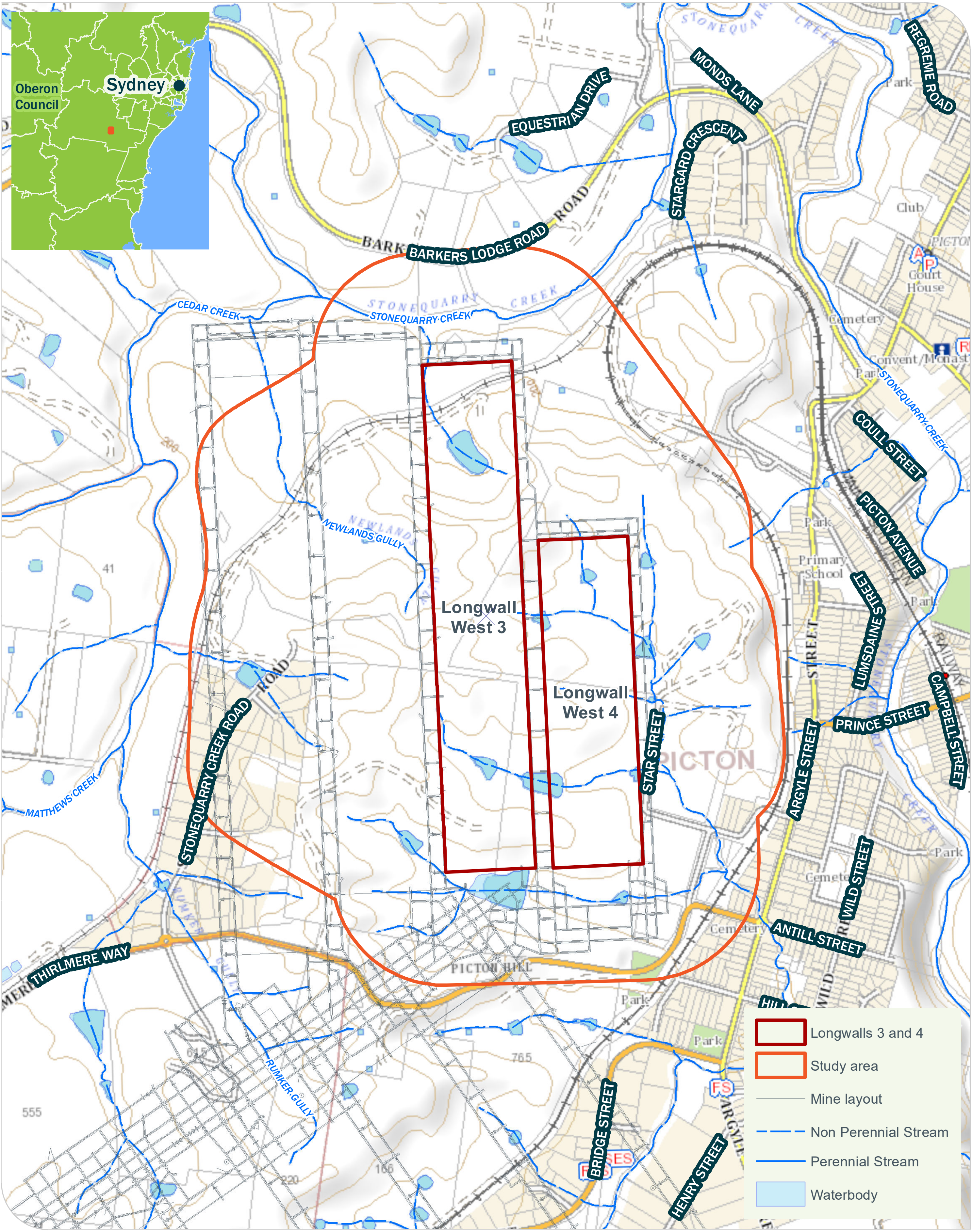
- Summary of the baseline data for existing habitat on the site, riparian vegetation condition, and threatened species habitat;
- Provisions for the management of potential impacts and environmental consequences of the proposed second workings (LW W3-W4) on threatened species, threatened populations and their habitats, and endangered ecological communities;
- Provision of a TARP that includes a description of performance indicators to be implemented to ensure compliance with negligible environmental consequences to threatened species, threatened populations and their habitats, and endangered ecological communities; as well as considerations for the management or remediation of any impacts and/or environmental consequences to terrestrial ecology; and
- Provisions for the inclusion of the monitoring of amphibian and riparian vegetation health and a description of any adaptive management practices implemented to guide future mining activities in the event of greater than predicted impacts on amphibian and riparian habitat.

1.5 Structure of this document

The main sections and attachments of this TBTR include the following:

Section 1	An introduction to the TBTR for LW W3-W4, including the purpose and scope of the TBTR and the document structure.
Section 2	Describes the regulatory requirements, the subsidence performance measures relevant to this TBTR for LW W3-W4 and a summary of relevant legislation and stakeholder consultation.
Section 3	Describes the existing environment within the Study Area.
Section 4	Summarises the predicted subsidence impacts and environmental consequences resulting from the extraction of LW W3-W4.
Section 5	Describes the management, monitoring and evaluation measures that will be implemented and how monitoring data will be used to assess the relevant performance indicators and performance measures.
Section 6	Provides a Contingency Plan to manage any unpredicted impacts and their consequences. This is shown in the TARP, which is a simple and transparent snapshot of the monitoring of environmental performance and where required the implementation of management and/or contingency measures.

Section 7	References
Appendix B	Niche (2020), Tahmoor Mine Western Domain Terrestrial Ecology Monitoring Report - Riparian vegetation and amphibian monitoring Autumn 2018-2020. Prepared for Tahmoor Coal. Dated May 2020.
Appendix C	Niche (2021a), Tahmoor Mine Western Domain Terrestrial Ecology Monitoring Report - Riparian vegetation and amphibian monitoring Spring 2017-2020. Prepared for Tahmoor Coal. Dated February 2021.



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GDA 1994 MGA Zone 56

Niche PM: Alex Christie
Niche Proj. #: 6122
Client: Tahmoor Coal Pty Ltd

Location and Study Area
Western Domain - Longwalls West 3 & West 4
Terrestrial Biodiversity Technical Report

Figure 1

Drawn by: JB File: T:\spatial\projects\a6100\a6122_TahmoorCoal_WesternDomain_Biodiversity\Maps\report\6122_Figure_1_StudyArea_PA4.mxd Last updated: 9/17/2020 10:57:02 AM

2. Statutory requirements

2.1 Project approval

Tahmoor Mine operates in the Tahmoor North mining area under Development Consent DA 67/98 which provides the conditional planning approval framework for mining activities in the Western Domain to be addressed within an Extraction Plan and supporting management plans and technical reports.

The proposed LW W3-W4 will be mined in the Tahmoor North mining area and will be conducted under Development Consents DA 57/93 and DA 67/98.

This TBTR for LW W3-W4 is a component of the Tahmoor LW W3-W4 Extraction Plan. This TBTR has been prepared specifically to address Approval Condition Schedule 2 Condition 13H(vii)(d) of DA 67/98 (Modification 5). Table 1 identifies the requirements of approval and how the condition has been addressed in this TBTR. It should be noted that a separate technical report has been prepared to address aquatic biodiversity (Niche 2021b).

Table 1. Development consent condition relevant to this TBTR

<table>
<tr><th>Condition</th><th colspan="2">Condition Requirement</th><th>Section Addressed</th></tr>
<tr><td colspan="4">SUBSIDENCE

Performance Measures – Natural and Heritage Features etc.</td></tr>
<tr><td>13A</td><td colspan="2">The Applicant must ensure that extraction of Longwall 33 and subsequent longwalls does not cause any exceedances of the performance measures in Table 1.

Note: The Applicant will be required to define more detailed performance indicators (including impact assessment criteria) for each of these performance measures in the various management plans that are required under this consent.</td><td rowspan="4">TARPs provided in Table 9 which addresses the biodiversity features.</td></tr>
<tr><td rowspan="3">Excerpt from Table 1</td><td>Feature</td><td>Performance Measure</td></tr>
<tr><td colspan="2">Biodiversity</td></tr>
<tr><td>Threatened species, threatened populations, or endangered ecological communities</td><td>• Negligible environmental consequences.</td></tr>
<tr><td>13B</td><td colspan="2">Measurement and monitoring of compliance with performance measures and performance indicators in this consent is to be undertaken using generally accepted methods that are appropriate to the environment and circumstances in which the feature or characteristic is located. These methods are to be fully described in the relevant management plans and monitoring programs. In the event of a dispute over the appropriateness of proposed methods, the Secretary will be the final arbiter.</td><td>Section 5, Section 6</td></tr>
<tr><td colspan="4">Additional Offsets</td></tr>
<tr><td>13C</td><td colspan="2">If the Applicant exceeds the performance measures in Table 1 and the Secretary determines that:

(i) it is not reasonable or feasible to remediate the subsidence impact or environmental consequence; or</td><td>Tahmoor Coal anticipate that Performance measures in</td></tr>
</table>

Condition	Condition Requirement	Section Addressed
	(ii) remediation measures implemented by the Applicant have failed to satisfactorily remediate the subsidence impact or environmental consequence, then the Applicant must provide a suitable offset to compensate for the subsidence impact or environmental consequence, to the satisfaction of the Secretary.	Table 1 of DA 67/98 will not be exceeded.
13D	The offset must give priority to like-for-like physical environmental offsets, but may also consider payment into any NSW Offset Fund established by ESS, or funding or implementation of supplementary measures such as: (i) actions outlined in threatened species recovery programs; (ii) actions that contribute to threat abatement programs; (iii) biodiversity research and survey programs; and/or (iv) rehabilitating degraded habitat. *Note: Any offset required under this condition must be proportionate with the significance of the impact or environmental consequence*	Tahmoor Coal anticipate that Performance measures in Table 1 of DA 67/98 will not be exceeded.
Extraction Plan		
13H	The Applicant must prepare an Extraction Plan for all second workings in Longwall 33 and subsequent longwalls to the satisfaction of the Secretary. Each Extraction Plan must:	See Extraction Plan Main Document.
13H(vi)	Describe in detail the performance indicators to be implemented to ensure compliance with the performance measures in Table 1 and Table 2, and manage or remediate any impacts and/or environmental consequences;	Section 5.1, Section 6 and Table 9.
13H(vii)(d)	Biodiversity Management Plan which has been prepared in consultation with ESS, which establishes a baseline data for the existing habitat on the site, including water table depth, vegetation condition, stream morphology and threatened species habitat, and provides for the management of potential impacts and environmental consequences of the proposed second workings on aquatic and terrestrial flora and fauna, with a specific focus on threatened species, populations and their habitats, EECs and groundwater dependent ecosystems;	Consultation detailed in Section 2.3. Monitoring details in Section 5. Management details in Section 6.
13H(vii)(h)	Trigger Action Response Plan/s addressing all features in Table 1 and Table 2, which contain: • appropriate triggers to warn of increased risk of exceedance of any performance measure; and • specific actions to respond to high risk of exceedance of any performance measure to ensure that the measure is not exceeded; • an assessment of remediation measures that may be required if exceedances occur and the capacity to implement the measures; and • adaptive management where monitoring indicates that there has been an exceedance of any performance measure in Table 1 or Table 2, or where any such exceedance appears likely.	Section 6.
13H(vii)(i)	Contingency Plan that expressly provides for:	Section 6.

Condition	Condition Requirement	Section Addressed
	• adaptive management where monitoring indicates that there has been an exceedance of any performance measure in Table 1 and Table 2, or where any such exceedance appears likely; and	
	• an assessment of remediation measures that may be required if exceedances occur and the capacity to implement those measures; and	
	• includes a program to collect sufficient baseline data for future Extraction Plans.	

2.2 Relevant legislation

2.2.1 NSW *Biodiversity Conservation Act 2016*

The NSW *Biodiversity Conservation Act 2016* (BC Act) provides protection for threatened species native to NSW (excluding fish and marine vegetation). Species, populations and ecological communities listed under Schedule 1 (Endangered) and Schedule 2 (Vulnerable) are considered to be threatened in NSW.

Protection is provided by integrating the conservation of threatened species, endangered populations and Endangered Ecological Communities / Critically Endangered Ecological Communities (EEC/CEECs) into development control processes under the *Environmental Planning and Assessment Act 1979* (EP&A Act).

The Terrestrial Ecology Assessment (Niche 2014) applied to the Study Area determined that no significant impacts to threatened biodiversity are likely as a result of the extraction of LW W3-W4. The findings of this assessment, and updates based on the MSEC (2021) predications for the Study Area are provided in Section 4. Given the MSEC (2021) do not exceed those predictions assessed in the Terrestrial Ecology Assessment (Niche 2014), similar conclusions regarding non-significant impacts to threatened biodiversity listed under the BC Act are likely as a result of the extraction of LW W3-W4.

2.2.2 Commonwealth *Environment Protection and Biodiversity Conservation Act 1999*

Under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act), approval from the Commonwealth Minister for Department of Agriculture, Water and the Environment is required for any action that may have a significant impact on matters of national environmental significance (MNES). These matters are:

- Listed threatened species and ecological communities;
- Migratory species protected under international agreements;
- Ramsar wetlands of international importance;
- The Commonwealth marine environment;
- World Heritage properties;
- National Heritage place;
- Great Barrier Reef Marine Park;
- Nuclear actions; and
- A water resource, in relation to coal seam gas development and large coal mining development.

The Terrestrial Ecology Assessment (Niche 2014) applied to the Study Area determined that no significant impacts to threatened biodiversity are likely as a result of the extraction of LW W3-W4. The findings of this assessment, and updates based on the MSEC (2021) predications for the Study Area are provided in Section 4. Given the MSEC (2021) do not exceed those predictions assessed in the Terrestrial Ecology Assessment

(Niche 2014), similar conclusions regarding non-significant impacts to threatened biodiversity listed under the EPBC Act are likely as a result of the extraction of LW W3-W4.

2.3 Consultation

A letter was sent to NSW Department of Planning, Industry and Environment (DPIE) – Environment, Energy and Science (EES) Group introducing the Extraction Plan for LW W3-W4. Tahmoor Coal provided a figure of the Extraction Plan Study Area, and an overview of the longwalls. Preliminary comments from EES have been received and Tahmoor Coal will complete further consultation with EES following the submission of the Extraction Plan.

In addition, Tahmoor Coal has undertaken correspondence with Wollondilly Shire Council (WSC) on the 18th September 2020 providing via letter a figure of the Extraction Plan Study Area, and an overview of the longwalls. As part of this correspondence WSC requested that the terrestrial assessment be based on the most up to date vegetation mapping and the implementation of the Plan involve targeted surveys for flora and fauna species identified as being likely to occur on the site prior to the commencement of works. In response Tahmoor Coal informed WSC that baseline terrestrial monitoring has been completed in the Western Domain since 2017 and will be continued during and after LW W3-W4 mining.

3. Existing Environment

3.1 Previous terrestrial ecology impact assessment

The existing environment is characterised by baseline studies and on-going terrestrial ecology monitoring (amphibians and riparian monitoring) in the Study Area.

In 2014, Niche completed a Terrestrial Ecology Assessment associated with the extraction of Longwalls 31 to 37 as part of the Tahmoor North Project (Niche 2014). This entailed a terrestrial flora and fauna assessment of the potential subsidence impacts associated with the proposed mining of Longwalls 31 to 37 at Tahmoor Mine. This area includes the current LW W3-W4 Study Area. The assessment was completed to accompany and inform the 2014 Subsidence Management Plan (SMP) Application for Longwalls 31 to 37.

Key survey tasks completed include the following:

- Field survey completed by ecologists on 15 to 17 October 2014 to complete the following:
  - Validated vegetation mapping;
  - Threatened flora surveys;
  - Habitat survey for threatened fauna;
- An additional amphibian survey was completed on 3 November 2014 by Dr Frank Lemckert (Amphibian expert); and
- Impact assessment under both State and Commonwealth legislation.

The outcomes of this assessment, including threatened biodiversity surveys and results are provided in the following sections.

3.2 Vegetation mapping

Vegetation in the Study Area has been mapped as part of Tozer *et al*. (2010) Native vegetation of southeast NSW, which was confirmed during the field survey completed by Niche (2014).

Six vegetation communities have been mapped within the Study Area by Tozer *et al*. (2006) and Niche (Niche 2014). Descriptions of each vegetation community along with associated Plant Community Types (PCT), and associated areas are detailed in Table 2, and shown on Figure 3.

Table 2. Vegetation mapping within the Study Area

Vegetation code & Vegetation community[1]	PCT	Description	Area (ha) Study Area
P2. Cumberland Shale Sandstone Transition Forest	1395 - Narrow-leaved Ironbark - Broad-leaved Ironbark - Grey Gum open forest of the edges of the Cumberland Plain, Sydney Basin Bioregion	Cumberland Shale Sandstone Transition Forest is a eucalypt forest or woodland with a mixed understorey of sclerophyll shrubs and grasses. It occurs on clay soils derived from Wianamatta shale (Bannerman and Hazelton 1990) predominantly on the margins of the Cumberland Plain, Sydney, where the underlying sandstone strata are near the surface. Minor occurrences are found on isolated shale remnants in the lower Blue Mountains and the Hornsby and Woronora plateaux and, more rarely, associated with shale lenses within sandstone strata. Cumberland Shale Sandstone Transition Forest is found up to 350 metres (m) ASL in areas where mean annual rainfall ranges from 800 to 1100 mm. Floristic Summary: Trees: *Eucalyptus crebra, Eucalyptus fibrosa, Allocasuarina littoralis, Eucalyptus punctata*. Shrubs: *Persoonia linearis, Bursaria spinosa, Ozothamnus diosmifolius, Hibbertia aspera.* Climbers: *Glycine clandestina.* Groundcover*: Lepidosperma laterale, Cheilanthes sieberi, Aristida vagans, Pratia purpurascens, Microlaena stipoides, Entolasia stricta, Lomandra multiflora, Themeda australis, Panicum simile, Echinopogon caespitosus, Pomax umbellata, Dichondra spp., Billardiera scandens, Opercularia diphylla*.	25.94
p33: Cumberland River Flat Forest	835 - Forest Red Gum - Rough-barked Apple grassy woodland on alluvial flats of the Cumberland Plain, Sydney Basin Bioregion	Cumberland River Flat Forest is a woodland to open forest with open shrub layer and continuous groundcover of grasses and forbs. Its distribution is restricted to the Hawkesbury-Nepean and Georges River systems on the Cumberland Plain, on stream banks and alluvial flats draining soils derived from Wianamatta Shale. It occurs at altitudes from 1 m to 160 m ASL, where mean annual rainfall is in the range 750-900 mm. Trees: *Eucalyptus tereticornis, Angophora floribunda, E. amplifolia*. Shrubs: *Acacia parramattensis, Bursaria spinosa, Sigesbeckia orientalis*. Groundcover: *Microlaena stipoides, Oplismenus aemulus, Dichondra spp., Entolasia marginata, Solanum prinophyllum, Pratia purpurascens, Echinopogon ovatus, Desmodium gunnii, Commelina cyanea, Veronica plebeia*.	1.75
P146: Sydney Hinterland Transition Woodland	1081 - Red Bloodwood - Grey Gum woodland on the edges of the Cumberland Plain, Sydney Basin Bioregion	Sydney Hinterland Transition Woodland is a eucalypt woodland with an open understorey of sclerophyll shrubs, sedges, forbs and grasses. This transition woodland encircles the Cumberland Plain rainshadow, on loamy soils typically derived from sediments belonging to the Hawkesbury or Mittagong formations. Floristic Summary: Trees: *Corymbia gummifera*, *Eucalyptus punctata*, *Angophora costata*, *Syncarpia glomulifera*. Shrubs: *Phyllanthus hirtellus*, *Persoonia linearis*, *Leptospermum trinervium*, *Acacia ulicifolia*, *Persoonia levis*, *Acacia linifolia*, *Banksia spinulosa*, *Pimelea linifolia*. Climbers: *Billardiera scandens*. Groundcover: *Entolasia stricta*, *Lomandra obliqua*, *Pomax umbellata*, *Themeda australis*, *Lomandra multiflora*, *Lepidosperma laterale*, *Dianella revoluta*, *Austrostipa pubescens*, *Goodenia hederacea*.	2.73
Total of native vegetation mapped in Study Area			30.41

[1] Tozer *et al*. (2010), Native vegetation of southeast NSW: a revised classification and map for the coast and eastern tablelands. Cunninghamia (2010) 11(3): 359-406.

3.2.1 Riparian vegetation

The vegetation along the riparian corridors of the Study Area were surveyed (where possible) as part of Niche (2014) survey, and portions surveyed as part of the Riparian Monitoring Program (Niche 2020, Niche 2021a).

Riparian monitoring sites have been set up along Matthews Creek, Cedar Creek and Stonequarry Creek (Niche 2020, Niche 2021a) given these riparian areas may potentially be exposed to subsidence related impacts. Vegetation descriptions along each of the riparian corridors have been provided in the sections below.

Stonequarry Creek, Matthews Creek and Cedar Creek

Vegetation along the upper banks of the Stonequarry Creek has been mapped as Cumberland Shale Sandstone Transition Forest (PCT1395) with a small section of Cumberland River-flat Forest (PCT835) occurring to the north of the longwalls.

Plots and observations during field survey completed by Niche (2014) confirmed the presence of diagnostic species for both these communities: *Eucalyptus crebra, Eucalyptus fibrosa, Eucalyptus punctata, Eucalyptus elata* and *Allocasuarina littoralis*. Dominant shrubs included: *Acacia decurrens, Bursaria spinosa, Ozothamnus diosmifolius* and *Persoonia linearis.* Groundcover included *Aristida vagans, Cheilanthes sieberi, Dichondra repens, Echinopogon caespitosus, Lomandra multiflora, Microlaena stipoides, Panicum simile, Pomax umbellata, Pratia purpurascens,* and *Themeda australis.*

The condition of the vegetation communities varied depending on grazing, historic clearing and invasion of introduced species. The condition of Cumberland River-flat Forest (PCT835) contained a greater number of introduced species. Common introduced species recorded included *Ageratina riparia, Conyza bonariensis, Hypochaeris radicata, Lactuca saligna, Ligustrum lucidum, Ligustrum sinense, Senecio madagascariensis, Sida rhombifolia,* and *Tradescantia fluminensis.*

A small patch of vegetation along the upper banks of Matthews Creek and Cedar Creek within the Study Area has been mapped as Hinterland Sandstone Gully Forest (PCT1181). Dominant species within this community included *Corymbia gummifera, Eucalyptus piperita, Persoonia linearis, Phyllanthus hirtellus, Leptospermum trinervium, Lomatia silaifolia, Banksia spinulosa, Platysace linearifolia,* and *Ceratopetalum gummiferum.* Groundcover included *Entolasia stricta, Pteridium esculentum, Dianella caerulea, Smilax glyciphylla, Lomandra longifolia, Lepidosperma laterale*, and *Lomandra obliqua*.

3.3 Biodiversity monitoring

3.3.1 Niche (2020 and 2021a) Riparian vegetation and amphibian monitoring reports

The Study Area includes monitoring sites associated with the biodiversity (amphibian and riparian) monitoring program (Niche 2020, Niche 2021a). This monitoring program included riparian vegetation monitoring along Stonequarry Creek, Cedar Creek, Matthews Creek, which entailed traverses of the creek and collection of flora plots/transect; and amphibian transects at set monitoring locations. A detailed methodology is provided in Niche (2020, 2021a).

A description for each of the impact and control sites is provided in Table 3 and the location of each monitoring site is provided in Figure 2.

The aquatic monitoring completed by Niche is described in the Aquatic Biodiversity Technical Report (Niche 2021b).

Table 3. Monitoring site locations

Treatment	Site Name	Stream	Existing impacts and features
Longwall Impact	Site 3	Cedar Creek near Stonequarry Creek junction	Rural residential, permanent stream, rainforest
	Site 4	Matthews Creek in gorge near Cedar Creek junction	Rural residential, permanent pools
	Site 5	Matthews Creek in gorge	Rural residential
Control	Site 6	Cedar Creek in gorge	Agriculture, permanent pools, rainforest
	Site 7	Cedar Creek	Rural residential
	Site 8	Cedar Creek	Rural residential
	Site 9	Stonequarry Creek	Agriculture, weed infestations
	Site 10	Stonequarry Creek in gorge	Rural residential, permanent pools, rainforest

3.3.2 Riparian vegetation monitoring baseline data

Details of the riparian monitoring baseline data are provided in Niche (2020, 2021a) which in included in Appendix B and Appendix C. The findings of the riparian vegetation monitoring have been discussed in the following sections.

3.3.3 Riparian vegetation - species diversity and richness

Based on the results of the riparian monitoring (Niche 2020, Niche 2021a), a total of 201 flora species were detected within the riparian monitoring sites during the 2020 Autumn monitoring season, of which 51 were exotic and 150 were native species. A total of 328 flora species were detected within the riparian monitoring sites during the 2020 Spring monitoring season, of which 284 were native plant species and 44 were exotic plant species. This differed from previous years where fewer species were detected overall. Changes in species diversity across years it likely attributed to seasonality, given some species flower at differing times of the year/season.

Species richness across monitoring sites ranged from 18 to 65 species. Species richness was generally greater in Spring compared with Autumn. The most frequently recorded species included: *Microlaena stipoides, Lomandra longifolia, Solanum prinophyllum, Adiantum aethiopicum, Persicaria decipiens, Oplismenus aemulus, Entolasia marginata, Ehrharta erecta, Morinda jasminoides, Bursaria spinosa, Oxalis perennans, Notelaea longifolia, Entolasia stricta* and *Backhousia myrtifolia.*

Floristic composition and vegetation cover at each site were relatively consistent over all monitoring events. Impact sites had a slightly lower mean species richness and percentage vegetation cover than control sites.

3.3.4 Riparian vegetation - composition, structure and function

During the riparian monitoring (Niche 2020, Niche 2021a), the key indicators collected in the DPIE (2020) Biodiversity Assessment Method (BAM) were utilised to assess condition, structure and function of vegetation/habitat features within each of the monitoring quadrats. Based on the three years of baseline monitoring, natural variation in the riparian vegetation has been observed. Given the riparian nature, a higher degree of variation in diversity, abundance and structure is expected. Other variation, such as vegetation condition, can be explained by difference in personal judgement.

Over the three years of monitoring, differences in some of the key attributes between the two seasons were observed. This is predicted given changes in foliage cover between seasons, vegetation growth, branch loss and natural die back of species such as annuals. The importance of the BAM is it provides a representation of the sites in terms of habitat condition, which can be compared to PCT specific benchmark conditions.

3.3.5 Riparian vegetation – floristic variability

The topographic and geological setting for the monitoring sites varies significantly. As a result, there is considerable "natural" variability between sites. Based on the results of the riparian monitoring (Niche 2020, Niche 2021a), the mean vegetation cover between sites fluctuated by up to 46 percent between monitoring events. In general, foliage cover between the first round of seasonal monitoring and the third round has decreased. Mean foliage cover for both the impact and control sites in Spring were higher than that of the Autumn monitoring events, with the exception of control sites in Autumn 2019, which were higher. Control sites for all monitoring events showed higher mean vegetation cover compared with the impact sites.

Exotic species, which typically made up only a small percentage of the site's foliage cover, remained relatively constant throughout all monitoring events. Native cover fluctuated much more, which is likely the result of the overall higher levels of native cover at all sites.

Sites which occurred in a more protected environment, such as deep gullies or cannons, tended to have less fluctuation in species richness and cover. This could reflect the sheltered environment which may provide a buffer to the seasonal conditions. However, these sites also tend to have poorer soils and are less suited to the establishment and persistence of annual species.

Flooding, which may have occurred as a result of heavy rain events, may have also contributed towards influencing species richness and vegetation cover. This may occur when vegetation such are trees or growth medium is washed away or deposited within the riparian zone.

3.4 Threatened ecological communities

A list of threatened ecological communities (TECs) occurring or potentially occurring within the locality was determined from database searches (the NSW Bionet Database Search tool and EPBC Act Protected Matters Search tool) and a literature review. Based on the results of the database searches, nine TECs have been identified as potentially occurring within the locality as outlined in Appendix A.

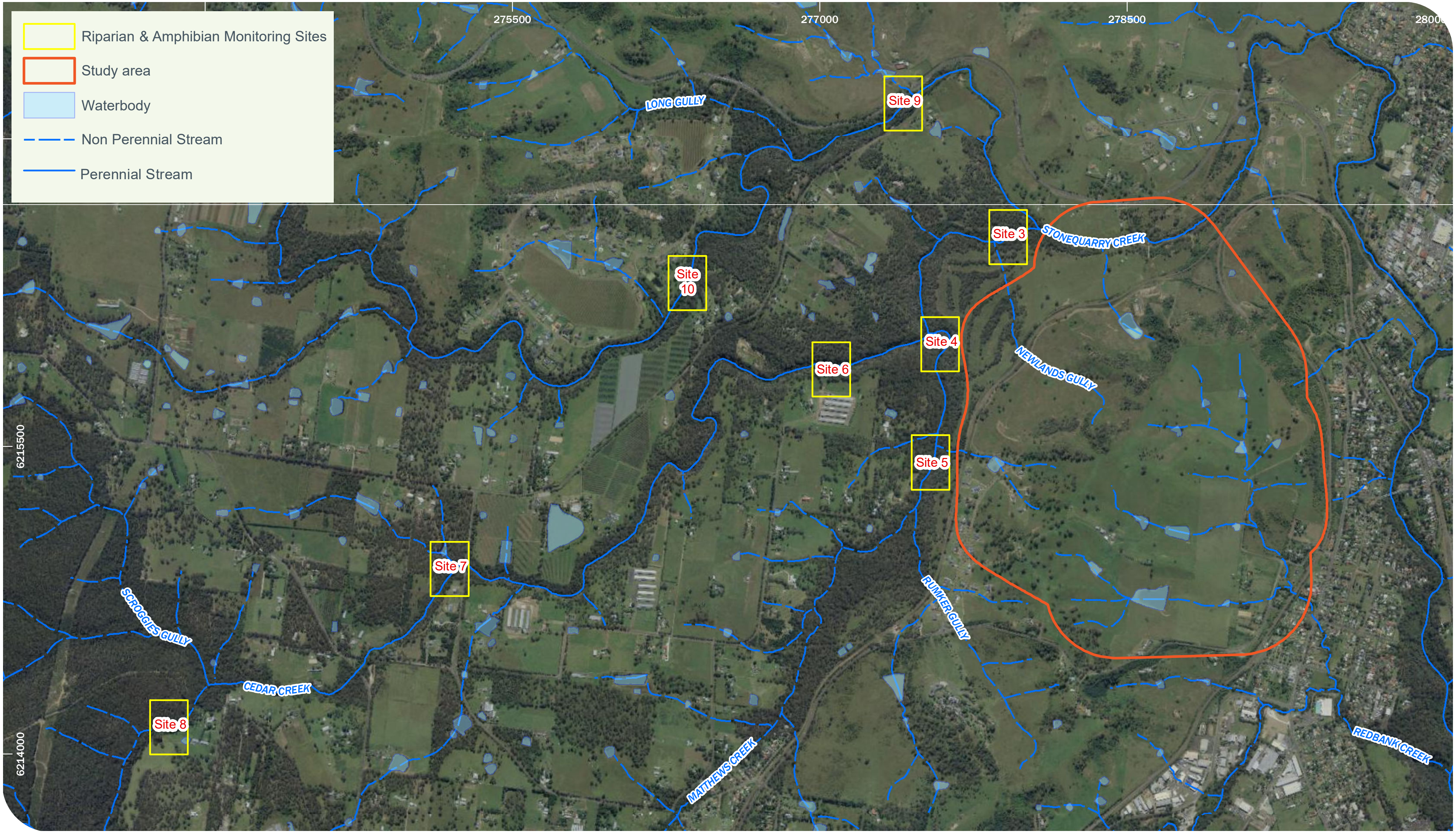
Based on Tozer (2006) and the results of the field survey completed by Niche (2014) and observations during the riparian monitoring (Niche 2020, Niche 2021a), two TECs are likely to occur in the Study Area, as shown in Table 4.

Table 4. Threatened ecological communities in the Study Area

Vegetation community[2]	PCT	Threatened Ecological Community	Area (ha) Study Area
P2. Cumberland Shale Sandstone Transition Forest	1395 - Narrow-leaved Ironbark - Broad-leaved Ironbark - Grey Gum open forest of the edges of the Cumberland Plain, Sydney Basin Bioregion	Shale Sandstone Transition Forest. Listed as Critically Endangered under the BC Act and EPBC Act.	25.94

[2] Tozer *et al*. (2010), Native vegetation of southeast NSW: a revised classification and map for the coast and eastern tablelands. *Cunninghamia* (2010) 11(3): 359–406.

Vegetation community[2]	PCT	Threatened Ecological Community	Area (ha) Study Area
p33: Cumberland River Flat Forest	835 - Forest Red Gum - Rough-barked Apple grassy woodland on alluvial flats of the Cumberland Plain, Sydney Basin Bioregion	River-Flat Eucalypt Forest. Listed as Endangered under the BC Act.	1.75



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Biodiversity monitoring sites

Western Domain - Longwalls West 3 & West 4 Terrestrial Biodiversity Technical Report

Niche PM: Alex Christie
Niche Proj. #: 6122
Client: Tahmoor Coal Pty Ltd

Figure 2

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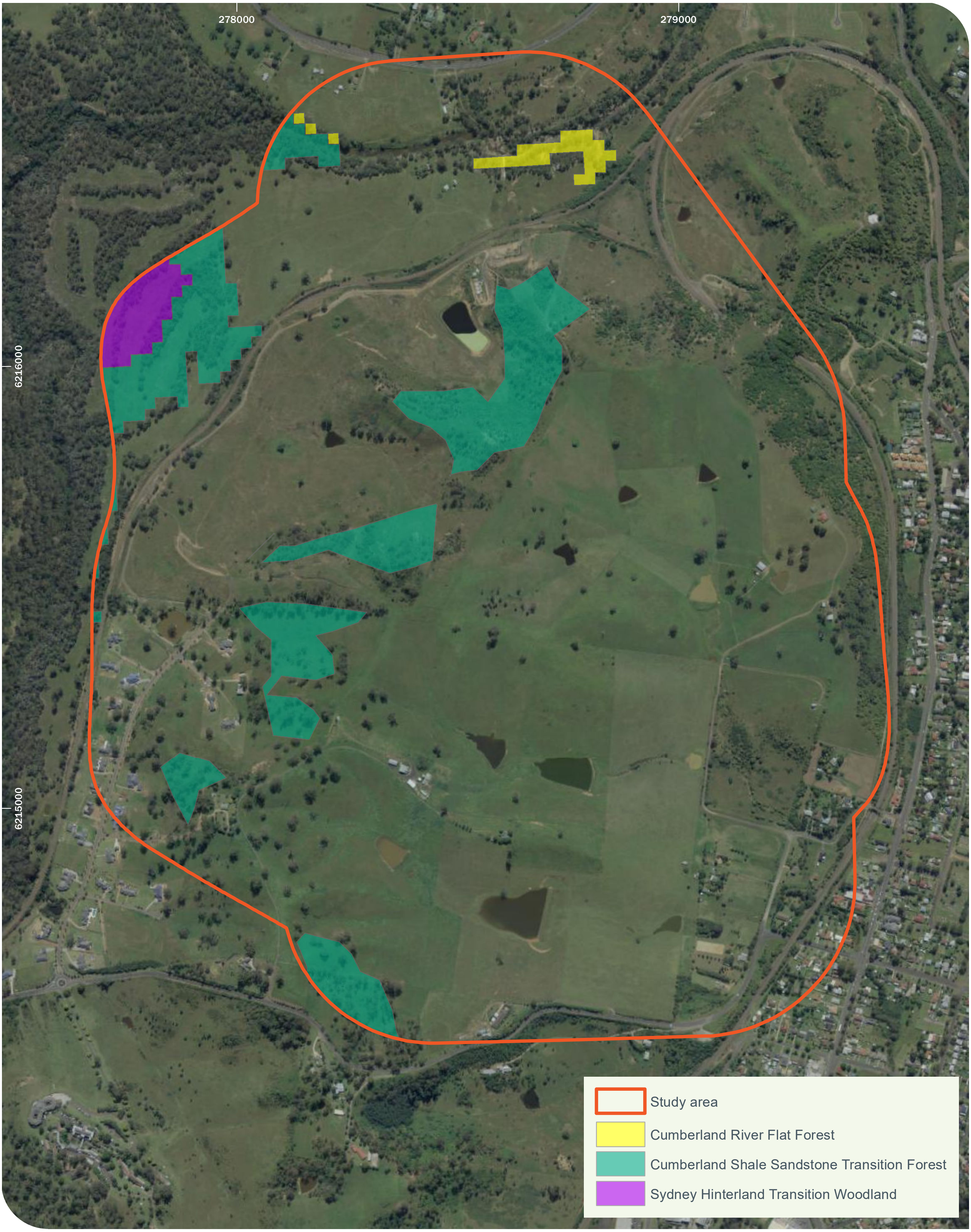

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Niche PM: Alex Christie
Niche Proj. #: 6122
Client: Tahmoor Coal Pty Ltd

Mapped native vegetation (DPIE, Niche)
Western Domain - Longwalls West 3 & West 4
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Figure 3

3.5 Threatened flora

A total of 36 threatened flora listed on the BC Act and/or EPBC Act were identified as subject species during the Terrestrial Ecology Assessment (Niche 2014). Subject species were identified through database searches of Bionet and the EPBC Act Protected Matter Search tool, and field surveys.

As detailed by Niche (2014), no threatened flora listed on the BC and/or EPBC Act were recorded in the Study Area. Furthermore, no threatened flora have been recorded during the riparian monitoring program to date.

Threatened flora which were attributed a moderate to high likelihood of occurrence in the Terrestrial Ecology Assessment (Niche 2014) and which are relevant to this TBTR are listed in Table 5.

Table 5. Threatened flora with a moderate to high likelihood of occurrence within the Study Area

Threatened flora	Potential occurrence in Study Area
Acacia pubescens	Occurs in open woodland and forest, in a variety of plant communities, including Cooks River/Castlereagh Ironbark Forest, Shale/Gravel Transition Forest and Cumberland Plain Woodland. Patches of Cumberland River Flat Forest have been previously mapped throughout the Study Area. Some of the areas were not able to be surveyed during the Niche (2014) assessment due to land holder access restrictions. Potential habitat includes Cumberland River Flat Forest.
Epacris purpurascens var. *purpurascens*	Potential habitat within lower lying areas of native vegetation, particularly along ephemeral drainage lines. Potential habitat associated with strong shale soil influence communities: Cumberland Shale Sandstone Transition Forest, Cumberland River Flat Forest and Hinterland Sandstone Gully Forest.
Grevillea parviflora subsp. *parviflora*	Potential habitat with shale/sandstone transition areas with populations are more commonly found in relatively open, disturbed sites along roads and tracks in areas of open-forest or woodland. Potential habitat includes Cumberland Shale Sandstone Transition Forest.
Leucopogon exolasius	Potential habitat on woodland on sandstone. Much of the land with potential habitat occurs along the banks and higher terrain adjacent to Matthews Creek and Cedar Creek. Potential habitat includes Hinterland Sandstone Gully Forest.
Persoonia bargoensis	Potential habitat within dry sclerophyll forest on sandstone and on heavier, well drained, loamy, gravelly soils of the Wianamatta Shale and Hawkesbury Sandstone. Potential habitat includes: Cumberland Shale Sandstone Transition Forest, Cumberland River Flat Forest and Hinterland Sandstone Gully Forest.
Pomaderris brunnea	Potential habitat along creekline vegetation. A large population has been previously been recorded by Niche (2014) approximately 10 kilometres to the south of the Study Area within Hinterland Sandstone Gully Forest. The species has potential habitat along Cedar Creek, Matthews Creek and Stonequarry Creek.
Pterostylis saxicola	Potential habitat for the species is on sandy soil over flat sheets of sandstone rock shelves above cliff lines and also in crevices between sandstone boulders; often in close proximity to streams. Limited habitat occurs along the ridgeline along Matthews Creek, Cedar Creek and Stonequarry creeks. Potential habitat includes Shale Sandstone Transition Forest.

Threatened flora	Potential occurrence in Study Area
Pimelea spicata	Potential to occur in associated with Grey Box communities (particularly Cumberland Plain Woodland variants and Moist Shale Woodland) and in areas of ironbark. Potential habitat in the Study Area includes Cumberland River Flat Forest.
Tetratheca glandulosa	Marginal habitat occurs toward the north of the Study Area in Cumberland Shale Sandstone Transition Forest associated with the Lucas Heights landscape.

3.6 Threatened fauna

A total of 61 threatened fauna listed on the BC Act and/or EPBC Act were identified as subject species during the Terrestrial Ecology Assessment (Niche 2014). Subject species were identified through database searches of Bionet and the EPBC Act Protected Matter Search tool, and field surveys.

No threatened fauna species have been recorded within the Study Area. Two threatened fauna species listed on the BC Act were recorded just outside the Study Area during the surveys conducted in 2012 and 2014. The Varied Sittella was recorded along Stonequarry Creek and the Cumberland Plain Land Snail recorded to the south of the Study Area (Figure 4). No threatened fauna have been identified during the ongoing biodiversity monitoring program which commenced in Spring 2017.

After considering the habitat present in the Study Area and the results of the Terrestrial Ecology Assessment and survey (Niche 2014), 32 of these threatened fauna were considered to have a moderate to high likelihood of occurrence in the Study Area. These species include:

- Amphibians: Red-crowned Toadlet;
- Birds: Regent Honeyeater, Great Egret, Bush Stone-curlew, Gang-gang Cockatoo, Glossy Black-Cockatoo, Brown Treecreeper (eastern subspecies), Varied Sittella, Little Eagle, White-throated Needletail, Swift Parrot, Hooded Robin (south-eastern form), Black-chinned Honeyeater (eastern subspecies), Rainbow Bee-eater, Black-faced Monarch, Satin Flycatcher, Turquoise Parrot, Barking Owl, Powerful Owl, Scarlet Robin, Speckled Warbler, Rufous Fantail, Masked Owl;
- Invertebrates: Cumberland Plain Land Snail; and
- Mammals: Large-eared Pied Bat, Little Bentwing-bat, Eastern Bentwing-bat, Eastern Freetail-bat, Southern Myotis, Koala, Grey-headed Flying-fox, Greater Broad-nosed Bat.

3.6.1 Amphibians

No threatened amphibians were recorded during the Niche (2014) Terrestrial Ecology Assessment, nor have any threatened amphibians been detected during the baseline monitoring (Niche 2020, Niche 2021a).

Despite the non-detection, potential habitat for the Red-crowned Toadlet exists across the riparian areas within the Study Area.

The baseline monitoring (Niche 2020, Niche 2021a) has confirmed that no threatened amphibian species were detected either as frogs or tadpoles. While the Study Area contains superficially suitable habitat, it is possible that the species would no longer be able to survive in the area due to predation pressures from two introduced predators: the Plague Minnow (*Gambusia holbrooki*) and the Yabbie (*Cherax destructor*), both of which were detected at all monitoring sites.

