RUSSELL VALE COLLIERY

REVISED UNDERGROUND EXPANSION PROJECT

Extraction Plan - Upland Swamp Monitoring Plan

RVC EC PLN 008

Revision

Property	Value
Approved by	DPE for implementation, Warwick Lidbury WRPL CEO for use
Document Owner	Tom McMahon, WRPL Group Environment Manager
Effective Date	TBC
Review Date	TBC

Revision History

Version	Date reviewed	Review team (consultation)	Nature of the amendment
V1 - D1	05/02/2021	Luke Stone (Biosis)	Initial draft plan for submission to WRPL.
V1 - D2	13/04/2021	Rebecca Dwyer (Biosis) Richard Sheehan (WRPL) Claire Stephenson and David Holmes (Umwelt)	Draft plan for consultation with BCD, WaterNSW, EPA and WCC.
V1 - D3	22/06/2021	Luke Stone (Biosis) Rebecca Dwyer (Biosis)	Update plan to incorporate consultation feedback from BCD for submission to DPE for approval.
V1 - D4	26/07/21	Richard Sheehan (WRPL) David Holmes (Umwelt)	Update plan to incorporate feedback from the project consultant team.
V1 - D5	21/09/2021	Tony Cable (Biosis) Rebecca Dwyer (Biosis)	Update plan for consistency with DCCEEW Final approval.
V1 - D6	06/10/2021	David Holmes (Umwelt)	Incorporate subsidence monitoring requirements.
V1 - D7	06/10/2021	David Holmes (Umwelt)	Incorporate subsidence monitoring requirements.
V1 - D8	06/10/2021	Richard Sheehan (WRPL)	TARP amendments.
V1 - D9	17/11/2021	Richard Sheehan (WRPL)	Incorporate changes from regulatory departments post submission.
Approved Plan = R0	19/11/2021	-	-
V2 - D1	4/3/2022	Caragh Heenan and Jane Raithby-Veall (Biosis)	Updates to include Stage 2 workings (PC27 to PC34).
V2 - D2	6/4/2022	Caragh Heenan and Jane Raithby-Veall (Biosis) Richard Sheehan (WRPL) Trescinda Brown and Matthew Copeland (Umwelt)	Draft plan for consultation with BCD, WaterNSW, EPA and WCC.
V2 - D3	10/6/2022	Caragh Heenan and Jane Raithby-Veall (Biosis) David Holmes (Umwelt)	Minor amendments.
V2 – 4 Final	19/7/2022	Caragh Heenan (Biosis)	-
V2 – 5 Final	7/10/2022	Caragh Heenan and Jane Raithby-Veall (Biosis) Matthew Copeland (Umwelt)	Amendments to address DPE Request for Information.

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1 INTRODUCTION

1.1 Overview

This Upland Swamp Monitoring Plan (USMP) has been prepared by Biosis on behalf of Wollongong Resources Pty Ltd (WRPL, formerly Wollongong Coal Pty Limited) in accordance with Condition C10(g)(v) of the Development Consent (DC) MP09_0013 granted by the Independent Planning Commission of NSW on 8 December 2020.

Specifically, the USMP is a part of the Extraction Plan (EP) required to address all second workings and is identified in WRPLs environmental management structure (Figure 4) for the Russell Vale Colliery (the Colliery).

The USMP is also subject to the requirements of the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act), with EPBC approval 2020/8702 being granted by the Commonwealth Department of Climate Change, Energy, the Environment and Water (DCCEEW, formerly Department of Agriculture, Water and the Environment) on 31 August 2021.

This Plan has been prepared by Biosis Pty Ltd Ecological Consultants, Luke Stone (Aquatic Ecologist), Zoe Goold (Project Zoologist) and Dr Caragh Heenan (Consultant Zoologist) and reviewed by Jane Raithby-Veall (Associate Director) as approved and consistent with the team, approved by NSW Department of Planning and Environment (DPE), and included in the EP. The integration of this plan with the subsidence monitoring framework has been prepared by David Holmes (Principal Environmental Consultant – Umwelt) consistent with the team approved by DPE and included in the EP.

