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Terrestrial Biodiversity Technical Report
Tahmoor North – Western Domain
Longwalls West 1 & West 2

Prepared for Tahmoor Coal | 11 July 2019

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Document control

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Glossary and list of abbreviations

Term or abbreviation	Definition
BC Act	*Biodiversity Conservation Act 2016*
CEEC	Critically Endangered Ecological Community
DP&E	Department of Planning and Environment
EEC	Endangered Ecological Community
EPBC Act	*Environment Protection and Biodiversity Conservation Act 1999*
GFC	GFG Alliance
ha	Hectare/s
km	Kilometre/s
LW	Longwalls
MNES	Matters of national environmental significance
PCT	Plant Community Type
ROM	Run of Mine
SIMEC	SIMEC Mining Division
SMP	Subsidence Management Plan
TCCO	Tahmoor Coking Coal Operations
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 (ROM) 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, trading as Tahmoor Coking Coal Operations (TCCO), is a subsidiary within the SIMEC Mining Division (SIMEC) of the GFG Alliance (GFG).

Tahmoor Coal has previously mined 31 longwalls to the north and west of the Tahmoor Mine's current pit top location. Tahmoor Coal is currently mining Longwall 32 in accordance with Development Consents and Subsidence Management Plan Approval.

Tahmoor Coal proposes to extent underground coal mining 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. The first two longwalls to be mined are LW W1 and Longwall West 2 (LW W2) (collectively referred to as LW W1-W2), 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 W1-W2 to address the Approval Conditions in accordance with DA 67/98 (as modified). 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 W1-W2 are located to the west of the township of Picton, between Matthews, Cedar and Stonequarry Creeks, the Main Southern Railway and the currently active longwall series. The layouts of the completed, active and proposed longwalls at the mine are shown in Drawings Nos. MSEC1019-01 and MSEC1019-02, provided in MSEC (2019), which have been illustrated on (herein referred to as the Study Area).

The Study Area is defined as the surface area that could be affected by the mining of LW W1-W2 as determined in MSEC (2019). As detailed in MSEC (2019), 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 W1-W2;
- The predicted limit of vertical subsidence, taken as the 20 mm subsidence contour, resulting from the extraction of LW W1-W2.

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 the LW W1-W2 on those values within the Study Area or likely to be impacted by far-field or valley related movements outside of the Study Area. Given a detailed assessment of greater subsidence impact predictions was carried out by Niche (2014), this TBTR has incorporated such findings.

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

This TBTR includes the following:

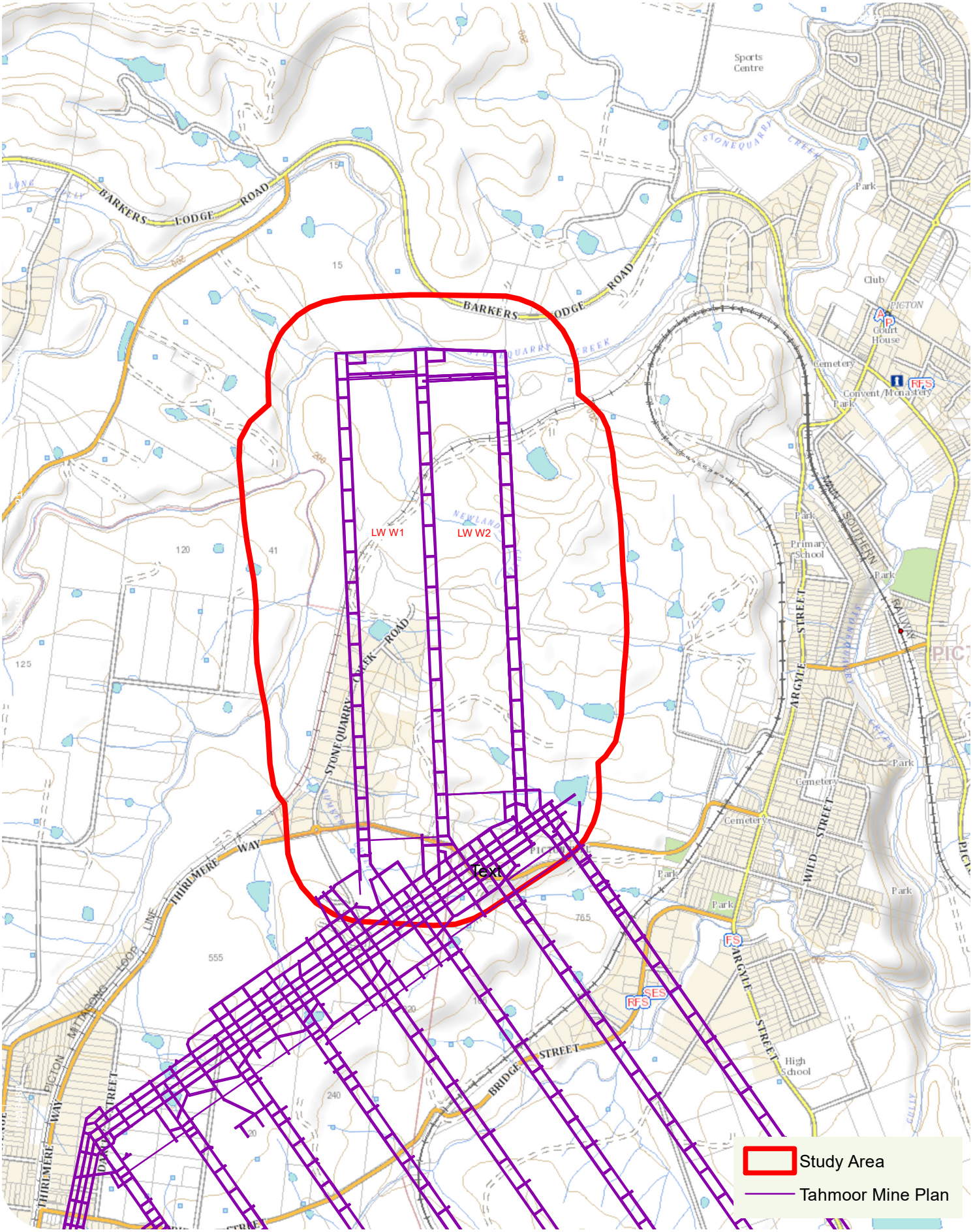
- Summary of the baseline data for existing habitat on the site, riparian vegetation condition, and threatened species habitat;
- Provisions for the management of potential impacts and environmental consequences of the proposed second workings on threatened species, threatened populations and their habitats, 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 this 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 text sections and attachments of this TBTR include the following:

Section 1	Provides an introduction to the TBTR for LW W1-W2, 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 W1-W2 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 W1-W2.
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 A	Niche (2019a), Tahmoor Mine Western Domain Terrestrial Ecology Baseline Monitoring Report - Baseline riparian vegetation and frog monitoring report 2019. Prepared for Tahmoor Coal June 2019.



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Tahmoor North – Western Domain - Longwalls West 1 & West 2

Terrestrial Biodiversity Technical Report
Study Area

Niche PM: Luke Baker
Niche Proj. #: 4794
Client: Tahmoor Coking Coal Operations

Figure 1

v2.0

2. Statuary Requirements

2.1 Project Approval

The proposed LW W1-W2 will be operating in the Tahmoor North mining area, and will be operated under Development Consents DA 57/93 and DA 67/98. 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.

This TBTR for LW W1-W2 is a component of the Tahmoor LW W1-W2 Extraction Plan. This TBTR has been prepared specifically to address Approval Condition Schedule 2 Condition 13H(vii)(d) of DA 67/98(as modified). 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, 2019b).

Table 1. Development consent condition relevant to this TBTR

Condition	Condition Requirement		Section Addressed
SUBSIDENCE **Performance Measures – Natural and Heritage Features etc.**			
13A	The Applicant must ensure that extraction of LW W1 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.*		TARPs provided in Appendix A which addresses the biodiversity features.
Excerpt from Table 1	**Feature**	**Performance Measure**	
	Biodiversity		
	Threatened species, threatened populations, or endangered ecological communities	• Negligible environmental consequences.	
13B	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.		Section 5, Section 6
Additional Offsets			
13C	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		Tahmoor Coal anticipate that Performance measures in Table 1 of DA 67/98 will not be exceeded.

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.	
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 OEH, 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 Appendix A.
13H(vii)(d)	Biodiversity Management Plan which has been prepared in consultation with OEH, 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:	Section 6 .
	• 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	
13H(vii)(i)	Contingency Plan that expressly provides for:	Section 6., Section 5.5

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 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 W1-W2. The findings of this assessment, and updates based on the MSEC (2019) predications for the Study Area are provided in Section 4. Given the MSEC (2019) 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 likely as a result of the extraction of LW W1-W2.

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 Environment (DoE) 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 W1-W2. The findings of this assessment, and updates based on the MSEC (2019) predications for the Study Area are provided in Section 4. Given the MSEC (2019) do not exceed those addressed in the Biodiversity Impact 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 W1-W2.

2.3 Consultation

A meeting with OEH was held with representative of OEH and representatives of Tahmoor Coal at the OEH Hurstville Office on 21 March 2019. The meeting was an opportunity to outline the proposed LW W1-W2 Extraction Plan and the proposed subsidence monitoring program for the LW W1-W2 Study Area.

OEH inquired if the baseline studies for ecology (amphibian, riparian vegetation and macroinvertebrate) would be publicly available. Tahmoor Coal advised that a copy of the baseline ecology report would be provided as part of the Extraction Plan. No further comments were made by OEH with regard to terrestrial biodiversity. A copy of the Terrestrial Ecology Baseline Monitoring Report (Niche, 2019a) is attached as Appendix A.

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 impact 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 W1 & LW W2 Study Area. The assessment was completed to accompany and inform the Subsidence Management Plan (SMP) associated with the mining activities.

Key survey tasks completed include the following:

- Field survey completed by ecologists on the 15th to 17th of October 2014 to complete the following:
    - Validated vegetation mapping
    - Threatened flora surveys
    - Habitat survey for threatened fauna
- An additional amphibian survey was completed on the 3rd of November 2014 by Dr Frank Lemckert (Amphibian expert)
- 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 Biodiversity monitoring

Niche (2019a) Riparian vegetation and amphibian monitoring report. The Study Area includes monitoring sites associated with the biodiversity (amphibian and riparian) monitoring program (Niche, 2019a). This monitoring program collected riparian vegetation monitoring along Stonequarry Creek, Cedar Creek, Newlands Gully, 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 by Niche (2014).

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

The monitoring is complimented by the 2014 aquatic monitoring completed by Niche which is described in Aquatic Biodiversity Technical Report (Niche, 2019b).

Table 2. Monitoring site locations

Treatment	Site Name	Stream	Existing impacts and features
Longwall Impact	F03i	Cedar Creek near Stonequarry Creek junction	Rural residential, permanent stream, rainforest
	F04i	Matthews Creek in gorge near Cedar Creek junction	Rural residential, permanent pools
	F05i	Matthews Creek in gorge	Rural residential
Control	F06c	Cedar Creek in gorge	Agriculture, permanent pools, rainforest
	F07c	Cedar Creek	Rural residential
	F08c	Cedar Creek	Rural residential
	F09c	Stonequarry Creek	Agriculture, weed infestations
	F10c	Stonequarry Creek in gorge	Rural residential, permanent pools, rainforest

3.2.1 Riparian vegetation monitoring baseline data

Details of the riparian monitoring baseline data are provided by Niche (2019a) which has been attached. A summary of the findings has been discussed in the following section to describe the study area.

3.3 Vegetation mapping

Vegetation in the Study Area has been mapped as part of NPWS (2002) Cumberland Plain Vegetation Mapping Project and Tozer (2006) 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 Type (PCT), and associated areas have been included in Table 3, and shown on

Table 3. Vegetation mapping within the Study Area

Vegetation code & Vegetation community [1]	PCT	Description[2]	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 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*.	45.30
p28: Cumberland Shale Hills Woodland	850 - Grey Box - Forest Red Gum grassy woodland on shale of the southern Cumberland Plain, Sydney Basin Bioregion	Cumberland Shale Hills Woodland is a eucalypt woodland with an open shrub layer and grassy groundcover, restricted to clay-loam soils derived from Wianamatta Shale on the southern half of the Cumberland Plain, Western Sydney. Cumberland Shale Hills Woodland is closely related to Cumberland Shale Plains Woodland but typically occurs on steeper and more undulating terrain. Trees: *Acacia implexa, Eucalyptus moluccana, E. tereticornis*. Shrubs: *Bursaria spinosa, Rubus parvifolius*. Climbers: *Clematis glycinoides, Glycine tabacina*. Groundcover: *Dichondra repens, Brunoniella australis, Desmodium gunnii, Aristida ramosa, Microlaena stipoides, Carex inversa, Themeda australis, Cyperus gracilis, Dichelachne micrantha, Asperula conferta, Oxalis perennans, Cheilanthes sieberi, Desmodium brachypodum, Sporobolus creber, Wahlenbergia gracilis.*	0.17
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*.	0.70

[1] Tozer (2010) South Coast Vegetation Mapping Project

[2] Tozer (2010) South Coast Vegetation Mapping Project

Vegetation code & Vegetation community [1]	PCT	Description[2]	Area (ha) Study Area
P131: Coastal Sandstone Ridetop Woodland	1083 - Red Bloodwood - scribbly gum heathy woodland on sandstone plateaux of the Sydney Basin Bioregion	Coastal Sandstone Ridgetop Woodland is a low eucalypt forest with a diverse sclerophyll shrub layer and open groundcover of sedges. It is extensively distributed on the Triassic Hawkesbury sandstone plateaux surrounding the Sydney Basin, and is widespread on ridgetops and upper valley slopes of the Hornsby and Woronora Plateaux and the lower Blue Mountains. Floristic Summary: Trees: *Corymbia gummifera, E. sieberi, E. racemosa.* Shrubs*: Leptospermum trinervium, Lambertia formosa, Persoonia levis, Banksia serrata, Platysace linearifolia, Acacia suaveolens, Isopogon anemonifolius, Dillwynia retorta, Petrophile pulchella, Banksia spinulosa, Bossiaea heterophylla, Banksia ericifolia, Acacia ulicifolia, Monotoca scoparia, Hakea dactyloides*. Groundcover: *Caustis flexuosa, Lomandra obliqua, Dampiera stricta, Entolasia stricta, Actinotus minor, Cyathochaeta diandra, Lomandra glauca.*	4.74
p142: Hinterland Sandstone Gully Forest	1181 - Smooth-barked Apple - Red Bloodwood - Sydney Peppermint heathy open forest on slopes of dry sandstone gullies of western and southern Sydney, Sydney Basin Bioregion	Hinterland Sandstone Gully Forest is an open eucalypt forest with an abundant sclerophyll shrub stratum and a groundcover dominated by sedges. This forest surrounds the Cumberland plain, occurring along the western portion of the Hornsby and Woronora plateaux and in the lower Blue Mountains. Within this distribution Hinterland Sandstone Gully Forest occurs on lower slopes of dry sandstone gullies up to 600 m ASL where average annual rainfall ranges from 850 to 1300 mm. Floristic Summary: Trees: *Angophora costata, Corymbia gummifera, Banksia serrata, Eucalyptus piperita*. Shrubs: *Persoonia linearis, P. levis, Phyllanthus hirtellus, Leptospermum trinervium, Lomatia silaifolia, Banksia spinulosa, Platysace linearifolia, Ceratopetalum gummiferum, Acacia ulicifolia, Acacia terminalis*. Climbers: *Billardiera scandens.* Groundcover: En*tolasia stricta, Pteridium esculentum, Dianella caerulea, Smilax glyciphylla, Xanthosia pilosa, Lomandra longifolia, Lepidosperma laterale, Lomandra obliqua.*	25.07
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.	24.02
Total of native vegetation mapped in Study Area			100.00

3.3.1 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 2019a).

Riparian monitoring sites set up along Matthews Creek, Cedar Creek, Stonequarry Creek, and Newlands Gully (Niche, 2019a) given riparian area may potentially be exposed to subsidence related impacts. Vegetation descriptions along each of the riparian corridors have been provided in the sections below.

Cedar Creek, Matthews Creek, Stonequarry Creek

Vegetation along the upper banks of the Stonequarry Creek, Matthew Creek and Stonequarry Creek have 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 include: *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.*

The vegetation along the banks of Matthews Creek and Cedar Creek 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*.

3.3.2 Riparian vegetation - species diversity and richness

Based on the results of the riparian monitoring (Niche 2019a), a total of 129 flora species were detected within the riparian monitoring sites during the 2018 spring monitoring session, of which 33 were exotic and 96 were native species. This differed from the total of 157 flora species were detected during the 2019 autumn monitoring session, of which 39 were exotic and 118 were native species. These numbers were lower for both monitoring events than the previous year of data collection with 154 species detected during the 2017 spring (38 exotic, 116 native) and 164 species detected during the 2018 Autumn surveys, (44 exotic, 120 native). This is likely due to dry conditions experienced recently throughout the region. Seasonality across differing years is likely attributed to the differing numbers given some species flower at differing times of the year/season.

Species richness across monitoring sites ranged from 22 to 63 species in spring 2018 and 22 to 56 species in autumn 2019. This is comparable with results from the first year of monitoring, where species richness ranged from 20 to 57 species in spring 2017 and 18 to 59 species in autumn 2018. 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.*

During the spring 2018 monitoring session, the 'impact monitoring sites' had an average of 39 species which was slightly lower than the average of 44.4 species recorded in the control sites. This was consistent with the previous year's results for spring 2017, with an average of 30.7 species present within impact sites and 42.4 in the control.

The autumn 2019 monitoring impact sites recorded an average of 40 species which was also slightly lower than the average of 46 species recorded in control sites. Similarly, this is consistent with the previous year's results, with autumn 2018 impact sites recording an average of 36.3 species, which was lower than the recorded average of 44.8 species recorded in the control sites.

3.3.3 Riparian vegetation - composition, structure and function

During the riparian monitoring (Niche 2019a), the key indicators collected in the OEH (2017) Biodiversity Assessment Methodology were utilised to assess condition, structure and function of vegetation/habitat features within each of the monitoring quadrats. Based on the two years of baseline monitoring, an understanding of the natural variation experienced 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 two years, 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 this tool is it provides a representation of the sites in term of habitat condition.

3.3.4 Riparian vegetation – floristic variability

The topographic and geological setting for the monitoring sites is across a range of types. As a result there is considerable "natural" variability between sites. Based on the results of the riparian monitoring (Niche 2019a), the mean vegetation cover between sites fluctuated by up to 37 percent between monitoring events. In general, cover between the first round of seasonal monitoring and the second round has decreased. Mean 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.