During the Niche (2020) amphibian baseline monitoring, amphibian detection was relatively inconsistent due to the relatively dry conditions across seasons. However, subsequent monitoring events have not detected the presence of threatened amphibians (Niche 2021a). All amphibians identified during monitoring represent an otherwise normal array of 'predator aware' species for the quality of habitat throughout the Study Area. The amphibian baseline monitoring concluded the following findings in relation to the Study Area (Niche2020, Niche 2021a):

- There were 663 detections of individual amphibians recorded during the Autumn monitoring and 1,133 detections recorded during the Spring monitoring, totalling 1,796 detections over the seven amphibian surveys.
- There were nine species of amphibian recorded across the monitoring sites during the Autumn monitoring. A total of 12 species of amphibian were recorded during the Spring monitoring. One additional species was noted nearby during the survey periods Orange-groined Toadlet (*Uperoleia laevigata*).
- All sites had at least one species of amphibian recorded during each survey, however, one site (Site 6) recorded no amphibians during the Autumn 2020 survey.
- The most widespread and abundant amphibian species during these surveys was the Clicking Froglet (*Crinia signifera*), which was detected on all sites during the Spring survey and seven of the eight sites during the Autumn 2020 survey period.
- The low amphibian counts observed during some survey events are almost certainly due to the dry conditions experienced prior to and during those surveys. Generally greater amphibian numbers were detected when there was significant rain prior to the survey or light rain with warm conditions during the survey. In at least one instance rainfall inhibited amphibian detection due to the extreme water noise from a rapidly flowing creek in a canyon.

Further details from the monitoring have been provided in Niche 2020 and Niche 2021a, which has been included in Attachment A.

3.7 Watercourses and stream morphology

The Study Area is located in the Stonequarry Creek catchment with the natural waterway features comprising Matthews Creek, Cedar Creek and Stonequarry Creek, as shown in Figure 2. Baseline pool water level and surface water quality data has been collected within and surrounding the Study Area by HEC (2020), which has been incorporated throughout this section.

Matthews Creek and Cedar Creek rise in low hills to the west of the Study Area, with their junction approximately 700 m west of LW W3. Stonequarry Creek also rises to the west and flows to east joining Cedar Creek approximately 350 m northwest of LW W3, before flowing east along the northern end of LW W3 and LW W4 and south through the town of Picton. Stonequarry Creek continues to flow south-east, approximately 800 m from LW W4, joining the Nepean River near Maldon.

3.7.1 Stonequarry Creek

Stonequarry Creek flows along the northern boundary of the Study Area and has an estimated catchment area of 44 km^2 to the downstream boundary of the Study Area. A minor tributary of Stonequarry Creek flows from south to north adjacent to the proposed LW W3. Stonequarry Creek then flows eastwards outside boundary of the Study Area, through the town of Picton, joining the Nepean River near Maldon. The catchment area of Stonequarry Creek upstream of the Study Area comprises mainly rural properties and farmland with localised housing development.

In the Study Area, the creek bed has a low gradient with rock bar, boulder and rock shelf constrained pools. The bed and banks are well vegetated and show little evidence of erosion or bank instability (GeoTerra, 2014).

The minor tributary of Stonequarry Creek within the Study Area is ephemeral and likely only flows during periods of extended or high rainfall. Surface water runoff from the headwater of the tributary is predominately captured by a farm dam with runoff from the tributaries likely to contribute to flow in Stonequarry Creek during periods of extended or significant rainfall only. Flow in the tributary passes through a culvert under the Picton Mittagong Loop Line before flowing to Stonequarry Creek.

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Threatened species recorded by Niche
Western Domain - Longwalls West 3 & West 4
Terrestrial Biodiversity Technical Report

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Figure 4

4. Predicted subsidence impacts and environmental consequences

4.1 Predicted subsidence impacts and environmental consequences

The positioning of the longwalls differs to that proposed in the previous 2014 SMP Application and the current layout of LW W3-W4. The key differences as discussed in MSEC (2021) include:

- LW W3-W4 do not mine directly beneath Matthews, Cedar and Stonequarry Creeks, whilst the previously proposed LWs 33 to 37 were located directly beneath the creeks. The change in mine plan will substantially reduce the severity and extent of mining-induced impacts on the creeks; and
- LW W1-W4 will progressively extract each longwall from west to east, whilst the previously proposed LWs 33 to 37 were sequenced in the opposite direction.

The impacts of the longwalls proposed in the 2014 SMP Application on the terrestrial ecology of the Study Area have been assessed in detail in the Terrestrial Ecology Assessment (Niche 2014). Given the changes in the size of the Study Area, and the avoidance of mining directly beneath Matthews, Cedar and Stonequarry creeks, the potential for impacts on terrestrial biodiversity are reduced when compared to the MSEC predictions considered in the 2014 SMP Application (Niche 2014).

The natural surface features which are sensitive to subsidence movements have been identified by MSEC (2021) and include the following: Stonequarry Creek, Matthews Creek and Cedar Creek, other drainage lines, creeks, rock outcrops, and cliffs. These features provide habitat for terrestrial ecology. However, no cliffs, pagodas or escarpments were identified within the Study Area.

A summary of the predicted impacts provided in MSEC (2021) that are of relevance to this assessment are provided in Table 6.

Table 6. MSEC predictions relevant to terrestrial ecology

Natural feature	Prediction of impacts in MSEC (2021) compared to MSEC predictions considered by Niche (2014)	Predicted impact greater than that by Niche (2014)
Watercourses	The mining-induced changes in grade along Stonequarry Creek are predicted to be negligible (MSEC 2021). It is unlikely, therefore, that the creek would experience adverse impacts due to increased levels of ponding, increased levels of scouring of the banks nor changes in stream alignment. The predictions provided in MSEC (2021) are less than those considered by Niche (2014).	No – impact predication less than that assessed in 2014.
Steep slopes	Natural steep slopes have been identified along the banks of Matthews, Cedar and Stonequarry creeks, where the near surface lithology is part of the Hawkesbury Sandstone group. It is unlikely that the mining-induced tilts would result in an adverse impact on the stability of the steep slopes. The predictions provided in MSEC (2021) are similar to that considered by Niche (2014).	No – impact predication similar to that assessed in 2014.

4.2 Potential subsidence impacts and environmental consequences

4.2.1 Vegetation

As detailed by Niche (2014), the majority of vegetation within the Study Area would not be impacted by subsidence due to underground mining but impacts may potentially occur for riparian vegetation. Riparian vegetation potentially impacted by subsidence is generally not mapped as discrete vegetation communities, rather these areas display structural and floristic variation within their composite community in response to more frequent contact with the local water table. As such, it would be hard to distinguish impacts to truly riparian vegetation and the intergrade between riparian and woodland communities.

Vegetation which occurs on undulating lands or on ridgelines is unlikely to be impacted by subsidence. It is possible that cracking may occur within these communities, however cracking is unlikely to result in vegetation change as these communities occur in drier soils and are not ultimately reliant upon groundwater for their floristic make up or distribution.

Riparian vegetation may be impacted by subsidence through water diversion, cracking of bedrock or the release of strata gas. The overall stability of the bed and banks of overlying creeks could be indirectly affected by subsidence induced fracturing and enhanced drainage of groundwater from the banks and bed of creeks leading to loss of riparian vegetation. However, based on previous observations within the Southern Coalfields and Tahmoor North to date, such incidents have generally not occurred (GeoTerra 2021).

MSEC (2021) states that gas emissions may occur as a result of subsidence, however, are historically rare. In the Southern Coalfield, impacts to vegetation as a result of subsidence are minor in occurrence. Previous examples of impacts include dieback of riparian vegetation as a result of subsidence which occurred nearby Cataract River during the 1990s (Eco Logical Australia 2004). Strata gas emissions association with subsidence are temporary, and therefore are unlikely to cause long-term adverse changes to the habitat of threatened riparian species (FloraSearch 2009).

As detailed by Niche (2014), impacts to vegetation associated with subsidence are unlikely, and if occurred, are likely to result in minor localised floristic changes. Given MSEC (2021) reports that gas releases resulting in observable vegetation die back are not common, and in the instance where it has occurred at Tower Colliery the impacts were limited to small areas that were successfully revegetated (Niche 2014), it is expected that any impacts to the PCTs as a result of gas emissions from the extraction of LW W3-W4 would be limited in extent and temporal in nature. In addition, as demonstrated by the sites previously affected by gas emissions, if vegetation die back was to occur, the vegetation would regenerate once the gas emissions ceased. As such, it is considered unlikely that gas emissions from subsidence would result in a decrease in the extent of the PCTs and habitat within the Study Area.

4.2.2 Destruction of vegetation/tree fall by rock falls and earth slippages

The steep slopes on the sides of valleys are predominantly found in Hawkesbury Sandstone, however, natural steep slopes are also located on the sides of ridges above the proposed longwalls, where the near surface lithology is part of the Wianamatta Shale group (MSEC 2021). Cliffs, pagodas or escarpments have not been identified as occurring within the Study Area.

Subsidence may result in the downslope movement of soils, causing tension cracks to appear at the tops of the slopes, and compression ridges to form at the bottoms of the slopes, which in turn has the potential to cause erosion (MSEC, 2021). However, as indicated by MSEC (2021), there would be no impact to cliffs as the nearest identified cliffs are a minimum of 700 m from the Study Area. As such, as assessed by Niche (2014), it is considered unlikely that any large-scale impacts to native vegetation due to earth and rock-face instability would occur. If such an event was to occur, the impacts would be localised.

Slippage of earth and rocks down steep slopes and rock falls have the potential to directly impact (destroy/smother) vegetation, flora and fauna habitat as well as directly injure or kill native fauna.

4.2.3 Threatened ecological communities

As discussed in Section 3.4, subsidence is unlikely to result in impacts to native vegetation that do not occur within the creeklines or immediately adjacent. This has been discussed in detailed in Niche (2014) which concluded that the TECs observed in the Study Area are predominately located toward the top portions of the creek valleys and therefore are unlikely to be exposed to any gas emissions from subsidence.

All the TECs that occur within the Study Area are associated with shale, alluvial and shale/sandstone transition soils which are unlikely to be subject to any biologically significant effects. As only minor changes in groundwater are predicted (SLR, 2021), it is unlikely significant impacts to native vegetation will occur as a result of the proposed longwalls.

4.2.4 Flora

As detailed in the Terrestrial Ecology Assessment (Niche 2014), threatened flora species reliant upon watercourses and riparian zones may be potentially impacted by subsidence. Within the Study Area, subsidence may potentially impact habitat for *Epacris purpurascens* var*. purpurascens* and *Pomaderris brunnea*. Impacts may occur as a result of the following:

- Gas emissions from sandstone fracturing above extracted longwalls may cause die back and changes in potential habitat within riparian vegetation;
- Changes in hydrology from creek bed cracking, causing localised vegetation structure and composition changes to potential habitat; and
- Loss of individuals due to changes in hydrology, and groundwater changes.

The remainder of subject threatened flora are not likely to be reliant on any landscape feature that may be significantly affected by subsidence.

As discussed in relation to native vegetation, die-back of plants from gas emissions is a rare event. If such an event was to happen, it would be localised and unlikely to result in large scale die-back of native flora. The likelihood for threatened flora to be located immediately adjacent to the edge of a watercourse, that may have foliage exposed to a gas emission event is considered to be low. Furthermore, the subject threatened flora generally occur on the high elevations in woodland that is positioned away from the watercourse bed. As such, the chances of a gas emission event affecting any potential population is considered to be low.

In relation to changes to water flow and standing pools, this is unlikely to affect the subject threatened flora as these species do not occur as submerged, immersed or directly connected via roots to the water within pools. The drying of pools or predicted changes to the hydrological regime to watercourses within the Study Area are, therefore, unlikely to result in impacts to these threatened flora species.

As discussed in Section 4.2.2, the likelihood for any large-scale impacts associated with potential rock falls/slipping of rock are low. The chances of threatened flora to be present directly in the locality of such events is considered low. As such, it is unlikely that any large-scale impacts to threatened flora due to earth and rock-face instability would occur.

As discussed in Niche (2014), based on previous experience at Dendrobium, Appin and Tower Mines within the Southern Coalfields, potential subsidence impacts are likely to have a minimal effect on vegetation composition, dispersal mechanisms, or isolation of potential populations where those vegetation communities are not dependent on surface water flows of groundwater levels. As such the Terrestrial Ecology Assessment (Niche 2014) concluded that subsidence impacts from the proposal are not considered likely to have a significant impact on threatened flora. In addition, this assessment of the altered longwall layout, is also not likely to have a significant impact on threatened flora.

4.2.5 Fauna

As detailed in the Terrestrial Ecology Assessment (Niche 2014), no significant impacts to threatened fauna are expected. Given that MSEC (2021) concludes that impacts of the proposed longwall layout of LW W3-W4 are less than those assessed in the Terrestrial Ecology Assessment (Niche 2014), it is reasonable to assume that similar impact conclusion would be reached.

As discussed in Niche (2014), a number of threatened subject fauna are mobile and/or potential habitat is unlikely to be impacted by subsidence. These species include:

- Birds: Regent Honeyeater, Great Egret, Bush Stone-curlew, Gang-gang Cockatoo, Glossy Black-Cockatoo, Brown Treecreeper (eastern subspecies), Varied Sittella, Little Eagle, White-throated Needletail, Swift Parrot, Hooded Robin (south-eastern form), Black-chinned Honeyeater (eastern subspecies), Rainbow Bee-eater, Black-faced Monarch, Satin Flycatcher, Turquoise Parrot, Barking Owl, Powerful Owl, Scarlet Robin, Speckled Warbler, Rufous Fantail, Masked Owl;
- Invertebrates: Cumberland Plain Land Snail; and
- Mammals: Koala and Grey-headed Flying Fox.

Assessments of Significance under the BC and/or EPBC Acts were undertaken by Niche (2014) for the following species:

- Amphibians: Red-crowned Toadlet; and
- Mammals: Large-eared Pied Bat, Little Bentwing-bat, Eastern Bentwing-bat, Eastern Freetail-bat, Southern Myotis, Greater Broad-nosed Bat.

As detailed in Niche (2014), no significant impacts to these threatened species were considered likely to occur. Given, the predictions of MSEC (2021) that subsidence impacts from LW W3-W4 are less than those assessed in the Niche (2014) assessment, the conclusion of no significant impact to these threatened fauna remains current for LW W3-W4.

5. Management, monitoring and evaluation

5.1 Performance measures and indicators

Biodiversity performance measures have been defined in DA 67/98 Condition 13A Table 1, and are summarised below in Table 7. Tahmoor Coal must ensure that there is no exceedance of the subsidence impact performance measures for biodiversity, as provided in Table 7, and have contingencies if these performance measures are exceeded.

Table 7. Biodiversity performance measures

Biodiversity feature	Subsidence performance measures	Subsidence performance indicators
Threatened species, threatened populations, or endangered ecological communities	Negligible environmental consequences	This performance indicator will be considered to be triggered if: • Statistically significant changes in amphibian diversity is detected from baseline attributed to mining, as detected during the Annual Amphibian Monitoring program; and/or • Statistically significant changes in riparian vegetation is detected from baseline attributed to mining, as detected during the Annual Riparian Monitoring program.

To establish compliance with the performance measures outlined in Table 7, a TARP has been developed to inform the operations if the performance measures are likely to be exceeded during secondary extraction within the Study Area, and to provide management/corrective actions for implementation if a risk is triggered. The TARP is described in Section 6 of this report.

5.2 Monitoring

5.2.1 Subsidence monitoring program

Subsidence parameters (i.e. subsidence, tilt, tensile strain, compressive strain, valley closure and closure strain) will be measured in accordance with the Subsidence Monitoring Program (part of the LW W3-W4 Extraction Plan).

The monitoring program outlined below will be implemented to monitor the impacts of subsidence on biodiversity within the LW W3-W4 Study Area and surrounding areas likely to be impacted by far-field movements. As subsidence effects to threatened biodiversity are predicted to be small in magnitude, the monitoring program outlined below reflects the magnitude of these expected impacts.

5.2.2 Terrestrial biodiversity monitoring program

The biodiversity (amphibian and riparian) monitoring program has been designed as a Before After Control Impact (BACI) study, as BACI is considered the most appropriate design for many impact studies as discussed in the Terrestrial Ecology Assessment (Niche 2014).

In accordance with BACI principles, the monitoring program has been designed to collect a sufficient amount of data over time in order to be able to compare any changes towards ecology indicators as a result of subsidence.

Appropriate replication in both impact (within the Study Area) and control (outside the Study Area) sites has been incorporated into the monitoring program so natural variability can be accounted for. The planned layout of the longwalls has changed since the original locating of the monitoring sites. However, all sites are still within their originally designated treatment areas. It is recommended that an additional monitoring site be added to the monitoring program downstream of the rock confluence on Stonequarry Creek. This area does not currently have a monitoring site in this area and would allow the monitoring of vegetation downstream of the Study Area, should there be any subsidence impacts to the upstream sections of Stonequarry Creek.

As discussed in the Terrestrial Ecology Assessment (Niche 2014), this monitoring program has considered recommendations of the Southern Coalfields Inquiry (Department of Planning 2008), Metropolitan Planning and Assessment Commission (PAC 2009) and Bulli Seam Planning Assessment Commission (PAC 2010), and includes the following:

- A minimum of 2 years of baseline data, collected at an appropriate frequency and scale provided for significant natural features including riparian vegetation along Stonequarry Creek, Cedar Creek and Matthews Creek;
- The monitoring will require regular reassessment of the data obtained to determine its effectiveness in meeting its goal of identifying any impacts. This adaptive monitoring may lead to changes in the extent and intensity of monitoring and will be reassessed on an annual basis; and
- Survey will be undertaken to current DPIE standards. DPIE standards would include utilising a suitable methodology (such as plot collection using the OEH (2014) BioBanking Assessment Methodology or the DPIE (2020) Biodiversity Assessment Methodology such as that utilised in Niche (2020, 2021a).

The biodiversity monitoring program is discussed in detailed in Niche (2020, 2021a). A description for each of the impact and control sites is provided in Table 8 and the location of each monitoring site is provided in Figure 2.

The monitoring is complimented by aquatic monitoring completed by Niche, described in the Aquatic Biodiversity Technical Report (Niche 2021b).

Table 8. Biodiversity monitoring program

Feature	Monitoring component / Location	Monitoring		
		Prior to extraction	During extraction	Post mining
Riparian Vegetation	Riparian vegetation at Sites 3-10.	Completed as part of baseline monitoring program (Niche 2020, Niche 2021a)	Bi-annually (Spring and Autumn)	Bi-annually (Spring and Autumn) for 12 months following the completion of LW W4. This period may be extended as per decision by the Environmental Response Group.

Feature	Monitoring component / Location	Monitoring		
		Prior to extraction	During extraction	Post mining
Amphibians	Amphibian monitoring at Sites 3-10.	Completed as part of baseline monitoring program (Niche 2020, Niche 2021a)	Bi-annually (Spring and Autumn)	Bi-annually (Spring and Autumn) for 12 months following the completion of LW W4. This period may be extended as per decision by the Environmental Response Group.

5.2.3 Riparian vegetation monitoring

The riparian vegetation monitoring will be completed by two botanists in Spring and Autumn of each year as required. The riparian monitoring methodology is outlined in the following sections.

Permanent vegetation plots

Eight BAM plots are established within riparian areas. The plots consist of three impact quadrats and five control quadrats as described in Table 3 and displayed in overview on Figure 2.

The plots are 50 x 20 m and sited immediately adjacent or across the water body. Floristic sub-plots are to be conducted in a 10 x 40 m plot along the creek line side of the measuring tape rather than a conventional 20 x 20 m plot. BAM plots will collect the following attributes:

- ***Composition***
    - native species richness (10 x 40 m plot)
- ***Structure***
    - native flora cover (% of the 10 x 40 m plot) divided into the growth forms:

      a) Tree
      b) Shrub
      c) Grass and grass like
      d) Forb
      e) Fern
      f) Other
    - exotic species cover
    - high threat weed vegetation cover
- ***Function***
    - tree regeneration (size classes present)
    - number of trees with hollows (within 50 x 20 m plot)
    - total length of fallen logs (within 50 x 20 m plot)
    - number of large trees (within 50 x 20 m plot)

- tree stem size class (within 50 x 20 m plot)
- litter cover (sampled in 5 x 1 m^2 quadrats within the plot as per the BAM).

Vegetation condition assessment

Within each of the vegetation quadrats, the condition and structure of vegetation is to be assessed using key indicators to ensure comparison between the results throughout different monitoring periods. The BAM is utilised in this regard, as it provides a standardised scoring system of key attributes.

Photo point monitoring

Photo monitoring is to be undertaken within each of the BAM plots.

Plant taxonomy

Plant taxonomy used is to be consistent with the nomenclature accepted by the National Herbarium of NSW (as per their PlantNet web site http://plantnet.rbgsyd.nsw.gov.au/).

5.2.4 Amphibian monitoring

The amphibian monitoring is to be conducted by two ecologists during Spring and Autumn. The Spring surveys are intended to cover amphibians that typically call and breed in Spring and the Autumn/Spring surveys are intended to allow for detection of Autumn/Winter calling species as well as allowing for the detection of tadpoles and juveniles from earlier breeding. Both the target threatened amphibian species, Red-crowned Toadlet (*Pseudophryne australis*) and Giant Burrowing Frog (*Heleioporus australiacus*), can call over a wide period of the year, driven more by weather conditions than by the season.

A total of eight amphibian monitoring transects are located in Picton and Thirlmere along riparian sites throughout Stonequarry Creek, Cedar Creek and Matthews Creek. The monitoring locations consist of five control sites and three impact sites, located in close proximity to the vegetation monitoring plots (Figure 2).

Amphibian surveys at each site are conducted along a 200 m transect that are searched once in each of the two above mentioned survey periods. The monitoring survey along transects comprise of:

- Night aural and visual searches of each site, targeted to locate and record the presence of Red-crowned Toadlet and Giant Burrowing Frog, as well as any other amphibians to occur at the site. The searches are constrained to an area 10 m either side of the permanent 200 m transect located along the length of stream;
- A minimum of half an hour is spent completing each transect;
- Tadpole searches are conducted as part of daytime transect surveys; and
- Opportunistic records of amphibians seen or heard calling during the day during the riparian vegetation surveys. Records are included in the monitoring if the species were undetected during nocturnal survey.

5.3 Photo-point monitoring

Photos are to be taken at all the riparian and amphibian monitoring sites. The photos are taken facing along the boundary line of the flora plot from the starting point.

An upstream and downstream photo is taken at the start of the amphibian monitoring sites.

These photographs would be taken each monitoring event and compared to baseline photographs.

5.4 Monitoring analysis

Depending on suitability, the statistical analysis methods listed below will be performed on monitoring data to evaluate whether or not a mining related significant change has occurred:

- Hierarchical agglomerative cluster analysis (producing a similarity matrix);
- ANOSIM to test for statistical differences; and
- Non-Metric Dimensional Multidimensional Scaling to visualise any patterns in the data.

6. Contingency plan

6.1 Adaptive management

As part of the management of terrestrial biodiversity, Tahmoor Coal recognises the need to be adaptive to unforeseeable impacts or changes associated with the extraction of LW W3-W4. Tahmoor Coal will implement the contingencies outlined in Section 6.2 and TARP (Table 9).

An Adaptive Management Framework provides for flexible decision making, adjusted to consider uncertainties as management outcomes are understood. Through feedback to the management process, the management procedures are changed in steps until monitoring shows that the desired outcome is obtained. The monitoring program has been developed so that there is statistical confidence in the outcome.

In adaptive management the goal to be achieved is set, so there is no uncertainty as to the outcome, and conditions requiring adaptive management do not lack certainty, but rather they establish a regime which would permit changes, within defined parameters, to the way the outcome is achieved.

Adaptive management involves:

- Planning – identifying performance measures and indicators, developing management strategies to meet performance measures and establishing programs to monitor against the performance measures;
- Implementation – implementing monitoring programs and management strategies;
- Review – reviewing and evaluating the effectiveness of monitoring and management strategies;
- Contingency Response – implementing the contingency plan in the event that a subsidence impact performance measure in relation to surface water resources has been exceeded; and
- Adjustment – adjusting management strategies to improve performance.

An adaptive management response would be detailed in an 'Investigation Report' prepared as a response to issues identified in the monitoring program. A management response may be developed and would be based on the monitoring data as supplemented by expert advice, if sought.

6.2 Trigger Action Response Plan (TARPs)

TARPs are used to set out response measures for unpredicted subsidence impacts and have been developed for potential impacts to sensitive terrestrial biodiversity features, such as amphibian habitat and riparian vegetation.

The monitoring results will be used to assess the impacts of mining in the Western Domain against the performance indicators and performance measures using the TARPs.

The frequency of assessment against the TARPs and the proposed method of analysis is summarised in Table 9 for each potential impact to terrestrial biodiversity. The impact assessment triggers, and proposed response/action plans are detailed in the Table 9. The terms "normal", "within prediction" and "exceeds prediction" are used for consistency with other Tahmoor Coal TARPs.

Table 9. TARPs associated with terrestrial biodiversity

Feature	Trigger	Action	Response
Decline in amphibian populations within watercourses of the Study Area	Level 1		
	Monitoring indicates amphibian population parameters are predominantly within a reasonable range of baseline data as supported by statistical analysis.	• Continue monitoring as per monitoring program.	• No response required.
	Level 2		
	Monitoring indicates amphibian population parameters are predominantly not within a reasonable range of baseline data as supported by statistical analysis. AND Subsidence monitoring program identifies potential for impact of watercourse parameters associated with sensitive amphibian habitat areas (within prediction compared to baseline).	• Continue monitoring as per monitoring program. • Convene Tahmoor Coal Environmental Response Group to review possible cause and response. • Review and confirm monitoring data, cross check biodiversity monitoring data against other related environmental data (e.g. control sites and benchmark data) and subsidence monitoring upon identification of the potential trigger. • Undertake further investigations as appropriate to confirm the potential issue and analyse data with the aim of determining whether the exceedance is likely to be mining related.	• As defined by Environmental Response Group. • Consider increasing monitoring frequency or additional monitoring where relevant.
	Level 3		
	Monitoring indicates amphibian population parameters are significantly not within a reasonable range of baseline data as supported by statistical analysis. AND Mining induced impacts (exceeds predication compared to baseline) for watercourse parameters associated with sensitive amphibian	• Continue monitoring as per monitoring program. • Convene Tahmoor Coal Environmental Response Group to review possible cause and response. • Review and confirm monitoring data, cross check biodiversity monitoring data against other related environmental data (e.g. control sites and benchmark data) and subsidence monitoring upon identification of the potential trigger. • Undertake further investigations as appropriate to confirm the potential issue and analyse data	• Notify DPIE and relevant stakeholders within 7 days of investigation completion. • Complete an investigation report including the identification of potential remediation measures, and implement remediation measures in consultation with DPIE.

	habitat are identified by environmental monitoring.	with the aim of determining whether the exceedance is likely to be mining related.	

Potential impact	Triggers	Action	Response
Dieback of riparian vegetation within watercourses of the Study Area	Level 1		
	Monitoring indicates riparian vegetation parameters are predominantly within a reasonable range of baseline data as supported by statistical analysis.	• Continue monitoring as per monitoring program.	• No response required.
	Level 2		
	Monitoring indicates riparian vegetation parameters are predominantly not within a reasonable range of baseline data as supported by statistical analysis. AND Subsidence monitoring program identifies potential for impact of watercourse parameters associated with sensitive riparian habitat areas (within prediction compared to baseline).	• Continue monitoring as per monitoring program. • Convene Tahmoor Coal Environmental Response Group to review possible cause and response. • Review and confirm monitoring data, cross check Biodiversity monitoring data against other related environmental data (e.g. control sites and benchmark data) and subsidence monitoring upon identification of the potential trigger. • Undertake further investigations as appropriate to confirm the potential issue and analyse data with the aim of determining whether the exceedance is likely to be mining related.	• As defined by Environmental Response Group. • Consider increasing monitoring frequency or additional monitoring where relevant.
	Level 3		
	Monitoring indicates riparian vegetation parameters are significantly not within a reasonable range of baseline data as supported by statistical analysis. AND Mining induced impacts (exceeds predication compared to baseline) for watercourse	• Continue monitoring as per monitoring program. • Convene Tahmoor Coal Environmental Response Group to review possible cause and response. • Review and confirm monitoring data, cross check biodiversity monitoring data against other related environmental data (e.g. control sites and benchmark data) and subsidence monitoring upon identification of the potential trigger.	• Notify DPIE and relevant stakeholders within 7 days of investigation completion. • Complete an investigation report including the identification of potential remediation measures, and implement remediation measures in consultation with DPIE.

	parameters associated with riparian vegetation are identified by environmental monitoring.	• Undertake further investigations as appropriate to confirm the potential issue and analyse data with the aim of determining whether the exceedance is likely to be mining related.	

6.3 Contingency measures

Due to the minimal subsidence and mine design criteria as presented in Section 5, the need to implement remediation measures for potential impacts are considered unlikely. However, in the event that remediation is required, Tahmoor Coal will undertake remediation in consultation with the relevant land holders and NSW Government Agencies. A response strategy will be adopted if a significant impact is detected as a result of mining activities within the LW W3-W4 Study Area.

Standard management measures will be implemented for negligible impacts to biodiversity where those impacts occur as a result of mining. These measures include continuation of the approved monitoring program and reporting.

Management measures for biodiversity will be employed where more than negligible impacts resulting from subsidence occur (e.g. 'within prediction' and 'exceeds prediction' triggers as described in the TARPs). Management measures include implementation of the standard management measures as well as the involvement of relevant stakeholders, agencies and specialists to investigate and report on the changes that are identified.

Assessment of biodiversity impacts by a suitability qualified Ecologist would be undertaken once an impact is confirmed. Additional monitoring would be undertaken with specialists providing updates on the investigation process and the relevant stakeholders and agencies would be provided with investigation results. In the event that the impacts of mine subsidence on habitats are greater than predicted, the following mitigation measures would also be considered, in consultation with key stakeholders:

- Should significant impacts on terrestrial biodiversity occur which are considered to be outside of the Performance Measures of the Approval, Tahmoor Coal would review future longwall configurations and potential impact implications;
- Implementing stream remediation measures, such as backfilling or grouting, in areas where fracturing of controlling rock bars and/or stream bed leads to diversion of stream flow and drainage of pools; and
- Implementing appropriate erosion/sedimentation control measures to limit the potential for deposition of eroded sediment into affected streams.

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Appendix A – Likelihood of occurrence table

Scientific Name	Common Name	BC Act	EPBC Act	Habitat	2016 Likelihood of occurrence	2020 Likelihood of occurrence
Anthochaera phrygia	Regent Honeyeater	CE	CE	The Regent Honeyeater mainly inhabits temperate woodlands and open forests of the inland slopes of south-east Australia. Birds are also found in drier coastal woodlands and forests in some years. Once recorded between Adelaide and the central coast of Queensland, its range has contracted dramatically in the last 30 years to between north-eastern Victoria and south-eastern Queensland. There are only three known key breeding regions remaining: north-east Victoria (Chiltern-Albury), and in NSW at Capertee Valley and the Bundarra-Barraba region. In NSW the distribution is very patchy and mainly confined to the two main breeding areas and surrounding fragmented woodlands. In some years flocks converge on flowering coastal woodlands and forests. The species inhabits dry open forest and woodland, particularly Box-Ironbark woodland, and riparian forests of River Sheoak. Regent Honeyeaters inhabit woodlands that support a significantly high abundance and species richness of bird species. These woodlands have significantly large numbers of mature trees, high canopy cover and abundance of mistletoes.	High	High – Previous BioNet records within the Study Area.
Apus pacificus	Fork-tailed Swift		M	The Fork-tailed Swift is almost exclusively aerial, flying from less than 1 m to at least 300 m above ground and probably much higher. In Australia, they mostly occur over inland plains but sometimes above foothills or in coastal areas. They often occur over cliffs and beaches and also over islands and sometimes well out to sea. They also occur over settled areas, including	Moderate – May fly over area	Moderate – May fly over area

				towns, urban areas and cities. They mostly occur over dry or open habitats, including riparian woodland and tea-tree swamps, low scrub, heathland or saltmarsh. They are also found at treeless grassland and sandplains covered with spinifex, open farmland and inland and coastal sand-dunes. The sometimes occur above rainforests, wet sclerophyll forest or open forest or plantations of pines.		
Artamus cyanopterus cyanopterus	Dusky Woodswallow	V		The Dusky Woodswallow is widespread from the coast to inland, including the western slopes of the Great Dividing Range and farther west. It is often recorded in woodlands and dry open sclerophyll forests, and has also been recorded in shrublands, heathlands regenerating forests and very occasionally in moist forests or rainforests. The understorey is typically open with sparse eucalypt saplings, acacias and other shrubs, often with coarse woody debris. It is also recorded in farmland, usually at the edges of forest or woodland or in roadside remnants or wind breaks with dead timber. The nest is an open shallow untidy cup frequently built in an open hollow, crevice or stump. Although Dusky Woodswallows have large home ranges, individuals may spend most of their time in about a 2 ha range and defend an area about 50 m around the nest. Dusky Woodswallows prefer larger remnants over smaller remnants. Competitive exclusion by Noisy Miners (*Manorina melanocephala*) is a significant threat to this species.	-	Moderate - occurs in a range of habitats, recorded within the Study Area
Bettongia penicillata penicillata	Brush-tailed Bettong (South-East Mainland)	Ext	Ext	The Brush-tailed bettong, in its various subspecies, once occupied most of the Australian mainland south of the tropics including the arid and semi-arid zones of Western Australia, the Northern Territory, South Australia, New South Wales and Victoria. It was believed that the nominate subspecies (penicillata) occurred across southern Australia from South Australia, through north-west Victoria to central inland	None	None

				Queensland. It was abundant in the mid-19th century. By the 1920s, it was extinct over much of its range, with the last records from NSW probably in the late 19th century.		
Botaurus poiciloptilus	Australasian Bittern	E	E	Australasian Bitterns are widespread but uncommon over south-eastern Australia. In NSW they may be found over most of the state except for the far north-west. The Species favours permanent freshwater wetlands with tall, dense vegetation, particularly bullrushes (Typha spp.) and spikerushes (Eleocharis spp.), it hides during the day amongst dense reeds or rushes and feed mainly at night on frogs, fish, yabbies, spiders, insects and snails. The species may construct feeding platforms over deeper water from reeds trampled by the bird; platforms are often littered with prey remains.	-	None – no wetland habitat present
Burhinus grallarius	Bush Stone-curlew	E		The Bush Stone-curlew is found throughout Australia except for the central southern coast and inland, the far south-east corner, and Tasmania. Only in northern Australia is it still common however and in the south-east it is either rare or extinct throughout its former range. It inhabits open forests and woodlands with a sparse grassy groundlayer and fallen timber, it's diet consists of insects and small vertebrates, such as frogs, lizards and snakes. It is largely nocturnal, being especially active on moonlit nights and nests on the ground in a scrape or small bare patch.	Moderate	Moderate
Callocephalon fimbriatum	Gang-gang Cockatoo	V		In New South Wales, the Gang-gang Cockatoo is distributed from the south-east coast to the Hunter region, and inland to the Central Tablelands and south-west slopes. It occurs regularly in the Australian Capital Territory. It is rare at the extremities of its range, with isolated records known from as far north as Coffs Harbour and as far west as Mudgee. In spring and summer, the species is generally found in tall mountain forests and woodlands, particularly in heavily timbered and mature wet	Moderate	Moderate

				sclerophyll forests. In autumn and winter, the species often moves to lower altitudes in drier more open eucalypt forests and woodlands,particularly box-gum and box-ironbark assemblages, or in dry forest in coastal areas and often found in urban areas.		
Calyptorhynchus lathami	Glossy Black-Cockatoo	V		The species is uncommon although widespread throughout suitable forest and woodland habitats, from the central Queensland coast to East Gippsland in Victoria, and inland to the southern tablelands and central western plains of NSW, with a small population in the Riverina. It inhabits open forest and woodlands of the coast and the Great Dividing Range where stands of sheoak occur. Black Sheoak (Allocasuarina littoralis) and Forest Sheoak (A. torulosa) are important foods. Inland populations feed on a wide range of sheoaks, including Drooping Sheoak, Allocasuaraina diminuta, and A. gymnathera. Belah is also utilised and may be a critical food source for some populations. The species is dependent on large hollow-bearing eucalypts for nest sites.	Moderate to High	Moderate to High
Cercartetus nanus	Eastern Pygmy-possum	V		The Eastern Pygmy-possum is found in south-eastern Australia, from southern Queensland to eastern South Australia and in Tasmania. In NSW it extends from the coast inland as far as the Pilliga, Dubbo, Parkes and Wagga Wagga on the western slopes. The species is found in a broad range of habitats from rainforest through sclerophyll (including Box-Ironbark) forest and woodland to heath, but in most areas woodlands and heath appear to be preferred, except in north-eastern NSW where they are most frequently encountered in rainforest. It feeds largely on nectar and pollen collected from banksias, eucalypts and bottlebrushes and is an important pollinator of heathland plants such as banksias; soft fruits are eaten when flowers are unavailable.	Low	Low

Chalinolobus dwyeri	Large-eared Pied Bat	V	V	The Large-eared Pied Bat is found mainly in areas with extensive cliffs and caves, from Rockhampton in Queensland south to Bungonia in the NSW Southern Highlands. It is generally rare with a very patchy distribution in NSW. There are scattered records from the New England Tablelands and North West Slopes. The species roosts in caves (near their entrances), crevices in cliffs, old mine workings and in the disused, bottle-shaped mud nests of the Fairy Martin (Petrochelidon ariel), frequenting low to mid-elevation dry open forest and woodland close to these features. Females have been recorded raising young in maternity roosts (c. 20-40 females) from November through to January in roof domes in sandstone caves and overhangs. It is found in well-timbered areas containing gullies.	High	High
Chthonicola sagittata	Speckled Warbler	V		The Speckled Warbler has a patchy distribution throughout south-eastern Queensland, the eastern half of NSW and into Victoria, as far west as the Grampians. The species is most frequently reported from the hills and tablelands of the Great Dividing Range, and rarely from the coast. There has been a decline in population density throughout its range, with the decline exceeding 40% where no vegetation remnants larger than 100ha survive. The Speckled Warbler lives in a wide range of Eucalyptus dominated communities that have a grassy understorey, often on rocky ridges or in gullies, typical habitat would include scattered native tussock grasses, a sparse shrub layer, some eucalypt regrowth and an open canopy. Large, relatively undisturbed remnants are required for the species to persist in an area.	-	Low – Large, relatively undisturbed remnants are not present at the Study Area
Climacteris picumnus victoriae	Brown Treecreeper (eastern subspecies)	V		The western boundary of the range of the Brown Treecreeper runs approximately through Corowa, Wagga Wagga, Temora, Forbes, Dubbo and Inverell and along this line the subspecies intergrades with the arid zone subspecies of	High	High

				Brown Treecreeper which then occupies the remaining parts of the state. The species is often found in eucalypt woodlands (including Box-Gum Woodland) and dry open forest of the inland slopes and plains inland of the Great Dividing Range; mainly inhabits woodlands dominated by stringybarks or other rough-barked eucalypts, usually with an open grassy understorey, sometimes with one or more shrub species; also found in mallee and River Red Gum (Eucalyptus camaldulensis) Forest bordering wetlands with an open understorey of acacias, saltbush, lignum, cumbungi and grasses; usually not found in woodlands with a dense shrub layer; fallen timber is an important habitat component for foraging; also recorded, though less commonly, in similar woodland habitats on the coastal ranges and plains.		
Cuculus optatus	Oriental Cuckoo			This species migrates to northern and eastern Australia in the warmer months. Occurs south to the Shoalhaven area. Occurs in a range of habitats, including monsoon forest, rainforest edges, leafy trees in paddocks, river flats, roadsides and mangroves.	-	Moderate – Generalist species that may occur on occasion
Daphoenositta chrysoptera	Varied Sittella	V		The Varied Sittella is sedentary and inhabits most of mainland Australia except the treeless deserts and open grasslands. Distribution in NSW is nearly continuous from the coast to the far west. The species inhabits eucalypt forests and woodlands, especially those containing rough-barked species and mature smooth-barked gums with dead branches, mallee and Acacia woodland.	Known	Known
Dasyurus maculatus	Spotted-tailed Quoll	V	E	The range of the Spotted-tailed Quoll has contracted considerably since European settlement. It is now found in eastern NSW, eastern Victoria, south-east and north-eastern Queensland, and Tasmania. Only in Tasmania is it still considered relatively common. The species has been recorded	Low – not been recorded in locality. Not recorded in better habitat	Low – not been recorded in locality. Not recorded in better habitat

				across a range of habitat types, including rainforest, open forest, woodland, coastal heath and inland riparian forest, from the sub-alpine zone to the coastline. Individual animals use hollow-bearing trees, fallen logs, small caves, rock outcrops and rocky-cliff faces as den sites. Females occupy home ranges of 200-500 hectares, while males occupy very large home ranges from 500 to over 4000 hectares. Are known to traverse their home ranges along densely vegetated creeklines.	during Niche (2014) approximately 11 km to south of Study Area.	during Niche (2014) approximately 11 km to south of Study Area.
Falsistrellus tasmaniensis	Eastern False Pipistrelle	V		The Eastern False Pipistrelle is found on the south-east coast and ranges of Australia, from southern Queensland to Victoria and Tasmania. The species prefer moist habitats, with trees taller than 20 m.	-	None – no habitat present
Gallinago hardwickii	Latham's Snipe		M	Latham's Snipe is a non-breeding migrant to the south east of Australia including Tasmania, passing through the north and New Guinea on passage. Latham's Snipe breed in Japan and on the east Asian mainland. Latham's Snipe are seen in small groups or singly in freshwater wetlands on or near the coast, generally among dense cover. They are found in any vegetation around wetlands, in sedges, grasses, lignum, reeds and rushes and also in saltmarsh and creek edges on migration. They also use crops and pasture.	Low – no wetlands	Low – no wetlands
Glossopsitta pusilla	Little Lorikeet	V		The Little Lorikeet is distributed widely across the coastal and Great Divide regions of eastern Australia from Cape York to South Australia. NSW provides a large portion of the species' core habitat, with lorikeets found westward as far as Dubbo and Albury. Nomadic movements are common, influenced by season and food availability, although some areas retain residents for much of the year and 'locally nomadic' movements are suspected of breeding pairs. The species forages primarily in the canopy of open Eucalyptus forest and woodland, yet also finds food in Angophora, Melaleuca and	Low	Low

				other tree species. Riparian habitats are particularly used, due to higher soil fertility and hence greater productivity.		
Grantiella picta	Painted Honeyeater	V	V	The Painted Honeyeater is nomadic and occurs at low densities throughout its range. The greatest concentrations of the bird and almost all breeding occurs on the inland slopes of the Great Dividing Range in NSW, Victoria and southern Queensland. During the winter it is more likely to be found in the north of its distribution. The species inhabits Boree/ Weeping Myall (Acacia pendula), Brigalow (A. harpophylla) and Box-Gum Woodlands and Box-Ironbark Forests. It is a specialist feeder on the fruits of mistletoes growing on woodland eucalypts and acacias. Prefers mistletoes of the genus Amyema.	-	None – no habitat present
Haliaeetus leucogaster	White-bellied Sea-Eagle	V		The White-bellied Sea-eagle is widespread along the New South Wales coast, and along all major inland rivers and waterways. The species habitats are characterised by the presence of large areas of open water including larger rivers, swamps, lakes, and the sea. It occurs at sites near the sea or sea-shore, such as around bays and inlets, beaches, reefs, lagoons, estuaries and mangroves; and at, or in the vicinity of freshwater swamps, lakes, reservoirs, billabongs and saltmarsh. The terrestrial habitats the species has been recorded in, include coastal dunes, tidal flats, grassland, heathland, woodland, and forest (including rainforest).	Low	Low
Heleioporus australiacus	Giant Burrowing Frog	V	V	The Giant Burrowing Frog is distributed in south eastern NSW and Victoria, and appears to exist as two distinct populations: a northern population largely confined to the sandstone geology of the Sydney Basin and extending as far south as Ulladulla, and a southern population occurring from north of Narooma through to Walhalla, Victoria. It is found in heath, woodland and open dry sclerophyll forest on a variety of soil types except those that are clay based.	Low – very limited habitat occurs toward Cedar and Stonequarry Creek, however no tadpoles were	Low – very limited habitat occurs toward Cedar and Stonequarry Creek, however no tadpoles were detected during

					detected during field survey and the species has not been previously recorded in Study Area.	field survey and the species has not been previously recorded in Study Area.
Hieraaetus morphnoides	Little Eagle	V		The Little Eagle is found throughout the Australian mainland excepting the most densely forested parts of the Dividing Range escarpment. It occurs as a single population throughout NSW. The species occupies open eucalypt forest, woodland or open woodland. Sheoak or Acacia woodlands and riparian woodlands of interior NSW are also used. It nests in tall living trees within a remnant patch, where pairs build a large stick nest in winter.	Moderate	Moderate
Hirundapus caudacutus	White-throated Needletail		V, M	White-throated Needletails often occur in large numbers over eastern and northern Australia. White-throated Needletails are aerial birds and for a time it was commonly believed that they did not land while in Australia. It has now been observed that birds will roost in trees, and radio-tracking has since confirmed that this is a regular activity.	High	High
Hoplocephalus bungaroides	Broad-headed Snake	E	V	The Broad-headed Snake is largely confined to Triassic and Permian sandstones, including the Hawkesbury, Narrabeen and Shoalhaven groups, within the coast and ranges in an area within approximately 250 km of Sydney. The species shelters in rock crevices and under flat sandstone rocks on exposed cliff edges during autumn, winter and spring.	Low – no known records in Study Area. Potential habitat marginal to the northern longwalls.	Low – no known records in Study Area. Potential habitat marginal to the northern longwalls.