1.2 Project background

WRPL operates the Russell Vale Colliery (RVC) (formerly the NRE No.1 Colliery) located in in the Southern Coalfield of New South Wales (NSW). The mine is located at Russell Vale, approximately 8 kilometres (km) north of Wollongong and 70 km south of Sydney, within the local government areas (LGAs) of Wollongong and Wollondilly in the Illawarra region of NSW (refer to Figure 1).

Mining has been undertaken at RVC since the 1880s, including mining within the Bulli Seam, Balgownie Seam and the Wongawilli Seam. All three seams outcrop along the Illawarra Escarpment and the seams are accessed by adits (underground mine entrances) directly into the seams. There are two main mining areas within the RVC lease area, which are referred to as Wonga East and Wonga West.

The RVC Pit Top consists of the main surface infrastructure and facilities for the colliery, including coal stockpiles, drift portals, conveyors, truck loading facilities, administration buildings and water management infrastructure. The location of the RVC and mining areas relating to this USMP are shown in Figure 1.

The RVC has been in 'care and maintenance' since 2015 until September 2021, when coal production from first workings commenced. Previous mine owners Gujarat NRE Coking Coal Ltd sought approval to expand the longwall mining operations at RVC in 2009, with subsequent amendments to submissions by new owners WRPL in 2013 and 2019 in response to reviews undertaken by the NSW Department of Planning and Environment (DPE). The July 2019 submission provided major changes to the project to significantly reduce impacts from subsidence, including an amended mine plan which no longer involves longwall mining.

Russell Vale Colliery operates under the current Development Consent (DC) granted by the NSW Independent Planning Commission (IPC) on 8 December 2020. The approval, known as the Underground Expansion Project (UEP), is based on the Revised Preferred Project Report and Response to Second PAC Review by Umwelt dated July 2019. Under the approval, WRPL may:

- Extract 1.2 Mt of Run of Mine (ROM) coal per annum, with a maximum of 1 Mt of ROM coal being processed from site in a calendar year; and
- Undertake mining operations for a period of five years from the date of commencement of mining operations.

Mining will be undertaken using the first workings bord and pillar mining methodology, resulting in minimal subsidence and negligible impact on the surface features above the mining area. This mining method was chosen due to the proximity of the proposed mining area to the Cataract Reservoir, the sensitive environmental features above the mining area (such as Coastal Upland Swamps), and the high level of community and stakeholder interest in the project. The location and layout of historical and future mine operations for the Russell Vale East (RVE) UEP are shown in Figure 2 and Figure 3.

The proposed underground workings within the Russell Vale Extraction Area are wholly contained within the WaterNSW Metropolitan Special Area, which is used to provide drinking water to Sydney and Wollongong region, and parts of the workings lie within the Dam Safety NSW (DS NSW) Notification Area for Cataract Reservoir.

No direct impacts to surface features are expected to result from the RVC operations with the exception of the Pit Top works) which is further addressed in the Russell Vale Colliery Pit Top Biodiversity Management Plan (Wollongong Coal 2021a) (see Figure 4). The UEP Project will not result in the direct removal or clearing of any vegetation. The only potential impacts to ecological values are limited to potential indirect impacts associated with subsidence (such as surface cracking) and hydrological changes affecting surface water regimes or near-surface groundwater.

1.3 Purpose and scope

The USMP has been prepared to address the consolidated consent conditions relevant to UEP workings as will be staged in accordance with the mine plan included in the project EP required by Condition C10. Condition C10(g)(v) of the DC requires the preparation of a swamp monitoring program. Given the sensitive nature of Coastal Upland Swamps, this USMP has been prepared as a separate management plan.

Management of non-swamp related biodiversity features is outlined within the Extraction Plan Biodiversity Management Plan (BMP) (WRPL 2022).

The purpose and scope of this USMP as required by Condition C10(g)(v) of the DC MP09_0013 is to:

- Outline statutory requirements, including any performance measures to be achieved.
- Summarise environmental impact assessments undertaken to date and provide baseline data.
- Detail the methodology for the upland swamp monitoring program, including baseline monitoring and the proposed approach to the analysis of this data.

- Describe measures that will be implemented to ensure compliance with any statutory requirements or performance measures.
- Develop specific performance indicators to ensure compliance with the specific performance measures.
- Outline an upland swamp monitoring program to assess the environmental impacts of mining and assess effectiveness of any management measures.
- Develop remedial or contingency plans and outline rehabilitation measures to manage any impacts that exceed performance measures.
- Outline reporting structures.