In regards to cover, no pattern can be established between spring and autumn 2017-2019 monitoring events. Three of the four impact sites cover scores (site 3, 4 and 6) decreased in autumn, while all of the autumn control sites cover scores increased.

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

Sites which occurred in a more protected environment, such are deep gullies or cannons, tended to have less fluctuation in species richness and cover. This could reflect the sheltered environment which may present 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 happen as 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 1.

Based on Tozer (2006) and the results of the field survey completed by Niche (2014) and observations during the riparian monitoring (Niche, 2019a), three 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 [3]	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.	45.30
p28: Cumberland Shale Hills Woodland	850 - Grey Box - Forest Red Gum grassy woodland on shale of the southern Cumberland Plain, Sydney Basin Bioregion	Cumberland Plain Woodland Listed as Critically Endangered under the BC Act and EPBC Act.	0.17
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.	0.70

[3] Tozer (2010) South Coast Vegetation Mapping Project

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Tahmoor North – Western Domain - Longwalls West 1 & West 2

Terrestrial Biodiversity Technical Report

Native vegetation

Niche PM: Luke Baker
Niche Proj. #: 4794
Client: Tahmoor Coking Coal Operations

Figure 2

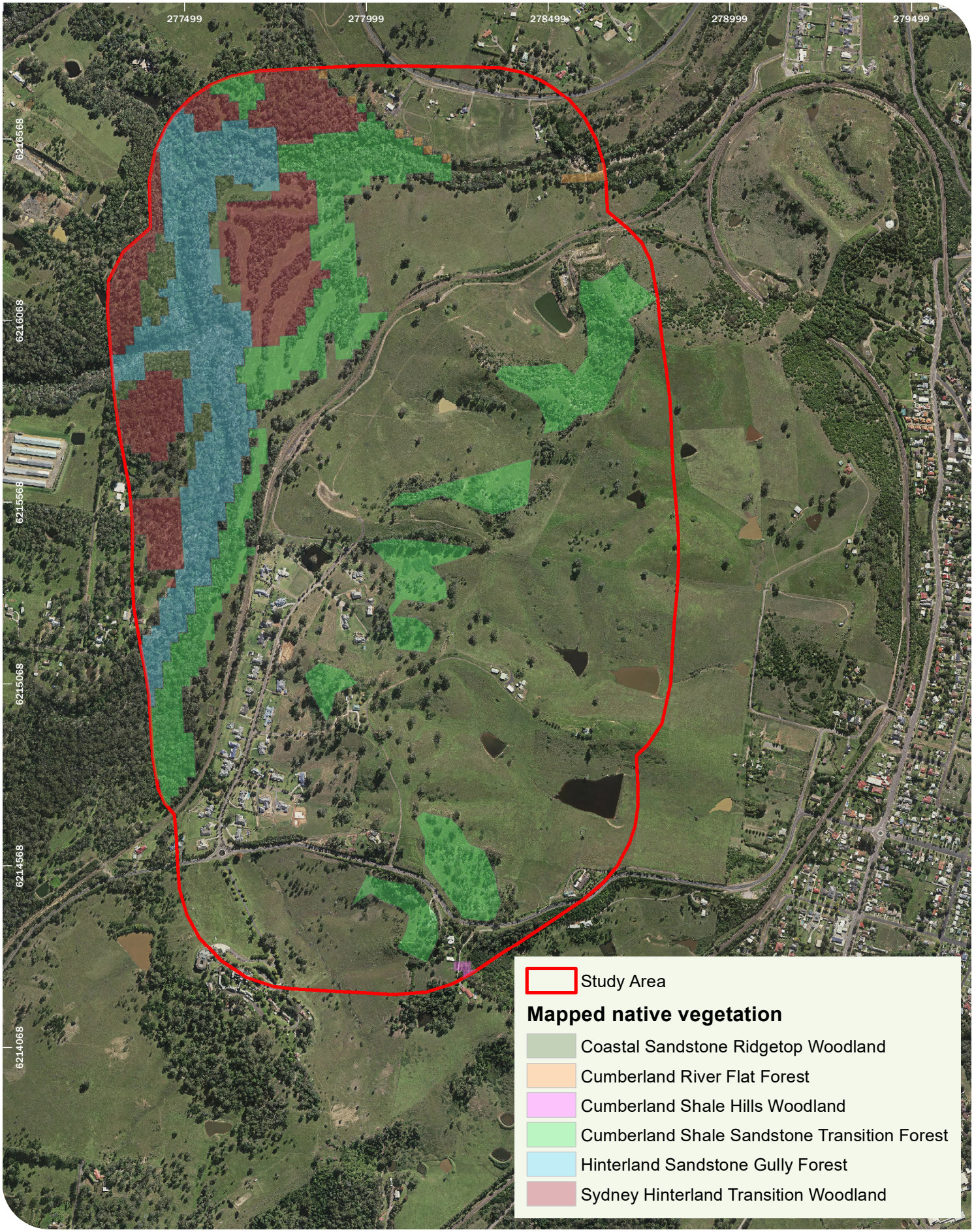

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Figure 3

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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 Biodiversity Impact Assessment (Niche, 2014) which was obtained during 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.

Those threatened flora which have been attributed a moderate to high likelihood of occurrence in the Biodiversity Impact Assessment (Niche, 2014) where are relevant to this TBTR include those species 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 Plain Woodland 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 Shale Hills Woodland, Cumberland River Flat Forest, and Cumberland Moist Shale Woodland.
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 Shale Hills Woodland, Cumberland River Flat Forest, Hinterland Sandstone Gully Forest and Cumberland Moist Shale Woodland.
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, Cumberland Shale Hills Woodland, and Cumberland Moist Shale Woodland.
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 the following vegetation communities: 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 Shale Hills Woodland, Cumberland River Flat Forest, Hinterland Sandstone Gully Forest and Cumberland Moist Shale Woodland.
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

Threatened flora	Potential occurrence in Study Area
	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 Creek. Potential habitat includes: Coastal Sandstone Ridgetop Woodland and Shale Sandstone Transition Forest.
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 Shale Hills Woodland, Cumberland River Flat Forest, and Cumberland Moist Shale Woodland.
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 Biodiversity Impact Assessment (Niche, 2014) which was obtained during database searches of Bionet and the EPBC Act Protected Matter Search tool, and field surveys.

One threatened fauna species listed on the BC Act was recorded within the Study Area during Niche (2014): The Varied Sittella which was recorded along Stonequarry Creek (Figure 4).

The Cumberland Plain Land Snail has been recorded just outside the Study Area during a previous assessment undertaken by Niche (Niche, 2012) (Figure 4).

After considering the habitat present in the Study Area and the results of the Biodiversity Impact Assessment and survey (Niche, 2014), 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.

3.6.1 Amphibians

No threatened amphibians were recorded during the Niche (2014) Terrestrial Ecology Impact Assessment, nor have any threatened amphibians been detected during the baseline monitoring (Niche 2019a).

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

The baseline monitoring (Niche 2019a) has confirmed that no threatened frog species were not detected either as frogs or tadpoles. 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 Yabbie (Cherax destructor) both of which were detected at all sites.

During the Niche (2019a) amphibian baseline monitoring, frog detection was relatively inconsistent due to the relatively dry conditions across seasons, however, the frog species found at the monitoring represent an otherwise normal array of 'predator aware' species for the study environments and conditions. The amphibian baseline monitoring concluded the following findings in relation to the study area:

- There were 663 detections of individual frogs during the four frog surveys.
- There were nine species of frog recorded on sites. One additional species was noted nearby during the survey periods (Orange-groined Toadlet Uperoleia laevigata).
- All sites had at least one species of frog during each survey but two sites (without surface water) recorded no frogs during the Autumn 2018 survey.
- The most widespread and abundant frog species during these surveys was the Clicking Froglet (Crinia signifera) which was detected on all sites during the summer sample and five of the sites during the autumn 2018 sample period.
- The lowest count of frogs, both by individuals and species was on an impact site at Matthews Creek.
- The low frog counts observed during some surveys is almost certainly due to the dry conditions experienced prior to and during those surveys. Generally greater frog 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 frog 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 2019a, which has been attached.

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 4. 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 and Cedar Creek rise in low hills to the west of the Study Area, with their junction approximately 200 m west of LW W1. Stonequarry Creek also rise to the west and flows to east along the northern boundary of the Study Area, joining Cedar Creek approximately 130 m north of LW W2, before flowing east and south through the town of Picton. Stonequarry Creek continues to flow south-east, joining the Nepean River near Maldon.

3.7.1 Matthews Creek

Matthews Creek is a 4th order stream where it flows within the vicinity of the Study Area. The Creek traverses the western boundary of the Study Area, running near parallel to the Picton Mittagong Loop Line before flowing into Cedar Creek. Eastern tributary gullies of Matthews Creek flow above the proposed LW W1-W2.

The headwaters of Matthews Creek lie within the residential area of Thirlmere, with the condition of the creek significantly affected by residential development. Within the Study Area, the creek channel is relatively incised in Hawkesbury Sandstone, with a steep sided valley and isolated vertical scarps (GeoTerra, 2014).

The minor eastern tributaries of Matthews Creek within the Study Area are ephemeral and likely only flow during periods of extended or high rainfall. 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.

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

3.7.2 Cedar Creek

Cedar Creek flows from south-west to north-east adjacent to the northern boundary of the Study Area. A minor tributary gully of Cedar Creek flows from east to west over the northern portion of LW W1-W2. Cedar Creek joins with Stonequarry Creek adjacent to the northern boundary of LW W2 and has an estimated catchment area of 27 km^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.

In 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. Rock bar, 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, 2014).

The minor tributary of Cedar 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 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.

Water level baseline data for Cedar Creek has been detailed in HEC (2019). As described by HEC (2019), Cedar Creek monitoring sites were fairly consistent during the 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, however, the water level was below the cease to flow level for the majority of the monitoring period prior to rising above the cease to flow level following rainfall in late January 2019 and again in March 2019.

3.7.3 Stonequarry Creek

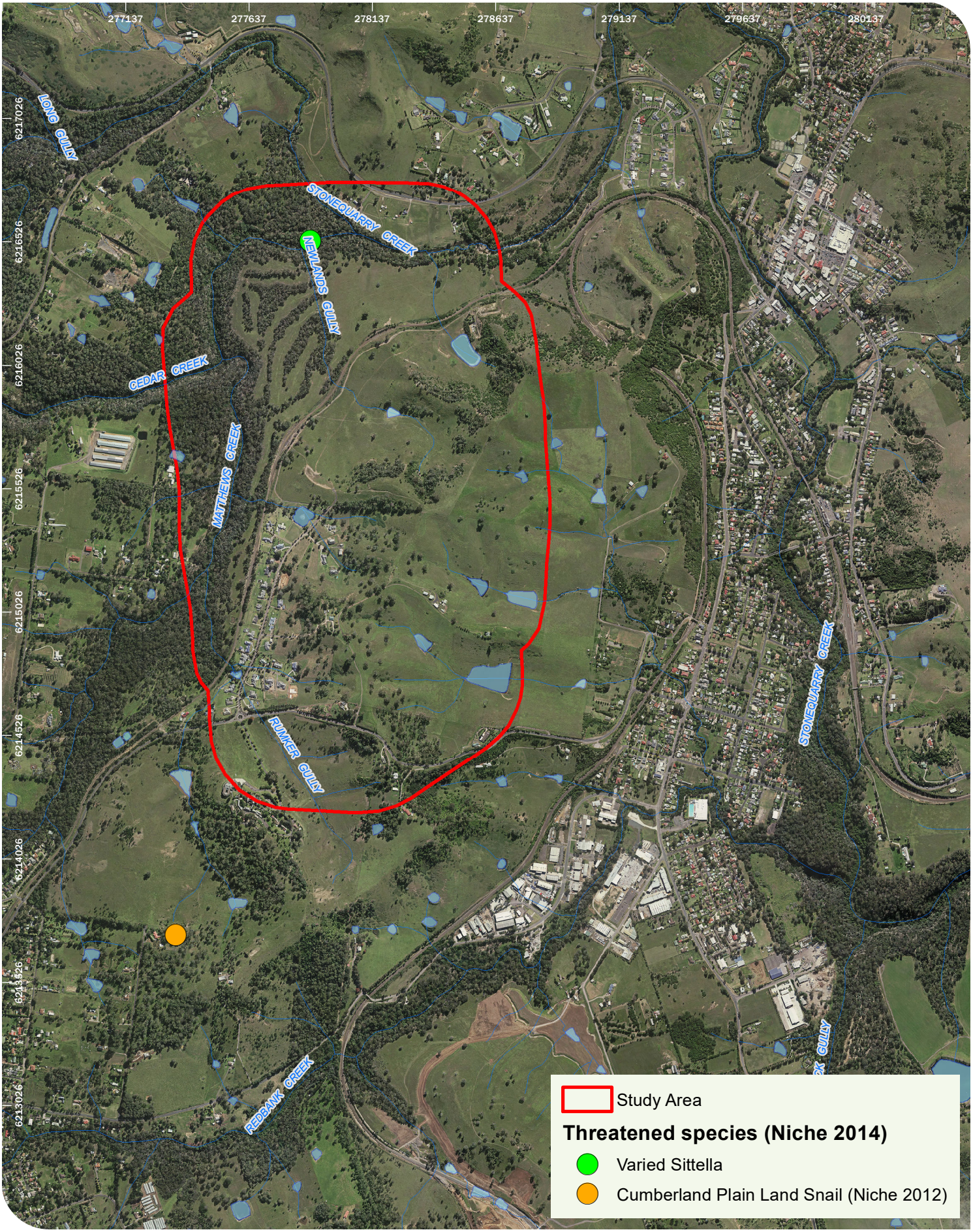
Stonequarry Creek flows along the northern boundary of the Study Area and has an estimated catchment area of 44 km2 to the downstream boundary of the Study Area. A minor tributary of Stonequarry Creek flows from south to north adjacent to the proposed LW W2. Stonequarry Creek then flows eastwards outside 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.

Water level data is available for two sites on Stonequarry Creek for the period October 2018 to March 2019 (refer Figure 2). Figure 6 presents the monitored water level at two sites on Stonequarry Creek in comparison with local rainfall records and the cease to flow (CTF) level for each of the monitoring site.

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



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Tahmoor North – Western Domain - Longwalls West 1 & West 2

Terrestrial Biodiversity Technical Report
Threatened species

Niche PM: Luke Baker
Niche Proj. #: 4794
Client: Tahmoor Coking Coal Operations

Figure 4

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4. Predicted Subsidence Impacts and Environmental Consequences

4.1 Approved 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 W1-W2. The key differences as discussed in MSEC (2019) include:

- LW W1-W2 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-W2 and future planned LW W3 and LW 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 natural surface features, which are sensitive to subsidence movements, have been identified by MSEC (2019) and include the following: Stone Quarry Creek, Matthews Creek and Cedar Creek, other drainage lines, creeks, rock outcrops, and cliffs. These features provide habitat for terrestrial ecology.

The impacts associated to the Study Area have been assessed in detail in the Biodiversity Impact 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 associated toward biodiversity are reduced when compared to the MSEC predictions considered in the 2014 SMP Application (Niche, 2014).

A summary of the predicted impacts provided in MSEC (2019) 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 (2019) compared to MSEC predictions considered by Niche (2014)	Predicted impact greater than that by Niche (2014)
Watercourses	The predictions provided in MSEC (2019) are less than that considered by Niche (2014). MSEC (2019) predicts that the mining-induced changes in grade along Matthews, Cedar and Stonequarry Creeks are predicted to be negligible. It is unlikely, therefore, that the creeks would experience adverse impacts due to increased levels of ponding, increased levels of scouring of the banks nor changes in stream alignment.	No – impact predication less than that assessed.
Cliffs and rock outcrops	The predictions provided in MSEC (2019) are similar to that considered by Niche (2014). Based on the previous experience of mining at Appin and Tower Collieries, it is possible that isolated rock falls could occur at the cliffs within the Study Area due to the extraction of LW W1-W2. It is unlikely that large-scale cliff instabilities would occur based on the experience of mining adjacent to but not directly beneath cliffs in the Southern Coalfield.	No – impact predication similar to that assessed.
Steep slopes	The predictions provided in MSEC (2019) are similar to that considered by Niche (2014). 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.	No – impact predication similar to that assessed.

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. Based on the present information, it is considered unlikely significant lowering of groundwater levels will occur. As only minor changes in ground water are predicted, it is unlikely significant impacts to native vegetation will occur as a result of the proposal.

MSEC (2019) 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 in TEC, 1997), and small localised changes to riparian vegetation along a section of the Waratah Rivulet (HC 2007). 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 be localised minor floristic changes. Given MSEC (2019) 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. It is expected that any impacts to the PCTs as a result of gas emissions from the extraction of LW W1-W2would 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 and consist of a mixture of cliffs and rock outcrops, which are stable at vertical to overhanging, and screed slopes with rocky soils and loose rock fragments. Much of these areas occur along the watercourses within the Study Area.

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.

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, 2019). However, as indicated by MSEC (2019), the total length of impact of cliffs that may be impacted above the longwalls amounts to approximately 25 to 35 m, and only 1% of cliffs located outside the extent of the longwalls may exhibit isolated rock falls. 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.

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 by Niche (2014) 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 ground water are predicted, it is unlikely significant impacts to native vegetation will occur as a result of the proposal.

4.2.4 Flora

A detailed in the Biodiversity Impact Assessment (Niche, 2014), 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.
- 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 (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 Biodiversity Impact Assessment (Niche, 2014) 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 Biodiversity Impact assessment (Niche, 2014), no significant impacts to threatened fauna are expected. Given that MSEC (2019) reports that impacts are less than that provided in the Biodiversity Impact Assessment (Niche, 2014), it is reasonable to assume that similar impact conclusion would be reached.

As discussed by Niche (2014) a number of threatened species are generally highly mobile, and are unlikely to have any potential habitat impacted by subsidence. These 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.
- Mammals: Koala and Grey-headed Flying Fox.

Assessments of Significance under the BC and/or EPBC Acts were carried out 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 by Niche (2014) no significant impacts to these species were likely to occur. Given, the predictions of MSEC (2019) are less than those predicted in during the Niche (2014) assessment, it is likely that the outcomes of the assessments would not result in significant impacts.

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 toward baseline attributed to mining, as detected during the Annual Amphibian Monitoring program; and/or • Statistically significant changes in riparian vegetation is detected toward 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 as outlined in the Extraction Plan.

The monitoring program outlined below will be implemented to monitor the impacts of subsidence effects to biodiversity within the LW W1-W2 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 Tahmoor North Longwalls 31 to 37 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 are) 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.