Isoodon obesulus obesulus	Southern Brown Bandicoot (eastern)	E	E	The Southern Brown Bandicoot has a patchy distribution. It is found in south-eastern NSW, east of the Great Dividing Range south from the Hawkesbury River, southern coastal Victoria and the Grampian Ranges, south-eastern South Australia, south-west Western Australia and the northern tip of Queensland. Southern Brown Bandicoots are largely crepuscular (active mainly after dusk and/or before dawn). They are generally only found in heath or open forest with a heathy understorey on sandy or friable soils. Males have a home range of approximately 5-20 hectares whilst females forage over smaller areas of about 2-3 hectares.	Low – not been recorded in locality. Not recorded in better habitat during Niche (2014) approximately 11 km to south of Study Area.	Low – not been recorded in locality. Not recorded in better habitat during Niche (2014) approximately 11 km to south of Study Area.
Lathamus discolor	Swift Parrot	E	CE	The Swift Parrot breeds in Tasmania during spring and summer, migrating in the autumn and winter months to south-eastern Australia from Victoria and the eastern parts of South Australia to south-east Queensland. In NSW mostly occurs on the coast and south west slopes. On the mainland the species occur in areas where eucalypts are flowering profusely or where there are abundant lerp (from sap-sucking bugs) infestations. Their favoured feed trees include winter flowering species such as Swamp Mahogany (*Eucalyptus robusta)*, Spotted Gum (*Corymbia maculata*), Red Bloodwood (C. *gummifera*), Forest Red Gum (E. *tereticornis*), Mugga Ironbark (E. *sideroxylon*), and White Box (E. *albens*).	Low – moderate	Low – moderate
Litoria aurea	Green and Golden Bell Frog	E	V	Since 1990 there have been approximately 50 recorded locations of Green and Golden Bell Frog in NSW, most of which are small, coastal, or near coastal populations. These locations occur over the species' former range, however they are widely separated and isolated. Large populations in NSW are located around the metropolitan areas of Sydney, Shoalhaven and mid north coast (one an island population). There is only one known population on the NSW Southern Tablelands. The species	Low – has not been recorded in previously Locality	Low – has not been recorded in previously Locality

				inhabits marshes, dams and stream-sides, particularly those containing bullrushes (Typha spp.) or spikerushes (Eleocharis spp.). Optimal habitat includes water-bodies that are unshaded, free of predatory fish such as Plague Minnow (Gambusia holbrooki), have a grassy area nearby and diurnal sheltering sites available. Some sites the species has been recorded in, occur in highly disturbed areas.		
Litoria littlejohni	Littlejohn's Tree Frog	V	V	Littlejohn's Tree Frog has a distribution that includes the plateaus and eastern slopes of the Great Dividing Range from Watagan State Forest (90 km north of Sydney) and south to Buchan in Victoria. The majority of records are within the Sydney Basin Bioregion with only scattered records south to the Victorian border. The species has not been recorded in southern NSW within the last decade and records are isolated and tend to be at high altitude. The species breeds in the upper reaches of permanent streams and in perched swamps. Non-breeding habitat is heath based forests and woodlands where it shelters under leaf litter and low vegetation, and hunts for invertebrate prey either in shrubs or on the ground.	Low – has not been recorded in locality	Low – has not been recorded in locality
Lophoictinia isura	Square-tailed Kite	V		The Square-tailed Kite ranges along coastal and subcoastal areas from south-western to northern Australia, Queensland, NSW and Victoria. In NSW, scattered records of the species throughout the state indicate that the species is a regular resident in the north, north-east and along the major west-flowing river systems. It is a summer breeding migrant to the south-east, including the NSW south coast, arriving in September and leaving by March. The species is found in a variety of timbered habitats including dry woodlands and open forests. Shows a particular preference for timbered watercourses. In arid north-western NSW, it has been observed	Low – marginal habitat towards northern longwalls	Low – marginal habitat towards northern longwalls

				in stony country with a ground cover of chenopods and grasses, open acacia scrub and patches of low open eucalypt woodland.		
Macquaria australasica	Macquarie Perch			The Macquarie Perch is known only from scattered localities in the cool upper reaches of the Murray-Darling system of New South Wales, including the Hawkesbury-Nepean and Shoalhaven catchments, Victoria and the Australian Capital Territory. Also found in man-made lakes on the NSW coast. The species inhabits cool, clear freshwaters of rivers with deep holes and shallow riffles. They are also found in lakes and reservoirs, where adults aggregate in small shoals during the spawning season.		None - no suitable rivers present on or near Study Area
Melanodryas cucullata cucullata	Hooded Robin (south-eastern form)	V		The Hooded Robin is widespread, found across Australia, except for the driest deserts and the wetter coastal areas - northern and eastern coastal Queensland and Tasmania. However, it is common in few places, and rarely found on the coast. It is considered a sedentary species, but local seasonal movements are possible. The south-eastern form (subspecies cucullata) is found from Brisbane to Adelaide and throughout much of inland NSW, with the exception of the extreme north-west, where it is replaced by subspecies picata. The species prefers lightly wooded country, usually open eucalypt woodland, acacia scrub and mallee, often in or near clearings or open areas. It also requires structurally diverse habitats featuring mature eucalypts, saplings, some small shrubs and a ground layer of moderately tall native grasses.	High	High
Melithreptus gularis gularis	Black-chinned Honeyeater (eastern subspecies)	V		In NSW the Black-chinned Honeyeater is widespread, with records from the tablelands and western slopes of the Great Dividing Range to the north-west and central-west plains and the Riverina. It is rarely recorded east of the Great Dividing Range, although regularly observed from the Richmond and Clarence River areas. It has also been recorded at a few	High	High

				scattered sites in the Hunter, Central Coast and Illawarra regions, though it is very rare in the latter. The species occupies mostly upper levels of drier open forests or woodlands dominated by box and ironbark eucalypts, especially Mugga Ironbark (Eucalyptus sideroxylon), White Box (E. albens), Inland Grey Box (E. microcarpa), Yellow Box (E. melliodora), Blakely's Red Gum (E. blakelyi) and Forest Red Gum (E. tereticornis). It also inhabits open forests of smooth-barked gums, stringybarks, ironbarks, river sheoaks (nesting habitat) and tea-trees.		
Meridolum corneovirens	Cumberland Plain Land Snail	E		Lives in small areas on the Cumberland Plain west of Sydney, from Richmond and Windsor south to Picton and from Liverpool west to the Hawkesbury and Nepean Rivers at the base of the Blue Mountains. The species primarily inhabits Cumberland Plain Woodland (a critically endangered ecological community). This community is a grassy, open woodland with occasional dense patches of shrubs. It is also known from Shale Gravel Transition Forests, Castlereagh Swamp Woodlands and the margins of River-flat Eucalypt Forest, which are also listed communities. It lives under litter of bark, leaves and logs, or shelters in loose soil around grass clumps. Occasionally shelters under rubbish.	Previously recorded to the immediate west of the Study Area during Niche (2012). Likely to occur in Study Area.	Previously recorded to the immediate west of the Study Area during Niche (2012). Likely to occur in Study Area.
Merops ornatus	Rainbow Bee-eater		M	In Australia the Rainbow Bee-eater is widespread, except in desert areas, and breeds throughout most of its range, although southern birds move north to winter over. The Rainbow Bee-eater is most often found in open forests, woodlands and shrublands, and cleared areas, usually near water. It will be found on farmland with remnant vegetation and in orchards and vineyards. It will use disturbed sites such as quarries, cuttings and mines to build its nesting tunnels.	High	High
Micronomus norfolkensis	Eastern Coastal Free-tailed Bat	V		The Eastern Freetail-bat is found along the east coast from south Queensland to southern NSW.The species typically	High	High

				inhabit dry sclerophyll forest, woodland, swamp forests and mangrove forests east of the Great Dividing Range. It roosts maily in tree hollows but will also roost under bark or in man-made structures.		
Miniopterus australis	Little Bent-winged Bat	V		The Little Bentwing-bat occurs along the east coast and ranges of Australia from Cape York in Queensland to Wollongong in NSW. It prefers moist eucalypt forest, rainforest, vine thicket, wet and dry sclerophyll forest, Melaleuca swamps, dense coastal forests and banksia scrub. Generally found in well-timbered areas. The species roost in caves, tunnels, tree hollows, abandoned mines, stormwater drains, culverts, bridges and sometimes buildings during the day, and at night forage for small insects beneath the canopy of densely vegetated habitats.	High	High
Miniopterus orianae oceanensis	Large Bent-winged Bat	V		Large Bentwing-bats occur along the east and north-west coasts of Australia. The species use caves as the primary roosting habitat, but also use derelict mines, storm-water tunnels, buildings and other man-made structures.	High	High
Mixophyes balbus	Stuttering Frog	E	V	Stuttering Frogs occur along the east coast of Australia from southern Queensland to north-eastern Victoria. Considered to have disappeared from Victoria and to have undergone considerable range contraction in NSW, particularly in south-east NSW. The Dorrigo region, in north-east NSW, appears to be a stronghold for this species. It is found in rainforest and wet, tall open forest in the foothills and escarpment on the eastern side of the Great Dividing Range. Outside the breeding season adults live in deep leaf litter and thick understorey vegetation on the forest floor.	Low – has not been recorded in locality	Low – has not been recorded in locality
Monarcha melanopsis	Black-faced Monarch			The Black-faced Monarch is found along the coast of eastern Australia, becoming less common further south. It is found in rainforests, eucalypt woodlands, coastal scrub and damp	High	High

				gullies. It may be found in more open woodland when migrating.		
Motacilla flava	Yellow Wagtail		M	The Yellow Wagtail breeds in temperate Europe and Asia. They occur within Australia in open country habitat with disturbed ground and some water. Recorded in short grass and bare ground, swamp margins, sewage ponds, saltmarshes, playing fields, airfields, ploughed land and town lawns.	-	Moderate – species known to occur in disturbed areas
Myiagra cyanoleuca	Satin Flycatcher			The Satin Flycatcher is found along the east coast of Australia from far northern Queensland to Tasmania, including south-eastern South Australia. It is also found in New Guinea. The Satin Flycatcher is not a commonly seen species, especially in the far south of its range, where it is a summer breeding migrant. The Satin Flycatcher is found in tall forests, preferring wetter habitats such as heavily forested gullies, but not rainforests.	Moderate	Moderate
Myotis macropus	Southern Myotis	V		The Southern Myotis is mainly coastal but may occur inland along large river systems. Usually associated with permanent waterways at low elevations in flat/undulating country, usually in vegetated areas. Forages over streams and watercourses feeding on fish and insects from the water surface. Roosts in a variety of habitats including caves, mine shafts, hollow-bearing trees, stormwater channels, buildings, under bridges and in dense foliage, typically in close proximity to water.	High	High
Neophema pulchella	Turquoise Parrot	V		The Turquoise Parrot's range extends from southern Queensland through to northern Victoria, from the coastal plains to the western slopes of the Great Dividing Range. The species typically lives on the edges of eucalypt woodland adjoining clearings, timbered ridges and creeks in farmland.	Moderate	Moderate
Ninox connivens	Barking Owl	V		The Barking Owl is found throughout continental Australia except for the central arid regions. The owls sometimes extend	Moderate – towards	Moderate – towards

				their home range into urban areas, hunting birds in garden trees and insects attracted to streetlights. Extensive wildfires in 2019-20 reduced habitat quality further, burnt many old, hollow-bearing trees needed as refuge by prey species and reduced the viability of some regional owl populations. The species inhabit woodland and open forest, including fragmented remnants and partly cleared farmland. It is flexible in its habitat use, and hunting can extend in to closed forest and more open areas. Sometimes able to successfully breed along timbered watercourses in heavily cleared habitats (e.g. western NSW) due to the higher density of prey found on these fertile riparian soils. The species typically roost in shaded portions of tree canopies, including tall midstorey trees with dense foliage such as Acacia and Casuarina species.	northern longwalls	northern longwalls
Ninox strenua	Powerful Owl	V		The Powerful Owl is endemic to eastern and south-eastern Australia, mainly on the coastal side of the Great Dividing Range from Mackay to south-western Victoria. In NSW, it is widely distributed throughout the eastern forests from the coast inland to tablelands, with scattered records on the western slopes and plains suggesting occupancy prior to land clearing. Now at low densities throughout most of its eastern range, rare along the Murray River and former inland populations may never recover. The Powerful Owl inhabits a range of vegetation types, from woodland and open sclerophyll forest to tall open wet forest and rainforest. The Powerful Owl requires large tracts of forest or woodland habitat but can occur in fragmented landscapes as well. The species breeds and hunts in open or closed sclerophyll forest or woodlands and occasionally hunts in open habitats. It roosts by day in dense vegetation comprising species such as Turpentine Syncarpia glomulifera, Black She-oak Allocasuarina littoralis,	Moderate – toward northern longwalls	Moderate – toward northern longwalls

				Blackwood Acacia melanoxylon, Rough-barked Apple Angophora floribunda, Cherry Ballart Exocarpus cupressiformis and a number of eucalypt species.		
Numenius madagascariensis	Eastern Curlew		CE, M	The Eastern Curlew is widespread in coastal regions in the north-east and south of Australia, including Tasmania, and scattered in other coastal areas. It is rarely seen inland. It breeds in Russia and north-eastern China. On passage, they are commonly seen in Japan, Korea and Borneo. Small numbers visit New Zealand. The Eastern Curlew is found on intertidal mudflats and sandflats, often with beds of seagrass, on sheltered coasts, especially estuaries, mangrove swamps, bays, harbours and lagoons.	-	None – no habitat present
Pandion haliaetus	Osprey	V		Eastern Ospreys are found right around the Australian coast line, except for Victoria and Tasmania. They are common around the northern coast, especially on rocky shorelines, islands and reefs. The species is uncommon to rare or absent from closely settled parts of south-eastern Australia. There are a handful of records from inland areas. The species favour coastal areas, especially the mouths of large rivers, lagoons and lakes. The species breeds in NSW from July to September.	Low	Low
Petauroides volans	Greater Glider		V	The greater glider is restricted to eastern Australia, occurring from the Windsor Tableland in north Queensland through to central Victoria (Wombat State Forest), with an elevational range from sea level to 1200 m above sea level. It prefers taller montane, moist eucalypt forest with relatively old trees and abundant hollows.	-	Low - limited remnant vegetation present
Petaurus australis	Yellow-bellied Glider	V		The Yellow-bellied Glider is found along the eastern coast to the western slopes of the Great Dividing Range, from southern Queensland to Victoria. The species occur in tall mature eucalypt forest generally in areas with high rainfall and nutrient	None – has not been recorded in locality and no	None – has not been recorded in locality and no old growth or

				rich soils. Vegetation preferences vary with latitude and elevation; mixed coastal forests to dry escarpment forests in the north; moist coastal gullies and creek flats to tall montane forests in the south.	old growth or coastal gully forest present	coastal gully forest present
Petaurus norfolcensis	Squirrel Glider	V		The Squirrel Glider is widely though sparsely distributed in eastern Australia, from northern Queensland to western Victoria. The species inhabits mature or old growth Box, Box-Ironbark woodlands and River Red Gum forest west of the Great Dividing Range and Blackbutt-Bloodwood forest with heath understorey in coastal areas.	-	None – habitat and large areas of remnant vegetation are not present
Petrogale penicillata	Brush-tailed Rock-wallaby	E	V	In NSW the Brush-tailed Rock-wallaby occurs from the Queensland border in the north to the Shoalhaven in the south, with the population in the Warrumbungle Ranges being the western limit. The species occupy rocky escarpments, outcrops and cliffs with a preference for complex structures with fissures, caves and ledges, often facing north. It typically shelters or basks during the day in rock crevices, caves and overhangs and are most active at night when foraging.	None – no records in Locality	None – no records in Locality
Petroica boodang	Scarlet Robin	V		In NSW, the Scarlet Robin from the coast to the inland slopes. After breeding, some Scarlet Robins disperse to the lower valleys and plains of the tablelands and slopes. Some birds may appear as far west as the eastern edges of the inland plains in autumn and winter. The Scarlet Robin lives in dry eucalypt forests and woodlands. The understorey is usually open and grassy with few scattered shrubs. This species lives in both mature and regrowth vegetation. It occasionally occurs in mallee or wet forest communities, or in wetlands and tea-tree swamps. The species habitat usually contains abundant logs and fallen timber: these are important components of its habitat.	Moderate-high	Moderate-high

Phascolarctos cinereus	Koala	V	V	The Koala has a fragmented distribution throughout eastern Australia from north-east Queensland to the Eyre Peninsula in South Australia. In New South Wales, koala populations are found on the central and north coasts, southern highlands, southern and northern tablelands, Blue Mountains, southern coastal forests, with some smaller populations on the plains west of the Great Dividing Range. The species inhabit eucalypt woodlands and forests, and feed on the foliage of more than 70 eucalypt species and 30 non-eucalypt species, but in any one area will select preferred browse species.	High	High
Prototroctes maraena	Australian Grayling			The Australian Grayling occurs in streams and rivers on the eastern and southern flanks of the Great Dividing Range, from Sydney, southwards to the Otway Ranges of Victoria and in Tasmania. The species is found in fresh and brackish waters of coastal lagoons, from Shoalhaven River in NSW to Ewan Ponds in South Australia	-	Low – could occur in Stonequarry Creek to the north of the site
Pseudomys novaehollandiae	New Holland Mouse		V	The New Holland Mouse has a fragmented distribution across Tasmania, Victoria, New South Wales and Queensland. The species is known to inhabit open heathlands, woodlands and forests with a heathland understorey and vegetated sand dunes	Low	Low
Pseudophryne australis	Red-crowned Toadlet	V		The Red-crowned Toadlet has a restricted distribution. It is confined to the Sydney Basin, from Pokolbin in the north, the Nowra area to the south, and west to Mt Victoria in the Blue Mountains. It occurs in open forests, mostly on Hawkesbury and Narrabeen Sandstones. The species inhabits periodically wet drainage lines below sandstone ridges that often have shale lenses or cappings.	High	High
Pteropus poliocephalus	Grey-headed Flying-fox	V	V	Grey-headed Flying-foxes are generally found within 200 km of the eastern coast of Australia, from Rockhampton in Queensland to Adelaide in South Australia. In times of natural	High – may forage in Study Area. No	High – may forage in Study Area. No camp

				resource shortages, they may be found in unusual locations. The species occur in subtropical and temperate rainforests, tall sclerophyll forests and woodlands, heaths and swamps as well as urban gardens and cultivated fruit crops. Roosting camps are generally located within 20 km of a regular food source and are commonly found in gullies, close to water, in vegetation with a dense canopy.	camp sites were recorded during field survey	sites were recorded during field survey
Chthonicola sagittata	Speckled Warbler	V		The Speckled Warbler has a patchy distribution throughout south-eastern Queensland, the eastern half of NSW and into Victoria, as far west as the Grampians. The species is most frequently reported from the hills and tablelands of the Great Dividing Range, and rarely from the coast. There has been a decline in population density throughout its range, with the decline exceeding 40% where no vegetation remnants larger than 100ha survive. The Speckled Warbler lives in a wide range of Eucalyptus dominated communities that have a grassy understorey, often on rocky ridges or in gullies, typical habitat would include scattered native tussock grasses, a sparse shrub layer, some eucalypt regrowth and an open canopy. Large, relatively undisturbed remnants are required for the species to persist in an area.	Moderate	Moderate
Rhipidura rufifrons	Rufous Fantail			The Rufous Fantail is found along NSW coast and ranges. Inhabits rainforest, dense wet forests, swamp woodlands and mangroves. During migration, it may be found in more open habitats or urban areas.	Moderate	Moderate
Rostratula australis	Australian Painted Snipe	E	E	In NSW many records of the Australian Painted Snipe are from the Murray-Darling Basin including the Paroo wetlands, Lake Cowal, Macquarie Marshes, Fivebough Swamp and more recently, swamps near Balldale and Wanganella. Other important locations with recent records include wetlands on the Hawkesbury River and the Clarence and lower Hunter	Low	Low

				Valleys. The species prefers fringes of swamps, dams and nearby marshy areas where there is a cover of grasses, lignum, low scrub or open timber.		
Saccolaimus flaviventris	Yellow-bellied Sheathtail-bat	V		The Yellow-bellied Sheathtail-bat is a wide-ranging species found across northern and eastern Australia. In the most southerly part of its range - most of Victoria, south-western NSW and adjacent South Australia - it is a rare visitor in late summer and autumn. There are scattered records of this species across the New England Tablelands and North West Slopes. It forages in most habitats across its very wide range, with and without trees; appears to defend an aerial territory.	-	Moderate – could forage in habitat present
Scoteanax rueppellii	Greater Broad-nosed Bat	V		The Greater Broad-nosed Bat is found mainly in the gullies and river systems that drain the Great Dividing Range, from north-eastern Victoria to the Atherton Tableland. It extends to the coast over much of its range. In NSW it is widespread on the New England Tablelands, however does not occur at altitudes above 500 m. The species utilises a variety of habitats from woodland through to moist and dry eucalypt forest and rainforest, though it is most commonly found in tall wet forest.	High	High
Stagonopleura guttata	Diamond Firetail	V		The Diamond Firetail is endemic to south-eastern Australia, extending from central Queensland to the Eyre Peninsula in South Australia. It is widely distributed in NSW, with a concentration of records from the Northern, Central and Southern Tablelands, the Northern, Cental and South Western Slopes and the North West Plains and Riverina. Not commonly found in coastal districts, though there are records from near Sydney, the Hunter Valley and the Bega Valley. This species has a scattered distribution over the rest of NSW, though is very rare west of the Darling River. The species is found in grassy eucalypt woodlands, including Box-Gum Woodlands and Snow Gum Eucalyptus pauciflora Woodlands. It also occurs in open	Low	Low

				forest, mallee, Natural Temperate Grassland, and in secondary grassland derived from other communities, and often found in riparian areas (rivers and creeks), and sometimes in lightly wooded farmland.		
Onychoprion fuscata	Sooty Tern	V		The Sooty Tern is found over tropical and sub-tropical seas and on associated islands and cays around Northern Australia. In NSW it is only known to breed at Lord Howe Island and is occasionally seen along coastal NSW, especially after cyclones.	None	None
Tyto novaehollandiae	Masked Owl	V		The Masked Owl occurs from the coast where it is most abundant to the western plains. Overall records for this species fall within approximately 90% of NSW, excluding the most arid north-western corner. There is no seasonal variation in its distribution. This species lives in dry eucalypt forests and woodlands from sea level to 1100 m an often hunts along the edges of forests, including roadsides. Roosts and breeds in moist eucalypt forested gullies, using large tree hollows or sometimes caves for nesting.	Moderate	Moderate
Tyto tenebricosa	Sooty Owl	V		The Sooty Owl occupies the easternmost one-eighth of NSW, occurring on the coast, coastal escarpment and eastern tablelands. This species occurs in rainforest, including dry rainforest, subtropical and warm temperate rainforest, as well as moist eucalypt forests. Sooty Owls roost by day in the hollow of a tall forest tree or in heavy vegetation and nest in very large tree hollows. This species hunts by night for small ground mammals or tree-dwelling mammals such as the Common Ringtail Possum (*Pseudocheirus peregrinus*) or Sugar Glider (*Petaurus breviceps*).	Low	Low
Acacia bynoeana	Bynoe's Wattle	E	V	Endemic to central eastern NSW, known a limited number of locations, often comprising populations of few plants. Grows mainly in heath/ dry sclerophyll forest on sandy soils, prefers	Low – no habitat surveyed	Low – no habitat surveyed which represent

				open, sometimes slightly disturbed sites such as trail margins, road edges, and in recently burnt open patches. Flowers September to March, and fruit matures in November.	which represe nt similar habitat where populations have been recorded	similar habitat where populations have been recorded
Acacia flocktoniae	Flockton Wattle	V	V	Only occurs in the southern Blue Mountains (Mt Victoria, Megalong Valley and Yerranderrie), between 500- 1000m asl in areas with average annual rainfall of 800-1200 mm. Grows in dry sclerophyll forest on low nutrient soils derived from sandstone. Associated species include Straight Wattle and Prickly Shaggy Pea. Flowering is sporadic throughout late winter and early spring.	Low	Low
Acacia pubescens	Downy Wattle	V	V	Occurs mainly in Bankstown-Fairfield-Rookwood and Pitt Town areas, with outliers at Barden Ridge, Oakdale and Mountain Lagoon. Grows on alluviums, shales and shale/sandstone intergrades. Soils characteristically gravely, often with ironstone. Occurs in open woodland and forest, in communities including Cooks River/ Castlereagh Ironbark Forest, Shale/ Gravel Transition Forest and Cumberland Plain Woodland. Flowers from August to October.	Moderate	Moderate
Allocasuarina glareicola		E	E	Primarily found in Richmond district; although outlier populations exist in Voyager Point, Liverpool. Found in open castlereagh woodland on lateritic soil. The species is associated with the following species: Parramatta Red Gum, Red Ironbark, Narrow-leaved Apple, Hard-leaved Scribbly Gum and Melaleuca decora. Common associated understorey species include Prickly-leaved Paperbark, Finger Hakea, Needlebush, *Dillwynia tenuifolia*, *Micromyrtus minutiflora*, Swamp Wattle, *Acacia brownei*, *Themeda australis* and *Xanthorrhoea minor*.	Low – not within known habitat	Low – not within known habitat

Asterolasia elegans		E	E	Occurs north of Sydney, in the Baulkham Hills, Hawkesbury and Hornsby LGAs, may also occur in the western part of Gosford LGA with seven known populations. Occurs on Hawkesbury sandstone, commonly amongst rocky outcrops and boulders in sheltered forests on mid- to lower slopes and valleys.	Low – not within known habitat	Low – not within known habitat
Caladenia tessellata	Thick-lip Spider Orchid	E	V	Occurs from Central Coast NSW to southern Victoria. Mostly coastal but extends inland to Braidwood in southern NSW. In NSW grows in grassy dry sclerophyll woodland on clay loam or sandy soils, and less commonly in heathland on sandy loam soils. Flowers between September and November.	Low – nearest population is Braidwood	Low – nearest population is Braidwood
Commersonia prostrata	Dwarf Kerrawang	E	E	In NSW occurs as individual plants at Penrose State Forest and Tallong with populations at Rowes Lagoon near the Corang and the Thirlmere lakes area, and at the Tomago sand beds near Newcastle. Grows on sandy, sometimes peaty soils in a variety of habitats.	Low – closest record is Picton Lakes 1911	Low – closest record is Picton Lakes 1911
Cryptostylis hunteriana	Leafless Tongue-orchid	V	V	Occurs in coastal areas from East Gippsland to southern Queensland. Habitat preferences not well defined. Grows mostly in coastal heathlands, margins of coastal swamps and sedgelands, coastal forest, dry woodland, and lowland forest. Prefers open areas in the understorey and is often found in association with Large Tongue Orchid and the Bonnet Orchid. Soils include moist sands, moist to dry clay loam and occasionally in accumulated eucalypt leaves. Flowers November-February.	Low – known to occur in the Pittswater subregion of CMA. No records in locality	Low – known to occur in the Pittswater su bregion of CMA. No records in locality
Cynanchum elegans	White-flowered Wax Plant	E	E	Occurs from Gerroa (Illawarra) to Brunswick Heads and west to Merriwa in the upper Hunter. Most common near Kempsey. Usually occurs on the edge of dry rainforest or littoral rainforest, but also occurs in Coastal Banksia Scrub, open forest and woodland, and Melaleuca scrub. Soil and geology types are	Low – habitat not suitable	Low – habitat not suitable

				not limiting. Flowering occurs between August and May, with the peak in November.		
Darwinia peduncularis		V		Disjunct populations in coastal NSW with isolated populations in the Blue Mountains. Recorded from Brooklyn, Berowra, Galston Gorge, Hornsby, Bargo River, Glen Davis, Mount Boonbourwa and Kings Tableland. Usually grows in dry sclerophyll forest on hillsides and ridges, on or near rocky outcrops on sandy, well drained, low nutrient soil over sandstone. Flowers in winter to early spring	Low – marginal habitat present	Low – marginal habitat present
Epacris purpurascens var. purpurascens		V		Occurs from Gosford in the north, Narrabeen in the east, Silverdale in the west and Avon Dam vicinity in the South. Grows in a range of sclerophyll forest, scrubs and swamps, most of which have a strong shale soil influence.	High	High
Eucalyptus benthamii	Camden White Gum	V	V	Occurs on the alluvial flats of the Nepean River and its tributaries. Known distribution from The Oaks (south) to Grose Wold (north) and Kedumba Valley (west). Two major subpopulations in Kedumba Valley and Bents Basin State Recreation Area. Occurs in wet open forest on alluvial flats, in well drained alluvial sands and gravels to 1 m deep. Requires a combination of deep alluvial sands and a flooding regime that permits seedling establishment.	Low – not detected in areas of River-flat Eucalypt Forest during survey	Low – not detected in areas of River-flat Eucalypt Forest during survey
Eucalyptus macarthurii	Paddys River Box, Camden Woollybutt	E	E	Occurs from Moss Vale to Kanangra Boyd National Park. In the Southern Highlands occurs mainly on private land, often as isolated paddock trees. Grows in grassy woodlands on relatively fertile soils on broad cold flats.	Low – known individual occurs just outside of Study Area	Low – known individual occurs just outside of Study Area
Genoplesium baueri	Bauer's Midge Orchid	E	E	Occurs from Ulladulla to Port Stephens, with only 13 known extant populations. Grows in sparse sclerophyll forest and moss gardens over sandstone. Flowers from February to March.	Low – no known populations in locality	Low – no known populations in locality

Grevillea parviflora subsp. parviflora	Small-flower Grevillea	V	V	Occurs between Moss Vale/Bargo and lower Hunter Valley, with most occurrences in Appin, Wedderburn, Picton and Bargo. Broad habitat range including heath, shrubby woodland and open forest on light clay or sandy soils, and often in disturbed areas such as on the fringes of tracks.	High	High
Grevillea raybrownii				Generally, occurs on ridgetops and, less often, slopes and benches of Hawkesbury Sandstone and Mittagong Formation. It occurs in Eucalyptus open forest and woodland with a shrubby understorey on sandy, gravelly loam soils derived from sandstone that are low in nutrients. Killed by fire and relies entirely on seed that is stored in the soil for regeneration. Recruitment appears to be promoted by fire or other disturbances.	-	None – no suitable geology present
Gyrostemon thesioides		E		Within NSW, has only ever been recorded at three sites, to the west of Sydney, near the Colo, Georges and Nepean Rivers. The most recent sighting was of a single male plant near the Colo River within Wollemi National Park. Despite searches, the species has not been recorded from the Nepean and Georges Rivers for 90 and 30 years respectively. Grows on hillsides and riverbanks and may be restricted to fine sandy soils.	Low – only known from three locations	Low – only known from three locations
Haloragis exalata subsp. exalata	Square Raspwort	V	V	Square Raspwort occurs in 4 widely scattered localities in eastern NSW. It is disjunctly distributed in the Central Coast, South Coast and North Western Slopes botanical subdivisions of NSW. Requires protected and shaded damp situations in riparian habitats.	Low – not previously recorded in locality	Low – not previously recorded in locality
Kunzea cambagei	Cambage Kunzea	V	V	Mainly occurs in the Yerranderie/Mt Werong area with other populations also along the Wingecarribee River, Loombah Plateau east of Mount Werong, Kanangra-Boyd NP and the Nattai NP. *Cambage Kunzea* is restricted to damp, sandy soils in	-	None – no habitat present

				wet heath or mallee open scrub at higher altitudes on sandstone outcrops or Silurian group sediments.		
Lepidium hyssopifolium		E	E	Currently known near Bathurst and Bungendore, with historic records near Armidale. Grows on light to heavy, often friable clay loams, often in highly modified environments amongst exotic pasture grasses and weeds. Requires bare ground to establish.	Low – not previously recorded in locality	Low – not previously recorded in locality
Leucopogon exolasius	Woronora Beard-heath	V	V	Occurs along the upper Georges River and in Heathcote NP, Royal NP and is also known from the Blue Mountains along the Grose River. Grows in woodland on sandstone and prefers rocky hillsides along creek banks up to 100 m altitude. Associated species include Sydney Peppermint and Silvertop Ash and Graceful Bush-pea, Flaky-barked Tea-tree and *Dillwynia retorta*.	Moderate	Moderate
Melaleuca biconvexa	Biconvex Paperbark	V	V	Scattered, disjunct populations in coastal areas from Jervis Bay to Port Macquarie, with most populations in the Gosford-Wyong areas. Grows in damp places, often near streams or low-lying areas on alluvial soils of low slopes or sheltered aspects.	Low – not previously recorded in locality	Low – not previously recorded in locality
Melaleuca deanei	Deane's Paperbark	V	V	Occurs from Nowra to St Albans and west to the Blue Mountains, with most records in Ku-ring-gai/Berowra and Holsworthy/Wedderburn areas. Mostly grows on broad flat ridgetops, dry ridges and slopes and strongly associated with low nutrient sandy loam soils, sometimes with ironstone. Grows in heath- open forest, often in sandstone ridgetop woodland communities.	Low – not previously recorded in locality	Low – not previously recorded in locality
Pelargonium sp. Striatellum	Omeo's Stork's-bill	E	E	Omeo Storksbill is known from only 4 locations in NSW, with three on lake-beds on the basalt plains of the Monaro and one at Lake Bathurst. It has a narrow habitat that is usually just above the high-water level of irregularly inundated or ephemeral lakes, in the transition zone between surrounding grasslands or pasture and the wetland or aquatic communities.	Low – not previously recorded in locality. Habitat not suitable	Low – not previously recorded in locality. Habitat not suitable

Persicaria elatior	Tall Knotweed	V	V	Tall Knotweed has been recorded in south-eastern NSW from Ulladulla to the Victorian border. In northern NSW it is known from Raymond Terrace and the Grafton area. This species normally grows in damp places, especially beside streams and lakes. Occasionally in swamp forest or associated with disturbance.	Low – recorded in Picton Lakes. Habitat in Study Area not suitable	Low – recorded in Picton Lakes. Habitat in Study Area not suitable
Persoonia acerosa	Needle Geebung	V	V	Recorded on central coast and in Blue Mountains, from Mt Tomah to Hill Top. Mainly in Katoomba, Wentworth Falls and Springwood areas. Inhabits dry sclerophyll forest, scrubby low woodland and heath on sandstone. Occurs in well-drained soils including sands, laterite and gravels between 550- 1000 m asl. May occur in disturbed areas such as roadsides.	Low – not previously recorded in locality	Low – not previously recorded in locality
Persoonia bargoensis	Bargo Geebung	E	V	Restricted to the western edge of the Woronora Plateau and the northern edge of the Southern Highlands, bounded by Picton, Douglas Park, Yanderra and the Cataract River. Occurs in woodland or dry sclerophyll forest on sandstone and clayey laterite on heavier, well drained, loamy, gravely soils of Hawkesbury Sandstone and Wianamatta Shale. Tends to occur in disturbed areas e.g. roadsides and trail margins.	Moderate – near main distribution	Moderate – near main distribution
Persoonia glaucescens	Mittagong Geebung	E	V	Found between Buxton and Berrima. The Mittagong Geebung grows in woodland to dry sclerophyll forest on clayey and gravely laterite. The preferred topography is ridge-tops, plateaux and upper slopes.	-	None – Study Area is outside known species distribution
Persoonia hirsuta	Hairy Geebung	E	E	Occurs within the Blue Mountains, Southern Highlands and Sydney coastal regions from Hilltop to Glen Davis and Royal NP to Gosford. Population within the Hills Shire particularly important due to high density of plants. Grows on sandy soils in dry sclerophyll open forest, woodland and heath on sandstone up to 600 m above sea level.	-	None – no habitat present

Pimelea spicata	Spiked Rice-flower	E	E	Disjunct populations within the Cumberland Plain ((Marayong and Prospect Reservoir south to Narellan and Douglas Park) and Illawarra (Landsdowne to Shellharbour to northern Kiama). In both the Cumberland Plain and Illawarra environments this species is found on well-structured clay soils. On the Cumberland Plain sites it is associated with Grey Box communities. In the coastal Illawarra it occurs commonly in Coast Banksia open woodland.	Moderate	Moderate
Pomaderris brunnea	Brown Pomaderris	E	V	Brown Pomaderris is found in a very limited area around the Colo, Nepean and Hawkesbury Rivers, including the Bargo area and near Camden. Brown Pomaderris grows in moist woodland or forest on clay and alluvial soils of flood plains and creek lines.	Moderate to High – close proximity to large population along Teatree Hollow Creek (Niche 2014)	Moderate to High – close proximity to large population along Teatree Hollow Creek (Niche 2014)
Pomaderris cotoneaster	Cotoneaster Pomaderris	E	E	Disjunct distribution including the Nungatta area, Tumut, the Tantawangalo area, near Tallong, the Yerranderie area, the Canyonleigh area and Ettrema Gorge. Found in wide range of habitats, including forest with deep, friable soil, amongst rock beside a creek, on rocky forested slopes and in steep gullies between sandstone cliffs.	-	None – no habitat present
Pterostylis saxicola	Sydney Plains Greenhood	E	E	Occurs in western Sydney between Picton and Freemans Reach. Grows in small pockets of shallow soil in depressions on sandstone rock shelves above cliff lines. Associated vegetation above these rock shelves is sclerophyll forest or woodland on shale or shale/sandstone transition soils.	Moderate – habitat along Matthews Creek, Cedar Creek and Stonequarry creek in north of Study Area	Moderate – habitat along Matthews Creek, Cedar Creek and Stonequarry creek in north of Study Area

Pultenaea glabra		V	V	In NSW restricted to higher Blue Mountains in the Katoomba-Hazelbrook and Mt Victoria areas. Unconfirmed sightings in Mt Wilson and Mt Irvine areas. Grows in swamp margins, hillslopes, gullies and creekbanks and occurs within dry sclerophyll forest and tall damp heath on sandstone.	None	None
Rhizanthella slateri	Eastern Australian Underground Orchid	V	E	Currently known only from 10 locations, including near Bulahdelah, the Watagan Mountains, the Blue Mountains, Wiseman's Ferry area, Agnes Banks and near Nowra. The species grows in eucalypt forest but no informative assessment of the likely preferred habitat for the species is available. Flowers September and November.	-	Low – site is not near known locations
Rhodamnia rubescens	Scrub Turpentine	CE		Occurs in coastal districts north from Batemans Bay in New South Wales, to areas inland of Bundaberg in Queensland. Populations of R. rubescens typically occur in coastal regions and occasionally extend inland onto escarpments up to 600 m a.s.l. in areas with rainfall of 1,000 -1,600 mm. Found in littoral, warm temperate and subtropical rainforest and wet sclerophyll forest usually on volcanic and sedimentary soils.	-	None – habitat not present
Streblus pendulinus	Siah's Backbone		E	Siah's Backbone occurs from Cape York Peninsula to Milton, south-east NSW, as well as Norfolk Island. Siah's Backbone is found in warmer rainforests, chiefly along watercourses. The species grows in well-developed rainforest, gallery forest and drier, more seasonal rainforest.	Low – habitat not suitable	Low – habitat not suitable
Syzygium paniculatum	Magenta Lilly Pilly	E	V	Occurs in narrow coastal strip from Upper Lansdowne to Conjola State Forest. Grows in rainforest on sandy soils or stabilised Quaternary sand dunes at low altitudes in coastal areas, often in remnant littoral or gallery rainforests.	-	None – no habitat present
Tetratheca glandulosa	Tetratheca glandulosa	V	V	Restricted to The Hills, Gosford, Hawkesbury, Hornsby, Ku-ring-gai, Pittwater, Ryde, Warringah, and Wyong LGAs. Associated with shale-sandstone transition habitat (shale-cappings over	Low – moderate	Low – moderate

				sandstone). Occupies ridgetops, upper-slopes and to a lesser extent mid-slope sandstone benches. Soils generally shallow, yellow, clayey/sandy loam, commonly with lateritic fragments. Vegetation varies from heath to open forest and is broadly equivalent to Sydney Sandstone Ridgetop Woodland community.		
Thelymitra kangaloonica	Kangaloon Sun Orchid	CE	CE	The Kangaloon Sun-orchid is only known to occur on the southern tablelands of NSW in the Moss Vale / Kangaloon / Fitzroy Falls area at 550-700 m above sea level. It is found in swamps in sedgelands over grey silty grey loam soils.	Low – no known populations in locality. No swamps or sedgelands.	Low – no known populations in locality. No swamps or sedgelands.
Thesium australe	Austral Toadflax	V	V	Found in small, scattered populations along the east coast, northern and southern tablelands. Occurs in grassland or grassy woodland and is often found in association with Kangaroo Grass.	Low – no known populations in locality	Low – no known populations in locality

*CE = Critically endangered, E = Endangered, V = Vulnerable, M = Migratory, Ext = Extinct

Appendix B – Riparian vegetation and amphibian monitoring report Autumn 2020

Excellence in your environment

Tahmoor Mine Western Domain

Terrestrial Ecology Monitoring Report

Riparian vegetation and amphibian monitoring Autumn 2018-2020

Prepared for Tahmoor Coal

Prepared by Niche Environment and Heritage | 7 May 2020

Document control

Project number	Client	Project director	Project manager	LGA
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Executive summary

Tahmoor Coal Pty Ltd (Tahmoor Coal) have approval to extend their underground coal mining operations to the north-west of the Main Southern Railway (referred to as the 'Western Domain'), which will include Longwalls West 1 (LW W1) to West 4 (LW W4) at Picton and Thirlmere. Niche Environment Heritage Pty Ltd (Niche) was engaged by Tahmoor Coal to conduct impact monitoring of terrestrial ecology within the area potentially affected by longwall mining. This report summarises the results of the autumn 2020 monitoring period and compares the results with the previous two years of autumn baseline monitoring data collected in 2018 and 2019.

The aim of the monitoring program is to collect data that will enable comparison of environmental variables pre and post-mining in the Western Domain via the collection of empirical data, mapping and establishment of photographic records at the sites.

Eight sites, including three impact sites and five control sites, were monitored. Riparian vegetation monitoring involved floristic surveys within established vegetation monitoring plots at each site. Amphibian monitoring included spotlighting, call provocation, listening for diagnostic frog calls and tadpole identification along established transects and were targeted at two threatened frog species: the Giant Burrowing Frog (*Heleioporus australiacus*) and the Red-crowned Toadlet (*Pseudophryne australis*).

Key results of the 2020 autumn riparian and amphibian monitoring include:

- River-flat Eucalypt Forest, which is listed as an Endangered Ecological Community under the BC Act, was recorded at control Site 9 with a high level of weed infestation.
- Floristic composition and vegetation cover at each site were relatively consistent over all autumn monitoring events.
- Impact sites had a slightly lower mean species richness and percentage vegetation cover than control sites.
- Anthropogenic influences were observed at sites that had been impacted by human disturbance, particularly weeds and altered flow regimes.
- Sites 7, 8, 9 tended to have higher fertility and nutrient loads, which lead to higher species diversity and generally more exotic species. These sites appeared to be more influenced by seasonal changes than sites further up the catchment (Sites 4, 5, 6 and 10), which tended to be protected in deep gullies and canyons.
- Frog detection rates were variable between monitoring events for most sites. There was a significant difference between control sites and impact sites but not across seasons within monitoring years 2018-2020. This is likely to due to the relatively small data set and the highly variable climatic conditions experienced across the survey periods.
- The targeted threatened frog species were not detected. The 6 species detected represent an otherwise normal array of common and robust species for the study environments and conditions.
- The targeted threatened frog species appear not to be present in the Study Area, at least not in a population that can be meaningfully monitored. While the study environment contains superficially suitable habitat, it is possible that the species would no longer be able to survive in the area due to predation pressures from two introduced predators: the Plague Minnow (Gambusia holbrooki) and the Yabby (Cherax destructor), both of which were detected at all sites. The frog community present contains at least 12 species which are likely still viable indicators of impending or current environmental change.

- The frog community of the Study Area was significantly different comparing impact and control sites. Both containing sites with low diversity and abundance of frogs, although control sites are consistently having higher abundance than impact sites.
- Frog detection rates were variable between monitoring events for most sites, most likely due to the highly variable weather and climatic conditions across the survey periods. There was a significant difference between control sites and impact sites (detection being greater at control sites), but not across monitoring years 2018-2020. This is due to the relatively small data set.
- No thresholds within the Trigger Action Response Plan (TARP) in the Biodiversity Management Plan (SIMEC 2019) have been triggered, and therefore, no remedial management actions are required.

It is recommended that annual monitoring continue in spring and autumn for riparian vegetation and in spring and autumn (or after rain deemed suitable by the ecologist) for amphibian monitoring to permit comparison between impact and control sites and allow for temporal changes to be monitored and assessed as the project progresses.

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1. Introduction

1.1 Background

Tahmoor Coal Pty Ltd (Tahmoor Coal) have approval to extend their underground coal mining operations to the north-west of the Main Southern Railway (referred to as the 'Western Domain'), which will include Longwalls West 1 (LW W1) to West 4 (LW W4) at Picton and Thirlmere (Figure 1). A Terrestrial Ecology Assessment for the Western Domain completed by Niche in 2014 (Niche 2014) identified a number of watercourses (including Stonequarry Creek, Cedar Creek, Newlands Gully, and Matthews Creek) (Study Area) that would be subject to subsidence related impacts as a result of the extension of operations. These watercourses to the north west of the Western Domain subsidence area are of high ecological value, given the relatively pristine condition of the bushland and extent of habitat available. Niche Environment and Heritage Pty Ltd (Niche) was commissioned by Tahmoor Coal to conduct terrestrial ecology monitoring for Longwalls West 1 to West 4 (LW W1-W4) in the Western Domain (Figure 1).

A Before, After, Control, Impact (BACI) monitoring program was designed to identify ecological change within the Study Area as a result of mine subsidence by permitting comparisons between control and impact areas before and after the impact. The monitoring was required for three years prior to the commencement of undermining and will continue now undermining has commenced.

Baseline monitoring of riparian vegetation and amphibians commenced in autumn 2018 and has continued each autumn (Niche 2018, Niche 2019). The latest monitoring event (autumn 2020) is the first round of impact monitoring since undermining began. Autumn surveys permit detection of autumn/winter calling amphibian species as well as allowing for the detection of tadpoles and juveniles from earlier breeding events.

This report presents the three years of autumn monitoring data. Raw data and results summarised from each autumn monitoring event are included in this report.

Additional monitoring and reporting for spring riparian vegetation and amphibian monitoring was also undertaken during 2017, 2018 and 2019, with the final baseline spring monitoring completed in 2019. The spring monitoring results will be presented in a separate monitoring report.

Mining within the Western Domain commenced on 15th November 2019. This autumn monitoring event was conducted after the commencement of mining in autumn 2020 (March 2020) and is now considered impact monitoring due to the current proximity of mining to monitoring sites. The next monitoring event (spring 2020) and all subsequent monitoring will be defined as post mining (Impact) monitoring.

1.2 Purpose and objectives

The aim of the monitoring program is to collect data that will enable comparison of environmental variables pre and post-mining in the Western Domain via the collection of empirical data, mapping and establishment of a photographic record for the sites. The specific objectives of this report include:

1. Present all raw data from autumn baseline and impact monitoring
2. Detail the methodology utilised
3. Discuss any limitations of the monitoring program

4. Analyse the results of the impact monitoring in relation to data from baseline monitoring and identify if mining has had an impact on riparian or amphibian communities
5. Identify if any features of the Trigger Action Response Plan (TARP) in the Biodiversity Management Plan (SIMEC 2019) have been triggered and remedial management actions are required
6. Provide recommendations to improve the monitoring program.

Mapping includes:

1. Location of amphibian monitoring transects and vegetation monitoring plots
2. Photo point monitoring locations (end of transects)
3. Baseline assessment of native vegetation and condition along riparian zones.

1.1 Biodiversity Management Plan Trigger Action Response Plan

A Biodiversity Management Plan for Tahmoor North Western Domain Longwalls West 1 and West 2 has been developed which contains a TARP (SIMEC 2019). The TARP contains a table of features with thresholds for when a mining related impact occurs, and a prescribed management action response is required to be undertaken for remedial action. The key thresholds relevant to this monitoring report include:

- Decline in amphibian populations within watercourses of the Study Area
- Dieback of riparian vegetation within watercourses of the Study Area.

This report will identify if either of these features are triggered and provide recommendations for appropriate remedial action.

2. Methodology

2.1 BACI monitoring program

This monitoring program was designed as a Before, After, Control, Impact (BACI) study. In accordance with BACI principles, the monitoring program was designed to collect sufficient data over time to compare changes in ecological indicators as a result of subsidence. The monitoring program considered recommendations of the Southern Coalfields Inquiry and Planning and Assessment Commission reports for Peabody Coal's Metropolitan and South 32's Bulli Seam Projects and includes the following:

- A minimum of two years of baseline data, collected over an appropriate area and at consistent seasonal frequencies to monitor amphibian populations and riparian vegetation along Stonequarry Creek, Cedar Creek and Matthews Creek
- Annual reassessment of the data to determine its effectiveness in meeting its goal of identifying impacts. This adaptive monitoring may lead to changes in the extent and intensity of monitoring
- Surveys will be undertaken to current NSW Department of Planning Industry and Environment (DPIE) standards.

2.2 Monitoring sites

Appropriate replication of both impact (directly adjacent to or over the mine) and control (outside direct impact zone) sites was incorporated into the monitoring program to account for natural variability across the landscape. The longwall plans were changed subsequent to the 2014 Terrestrial Ecology Assessment (Niche 2014) and, as such, site locations were shifted accordingly. The planned layout of the longwalls subsequently changed again after the establishment of the monitoring sites, however, all sites remain within their originally designated treatment areas. Riparian and amphibian monitoring was conducted at eight sites, including three impact sites and five control sites. A more detailed description of the riparian and amphibian monitoring methodology is provided below. Details of each impact and control site is provided in Table 1, with details provided in Appendix 2 and location shown in Figure 1.

Table 1: Riparian vegetation and amphibian monitoring sites and their existing characteristics

Treatment	Site number	Stream	Existing impacts and features	Mined beneath
Longwall Impact	3	Cedar Creek above Stonequarry Creek junction and adjacent to Newlands Gully	Rural residential, permanent stream, rainforest	Yes. Mining commenced November 2019.
	4	Matthews Creek in gorge near Cedar Creek junction	Rural residential, permanent pools, rocky	No. Mining of the longwall has not begun near this site. The site is located 20 m west of the Longwall (Figure 1).
	5	Matthews Creek in gorge	Rural residential, rocky	No. Mining of the longwall has not begun near this site. The site is located 100 m west of the Longwall (Figure 1).
Control	6	Cedar Creek in gorge	Agriculture, permanent pools, rainforest	No
	7	Cedar Creek	Rural residential, sandy	No

	8	Cedar Creek	Rural residential, sandy	No
	9	Stonequarry Creek	Agriculture, weed infestations	No
	10	Stonequarry Creek in gorge	Rural residential, permanent pools, rainforest, rocky	No

2.3 Riparian vegetation monitoring

The riparian vegetation monitoring was conducted by Alex Christie (Ecologist) and Sarah Hart (Ecologist) on 23 and 24 March 2020. Tasks completed during riparian monitoring using the Biodiversity Assessment Methodology (BAM; OEH 2016) are detailed below.

2.3.1 Permanent vegetation plots

One vegetation plot (BAM plot) was established within each of the eight monitoring sites and consisted of the following:

- One 50 x 20 metres (m) functional plot immediately adjacent to or spanning the water body
- One 10 x 40 m floristic plot following the creek line to accommodate the steep, narrow gullies.

The following attributes were collected within the BAM plots:

- Composition:
  - native species richness (10 x 40 m plot)
- Structure:
  - native flora cover (% of the 10 x 40 m plot) divided into the growth forms:
    a) Tree
    b) Shrub
    c) Grass and grass like
    d) Forb
    e) Fern
    f) Other
  - exotic species cover
  - high threat weed vegetation cover
- Function
  - tree regeneration (size classes present)
  - number of trees with hollows (within 50 x 20 m plot)
  - total length of fallen logs (within 50 x 20 m plot)
  - number of large trees (within 50 x 20 m plot)
  - tree stem size class (within 50 x 20 m plot)
  - litter cover (sampled in 5 x 1 m quadrats within the 50 x 20 m plot).

The BAM plot location was marked for repeated survey using GPS coordinates, flagging tape and photo points.

2.3.2 Vegetation condition assessment

Within each of the BAM plots, the condition and structure of vegetation are assessed using key indicators to permit comparison of results throughout different monitoring periods. The BAM was applied as it provides a standardised scoring system of key attributes.

2.3.3 Photo point monitoring

Photo monitoring from a permanent photo point was undertaken within each of the BAM plots.

2.3.4 Plant taxonomy

Plant taxonomy used was consistent with the nomenclature accepted by the National Herbarium of NSW (as per their PlantNet website http://plantnet.rbgsyd.nsw.gov.au/). All floristic data were entered into the Niche Flora Information System (FIS) to allow data manipulation and export for species lists and analysis.

2.4 Amphibian monitoring

The amphibian monitoring was conducted by Sarah Hart (Ecologist) and Stephen Bloomfield (Ecologist) on three occasions: 10, 11 and 16 March 2020. Survey timing was dependent on rainfall and therefore did not necessarily occur within consecutive days in the autumn season.

Surveys targeted the threatened frog species, Red-crowned Toadlet (*Pseudophryne australis*) and Giant Burrowing Frog (*Heleioporus australiacus*). These species are known to call over a wide period of the year, driven more by weather conditions than by the season.

One amphibian monitoring transect (200 m) was located in each of the eight monitoring sites. Frog transect locations were marked using GPS tracking coordinates for repeated survey. All detected frog species were recorded during surveys, which involved the following:

- Nocturnal aural and visual searches of watercourses. The search area was restricted to within 10 m either side of the 200 m transect. A minimum of 30 minutes was spent searching along each transect, although time spent was often considerably longer to account for difficult terrain or high frog abundance. Handheld LED spotlights and head torches were used.
- Attempts were made to elicit calls from the target species using call-playback of male advertising calls for the Giant Burrowing Frog and a sudden loud noise for the Red-crowned Toadlet.
- Tadpole searches were conducted during diurnal and nocturnal surveys. Tadpoles were identified using the resources in Anstis (2013).
- Opportunistic records of frogs seen or heard calling during the riparian vegetation surveys. These records were included as presence for that period if the species was otherwise undetected during targeted nocturnal survey for that monitoring event and site.

2.5 Data analysis

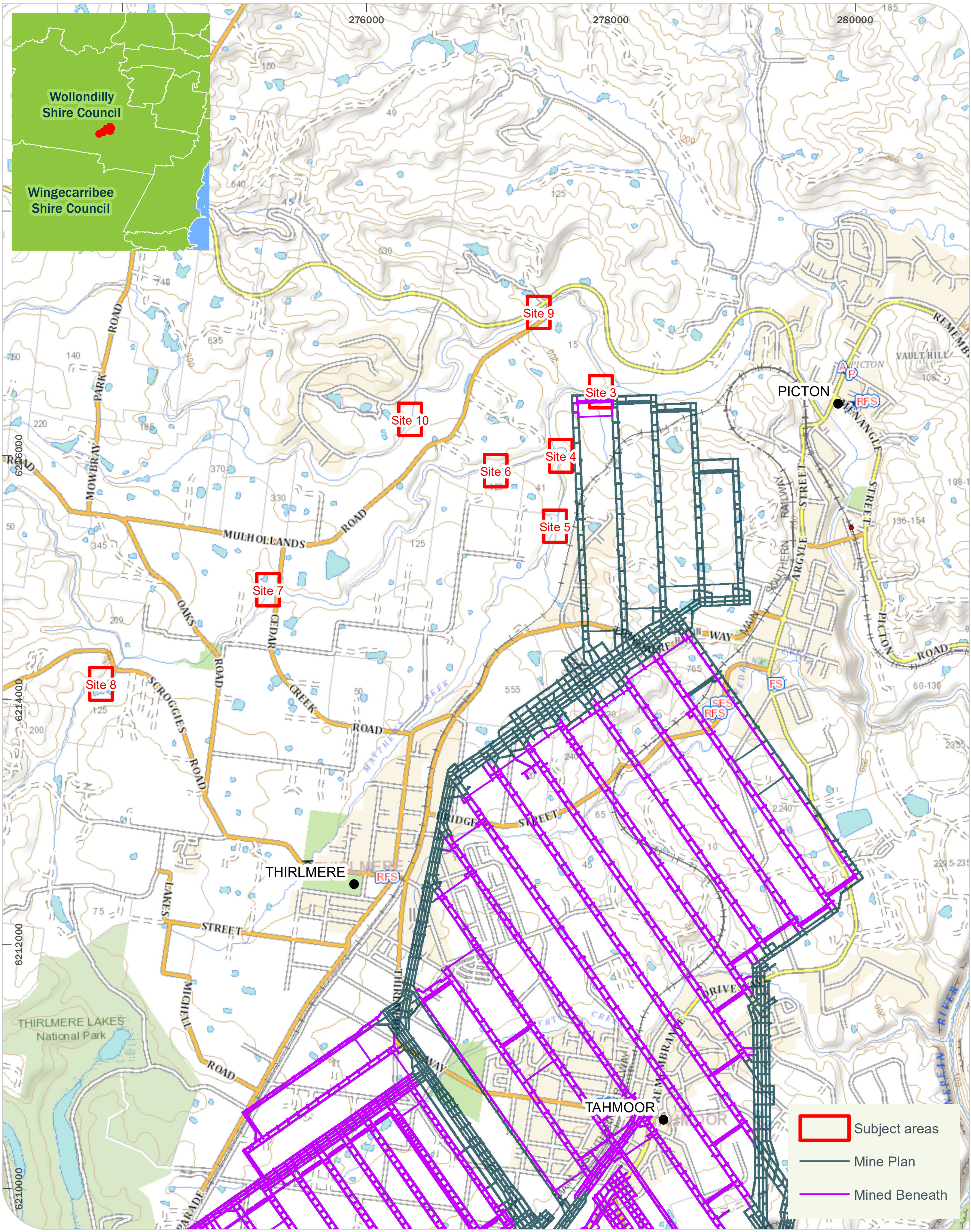
The vegetation cover scores, and the frog data were analysed separately by Mathew Vickers PhD (Ecologist/Statistician). Redundancy analysis using Bray-Curtis dissimilarity index was performed to reduce the dimensionality of the data. This analysis provides a visual representation of the data and is used to identify obvious trends and patterns. This analysis is not for making statistical claims of significance.

The similarity measures were investigated visually with Hierarchical Cluster Analysis and ordination plots using Non-parametric Multi-dimensional Scaling in the statistical program R (R Core Team 2020) (Version 3.6.3). Data were analysed in an untransformed state, which allows the dominant species to drive the analysis. It was also analysed in a strongly transformed state (4th root transformation), which distributes the data weight more evenly across all species present. However, it still maintains some weighting for abundance that would be lost if a presence/absence transformation were used. Both approaches are considered appropriate given the natural variability of both plant and frog communities over time. Considering both the dominant species and the full community will allow for a deeper understanding of any changes that come about due to mine impacts. PERMANOVA (package 'vegan', 'and 'BiodiversityR') was performed on constrained redundancy analysis scores for statistical hypothesis testing.

2.6 Limitations of the monitoring program

Limitations of the current monitoring project include the following:

- Control sites were limited to areas that are not expected to be impacted by mining operations, were accessible, and minimised safety concerns
- No two creeks are identical, and therefore eliminating all variables between control and impact sites is a complex task and not possible in this instance
- Some plant species are cryptic and may remain undetected during the survey. This is the case with orchid species, annuals (completing their life cycle within a single season) and some perennials being inconspicuous unless flowering or in fruit. Some individual plant samples were in a juvenile state or were annual species that had already died. Therefore, not all plants found could be accurately identified. These species were identified to genus level where possible and may need to be identified to species level in subsequent monitoring seasons
- Due to the limited number of amphibian species recorded during the autumn monitoring events, spring data has been included in the analysis. This doesn't affect the analysis, only allows a more accurate comparison of species over the sites.



Location map

Western Domain - Riparian and Amphibian Monitoring Report 2020

niche Environment and Heritage

0 750
m
GDA 1994 MGA Zone 56

Niche PM: Alex Christie
Niche Proj. #: 5750
Client: Tahmoor Coal Pty Ltd

Figure 1

3. Results and discussion

3.1 Riparian vegetation monitoring results

The full floristic results of the riparian vegetation monitoring (10 m x 40 m plots) are provided in Appendix 2. An overview is provided below.

3.1.1 Species richness

Table 2 presents the species richness of each site for the three autumn monitoring periods. A total of 150 native plant species and 51 exotic plant species were recorded across the eight sites over the three years of autumn sampling (Appendix 3). Impact sites had a slightly lower species richness of both native and exotic plant species with an average of 31.7 native species and 5.7 exotic species per vegetation plot (n = 3) compared with 31.8 native and 11.6 exotic species at control vegetation plots (n = 5) (Figure 2, Figure 3). Species richness remained relatively consistent between autumn monitoring events.

Native Species richness in autumn 2020 ranged from 20 to 42 species. This is comparable with results from previous monitoring events, where native species richness ranged from 20 to 46 in autumn 2018 and 17 to 51 species in autumn 2017. The most frequently recorded species included: *Lomandra longifolia, Microlaena stipoides, Entolasia marginata, Adiantum aethiopicum*, *Glycine tabacina*, *Oplismenus aemulus*, *Backhousia myrtifolia.* These dominant species have remained common throughout subsequent monitoring events.

During autumn 2020 impact sites had an average total species richness of 37.3, which was slightly lower than the average species richness of 43.4 at the control sites. This was consistent with the results for autumn 2019, whereby impact sites had a slightly lower average species richness (40.3) than control sites (46.4). Similarly, average species richness during autumn 2018 was lower at impact sites (36.3) than control sites (44.8), however average species richness at impact sites in 2017 was substantially lower than the following two monitoring events 2018, 2019.

Control sites 7, 8 and 10 consistently had the highest species richness each year. Although impact sites 3 and 4 recorded lower species richness (29, 35) than these high control sites during 2020 monitoring, impact site 5 (48) was higher than control sites 6 (20) site 9 (38). This pattern has been consistent across all monitoring events.

Table 2: Species richness

		Autumn 2018			Autumn 2019			Autumn 2020		
Treatment	**Site**	**Native**	**Exotic**	**All Species**	**Native**	**Exotic**	**All Species**	**Native**	**Exotic**	**All Species**
Impact	3	30	11	41	35	8	43	26	3	29
	4	28	4	32	33	5	38	29	6	35
	5	29	7	36	31	9	40	40	8	48
Control	6	17	1	18	20	2	22	20	0	20
	7	46	13	59	38	14	52	36	19	55
	8	39	11	50	43	13	56	42	17	59
	9	19	19	38	24	23	47	20	18	38
	10	51	8	59	46	9	55	41	4	45
Impact Mean		**29.0**	**7.3**	**36.3**	**33.0**	**7.3**	**40.3**	**31.7**	**5.7**	**37.3**
Control Mean		**34.4**	**10.4**	**44.8**	**34.2**	**12.2**	**46.4**	**31.8**	**11.6**	**43.4**

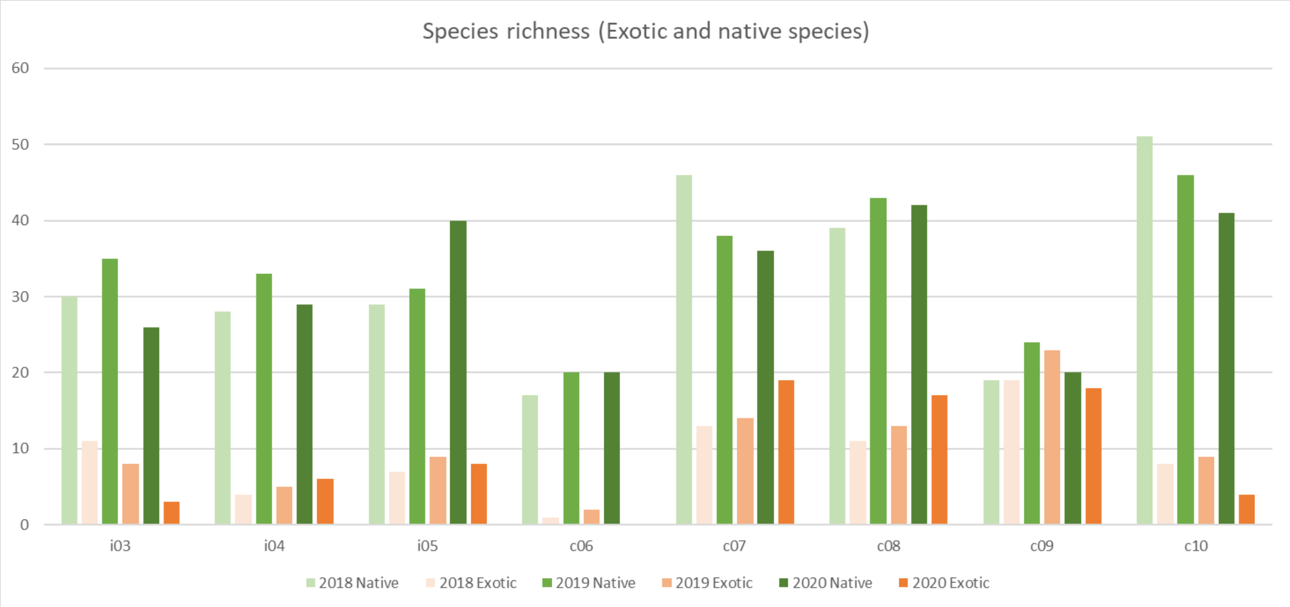


Figure 2: Species richness across monitoring 2018-2020 (Native/Exotic)

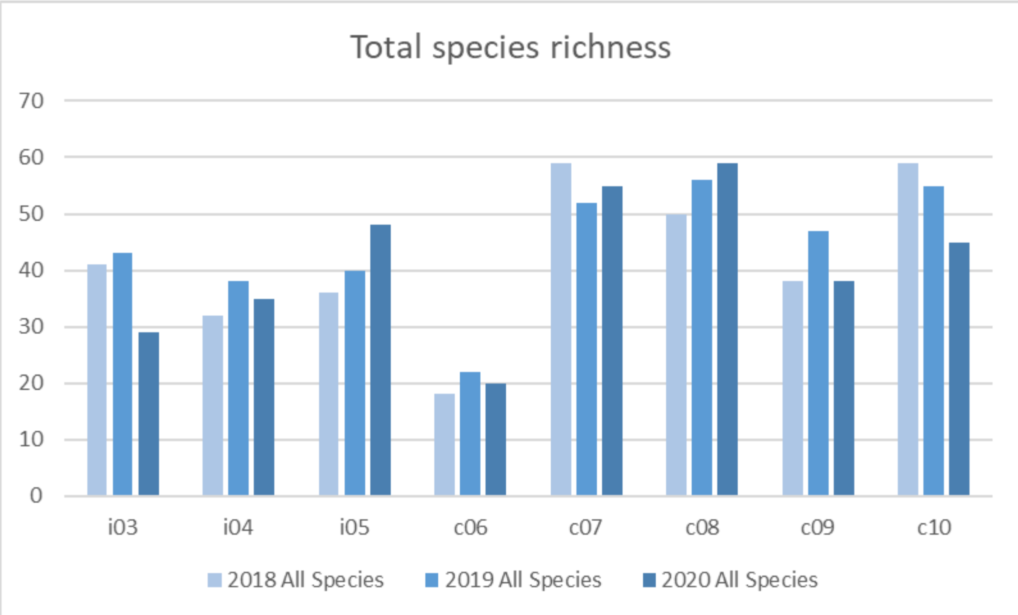


Figure 3: Total species richness across monitoring 2018-2020

Threatened species and habitat

No threatened flora species were recorded during the monitoring surveys. However, River-flat Eucalypt Forest, which is listed as an Endangered Ecological Community under the NSW *Biodiversity Conservation Act 2016* (BC Act), occurs at control Site 9. It occurs there in a highly disturbed state, with high exotic species abundance. In autumn 2020, Site 7 was found to have the highest exotic species richness of all monitoring sites.

3.1.2 Composition, structure and function

The key indicators collected in the BAM plots were used to assess condition, structure and function of vegetation and habitat features within each of the plots. The raw data is contained in Table 8, Table 10 and Table 12 and the floristic composition data for the three monitoring events is included in Appendix 3. A high degree of variation in diversity, abundance and structure is expected due to natural variation associated with the topography and hydrology of each of the different sites.

Over the three years, differences in some of the key attributes were observed, including fluctuations in fallen logs and mean litter cover. This is predicted given vegetation growth and die back over time, branch loss and natural die back of species such as annuals. Ongoing declining key attribute scores may indicate factors impeding the health of the riparian ecosystem. There was no ongoing decline in key attributes observed during baseline monitoring. Observed variations in key attributes are considered likely to be due to natural seasonal and temporal changes and clarity in data recording methods over time. The BAM method does not account for habitat features that may be within water, particularly when the water level varies between monitoring events. As more data is collected over time, the influence on variability would reduce.

3.1.3 Floristic cover

Vegetation cover was recoded as part of the BAM plots. Mean vegetation cover scores at control and impact sites for each monitoring event are provided in Table 3, Figure 4 and Figure 5. The topographic and geological setting of the sites is variable. As a result, there is considerable natural variation in vegetation cover among sites, while between year variation at each site was limited. For all monitoring events, control sites showed higher mean vegetation cover compared with the impact sites.

Table 3: Vegetation cover (%)

	Autumn 2018			Autumn 2019			Autumn 2020		
Treatment site	**Native**	**Exotic**	**All Species**	**Native**	**Exotic**	**All Species**	**Native**	**Exotic**	**All Species**
Impact									
3	78.7	1.6	80.3	46.3	1.2	47.5	80	1.1	81.1
4	78.3	0.4	78.7	44.1	0.6	44.7	43.5	0.6	44.1
5	67.8	2.2	70.0	77.7	2.7	80.4	87.3	3.1	90.4
Control									
6	89.2	0.1	89.3	59.6	0.3	59.9	76.1	0	76.1
7	103.3	3.9	107.2	124.5	3.6	128.1	88.7	10.5	99.2
8	67.7	2.9	70.6	148.5	3.7	152.2	106.9	6.7	113.6
9	50.9	37.6	88.5	40.2	68.0	108.2	38.8	45.2	84
10	92.2	1.6	93.8	61.7	1.1	62.8	89.6	1.2	90.8
Impact Mean	**74.9**	**1.4**	**76.3**	**56.0**	**1.5**	**57.5**	**70.3**	**1.6**	**71.9**
Control Mean	**80.7**	**9.2**	**89.9**	**86.9**	**15.3**	**102.2**	**80.0**	**12.7**	**92.7**

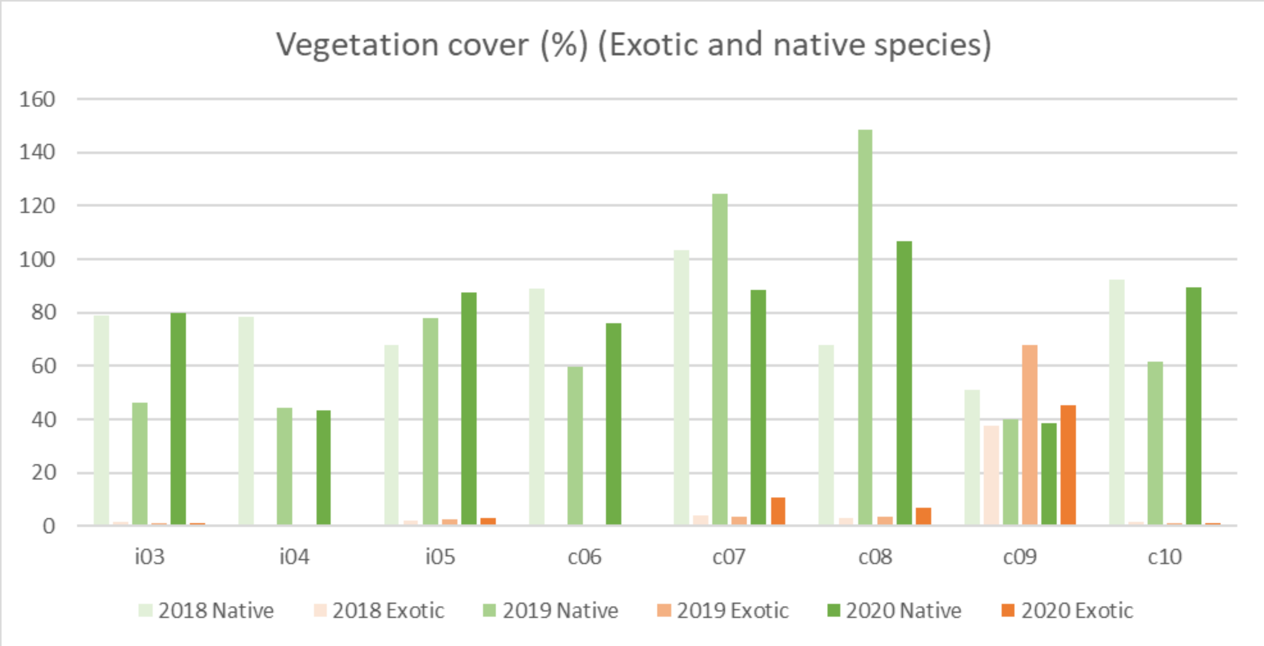


Figure 4: Vegetation cover (%) across monitoring 2018-2020

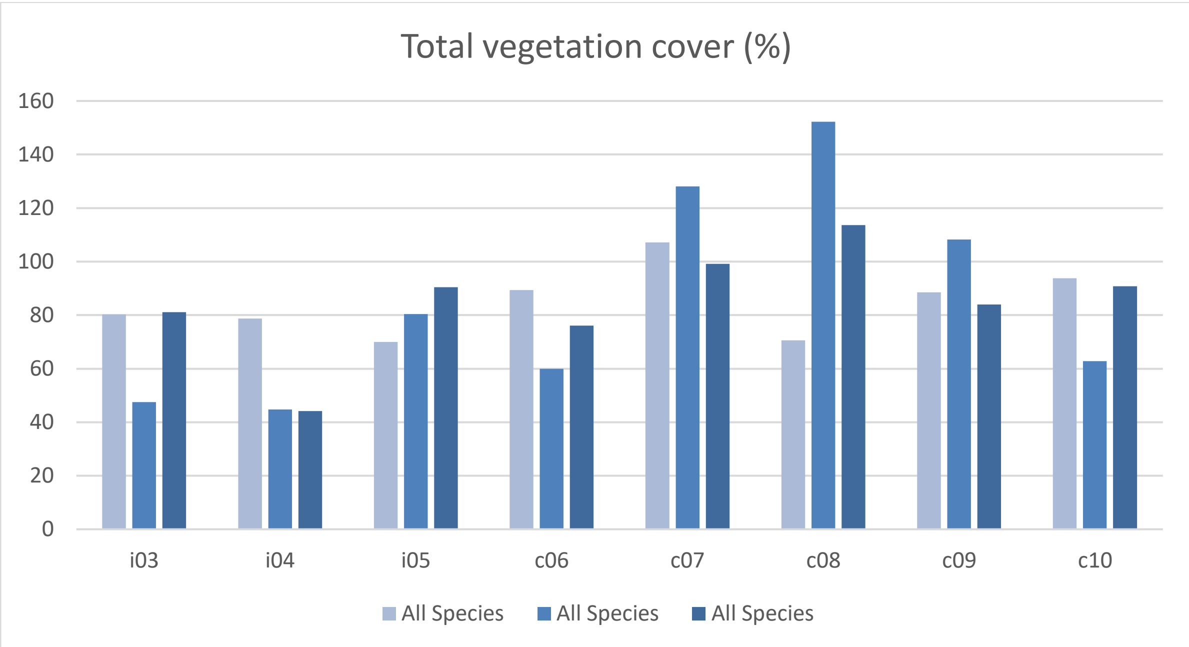


Figure 5: Total vegetation cover (%) across monitoring 2018-2020

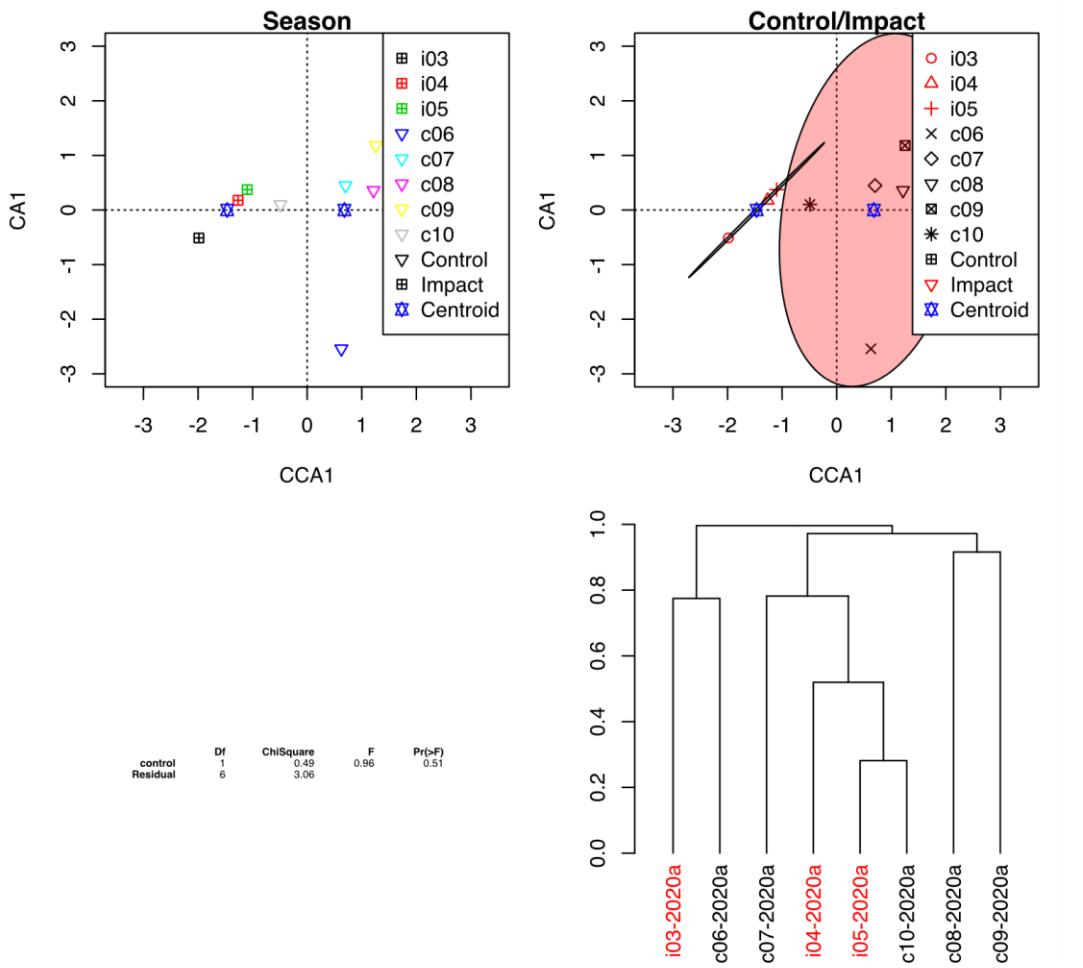


Figure 6: The floristic relationships of impact and control sites across autumn 2020

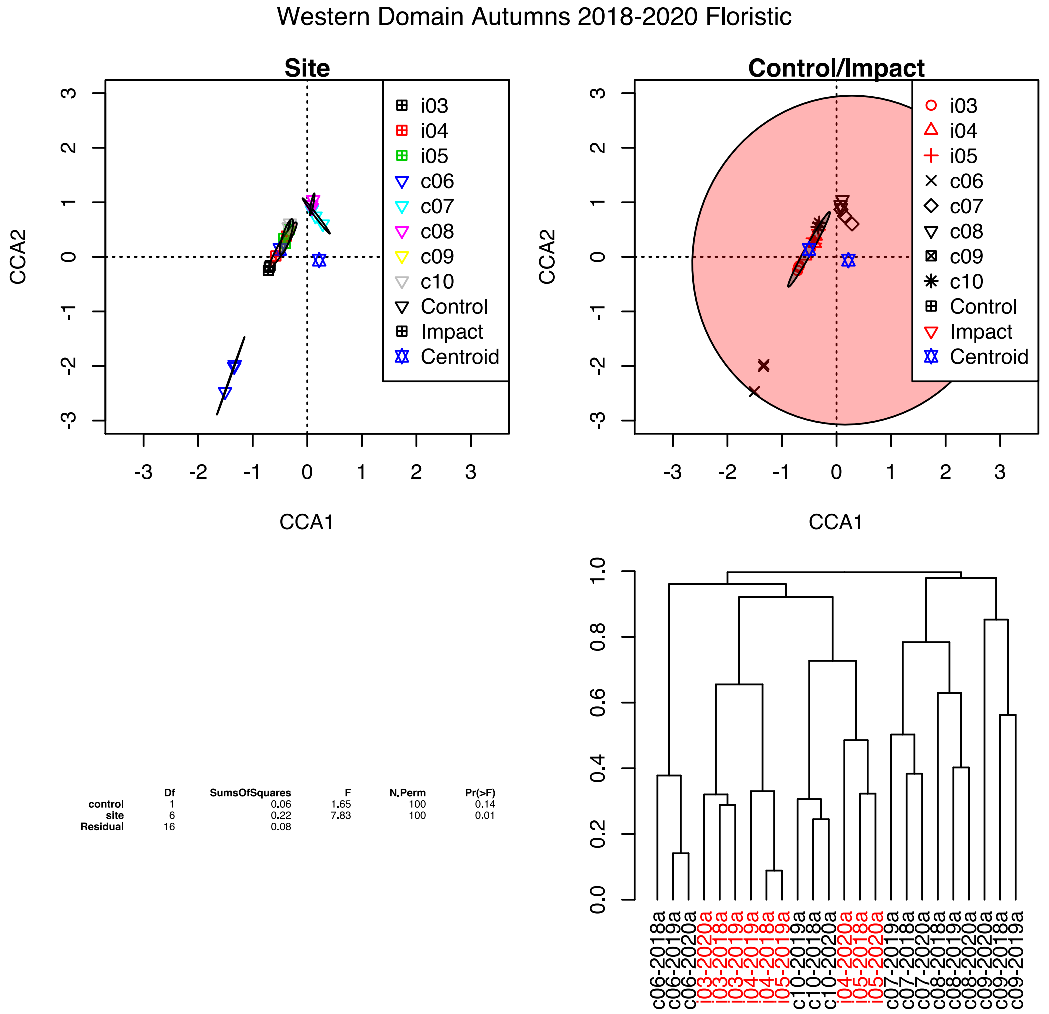
Figure 6 shows the floristic relationships of impact and control sites based on percent cover scores and displayed using a multi-dimensional scaling ordination without transformation for the autumn 2020 dataset only. There was no significant effect of control/impact for floristic assemblage in autumn 2020. The floristic similarity of the sites is plotted in the season graph. On the control/impact graph the grey ellipse (which groups the control sites) and the larger red ellipse (impact) have a strong overlap. Statistical analysis of this using ANOVA, (df=1,6, F=0.96, p=0.49) indicates the data sets are not significantly different (P>0.01).