As discussed in the Terrestrial Ecology Assessment (Niche, 2014), this monitoring program has taken into account recommendations of the Southern Coalfields Inquiry (DoE 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 OEH standards. OEH standards would include utilising a suitable methodology (such as plot collection using the OEH (2014) BioBanking Assessment Methodology or (OEH 2017) Biodiversity Assessment Methodology) such as that utilised in Niche (2019a).

The biodiversity monitoring program is discussed in detailed in Niche (2019a), Tahmoor Mine Western Domain Terrestrial Ecology Baseline Monitoring Report - Baseline riparian vegetation and frog monitoring report 2019. Prepared for Tahmoor Coal June 2019.

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 the 2014 aquatic monitoring completed by Niche which is described in Aquatic Biodiversity Technical Report (Niche, 2019b).

Table 8. Biodiversity Monitoring program

Feature	Monitoring component / Location	Monitoring		
		Prior to extraction	During extraction	Post mining
Riparian Vegetation	Riparian vegetation at Sites F01i, F02i, F03i, F04i, F05i, F06c, F07c, F08c, F09c, F10c.	Completed as part of baseline monitoring program	Bi-annually (first occurring in spring 2019)	Bi-annually (spring and autumn) until remediation complete
Amphibians	Amphibian monitoring at Sites F01i, F02i, F03i, F04i, F05i, F06c, F07c, F08c, F09c, F10c.	Completed as part of baseline monitoring program	Bi-annually (spring and summer, with first occurring in spring 2019)	Bi-annually (spring and summer) until remediation complete

5.2.3 Riparian vegetation monitoring

The riparian vegetation monitoring will completed by two botanists in Summer 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 2 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 Summer and Autumn. The two surveys are intended to cover frogs that typically call and breed in Spring/Summer and the later 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 frog species can call over a wide period of the year driven more by weather conditions than by the season.

A total of eight frog monitoring transects are located in Picton and Thirlmere along riparian sites throughout Stonequarry, Cedar, Matthews creeks in the Study Area. The monitoring locations consist of five control sites and three impact sites being in the same general locations as the vegetation monitoring plots (To assist in the preparation of future Extraction Plans, the riparian and amphibian monitoring as outlined sections 5.2.3 and 5.2.4, will be continued beyond the active subsidence period for LW W1-W2. This will provide sufficient baseline data to assist the preparation of the Extraction Plan for LW W3-W4.

).

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

- Night aural and visual searches of selected watercourses targeted to locate and record the presence of Red-crowned Toadlet and Giant Burrowing Frog and the entire frog community. The searches are area constrained, searching within 10 m either side of the selected 200 m length of stream;
- A minimum of half an hour is to be spent completing each transect;
- Tadpole searches, to be conducted as part of daytime transect surveys;
- Opportunistic records of frogs seen or heard calling during the day during the riparian vegetation surveys. Records are to be included in the monitoring if the species was 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 to be taken to look along the boundary line of the flora plot from the starting point.

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

These photographs would be taken each monitoring year 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 change has occurred:

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

5.5 Baseline Monitoring for Future Extraction Plans

To assist in the preparation of future Extraction Plans, the riparian and amphibian monitoring as outlined sections 5.2.3 and 5.2.4, will be continued beyond the active subsidence period for LW W1-W2. This will provide sufficient baseline data to assist the preparation of the Extraction Plan for LW W3-W4.

6. Contingency Plan

6.1 Adaptive Management

As part of the management of biodiversity, Tahmoor Coal recognises the need to be adaptive to unforeseeable impacts or changes associated with the extraction of LW W1-W2. 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 the table. The terms "normal", "within prediction" and "exceeds prediction" are used for consistency with other Tahmoor Coal TARPs.

Table 9. TARPs associated with terrestrial biodiversity

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 baseline 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 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).	• 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 baseline data as supported by statistical analysis. AND Mining induced impacts (exceeds predicationcompared to baseline) 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.

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 baseline 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 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).	• 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 baseline data as supported by statistical analysis. AND Mining induced impacts (exceeds predication compared to baseline) 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.

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 W1-W2 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 TARP). 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 an Accredited 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 aquatic 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.

7. References

Department of Planning (2008) Impacts of underground coal mining on natural features in the Southern Coalfield: strategic review State of New South Wales through the NSW Department of Planning, 2008

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), Longwall Panels 31 to 37 Streams, Dams and Groundwater Assessment. Prepared for Tahmoor Colliery, December.

Hydro Engineering and Consulting (2019), Tahmoor Mine Extraction Plan LW W1– W2 Surface Water Technical Report.

Mine Subsidence Engineering Consultants (2019), SIMEC Mining: Tahmoor Coking Coal Operations – Longwalls W1 and W2 Subsidence Predictions and Impact Assessments for Natural and Built Features due to the Extraction of the Proposed Longwalls W1 and W2 in Support of the Extraction Plan Application.

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

Niche (2019a), Tahmoor Mine Western Domain Terrestrial Ecology Baseline Monitoring Report - Baseline riparian vegetation and frog monitoring report 2019. Prepared for Tahmoor Coal June 2019.

Niche (2019b), Aquatic Biodiversity Technical Report Tahmoor North – Western Domain Longwalls West 1 & West 2. Prepared for Tahmoor Coal June 2019.

NPWS (2002), Cumberland Plain Vegetation Mapping Project and Tozer (2006) Native vegetation of southeast NSW.

Office of Environment and Heritage (2014) BioBanking Assessment Methodology

Office of Environment and Heritage (2017) Biodiversity Assessment Methodology

PAC (2009) The Metropolitan Coal Project Review Report. State of NSW through the NSW Planning Assessment Commission, 2009

PAC (2010) The PAC Review of the Bulli Seam Operations Project. State of New South Wales through the NSW Planning Assessment Commission, 2010

8. Appendix A

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Environment and Heritage

Tahmoor Mine Western Domain Terrestrial Ecology Baseline Monitoring Report

Baseline riparian vegetation and frog monitoring report 2019

Prepared for Tahmoor Coal

July 2019

Document control

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Cover photograph: Leaf-green Tree Frog, Cedar Creek.

Executive summary

Tahmoor Coal Pty Ltd (Tahmoor Coal) proposes to extent underground coal mining 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) were engaged by Tahmoor Coal to conduct baseline monitoring of terrestrial ecology within the area potentially affected by long-wall mining. This report documents the terrestrial ecology of two years of biannual (Spring/Autumn) monitoring within the Study Area and surrounds conducted by Niche Environment and Heritage Pty Ltd (Niche) from November 2017 to April 2019.

The aim of the monitoring program is to document changes in the riparian vegetation and frog community at future impacted sites compared with nearby control sites. The monitoring methodology employs fixed floristic plots to collect vegetation condition data, strategic photo-point monitoring and vegetation mapping. For the frog community, targeted nocturnal transects were undertaken using spotlighting, call provocation and listening for diagnostic frog calls combined with identification of tadpoles encountered. These methods were ideal and targeted for two threatened frog species: The Giant Burrowing Frog (*Heleioporus australiacus*) and the Red-crowned Toadlet (*Pseudophryne australis*).

There were a total of 182 native plant species and 63 exotic plant species detected on the sample sites over the two years of monitoring. Future impact sites had a slightly lower species richness of both native and exotic plant species with an average of 30.33 native species and 6.33 exotic species per plot against 33 native and 11.5 exotic species for control sites. Species richness was slightly higher in Autumn samples than Spring samples.

Patterns in the data between monitoring events correlate to seasonal conditions experienced over the past two years. Particularly dry conditions experienced through the second half of 2017 and early Spring 2018, as well as an ongoing rainfall deficit can be observed in changes in the data. Anthropogenic influences could also be detected at sites which had been impacted by human disturbance, particularly weeds and altered flow regimes.

There is one threatened plant community on a control site which was infested with weed species, particularly by the later samples of this study. Sites which were lower in the catchment tended to have higher fertility and nutrient loads which lead higher species diversity and generally more exotic species. These sites appeared to be more influenced by seasonal changes than sites further up the catchment and sites protected in deep gullies and canyons.

Continued monitoring and analysis of data collected at these sites will allow for correct diagnosis of the causes of fluctuations in vegetation cover. A reduction in monitoring frequency could give the false impression that there has been an impact by mining or other local activity.

The targeted threatened frog species were not detected either as frogs or tadpoles. 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. Frog detection was relatively inconsistent due to the conditions, however, the 12 species detected at the study sites represent an otherwise normal array of 'predator aware' species for the study environments and conditions. There was

a distinct division of sites based on the species present. The Before, After, Control, Impact (BACI) design of this study is essential to account for the differences in species composition.

It is recommended that future frog monitoring be conducted at the same intensity but with two samples in spring/summer as opposed to spring/autumn. Where possible, frog surveys should be driven by good survey conditions rather than a pre-set survey schedule.

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Tables

Figures

Abbreviations

Acronym	Term/Definition
BACI	Before, After, Control and Impact Study
BAM	Biodiversity Assessment Methodology
BC Act	*Biodiversity Conservation Act 2016* (NSW)
EEC	Endangered Ecological Community
EPBC Act	*Environment Protection and Biodiversity Conservation Act 1999* (Commonwealth)
ha	Hectare/s
IBRA	Interim Biogeographic Regionalisation for Australia
LGA	Local Government Area
OEH	Office of Environment and Heritage (formerly DECCW, DECC, DEC)
TEC	Threatened Ecological Community

1. Introduction

1.1 Background

Niche Environment and Heritage Pty Ltd (Niche) was commissioned by Tahmoor Coal to conduct riparian monitoring for Longwalls West 1 to West 4 (LW W1-W4) in the Western Domain (Figure 1). A previous Terrestrial Ecology Assessment completed by Niche in 2014 identified a number of watercourses (including Stonequarry Creek, Cedar Creek, Newlands Gully, and Matthews Creek) that would be subject to subsidence related impacts. Many of the watercourses to the north of the Western Domain subsidence area are of a high ecological value, given the condition of the bushland and the availability of habitat. The purpose of the monitoring program is to identify any significant ecological change within the study area as a result of mine subsidence.

The monitoring program has been designed to be a Before, After, Control, Impact (BACI) study. The collection of a sufficient level of data over time will enable comparisons of population trends in control and impact areas to detect any significant ecological change within the study area as a result of mine subsidence.

As undermining has not been undertaken yet in the Western Domain, this report presents the baseline monitoring data collected during Spring 2017, Autumn 2018, Spring 2018 and Autumn 2019 for these sites Baseline data will allow for robust statistic methods and the establishment of environmental baseline variables. Raw data and results summarised from both years of monitoring have been included in this report.

1.2 Purpose and objectives

The aim of the monitoring program is to collect data which will enable comparison between pre and post mining in the Western Domain. This will be done through the collection of empirical data, mapping and establishment of a photographic record for the site. The specific objectives of this report include:

1. Present all raw data from baseline monitoring;
2. Detail the methodology utilised;
3. Discuss the limitations of the monitoring program; and
4. Provide recommendations to improve the monitoring program.

Mapping included:

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

2. Methodology

2.1 BACI Monitoring design

This monitoring program has been designed as a Before, After, Control, Impact (BACI) study, as BACI is considered the most appropriate design for many impact monitoring studies.

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 in ecological indicators as a result of subsidence.

Appropriate replication in both impact (directly adjacent or over the mine) and control (outside direct impact zone) sites has been incorporated into the monitoring program so natural variability can be accounted for. The longwall plans were changed between the 2014 Terrestrial Ecology Assessment and the start of the monitoring project so it was not possible to use exactly the same plot locations as that report. The planned layout of the longwalls has changed again since the establishment of the monitoring sites. However, all sites are still within their originally designated treatment areas.

This report details the findings from the baseline data collection for the monitoring program.

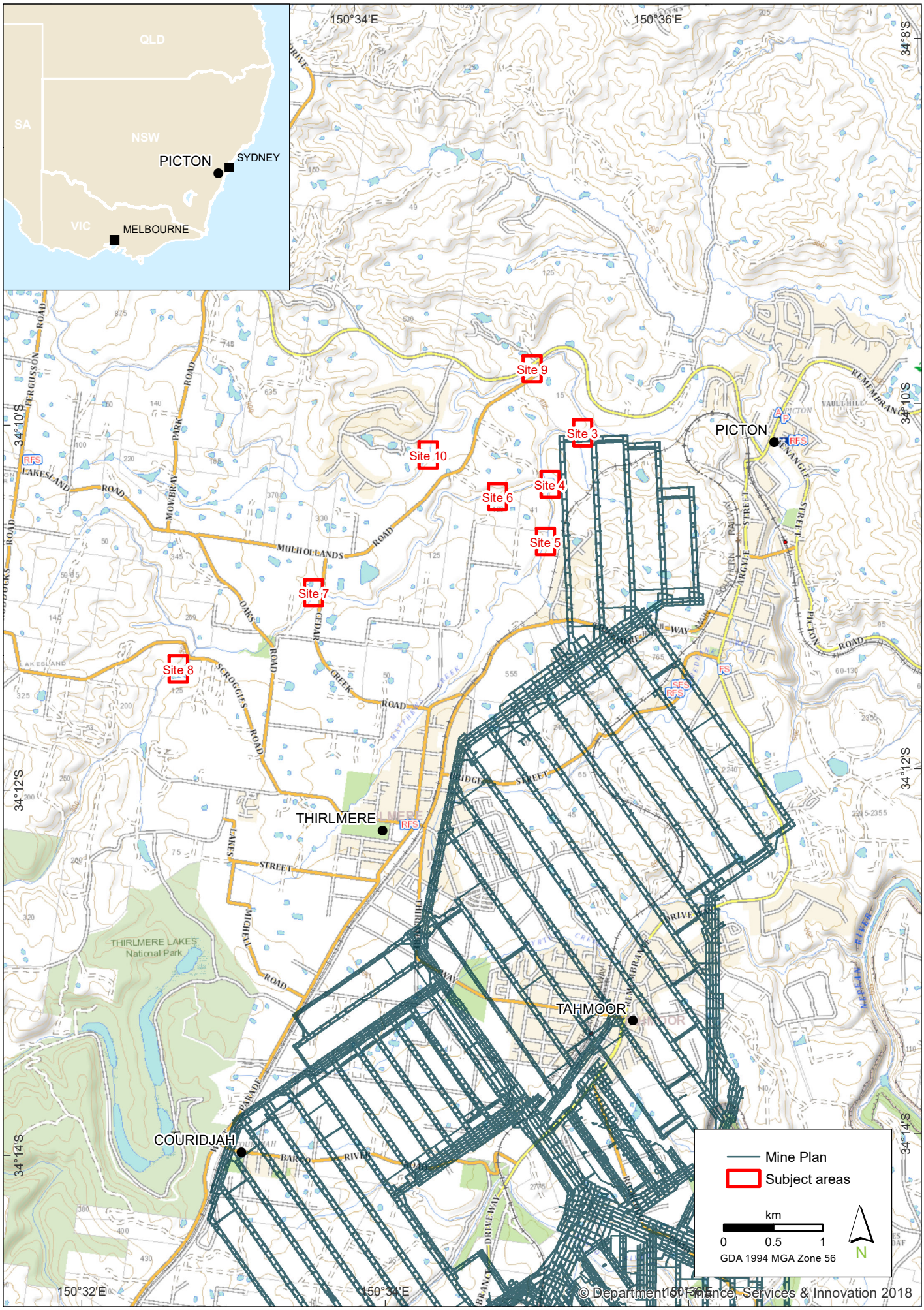
The monitoring program has taken into account recommendations of the Southern Coalfields Inquiry and Planning and Assessment Commission reports for Peabody Coal's Metropolitan and South 32's Bulli Seam Projects and includes the following:

- A minimum of 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 NSW Office of Environment and Heritage (OEH) standards.

2.2 Monitoring sites

The location and plot layout of each monitoring site is provided in Appendix 1 and an overview in Figure 1.

This report is complimented by the Niche Aquatic Ecology Baseline Monitoring Report (Niche, 2019) for the Western Domain covering the same impact area and the same control areas. A description for each of the impact and control sites is provided in Table 1.



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Location map

Tahmoor Western Domain - Riparian and Amphibian Monitoring 2018-2019

FIGURE 1

niche Environment and Heritage

2.2.1 Riparian vegetation monitoring

The riparian vegetation monitoring was conducted by Alex Christie (Botanist) and accompanying Niche ecologists on the 7th, 13th and 14th of December 2017 (Spring 2017 monitoring), 13th, 19th and 20th of April 2018 (Autumn 2018 monitoring), 26th, 29th and 30th of November 2018 (Spring 2018 monitoring), and 8th and 9th of April 2019 (Autumn 2019 monitoring).

The following tasks were completed during riparian monitoring utilising the BAM (OEH 2016).

Permanent Vegetation Plots

Eight BAM plots were placed across the Study Area. The plots were located on three future impact sites and five control sites as described in Table 1, displayed in overview on Figure 1 and in detail for each site in Appendix 1.

The plots are 50 x 20 metres (m) and are sited immediately adjacent or across the water body. Floristic sub-plots are 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. This was done as vegetation communities along these riparian zones are confined to steep, narrow gullies. BAM plots 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 m2 quadrats within the plot as per the BAM)

Pink flagging tape was used along with GPS coordinates, to mark the plots for repeated survey. These sites were accessed through GPS points and photo points for subsequent rounds of monitoring.

Vegetation Condition Assessment

Within each of the vegetation plots, the condition and structure of vegetation are 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 undertaken within each of the BAM plots.

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.

2.2.2 Amphibian monitoring

The amphibian monitoring was conducted by Matthew Stanton (Research Ecologist) and accompanying Niche ecologists across two Spring (2017/2018) and two Autumn (2018/2019) census periods (Table 9). The two surveys seasons were intended to cover frogs that typically call and breed in Spring or Summer and the later 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 frog 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 frog monitoring transects were co-located with the riparian vegetation monitoring plots in Picton and Thirlmere throughout Stonequarry, Cedar and Matthews Creeks (Figure 1). The monitoring locations consist of three impact sites and five control sites. Details of the sites are provided in Appendix 1 and illustrated in Appendix 3.

Surveys at each site were conducted along the pre-defined 200 m transect that was searched once in each of the four above mentioned survey periods. The monitoring survey along transects comprised:

- Night aural and visual searches of selected watercourses targeted to locate and record the presence of Red-crowned Toadlet and Giant Burrowing Frog and other species of the frog community. The search area was constrained to within 10 m either side of the selected 200 m length of stream. A minimum of half an hour was spent completing each transect although often considerably longer was required to account for difficult terrain or high frog abundance. Handheld LED spotlights and head torches were used;
- Attempts were made at each site to elicit calls from the target species. For Giant Burrowing Frog this was call playback of male advertising calls. For Red-crowned Toadlet this was simply making a sudden loud noise;
- Tadpole searches were conducted as part of daytime and nocturnal transect surveys. Tadpoles were identified using the resources in Anstis (2013); and
- Opportunistic records of frogs seen or heard calling during the day during the riparian vegetation surveys. These records were included as presence for that period if the species was otherwise undetected during nocturnal survey for that monitoring event and site.