3.1.4 Variability between years

The mean vegetation cover (Table 3) at any one site fluctuated by up to 38 percent between 2019 and 2020 monitoring events. This is far less than the 81.6 percent fluctuation in mean vegetation cover at Site 8 between 2018 and 2019 monitoring events. Exotic species, which typically represented a small proportion of the vegetation cover at each site, increased slightly over three years monitoring 2018, 2019 and 2020 at some sites, however there was no consistent trend Figure 4.

Native cover fluctuated much more over this period; decreasing from 2018 to 2019 but returning to similar 2018 results in 2020 at all sites. This is likely the result of the overall higher levels of cover in 2018 and drier than usual conditions experienced at all sites in 2019, and then after rainfall in early 2020 the cover scores returned to similar 2018 levels.

In Figure 7, each monitoring event is represented by the site name and the year of survey (e.g. c06-2020a). Figure 7 displays the relationship between data collected during each monitoring event and the similarity of data between monitoring events for each of the eight sites. Figure 7, the hierarchical cluster (bottom right, where monitoring events with shorter links towards the bottom of the plot are more similar than monitoring events joined by links higher on the plot) shows all sites to be grouped together; that is, the floristics at each site are consistently most similar to each other over the three monitoring periods; with the exception of Site 4 (i04-2020) which in 2020 was more similar to Site 5 in 2018 and 2020 and the other Site 5 (i05-2019) was more similar to Site 4 in 2018 and 2020.



	Df	SumsOfSquares	F	N.Perm	Pr(>F)
control	1	0.06	1.65	100	0.14
site	6	0.22	7.83	100	0.01
Residual	16	0.08			

Figure 7: The floristic relationships of impact and control sites across autumn monitoring 2018-2020

Figure 7 shows the floristic relationships of impact and control sites based on percent cover scores and displayed using a multi-dimensional scaling ordination without transformation. There was no significant effect of control/impact for floristic assemblage across all autumn monitoring events. On the control/impact graph (top right) the smaller grey ellipse (control) and the large red ellipse (impact) have a strong overlap, the grey (control) being completely inside the red (impact). Statistical analysis of this using ANOVA, (df=1,6, F=1.65, p=0.14) indicates the data sets are not significantly different. Although, there is no overlap in the site graph (top left) indicating a visual dissimilarity, and that there was a significant difference among sites (ANOVA, df=6,16, F=7.834, p=0.01).

3.2 Frog surveys

3.2.1 Climatic conditions

Monthly climate data since January 2018 is provided in Appendix 5, Table 13. Rainfall values are taken from the Picton Council Depot to the east of the Study Area and temperature values are taken from Camden Bureau of Meteorology weather station (station ID 94755), 16 to 20 km from the Study Area. Table 14 shows the conditions during each frog survey. All frog surveys were undertaken within a week of rainfall, with no minimum trigger value set.

Monthly rainfall had been below monthly averages five months prior to the autumn 2019 surveys (March 2019) and thus conditions were considered to be dry and suboptimal for frogs. There was slightly higher than average rain in September 2019 and back to well below monthly averages until a heavy influx of rain in January and February 2020. Lower than average rainfall for extended periods of time has resulted in reduced stream flow and absence of surface water at some sites, in particular 4, 5, 7 and 9. This was then complicated by heavy rains and fast flowing water in a short time period (January and February 2020) shortly preceding the autumn 2020 surveys with notable sediment and debris movements.

3.2.2 Frog distribution and abundance

Table 4 and Table 5 present the frog records for autumn 2020 and all autumn monitoring events, respectively. There were 69 individual frog records during the autumn 2020 frog surveys. Three species of frogs were recorded in 2020 and a total of 6 frog species have been recorded over all monitoring events. A maximum of two species was recorded at any one site during autumn 2020 monitoring. With the exception of Site 5 and Site 6, all sites recorded only one species. Site 5 recorded two species, and Site 6 recorded the lowest species diversity with no frogs recorded.

In autumn 2020, the most widespread and abundant frog species was the Clicking Froglet (*Crinia signifera*), which was detected at all but one site (Site 6). Lesueur's Tree Frog (*Litoria lesueuri*) was detected at one of the eight sites (Site 5). The greatest number of frogs detected were at the control sites.

Overall, one species occurred more abundantly at control sites compared to impact sites - the Common Eastern Froglet (*Crinia signifiera*). Additionally *Litoria lesueuri* was only recoded at one of the impact sites.

The two primary target species (Red-crowned Toadlet and Giant Burrowing Frog) were not detected during these surveys, nor are there existing records in public databases for these species within the same catchment or near the impact sites. Superficially there is suitable habitat for both species at a range of the impact and control sites and there are historical records, either within 10 km of the Study Area or within the greater Bargo River catchment.

The Giant Burrowing Frog is known to have a long tadpole stage, which would make the species vulnerable to introduced predators such as the Plague Minnow (*Gambusia holbrooki*) and the Yabby (*Cherax destructor*), which are widespread in the area. The absence of Red-crowned Toadlet from the Study Area may be due to the shale capping geology in the area as this species is a sandstone specialist (Anstis 2013).

Table 4: Impact and control site frog records

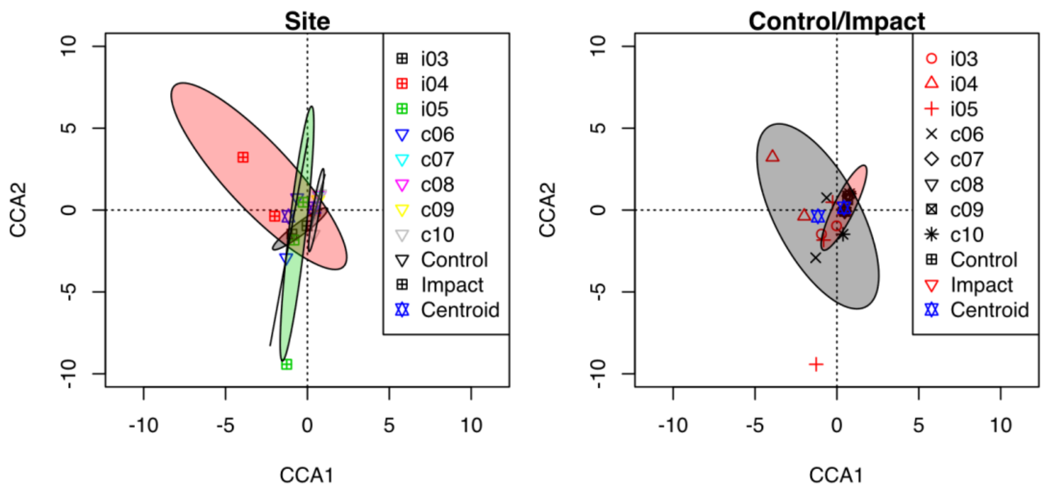
	Impact site			Control site				
Species	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
Crinia signifera	2	2	5	0	20	18	10	11
Litoria lesueuri	0	0	1	0	0	0	0	0
Number of species	**1**	**1**	**2**	**0**	**1**	**1**	**1**	**1**
Number of individuals	**2**	**2**	**6**	**0**	**20**	**18**	**10**	**11**

Table 5: Autumn monitoring frog records

Species (in order of abundance)	**Autumn 2018**	**Autumn 2019**	**Autumn 2020**	**Mean Autumn Count**
Crinia signifera	17	65	68	50
Limnodynastes peronii	2	20	0	7.33
Litoria phyllochroa	2	3	0	1.66
Litoria lesueuri	4	13	1	6
Litoria peronii	5	7	0	5.33
Litoria verreauxii	0	4	0	1.33
All Species	**30**	**112**	**69**	**11.94**


Stoney Creek Frog *Litoria lesueuri* (in amplexus) Leaf-green Tree Frog Litoria phyllochroa

Plate 1: Common frog species present within the Study Area



	Df	SumsOfSquares	F	N.Perm	Pr(>F)
control	1	0.02	1.79	100	0.15
site	6	0.08	1.03	100	0.35
Residual	15	0.19			

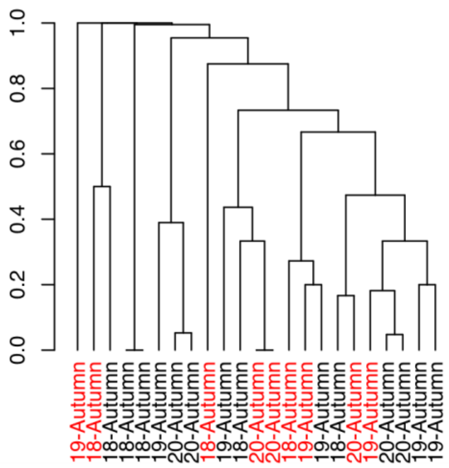
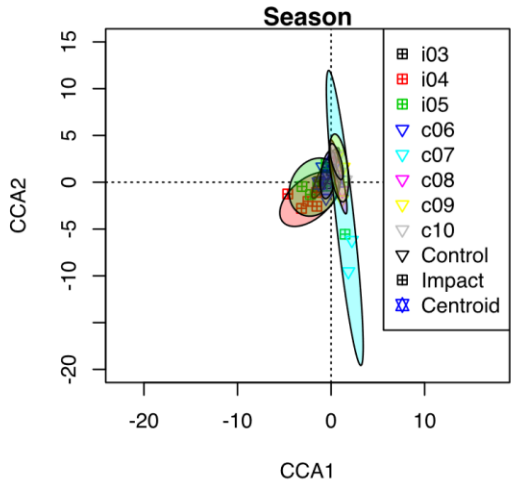


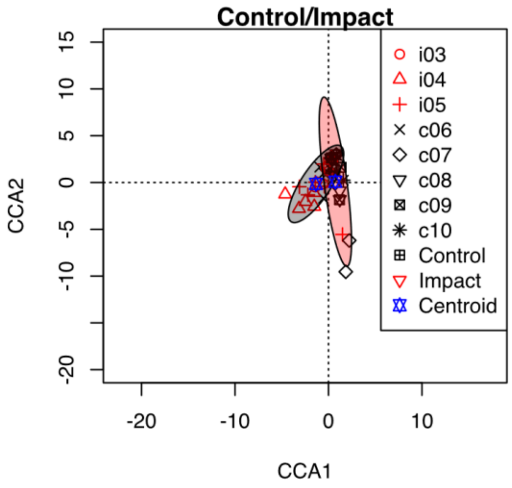
Figure 8: Frog site comparisons, autumn across all monitoring years 2018-2020

Figure 8 shows frog sites (transformed mean counts) compared by multi-dimensional scaling ordination. The data is transformed to give more power to the species mix than to frog abundance. There was no significant effect of control/impact for frog abundance in autumn across all monitoring years 2018-2020. On the control/impact graph (top right) the larger grey ellipse (control) and the small red ellipse (impact) have a strong overlap, the red (impact) being mostly inside the grey (control). Statistical analysis of this using ANOVA, (df=1,6, F=1.79, p=0.15) the data sets are not significantly different. This is also true for the relationship per site with the strong overlap of many ellipses and the ANOVA results (df=6,15, F=1.03, p=0.35) which indicates the data sets are not significantly different.

3.2.3 Variability between years

Table 5 shows total frog records were much lower in autumn 2020 than previous monitoring in 2019, (69 and 112 individuals recorded respectively), while autumn 2019 records increased by approximately 27 percent from 2018 it decreased again by 61 percent in 2020.





	Df	ChiSquare	F	Pr(>F)
control	1	0.25	6.16	0
season	1	0.04	1.04	0.34
control:season	1	0.03	0.73	0.62
Residual	43	1.77		

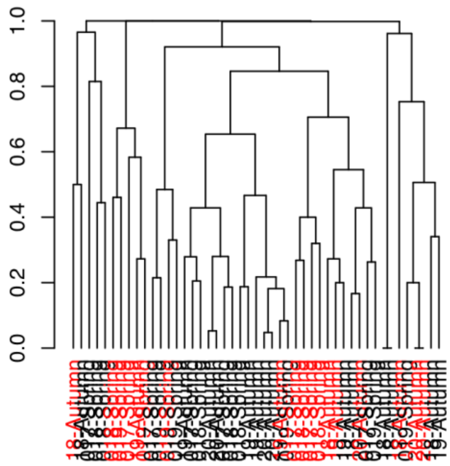


Figure 9: Frog survey records in spring and autumn monitoring across all monitoring years 2018-2020

Figure 9 shows the similarity of sites between monitoring events, including spring monitoring events. This plot ordination (using multi-dimensional scaling) was created with data transformed with a 4th root function to reduce the impact of large counts and to weight the data for the species detected rather than the abundance of a few common species. sites that are closer to each other on the ordination plot are more similar in species composition (with abundance still having an effect).

Most sites have shown variability in frog detection rates over the different monitoring events, resulting in similarities between different sites as opposed to similarities between years for the same sites.

Analysis of the potential effect of season on the data showed strong overlap of many ellipses (Figure 9) and the ANOVA results (df=1,1, F=1.04, p=0.34) indicated that the data sets (autumn and spring among the different sites) are not significantly different.

The low frog counts observed during some surveys are likely due to the dry conditions experienced prior to and during those surveys. Greater frog numbers were detected when there was substantial rain prior to the survey or light rain with warm conditions during the survey. The recent rains in late summer 2020 brought large debris and sediment movement within the creeks potentially having a negative impact on the frog populations.

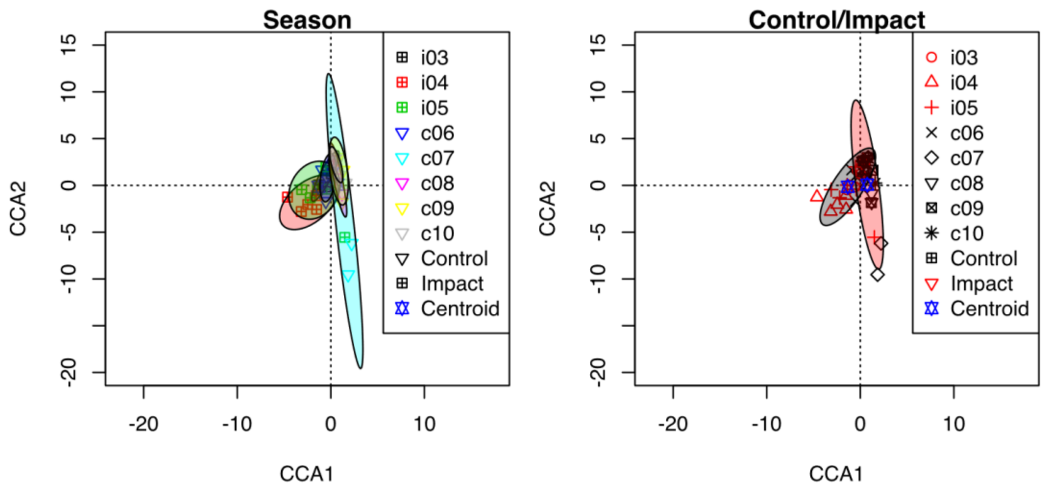
3.2.4 Site variability

There was a significant effect of control/impact for frog abundance in autumn across all monitoring years 2018-2020 but not across seasons. On the control/impact graph (top right of Figure 9) the grey ellipse (control) and the red ellipse (impact) have a weak overlap, using this and the ANOVA, (df=1, F= 6.162, p=0.001) indicate that the data sets are significantly different indicating a change in control sites and impact sites.

Site 3 has maintained a constant water level during all monitoring events, possibly due to a groundwater source for Cedar Creek in this vicinity. Site 6 is in the deepest part of the canyon of Cedar Creek and retains permanent ponds due to geology and the heavy shade afforded by the canyon and rainforest canopy. These two sites might be regarded as refuge sites for frogs where many species can retreat during drought conditions. As mentioned above, during the heavy rains early in 2020 much vegetation and debris was washed downstream and a large amount of sediment had moved potentially disturbing the microclimates and habitat for frogs and this may have affected the autumn 2020 results with no frogs detected at Site 6 and only a small number (2 individuals calling) of *Crinia signifera* at Site 3.

Most sites retained some water during dry periods, however, Site 7 and Site 9 were both completely dry in autumn 2019. These dry conditions were reflected in the low frog abundance and diversity at these two sites. Fortunately, in autumn 2020 these sites retained water after the earlier rain events but with the highly disturbed creek banks the frog detection rate was still low in comparison to previous years.

The apparent drought-proof nature of Site 3 and Site 6 highlights the importance of these sites for monitoring. A marked change at these sites may indicate a driver other than drought.



	Df	ChiSquare	F	Pr(>F)
control	1	0.25	6.16	0
season	1	0.04	1.04	0.34
control:season	1	0.03	0.73	0.62
Residual	43	1.77		

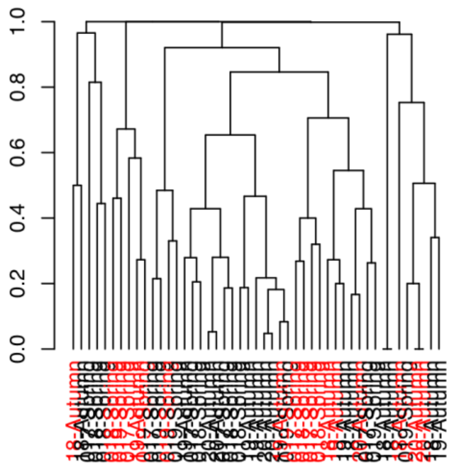


Figure 9: Frog survey records in spring and autumn monitoring across all monitoring years 2018-2020

4. Summary and conclusion

Eight sites, including three impact and five control sites, were monitored. The key results of the autumn riparian and amphibian monitoring include:

- River-flat Eucalypt Forest, which is listed as an Endangered Ecological Community under the BC Act, was recorded at control Site 9 with a high level of weed infestation.
- Floristic composition and vegetation cover at each site were relatively consistent over all autumn monitoring events.
- Impact sites had a slightly lower mean species richness and percentage vegetation cover than control sites.
- Anthropogenic influences were observed at sites that had been impacted by human disturbance, particularly weeds and altered flow regimes.
- Sites 7, 8, 9 tended to have higher fertility and nutrient loads, which lead to higher species diversity and generally more exotic species. These sites appeared to be more influenced by seasonal changes than sites further up the catchment (Sites 4, 5, 6 and 10), which tended to be protected in deep gullies and canyons.
- Frog detection rates were variable between monitoring events for most sites. There was a significant difference between control sites and impact sites but not across seasons within monitoring years 2018-2020. This is likely to due to the relatively small data set and the highly variable climatic conditions experienced across the survey periods.
- The targeted threatened frog species were not detected. The 6 species detected represent an otherwise normal array of common and robust species for the study environments and conditions.
- The targeted threatened frog species appear not to be present in the Study Area, at least not in a population that can be meaningfully monitored. While the study environment contains superficially suitable habitat, it is possible that the species would no longer be able to survive in the area due to predation pressures from two introduced predators: the Plague Minnow (*Gambusia holbrooki*) and the Yabby (*Cherax destructor*), both of which were detected at all sites. The frog community present contains at least 12 species which are likely still viable indicators of impending or current environmental change.
- The frog community of the Study Area was significantly different comparing impact and control sites. Both containing sites with low diversity and abundance of frogs, although control sites are consistently having higher abundance than impact sites.
- Frog detection rates were variable between monitoring events for most sites, most likely due to the highly variable weather and climatic conditions across the survey periods. There was a significant difference between control sites and impact sites (detection being greater at control sites), but not across monitoring years 2018-2020. This is due to the relatively small data set.
- No thresholds within the Trigger Action Response Plan (TARP) in the Biodiversity Management Plan (SIMEC 2019) have been triggered, and therefore, no remedial management actions are required.

It is recommended that annual monitoring continue in spring and autumn for riparian vegetation monitoring and in spring and autumn (or after rain deemed suitable by the ecologist) for amphibian monitoring to permit comparison between impact and control sites and allow for temporal changes to be assessed as the project progresses.

5. References

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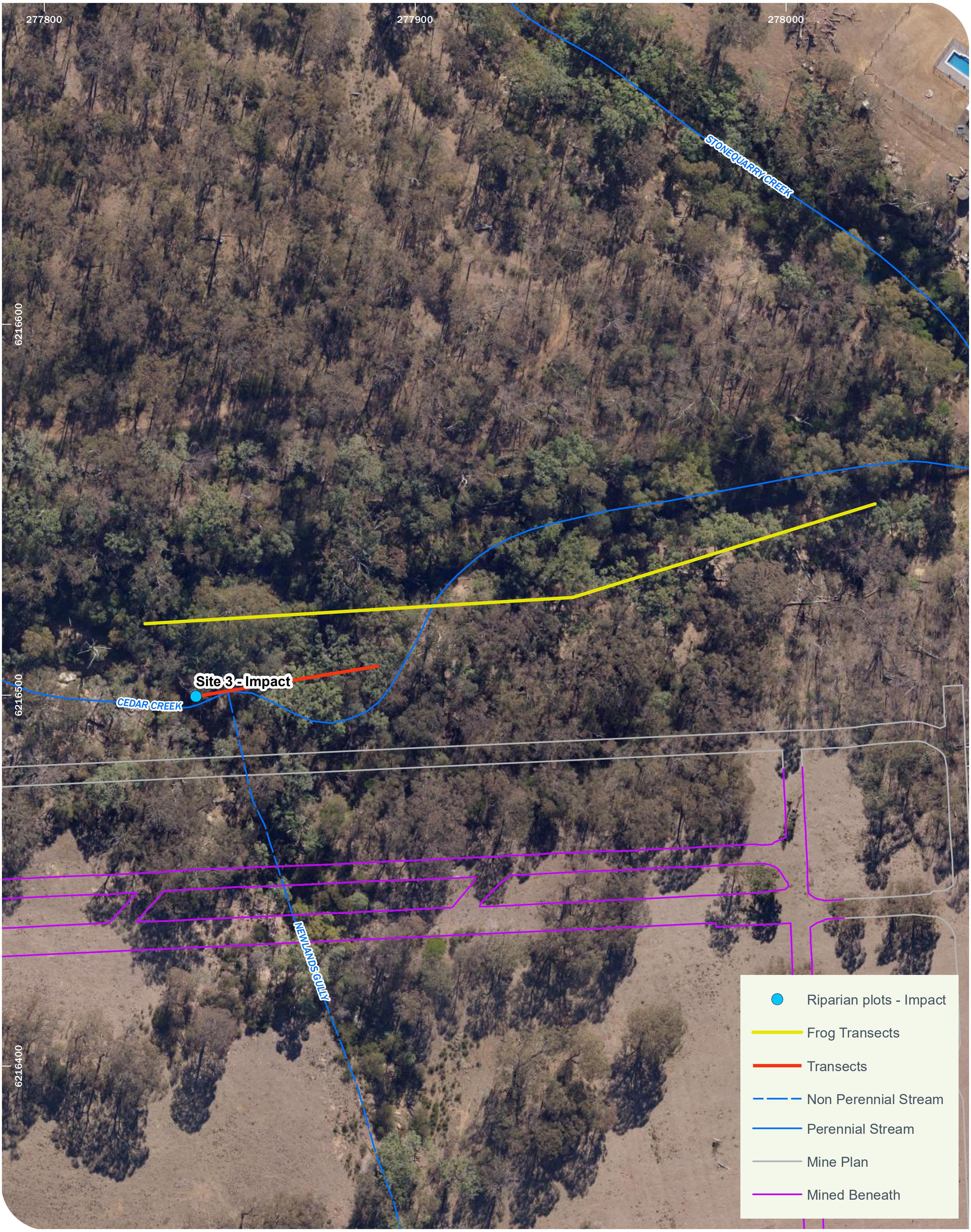
Appendix 1 - Detailed Site Maps



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Site 3 - Amphibian and riparian vegetation plot

Western Domain - Riparian and Amphibian Monitoring Report 2020

Niche PM: Alex Christie
Niche Proj. #: 5750
Client: Tahmoor Coal Pty Ltd

Appendix 1 - Map 1

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Site 4 - Amphibian and riparian vegetation plot

Western Domain - Riparian and Amphibian Monitoring Report 2020

Niche PM: Alex Christie
Niche Proj. #: 5750
Client: Tahmoor Coal Pty Ltd

Appendix 1 - Map 2

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Site 5 - Amphibian and riparian vegetation plot

Western Domain - Riparian and Amphibian Monitoring Report 2020

Niche PM: Alex Christie
Niche Proj. #: 5750
Client: Tahmoor Coal Pty Ltd

Appendix 1 - Map 3

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Site 6 - Amphibian and riparian vegetation plot

Western Domain - Riparian and Amphibian Monitoring Report 2020

Niche PM: Alex Christie
Niche Proj. #: 5750
Client: Tahmoor Coal Pty Ltd

Appendix 1 - Map 4

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Site 7 - Amphibian and riparian vegetation plot

Western Domain - Riparian and Amphibian Monitoring Report 2020

Niche PM: Alex Christie
Niche Proj. #: 5750
Client: Tahmoor Coal Pty Ltd

Appendix 1 - Map 5

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GDA 1994 MGA Zone 56

Site 8 - Amphibian and riparian vegetation plot

Western Domain - Riparian and Amphibian Monitoring Report 2020

Niche PM: Alex Christie
Niche Proj. #: 5750
Client: Tahmoor Coal Pty Ltd

Appendix 1 - Map 6

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GDA 1994 MGA Zone 56

Site 9 - Amphibian and riparian vegetation plot

Western Domain - Riparian and Amphibian Monitoring Report 2020

Niche PM: Alex Christie
Niche Proj. #: 5750
Client: Tahmoor Coal Pty Ltd

Appendix 1 - Map 7

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GDA 1994 MGA Zone 56

Site 10 - Amphibian and riparian vegetation plot

Western Domain - Riparian and Amphibian Monitoring Report 2020

Niche PM: Alex Christie
Niche Proj. #: 5750
Client: Tahmoor Coal Pty Ltd

Appendix 1 - Map 8

Appendix 2. Monitoring Site locations, vegetation plots and frog survey transect maps

Table 6. Riparian and amphibian monitoring site locations

Plot Code	Creek Name	Description	Type	Latitude	Longitude
Site 3	Cedar Creek	At Newlands Gully	Impact	-34.16882	150.58981
Site 4	Matthews Creek	In canyon just above Cedar Creek	Impact	-34.17310	150.58738
Site 5	Matthews Creek	In canyon	Impact	-34.17795	150.58656
Site 6	Cedar Creek	In canyon	Control	-34.17415	150.58180
Site 7	Cedar Creek	Above Cedar Creek Road	Control	-34.18220	150.56143
Site 8	Cedar Creek	Above Scroggies Road	Control	-34.18926	150.54626
Site 9	Stonequarry Creek	Above Mulhollands Road	Control	-34.16246	150.58566
Site 10	Stonequarry Creek	In canyon at The Vintage Estate	Control	-34.16966	150.57411

Appendix 3. Riparian vegetation monitoring results

Table 7. Floristic data – Autumn 2018

* denotes exotic species

Family	Species	Common Name	Count	03 cover	04 cover	05 cover	06 cover	07 cover	08 cover	09 cover	10 cover
Adiantaceae	*Adiantum aethiopicum*	Common Maidenhair	7	0.1	0.1	0.1	0.5	0.5	1		0.1
Adiantaceae	*Adiantum diaphanum*	Filmy Maidenhair	1		0.1						
Amaranthaceae	*Alternanthera denticulata*	Lesser Joyweed	2					0.5		0.1	
Anthericaceae	*Chlorophytum comosum**	Spider Plant	3	0.2		1					0.2
Apiaceae	*Daucus glochidiatus*	Native Carrot	1								
Apiaceae	*Hydrocotyle laxiflora*	Stinking Pennywort	5	0.5				0.2	0.4		0.2
Apiaceae	*Platysace lanceolata*	Shrubby Platysace	1		0.1						
Apocynaceae	*Parsonsia straminea*	Common Silkpod	2								0.1
Araliaceae	*Astrotricha latifolia*		3		0.2	0.1			0.5		
Asparagaceae	*Asparagus asparagoides**	Bridal Creeper	3								0.1
Aspleniaceae	*Asplenium flabellifolium*	Necklace Fern	3	0.1	0.1						0.1
Asteraceae	*Ageratina adenophora**	Crofton Weed	4	0.1		0.1			1	0.2	
Asteraceae	*Bidens pilosa**	Cobbler's Pegs	3					0.2		0.2	
Asteraceae	*Calotis dentex*	Burr-daisy	1								
Asteraceae	*Calotis spp.*	A Burr-daisy	1			0.1					
Asteraceae	*Cirsium vulgare**	Spear Thistle	3	0.1						0.1	
Asteraceae	*Conyza bonariensis**	Flaxleaf Fleabane	7	0.1	0.1	0.1		0.5		0.2	0.1

Family	Species	Common Name	Count	03 cover	04 cover	05 cover	06 cover	07 cover	08 cover	09 cover	10 cover
Asteraceae	*Delairea odorata**	Cape Ivy	1			0.1					
Asteraceae	*Gamochaeta americana**	Cudweed	1						0.1		
Asteraceae	*Hypochaeris radicata**	Catsear	2					0.1	0.1		
Asteraceae	*Olearia viscidula*	Wallaby Weed	2			0.2					0.1
Asteraceae	*Senecio madagascariensis**	Fireweed	1							0.1	
Asteraceae	*Senecio minimus*		1						0.1		
Asteraceae	*Senecio sp. 1*		1								
Asteraceae	*Senecio spp.**	Groundsel, Fireweed	4	0.1					0.2		0.1
Asteraceae	*Sigesbeckia australiensis*		1					0.1			
Asteraceae	*Sigesbeckia orientalis subsp. orientalis*	Indian Weed	1							0.7	
Asteraceae	*Sonchus oleraceus**	Common Sowthistle	1								
Asteraceae	*Tagetes minuta**	Stinking Roger	1							0.1	
Asteraceae	*Taraxacum officinale**	Dandelion	1					0.1			
Asteraceae	*Vittadinia sulcata*		1								
Bignoniaceae	*Pandorea pandorana*	Wonga Vine	2								
Blechnaceae	*Blechnum cartilagineum*	Gristle Fern	2				0.5		0.5		
Blechnaceae	*Doodia aspera*	Prickly Rasp Fern	4	0.1		0.2					0.1
Brassicaceae	*Cardamine hirsuta**	Common Bittercress	1		0.1						
Brassicaceae	*Rorippa palustris**	Yellow Cress	1								
Campanulaceae	*Wahlenbergia spp.*	Bluebell	1								0.1
Caprifoliaceae	*Lonicera japonica**	Japanese Honeysuckle	3					1	0.5		
Caryophyllaceae	*Stellaria media**	Common Chickweed	1							0.2	
Casuarinaceae	*Allocasuarina littoralis*	Black She-Oak	3		0.5	0.5			0.5		

Family	Species	Common Name	Count	03 cover	04 cover	05 cover	06 cover	07 cover	08 cover	09 cover	10 cover
Chenopodiaceae	*Einadia hastata*	Berry Saltbush	2							0.3	
Chenopodiaceae	*Einadia nutans*	Climbing Saltbush	2							0.1	
Commelinaceae	*Commelina cyanea*	Native Wandering Jew	3	0.1					0.1		0.1
Commelinaceae	*Tradescantia fluminensis**	Wandering Jew	6	0.1			0.1	0.1		0.3	
Convolvulaceae	*Dichondra repens*	Kidney Weed	4	0.1		0.1				0.1	0.1
Cunoniaceae	*Callicoma serratifolia*	Black Wattle	2		0.5				0.5		
Cunoniaceae	*Ceratopetalum apetalum*	Coachwood	2	0.5			75				
Cunoniaceae	*Ceratopetalum gummiferum*	Christmas Bush	1								0.1
Cyperaceae	*Carex inversa*	Knob Sedge	5	0.5				0.2	0.3	0.1	
Cyperaceae	*Carex spp.*		1								0.1
Cyperaceae	*Cyperus eragrostis**	Umbrella Sedge	6	0.1	0.1			0.1	0.1	0.5	
Cyperaceae	*Eleocharis sphacelata*	Tall Spike Rush	1					0.2			
Cyperaceae	*Gahnia spp.*		1								
Cyperaceae	*Lepidosperma laterale*	Variable Sword-sedge	4		0.5	0.2					0.1
Cyperaceae	*Lepidosperma spp.*		1					0.1			
Cyperaceae	*Schoenus melanostachys*		4		1	0.2			5		0.1
Dennstaedtiaceae	*Pteridium esculentum*	Bracken	2					1	3		
Dicksoniaceae	*Calochlaena dubia*	Rainbow Fern	2				0.1		3		
Dilleniaceae	*Hibbertia aspera*	Rough Guinea Flower	3			0.1		0.3	0.1		
Dilleniaceae	*Hibbertia spp.*		1					0.5			
Elaeocarpaceae	*Elaeocarpus spp.*		1								0.5
Ericaceae	*Leucopogon spp.*	A Beard-heath	1			0.2					
Ericaceae	*Lissanthe strigosa*	Peach Heath	2			0.1					0.1

Family	Species	Common Name	Count	03 cover	04 cover	05 cover	06 cover	07 cover	08 cover	09 cover	10 cover
Fabaceae (Faboideae)	*Desmodium varians*	Slender Tick-trefoil	1						0.1		
Fabaceae (Faboideae)	*Glycine tabacina*	Variable Glycine	5			0.1		0.1	0.1		0.1
Fabaceae (Faboideae)	*Gompholobium minus*	Dwarf Wedge Pea	1					0.2			
Fabaceae (Faboideae)	*Kennedia rubicunda*	Dusky Coral Pea	1					0.5			
Fabaceae (Mimosoideae)	*Acacia binervia*	Coast Myall	1		0.5						
Fabaceae (Mimosoideae)	*Acacia decurrens*	Black Wattle	1					0.3			
Fabaceae (Mimosoideae)	*Acacia linearifolia*	Narrow-leaved Wattle	1								
Fabaceae (Mimosoideae)	*Acacia linifolia*	White Wattle	2	1							0.1
Fabaceae (Mimosoideae)	*Acacia longifolia*		2					0.7	1		
Fabaceae (Mimosoideae)	*Acacia maidenii*	Maiden's Wattle	1							4	
Fabaceae (Mimosoideae)	*Acacia parramattensis*	Parramatta Wattle	1					1.8			
Geraniaceae	*Geranium solanderi*	Native Geranium	1						0.1		
Gleicheniaceae	*Sticherus flabellatus var. flabellatus*	Umbrella Fern	1				0.8				
Goodeniaceae	*Goodenia hederacea*	Ivy Goodenia	2			0.2		0.1			
Goodeniaceae	*Goodenia spp.*		2	0.1							0.3
Iridaceae	*Libertia spp.*		4		0.1	0.1					0.2
Juncaceae	*Juncus spp.*	A Rush	3		0.1					0.1	

Family	Species	Common Name	Count	03 cover	04 cover	05 cover	06 cover	07 cover	08 cover	09 cover	10 cover
Lamiaceae	*Plectranthus parviflorus*		2								0.1
Lauraceae	*Cassytha glabella*		4		2.1	0.2				3	
Lobeliaceae	*Pratia purpurascens*	Whiteroot	4		0.1			0.2	0.2		0.1
Lomandraceae	*Lomandra cylindrica*		1								
Lomandraceae	*Lomandra filiformis*	Wattle Matt-rush	1					0.1			
Lomandraceae	*Lomandra longifolia*	Spiny-headed Mat-rush	10	0.3	30	10	0.2	30	2	0.4	2
Luzuriagaceae	*Geitonoplesium cymosum*	Scrambling Lily	3	0.5							0.1
Malvaceae	*Modiola caroliniana**	Red-flowered Mallow	1							0.1	
Malvaceae	*Sida rhombifolia**	Paddy's Lucerne	3	0.1						0.5	
Meliaceae	*Melia azedarach*	White Cedar	1						0.1		
Menispermaceae	*Stephania japonica var. discolor*	Snake Vine	1						0.1		
Myrsinaceae	*Anagallis arvensis**	Scarlet Pimpernel	1	0.1							
Myrsinaceae	*Rapanea variabilis*	Muttonwood	3			0.1					0.1
Myrtaceae	*Angophora floribunda*	Rough-barked Apple	2					3		20	
Myrtaceae	*Backhousia myrtifolia*	Grey Myrtle	6		10	35	1				40
Myrtaceae	*Callistemon salignus*	Willow Bottlebrush	1					1.5			
Myrtaceae	*Eucalyptus crebra*	Narrow-leaved Ironbark	1			3					
Myrtaceae	*Eucalyptus deanei*	Mountain Blue Gum	2						5		25
Myrtaceae	*Eucalyptus elata*	River Peppermint	1	35							
Myrtaceae	*Eucalyptus piperita*	Sydney Peppermint	2					15	25		
Myrtaceae	*Eucalyptus punctata*	Grey Gum	2					15			
Myrtaceae	*Eucalyptus tereticornis*	Forest Red Gum	2							20	
Myrtaceae	*Leptospermum polygalifolium*	Tantoon	1								0.1

Family	Species	Common Name	Count	03 cover	04 cover	05 cover	06 cover	07 cover	08 cover	09 cover	10 cover
Myrtaceae	*Melaleuca linariifolia*	Flax-leaved Paperbark	5	2	1			0.8	0.2		2
Myrtaceae	*Tristaniopsis laurina*	Kanooka	5	25	30	15	3				5
Oleaceae	*Ligustrum lucidum**	Large-leaved Privet	2							3	
Oleaceae	*Ligustrum sinense**	Small-leaved Privet	4	0.5		0.7		0.5		20	
Oleaceae	*Notelaea longifolia*	Large Mock-olive	6	0.1	0.2	0.2	3	2			
Oleaceae	*Olea europaea**	Common Olive	1	0.1							
Orchidaceae	*Plectorrhiza tridentata*	Tangle Orchid	1								0.1
Osmundaceae	*Todea barbara*	King Fern	3	0.2			0.4				0.1
Oxalidaceae	*Oxalis perennans*		1							0.1	
Oxalidaceae	*Oxalis spp.*		1						0.1		
Phormiaceae	*Dianella caerulea var. producta*		5	0.1				0.4	5		0.1
Phormiaceae	*Stypandra glauca*	Nodding Blue Lily	1								
Phyllanthaceae	*Breynia oblongifolia*	Coffee Bush	3						0.2		0.1
Phyllanthaceae	*Phyllanthus gunnii*		2					0.8	0.5		
Phytolaccaceae	*Phytolacca octandra**	Inkweed	1							0.5	
Pittosporaceae	*Billardiera scandens*	Hairy Apple Berry	2						0.1		0.1
Pittosporaceae	*Bursaria spinosa*	Native Blackthorn	7	0.1	0.2	0.2		0.5			0.3
Pittosporaceae	*Pittosporum revolutum*	Rough Fruit Pittosporum	3	0.1			0.1				0.1
Pittosporaceae	*Pittosporum undulatum*	Sweet Pittosporum	3					1.5	0.5		0.1
Plantaginaceae	*Veronica spp.**		2			0.1					0.2
Poaceae	*Bouteloua dactyloides**	Buffalo Grass	1						0.1		
Poaceae	*Cynodon dactylon*	Common Couch	3		0.1						0.5
Poaceae	*Echinopogon caespitosus*	Bushy Hedgehog-grass	1								0.1

Family	Species	Common Name	Count	03 cover	04 cover	05 cover	06 cover	07 cover	08 cover	09 cover	10 cover
Poaceae	*Echinopogon ovatus*	Forest Hedgehog Grass	1					0.5			
Poaceae	*Ehrharta erecta**	Panic Veldtgrass	6			0.1		0.5	0.5	5	0.5
Poaceae	*Entolasia marginata*	Bordered Panic	7	0.5	0.1			0.2	0.2	0.1	1
Poaceae	*Entolasia stricta*	Wiry Panic	9	2	0.1	0.1	0.1	1	5	0.3	5
Poaceae	*Imperata cylindrica*	Blady Grass	2					0.5	0.2		
Poaceae	*Microlaena stipoides*	Weeping Grass	7	0.5	0.1	0.3		20	5	1	3
Poaceae	*Oplismenus aemulus*		7	0.1	0.1	0.1		0.5	0.5	0.2	0.1
Poaceae	*Paspalum dilatatum**	Paspalum	2					0.1	0.1		
Poaceae	*Pennisetum clandestinum**	Kikuyu Grass	1								
Poaceae	*Setaria spp.**		1								
Polygonaceae	*Acetosa sagittata**	Rambling Dock	1		0.1						
Polygonaceae	*Persicaria decipiens*	Slender Knotweed	7	0.1	0.1			1	0.2	0.2	0.1
Polypodiaceae	*Pyrrosia rupestris*	Rock Felt Fern	2								0.1
Potamogetonaceae	*Potamogeton crispus*	Curly Pondweed	1					0.1			
Primulaceae	*Samolus valerandi*	Common Brookweed	2	0.2							
Proteaceae	*Lomatia myricoides*	River Lomatia	2				2				0.8
Proteaceae	*Stenocarpus salignus*	Scrub Beefwood	4		0.2	0.5	0.2				0.5
Ranunculaceae	*Clematis aristata*	Old Man's Beard	3	0.1				0.1			
Ranunculaceae	*Ranunculus repens**	Creeping Buttercup	1								
Rosaceae	*Rubus fruticosus**	Blackberry complex	2					0.5	0.1		
Rosaceae	*Rubus parvifolius*	Native Raspberry	1					0.1			
Rubiaceae	*Morinda jasminoides*	Sweet Morinda	5	0.5		0.5	2				0.5
Rubiaceae	*Opercularia aspera*	Coarse Stinkweed	4			0.1		0.5	1		0.2
Rutaceae	*Zieria smithii*	Sandfly Zieria	3		0.1						0.1
Sapindaceae	*Dodonaea triquetra*	Large-leaf Hop-bush	2					0.3	0.1		

Family	Species	Common Name	Count	03 cover	04 cover	05 cover	06 cover	07 cover	08 cover	09 cover	10 cover
Scrophulariaceae	*Verbascum virgatum**	Twiggy Mullein	1						0.1		
Smilacaceae	*Smilax glyciphylla*	Sweet Sarsparilla	1				0.1				
Solanaceae	*Lycium ferocissimum**	African Boxthorn	1								
Solanaceae	*Solanum capsicoides**	Devil's Apple	1								0.2
Solanaceae	*Solanum nigrum**	Black-berry Nightshade	1					0.1			
Solanaceae	*Solanum prinophyllum*	Forest Nightshade	5	0.2				0.1		0.1	
Solanaceae	*Solanum pseudocapsicum**	Madeira Winter Cherry	2							0.5	
Sterculiaceae	*Lasiopetalum ferrugineum*		1					0.1			
Thymelaeaceae	*Pimelea linifolia*	Slender Rice Flower	1					0.1			
Urticaceae	*Urtica spp.**		1							1	
Verbenaceae	*Lantana camara**	Lantana	3							5	0.2
Verbenaceae	*Verbena bonariensis**	Purpletop	2					0.1		0.1	
Violaceae	*Viola hederacea*	Ivy-leaved Violet	5	8			0.2	0.1	0.2		2

Table 8. Autumn 2019 BAM, structure and function data

Treatment Site	Date	Time	Vegetation type	Vegetation condition	Bearing	Number of large trees	Tree stem class size	Number of hollow trees	Fallen logs	Mean litter
Impact 03	19/04/2018	12:41	Water gum peppermint gully	Good	93	4	<5,5-9,10-19,20-29,50-79,80+	2	43	70
Impact 04	13/04/2018	11:18	Backhousia gully rainforest	Good	185	0	<5,5-9,10-19,20-29	0	11	40
Impact 05	13/04/2018	9:30	Backhousia gully rainforest	Good	185	1	<5,5-9,10-19,20-29,50-79	1	32	48
Control 06	19/04/2018	11:16	Coachwood rainforest gully	Good	270	2	<5,5-9,10-19,20-29,30-49,50-79	3	42	72
Control 07	20/04/2018	10:08	Peppermint gully forest	Moderate	250	4	<5,5-9,10-19,20-29,50-79,80+	2	25	68
Control 08	20/04/2018	8:37	Peppermint gully forest	Moderate	240	3	<5,5-9,20-29,30-49,50-79,80+	2	42	70
Control 09	20/04/2018	11:57	River-flat eucalypt forest	Degraded	252	1	<5,5-9,10-19,30-49,50-79	2	46	62
Control 10	13/04/2018	13:33	Backhousia gully rainforest	Good	197	2	<5,5-9,10-19,20-29,50-79,80+	2	17	74

Table 9. Floristic data - Autumn 2019

* denotes exotic species

Family	Species	Common Name	Count	03 cover	04 cover	05 cover	06 cover	07 cover	08 cover	09 cover	10 cover
Acanthaceae	*Brunoniella australis*	Blue Trumpet	3		0.1	0.1					
Adiantaceae	*Adiantum aethiopicum*	Common Maidenhair	8	0.3	0.5	0.5	0.2	20	2		0.2
Adiantaceae	*Adiantum hispidulum*	Rough Maidenhair	1	0.1							
Adiantaceae	*Cheilanthes sieberi*	Rock Fern	2		0.1					0.1	
Adiantaceae	*Pellaea falcata*	Sickle Fern	2								0.1
Amaranthaceae	*Alternanthera spp.*	Joyweed	3	0.1				0.4		0.1	
Anthericaceae	*Arthropodium milleflorum*	Pale Vanilla-lily	3		0.1						0.1
Anthericaceae	*Chlorophytum comosum**	Spider Plant	4	0.3	0.2	1					0.2
Apiaceae	*Centella asiatica*	Indian Pennywort	2	0.1							0.3
Apiaceae	*Hydrocotyle laxiflora*	Stinking Pennywort	4	0.2				0.1	0.1		0.1
Apiaceae	*Platysace lanceolata*	Shrubby Platysace	1		0.1						
Apocynaceae	*Gomphocarpus fruticosus**	Narrow-leaved Cotton Bush	1							0.1	
Apocynaceae	*Melodinus australis*	Southern Melodinus	1				0.2				
Apocynaceae	*Parsonsia straminea*	Common Silkpod	2								0.2
Asparagaceae	*Asparagus asparagoides**	Bridal Creeper	2								
Aspleniaceae	*Asplenium spp.*		1		0.1						
Asteraceae	*Ageratina adenophora**	Crofton Weed	5	0.1	0.1	0.1			0.5	0.1	
Asteraceae	*Bidens pilosa**	Cobbler's Pegs	4					0.1		10	0.1
Asteraceae	*Calotis dentex*	Burr-daisy	4	0.1		0.1					
Asteraceae	*Cirsium vulgare**	Spear Thistle	2						0.1	0.1	
Asteraceae	*Conyza bonariensis**	Flaxleaf Fleabane	5	0.1		0.1		0.1	0.1	0.3	
Asteraceae	*Delairea odorata**	Cape Ivy	1			0.1					
Asteraceae	*Epaltes australis*	Spreading Nut-heads	1	0.1							

Family	Species	Common Name	Count	03 cover	04 cover	05 cover	06 cover	07 cover	08 cover	09 cover	10 cover
Asteraceae	*Euryops chrysanthemoides**		2					0.1			
Asteraceae	*Hypochaeris radicata**	Catsear	2	0.1				0.1			
Asteraceae	*Hypochoeris radicata**	Catsear	1						0.1		
Asteraceae	*Lagenifera stipitata*	Blue Bottle-daisy	1								0.1
Asteraceae	*Lagenophora stipitata*	Common Lagenophora	1		0.1						
Asteraceae	*Olearia viscidula*	Wallaby Weed	3			0.1		0.1			0.1
Asteraceae	*Senecio madagascariensis**	Fireweed	4	0.1					0.1	0.1	
Asteraceae	*Senecio sp. 1*		1						0.1		
Asteraceae	*Senecio spp.**	Groundsel, Fireweed	4		0.1				0.1		
Asteraceae	*Sigesbeckia australiensis*		5					0.1	0.2	20	
Asteraceae	*Sonchus oleraceus**	Common Sowthistle	2					0.1		0.1	
Asteraceae	*Tagetes minuta**	Stinking Roger	1							1	
Bignoniaceae	*Pandorea pandorana*	Wonga Vine	2								
Blechnaceae	*Blechnum cartilagineum*	Gristle Fern	2				0.5		5		
Blechnaceae	*Doodia aspera*	Prickly Rasp Fern	4	0.1		1					0.2
Brassicaceae	*Cardamine hirsuta**	Common Bittercress	1			0.1					
Brassicaceae	*Rorippa palustris**	Yellow Cress	1								
Campanulaceae	*Wahlenbergia spp.*	Bluebell	2					0.1	0.1		
Caprifoliaceae	*Lonicera japonica**	Japanese Honeysuckle	3					1	2		
Caryophyllaceae	*Stellaria media**	Common Chickweed	1							0.1	
Casuarinaceae	*Allocasuarina littoralis*	Black She-Oak	3		0.3	0.5			0.5		
Chenopodiaceae	*Einadia hastata*	Berry Saltbush	2							0.5	
Chenopodiaceae	*Einadia nutans*	Climbing Saltbush	2							0.2	
Chenopodiaceae	*Einadia trigonos*	Fishweed	1								
Commelinaceae	*Commelina cyanea*	Native Wandering Jew	1	0.1							

Family	Species	Common Name	Count	03 cover	04 cover	05 cover	06 cover	07 cover	08 cover	09 cover	10 cover
Commelinaceae	*Tradescantia fluminensis**	Wandering Jew	7			0.1	0.2	0.2		5	0.1
Convolvulaceae	*Dichondra repens*	Kidney Weed	4		0.1					0.1	0.1
Cunoniaceae	*Callicoma serratifolia*	Black Wattle	2		0.3				0.5		
Cunoniaceae	*Ceratopetalum apetalum*	Coachwood	2	1			40				
Cyperaceae	*Carex inversa*	Knob Sedge	5		0.1	0.1			0.1	0.1	0.1
Cyperaceae	*Cyperus eragrostis**	Umbrella Sedge	5	0.1		0.1		0.2		0.2	0.1
Cyperaceae	*Cyperus spp.*		1								
Cyperaceae	*Lepidosperma laterale*	Variable Sword-sedge	3		0.1	0.3					
Cyperaceae	*Lepidosperma spp.*		1								0.1
Cyperaceae	*Schoenus melanostachys*		3		0.2	0.2			3		
Dennstaedtiaceae	*Pteridium esculentum*	Bracken	3	0.1				20	40		
Dicksoniaceae	*Calochlaena dubia*	Rainbow Fern	2				0.2		5		
Dilleniaceae	*Hibbertia aspera*	Rough Guinea Flower	1			0.1					
Dilleniaceae	*Hibbertia diffusa*	Wedge Guinea Flower	1					0.1			
Ericaceae	*Acrotriche divaricata*		1		0.1						
Ericaceae	*Astroloma humifusum*	Native Cranberry	2			0.1					
Ericaceae	*Lissanthe strigosa*	Peach Heath	3			0.1					0.1
Fabaceae (Faboideae)	*Desmodium rhytidophyllum*		1	0.1							
Fabaceae (Faboideae)	*Glycine tabacina*	Variable Glycine	6					0.1	0.2	0.1	0.1
Fabaceae (Faboideae)	*Kennedia rubicunda*	Dusky Coral Pea	1					0.1			
Fabaceae (Faboideae)	*Trifolium repens**	White Clover	1								0.1

Family	Species	Common Name	Count	03 cover	04 cover	05 cover	06 cover	07 cover	08 cover	09 cover	10 cover
Fabaceae (Mimosoideae)	*Acacia binervia*	Coast Myall	1		1						
Fabaceae (Mimosoideae)	*Acacia floribunda*	White Sally	1					0.5			
Fabaceae (Mimosoideae)	*Acacia linearifolia*	Narrow-leaved Wattle	1								
Fabaceae (Mimosoideae)	*Acacia linifolia*	White Wattle	2	0.1							0.5
Fabaceae (Mimosoideae)	*Acacia longifolia*		1						1		
Fabaceae (Mimosoideae)	*Acacia maidenii*	Maiden's Wattle	1							0.1	
Fabaceae (Mimosoideae)	*Acacia mearnsii*	Black Wattle	1								
Fabaceae (Mimosoideae)	*Acacia parramattensis*	Parramatta Wattle	1					2			
Fabaceae (Mimosoideae)	*Acacia spp.*	Wattle	2							0.1	
Geraniaceae	*Geranium solanderi*	Native Geranium	2						0.1	0.1	
Gleicheniaceae	*Sticherus flabellatus var. flabellatus*	Umbrella Fern	1				0.2				
Haloragaceae	*Gonocarpus tetragynus*	Poverty Raspwort	1						0.1		
Juncaceae	*Juncus spp.*	A Rush	4						0.2	0.1	0.1
Lamiaceae	*Plectranthus parviflorus*		5		0.1	0.1					0.3
Lauraceae	*Cassytha glabella*		1							0.5	
Lindsaeaceae	*Lindsaea linearis*	Screw Fern	3		0.1						0.1
Lobeliaceae	*Pratia purpurascens*	Whiteroot	6		0.1	0.2		0.2	0.1		0.1
Lomandraceae	*Lomandra filiformis*	Wattle Matt-rush	2								
Lomandraceae	*Lomandra longifolia*	Spiny-headed Mat-rush	10	0.2	8	30	0.3	30	10	0.2	2

Family	Species	Common Name	Count	03 cover	04 cover	05 cover	06 cover	07 cover	08 cover	09 cover	10 cover
Luzuriagaceae	*Geitonoplesium cymosum*	Scrambling Lily	3	0.2							0.1
Malvaceae	*Modiola caroliniana**	Red-flowered Mallow	2						0.1	0.1	
Malvaceae	*Sida rhombifolia**	Paddy's Lucerne	3	0.1				0.1			
Meliaceae	*Melia azedarach*	White Cedar	1						0.2		
Myrsinaceae	*Rapanea variabilis*	Muttonwood	2				0.1				0.1
Myrtaceae	*Angophora floribunda*	Rough-barked Apple	1							5	
Myrtaceae	*Backhousia myrtifolia*	Grey Myrtle	5	0.2	1	10					30
Myrtaceae	*Callistemon viminalis*	Weeping Bottlebrush	1					0.5			
Myrtaceae	*Eucalyptus crebra*	Narrow-leaved Ironbark	1			1					
Myrtaceae	*Eucalyptus deanei*	Mountain Blue Gum	2						20		20
Myrtaceae	*Eucalyptus elata*	River Peppermint	1	20							
Myrtaceae	*Eucalyptus globoidea*	White Stringybark	1					10			
Myrtaceae	*Eucalyptus piperita*	Sydney Peppermint	2					20	20		
Myrtaceae	*Eucalyptus punctata*	Grey Gum	2					5			
Myrtaceae	*Eucalyptus tereticornis*	Forest Red Gum	2							5	
Myrtaceae	*Melaleuca linariifolia*	Flax-leaved Paperbark	5	1	0.2			0.2	0.3		1
Myrtaceae	*Tristaniopsis laurina*	Kanooka	5	20	30	30	15				1
Oleaceae	*Ligustrum lucidum**	Large-leaved Privet	2							15	
Oleaceae	*Ligustrum sinense**	Small-leaved Privet	6	0.3		1	0.1	1		15	
Oleaceae	*Notelaea longifolia*	Large Mock-olive	7	0.1	0.1	0.5	0.1	1			0.1
Oleaceae	*Olea europaea**	Common Olive	1								0.1
Orchidaceae	*Acianthus exsertus*	Mosquito Orchid	1								
Orchidaceae	*Pterostylis spp.*	Greenhood	2			0.2					
Osmundaceae	*Todea barbara*	King Fern	3	0.2			1				0.1
Oxalidaceae	*Oxalis perennans*		7		0.1			0.1	0.1	0.1	0.1

Family	Species	Common Name	Count	03 cover	04 cover	05 cover	06 cover	07 cover	08 cover	09 cover	10 cover
Phormiaceae	*Dianella caerulea var. producta*		5	0.1				0.5	0.5		0.1
Phyllanthaceae	*Breynia oblongifolia*	Coffee Bush	2								
Phyllanthaceae	*Phyllanthus gunnii*		2					0.2	0.5		
Phytolaccaceae	*Phytolacca octandra**	Inkweed	1								
Pittosporaceae	*Billardiera scandens*	Hairy Apple Berry	1						0.1		
Pittosporaceae	*Bursaria spinosa*	Native Blackthorn	7	0.1	0.2	0.2		0.3			0.2
Pittosporaceae	*Pittosporum revolutum*	Rough Fruit Pittosporum	3	0.1			0.1				0.2
Pittosporaceae	*Pittosporum undulatum*	Sweet Pittosporum	2					0.5	0.2		
Plantaginaceae	*Plantago lanceolata**	Lamb's Tongues	2						0.1	0.1	
Plantaginaceae	*Veronica plebeia*	Trailing Speedwell	4		0.1	0.1			0.1		0.1
Poaceae	*Cynodon dactylon*	Common Couch	1								
Poaceae	*Echinopogon caespitosus*	Bushy Hedgehog-grass	3					0.5	0.5		
Poaceae	*Ehrharta erecta**	Panic Veldtgrass	7		0.1	0.1		0.2		10	0.1
Poaceae	*Entolasia marginata*	Bordered Panic	7	0.1	0.1		0.1	0.3	0.2		0.2
Poaceae	*Entolasia stricta*	Wiry Panic	6	0.5		0.3	0.1			0.2	0.2
Poaceae	*Imperata cylindrica*	Blady Grass	2					0.2	0.3		
Poaceae	*Microlaena stipoides*	Weeping Grass	10	0.1	0.1	0.5	0.1	10	30	2	1
Poaceae	*Oplismenus aemulus*		8	0.1		0.5		0.2	5	5	0.1
Poaceae	*Rytidosperma spp.*		1								
Poaceae	*Setaria gracilis**	Slender Pigeon Grass	2							0.1	
Poaceae	*Stenotaphrum secundatum**	Buffalo Grass	1						0.2		
Polygonaceae	*Acetosa sagittata**	Rambling Dock	1								
Polygonaceae	*Acetosella vulgaris**	Sheep Sorrel	2		0.1				0.1		
Polygonaceae	*Persicaria decipiens*	Slender Knotweed	7	0.1	0.1			0.3	0.2	0.1	0.1
Polygonaceae	*Rumex brownii*	Swamp Dock	1							0.1	

Family	Species	Common Name	Count	03 cover	04 cover	05 cover	06 cover	07 cover	08 cover	09 cover	10 cover
Polygonaceae	*Rumex crispus**	Curled Dock	2							0.1	
Polypodiaceae	*Pyrrosia rupestris*	Rock Felt Fern	2								0.3
Primulaceae	*Samolus valerandi*	Common Brookweed	1	0.1							
Proteaceae	*Lomatia myricoides*	River Lomatia	1				0.1				
Proteaceae	*Stenocarpus salignus*	Scrub Beefwood	4		0.2	0.2	0.1				0.5
Ranunculaceae	*Clematis aristata*	Old Man's Beard	5	0.1		0.1		0.2			
Rosaceae	*Rubus fruticosus**	Blackberry complex	2					0.2	0.1		
Rubiaceae	*Galium aparine**	Goosegrass	1								
Rubiaceae	*Galium binifolium*		5	0.1	0.1	0.1			0.1		0.1
Rubiaceae	*Morinda canthoides*	Veiny Morinda	1								0.5
Rubiaceae	*Morinda jasminoides*	Sweet Morinda	4	0.2		0.2	1				
Rubiaceae	*Opercularia diphylla*	Stinkweed	1						0.3		
Rubiaceae	*Opercularia hispida*	Hairy Stinkweed	1								0.2
Rubiaceae	*Opercularia spp.*		1					0.2			
Rutaceae	*Zieria smithii*	Sandfly Zieria	5		0.1	0.1			0.1		0.2
Sapindaceae	*Dodonaea triquetra*	Large-leaf Hop-bush	2					0.1	0.2		
Smilacaceae	*Smilax glyciphylla*	Sweet Sarsparilla	1				0.1				
Solanaceae	*Datura ferox**	Fierce Thornapple	1							0.1	
Solanaceae	*Lycium ferocissimum**	African Boxthorn	1								
Solanaceae	*Solanum mauritianum**	Wild Tobacco Bush	1						0.1		
Solanaceae	*Solanum nigrum**	Black-berry Nightshade	3					0.1		0.1	
Solanaceae	*Solanum prinophyllum*	Forest Nightshade	9	0.1	0.1	0.2		0.1	0.1	0.2	0.1
Solanaceae	*Solanum pseudocapsicum**	Madeira Winter Cherry	2							0.2	0.1
Sterculiaceae	*Lasiopetalum ferrugineum*		1					0.1			
Sterculiaceae	*Lasiopetalum spp.*		2						1		0.1

Family	Species	Common Name	Count	03 cover	04 cover	05 cover	06 cover	07 cover	08 cover	09 cover	10 cover
Thymelaeaceae	*Pimelea linifolia*	Slender Rice Flower	1					0.1			
Ulmaceae	*Trema tomentosa*		1						0.1		
Urticaceae	*Urtica incisa*	Stinging Nettle	1							0.2	
Verbenaceae	*Lantana camara**	Lantana	3							10	0.2
Verbenaceae	*Verbena bonariensis**	Purpletop	2					0.1		0.1	
Violaceae	*Viola hederacea*	Ivy-leaved Violet	4	0.1			0.1	0.1	0.1		

Table 10. Autumn 2019 BAM, structure and function data

Treatment Site	Date	Time	Vegetation type	Vegetation condition	Bearing	Number of large trees	Tree stem class size	Number of hollow trees	Fallen logs	Mean litter
Impact 03	09/05/2019	11:29	Water gum peppermint gully	Good	90	5	<5,5-9,10-19,20-29,50-79,80+	5	33	61.6
Impact 04	09/05/2019	9:10	Backhousia gully rainforest	Good	190	0	<5,5-9,10-19,20-29	0	24	15
Impact 05	09/05/2019	12:47	Backhousia gully rainforest	Good	185	2	<5,5-9,10-19,20-29,30-49,80+	1	22	54
Control 06	09/05/2019	10:08	Coachwood rainforest gully	Good	270	2	<5,5-9,10-19,20-29,30-49,80+	3	16	36
Control 07	09/05/2019	14:18	Peppermint gully forest	Moderate	250	2	<5,5-9,10-19,20-29,30-49,80+	2	13	48
Control 08	09/05/2019	15:02	Peppermint gully forest	Moderate	240	2	<5,5-9,10-19,20-29,30-49,80+	2	52	29
Control 09	08/05/2019	13:54	River-flat eucalypt forest	Degraded	245	5	<5,5-9,10-19,20-29,30-49,80+	2	36	32.8
Control 10	08/05/2019	11:50	Backhousia gully rainforest	Good	180	2	<5,5-9,10-19,20-29,30-49,80+	1	20	64

Table 11. Floristic data – Autumn 2020

* denotes exotic species

Family	Species	Common Name	Count	03 cover	04 cover	05 cover	06 cover	07 cover	08 cover	09 cover	10 cover
Acanthaceae	*Pseuderanthemum variabile*	Pastel Flower	5	0.1		0.5		0.1			0.1
Adiantaceae	*Adiantum aethiopicum*	Common Maidenhair	8	0.5	1	5	0.2	10	1		0.5
Adiantaceae	*Cheilanthes sieberi*	Rock Fern	2		0.1						
Adiantaceae	*Pellaea falcata*	Sickle Fern	1			0.1					
Amaranthaceae	*Alternanthera denticulata*	Lesser Joyweed	2					0.5			0.1
Anthericaceae	*Arthropodium milleflorum*	Pale Vanilla-lily	4		0.2	0.1					0.2
Apiaceae	*Hydrocotyle laxiflora*	Stinking Pennywort	5	0.1	0.1			0.5	0.1		
Apocynaceae	*Parsonsia straminea*	Common Silkpod	3				0.1				0.1
Araliaceae	*Astrotricha latifolia*		2			0.1			0.1		
Asteraceae	*Calotis dentex*	Burr-daisy	4			0.1					0.1
Asteraceae	*Cotula australis*	Common Cotula	2			0.1				0.1	
Asteraceae	*Lagenophora stipitata*	Common Lagenophora	1		0.1						
Asteraceae	*Sigesbeckia australiensis*		7			0.1		2	1	20	0.1
Bignoniaceae	*Pandorea pandorana*	Wonga Vine	2								
Blechnaceae	*Blechnum cartilagineum*	Gristle Fern	1				5				
Blechnaceae	*Doodia aspera*	Prickly Rasp Fern	3			1					0.5
Campanulaceae	*Wahlenbergia spp.*	Bluebell	3			0.1		0.1	0.1		
Casuarinaceae	*Allocasuarina littoralis*	Black She-Oak	2		2	1					
Chenopodiaceae	*Chenopodium pumilio*	Small Crumbweed	2							0.1	
Chenopodiaceae	*Einadia hastata*	Berry Saltbush	2							0.5	

Family	Species	Common Name	Count	03 cover	04 cover	05 cover	06 cover	07 cover	08 cover	09 cover	10 cover
Chenopodiaceae	*Einadia nutans*	Climbing Saltbush	2							0.2	
Chenopodiaceae	*Einadia trigonos*	Fishweed	1								
Commelinaceae	*Commelina cyanea*	Native Wandering Jew	7	0.1	0.2	0.2		0.1	0.2	0.5	0.2
Convolvulaceae	*Dichondra repens*	Kidney Weed	4			0.1					0.1
Cunoniaceae	*Callicoma serratifolia*	Black Wattle	2		0.2				0.1		
Cunoniaceae	*Ceratopetalum apetalum*	Coachwood	2	0.5			50				
Cyperaceae	*Carex inversa*	Knob Sedge	3	0.5							0.1
Cyperaceae	*Carex spp.*		1						0.1		
Cyperaceae	*Cyperus spp.*		1								
Cyperaceae	*Lepidosperma laterale*	Variable Sword-sedge	3			0.1			0.1		
Cyperaceae	*Schoenus melanostachys*		1						5		
Dennstaedtiaceae	*Pteridium esculentum*	Bracken	2					1	60		
Dicksoniaceae	*Calochlaena dubia*	Rainbow Fern	4	0.1			0.2		1		0.1
Dilleniaceae	*Hibbertia scandens*	Climbing Guinea Flower	1					0.1			
Ericaceae	*Astroloma humifusum*	Native Cranberry	2			0.2					
Ericaceae	*Leucopogon spp.*	A Beard-heath	1		0.1						
Ericaceae	*Lissanthe strigosa*	Peach Heath	1								0.1
Fabaceae (Faboideae)	*Desmodium brachypodum*	Large Tick-trefoil	1	0.1							
Fabaceae (Faboideae)	*Glycine clandestina*	Twining glycine	2						0.1		
Fabaceae (Faboideae)	*Glycine tabacina*	Variable Glycine	8	0.1	0.1	0.1		0.5	0.5	0.1	0.1
Fabaceae (Faboideae)	*Kennedia rubicunda*	Dusky Coral Pea	3			0.1		0.2			

Family	Species	Common Name	Count	03 cover	04 cover	05 cover	06 cover	07 cover	08 cover	09 cover	10 cover
Fabaceae (Mimosoideae)	*Acacia binervia*	Coast Myall	1		2						
Fabaceae (Mimosoideae)	*Acacia decurrens*	Black Wattle	1					1			
Fabaceae (Mimosoideae)	*Acacia linifolia*	White Wattle	3	0.1							0.2
Fabaceae (Mimosoideae)	*Acacia longifolia*		1						0.5		
Fabaceae (Mimosoideae)	*Acacia spp.*	Wattle	4		0.1	0.1			0.1		
Geraniaceae	*Geranium solanderi*	Native Geranium	5			0.1		0.2	0.1	0.1	0.1
Gleicheniaceae	*Sticherus flabellatus var. flabellatus*	Umbrella Fern	1				0.1				
Haloragaceae	*Gonocarpus longifolius*		1		0.1						
Juncaceae	*Juncus spp.*	A Rush	5		0.5	1			0.5	0.1	
Lamiaceae	*Plectranthus parviflorus*		4		0.1	0.1					0.1
Lindsaeaceae	*Lindsaea linearis*	Screw Fern	3		0.1						0.1
Lobeliaceae	*Pratia purpurascens*	Whiteroot	7	0.1	0.1	0.1		0.5	0.1		0.1
Lomandraceae	*Lomandra filiformis*	Wattle Matt-rush	3					0.1			
Lomandraceae	*Lomandra longifolia*	Spiny-headed Mat-rush	10	0.5	15	15	0.2	20	0.1	0.5	15
Luzuriagaceae	*Eustrephus latifolius*	Wombat Berry	1								
Luzuriagaceae	*Geitonoplesium cymosum*	Scrambling Lily	3	0.5							0.1
Meliaceae	*Melia azedarach*	White Cedar	1						0.1		
Myrsinaceae	*Rapanea variabilis*	Muttonwood	2			0.1					
Myrtaceae	*Angophora floribunda*	Rough-barked Apple	2					5		5	
Myrtaceae	*Backhousia myrtifolia*	Grey Myrtle	7	1	10	50	2				40
Myrtaceae	*Callistemon viminalis*	Weeping Bottlebrush	1					0.5			
Myrtaceae	*Eucalyptus crebra*	Narrow-leaved Ironbark	1			2					

Family	Species	Common Name	Count	03 cover	04 cover	05 cover	06 cover	07 cover	08 cover	09 cover	10 cover
Myrtaceae	*Eucalyptus deanei*	Mountain Blue Gum	2						10		15
Myrtaceae	*Eucalyptus elata*	River Peppermint	1	25							
Myrtaceae	*Eucalyptus piperita*	Sydney Peppermint	2					10	10		
Myrtaceae	*Eucalyptus punctata*	Grey Gum	2					20			
Myrtaceae	*Eucalyptus tereticornis*	Forest Red Gum	2							5	
Myrtaceae	*Melaleuca linariifolia*	Flax-leaved Paperbark	3	3				1			5
Myrtaceae	*Tristaniopsis laurina*	Kanooka	5	40	10	5	15				5
Oleaceae	*Notelaea longifolia*	Large Mock-olive	4			0.1	1	3			
Orchidaceae	*Acianthus exsertus*	Mosquito Orchid	1								
Orchidaceae	*Pterostylis spp.*	Greenhood	1								
Osmundaceae	*Todea barbara*	King Fern	3	0.2			1		0.5		
Oxalidaceae	*Oxalis perennans*		6			0.1		0.2	0.1	0.1	0.1
Phormiaceae	*Dianella caerulea var. producta*		6	0.1		0.1		0.2	0.2		0.2
Phyllanthaceae	*Breynia oblongifolia*	Coffee Bush	4	0.1	0.1				0.1		
Phyllanthaceae	*Phyllanthus gunnii*		2					1	0.5		
Pittosporaceae	*Bursaria spinosa*	Native Blackthorn	6		0.1	0.1		0.5			0.5
Pittosporaceae	*Pittosporum undulatum*	Sweet Pittosporum	3					2	0.1		0.5
Plantaginaceae	*Veronica plebeia*	Trailing Speedwell	1						0.1		
Poaceae	*Cynodon dactylon*	Common Couch	1								
Poaceae	*Digitaria parviflora*	Small-flowered Finger Grass	1						0.1		
Poaceae	*Echinopogon caespitosus*	Bushy Hedgehog-grass	4					1	0.2		0.1
Poaceae	*Enneapogon avenaceus*	Bottle Washers	1								
Poaceae	*Entolasia marginata*	Bordered Panic	9	5	0.2	1	0.1	0.5	2		0.5
Poaceae	*Entolasia stricta*	Wiry Panic	4						0.5	0.5	1

Family	Species	Common Name	Count	03 cover	04 cover	05 cover	06 cover	07 cover	08 cover	09 cover	10 cover
Poaceae	*Imperata cylindrica*	Blady Grass	2					0.5	0.5		
Poaceae	*Microlaena stipoides*	Weeping Grass	10	1	0.5	2	0.1	5	10	5	1
Poaceae	*Oplismenus aemulus*		8	0.5	0.1	0.1			0.5	0.5	0.5
Poaceae	*Oplismenus imbecillis*		1				0.1				
Polygonaceae	*Persicaria decipiens*	Slender Knotweed	5			0.1		0.5	0.2	0.1	
Polygonaceae	*Rumex brownii*	Swamp Dock	1							0.1	
Polypodiaceae	*Pyrrosia rupestris*	Rock Felt Fern	3				0.1				0.1
Proteaceae	*Lomatia myricoides*	River Lomatia	2				0.1				0.2
Proteaceae	*Stenocarpus salignus*	Scrub Beefwood	4		0.1	0.2	0.1				1
Ranunculaceae	*Clematis aristata*	Old Man's Beard	6	0.1		0.1		0.2			0.1
Ranunculaceae	*Clematis glycinoides*	Headache Vine	1								
Rubiaceae	*Galium propinquum*	Maori Bedstraw	1		0.1						
Rubiaceae	*Morinda jasminoides*	Sweet Morinda	6	0.2	0.1	0.2	0.5				0.5
Rubiaceae	*Opercularia hispida*	Hairy Stinkweed	1								0.1
Rutaceae	*Zieria smithii*	Sandfly Zieria	3			0.2					0.1
Sapindaceae	*Dodonaea triquetra*	Large-leaf Hop-bush	2					0.1	0.1		
Smilacaceae	*Smilax glyciphylla*	Sweet Sarsparilla	1				0.1				
Solanaceae	*Solanum prinophyllum*	Forest Nightshade	6		0.1	0.5		0.5		0.1	
Sterculiaceae	*Lasiopetalum ferrugineum*		2					0.1	0.1		
Ulmaceae	*Trema tomentosa var. aspera*	Native Peach	1						0.1		
Urticaceae	*Urtica incisa*	Stinging Nettle	1							0.2	
Violaceae	*Viola hederacea*	Ivy-leaved Violet	3	0.5			0.1		0.1		
Anthericaceae	*Chlorophytum comosum**	Spider Plant	3	0.5		2					0.5
Araceae	*Zantedeschia aethiopica**	Arum Lily	2							0.1	

Family	Species	Common Name	Count	03 cover	04 cover	05 cover	06 cover	07 cover	08 cover	09 cover	10 cover
Asparagaceae	*Asparagus asparagoides**	Bridal Creeper	2								
Asteraceae	*Ageratina adenophora**	Crofton Weed	3		0.1	0.1			0.1		
Asteraceae	*Bidens pilosa**	Cobbler's Pegs	5			0.1		1		10	
Asteraceae	*Cirsium vulgare**	Spear Thistle	3					0.1	0.1	0.1	
Asteraceae	*Conyza bonariensis**	Flaxleaf Fleabane	4		0.1			0.2	0.2	0.2	
Asteraceae	*Euryops chrysanthemoides**		2					0.1			
Asteraceae	*Gamochaeta americana**	Cudweed	1						0.1		
Asteraceae	*Hypochaeris radicata**	Catsear	2					0.1	0.1		
Asteraceae	*Senecio madagascariensis**	Fireweed	4		0.1	0.1		0.1	0.1		
Asteraceae	*Senecio spp.**	Groundsel, Fireweed	1						0.1		
Asteraceae	*Sonchus oleraceus**	Common Sowthistle	1								
Asteraceae	*Tagetes minuta**	Stinking Roger	5					0.1	0.1	0.5	
Caprifoliaceae	*Lonicera japonica**	Japanese Honeysuckle	3					0.5	5		
Caryophyllaceae	*Paronychia brasiliana**	Chilean Whitlow Wort, Brazilian Whitlow	1						0.1		
Caryophyllaceae	*Stellaria media**	Common Chickweed	3			0.1				0.1	
Commelinaceae	*Tradescantia fluminensis**	Wandering Jew	4					0.1		0.1	
Cyperaceae	*Cyperus eragrostis**	Umbrella Sedge	1							1	
Malvaceae	*Modiola caroliniana**	Red-flowered Mallow	2					0.1		0.1	
Malvaceae	*Sida rhombifolia**	Paddy's Lucerne	4			0.1		0.1		1	
Myrsinaceae	*Anagallis arvensis**	Scarlet Pimpernel	4		0.1			0.1	0.1	0.1	
Oleaceae	*Ligustrum lucidum**	Large-leaved Privet	2							10	
Oleaceae	*Ligustrum sinense**	Small-leaved Privet	5	0.5		0.5		2		20	

Family	Species	Common Name	Count	03 cover	04 cover	05 cover	06 cover	07 cover	08 cover	09 cover	10 cover
Oleaceae	*Olea europaea**	Common Olive	1	0.1							
Passifloraceae	*Passiflora spp.**		1						0.1		
Phytolaccaceae	*Phytolacca octandra**	Inkweed	4			0.1		0.1		0.1	
Poaceae	*Ehrharta erecta**	Panic Veldtgrass	5					5		1	0.5
Poaceae	*Pennisetum clandestinum**	Kikuyu Grass	1						0.1		
Poaceae	*Setaria gracilis**	Slender Pigeon Grass	2							0.1	
Polygonaceae	*Acetosa sagittata**	Rambling Dock	2		0.1						
Polygonaceae	*Acetosella vulgaris**	Sheep Sorrel	1						0.1		
Rosaceae	*Rubus fruticosus**	Blackberry complex	1					0.5			
Rubiaceae	*Galium aparine**	Goosegrass	1								
Scrophulariaceae	*Verbascum virgatum**	Twiggy Mullein	1						0.1		
Solanaceae	*Solanum lycopersicum**	Tomato	1					0.1			
Solanaceae	*Solanum nigrum**	Black-berry Nightshade	4		0.1			0.1	0.1		
Solanaceae	*Solanum pseudocapsicum**	Madeira Winter Cherry	2							0.2	0.1
Verbenaceae	*Lantana camara**	Lantana	3							0.5	0.1
Verbenaceae	*Verbena bonariensis**	Purpletop	2					0.1	0.1		

Table 12. Autumn 2020 BAM, structure and function data

Treatment Site	Date	Time	Vegetation type	Vegetation condition	Bearing	Number of large trees	Tree stem class size	Number of hollow trees	Fallen logs	Mean litter
Impact 03	9/05/2019	11:29	Water gum peppermint gully	Good	90	5	<5,5-9,10-19,20-29,50-79,80+	5	33	61.6
Impact 04	9/05/2019	9:10	Backhousia gully rainforest	Good	190	0	<5,5-9,10-19,20-29	0	24	15
Impact 05	9/05/2019	12:47	Backhousia gully rainforest	Good	185	2	<5,5-9,10-19,20-29,30-49,80+	1	22	54
Control 06	9/05/2019	10:08	Coachwood rainforest gully	Good	270	2	<5,5-9,10-19,20-29,30-49,80+	3	16	36

Control 07	9/05/2019	14:18	Peppermint gully forest	Moderate	250	2	<5,5-9,10-19,20-29,30-49,80+	2	13	48
Control 08	9/05/2019	15:02	Peppermint gully forest	Moderate	240	2	<5,5-9,10-19,20-29,30-49,80+	2	52	29
Control 09	8/05/2019	13:54	River-flat eucalypt forest	Degraded	245	5	<5,5-9,10-19,20-29,30-49,80+	2	36	32.8
Control 10	8/05/2019	11:50	Backhousia gully rainforest	Good	180	2	<5,5-9,10-19,20-29,30-49,80+	1	20	64

Appendix 4. Photo-point monitoring 2018-2020 (3 years)

Plate 1: Autumn 2020 Site 3

Plate 2: Autumn 2019 Site 3

Plate 2: Autumn 2018 Site 3

Plate 4: Autumn 2020 Site 4

Plate 3: Autumn 2019 Site 4

Plate 6: Autumn 2018 Site 4

Plate 7: Autumn 2020 Site 5

Plate 8: Autumn 2019 Site 5

Plate 9: Autumn 2018 Site 5

Plate 10: Autumn 2020 Site 6

Plate 11: Autumn 2019 Site 6

Plate 12: Autumn 2018 Site 6

Plate 13: Autumn 2020 Site 7

Plate 14: Autumn 2019 Site 7

Plate 15: Autumn 2018 Site 7

Plate 16: Autumn 2020 Site 8

Plate 17: Autumn 2019 Site 8

Plate 18: Autumn 2018 Site 8

Plate 19: Autumn 2020 Site 9

Plate 20: Autumn 2019 Site 9

Plate 21: Autumn 2018 Site 9

Plate 22: Autumn 2020 Site 10

Plate 23: Autumn 2019 Site 10

Plate 24: Autumn 2018 Site 10

Appendix 5: Climate data

Table 13: Climate data

Rainfall totals (Picton) and temperature monthly averages (Camden) during the study period compared with long-term monthly averages. Sampling months are highlighted in grey.

Month	Rainfall mm	Long-term average Rainfall mm	% of Average Rainfall	Mean Max Temperature °C	Long-term Mean Max Temp. °C	Temperature difference °C
Jan 2018	41.2	79.8	52%	32.9	29.7	+3.2
Feb 2018	47.2	97.3	49%	30.7	28.7	+2.0
Mar 2018	45.6	89.6	51%	28.3	26.8	+1.5
April 2018	10.6	65.8	16%	27.9	24.0	+3.9
May 2018	**3.0**	**53.0**	**6%**	**22.2**	**20.7**	**+1.5**
June 2018	48.0	66.6	72%	17.7	17.7	0.0
July 2018	1.6	35.5	4%	19.5	17.4	+2.1
Aug 2018	6.4	40.7	16%	19.2	19.1	+0.1
Sept 2018	40.0	38.3	104%	22.2	22.0	+0.2
Oct 2018	108.0	61.8	175%	23.7	24.3	-0.6
Nov 2018	87.8	75.4	116%	26.8	26.3	+0.5
Dec 2018	122.8	57.9	212%	30.2	28.6	+1.6
Jan 2019	77.4	79.7	97%	33.3	29.7	+3.6
Feb 2019	18.0	95.4	19%	30.2	28.7	+1.5
Mar 2019	**66.6**	**89.6**	**74%**	**28.0**	**26.9**	**+1.1**
Apr 2019	9.2	65.8	14%	25.3	24	+1.3
May 2019	9.8	52	19%	22.1	20.7	+1.4
Jun 2019	47.4	66.2	72%	18.5	17.8	+0.7
Jul 2019	20.6	35.1	59%	18.8	17.4	+1.4
Aug 2019	18.4	40.2	46%	19.8	19.1	+0.7
Sep 2019	45.4	38.5	118%	23.2	22.1	+1.1
Oct 2019	19.4	60.9	32%	26.9	24.4	+2.5
Nov 2019	38.6	74.6	52%	30.2	26.4	+3.8
Dec 2019	0.2	56.6	<0.01%	31.8	28.7	+3.1
Jan 2020	89.0	79.9	110%	30.9	29.8	-1.1
Feb 2020	368.8	101.6	362%	28.8	28.7	+0.1
Mar 2020	**88.4**	**89.6**	**98%**	**25.9**	**26.9**	**-1.0**

Table 14: Rainfall (Picton) and temperature (on site) conditions during each frog survey

Period	Start Date	Sites surveyed	Rain in previous 48 hours (mm)	Max temp (°C)	Min temp (°C)
May 2018	03/05/2018	9, 10	0.2	20	15
	08/05/2018	3, 4, 5, 6	0	21	16
	17/05/2018	7, 8	0	19	16
March 2019	19/03/2019	7, 8, 9, 10	11.8	28.1	19
	20/03/2019	3, 4, 6	7.8	28.3	19
	21/03/2019	5	7.8	19	19
March 2020	10/03/2020	3, 4, 6	1.6	24.4	13.1
	11/03/2020	10	0	26.0	11.4
	16/03/2020	7, 8, 9, 5	8.4	22.1	13.1

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Accredited BAM assessors (NSW)
Biodiversity Stewardship Site Agreements (NSW)
Offset site establishment and management
Offset brokerage
Advanced Offset establishment (QLD)

Appendix C – Riparian vegetation and amphibian monitoring report Spring 2020

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Tahmoor Mine Western Domain

Terrestrial Ecology Monitoring Report

Riparian vegetation and amphibian monitoring Spring 2020

Prepared for Tahmoor Coal

Prepared by Niche Environment and Heritage | 23 February 2021

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Document control

Project number	Client	Project director	Project manager	LGA
6149	Tahmoor Coal	Matthew Richardson	Matthew Russell	Wollondilly Shire Council

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Executive summary

Tahmoor Coal Pty Ltd (Tahmoor Coal) currently occupy underground coal mining to the north-west of the Main Southern Railway (referred to as the 'Western Domain'), which includes Longwalls West 1 (LW W1) to West 4 (LW W4) at Picton and Thirlmere (the 'Study Area'). Niche Environment Heritage Pty Ltd (Niche) was engaged by Tahmoor Coal to conduct impact monitoring of terrestrial ecology within the area potentially affected by longwall mining.

A Before, After, Control, Impact monitoring program was designed to identify ecological change within the Study Area as a result of mine subsidence by permitting comparisons between control and impact areas before and after the impact. The monitoring was required for three years prior to the commencement of undermining and will continue now that mining in the study area has commenced.

This report summarises the results of the first post-mining Spring 2020 monitoring period and compares the results with the previous three years of before-mining Spring monitoring data collected in 2017, 2018 and 2019.

Eight Sites, including three impact Sites and five control Sites, were monitored. Riparian vegetation monitoring involved floristic surveys within established vegetation monitoring plots at each Site. Amphibian monitoring included spotlighting, call provocation, listening for diagnostic frog calls and tadpole surveys along established transects and were targeted at two threatened frog species: the Giant Burrowing Frog (*Heleioporus australiacus*) and the Red-crowned Toadlet (*Pseudophryne australis*).

Key results of the Spring riparian and amphibian monitoring for 2020 include:

Riparian monitoring:

- River-flat Eucalypt Forest, which is listed as an Endangered Ecological Community under the BC Act, was recorded at control Site 9 with a high level of weed infestation (119.7% cover across the combined growth forms).
- Floristic composition and vegetation cover at each Site increased by 15 percent at the impact Sites and 14 percent at control Sites compared to pre-mining values, most likely due to increased rainfall across 2020.
- Impact Sites had a slightly lower mean species richness and percentage vegetation cover than control Sites, although the exotic cover in the control Sites is relatively high at approximately 28.9 percent compared to one percent at impact Sites.
- Anthropogenic influences were observed at Sites that had been impacted by human disturbance, particularly weeds and altered flow regimes.
- Sites 7, 8 and 9 tended to have higher fertility and nutrient loads, which lead to higher species diversity and generally more exotic species. These Sites appeared to be more influenced by seasonal changes than Sites further up the catchment (Sites 4, 5, 6 and 10), which tended to be protected in deep gullies and canyons.