2.3 Photo-point monitoring

Photos were taken at all the riparian monitoring sites. These were taken to look along the boundary line on the flora plot from the starting point and in the direction indicated in Table 3.

Table 1: Riparian study sites and their existing characteristics

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

2.4 Data analysis

The vegetation cover scores and the frog data were analysed with the Bray-Curtis similarity index and where appropriate quantify differences between samples with ANOSIM.

The similarity measures were investigated visually with Hierarchical Cluster Analysis and ordinations using Non-metric Multi-dimensional Scaling in Primer. Data was investigated in an untransformed state which allows the dominant species to drive the analysis and also in a strongly transformed state (4th root transformation) which throws the data weight more evenly across all species present but 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.

2.5 Limitations of monitoring program

Limitations of the current monitoring project include the following:

- The monitoring program proposed in this study focuses on areas likely to be impacted by subsidence, such as creeks and riparian vegetation;
- Control sites were limited to areas to which are not forecast to be impacted by mining operations, were accessible, and would not be associated with 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.; and
- Some plant species are cryptic and may remain undetected during the survey. This is the case with orchid species with 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 refined in future monitoring seasons.

3. Results and discussion

3.1 Riparian vegetation results

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

3.1.1 Species diversity and richness

There were a total of 182 native plant species and 63 exotic plant species detected on the sample sites through the two years of sampling in this study. Impact sites had a slightly lower species richness of both native and exotic plant species with an average of 30.33 native species and 6.33 exotic species per plot count against 33 native and 11.5 exotic species for control sites. Species richness was slightly higher in Autumn samples than Spring samples.

A total of 129 flora species were detected during the 2018 Spring monitoring, of which 33 were exotic and 96 were native species. A total of 157 flora species were detected during the 2019 Autumn monitoring, of which 39 were exotic and 118 were native species. These numbers were lower for both monitoring events in the previous year of data collection with 154 species detected during Spring 2017 (38 exotic, 116 native) and 164 species detected during the 2018 Autumn surveys (44 exotic, 120 native). This is likely due to dry conditions experienced recently throughout the region.

Table 2: Species richness for spring and autumn flora surveys across eight sites

		Spring 2017			Autumn 2018			Spring 2018			Autumn 2019		
Treatment	**Site**	**Native**	**Exotic**	**All Species**	**Native**	**Exotic**	**All Species**	**Native**	**Exotic**	**All Species**	**Native**	**Exotic**	**All Species**
Impact	3	31	9	40	30	11	41	38	7	45	35	8	43
	4	25	3	28	28	4	32	29	2	31	33	5	38
	5	23	1	24	29	7	36	33	8	41	31	9	40
Control	6	18	2	20	17	1	18	21	1	22	20	2	22
	7	43	14	57	46	13	59	39	12	51	38	14	52
	8	36	11	47	39	11	50	43	20	63	43	13	56
	9	20	23	43	19	19	38	17	18	35	24	23	47
	10	38	7	45	51	8	59	42	9	51	46	9	55
Impact Mean		26.3	4.3	30.7	29.0	7.3	36.3	33.3	5.7	39.0	33.0	7.3	40.3
Control Mean		31.0	11.4	42.4	34.4	10.4	44.8	32.4	12.0	44.4	34.2	12.2	46.4

Species richness across sites ranged from 22 to 63 species in Spring 2018 and 22 to 56 species in Autumn 2019 (Table 2). This is comparable with results from the first year of monitoring, where species richness ranged from 20 to 57 species in Spring 2017 and 18 to 59 species in Autumn 2018. 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 strict and Backhousia myrtifolia.*

During the Spring 2018 monitoring the impact sites had an average of 39 species which was slightly lower than the average of 44.4 species recorded in the control sites. This was consistent with the results for Spring 2017, with an average of 30.7 species present within impact sites and 42.4 in the control. The Autumn 2019 monitoring impact sites recorded an average of 40.3 species which was also slightly lower than the average of 46.4 species recorded in control sites. Similarly, this is consistent with the Autumn 2018 impact sites recording an average of 36.3 species, which was lower than the recorded average of 44.8 species recorded in the control sites.

Control sites 7, 8 and 10 were found to have the highest species richness throughout the second year of data collection, averaging 51.5, 58 and 57 respectively. These results are consistent with the previous years, with the exception of site 8, which has increased in richness comparatively to other sites. Species richness was lower at control site 6, which is consistent with the results of the previous year. Impact sites for all monitoring events recorded lower species diversity than control sites.

The species richness is generally higher on the impact sites than on the nearest sites reported in the 2014 Terrestrial Ecology Assessment (Niche, 2014). However, sites are not collocated.

3.1.2 Threatened species and habitat

No threatened 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 here in a highly disturbed state, with high exotic plant abundance. In Autumn 2019, site 9 was found to have the highest exotic species richness of all sampled sites. This confirmed the findings of the first year of baseline monitoring, where site 9 was found to have the highest weed abundance in both spring and autumn survey efforts.

3.1.3 Composition, structure and function

The key indicators collected in the BAM methodology were utilised to assess condition, structure and function of vegetation/habitat features within each of the plots. The raw data summary is contained in Table 3, Table 4, Table 5 and Table 6. The composition data for both years of survey is included in Appendix 2. Two years of baseline monitoring has allowed for an understanding of the natural variation experienced in these ecosystems. Given their 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 two years, 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 this tool is it provides a representation of the sites in term of habitat condition. Years of declining scores of the key attributes within the creeks may indicate factors impeding the health of the riparian ecosystem. Over the previous two years, no decline has been confirmed, however, ambiguity in the methodology relating to ground log amounts may explain a large amount of the variation in this indicator over both years and seasons. The BAM method does not account for habitat features that may be within water, particularly when the water level varies between samples. Clarification on these methods within field survey teams will allow for more robust monitoring going forward.

Table 3. 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 4. Spring 2018 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	29/11/2018	9:38	Water gum peppermint gully	Good	90	5	<5,5-9,10-19,20-29,50-79,80+	5	30	70
Impact 04	29/11/2018	10:42	Backhousia gully rainforest	Good	190	0	<5,5-9,10-19,20-29	0	7	31.8
Impact 05	29/11/2018	11:36	Backhousia gully rainforest	Good	185	2	<5,5-9,10-19,20-29,30-49,80+	1	23	48
Control 06	06/12/2018	1:36	Coachwood rainforest gully	Moderate	270	2	<5,5-9,10-19,20-29,30-49,80+	3	31	83
Control 07	30/11/2018	9:51	Peppermint gully forest	Good	250	2	<5,5-9,10-19,20-29,30-49,80+	2	12	28
Control 08	29/11/2018	13:30	Peppermint gully forest	Good	240	2	<5,5-9,10-19,20-29,30-49,80+	2	42	48
Control 09	30/11/2018	10:26	River-flat eucalypt forest	Degraded	245	5	<5,5-9,10-19,20-29,30-49,80+	2	38	51
Control 10	29/11/2018	15:18	Backhousia gully rainforest	Good	180	2	<5,5-9,10-19,20-29,30-49,80+	1	11	81

Table 5. Autumn 2018 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 6. Spring 2017 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	13/12/2017	14:25	Water gum peppermint gully	Good	93	3	<5,5-9,10-19,20-29,50-79,80+	2	33	82
Impact 04	13/12/2017	11:03	Backhousia gully rainforest	Good	185	0	<5,5-9,10-19,20-29	0	43	27
Impact 05	13/12/2017	9:11	Backhousia gully rainforest	Good	185	1	<5,5-9,10-19,20-29,50-79	1	9	50
Control 06	13/12/2017	12:49	Coachwood rainforest gully	Good	270	1	<5,5-9,10-19,20-29,30-49,50-79	1	27	70
Control 07	07/12/2017	16:13	Peppermint gully forest	Moderate	250	1	<5,5-9,10-19,20-29,50-79	1	16	52
Control 08	07/12/2017	18:26	Peppermint gully forest	Moderate	240	1	5-9,20-29,30-49,50-79,80+	1	38	46
Control 09	14/12/2017	7:57	River-flat eucalypt forest	Degraded	252	1	<5,5-9,10-19,30-49,50-79	2	45	46
Control 10	13/12/2017	17:21	Backhousia gully rainforest	Good	197	2	<5,5-9,10-19,20-29,50-79,80+	2	9	68

3.1.4 Floristic cover variability between sites

Vegetation Cover was recoded as part of the floristic plots collected at each site. Averages of control and impact sites for each monitoring event are displayed on Table 7 below.

Table 7. Vegetation cover (%) for spring and autumn flora surveys across eight sites

	Spring 2017			Autumn 2018			Spring 2018			Autumn 2019		
Treatment Site	**Native**	**Exotic**	**All Species**	**Native**	**Exotic**	**All Species**	**Native**	**Exotic**	**All Species**	**Native**	**Exotic**	**All Species**
Impact												
3	81.2	2.0	83.2	78.7	1.6	80.3	81.4	1.5	82.9	46.3	1.2	47.5
4	45.5	0.3	45.8	78.3	0.4	78.7	50.7	0.5	51.2	44.1	0.6	44.7
5	111.3	0.1	111.4	67.8	2.2	70.0	61.1	1.6	62.7	77.7	2.7	80.4
Control												
6	87.8	0.3	88.1	89.2	0.1	89.3	104.9	0.3	105.2	59.6	0.3	59.9
7	130.9	2.5	133.4	103.3	3.9	107.2	74.1	3.5	77.6	124.5	3.6	128.1
8	146.0	7.3	153.3	67.7	2.9	70.6	85.8	2.7	88.5	148.5	3.7	152.2
9	73.4	58.7	132.1	50.9	37.6	88.5	31.2	46.0	77.2	40.2	68.0	108.2
10	117.8	1.1	118.9	92.2	1.6	93.8	46.8	1.4	48.2	61.7	1.1	62.8
Impact Mean	79.3	0.8	80.1	74.9	1.4	76.3	64.4	1.2	65.6	56.0	1.5	57.5
Control Mean	111.2	14.0	125.2	80.7	9.2	89.9	68.6	10.8	79.3	86.9	15.3	102.2

The topographic and geological setting for the sites is variable. As a result there is considerable 'natural' variability between sites in vegetation cover. Only two site pairs came in with a Bray Curtis similarity score of better than 50% being sites 4 and 5 (both impact sites) at 65% and sites 5 and 10 at 52%. The site with the lowest similarity scores was site 9 which had a similarity score of 7% with site 7 and less for every other pairing. As a result, site 9 stands out on its own on the multi-dimensional scaling ordination (Figure 2). There is a loose collection of the three impact sites and control site 10 which are all within 40% similarity.

Variation between sites is influenced by vegetation composition and structure. The groupings at 40% similarity in Figure 2 broadly align to the vegetation type groupings allocated in Table 3 to Table 6.

If the strong dominant species bias is removed from the data with a 4^{th} root transformation, the grouping of sites 3, 4, 5 and 10 become stronger as does the grouping of site 7 and 8 (Figure 3). Site 9 can now be incorporated into the group with a similarity value of better than 30%. This is probably driven by down-weighting the prolific weed cover dominating the flora of site 9.

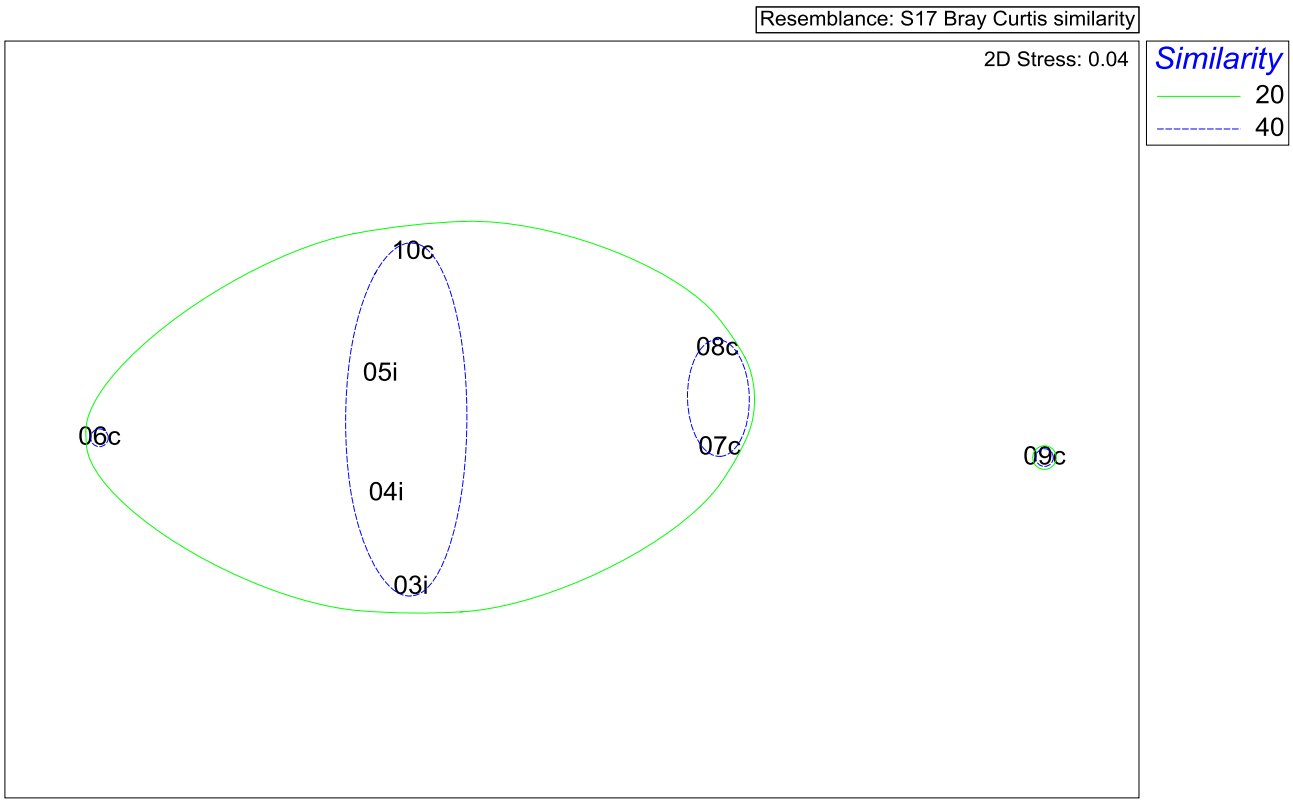

Figure 2: The floristic relationships of impact and control sites based on cover scores and displayed by a multi-dimensional scaling ordination without transformation

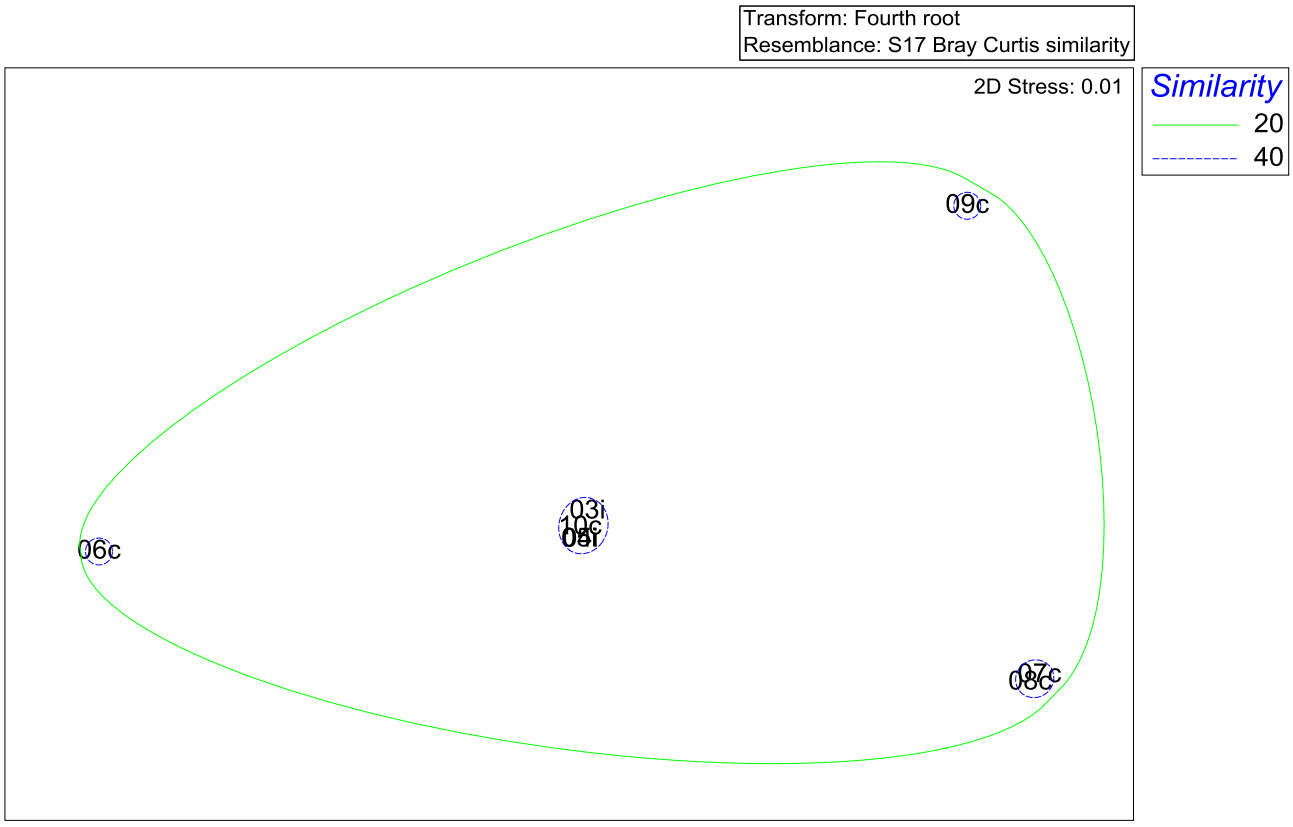

Figure 3: The floristic relationships of impact and control sites based on cover scores and displayed by a multi-dimensional scaling ordination with 4th root transformation

3.1.5 Variability between samples

There were structural differences recorded between samples of the same site. Likewise, there were floristic differences found between samples. However, these floristic differences appear to have been less than the differences between sites. This is displayed graphically in the following two figures (Figures 4 and 5). Figure 4 displays the relationship of each sample to other samples with more similar samples linked lower on the plot than more dissimilar samples. In every case, the samples are closest related to other samples from the same site. This gives us confidence that the sample method is reliably measuring the important features of the sites and that the site vegetation is staying relatively consistent over time. If the closest related site (Figure 5) were from different sites, it would be indicating that there was either a flaw in the survey method or that the sites were changing at a rapid rate either due to the season or due to some other ongoing change in the environment causing the vegetation community to be in a non-climax state.

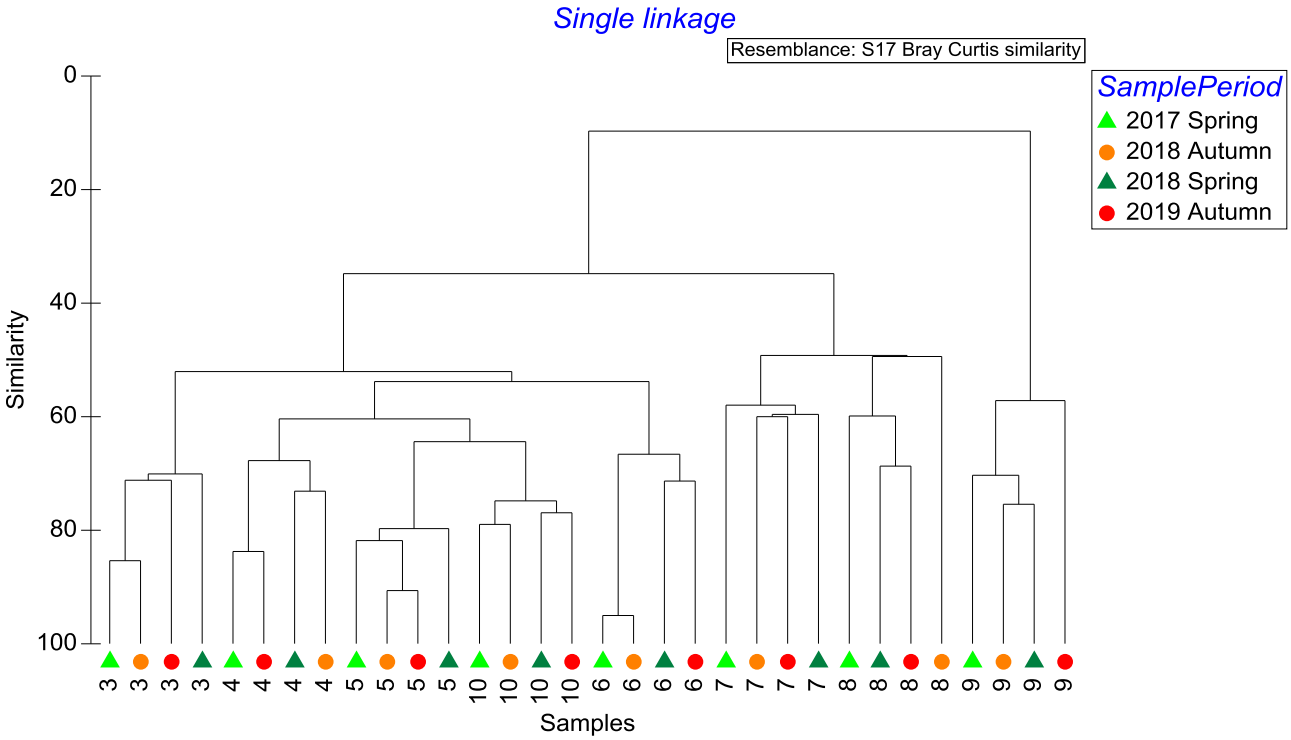

Figure 4: Floristic cover cluster data analysis showing the most similar samples (four samples per site). Items with shorter links towards the bottom of the plot are more similar than items joined by links higher on the plot.

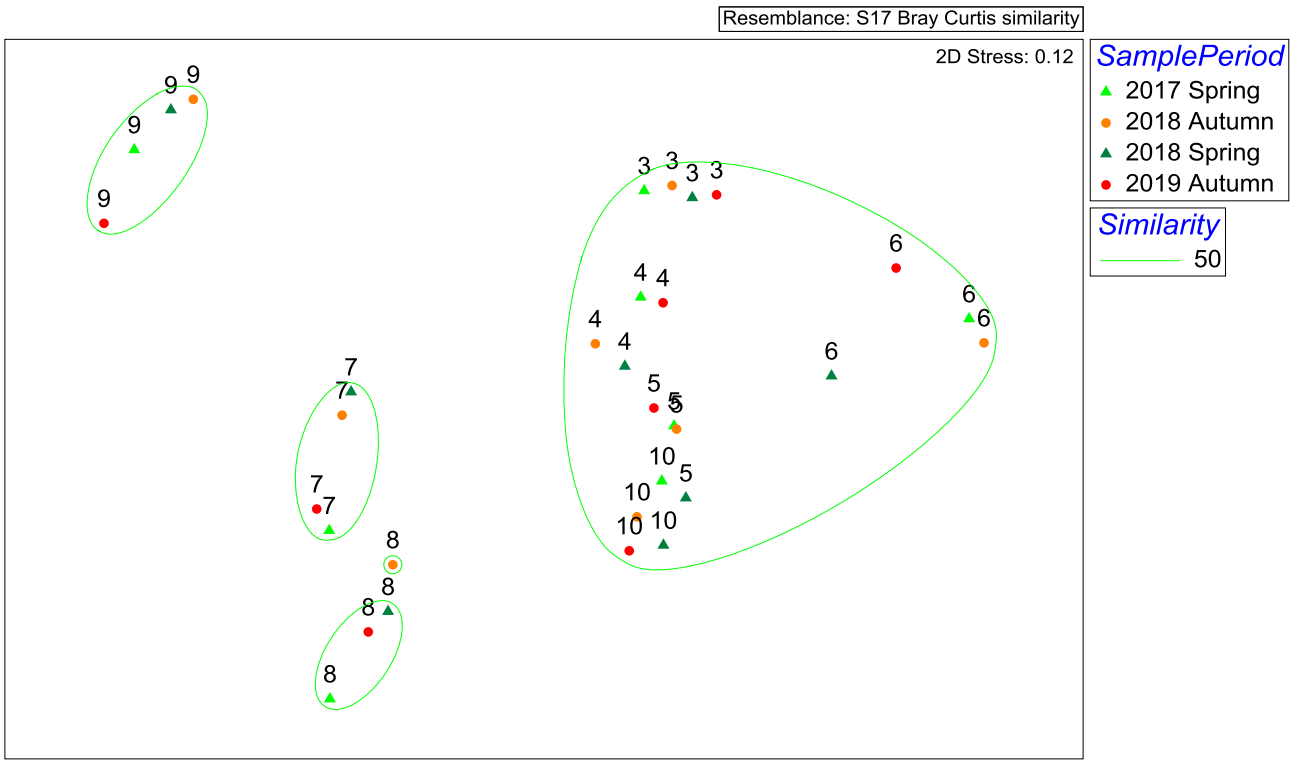

Figure 5: Floristic cover data ordination by multi-dimensional scaling showing the multivariate spacing of samples. Samples located closer together are generally similar while those further away are floristically dissimilar

The mean cover between sites fluctuated by up to 37 percent between monitoring events. In general, cover between the first round of seasonal monitoring and the second round decreased. Mean 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.

In regards to cover, no clear seasonal pattern can be established across all the sites between monitoring events. The cover of native species has behaved differently on different sites, for example three of the four impact sites cover scores (site 3, 4 and 6) decreased in Autumn 2019, while all of the other Autumn 2019 sites cover scores increased (Table 7).

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

Site 9 also showed some large fluctuations over the four monitoring events. These fluctuations could be explained by the high number of short lived annual species, both weeds and natives, recorded at the site. These species favour good seasonal conditions and contribute substantially to the increase vegetation cover following rain events.

Site 8 was impacted through slashing of the site by the landholder between Spring 2017 and Autumn 2019 monitoring events. This is evident in Figure 5 where the following Autumn 2018 monitoring is shown outside of the similarity circle. This disturbance event can be seen to significantly decrease cover of some dominant species at the site. However, this decrease in dominant species has seemingly led to the increase in species diversity, shown in the Spring 2018 and Autumn 2019 monitoring events (Table 2).

Sites which occurred in a more protected environment, such are deep gullies or cannons, tended to have less fluctuation in species richness and cover. This could reflect the sheltered environment which may present 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. Sites such as site 9 and site 3 have much higher nutrient levels and are therefore much better suited to supporting a number of annual species, whose seed may be washed down and establish in the more fertile river flats.

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 happen as vegetation such as trees or growth medium is washed away or deposited within the riparian zone.

3.2 Frog surveys

3.2.1 Conditions

Conditions for frog surveys improved somewhat in Spring 2018 and compared with the previous year when the designated survey periods had particularly low rainfall resulting in a natural reduction in the flow of streams and in Autumn 2018, the complete depletion of surface water at some sites. Rainfall is from Picton Council Depot which is just to the east of the study sites. This station does not report temperature. Temperature conditions are presented for the closest comprehensive Bureau of Meteorology weather-station at Camden, 16 to 20 km from the study sites (Table 8). As can be seen in the table, conditions were already abnormally dry and warm for the December 2017 sample period (held off through Spring waiting for a rainfall event). There were no significant rainfall events (>40 mm) during the proposed sample periods. After June 2017, every month had around half the long-term average rainfall or less (with the exception of October 2017 which followed on from no rain in September). Spring 2018 saw a return of normal to high rainfall which mostly compensated for the previous rainfall deficit. Rainfall for the Autumn 2019 counts was patchy, even across the range of sites in this study. Some sites showed high stream flows while others remained at low flow conditions.

Table 8: Rainfall totals (Picton) and temperature monthly averages (Camden) during the study period compared with long-term monthly averages. Sampling months 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
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
March 2019	**66.6**	**89.6**	**74%**	**28.0**	**26.9**	**+1.1**

Table 9 shows the specific conditions for each frog survey. All surveys dates had some rainfall within the previous 48 hours except for the Autumn 2018 survey. Those surveys were delayed while the survey team waited for rain that did not eventuate.

Table 9: Rainfall (Picton) and temperature (on site) conditions for 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
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
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
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

3.2.2 Frog distribution and abundance

There were 663 detections of individual frogs during the four frog surveys (Table 10 and Table 11). The two primary target species (Red-crowned Toadlet *Pseudophryne australis* and Giant Burrowing Frog *Heleioporus australiacus*) were not detected during these surveys, nor are there existing records in public databases for these species within the same catchment and 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 some sites or within the greater Bargo River catchment. *H. australiacus* 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 *P. australis* in this area is not currently understood but could be due to the shale capping geology in the area. *P. australis* is a sandstone specialist (Anstis 2013).

There were 12 species of frog recorded on sites (Table 10). One additional species was noted nearby during the survey periods (Orange-groined Toadlet *Uperoleia laevigata*). All sites had at least one species of frog during each survey with the exception of two sites (without surface water) that recorded no frogs during the Autumn 2018 survey.

The most widespread and abundant frog species during these surveys was the Clicking Froglet (*Crinia signifera*) which was detected on all sites. The Striped Marsh Frog (*Limnodynastes peronii*) was also detected on all eight of the sites. The only other species detected across all sites was the Emerald-spotted Tree Frog (*Litoria peronii*). However, detection of that species was at lower abundances and with less consistency being most commonly detected in the Spring 2018 sample.

Table 10: Frog records on impact and control sites. Numbers represent the total frogs recorded on the site during all four surveys.

Species (in order of abundance)	Site i3	Site i4	Site i5	Site c6	Site c7	Site c8	Site c9	Site c10	Mean count on Impacts	Mean count on Controls
Crinia signifera	38	6	20	62	32	40	37	71	5.3	12.1
Limnodynastes peronii	7	3	2	6	16	16	13	24	1.0	3.8
Litoria phyllochroa	21	20	14	13					4.6	0.7
Litoria fallax		5		2	53	5	1	2	0.4	3.2
Litoria lesueuri	5	31	9	5			1		3.8	0.3
Litoria peronii	4	2	5	5	13	14	1	2	0.9	1.8
Litoria verreauxii					7	2	4	0	0	0.7
Litoria tyleri					8	3			0	0.6
Litoria dentata					8			1	0	0.5
Limnodynastes tasmaniensis							2		0	0.1
Litoria latopalmata						1			0	0.1
Limnodynastes dumerilii							1		0	0.1
All species	75	67	50	93	137	81	60	100	16	24
Number of species	5	6	5	6	7	7	8	5	5.33	6.8

Table 11: Total frog counts by sample period with seasonal average counts

Species (in order of abundance)	Spring 2017	Autumn 2018	Spring 2018	Autumn 2019	Mean Spring Count	Mean Autumn Count
Crinia signifera	125	17	99	65	14.0	5.1
Limnodynastes peronii	31	2	34	20	4.1	1.4
Litoria phyllochroa	27	2	36	3	3.9	0.3
Litoria fallax	56		12		4.3	0.0
Litoria lesueuri	9	4	25	13	2.1	1.1
Litoria peronii	6	5	28	7	2.1	0.8
Litoria verreauxii	2		7	4	0.6	0.3
Litoria tyleri			11		0.7	0.0
Litoria dentata			9		0.6	0.0
Limnodynastes tasmaniensis			2		0.1	0.0
Litoria latopalmata	1				0.1	0.0
Limnodynastes dumerilii	1				0.1	0.0
All Species	258	30	263	112	521	142

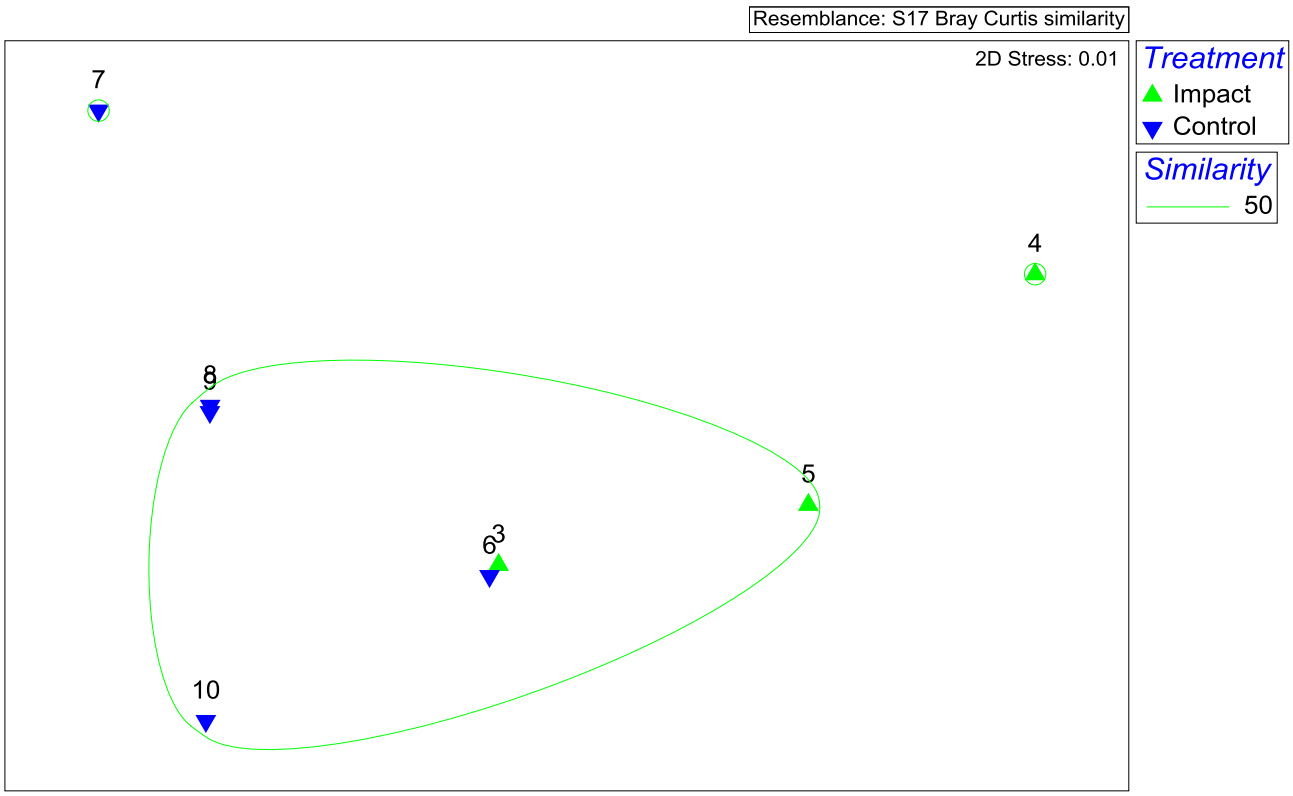

Figure 6: Frog sites (mean counts) compared by multi-dimensional scaling ordination. The data is untransformed giving more power to the most abundant species, particularly *Crinia signifera*.

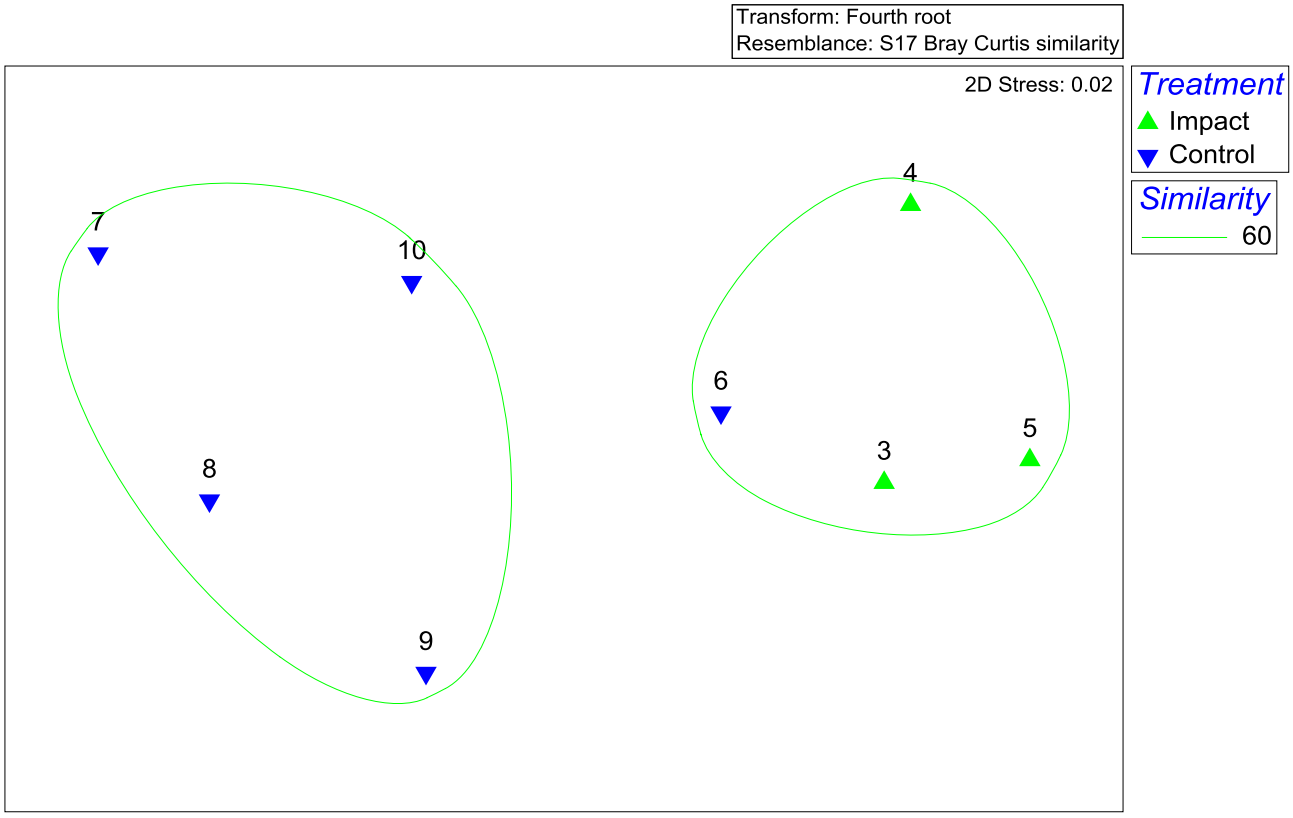

Figure 7: Frog sites (transformed mean counts) compared by multi-dimensional scaling ordination. The data is transformed to give more power to the species mix than to frog abundance.