Amphibian monitoring:

- Frog detection rates were variable between before monitoring events and impact monitoring event 2020 for most Sites. There was a significant difference in species diversity between control Sites and impact Sites, with the reduction in control Sites. One impact Site had an increase in individuals of one species. This may be due to the recent rainfall which likely triggered a breeding event at Site 4.

- The targeted threatened frog species were not detected. The six species detected represent an otherwise normal assemblage of common species that may be expected to be present in the Study Area under the current climatic conditions.
- The targeted threatened frog species appear not to be present in the Study Area, at least not in a numbers that can be detected by the current monitoring program. While the Study Area contains superficially suitable habitat, it is possible that the species would no longer be able to survive in the area due to predation pressures from two introduced predators: the Plague Minnow (*Gambusia holbrooki*) and the Yabby (*Cherax destructor*), both of which were detected at all Sites. The frog community present contains at least 12 species which are likely still viable indicators of impending or current environmental change.
- Frog detection rates were variable between monitoring events for most Sites, most likely due to the highly variable weather and climatic conditions across the survey periods. There was a significant difference between control Sites and impact Sites (detection being greater at impact Sites).

No thresholds within the Trigger Action Response Plan (TARP) in the Biodiversity Management Plan have been triggered, and therefore, no remedial management actions are required.

It is recommended that, given the likely lag time from start of impact to detection of any differences/effects on the plant and animal communities, the annual monitoring continue in Spring and Autumn for riparian vegetation monitoring and in Spring and Autumn (or after rain deemed suitable by the ecologist) for amphibian monitoring to permit comparison between impact and control Sites and before and after mining impacts. After one season of impact monitoring this has shown the variability across the seasons and weather experienced, over time this program will allow changes to be seen.

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1. Introduction

1.1 Background

Tahmoor Coal Pty Ltd (Tahmoor Coal) currently occupy underground coal mining to the north-west of the Main Southern Railway (referred to as the 'Western Domain'), which includes Longwalls West 1 (LW W1) to West 4 (LW W4) at Picton and Thirlmere (Figure 1). Tahmoor Coal have recently completed mining LW1 and will begin LW2 in 2021.

A Terrestrial Ecology Assessment for the Western Domain completed by Niche in 2014 (Niche 2014) identified a number of watercourses (including Stonequarry Creek, Cedar Creek, Newlands Gully, and Matthews Creek) (Study Area) that would be subject to subsidence related impacts as a result of the extension of operations. These watercourses to the north-west of the Western Domain subsidence area are of high ecological value, given the relatively pristine condition of the bushland and extent of habitat available. Niche Environment and Heritage Pty Ltd (Niche) was commissioned by Tahmoor Coal to conduct terrestrial ecology monitoring for Longwalls West 1 to West 4 (LW W1-W4) in the Western Domain (Figure 1).

A Before, After, Control, Impact (BACI) monitoring program was designed to identify ecological change within the Study Area as a result of mine subsidence by permitting comparisons between control and impact areas before and after the impact. The monitoring was required for three years prior to the commencement of undermining and will continue now undermining has commenced.

Before mining monitoring (Before) of riparian vegetation and amphibians commenced in Spring 2017 (Niche 2018) and monitoring has continued each Spring (Niche 2018, Niche 2019, Niche 2020). Mining within the Western Domain commenced on 15 November 2019. Due to the proximity of the mining activity to the monitoring sites, the latest monitoring event (Spring 2020) is considered to be the first round of impact monitoring. This report presents the four years of Spring monitoring data (2017, 2018, 2019 and 2020). Raw data and results summarised from each Spring monitoring event are included in this report.

Additional Autumn monitoring of riparian vegetation and amphibians is also being undertaken. Autumn monitoring was undertaken in 2018, 2019 and 2020, with the final pre-mining (Before)Autumn monitoring completed in 2019. These Autumn monitoring results are presented in a separate monitoring report. All subsequent monitoring will be defined as post-mining (After) monitoring. Only references to Spring survey data are discussed in this report.

1.2 Purpose and objectives

The aim of the monitoring program is to collect data that will enable comparison of environmental variables pre and post-mining in the Western Domain via the collection of empirical data, mapping and establishment of a photographic record for the Sites. The specific objectives of this report include:

1. Present all raw data from Spring Before and After monitoring.
2. Detail the methodology utilised.
3. Discuss any limitations of the monitoring program.
4. Analyse the results of the impact monitoring in relation to data from Before monitoring and identify if mining has had an impact on riparian or amphibian communities.

5. Identify if any features of the Trigger Action Response Plan (TARP) in the Biodiversity Management Plan (SIMEC 2019) have been triggered and remedial management actions are required.
6. Provide recommendations to improve the monitoring program.

Mapping includes:

1. Location of amphibian monitoring transects and vegetation monitoring plots.
2. Photo point monitoring locations (end of transects).
3. Before assessment of native vegetation and condition along riparian zones.

1.3 Biodiversity Management Plan Trigger Action Response Plan (TARP)

A Biodiversity Management Plan for Tahmoor North Western Domain Longwalls West 1 and West 2 has been developed which contains a Trigger Action Response Plan (TARP) (SIMEC 2019). The TARP contains a table of features with thresholds for when a mining related impact occurs, and a prescribed management action response is required to be undertaken for remedial action (Appendix 6). The key thresholds relevant to this monitoring report include:

- Decline in amphibian populations within watercourses of the Study Area.
- Dieback of riparian vegetation within watercourses of the Study Area.

This report will identify if either of these features are triggered and provide recommendations for appropriate remedial action.

2. Methodology

2.1 BACI monitoring program

This monitoring program was designed as a Before, After, Control, Impact (BACI) study. In accordance with BACI principles, the monitoring program was designed to collect sufficient data over time to compare changes in ecological indicators as a result of subsidence. The monitoring program considered recommendations of the Southern Coalfields Inquiry and Planning and Assessment Commission reports for Peabody Coal's Metropolitan and South 32's Bulli Seam Projects and includes the following:

- A minimum of three years of Before data, collected over an appropriate area and at consistent seasonal frequencies to monitor amphibian populations and riparian vegetation along Stonequarry Creek, Cedar Creek and Matthews Creek.
- Annual reassessment of the data to determine its effectiveness in meeting its goal of identifying impacts. This adaptive monitoring may lead to changes in the extent and intensity of monitoring.
- Surveys will be undertaken to current NSW Department of Planning Industry and Environment (DPIE) standards.

2.2 Monitoring Sites

Appropriate replication of both impact (directly adjacent to or over the mine) and control (outside direct impact zone) monitoring Sites (referred to as Sites) was inco.rporated into the monitoring program to account for natural variability across the landscape. The longwall plans were changed subsequent to the 2014 Terrestrial Ecology Assessment (Niche 2014) and, as such, Site locations were shifted accordingly. The planned layout of the longwalls subsequently changed again after the establishment of the monitoring Sites, however, all Sites remain within their originally designated treatment areas. Riparian and amphibian monitoring was conducted at eight Sites, including three impact Sites and five control Sites. A more detailed description of the riparian and amphibian monitoring methodology is provided below. Details of each impact and control Site is provided in Table 1, with further details provided in Appendix 2 and location shown in Figure 1.

Table 1: Riparian vegetation and amphibian monitoring Sites and their existing characteristics

Treatment	Site number	Stream	Existing impacts and features	Mined beneath
Longwall Impact	3	Cedar Creek above Stonequarry Creek junction and adjacent to Newlands Gully	Rural residential, permanent stream, rainforest	Directly above Longwall panel 37, northern end. Mining commenced November 2019.
	4	Matthews Creek in gorge near Cedar Creek junction	Rural residential, permanent pools, rocky	20 m west and 450 m south from northern end of Longwall panel 37
	5	Matthews Creek in gorge	Rural residential, rocky	100 m west and 960 m south from northern end of Longwall panel 37
Control	6	Cedar Creek in gorge	Agriculture, permanent pools, rainforest	No
	7	Cedar Creek	Rural residential, sandy	No
	8	Cedar Creek	Rural residential, sandy	No
	9	Stonequarry Creek	Agriculture, weed infestations	No

Treatment	Site number	Stream	Existing impacts and features	Mined beneath
	10	Stonequarry Creek in gorge	Rural residential, permanent pools, rainforest, rocky	No

2.3 Riparian vegetation monitoring

The riparian vegetation monitoring was conducted by Sarah Hart (Ecologist), Kayla Asplet (Ecologist) and Christie Chapman (Ecologist) on 9 and 10 November 2020. Tasks completed during riparian monitoring using the Biodiversity Assessment Methodology (BAM) (DPIE 2020) are detailed below.

2.3.1 Permanent vegetation plots

One vegetation plot (BAM plot) was established within each of the eight monitoring Sites and consisted of the following:

- One 50 x 20 metres (m) functional plot immediately adjacent to or spanning the water body.
- One 10 x 40 m floristic plot following the creek line to accommodate the steep, narrow gullies.

The following attributes were collected within the BAM plots:

- Composition:
  - native species richness (10 x 40 m plot)
- Structure:
  - native flora cover (% of the 10 x 40 m plot) divided into the growth forms:
    a) Tree
    b) Shrub
    c) Grass and grass like
    d) Forb
    e) Fern
    f) Other
  - exotic species cover
  - high threat weed vegetation cover
- Function (within 50 x 20 m plot)
  - tree regeneration (size classes present)
  - number of trees with hollows
  - total length of fallen logs
  - number of large trees
  - tree stem size class
  - litter cover (sampled in 5 x 1 m quadrats within the 50 x 20 m plot).

The BAM plot location was marked for repeated survey using GPS coordinates, flagging tape and photo points (Appendix 4).

2.3.2 Vegetation condition assessment

Within each of the BAM plots, the condition and structure of vegetation are assessed using key indicators to permit comparison of results throughout different monitoring periods. The BAM was applied as it provides a standardised scoring system of key attributes.

2.3.3 Photo point monitoring

Photo monitoring from a permanent photo point was undertaken within each of the BAM plots (Appendix 4).

2.3.4 Plant taxonomy

Plant taxonomy used was consistent with the nomenclature accepted by the National Herbarium of NSW (as per their PlantNet website http://plantnet.rbgsyd.nsw.gov.au/). All floristic data were entered into the Niche Flora Information System (FIS) to allow data manipulation and export for species lists and analysis.

2.4 Amphibian monitoring

The amphibian monitoring was conducted by Sarah Hart (Ecologist) and David Wilkinson (Ecologist) on three occasions: 28, 29 and 30 September 2020. Survey timing was dependent on rainfall and the season and therefore did not necessarily occur on consecutive days.

Surveys targeted the threatened frog species, Red-crowned Toadlet (*Pseudophryne australis*) and Giant Burrowing Frog (*Heleioporus australiacus*). These species are known to call over an extended period of the year, driven more by rainfall conditions than by the season.

One amphibian monitoring transect (200 m) was located in each of the eight monitoring Sites. Frog transect locations were marked using GPS tracking coordinates for repeated survey. All detected frog species were recorded during surveys, which involved the following:

- Nocturnal aural and visual searches of watercourses. The search area was restricted to within 10 m either side of the 200 m transect. A minimum of 30 minutes was spent searching along each transect, although time spent was often considerably longer to account for difficult terrain or high frog abundance. Handheld LED spotlights and head torches were used.
- Attempts were made to elicit calls from the target species using call-playback of male advertising calls for the Giant Burrowing Frog and a sudden loud noise for the Red-crowned Toadlet.
- Tadpole searches were conducted during diurnal and nocturnal surveys. Tadpoles were identified using the resources in Anstis (2013).
- Opportunistic records of frogs seen or heard calling during the riparian vegetation surveys. These records were included as presence for that period if the species was otherwise undetected during targeted nocturnal survey for that monitoring event and Site.

2.5 Data analysis

The vegetation cover scores, and the frog data were analysed separately by Mathew Vickers PhD (Ecologist/Statistician) using the statistical program R (R Core Team 2020) (Version 3.6.3) for statistical hypothesis testing.

Data were double square-root transformed to control the influence of highly abundant species. A Bray-Curtis dissimilarity index was constructed, and those distances were used in a fully factorial permanova (package vegan) to test whether there was an effect of mining using a BACI design. The presence of a significant interaction between Before/After and Control/Impact indicates the mining activity has an effect on frog or vegetation cover assemblages.

The start of longwall mining took place late 2019, all monitoring data collected prior to Spring 2020 is considered to be 'Before', and all data after Spring 2019 were considered to be 'After'. Before and after analysis was undertaken for Spring-only data, as well as Spring and Autumn data combined in an effort to increase the data sets that may allow for observations of changes at the community level.

The distance matrix of untransformed species abundance data were used in Non-parametric Multi-dimensional Scaling (NMDS) (package vegan) for visualisation and understanding any observed shifts in community assemblages.

2.6 Limitations of the monitoring program

Limitations of the current monitoring program include the following:

- Control Sites were limited to areas that are not expected to be impacted by mining operations, were accessible, and minimised safety concerns.
- No two creeks are identical, and therefore eliminating all variables between control and impact Sites is a complex task and not possible in this instance.
- Some plant species are cryptic and may remain undetected during the survey. This is the case with orchid species, annuals (completing their life cycle within a single season) and some perennials being inconspicuous unless flowering or in fruit. Some individual plant samples were in a juvenile state or were annual species that had already died. Therefore, not all plants found could be accurately identified. These species were identified to genus level where possible and may need to be identified to species level in subsequent monitoring seasons.
- The data to be analysed required both Autumn and Spring monitoring data to be combined, for both frog assemblages and vegetation cover scores. This is partly due to the long-term monitoring program; also allows are more comprehensive view of the changes for control and impacts. This may include limitations and a few more analysis to include the variability of seasons, although gives more power to the statistical analysis.

Figure 1: Site location

3. Results and discussion

3.1 Riparian vegetation monitoring results

The full floristic results of the riparian vegetation monitoring (10 m x 40 m plots) are provided in Appendix 3. An overview is provided below.

3.1.1 Threatened species and habitat

No threatened flora species were recorded during the monitoring surveys. However, River-flat Eucalypt Forest, which is listed as an Endangered Ecological Community under the NSW *Biodiversity Conservation Act 2016* (BC Act), occurs at control Site 9. It occurs there in a highly disturbed state, with high exotic species abundance. In Spring 2020, Sites 7, 8 and 9 were found to have the highest exotic species richness, 15 species, of all monitoring Sites.

3.1.2 Composition, structure and function

The key indicators (key attributes) collected in the BAM plots were used to assess condition, structure and function of vegetation and habitat features within each of the plots.

The raw data is contained in previous Before monitoring reports (Niche 2018, Niche 2019 and Niche 2020) including the floristic composition data for the three monitoring events. A high degree of variation in diversity, abundance and structure is expected due to natural variation associated with the topography and hydrology of each of the different Sites.

Over the three years, differences in some of the key attributes were observed, including fluctuations in fallen logs and mean litter cover. This is predicted given vegetation growth and die back over time, branch loss and natural die back of species such as annuals. Ongoing declining key attribute scores may indicate factors impeding the health of the riparian ecosystem. There was no ongoing decline in key attributes observed during Before monitoring. Observed variations in key attributes are considered likely to be due to natural seasonal and temporal changes and clarity in data recording methods over time. The BAM method does not account for habitat features that may be within water, particularly when the water level varies between monitoring events. As more data is collected over time, the factors affecting variability in the data are expected to be better understood.

3.1.3 Species richness data

Species richness of each Site presented in Table 2 for the three Before monitoring periods. A total of 284 native plant species and 44 exotic plant species were recorded within the eight Sites over the three years of Spring sampling. Future impact Sites (After) had a slightly lower species richness of both native and exotic plant species with an average of 30 native species and 6.2 exotic species per vegetation plot (n = 3) compared with 32 native and 11.8 exotic species at control vegetation plots (n = 5). Species richness remained relatively consistent between Spring monitoring events. Across the three Before monitoring periods the total species richness was higher at the control Sites on average (Table 2, Graph 1). This information will be used to assess changes between Before monitoring and After monitoring.

Species richness in Spring 2020 ranged from 20 to 55 species. This is comparable with results from previous monitoring events, where species richness ranged from22 to 65 in Spring 2019, 22 to 63 in Spring 2018 and 20 to 57 species in Spring 2017 (Table 2, Graph 2). The most frequently recorded species included: *Lomandra longifolia, Adiantum aethiopicum*, *Entolasia stricta*, *Microlaena stipoides*, *Conyza bonariensis**, *Entolasia marginata, Persicaria decipiens*, *Solanum prinophyllum* and *Ehrharta erecta**. These dominant species have remained common throughout subsequent monitoring events.

During Spring 2020 impact Sites (After) had an average species richness of 36.7, although lower than the average species richness of 39.8 at the control Sites. In 2020 the species richness at the impact Sites was slightly higher than the Before average species richness of 36.1 (Table 2).

3.1.4 Floristic cover

Vegetation cover was recoded as part of the BAM plots. Mean percent vegetation cover scores at control and impact Sites for each monitoring event are provided in Table 3. The topographic and geological setting of the Sites is variable. As a result, there is considerable natural variation in vegetation cover among Sites, while between year variation at each Site was relatively limited. For all monitoring events, control Sites showed higher mean vegetation cover compared with the impact Sites.

The overall reduction of vegetation cover between 2017 to 2020 monitoring may be due to the extended dry periods throughout recent years with only four months in 2018 having near or more than average rainfall and two months in 2019 (Appendix 5).

The percent of vegetation cover present in Spring 2020 ranged from 61.8 to 133.6 percent. This is comparable to results from Before monitoring events, where percent vegetation cover ranged from 32.5 to 88.8 in Spring 2019, 48.2 to 105.2 in Spring 2018 and 45.8 to153.3 in Spring 2017 (Table 3, Graph 2). Note, the value of percent cover can be over 100 percent due to each species being assigned a percentage of cover and due to overlapping growth stratums, when combined, these have the potential to be greater than 100% over all vegetation cover.

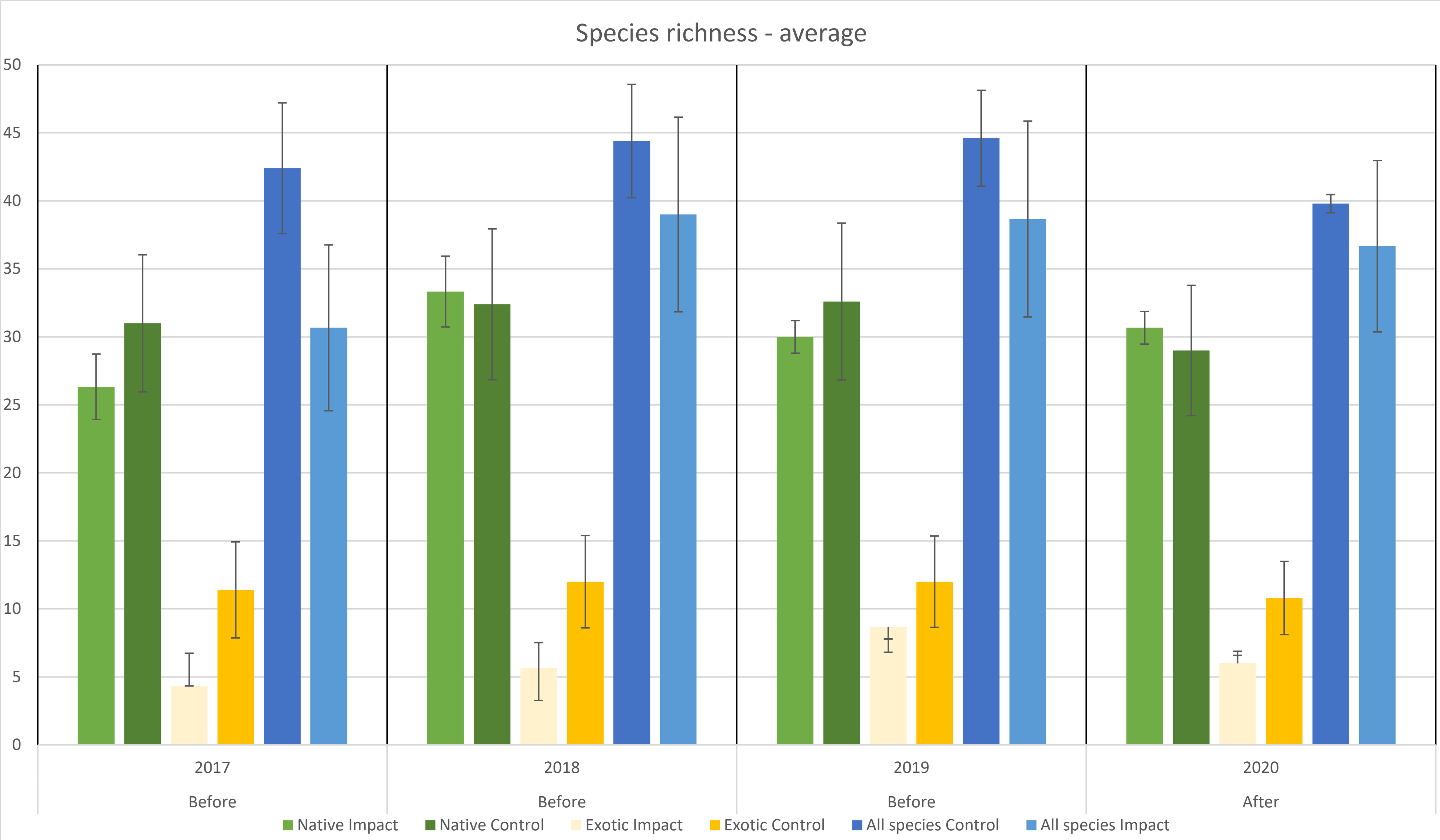
During Spring 2020 impact Sites had an average percent vegetation cover of 68.5, while there was a lower than average percent vegetation cover of 88.5 at the control Sites. While there was a reduction in percent cover for three sites between 2019 and 2020 (one impact and two control sites), four of the sites (two impact and three control) recorded an increase in percent cover such that, between 2019 and 2020 across all the sites. (Table 3, Graph 2). This is likely due the rainfall in early 2020 with all months (except April and June) exceeding their monthly average rainfall (Appendix 5).

Table 2: Species richness 2017 – 2019.

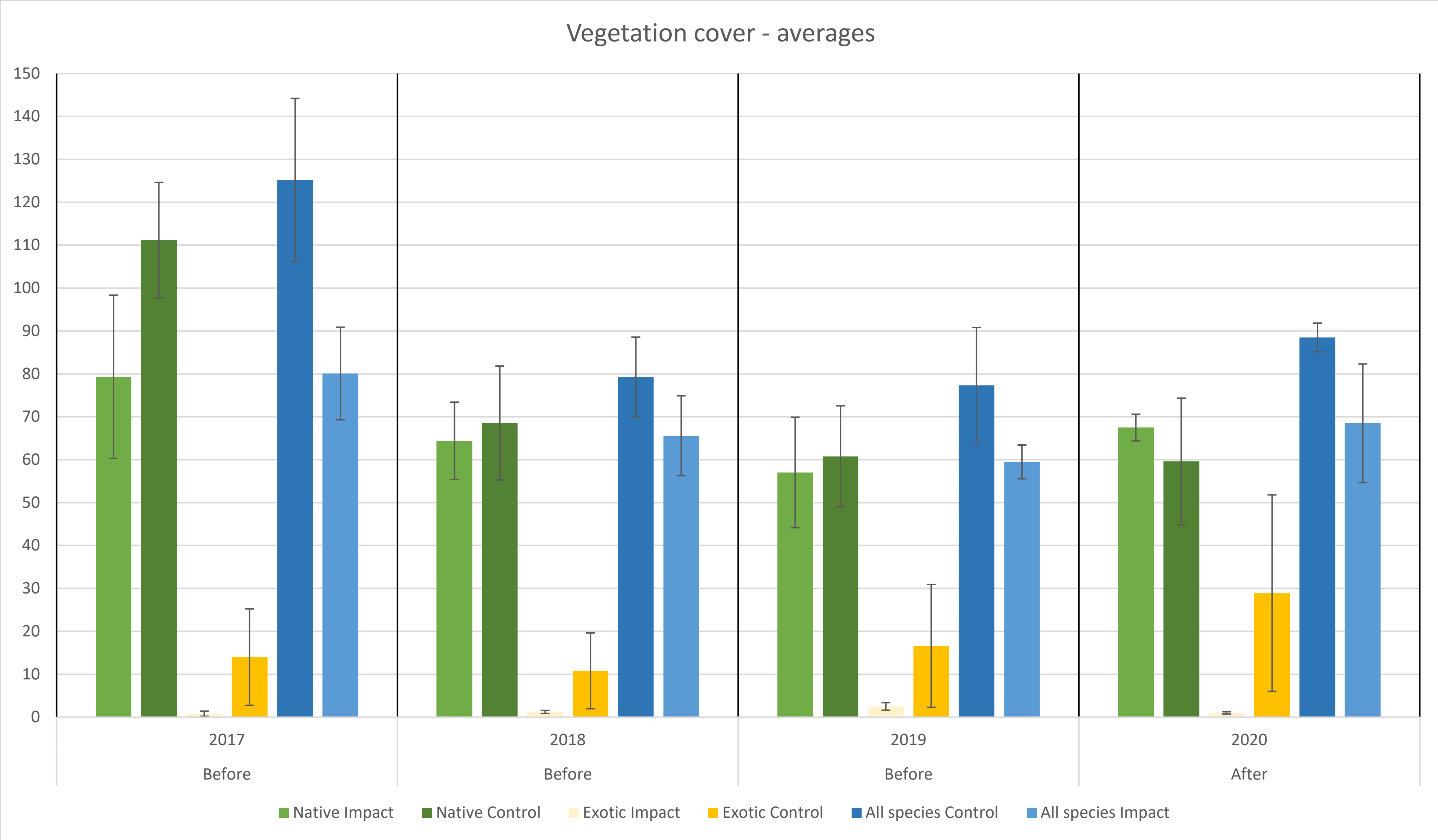
Treatment	Site	Spring 2017			Spring 2018			Spring 2019			Spring 2020		
		Native	Exotic	All Species	Native	Exotic	All Species	Native	Exotic	All Species	Native	Exotic	All Species
Impact	3	31	9	40	38	7	45	31	9	40	30	6	36
	4	25	3	28	29	2	31	25	7	32	29	7	36
	5	23	1	24	33	8	41	34	10	44	33	5	38
Control	6	18	2	20	21	1	22	21	1	22	18	2	20
	7	43	14	57	39	12	51	34	14	48	35	15	50
	8	36	11	47	43	20	63	47	18	65	40	15	55
	9	20	23	43	17	18	35	18	19	37	17	15	32
	10	38	7	45	42	9	51	43	8	51	35	7	42
Impact Mean		**26.3**	**4.3**	**30.7**	**33.3**	**5.7**	**39.0**	**30.0**	**8.7**	**38.7**	**30.7**	**6.0**	**36.7**
Control Mean		**31.0**	**11.4**	**42.4**	**32.4**	**12.0**	**44.4**	**32.6**	**12.0**	**44.6**	**29.0**	**10.8**	**39.8**

Table 3: Vegetation cover scores 2017- 2020

Treatment	Site	Spring 2017			Spring 2018			Spring 2019			Spring 2020		
		Native	Exotic	All Species	Native	Exotic	All Species	Native	Exotic	All Species	Native	Exotic	All Species
Impact	3	81.2	2	83.2	81.4	1.5	82.9	69.5	2	71.5	70.7	1	71.7
	4	45.5	0.3	45.8	50.7	0.5	51.2	31.3	1.2	32.5	70.5	1.4	71.9
	5	111.3	0.1	111.4	61.1	1.6	62.7	70.3	4.2	74.5	61.3	0.5	61.8
Control	6	87.8	0.3	88.1	104.9	0.3	105.2	76.4	0.1	76.5	75.4	0.2	75.6
	7	130.9	2.5	133.4	74.1	3.5	77.6	66.6	4.6	71.2	41	17.1	58.1
	8	146	7.3	153.3	85.8	2.7	88.5	80	3.1	83.1	99.6	6.5	106.1
	9	73.4	58.7	132.1	31.2	46	77.2	15	73.8	88.8	13.9	119.7	133.6
	10	117.8	1.1	118.9	46.8	1.4	48.2	65.8	1.3	67.1	68	0.9	68.9
Impact Mean		**79.3**	**0.8**	**80.1**	**64.4**	**1.2**	**65.6**	**57**	**2.5**	**59.5**	**67.5**	**1**	**68.5**
Control Mean		**111.2**	**14**	**125.2**	**68.6**	**10.8**	**79.3**	**60.8**	**16.6**	**77.3**	**59.6**	**28.9**	**88.5**



Graph 1: Species richness (2017-2020



Graph 2: Vegetation Cover 2017-2020

Spring and Autumn data were combined to increase the data set and thus power of analysis to determine the nature of the relationship between control and impact sites before and after mining.

Table 4: Statistical ANOVA for interactions across all riparian data

	Df	SumOfSqs	R2	F	p
Control:impact	1	1.405	0.129	4.292	0.001
Before:After	1	0.172	0.016	0.526	0.837
control:BA	1	0.111	0.01	0.34	0.976
Residual	28	9.164	0.844		
Total	31	10.852	1		

*Df= degrees frequency, SumOfsq = Sum of squares, R2= R-squared, F= factorial index, P= significance value

As per Table 4 there was no significant interaction between Control/Impact and Before/After in vegetation cover (ANOVA, $F_{(1,28)}$=0.34, p=0.976). There was no significant effect of Before/After on cover (ANOVA, $F_{(1,28)}$=0.526, p=0.837). Although there was a significant difference between Control and Impact Sites in vegetation cover (ANOVA, $F_{(1,28)}$=4.292, p=0.001).

Table 5: Tukey's Honestly Significant Difference (HSD) for interactions across all riparian data

	diff	lwr	upr	p
Impact.after-Control.after	-0.112	-0.204	-0.02	0.011
Control.before-Control.after	-0.023	-0.09	0.044	0.797
Impact.before-Control.after	-0.151	-0.223	-0.078	<0.01
Control.before-Impact.after	0.089	0.008	0.17	0.026
Impact.before-Impact.after	-0.039	-0.125	0.047	0.631
Impact.before-Control.before	-0.128	-0.186	-0.069	<0.01

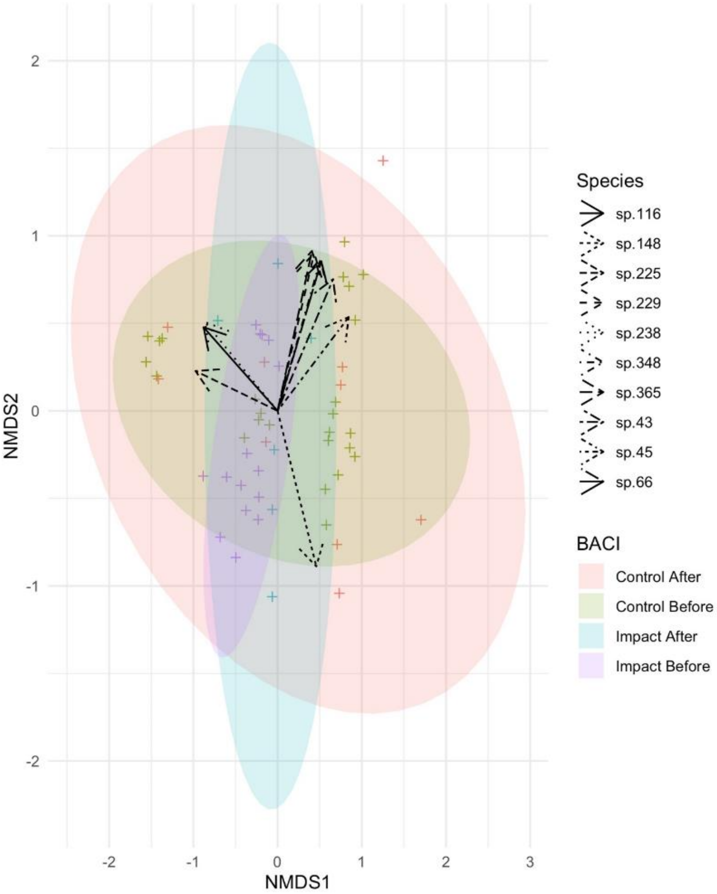
*diff= difference value, lwr = lower values, upr= upper value, p= significance value

Tukey's Honestly Significant Difference (HSD) is a pairwise comparison that illustrates exactly which effects were different, leading to the significant effects we saw in the ANOVA. Table 5 shows a significant difference between four sets of variables:

- Impact After and Control After
- Impact Before and Control After
- Control Before and Impact After
- Impact Before and Control Before.

Control before and control after (and Impact before and Impact after) were not significantly different indicating there is no evidence to suggest that mining activity to date is having a significant effect on vegetation cover at the sites. The significant effects observed across the other sites indicates inherent differences in the sites themselves, and possibly the effect of the increases in rainfall across the year. This is represented visually below in Graph 3.

There was strong overlap in the confidence ellipses for all treatments in terms of vegetation cover for all data. The stress was reasonable (0.18) indicating that this is a decent visualisation of vegetation cover and that all Sites had quite similar floristic communities.



Graph 3: Non-metric Multidimensional Scaling (NMDS) graph for vegetation cover for all data (Autumn/ Spring combined).

The two control ellipses are rather round and centred, the impact ellipses are much skinnier but also centred, both after ellipses are larger due to the amount of data being smaller than the before data becoming more accurate.

A similar analysis was done for Spring only data (taking the average of Spring Before) Table 6.

Table 6: Statistical ANOVA for interactions across all Spring data

	Df	SumOfSqs	R2	F	p
Control:impact	1	0.85	0.11	3.805	0.001
Before:After	1	0.506	0.065	2.268	0.033
control:BA	1	0.143	0.018	0.642	0.816
Residual	28	6.251	0.807		
Total	31	7.75	1		

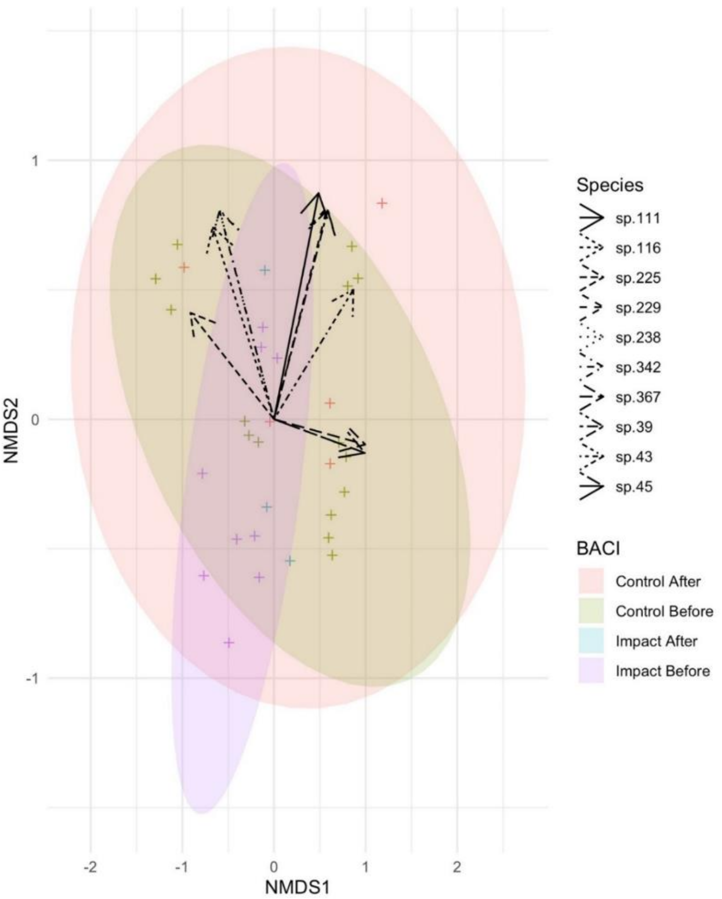
*Df= degrees frequency, SumOfsq = Sum of squares, R2= R-squared , F= factorial index, P= significance value

There was a significant difference (Table 6) in cover communities in Spring between Before and After (ANOVA, $F_{(1,28)}$=2.268, p=0.033). There was a significant difference in percent cover in Spring between Control and Impact Sites (ANOVA, $F_{(1,28)}$=3.805, p=0.001). Although there was no interaction between Before/After and Control/Impact for the percent cover in Spring (ANOVA, $F_{(1,28)}$=0.642, p=0.816). This suggests that the impacts are not influenced by mining, the significant difference in percent cover in Spring is potentially a result of increased exotics across control sites, due to the rapid response of these invasive plants compared with native after rainfall.

Table 7: Tukey's Honestly Significant Difference (HSD) for interactions across all Spring data

	diff	lwr	upr	p
Impact.after-Control.after	-0.129	-0.282	0.024	0.124
Control.before-Control.after	0.039	-0.069	0.148	0.756
Impact.before-Control.after	-0.083	-0.2	0.034	0.233
Control.before-Impact.after	0.168	0.035	0.3	0.009
Impact.before-Impact.after	0.045	-0.094	0.185	0.813
Impact.before-Control.before	-0.123	-0.211	-0.034	0.004

Tukey's HSD for Spring data only (Table 7) showed a significant difference between Control Before and Impact After, and also between Impact Before and Control Before. This is consistent with differences observed in the ANOVA, suggesting that the control and impact sites have a significant difference and the before and after also have a significant difference but there is currently no interaction between them. The observed differences may be explained by the increases in rainfall for the Impact After Spring data.



Graph 4: Non-metric Multidimensional Scaling (NMDS) graph for vegetation cover for Spring data

There was insufficient data to construct an ellipse for Impact After for Spring vegetation cover, though this is expected to change with more sampling over coming years. Stress was reasonable (0.16), indicating that this is a reasonable visualisation of the vegetation cover for Spring, and that all Sites are quite similar.

3.2 Frog surveys

The complete raw data results of the amphibian monitoring (200 m transects) are provided in Appendix 3. An overview is provided below.

3.2.1 Threatened species and habitat

The two primary target species (Red-crowned Toadlet and Giant Burrowing Frog) were not detected during these surveys, nor are there existing records in public databases for these species within the same catchment or near the impact Sites. Superficially there is suitable habitat for both species at a range of the impact and control Sites and there are historical records, either within 10 km of the Study Area or within the greater Bargo River catchment. The Giant Burrowing Frog is known to have a long tadpole stage, which would make the species vulnerable to introduced predators such as the Plague Minnow (Gambusia holbrooki) and the Yabby (Cherax destructor), which are widespread in the area. The absence of Red-crowned Toadlet from the Study Area may be due to the shale capping geology in the area as this species is a sandstone specialist (Anstis 2013).

3.2.2 Climatic conditions

Monthly climate data since July 2017 is provided in Appendix 5, Table 15. Rainfall and temperature values were supplied by Tahmoor Colliery and compared with Camden Airport AWS (station ID 068192), 16 to 20 km from the Study Area. Table 16 shows the conditions during each frog survey. All frog surveys were undertaken within a week of rainfall, with no minimum trigger value set. In August there was above average rainfall and frog surveys were undertaken to take advantage of this early Spring weather.

Previously lower than average rainfall for extended periods of time has resulted in reduced stream flow and absence of surface water at some Sites, in particular sites 4, 5, 7 and 9. This was then complicated by heavy rains and fast flowing water in a short time period (January and February 2020) shortly preceding the Autumn 2020 surveys with notable sediment and debris movements. However, by Spring 2020 (late September) the rain had been steady with monthly averages above or exceeding since January 2020 (except April and June, which were just below average) prior to the Spring 2020 surveys (late September 2020) and thus conditions were considered to be adequate for frog activity.

3.2.3 Frog distribution and abundance

Table 8 presents the average number of frogs recorded during Before surveys (2017-2019) in all Spring events. The average abundance for all control Sites, except *Litoria lesueuri, Litoria phyllochroa*, have a higher abundance of each species. Overall, the Before average was the same when all species data was combined.

Table 8: Mean Spring count across all Spring years

Species (in order of abundance)	Spring 2017	Spring 2018	Spring 2019	Spring 2020	Mean Spring Count
Crinia signifera	125	99	249	134	151.75
Limnodynastes peronii	31	34	10	9	21
Litoria phyllochroa	27	36	15	17	23.75
Litoria fallax	56	12	8	0	19
Litoria lesueuri	9	25	32	86	38
Litoria peronii	6	28	26	7	16.75
Litoria verreauxii	2	7	1	0	2.5

Species (in order of abundance)	Spring 2017	Spring 2018	Spring 2019	Spring 2020	Mean Spring Count
Litoria tyleri	0	11	0	0	2.75
Litoria dentata	0	9	0	0	2.25
Limnodynastes tasmaniensis	0	2	2	1	1.25
Litoria latopalmata	1	0	0	0	0.25
Limnodynastes dumerilii	1	0	0	0	0.25
All Species	**258**	**263**	**358**	**254**	**293**

Stoney Creek Frog *Litoria lesueuri* (in amplexus)	Leaf-green Tree Frog *Litoria phyllochroa*	Peron’s tree frog *Litoria peronii*

Plate 1: Common frog species present within the Study Area

Table 9: Frog abundance for Spring 2020 per Site.

	Site							
	Impact			Control				
Species	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
Litoria dentata	0	0	0	0	0	0	0	0
Limnodynastes peronii	0	0	1	0	1	7	0	0
Crinia signifera	15	15	7	30	15	20	12	20
Litoria fallax	0	0	0	0	0	0	0	0
Litoria nudidigita/phyllochroa	0	0	0	0	0	0	0	0
Litoria phyllochroa	6	5	4	2	0	0	0	0
Litoria lesueuri	3	83	0	0	0	0	0	0
Litoria peronii	0	0	0	0	0	7	0	0
Limnodynastes tasmaniensis	1	0	0	0	0	0	0	0
Litoria verreauxii	0	0	0	0	0	0	0	0
Number of species	**4**	**3**	**3**	**2**	**2**	**3**	**1**	**1**
Number of individuals	**25**	**103**	**12**	**32**	**16**	**34**	**12**	**20**

In Spring 2020, the most widespread and abundant frog species was the Clicking Froglet (*Crinia signifera*), which was detected at all Sites. The Leaf-green Tree Frog (*Litoria phyllochroa*) was detected at four of the eight Sites, three of which are impact sites (Sites 3, 4, 5). The greatest number of frogs detected were at Site 5 with 83 individual *Litoria lesueuri* recorded.

Overall, in 2020, the impact Sites had higher diversity and abundance compared to Spring 2020 control Sites (Table 9). This result is strange; may be explained by the survey nights being cooler and potentially not optimal or too early in the season for any large breeding events such that was found at Site 4 of *Litoria lesueuri,* which spiked the impact Sites abundance results this year. The annual rainfall was also good leading up to the surveys and may have triggered a breeding event around the time of survey for this species.