The site with the largest number of frog species was one of the control sites (9). However, site 9 had low abundances of most species except the two common species already mentioned and no species were detected on the transect for site 9 in Autumn 2018. The lowest count of frogs, both by individuals and species was on an impact site at Matthews Creek (site 5), although another impact and a control site also had just five species.

Stoney Creek Frog *Litoria lesueuri* (in amplexus)

Leaf-green Tree Frog *Litoria phyllochroa*

Eastern Sedge Frog *Litoria fallax*

Plate 1: Three species of frog most responsible for variation in the frog assemblages across the study sites

The balance of some species across the designated impact and control sites was strongly skewed. Most species were overall more abundant on the control sites. Bucking the trend were the Stoney Creek Frog (*Litoria lesueuri*) and the Leaf-green Tree Frog (*Litoria phyllochroa*) which were more widespread on impact sites (see Plate 1). Almost in inverse to those species, the Eastern Sedge Frog (*Litoria fallax*) was more widespread on control sites. These differences are driving the strong clustering of sites into two groups in Figure 7 and Figure 8. The three impact sites cluster at a 60% level of similarity with the nearby site 6 which had the same restricted frog species. Thus site 6 is an important monitoring site for this study as it has the most similar frog fauna before impact. Note that site 6 also clustered closely with site 3 on the untransformed frog data (Figure 6). On that analysis site 4 clustered separately from the other impact sites. Site 7 is the only control site that does not cluster with any impact site in either analysis.

3.2.3 Variability between samples

The four study periods noted large variation in frog numbers across most sites (Table 11). The similarity of samples to each other is shown in Figure 8. This plot was created with data transformed with a 4th root function to reduce the impact of large counts and weight the data for the species detected rather than the abundance of a few common species. Samples that are closer to each other on the ordination plot are more similar in species composition (with abundance still having an effect). The variability in detection rates for frogs has caused some site samples to be more similar to samples from other sites than to their samples from the same site. Two sites retained a high level of similarity across all samples. These were site 3 and site 6. Both sites fell within the same 60% similarity boundary for all sites along with three of the samples for site 5 and the spring samples for site 4.

The low frog counts observed during some surveys is almost certainly due to the dry conditions experienced prior to and during those surveys. Generally greater frog 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 frog detection due to the extreme water noise from a rapidly flowing creek in a canyon.

Site 3 is a location that maintains a constant water level through all the flow conditions experienced during this study. Presumably there is a groundwater source for Cedar Creek in this vicinity. Site 6 is in the deepest

part of the canyon of Cedar Creek and also retains ponds permanently 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. Most sites retained some water during the dry period. However, site 7 and site 9 both were completely dry in late Autumn 2018. These two sites actually had higher frog diversity overall than sites 3 and 6. The Autumn 2018 sample did not detect any frogs on these two dry sites although there were frogs heard or seen nearby in each case.

The apparent drought proof nature of site 3 and 6 should mark these sites as critical for monitoring. If there is a marked difference in a sample at these sites (arbitrarily at 60% similarity level) then a cause outside of drought should be looked for. There may be other causes beyond what might be expected due to mining subsidence and if that is the case it could be expected that the effects would be seen on both of these sites rather than just on site 3.

Frogs, as amphibians, are highly reliant on water, particularly for breeding but also for day to day survival of adults and juveniles. Thus, it is quite normal to have fluctuations in their detectability related to weather and climate conditions. However, some species of frogs rely on water bodies being ephemeral in order to kill off potential tadpole predators, thus will only be detectable on sites with water bodies subject to drying out. Rainfall also allows frogs to move away from riparian areas to exploit food sources unrelated to the stream area. These factors add to the complexity of monitoring frog populations.

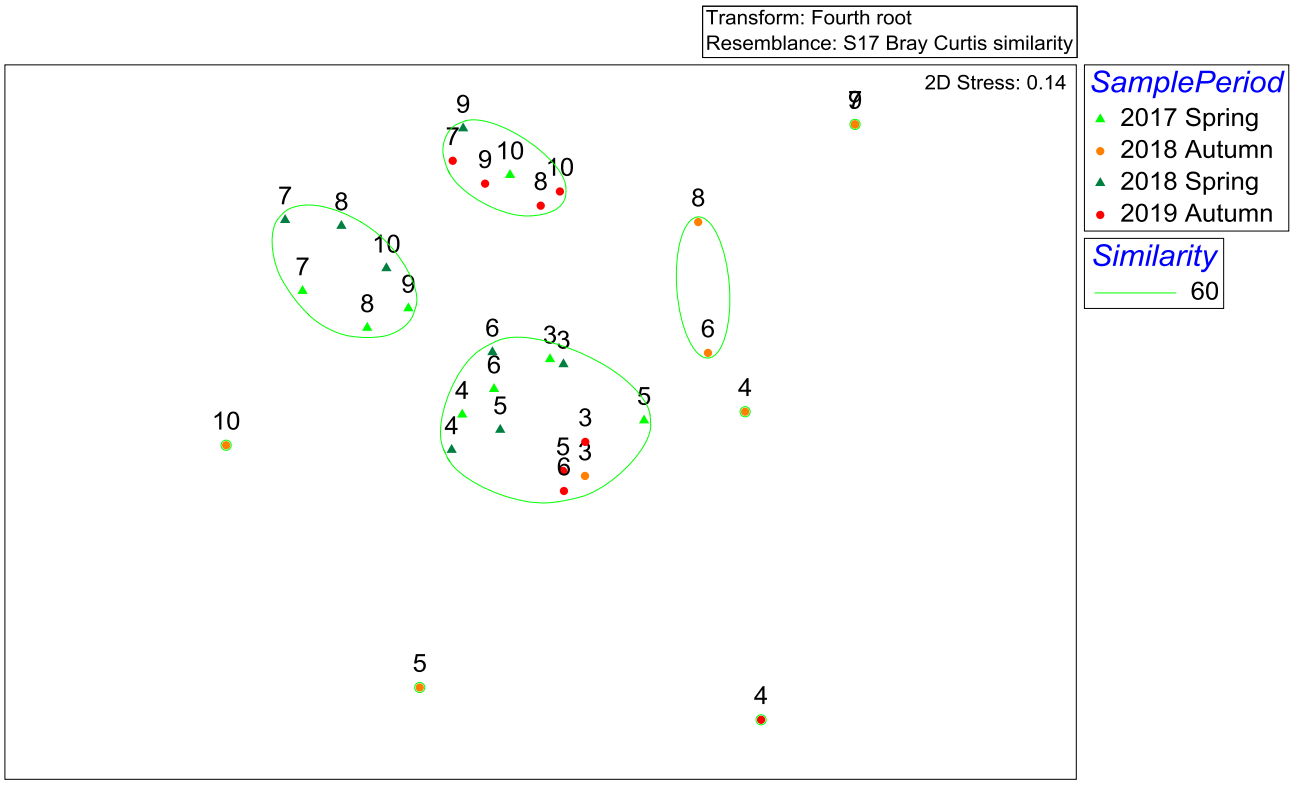

Figure 8: Frog survey records transformed to increase the influence of species presence and absence over abundance displayed in a multi-dimensional scaling ordination. Samples with similar species and abundances are plotted closer together while samples less similar will be plotted further apart. Green boundaries indicate groups of samples with greater than 60% similarity.

4. Conclusion

This report details the results of two years of baseline riparian vegetation and frog monitoring study for Tahmoor Coal LW W1-W4. The riparian monitoring program has a focus on riparian vegetation, watercourses and amphibian monitoring, as these areas where determined to be more susceptible to impacts from subsidence (Niche, 2014).

Monitoring data was collected from 8 riparian vegetation sites. While comparisons between impact and control sites are difficult to make with only two years of monitoring data available, several observations can be seen between sites. Patterns in the data between monitoring events correlate to seasonal conditions experienced over two years. Particularly dry conditions experienced through the second half of 2017 and up to Spring 2018 and an ongoing rainfall deficit can be observed in changes in the data. Anthropogenic influences could also be detected at sites which had been impacted by human disturbance.

There is one threatened plant community on a control site which was infested with weed species, particularly by the later samples of this study. Sites which were lower in the catchment 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 and sites protected in deep gullies.

Species richness and vegetation cover was slightly higher for control sites compared to impact sites for all monitoring events. Whilst there where some substantial fluctuations in the species richness and vegetation cover between samples, patterns to understand these fluctuations could not be entirely determined from the data. It can be expected that seasonal and climatic variation will continue to take place at these sites, therefore it is vital that monitoring be maintained at a frequency that allows that variability to be seen as a factor outside of the primary factor the study is aiming to detect, those caused by mine subsidence. Reducing the regularity of sampling might cause a single low reading to be misinterpreted as a sign of mine induced change, when it could be caused by flood or fire events, season or longer term climate change as was probably the case in this baseline data set.

The targeted threatened frog species appear not to be present in the area, at least not in a population that can be meaningfully monitored. However the frog community present does contain at least 12 species and could still be viable indicators of impending or current environmental change.

The frog community of the area shows a split between the impact sites (with one control site) and the remaining four control sites. While this will make future monitoring comparisons more difficult, the presence of a range of frog community states in the study area may help with the interpretation of future changes. The main feature of the frog community present at the impact sites is that they are relatively stable and consistent, particularly with spring survey. Many of the control sites showed greater fluctuations in species diversity and frog numbers.

Frogs were generally better surveyed during the spring census counts with more species and greater numbers found. For this reason Niche recommends that future frog monitoring be conducted at the same intensity but with two samples in Spring/Summer as opposed to Spring/Autumn performing both yearly census counts in the spring/summer season. Niche also recommend aligning at least one of the counts with a rain event.

5. References

Anstis, M. (2013) *Tadpoles and Frogs of Australia*, New Holland Publishers, Sydney

Bionet. Gateway to NSW Biodiversity Information, OEH, Sydney. http://www.environment.nsw.gov.au/atlaspublicapp/UI_Modules/ATLAS_/AtlasSearch.aspx

EPBC Act Protected Matters Search Tool, Department of the Environment and Energy, Canberra. http://www.environment.gov.au/webgis-framework/apps/pmst/pmst-coordinate.jsf (May 2019)

Niche (2014) *Tahmoor North Project Terrestrial Ecology Assessment - Longwalls 31 to 37*, prepared for Glencore Xstrata Tahmoor Colliery.

Niche (2018) *Tahmoor Colliery Longwalls 31 to 37: Baseline riparian vegetation and frog monitoring report 2018*, Prepared for Tahmoor Colliery, 24 July 2018

Niche (2019) Aquatic Ecology Baseline Monitoring Report: Tahmoor North - Western Domain 2017- 2019, Prepared for Tahmoor Coal 5 July 2019

PlantNET (The NSW Plant Information Network System). Royal Botanic Gardens and Domain Trust, Sydney. http://plantnet.rbgsyd.nsw.gov.au [May 2019]

Appendix 1. Monitoring site locations, vegetation plots and frog survey transects maps

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

Site 3 – Amphibian and riparian vegetation plot

Tahmoor Western Domain - Riparian and Amphibian Monitoring 2018-2019

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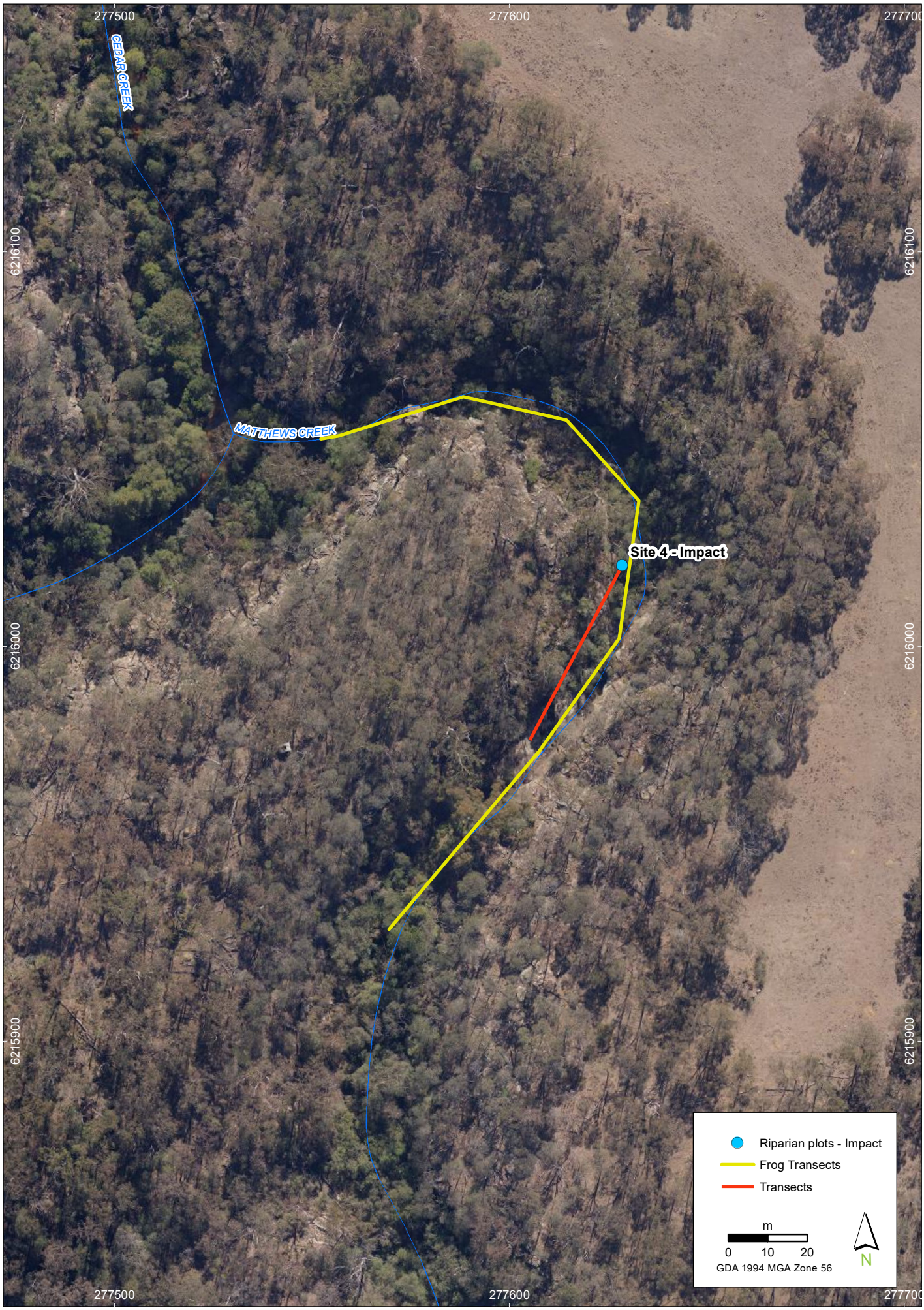
Appendix 1 - Map 1

Imagery: (c) LPI 2016-11-04



Site 4 – Amphibian and riparian vegetation plot

Tahmoor Western Domain - Riparian and Amphibian Monitoring 2018-2019

Appendix 1 - Map 2

Imagery: (c) LPI 2016-11-04

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Site 5 – Amphibian and riparian vegetation plot

Tahmoor Western Domain - Riparian and Amphibian Monitoring 2018-2019

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Appendix 1 - Map 3

Imagery: (c) LPI 2016-11-04

Site 6 – Amphibian and riparian vegetation plot

Tahmoor Western Domain - Riparian and Amphibian Monitoring 2018-2019

Appendix 1 - Map 4

Imagery: (c) LPI 2016-11-04

Site 7 – Amphibian and riparian vegetation plot

Tahmoor Western Domain - Riparian and Amphibian Monitoring 2018-2019

Appendix 1 - Map 5

Imagery: (c) LPI 2016-11-04

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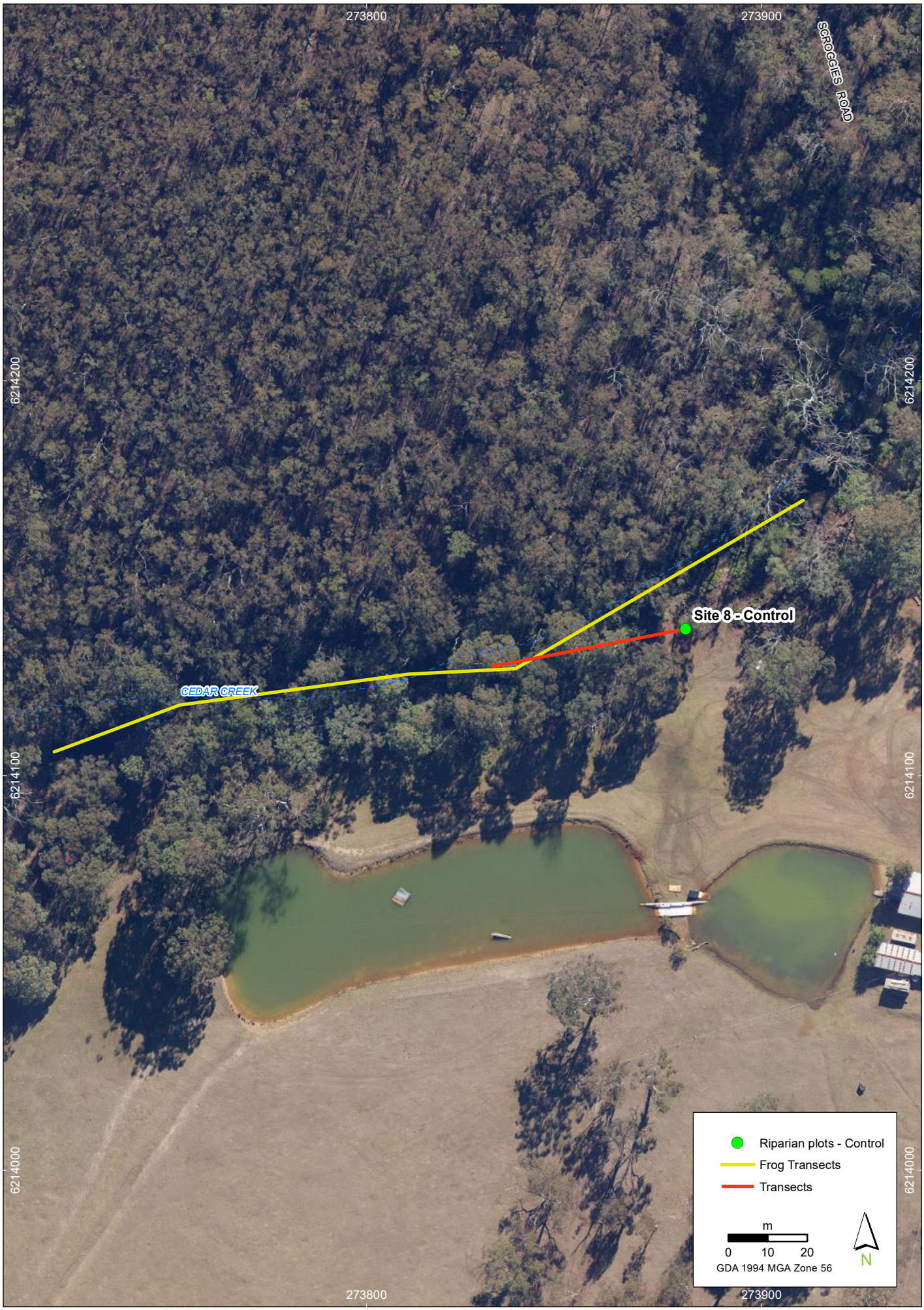

Site 8 – Amphibian and riparian vegetation plot

Tahmoor Western Domain - Riparian and Amphibian Monitoring 2018-2019

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Appendix 1 - Map 6

Imagery: (c) LPI 2016-11-04

Site 9 – Amphibian and riparian vegetation plot

Tahmoor Western Domain - Riparian and Amphibian Monitoring 2018-2019

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Appendix 1 - Map 7

Imagery: (c) LPI 2016-11-04

Site 10 – Amphibian and riparian vegetation plot

Tahmoor Western Domain - Riparian and Amphibian Monitoring 2018-2019

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Appendix 1 - Map 8

Imagery: (c) LPI 2016-11-04

Appendix 2. Riparian Vegetation Monitoring Results

Table 12. Floristic data – Spring 2017

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	8	0.1	0.1	1	0.2	5	0.2		0.1
Anthericaceae	*Caesia parviflora*	Pale Grass-lily	1					0.1			
Anthericaceae	*Chlorophytum comosum**	Spider Plant	3	0.2	0.1						0.2
Apiaceae	*Daucus glochidiatus*	Native Carrot	1	0.1							
Apiaceae	*Hydrocotyle geraniifolia*	Forest Pennywort	1								0.1
Apiaceae	*Hydrocotyle laxiflora*	Stinking Pennywort	1					0.1			
Apiaceae	*Hydrocotyle peduncularis*	A Pennywort	1						0.1		
Apiaceae	*Hydrocotyle tripartita*	Pennywort	2	0.1	0.1						
Apiaceae	*Platysace lanceolata*	Shrubby Platysace	1		0.1						
Apocynaceae	*Araujia sericifera**	Moth Vine	2							0.5	
Apocynaceae	*Parsonsia straminea*	Common Silkpod	1								
Araceae	*Zantedeschia aethiopica**	Arum Lily	1							0.1	
Araliaceae	*Astrotricha latifolia*		3		0.2	0.2			0.2		
Araliaceae	*Astrotricha longifolia*		1	2							
Asteraceae	*Ageratina adenophora**	Crofton Weed	2	0.1					0.5		
Asteraceae	*Bidens pilosa**	Cobbler's Pegs	2							0.5	0.1
Asteraceae	*Calotis dentex*	Burr-daisy	1								
Asteraceae	*Cirsium vulgare**	Spear Thistle	3	0.1						0.2	
Asteraceae	*Conyza bonariensis**	Flaxleaf Fleabane	6	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	*Conyza sumatrensis**	Tall fleabane	1		0.1						
Asteraceae	*Cymbonotus lawsonianus*	Bear's Ear	2						0.1		
Asteraceae	*Gamochaeta americana**	Cudweed	3	0.1					0.2	0.1	
Asteraceae	*Hypochaeris radicata**	Catsear	3	0.1				0.1	0.1		
Asteraceae	*Olearia megalophylla*	Large-leaf Daisy-bush	1					0.2			
Asteraceae	*Olearia viscidula*	Wallaby Weed	2			0.2					0.1
Asteraceae	*Senecio madagascariensis**	Fireweed	1								
Asteraceae	*Senecio minimus*		1						0.1		
Asteraceae	*Senecio quadridentatus*	Cotton Fireweed	1						0.1		
Asteraceae	*Sigesbeckia orientalis subsp. orientalis*	Indian Weed	2							3	
Asteraceae	*Sonchus oleraceus**	Common Sowthistle	1							0.1	
Asteraceae	*Tagetes minuta**	Stinking Roger	2							0.5	
Asteraceae	*Vittadinia muelleri*	A Fuzzweed	1						0.1		
Asteraceae	*Vittadinia sulcata*		1								
Bignoniaceae	*Pandorea pandorana*	Wonga Wonga Vine	1								
Blechnaceae	*Blechnum cartilagineum*	Gristle Fern	3	0.1			0.5		1		
Blechnaceae	*Doodia aspera*	Prickly Rasp Fern	5	0.1		20	0.2				1
Blechnaceae	*Doodia caudata*	Small Rasp Fern	2	0.1	0.1						
Brassicaceae	*Rorippa microphylla**	One-rowed Watercress	1								
Campanulaceae	*Wahlenbergia communis*	Tufted Bluebell	4	0.1	0.1			0.1			0.1
Caprifoliaceae	*Lonicera japonica**	Japanese Honeysuckle	3					0.2	5		
Casuarinaceae	*Allocasuarina littoralis*	Black She-Oak	2			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 nutans*	Climbing Saltbush	2							2	
Commelinaceae	*Commelina cyanea*	Native Wandering Jew	3	0.1					0.1		0.1
Commelinaceae	*Tradescantia fluminensis**	Wandering Jew	4				0.2	0.1		1	
Convolvulaceae	*Dichondra repens*	Kidney Weed	2							0.1	
Cunoniaceae	*Callicoma serratifolia*	Black Wattle	1		0.5						
Cunoniaceae	*Ceratopetalum apetalum*	Coachwood	2	0.5			75				
Cunoniaceae	*Ceratopetalum gummiferum*	Christmas Bush	1								0.1
Cyperaceae	*Carex inversa*	Knob Sedge	5	0.2					1	0.4	0.2
Cyperaceae	*Cyperus eragrostis**	Umbrella Sedge	6	0.2				0.1	0.1	0.2	0.1
Cyperaceae	*Lepidosperma laterale*	Variable Sword-sedge	2		0.1						
Cyperaceae	*Schoenus melanostachys*		3		1	2			2		
Dennstaedtiaceae	*Pteridium esculentum*	Bracken	2					20	50		
Dicksoniaceae	*Calochlaena dubia*	Rainbow Fern	4	0.1			0.1	0.2	2		
Dilleniaceae	*Hibbertia aspera*	Rough Guinea Flower	2			0.1		0.1			
Dilleniaceae	*Hibbertia diffusa*	Wedge Guinea Flower	1					0.5			
Ericaceae	*Lissanthe strigosa*	Peach Heath	1								
Fabaceae (Faboideae)	*Desmodium varians*	Slender Tick-trefoil	1		0.1						
Fabaceae (Faboideae)	*Glycine tabacina*	Variable Glycine	4					0.1	0.1		0.1
Fabaceae (Faboideae)	*Kennedia rubicunda*	Dusky Coral Pea	1					0.5			

Family	Species	Common Name	Count	03 cover	04 cover	05 cover	06 cover	07 cover	08 cover	09 cover	10 cover
Fabaceae (Mimosoideae)	*Acacia decurrens*	Black Wattle	1					1			
Fabaceae (Mimosoideae)	*Acacia linifolia*	White Wattle	3	0.5							1
Fabaceae (Mimosoideae)	*Acacia longifolia*		2					0.5	3		
Fabaceae (Mimosoideae)	*Acacia maidenii*	Maiden's Wattle	1							1	
Fabaceae (Mimosoideae)	*Acacia parramattensis*	Parramatta Wattle	1					0.2			
Geraniaceae	*Geranium solanderi*	Native Geranium	2					0.01	0.1		
Gleicheniaceae	*Sticherus flabellatus var. flabellatus*	Umbrella Fern	1				0.5				
Goodeniaceae	*Dampiera purpurea*		1					0.01			
Haloragaceae	*Myriophyllum aquaticum**	Parrots Feather	1							0.1	
Iridaceae	*Libertia pulchella*		1								0.1
Lamiaceae	*Plectranthus parviflorus*		2			0.1					0.2
Lauraceae	*Cassytha glabella*		3		0.5	1				1	
Lobeliaceae	*Lobelia alata*	Angled Lobelia	1								0.1
Lobeliaceae	*Pratia purpurascens*	Whiteroot	3	0.1				0.2			
Lomandraceae	*Lomandra filiformis*	Wattle Matt-rush	1								
Lomandraceae	*Lomandra longifolia*	Spiny-headed Mat-rush	10	0.5	5	10	0.5	30	2	0.2	5
Luzuriagaceae	*Geitonoplesium cymosum*	Scrambling Lily	4	0.5						0.1	0.1
Malvaceae	*Modiola caroliniana**	Red-flowered Mallow	1								
Malvaceae	*Sida rhombifolia**	Paddy's Lucerne	3					0.1		2	
Myrsinaceae	*Anagallis arvensis**	Scarlet Pimpernel	3						0.1	0.5	0.1

Family	Species	Common Name	Count	03 cover	04 cover	05 cover	06 cover	07 cover	08 cover	09 cover	10 cover
Myrsinaceae	*Rapanea variabilis*	Muttonwood	3			0.2					0.1
Myrtaceae	*Angophora floribunda*	Rough-barked Apple	2					1		30	
Myrtaceae	*Backhousia myrtifolia*	Grey Myrtle	5		2	35	0.5				50
Myrtaceae	*Callistemon salignus*	Willow Bottlebrush	1					0.2			
Myrtaceae	*Eucalyptus crebra*	Narrow-leaved Ironbark	1			3					
Myrtaceae	*Eucalyptus deanei*	Mountain Blue Gum	2						10		25
Myrtaceae	*Eucalyptus elata*	River Peppermint	1	35							
Myrtaceae	*Eucalyptus piperita*	Sydney Peppermint	2					15	30		
Myrtaceae	*Eucalyptus punctata*	Grey Gum	1								
Myrtaceae	*Eucalyptus punctata subsp. punctata*		1					30			
Myrtaceae	*Eucalyptus tereticornis*	Forest Red Gum	2							30	
Myrtaceae	*Melaleuca linariifolia*	Flax-leaved Paperbark	5	2	1			5	0.5		2
Myrtaceae	*Tristaniopsis laurina*	Kanooka	5	25	30	35	5				15
Oleaceae	*Ligustrum lucidum**	Large-leaved Privet	3		0.1					20	
Oleaceae	*Ligustrum sinense**	Small-leaved Privet	5	1			0.1	0.2		25	
Oleaceae	*Notelaea longifolia*	Large Mock-olive	7	0.2		1	0.2	3	0.2		0.5
Osmundaceae	*Todea barbara*	King Fern	3	0.2			1				0.1
Oxalidaceae	*Oxalis perennans*		5					0.01	0.1	0.1	0.1
Phormiaceae	*Dianella caerulea var. producta*		5			0.1		0.1	5		0.1
Phormiaceae	*Stypandra glauca*	Nodding Blue Lily	1								

Family	Species	Common Name	Count	03 cover	04 cover	05 cover	06 cover	07 cover	08 cover	09 cover	10 cover
Phyllanthaceae	*Phyllanthus gunnii*		2					2	0.5		
Phytolaccaceae	*Phytolacca octandra**	Inkweed	1							0.3	
Pittosporaceae	*Billardiera scandens*	Hairy Apple Berry	1								
Pittosporaceae	*Bursaria spinosa*	Native Blackthorn	7	0.5	0.2	0.1				0.1	0.2
Pittosporaceae	*Bursaria spinosa subsp. spinosa*	Native Blackthorn	1					0.5			
Pittosporaceae	*Pittosporum revolutum*	Rough Fruit Pittosporum	1				0.1				
Pittosporaceae	*Pittosporum undulatum*	Sweet Pittosporum	3					5	0.1		2
Plantaginaceae	*Plantago lanceolata**	Lamb's Tongues	2					0.1	0.1		
Plantaginaceae	*Veronica calycina*	Hairy Speedwell	1								0.1
Poaceae	*Austrostipa scabra*	Speargrass	1								
Poaceae	*Briza maxima**	Quaking Grass	1					0.1			
Poaceae	*Cynodon dactylon*	Common Couch	1								
Poaceae	*Echinopogon ovatus*	Forest Hedgehog Grass	3					0.5	0.5		
Poaceae	*Ehrharta erecta**	Panic Veldtgrass	5			0.1		1		5	0.2
Poaceae	*Entolasia marginata*	Bordered Panic	4		0.2			1	20		0.2
Poaceae	*Entolasia stricta*	Wiry Panic	8	10	2	0.1	0.1			0.5	10
Poaceae	*Holcus lanatus**	Yorkshire Fog	1					0.1			
Poaceae	*Imperata cylindrica*	Blady Grass	2					1	0.5		
Poaceae	*Microlaena stipoides*	Weeping Grass	6	1	1	0.5				3	
Poaceae	*Microlaena stipoides var. stipoides*	Weeping Grass	2					5	10		
Poaceae	*Oplismenus aemulus*		5	0.1				1	5	1	0.1
Poaceae	*Paspalum dilatatum**	Paspalum	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	*Themeda australis*	Kangaroo Grass	1								
Polygonaceae	*Acetosa sagittata**	Rambling Dock	1								
Polygonaceae	*Acetosella vulgaris**	Sheep Sorrel	1						0.1		
Polygonaceae	*Persicaria decipiens*	Slender Knotweed	6	0.1				0.5	0.1	0.5	0.1
Polygonaceae	*Rumex brownii*	Swamp Dock	1							0.1	
Potamogetonaceae	*Potamogeton crispus*	Curly Pondweed	1					0.2			
Primulaceae	*Samolus valerandi*	Common Brookweed	2	0.1						0.1	
Proteaceae	*Lomatia myricoides*	River Lomatia	2				1				1
Proteaceae	*Stenocarpus salignus*	Scrub Beefwood	4		0.5	0.5	0.3				1
Ranunculaceae	*Clematis aristata*	Old Man's Beard	2	0.1				0.2			
Ranunculaceae	*Ranunculus lappaceus*	Common Buttercup	1								
Ranunculaceae	*Ranunculus repens**	Creeping Buttercup	1								
Rosaceae	*Rubus fruticosus**	Blackberry complex	2					0.1		0.1	
Rubiaceae	*Cyclophyllum longipetalum*	Coast Canthium	1		0.2						
Rubiaceae	*Galium gaudichaudii*	Rough Bedstraw	1								0.1
Rubiaceae	*Galium propinquum*	Maori Bedstraw	2		0.1					0.1	
Rubiaceae	*Morinda jasminoides*	Sweet Morinda	6	1	0.1	0.5	2				1
Rubiaceae	*Opercularia aspera*	Coarse Stinkweed	3					0.1	0.5		
Rubiaceae	*Opercularia hispida*	Hairy Stinkweed	1								0.1
Rutaceae	*Zieria smithii*	Sandfly Zieria	5	0.1	0.2	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
Sapindaceae	*Dodonaea triquetra*	Large-leaf Hop-bush	1					0.2			
Smilacaceae	*Smilax glyciphylla*	Sweet Sarsparilla	2				0.5				
Solanaceae	*Solanum nigrum**	Black-berry Nightshade	3					0.1		0.1	
Solanaceae	*Solanum prinophyllum*	Forest Nightshade	6	0.1	0.1			0.3	0.1	0.1	
Solanaceae	*Solanum pseudocapsicum**	Madeira Winter Cherry	2							1	
Sterculiaceae	*Lasiopetalum ferrugineum*		1					0.1			
Thymelaeaceae	*Pimelea linifolia subsp. linifolia*		1					0.1			
Typhaceae	*Typha australis**		1							0.1	
Ulmaceae	*Trema tomentosa var. viridis*	Native Peach	1						0.1		
Verbenaceae	*Lantana camara**	Lantana	2							1	0.3
Verbenaceae	*Verbena bonariensis**	Purpletop	4	0.1				0.1	0.5	0.1	
Violaceae	*Viola hederacea*	Ivy-leaved Violet	7	0.5		0.1	0.1	0.1	0.1		0.5

Table 13. Floristic data – Autumn 2018

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
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

Family	Species	Common Name	Count	03 cover	04 cover	05 cover	06 cover	07 cover	08 cover	09 cover	10 cover
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 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		
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	

Family	Species	Common Name	Count	03 cover	04 cover	05 cover	06 cover	07 cover	08 cover	09 cover	10 cover
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
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			

Family	Species	Common Name	Count	03 cover	04 cover	05 cover	06 cover	07 cover	08 cover	09 cover	10 cover
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	
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

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	0.5							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
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

Family	Species	Common Name	Count	03 cover	04 cover	05 cover	06 cover	07 cover	08 cover	09 cover	10 cover
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
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

Family	Species	Common Name	Count	03 cover	04 cover	05 cover	06 cover	07 cover	08 cover	09 cover	10 cover
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		
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	

Family	Species	Common Name	Count	03 cover	04 cover	05 cover	06 cover	07 cover	08 cover	09 cover	10 cover
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 14. Floristic data - Spring 2018