The statistical analysis has been applied to determine if there is an interaction in the assemblage of frogs present Before and After mining and, at Control and Impact Sites, across all data (taking the average of Spring and Autumn results).

Table 10: Statistical ANOVA for interactions across all frog data

	Df	SumOfSqs	R2	F	p
control	**1**	**1.118**	**0.163**	**6.045**	**0.001**
BA	**1**	**0.492**	**0.072**	**2.661**	**0.019**
control:BA	1	0.064	0.009	0.343	0.922
Residual	28	5.18	0.756		
Total	31	6.854	1		

*Df= degrees frequency, SumOfsq = Sum of squares, R2= R-squared , F= factorial index, P= significance value

There was no significant interaction between Control/Impact and Before/After in frog communities (ANOVA, $F_{(1,28)}$=0.343, p=0.9). There was a significant effect of Before/After in frog communities (ANOVA, $F_{(1,28)}$=2.6, p=0.019). This means frog communities differed before and after the mining event. There was a significant difference between control and impact Sites (ANOVA, $F_{(1,28)}$=6.04, p=0.001). This means control and impact Sites were innately different.

In Table 11 the Tukey's HSD analysis showed a significant difference between the following paired variables: Impact After and Control After, Control Before and Control After, Impact Before and Control After.

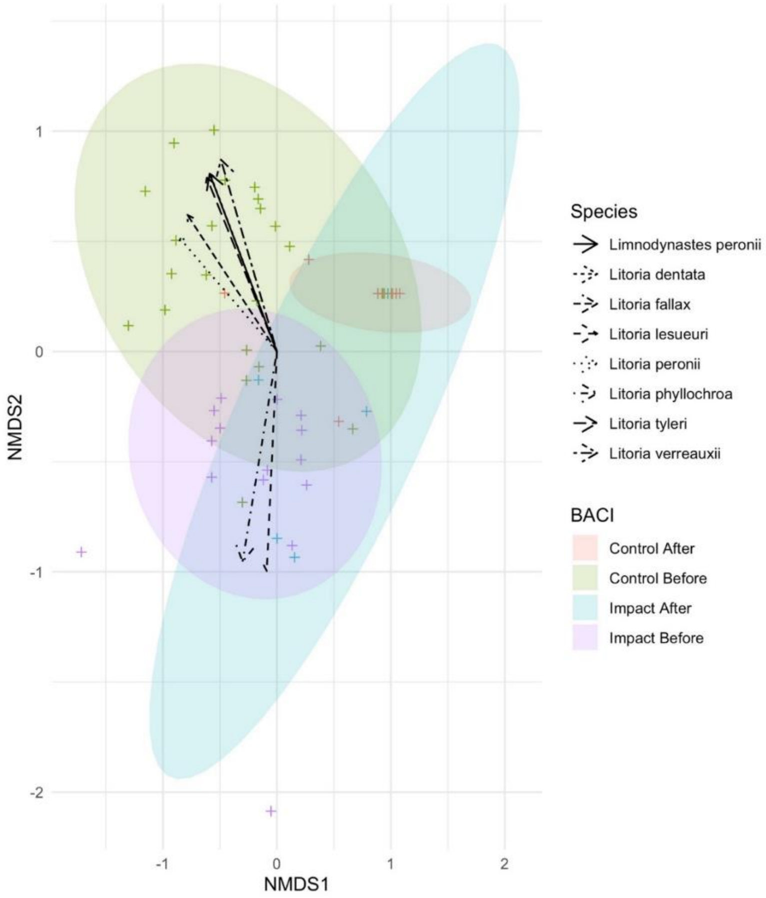
Table 11: Tukey's HSD for interactions across all frog data

	diff	lwr	upr	p
Impact.after-Control.after	0.276	0.053	0.499	0.009
Control.before-Control.after	0.323	0.158	0.487	<0.01
Impact.before-Control.after	0.304	0.126	0.483	<0.01
Control.before-Impact.after	0.047	-0.146	0.239	0.918
Impact.before-Impact.after	0.028	-0.176	0.232	0.984
Impact.before-Control.before	-0.019	-0.157	0.119	0.984

Control before and control after are significantly different which suggests that the difference between before mining and after mining (Before and After) was changed at the control Sites but not at the Impact Sites. This is represented visually below in Graph 5 and Graph 6.

It would suggest a reduction in individuals detected at control Sites and a spike in one species at an impact site. This may be explained due to a breeding event on the night of survey, triggered by recent good weather and rainfall.

There was overlap in the confidence ellipses for all treatments in terms of cover for all data. The stress was reasonable (0.16) indicating that this is a decent visualisation of frog assemblages, and that both impact and control Sites after mining had quite similar assemblages and both impact and control Sites before mining had quite similar assemblages.



Graph 5: Non-metric Multidimensional Scaling (NMDS) graph for frog abundance for all data (Autumn/ Spring combined).

The shift of the control after ellipse, down and right, shows there was change in assemblage. The same for the impact after ellipse, longer tilting to the right. This is the visual representation of the data presented above (Graph 5).

In comparison to the statistical analysis for community assemblage of frogs for all data, is understanding if there was an interaction in the community assemblage of frogs across Spring only data (taking the average of Spring Before) Table 12

Table 12: Statistical ANOVA for interactions across Spring frog data

	Df	SumOfSqs	R2	F	p
control	1	1.076	0.287	14.321	0.001
BA	1	0.55	0.146	7.317	0.001
control:BA	1	0.024	0.006	0.319	0.836
Residual	28	2.104	0.56		
Total	31	3.753	1		

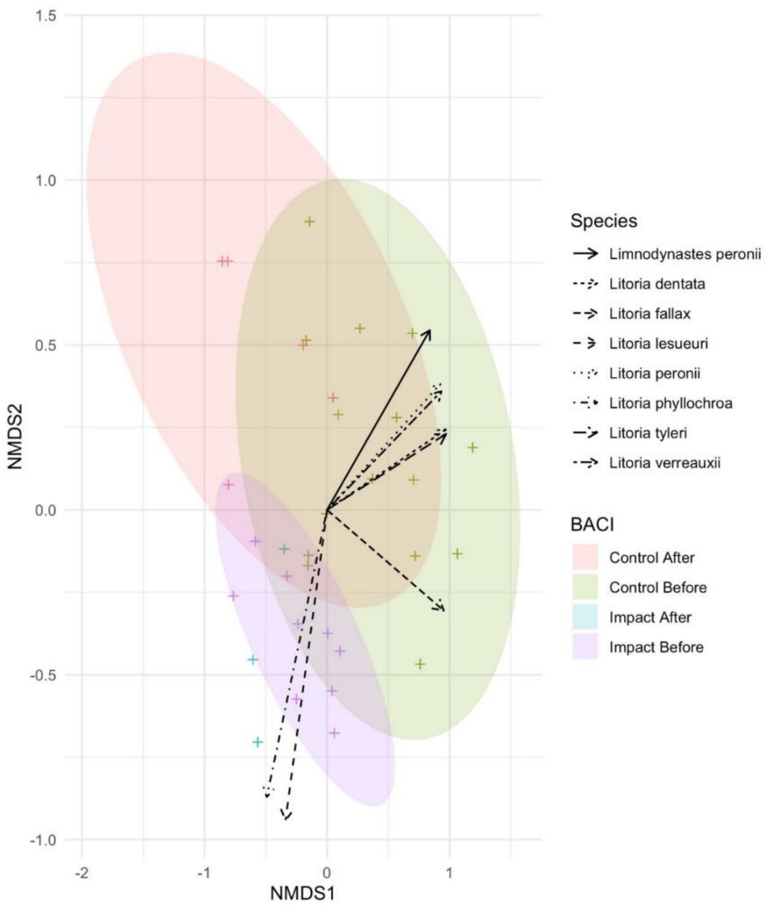
There was a significant difference in frog communities in Spring at the Control Sites compared to the Impact Sites (ANOVA, $F_{(1,28)}$=14.321, p=0.001), and a significant difference in frog communities in Spring between Before and After (ANOVA, $F_{(1,28)}$=7.317, p=0.001). There was no significant interaction in Spring between Control/Impact and Before/After sites (ANOVA, $F_{(1,28)}$=0.319, p=0.836). This suggests that there is no definite mining impacts observed in the frog abundance.

Table 13: Tukey's HSD for interactions across Spring frog data

	diff	lwr	upr	p
Impact.after-Control.after	0.002	-0.187	0.192	1
Control.before-Control.after	0.106	-0.029	0.24	0.164
Impact.before-Control.after	0.003	-0.142	0.148	1
Control.before-Impact.after	0.103	-0.061	0.267	0.337
Impact.before-Impact.after	0.001	-0.173	0.174	1
Impact.before-Control.before	-0.102	-0.212	0.007	0.074

In Table 13 the Tukey's HSD analysis showed no significant difference in Spring frog communities between any two Sites.

NMDS is missing an ellipse for Impact After due to insufficient sample size. This will likely be rectified in coming years with further data collection. Most likely this also impacted the ANOVA results earlier, though only time will tell. Stress was 0.17, indicating that this is a reasonable representation of the frog community. The control after ellipses (red), there was a shift away from control before ellipses (green), this may be due to the spike in impact records skewing the results to favour impact Sites.



Graph 6: Non-metric Multidimensional Scaling (NMDS) graph for frog abundance for Spring data.

3.3 Discussion

The Before data was collected across a period of low annual rainfall; zero months above annual average in 2017, four months in 2018 and one month in 2019. Similarly, temperatures over this period were above average; with five months in 2017, ten months in 2018 and all twelve months in 2019. The fluctuations of Before data may have skewed the averages to have large variations.

Using the Before ('before') data and comparing it to after aims to determine if there are any significant differences in the vegetation communities and frog assemblages present since mining ('after'). Overall, there is no detectable impact of mining at this stage. However, only one set of 'after' mining data has been collected and used in the analysis to date. It is recommended to complete more sampling over the next year (2021) during Autumn and Spring to continue to monitor this more thoroughly, as there are indications of assemblage shifts.

There is expected to be a varying amount of time; depending on the species and tolerance to stress; between the reduction (if any) in water and/or resources within the creeks and riparian zone and the response to plant growth or amphibian breeding events. If the stress is prolonged in general there would be visible signs of plant stress (yellowing, dieback) in the mature perennial species, the vegetation cover is also expected to reduce over time. Also, with amphibians, we might expect to see low frog abundance in common species, such as *Crinia* signifiera. At present it is difficult to disentangle the effect of mining from stochastic effects, for example weather variation among years, especially the variability in climatic conditions experienced over 2019 and 2020.

Most Sites have shown variability in frog detection rates over the different monitoring events, resulting in similarities between different Sites as opposed to similarities between years for the same Sites. The low frog counts observed during some surveys are likely due to the dry conditions experienced prior to and during those surveys. Greater frog numbers were detected when there was substantial rain prior to the survey or light rain with warm conditions during the survey. The recent rains in early summer 2020 brought large debris and sediment movement within the creeks potentially having a negative impact on the frog populations. As mentioned above, overall, there is no detectable impact of mining at this stage. However, only one set of ‘after’ mining data has been collected and used in the analysis to date. there appears to be no impact of mining, though it is recommended to complete more sampling over the next year 2021 during Autumn and Spring to enable a more robust comparison of frog assemblages before and after mining.

The 2020 monitoring results indicate that riparian vegetation and amphibian population parameters are predominantly within a reasonable range of previously measured Before data values (as supported by statistical analysis) and therefore the TARP is listed as normal. Consequently, no response is required and Tahmoor will continue the Subsidence Monitoring Program, which includes monitoring of biodiversity (Table 17, Table 18; Appendix 6).

4. Summary and conclusion

Eight Sites, including three impact and five control Sites, were monitored. The key results of the Spring riparian and amphibian monitoring include:

Riparian monitoring:

- River-flat Eucalypt Forest, which is listed as an Endangered Ecological Community under the BC Act, was recorded at control Site 9 with a high level of weed infestation (119.7% cover across the combined growth stratums).
- Floristic composition and vegetation cover at each Site increase by 15 percent at the impact Sites and 14% at control Sites, this may be due to the weather and increased rainfall across 2020.
- Impact Sites had a slightly lower mean species richness and percentage vegetation cover than control Sites, although the exotic cover in the control Sites it high at approximately 28.9 percent compared to one percent at impact Sites.
- Anthropogenic influences were observed at Sites that had been impacted by human disturbance, particularly weeds and altered flow regimes.
- Sites 7, 8 and 9 tended to have higher fertility and nutrient loads, which lead to higher species diversity and generally more exotic species. These Sites appeared to be more influenced by seasonal changes than Sites further up the catchment (Sites 4, 5, 6 and 10), which tended to be protected in deep gullies and canyons.

Amphibian monitoring:

- Frog detection rates were variable between Before monitoring events and impact monitoring event 2020, for most Sites. There was a significant difference between control Sites and impact Sites, with the reduction in control Sites. One impact site had an increase in individuals of one species. This may be due to the recent rainfall and triggered a breeding event at Site 4.
- The targeted threatened frog species were not detected. The 6 species detected represent an otherwise normal array of common and robust species for the study environments and conditions.
- The targeted threatened frog species appear not to be present in the Study Area, at least not in a population that can be meaningfully monitored. While the study environment contains superficially suitable habitat, it is possible that the species would no longer be able to survive in the area due to predation pressures from two introduced predators: the Plague Minnow (*Gambusia holbrooki*) and the Yabby (*Cherax destructor*), both of which were detected at all Sites. The frog community present contains at least 12 species which are likely still viable indicators of impending or current environmental change.
- Frog detection rates were variable between monitoring events for most Sites, most likely due to the highly variable weather and climatic conditions across the survey periods. There was a significant difference between control Sites and impact Sites (detection being greater at impact Sites).

No thresholds within the Trigger Action Response Plan (TARP) in the Biodiversity Management Plan (SIMEC 2019) have been triggered, and therefore, no remedial management actions are required (Table 17; Table 18).

It is recommended that, due to the long term processes in responses of plants and animals, the annual monitoring continue in Spring and Autumn for riparian vegetation monitoring and in Spring and Autumn (or after rain deemed suitable by the ecologist) for amphibian monitoring to permit comparison between impact and control Sites, before and after mining impacts, to allow for temporal changes to be assessed as the project progresses. After one season of impact monitoring this has shown the variability across the seasons and weather experienced, over time this program will allow changes to be seen.

5. References

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Appendix 1 - Detailed Site Maps

Site 3 - Amphibian and riparian vegetation plot

Tahmoor Western Domain - Riparian and Amphibian Monitoring 2017 - 2020

Niche PM: Matthew Russell
Niche Proj. #: 6149
Client: Tahmoor Coal Pty Ltd

Appendix 1 - Map 1

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Site 4 - Amphibian and riparian vegetation plot

Tahmoor Western Domain - Riparian and Amphibian Monitoring 2017 - 2020

Niche PM: Matthew Russell
Niche Proj. #: 6149
Client: Tahmoor Coal Pty Ltd

Appendix 1 - Map 2

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Site 5 - Amphibian and riparian vegetation plot

Tahmoor Western Domain - Riparian and Amphibian Monitoring 2017 - 2020

Niche PM: Matthew Russell
Niche Proj. #: 6149
Client: Tahmoor Coal Pty Ltd

Appendix 1 - Map 3

Drawn by: GT File: T:\spatial\projects\a5200\a5299_Tahmoor_Western_Domain_MonMaps\report\5299_Appendix_1_Map_DDP.mxd Last updated: 18-Dec-19 5:02:49 PM

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Site 6 - Amphibian and riparian vegetation plot

Tahmoor Western Domain - Riparian and Amphibian Monitoring 2017 - 2020

Niche PM: Matthew Russell
Niche Proj. #: 6149
Client: Tahmoor Coal Pty Ltd

Appendix 1 - Map 4

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Niche Environment and Heritage

Site 7 - Amphibian and riparian vegetation plot

Tahmoor Western Domain - Riparian and Amphibian Monitoring 2017 - 2020

Niche PM: Matthew Russell
Niche Proj. #: 6149
Client: Tahmoor Coal Pty Ltd

Appendix 1 - Map 5

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GDA 1994 MGA Zone 56

Site 8 - Amphibian and riparian vegetation plot

Tahmoor Western Domain - Riparian and Amphibian Monitoring 2017 - 2020

Niche PM: Matthew Russell
Niche Proj. #: 6149
Client: Tahmoor Coal Pty Ltd

Appendix 1 - Map 6

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GDA 1994 MGA Zone 56

Site 9 - Amphibian and riparian vegetation plot

Tahmoor Western Domain - Riparian and Amphibian Monitoring 2017 - 2020

Niche PM: Matthew Russell
Niche Proj. #: 6149
Client: Tahmoor Coal Pty Ltd

Appendix 1 - Map 7

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GDA 1994 MGA Zone 56

Site 10 - Amphibian and riparian vegetation plot

Tahmoor Western Domain - Riparian and Amphibian Monitoring 2017 - 2020

Niche PM: Matthew Rusell
Niche Proj. #: 6149
Client: Tahmoor Coal Pty Ltd

Appendix 1 - Map 8

Drawn by: GT File: T:\spatial\projects\a5200\a5299_Tahmoor_Western_Domain_MonMaps\report\5299_Appendix_1_Map_DDP.mxd Last updated: 18-Dec-19 5:02:49 PM

Appendix 2. Monitoring Site locations, vegetation plots and frog survey transect maps

Table 14. Riparian and amphibian monitoring Site locations

Plot Code	Creek Name	Description	Type	Latitude	Longitude
Site 3	Cedar Creek	At Newlands Gully	Impact	-34.16882	150.58981
Site 4	Matthews Creek	In canyon just above Cedar Creek	Impact	-34.17310	150.58738
Site 5	Matthews Creek	In canyon	Impact	-34.17795	150.58656
Site 6	Cedar Creek	In canyon	Control	-34.17415	150.58180
Site 7	Cedar Creek	Above Cedar Creek Road	Control	-34.18220	150.56143
Site 8	Cedar Creek	Above Scroggies Road	Control	-34.18926	150.54626
Site 9	Stonequarry Creek	Above Mulhollands Road	Control	-34.16246	150.58566
Site 10	Stonequarry Creek	In canyon at The Vintage Estate	Control	-34.16966	150.57411

Appendix 3. Riparian vegetation monitoring results 2020 & All frog monitoring results

*denotes exotic species

Family	Species	i03	i04	i05	c06	c07	c08	c09	c10
Acanthaceae	*Pseuderanthemum variabile*			0.1					
Adiantaceae	*Adiantum aethiopicum*	5	3	0.1	0.2	2	5		0.2
Adiantaceae	*Cheilanthes spp.*		0.1						
Anthericaceae	*Chlorophytum comosum**		0.3						
Apiaceae	*Foeniculum vulgare*							0.1	
Apiaceae	*Xanthosia tridentata*	0.1	0.1						
Asteraceae	*Ageratina adenophora**	0.1	0.3	0.1			0.5	30	
Asteraceae	*Anthemis arvensis*							0.1	
Asteraceae	*Arctotheca calendula*					0.1			
Asteraceae	*Bidens pilosa**	0.1	0.1	0.1		0.1		1	0.1
Asteraceae	*Cirsium vulgare**					0.1	0.1	0.1	
Asteraceae	*Conyza bonariensis**	0.1	0.1			0.1	0.1	0.1	
Asteraceae	*Cyanthillium cinereum*	0.2							
Asteraceae	*Delairea odorata**			0.1					
Asteraceae	*Gnaphalium purpureum*		0.1					0.1	
Asteraceae	*Hypochaeris radicata**					0.3	0.1		0.1
Asteraceae	*Senecio madagascariensis**	0.1	0.3			0.1	0.1	0.3	0.1
Asteraceae	*Sigesbeckia orientalis*			0.2		0.5	0.2	0.1	0.2
Asteraceae	*Solidago canadensis*							0.2	
Asteraceae	*Tagetes minuta**					0.1	0.1		
Bignoniaceae	*Pandorea pandorana*				0.1				0.1
Blechnaceae	*Blechnum cartilagineum*				3				
Blechnaceae	*Doodia aspera*			1					0.1

Family	Species	i03	i04	i05	c06	c07	c08	c09	c10
Brassicaceae	*Raphanus raphanistrum*							0.1	
Campanulaceae	*Wahlenbergia spp.*		0.1	0.1					
Caprifoliaceae	*Lonicera japonica**					0.2	4		0.1
Caryophyllaceae	*Stellaria media**							1	
Casuarinaceae	*Allocasuarina littoralis*								0.3
Commelinaceae	*Commelina cyanea*			0.2		0.1			
Commelinaceae	*Tradescantia fluminensis**				0.1		0.5	0.5	
Convolvulaceae	*Dichondra repens*			0.1		0.1	0.1		
Cunoniaceae	*Ceratopetalum apetalum*				35		0.1		2
Cyperaceae	*Carex inversa*	0.3	0.1	0.1			0.2		0.1
Cyperaceae	*Cyperus spp.*	0.3						2	
Cyperaceae	*Lepidosperma laterale*		0.2	0.1					
Cyperaceae	*Schoenus melanostachys*		0.1	0.1			2		0.2
Dennstaedtiaceae	*Pteridium esculentum*	0.1				0.1	40		
Dicksoniaceae	*Calochlaena dubia*				0.5				
Dilleniaceae	*Hibbertia scandens*					0.1			
Ericaceae	*Leucopogon lanceolatus*		0.2						
Ericaceae	*Lissanthe strigosa*								0.1
Euphorbiaceae	*Ricinus communis*							0.1	
Fabaceae (Faboideae)	*Glycine clandestina*						0.2		
Fabaceae (Faboideae)	*Glycine tabacina*			0.3		0.1	0.3		
Fabaceae (Mimosoideae)	*Acacia dealbata*	0.1	3						
Fabaceae (Mimosoideae)	*Acacia decurrens*					0.2			
Fabaceae (Mimosoideae)	*Acacia linearifolia*	0.1							
Fabaceae (Mimosoideae)	*Acacia linifolia*			0.1					
Fabaceae (Mimosoideae)	*Acacia longifolia*					1	0.5		0.5
Fabaceae (Mimosoideae)	*Acacia terminalis*								0.2
Geraniaceae	*Geranium solanderi*			0.1		0.2	0.3		0.2

Family	Species	i03	i04	i05	c06	c07	c08	c09	c10
Gleicheniaceae	*Sticherus flabellatus*				0.4				
Haloragaceae	*Gonocarpus tetragynus*		0.1						
Juncaceae	*Juncus spp.*		0.1				0.1		
Lamiaceae	*Plectranthus parviflorus*			0.1					0.2
Lamiaceae	*Plectranthus spp.*		0.5				0.1		
Lauraceae	*Cassytha glabella*		0.1						
Lobeliaceae	*Pratia purpurascens*			0.1		0.1	0.2		
Lomandraceae	*Lomandra longifolia*	0.2	35	5	0.2	2	2	0.1	0.1
Lomandraceae	*Lomandra multiflora*								0.1
Luzuriagaceae	*Geitonoplesium cymosum*	0.2							0.1
Malvaceae	*Sida rhombifolia**					0.1		0.1	
Meliaceae	*Melia azedarach*							0.1	
Myrsinaceae	*Anagallis arvensis**			0.1		0.5	0.1	0.5	
Myrsinaceae	*Angophora costata*					5		5	
Myrtaceae	*Backhousia myrtifolia*		10	40	1				40
Myrtaceae	*Callistemon viminalis*					0.1			
Myrtaceae	*Eucalyptus deanei*						3		10
Myrtaceae	*Eucalyptus elata*	20							
Myrtaceae	*Eucalyptus piperita*					10	35		
Myrtaceae	*Eucalyptus punctata*					2			
Myrtaceae	*Eucalyptus tereticornis*	5						5	
Myrtaceae	*Leptospermum polygalifolium*					0.3			
Myrtaceae	*Melaleuca linariifolia*			0.5		10	0.1		1
Myrtaceae	*Melaleuca styphelioides*	0.5							
Myrtaceae	*Tristaniopsis laurina*	35	15	5	30		0.1		3
Ochnaceae	*Ochna serrulata*	0.1							
Oleaceae	*Ligustrum lucidum**							5	
Oleaceae	*Ligustrum sinense**	0.5			0.1	15		55	0.2

Family	Species	i03	i04	i05	c06	c07	c08	c09	c10
Oleaceae	*Notelaea longifolia*				2				
Osmundaceae	*Todea barbara*	0.1					0.1		0.1
Oxalidaceae	*Oxalis perennans*	0.1	0.1	0.1			0.2		
Passifloraceae	*Passiflora spp.**						0.1		
Phormiaceae	*Dianella caerulea*			0.1		0.2	1		0.1
Phyllanthaceae	*Phyllanthus gunnii*					0.1	0.1		
Phyllanthaceae	*Phyllanthus tenellus*					0.5	0.3		
Phyllanthaceae	*Poranthera spp.*						0.1		
Pittosporaceae	*Bursaria spinosa*	0.1	0.3	0.1		0.2			1
Pittosporaceae	*Pittosporum revolutum*						0.2		
Pittosporaceae	*Pittosporum undulatum*					1			
Plantaginaceae	*Plantago lanceolata*	0.1	0.1				0.1	0.1	0.1
Poaceae	*Cynodon dactylon*			0.3					
Poaceae	*Echinopogon spp.*						0.1		
Poaceae	*Ehrharta erecta**		0.2			0.1		0.5	0.2
Poaceae	*Entolasia marginata*	1	0.1	0.5	0.1	2			1
Poaceae	*Entolasia stricta*		0.2		0.1		0.3		0.2
Poaceae	*Eriochloa crebra*			5					
Poaceae	*Imperata cylindrica*					0.5	5		
Poaceae	*Microlaena stipoides*	0.1			0.1	0.4	0.2	0.4	0.2
Poaceae	*Oplismenus hirtellus*	0.2	0.2	0.2	0.1	0.2	0.5	0.2	0.1
Poaceae	*Pennisetum clandestinum**					0.1	0.2		
Poaceae	*Setaria pumila*	0.1				1	0.2		
Polygonaceae	*Persicaria decipiens*	0.2	0.2			0.2			0.2
Polygonaceae	*Rumex brownii*		0.3	0.1		0.2	0.1		
Portulacaceae	*Portulaca spp.*							0.1	
Proteaceae	*Stenocarpus salignus*			0.5	1				
Ranunculaceae	*Clematis decipiens*								0.1

Family	Species	i03	i04	i05	c06	c07	c08	c09	c10
Rosaceae	*Rubus fruticosus**					0.1	0.2		
Rubiaceae	*Galium spp.*	0.1							
Rubiaceae	*Morinda jasminoides*	1		0.3	1				5
Rubiaceae	*Opercularia hispida*	0.1	0.8	0.2		0.1	0.1		0.5
Rutaceae	*Zieria smithii*		0.1	0.1			0.1		0.5
Sapindaceae	*Dodonaea triquetra*					0.1	0.5		
Smilacaceae	*Smilax glyciphylla*	0.1			0.5	0.1			
Solanaceae	*Solanum mauritianum**						0.1		
Solanaceae	*Solanum nigrum**	0.1	0.1	0.1		0.1	0.2	0.5	
Solanaceae	*Solanum prinophyllum*	0.1	0.2	0.4		0.2	0.1		0.1
Sterculiaceae	*Lasiopetalum ferrugineum*						0.4		
Stylidiaceae	*Stylidium lineare*		0.1						
Urticaceae	*Urtica incisa*							0.1	
Verbenaceae	*Lantana camara**							25	0.1
Verbenaceae	*Verbena bonariensis**					0.1	0.1	0.1	
Violaceae	*Viola hederacea*	0.1		0.1	0.1		0.4		0.1

Treatment Site	Date	Time	Vegetation type	Vegetation condition	Bearing	Number of large trees	Tree stem class size	Number of hollow trees	Fallen logs	Mean litter
Impact 03	9/11/2020	13:44	Water gum peppermint gully	Good	90	5	<5,5-9,10-19,20-29,50-79,80+	5	68	27
Impact 04	9/11/2020	12:43	Backhousia gully rainforest	Good	190	0	<5,5-9,10-19,20-29	0	67	23
Impact 05	10/11/2020	13:52	Backhousia gully rainforest	Good	185	2	<5,5-9,10-19,20-29,30-49,80+	1	15	48
Control 06	9/11/2020	10:28	Coachwood rainforest gully	Good	270	2	<5,5-9,10-19,20-29,30-49,80+	3	54	65
Control 07	10/11/2020	11:06	Peppermint gully forest	Moderate	250	2	5-9,10-19,20-29,30-49,80+	2	20	25
Control 08	10/11/2020	9:42	Peppermint gully forest	Moderate	240	2	5-9,10-19,20-29,30-49,80+	2	46	42
Control 09	28/09/2020	17:34	River-flat eucalypt forest	Degraded	245	5	<5,5-9,10-19,20-29,30-49,80+	2	20	5
Control 10	10/11/2020	11:54	Backhousia gully rainforest	Good	180	2	<5,5-9,10-19,20-29,30-49,80+	1	8	47

Frog data 2017 data

	Crinia signifera	*Limnodynastes dumerilii*	*Limnodynastes peronii*	*Limnodynastes tasmaniensis*	*Litoria dentata*	*Litoria fallax*	*Litoria latopalmata*	*Litoria lesueuri*	*Litoria peronii*	*Litoria phyllochroa*	*Litoria tyleri*	*Litoria verreauxii*	*No Frogs*	*Uperoleia laevigata*	*All species*
i03	7	0	6	0	0	0	0	1	0	11	0	0	0	0	25
i04	2	0	2	0	0	3	0	5	0	2	0	0	0	0	14
i05	9	0	0	0	0	0	0	1	0	5	0	0	0	0	15
c06	30	0	4	0	0	0	0	1	1	9	0	0	0	0	45
c07	2	0	1	0	0	50	0	0	3	0	0	1	0	0	57
c08	5	0	2	0	0	2	1	0	1	0	0	0	0	0	11
c09	20	1	4	0	0	1	0	1	1	0	0	1	0	0	29
c10	50	0	12	0	0	0	0	0	0	0	0	0	0	0	62
Impact Mean	6	0	2.666667	0	0	1	0	2.333333	0	6	0	0	0	0	18
Control Mean	21.4	0.2	4.6	0	0	10.6	0.2	0.4	1.2	1.8	0	0.4	0	0	40.8

Frog data 2018 data

	Crinia signifera	*Limnodynastes dumerilii*	*Limnodynastes peronii*	*Limnodynastes tasmaniensis*	*Litoria dentata*	*Litoria fallax*	*Litoria latopalmata*	*Litoria lesueuri*	*Litoria peronii*	*Litoria phyllochroa*	*Litoria tyleri*	*Litoria verreauxii*	*No Frogs*	*Uperoleia laevigata*	*All*
i03	15	0	1	0	0	0	0	1	0	9	0	0	0	0	26
i04	3	0	1	0	0	2	0	16	2	16	0	0	0	0	40
i05	6	0	2	0	0	0	0	7	2	8	0	0	0	0	25
c06	25	0	2	0	0	2	0	1	0	3	0	0	0	0	33
c07	3	0	4	0	8	3	0	0	10	0	8	3	0	0	39
c08	21	0	9	0	0	3	0	0	13	0	3	2	0	0	51

	Crinia signifera	*Limnodynastes dumerilii*	*Limnodynastes peronii*	*Limnodynastes tasmaniensis*	*Litoria dentata*	*Litoria fallax*	*Litoria latopalmata*	*Litoria lesueuri*	*Litoria peronii*	*Litoria phyllochroa*	*Litoria tyleri*	*Litoria verreauxii*	*No Frogs*	*Uperoleia laevigata*	*All*
c09	8	0	7	2	0	0	0	0	0	0	0	2	0	0	19
c10	18	0	8	0	1	2	0	0	1	0	0	0	0	0	30
Impact Mean	8	0	1.333333	0	0	0.666667	0	8	1.333333	11	0	0	0	0	30.33333
Control Mean	15	0	6	0.4	1.8	2	0	0.2	4.8	0.6	2.2	1.4	0	0	34.4

Frog data 2019

	Crinia signifera	*Limnodynastes dumerilii*	*Limnodynastes peronii*	*Limnodynastes tasmaniensis*	*Litoria dentata*	*Litoria fallax*	*Litoria latopalmata*	*Litoria lesueuri*	*Litoria peronii*	*Litoria phyllochroa*	*Litoria tyleri*	*Litoria verreauxii*	*No Frogs*	*Uperoleia laevigata*	*All species*
i03	99	0	0	0	0	0	0	4	1	14	0	0	0	0	118
i04	20	0	0	0	0	6	0	20	2	1	0	0	0	0	49
i05	1	0	2	0	0	0	0	8	0	1	0	0	0	0	12
c06	10	0	1	0	0	0	0	0	1	1	0	0	0	0	13
c07	2	0	0	0	0	0	0	0	1	0	0	0	0	0	3
c08	71	0	5	0	0	1	0	0	20	0	0	0	0	0	97
c09	4	0	1	1	0	1	0	0	1	0	0	0	0	0	8
c10	41	0	1	1	0	0	0	0	0	1	0	1	0	0	45
Impact Mean	40	0	0.666667	0	0	2	0	10.66667	1	5.333333	0	0	0	0	59.66667
Control Mean	25.6	0	1.6	0.4	0	0.4	0	0	4.6	0.4	0	0.2	0	0	33.2

Appendix 4. Photo-point monitoring 2017-2020 (4 years)


Plate 2: Spring 2017 Site 3


Plate 3: Spring 2018 Site 3


Plate 4: Spring 2019 Site 3


Plate 5: Spring 2020 Site 3


Plate 6: Spring 2017 Site 4


Plate 7: Spring 2018 Site 4


Plate 8: Spring 2019 Site 4


Plate 9: Spring 2020 Site 4


Plate 10: Spring 2017 Site 5


Plate 11: Spring 2018 Site 5


Plate 12: Spring 2019 Site 5


Plate 13: Spring 2020 Site 5

Plate 14: Spring 2017 Site 6

Plate 15: Spring 2018 Site 6

Plate 16: Spring 2019 Site 6

Plate 17: Spring 2020 Site 6

Plate 18: Spring 2017 Site 7

Plate 19: Spring 2018 Site 7

Plate 20: Spring 2019 Site 7

Plate 21: Spring 2020 Site 7

Plate 22: Spring 2017 Site 8

Plate 23: Spring 2018 Site 8

Plate 24: Spring 2019 Site 8

Plate 25: Spring 2020 Site8

Plate 26: Spring 2017 Site 9

Plate 27: Spring 2018 Site 9

Plate 28: Spring 2019 Site 9

Plate 29: Spring 2020 Site 9

Plate 30: Spring 2017 Site 10

Plate 31: Spring 2018 Site 10

Plate 32: Spring 2019 Site 10

Plate 33: Spring 2020 Site 10

Appendix 5: Climate data

Table 15: Climate data

Rainfall totals (Picton) and temperature monthly averages (Camden) during the study period compared with long-term monthly averages. Sampling months are highlighted in dark grey.

Month	Rainfall mm	Long-term average Rainfall mm	% of Average Rainfall	Mean Max Temperature °C	Long-term Mean Max Temp. °C	Temperature difference °C
July 2017	1.6	36.2	4%	18.2	17.3	+0.9
Aug 2017	22.0	41.5	53%	19.2	19.1	+0.1
Sept 2017	0	38.3	0%	24.1	22.0	+2.1
Oct 2017	48.8	60.7	80%	26.1	24.4	+1.7
Nov 2017	31.0	75.1	41%	26.0	26.3	-0.3
Dec 2017	**25**	**56.4**	**44%**	**31.8**	**28.6**	**+3.2**
Jan 2018	41.2	79.8	52%	32.9	29.7	+3.2
Feb 2018	47.2	97.3	49%	30.7	28.7	+2.0
Mar 2018	45.6	89.6	51%	28.3	26.8	+1.5
April 2018	10.6	65.8	16%	27.9	24.0	+3.9
May 2018	3.0	53.0	6%	22.2	20.7	+1.5
June 2018	48.0	66.6	72%	17.7	17.7	0.0
July 2018	1.6	35.5	4%	19.5	17.4	+2.1
Aug 2018	6.4	40.7	16%	19.2	19.1	+0.1
Sept 2018	40.0	38.3	104%	22.2	22.0	+0.2
Oct 2018	108.0	61.8	175%	23.7	24.3	-0.6
Nov 2018	87.8	75.4	116%	26.8	26.3	+0.5
Dec 2018	**122.8**	**57.9**	**212%**	**30.2**	**28.6**	**+1.6**
Jan 2019	77.4	79.7	97%	33.3	29.7	+3.6
Feb 2019	18.0	95.4	19%	30.2	28.7	+1.5
Mar 2019	66.6	89.6	74%	28.0	26.9	+1.1
Apr 2019	9.2	65.8	14%	25.3	24	+1.3
May 2019	9.8	52	19%	22.1	20.7	+1.4
Jun 2019	47.4	66.2	72%	18.5	17.8	+0.7
Jul 2019	20.6	35.1	59%	18.8	17.4	+1.4
Aug 2019	18.4	40.2	46%	19.8	19.1	+0.7
Sep 2019	45.4	38.5	118%	23.2	22.1	+1.1
Oct 2019	**19.4**	**60.9**	**32%**	**26.9**	**24.4**	**+2.5**
Nov 2019	38.6	74.6	52%	30.2	26.4	+3.8
Dec 2019	0.2	56.6	<0.01%	31.8	28.7	+3.1
Jan 2020	89.0	79.9	110%	30.9	29.8	-1.1
Feb 2020	368.8	101.6	362%	28.8	28.7	+0.1
Mar 2020	88.4	89.6	98%	25.9	26.9	-1.0
April 2020	**40.6**	65.8	62%	24.0	24.0	0

Month	Rainfall mm	Long-term average Rainfall mm	% of Average Rainfall	Mean Max Temperature °C	Long-term Mean Max Temp. °C	Temperature difference °C
May 2020	**51.6**	52	99%	19.9	20.7	+0.8
June 2020	**28.2**	66.2	43%	18.3	17.8	-0.5
Jul 2020	**66.2**	35.1	188%	18.0	17.4	-0.6
Aug 2020	**82.6**	40.2	205%	18.7	19.1	+0.4
Sep 2020	**36.4**	**38.5**	**94%**	**22.5**	**22.1**	**-0.3**
Oct 2020	**89.4**	60.9	147%	25.3	24.4	-0.9
Nov 2020	**61.2**	74.6	82%	28.2	26.4	-1.6

Table 16: Rainfall (Picton) and temperature (on Site) conditions during each frog survey

Period	Start Date	Sites surveyed	Rain in previous 48 hours (mm)	Max temp (°C)	Min temp (°C)
December 2017	04/12/2017	3, 4, 5	14.2	20	18
	05/12/2017	6, 9, 10	5.6	22	19
	07/12/2017	7, 8	2.0	28	22
December 2018	04/12/2018	5, 9, 10	1.8	30.8	16
	05/12/2018	4, 8, 7	2.4	25.7	17
	06/12/2018	3, 6	2.4	17	16
October 2019	14/10/2019	9, 10	7.8	26.2	6.4
	16/10/2019	4, 6, 8	0	25.3	11.4
	21/10/2019	3, 5, 7	0	26.5	5.7
September 2020	28/09/2020	7, 9, 10	1.4	20.6	3.5
	29/09/2020	4, 5, 6	0	21.0	8.1
	30/09/2020	3, 8	0	19.2	6.7

Appendix 6 TARPs associated with terrestrial biodiversity

Table 17: TARPs associated with amphibian populations

Potential impact	Trigger	Action / Response
Decline in amphibian populations within watercourses of the Study Area	Normal	
	Monitoring indicates amphibian population parameters are predominantly within a reasonable range of Before data as supported by statistical analysis.	• No response required. • Continue Subsidence monitoring program. • Continue Biodiversity monitoring program.
	Within prediction	
	Monitoring indicates amphibian population parameters are predominantly not within a reasonable range of Before data as supported by statistical analysis. AND Subsidence monitoring program identifies potential for impact of watercourse parameters associated with sensitive amphibian habitat areas (within prediction compared to Before).	• Review and confirm monitoring data, cross check biodiversity monitoring data against other related environmental data (e.g. control Sites and benchmark data) and subsidence monitoring upon identification of the potential trigger. • Undertake further investigations as appropriate to confirm the potential issue and analyse data with the aim of determining whether the exceedance is likely to be mining related. • Assess need for any increase to monitoring frequency or additional monitoring where relevant. • Continue monitoring programs.
	Exceeds prediction	
	Monitoring indicates amphibian population parameters are significantly not within a reasonable range of Before data as supported by statistical analysis. AND Mining induced impacts (exceeds predication compared to Before) for watercourse parameters associated with sensitive amphibian habitat are identified by environmental monitoring.	• Notify OEH and relevant stakeholders within 7 days of current findings and proposed approach for investigation upon identification of the potential trigger. • Take all necessary steps to ensure that the exceedance ceases and does not recur. • Convene Tahmoor Coal Environmental Response Group to review response. • Implement remediation measures to the satisfaction of the secretary of DPE. • Review of mining design / predictions against mine design criteria. • Written reporting as per consent and relevant approvals.

Table 18: TARPs associated with amphibian populations

Potential impact	Triggers	Actions
Dieback and of riparian vegetation within watercourses of the Study Area	Normal	
	Monitoring indicates riparian vegetation parameters are predominantly within a reasonable range of Before data as supported by statistical analysis.	• No action or response required. • Continue Subsidence monitoring program. • Continue Biodiversity monitoring program.
	Within prediction	
	Monitoring indicates riparian vegetation parameters are predominantly not within a reasonable range of Before data as supported by statistical analysis. AND Subsidence monitoring program identifies potential for impact of watercourse parameters associated with sensitive riparian habitat areas (within prediction compared to Before).	• Review and confirm monitoring data, cross check Biodiversity monitoring data against other related environmental data (e.g. control Sites and benchmark data) and subsidence monitoring upon identification of the potential trigger. • Undertake further investigations as appropriate to confirm the potential issue and analyse data with the aim of determining whether the exceedance is likely to be mining related. • Assess need for any increase to monitoring frequency or additional monitoring where relevant. • Continue monitoring programs.
	Exceeds prediction	
	Monitoring indicates riparian vegetation parameters are significantly not within a reasonable range of Before data as supported by statistical analysis. AND Mining induced impacts (exceeds predication compared to Before) for watercourse parameters associated with riparian vegetation are identified by environmental monitoring.	• Notify OEH and relevant stakeholders within 7 days of current findings and proposed approach for investigation upon identification of the potential trigger. • Take all necessary steps to ensure that the exceedance ceases and does not recur. Convene Tahmoor Coal Environmental Response Group to review response. • Implement remediation measures to the satisfaction of the secretary of DPE. • Review of mining design / predictions against mine design criteria. • Written reporting as per consent and relevant approvals.

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Archaeological, built and landscape values

Environmental management and approvals
Impact assessments
Development and activity approvals
Rehabilitation
Stakeholder consultation and facilitation
Project management

Environmental offsetting
Offset strategy and assessment (NSW, QLD, Commonwealth)
Accredited BAM assessors (NSW)
Biodiversity Stewardship Site Agreements (NSW)
Offset site establishment and management
Offset brokerage
Advanced Offset establishment (QLD)