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	8	0.2	0.2	0.2	0.3	0.2	0.3		0.3
Adiantaceae	*Cheilanthes sieberi*	Rock Fern	1		0.1						
Adiantaceae	*Pellaea falcata*	Sickle Fern	2				0.1				
Amaranthaceae	*Alternanthera spp.*	Joyweed	1					0.1			
Anthericaceae	*Arthropodium milleflorum*	Pale Vanilla-lily	4		0.1	0.1					0.1
Anthericaceae	*Chlorophytum comosum**	Spider Plant	4	0.2	0.1	0.5					0.3
Apiaceae	*Hydrocotyle laxiflora*	Stinking Pennywort	4	0.2				0.2	0.1		0.1
Apiaceae	*Platysace lanceolata*	Shrubby Platysace	1		0.2						
Apocynaceae	*Araujia sericifera**	Moth Vine	2							0.1	
Apocynaceae	*Parsonsia straminea*	Common Silkpod	3				0.1				0.1
Araliaceae	*Astrotricha latifolia*		2			0.1			0.2		
Asparagaceae	*Asparagus asparagoides**	Bridal Creeper	2								
Aspleniaceae	*Asplenium flabellifolium*	Necklace Fern	1		0.2						
Asteraceae	*Ageratina adenophora**	Crofton Weed	3	0.1		0.1			0.2		
Asteraceae	*Bidens pilosa**	Cobbler's Pegs	4					0.1		0.2	0.1
Asteraceae	*Calotis dentex*	Burr-daisy	2	0.1							
Asteraceae	*Calotis spp.*	A Burr-daisy	1			0.1					
Asteraceae	*Cirsium vulgare**	Spear Thistle	3					0.1	0.1	0.1	
Asteraceae	*Conyza bonariensis**	Flaxleaf Fleabane	6	0.1		0.1		0.2	0.1	0.2	0.1
Asteraceae	*Delairea odorata**	Cape Ivy	1			0.1					
Asteraceae	*Gamochaeta americana**	Cudweed	2					0.1	0.1		
Asteraceae	*Hypochaeris radicata**	Catsear	2					0.1	0.2		
Asteraceae	*Olearia viscidula*	Wallaby Weed	3			0.2		0.1			0.1
Asteraceae	*Senecio madagascariensis**	Fireweed	4	0.2				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
Asteraceae	*Senecio quadridentatus*	Cotton Fireweed	1	0.1							
Asteraceae	*Senecio spp.**	Groundsel, Fireweed	3					0.1	0.1		0.1
Asteraceae	*Sigesbeckia orientalis subsp. orientalis*	Indian Weed	3			0.1			0.1	1	
Asteraceae	*Sonchus asper**	Prickly Sowthistle	2						0.1	0.1	
Asteraceae	*Sonchus oleraceus**	Common Sowthistle	1								
Asteraceae	*Tagetes minuta**	Stinking Roger	2							0.1	
Bignoniaceae	*Pandorea pandorana*	Wonga Wonga Vine	3								0.1
Blechnaceae	*Blechnum cartilagineum*	Gristle Fern	1				2				
Blechnaceae	*Doodia aspera*	Prickly Rasp Fern	4			1	0.2				0.1
Campanulaceae	*Wahlenbergia spp.*	Bluebell	1						0.1		
Caprifoliaceae	*Lonicera japonica**	Japanese Honeysuckle	3					0.5	0.1		
Caryophyllaceae	*Paronychia brasiliana**	Chilean Whitlow Wort, Brazilian Whitlow	1						0.1		
Caryophyllaceae	*Stellaria media**	Common Chickweed	1								
Casuarinaceae	*Allocasuarina littoralis*	Black She-Oak	2			0.5			0.2		
Chenopodiaceae	*Einadia hastata*	Berry Saltbush	2							0.1	
Chenopodiaceae	*Einadia nutans*	Climbing Saltbush	2							0.5	
Commelinaceae	*Commelina cyanea*	Native Wandering Jew	2	0.1					0.1		
Commelinaceae	*Tradescantia fluminensis**	Wandering Jew	5				0.3			1	0.1
Convolvulaceae	*Dichondra repens*	Kidney Weed	6	0.1		0.1			0.1	0.1	0.1
Convolvulaceae	*Polymeria calycina*		1	0.1							
Cunoniaceae	*Callicoma serratifolia*	Black Wattle	1		0.3						
Cunoniaceae	*Ceratopetalum apetalum*	Coachwood	2	1			40				
Cyperaceae	*Carex inversa*	Knob Sedge	5	0.2				0.1	0.1	0.1	0.2
Cyperaceae	*Carex spp.*		1	0.1							

Family	Species	Common Name	Count	03 cover	04 cover	05 cover	06 cover	07 cover	08 cover	09 cover	10 cover
Cyperaceae	*Cyperus eragrostis**	Umbrella Sedge	6	0.2		0.1		0.1		0.2	0.1
Cyperaceae	*Lepidosperma laterale*	Variable Sword-sedge	4		0.1	0.1					0.1
Cyperaceae	*Schoenus melanostachys*		4		0.5	0.5			3		0.1
Dennstaedtiaceae	*Pteridium esculentum*	Bracken	2					5	40		
Dicksoniaceae	*Calochlaena dubia*	Rainbow Fern	1				0.2				
Dilleniaceae	*Hibbertia aspera*	Rough Guinea Flower	2			0.1		0.1			
Ericaceae	*Acrotriche divaricata*		1		0.1						
Ericaceae	*Astroloma humifusum*	Native Cranberry	3			0.1					0.1
Ericaceae	*Lissanthe strigosa*	Peach Heath	2								0.2
Fabaceae (Faboideae)	*Desmodium rhytidophyllum*		1		0.1						
Fabaceae (Faboideae)	*Desmodium varians*	Slender Tick-trefoil	3	0.1				0.1	0.1		
Fabaceae (Faboideae)	*Glycine clandestina*	Twining glycine	2						0.1		0.1
Fabaceae (Faboideae)	*Glycine tabacina*	Variable Glycine	6	0.1	0.1	0.1		0.1	0.2		
Fabaceae (Faboideae)	*Hardenbergia violacea*	False Sarsaparilla	1						0.1		
Fabaceae (Faboideae)	*Trifolium spumosum**		1						0.1		
Fabaceae (Mimosoideae)	*Acacia binervia*	Coast Myall	1		2						
Fabaceae (Mimosoideae)	*Acacia decurrens*	Black Wattle	1					2			
Fabaceae (Mimosoideae)	*Acacia linifolia*	White Wattle	3	0.2					0.2		0.5
Fabaceae (Mimosoideae)	*Acacia longifolia*		2					5	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 maidenii*	Maiden's Wattle	2							1	
Fabaceae (Mimosoideae)	*Acacia parramattensis*	Parramatta Wattle	1					0.2			
Gentianaceae	*Centaurium erythraea**	Common Centaury	1						0.2		
Geraniaceae	*Geranium solanderi*	Native Geranium	1						0.3		
Gleicheniaceae	*Sticherus flabellatus var. flabellatus*	Umbrella Fern	1				0.5				
Goodeniaceae	*Brunonia australis*	Blue Pincushion	1		0.1						
Haloragaceae	*Gonocarpus tetragynus*	Poverty Raspwort	1						0.1		
Juncaceae	*Juncus spp.*	A Rush	3						0.2	0.2	
Lamiaceae	*Plectranthus parviflorus*		4			0.1					0.2
Lauraceae	*Cassytha glabella*		1							1	
Lobeliaceae	*Lobelia dentata*		1								0.1
Lobeliaceae	*Pratia purpurascens*	Whiteroot	5	0.1		0.1		0.2	0.1		0.1
Lomandraceae	*Lomandra filiformis*	Wattle Matt-rush	2	0.1				0.1			
Lomandraceae	*Lomandra longifolia*	Spiny-headed Mat-rush	10	0.2	20	5	2	25	10	0.5	0.5
Lomandraceae	*Lomandra multiflora subsp. multiflora*	Many-flowered Mat-rush	1						0.1		
Lomandraceae	*Lomandra spp.*	Mat-rush	1								
Luzuriagaceae	*Geitonoplesium cymosum*	Scrambling Lily	2	0.3							0.1
Malvaceae	*Modiola caroliniana**	Red-flowered Mallow	1								
Malvaceae	*Sida rhombifolia**	Paddy's Lucerne	2							0.1	
Meliaceae	*Melia azedarach*	White Cedar	1						0.2		
Myrsinaceae	*Anagallis arvensis**	Scarlet Pimpernel	2						0.3	0.1	
Myrsinaceae	*Rapanea variabilis*	Muttonwood	3			0.1					0.1
Myrtaceae	*Angophora floribunda*	Rough-barked Apple	2					3		20	

Family	Species	Common Name	Count	03 cover	04 cover	05 cover	06 cover	07 cover	08 cover	09 cover	10 cover
Myrtaceae	*Backhousia myrtifolia*	Grey Myrtle	6	1	10	40	25				30
Myrtaceae	*Callistemon viminalis*	Weeping Bottlebrush	1					0.2			
Myrtaceae	*Eucalyptus crebra*	Narrow-leaved Ironbark	1			5					
Myrtaceae	*Eucalyptus deanei*	Mountain Blue Gum	2						5		5
Myrtaceae	*Eucalyptus elata*	River Peppermint	1	20							
Myrtaceae	*Eucalyptus globoidea*	White Stringybark	1					10			
Myrtaceae	*Eucalyptus piperita*	Sydney Peppermint	2					10	20		
Myrtaceae	*Eucalyptus punctata*	Grey Gum	2					3			
Myrtaceae	*Eucalyptus tereticornis*	Forest Red Gum	2							5	
Myrtaceae	*Leptospermum spp.*	Tea-tree	2						0.2		0.1
Myrtaceae	*Melaleuca linariifolia*	Flax-leaved Paperbark	3	3				3			1
Myrtaceae	*Tristaniopsis laurina*	Kanooka	5	50	15	5	30				1
Oleaceae	*Ligustrum lucidum**	Large-leaved Privet	2							15	
Oleaceae	*Ligustrum sinense**	Small-leaved Privet	6	0.5		0.4		1	0.1	20	
Oleaceae	*Notelaea longifolia*	Large Mock-olive	6	0.2		0.2	0.5	1			0.2
Oleaceae	*Olea europaea subsp. africana**		1	0.1							
Osmundaceae	*Todea barbara*	King Fern	2	0.5			0.5				
Oxalidaceae	*Oxalis perennans*		3		0.1				0.1		
Oxalidaceae	*Oxalis spp.*		2			0.1				0.1	
Phormiaceae	*Dianella caerulea var. producta*		6	0.2	0.1			0.2	0.3		0.1
Phormiaceae	*Stypandra glauca*	Nodding Blue Lily	1								
Phyllanthaceae	*Breynia oblongifolia*	Coffee Bush	1								
Phyllanthaceae	*Phyllanthus gunnii*		3	0.1				0.1	0.1		
Phyllanthaceae	*Poranthera microphylla*	Small Poranthera	1	0.1							
Pittosporaceae	*Billardiera scandens*	Hairy Apple Berry	1		0.1						
Pittosporaceae	*Bursaria spinosa*	Native Blackthorn	7	0.1	0.2	0.4		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
Pittosporaceae	*Pittosporum revolutum*	Rough Fruit Pittosporum	1				0.5				
Pittosporaceae	*Pittosporum undulatum*	Sweet Pittosporum	3					1	0.1		0.2
Plantaginaceae	*Plantago lanceolata**	Lamb's Tongues	2						0.1	0.1	
Plantaginaceae	*Veronica plebeia*	Trailing Speedwell	2			0.1			0.1		
Poaceae	*Bromus spp.**	A Brome	1							0.2	
Poaceae	*Cynodon dactylon*	Common Couch	2	0.2							
Poaceae	*Echinopogon caespitosus*	Bushy Hedgehog-grass	1					1			
Poaceae	*Echinopogon ovatus*	Forest Hedgehog Grass	1						0.1		
Poaceae	*Ehrharta erecta**	Panic Veldtgrass	9	0.1	0.1	0.2		1	0.2	5	0.2
Poaceae	*Entolasia marginata*	Bordered Panic	8	1			0.1	0.5	0.2	0.1	0.2
Poaceae	*Entolasia stricta*	Wiry Panic	5		0.2	0.2			2		0.5
Poaceae	*Imperata cylindrica*	Blady Grass	2					0.1	0.1		
Poaceae	*Microlaena stipoides*	Weeping Grass	10	0.5	0.3	0.3	0.1	1	0.5	1	0.5
Poaceae	*Oplismenus aemulus*		7	0.2	0.1	0.1		0.1	0.1	0.2	0.1
Poaceae	*Rytidosperma spp.*		3					0.2			
Polygonaceae	*Acetosa sagittata**	Rambling Dock	3		0.3	0.1					
Polygonaceae	*Acetosella vulgaris**	Sheep Sorrel	1						0.1		
Polygonaceae	*Persicaria decipiens*	Slender Knotweed	4	0.1				0.1			0.2
Polygonaceae	*Rumex brownii*	Swamp Dock	1						0.1		
Polypodiaceae	*Pyrrosia rupestris*	Rock Felt Fern	3			0.1					0.1
Primulaceae	*Samolus valerandi*	Common Brookweed	1	0.1							
Proteaceae	*Lomatia myricoides*	River Lomatia	1				0.5				
Proteaceae	*Lomatia silaifolia*	Crinkle Bush	1					0.1			
Proteaceae	*Stenocarpus salignus*	Scrub Beefwood	4		0.1	0.3	1				3
Ranunculaceae	*Clematis aristata*	Old Man's Beard	4	0.1				0.1		0.1	
Ranunculaceae	*Ranunculus spp.*		1								

Family	Species	Common Name	Count	03 cover	04 cover	05 cover	06 cover	07 cover	08 cover	09 cover	10 cover
Rosaceae	*Rubus fruticosus**	Blackberry complex	1						0.1		
Rubiaceae	*Galium binifolium*		1								0.1
Rubiaceae	*Galium propinquum*	Maori Bedstraw	2		0.1	0.1					
Rubiaceae	*Morinda jasminoides*	Sweet Morinda	6	0.3	0.1	0.5	1				0.5
Rubiaceae	*Opercularia spp.*		4					0.4	0.2		0.2
Rutaceae	*Zieria smithii*	Sandfly Zieria	5		0.1	0.1			0.1		0.2
Sapindaceae	*Dodonaea triquetra*	Large-leaf Hop-bush	1					0.1			
Scrophulariaceae	*Verbascum virgatum**	Twiggy Mullein	1						0.1		
Smilacaceae	*Smilax australis*	Lawyer Vine	1						0.1		
Smilacaceae	*Smilax glyciphylla*	Sweet Sarsparilla	1				0.1				
Solanaceae	*Solanum prinophyllum*	Forest Nightshade	3	0.1	0.1						
Solanaceae	*Solanum pseudocapsicum**	Madeira Winter Cherry	3							0.3	0.1
Sterculiaceae	*Brachychiton populneus*	Kurrajong	1								
Sterculiaceae	*Lasiopetalum ferrugineum*		1					0.1			
Thymelaeaceae	*Pimelea linifolia*	Slender Rice Flower	1					0.1			
Urticaceae	*Urtica incisa*	Stinging Nettle	1							0.2	
Verbenaceae	*Lantana camara**	Lantana	3							3	0.3
Verbenaceae	*Verbena bonariensis**	Purpletop	3					0.1	0.1	0.2	
Violaceae	*Viola hederacea*	Ivy-leaved Violet	4	0.3			0.2		0.2		0.1
Violaceae	*Viola spp.*		1								

Table 15. Floristic data – Autumn 2019

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							
Asteraceae	*Euryops chrysanthemoides**		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	*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 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							
Commelinaceae	*Tradescantia fluminensis**	Wandering Jew	7			0.1	0.2	0.2		5	0.1

Family	Species	Common Name	Count	03 cover	04 cover	05 cover	06 cover	07 cover	08 cover	09 cover	10 cover
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
Fabaceae (Mimosoideae)	*Acacia binervia*	Coast Myall	1		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 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
Luzuriagaceae	*Geitonoplesium cymosum*	Scrambling Lily	3	0.2							0.1
Malvaceae	*Modiola caroliniana**	Red-flowered Mallow	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
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
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		

Family	Species	Common Name	Count	03 cover	04 cover	05 cover	06 cover	07 cover	08 cover	09 cover	10 cover
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	
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							

Family	Species	Common Name	Count	03 cover	04 cover	05 cover	06 cover	07 cover	08 cover	09 cover	10 cover
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
Thymelaeaceae	*Pimelea linifolia*	Slender Rice Flower	1					0.1			
Ulmaceae	*Trema tomentosa*		1						0.1		
Urticaceae	*Urtica incisa*	Stinging Nettle	1							0.2	

Family	Species	Common Name	Count	03 cover	04 cover	05 cover	06 cover	07 cover	08 cover	09 cover	10 cover
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		

Appendix 1: Photo Point Monitoring 2017-2019 (2 years/4 samples)

Plate 1: Autumn 2019 Site 3

Plate 2: Spring 2018 Site 3

Plate 3: Autumn 2018 Site 3

Plate 4: Spring 2017 Site 3

Plate5: Autumn 2019 Site 4

Plate 6: Spring 2018 Site 4

Plate7: Autumn 2018 Site 4

Plate 8: Spring 2017 Site 4

Plate 9: Autumn 2019 Site 5

Plate 10: Spring 2018 Site 5

Plate 11: Autumn 2018 Site 5

Plate 12: Spring 2017 Site 5

Plate 13: Autumn 2019 Site 6

Plate 14: Spring 2018 Site 6

Plate 15: Autumn 2018 Site 6

Plate 16: Spring 2017 Site 6

Plate 17: Autumn 2019 Site 7

Plate 18: Spring 2018 Site 7

Plate 19: Autumn 2018 Site 7

Plate 20: Spring 2017 Site 7

Plate 21: Autumn 2019 Site 8

Plate 22: Spring 2018 Site 8

Plate 23: Autumn 2018 Site 8

Plate 24: Spring 2017 Site 8

Plate 25: Autumn 2019 Site 9

Plate 26: Spring 2018 Site 9

Plate 27: Autumn 2018 Site 9

Plate 28: Spring 2017 Site 9

Plate 29: Autumn 2019 Site 10

Plate 30: Spring 2018 Site 10

Plate 31: Autumn 2018 Site 10

Plate 32: Spring 2017 Site 10

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Our services

Ecology and biodiversity
Terrestrial
Freshwater
Marine and coastal
Research and monitoring
Wildlife Schools and training

Heritage management
Aboriginal heritage
Historical heritage
Conservation management
Community consultation
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)