In accordance with Condition A21 and A22 of the DC, the development of the EP (under Condition C10) is intended to be staged, as outlined in Table 1. Second workings will generally occur in a staged approach (which may be undertaken concurrently) as per the following:

- Staging of second workings (staging defined in Figure 3):
  - Stage 1 – PC21 to PC25 and PC07 to PC08.
  - Stage 2 – PC27 to PC34.

Timeframes for the monitoring of Coastal Upland Swamps are discussed in Section 3.

Section 2 of the main EP, 'Project Description', provides a full summary of the project, including details on the:

- Mine planning and design.
- Mining methodologies.
- Phasing of the surface infrastructure relating to the project over three stages, which are both wholly covered under the EP.

Table 1 Extraction Plan staging and relevance to this Plan

Stage	Description	Extraction Plan Relevance
Stage 1(a)	Mining of panels: ▪ PC21 to PC25	Entirely covered by the EP and this USMP.
Stage 1(b)	Mining of panels: ▪ PC07 to PC08	Entirely covered by the EP and this USMP. The secondary workings will be commenced in PC07 and PC08 following data acquisition obtained from PC21 monitoring.
Stage 2	Mining of panels: ▪ PC27 to PC34	Entirely covered by the EP and this USMP.
Future Stages	Further mining within the approved UEP. Panel configuration with schedule to be included within subsequent EPs.	Pre-mining monitoring referenced within the EP and this USMP.

The monitoring methodologies included in this framework are based upon those currently being undertaken in the Russell Vale East area (WRPL 2022). These methodologies are based upon those relevant to NSW Project Approval 10_0046 granted by the NSW PAC on 13 October 2011, along with the first modification (MOD1) approved by the PAC in 2012, MOD2 in 2014 and MOD

3, extending the project timeframe, also in 2014. A summary of the current ecological monitoring program and results to date is provided in Section 3 and 4.

This monitoring plan details the monitoring framework for upland swamps (referred to in this plan and the broader EP as 'Coastal Upland Swamps' consistent with the listing criteria for this community) that is intended to continue in surface areas within the vicinity of the underground mining as represented in the EP with a focus on monitoring ecological values that have been determined to be most at risk as part of the UEP. This will ensure that in the unlikely event that impacts associated with the underground mining do impact on threatened species or communities, those impacts can be quantified, and further management actions prescribed.

1.4 Management Plan structure

The structure of the remainder of the upland swamp monitoring plan is as follows:

- Section 2: Outlines the statutory requirements applicable to the USMP.
- Section 3: Outlines the upland swamp monitoring operating within the Russell Vale East area and summarises the findings from the baseline data that support this plan.
- Section 4: Describes the ongoing and proposed monitoring program.
- Section 5: Describes the potential direct and indirect impacts from the extraction to the upland swamp monitoring plan to be undertaken during the UEP.
- Section 6: Details the performance measures and indicators that will be used to assess the impacts of mining.
- Section 7: Describes the management and mitigation measures that will be implemented to reduce potential impacts as well as the Contingency Plan to manage any unpredicted impacts and their consequences.
- Section 8: Describes the incidents, complaints, and non-conformance process.
- Section 9: Describes the reporting framework.
- Section 10: Details the administration of this plan.
- Section 11: Describes the process of audit and review of this plan, and the EP.

Environmental management will be undertaken in accordance with the process identified in Figure 5.

A summary of the appendices to this USMP is provided within Table 2 below.

Table 2 Summary of appendices

Appendix	Description
Stage 1	
Appendix A: Agency Consultation	Documents the stakeholder consultation undertaken as part of the preparation of the USMP as detailed in Section 2.6.
Appendix B: Monitoring data and analysis	Contains monitoring data relevant to section Condition C10(g)(v) and Section 4.3.3.3.
Appendix C: Coastal Upland Swamp Risk Assessment Summary	Contains the Coastal Upland Swamp risk assessment summary relevant to Section 4.
Appendix D: TARPs	Contains all necessary TARPs for the USMP. Relevant to Stage 1 and Stage 2 mining.

Appendix	Description
Stage 2	
Appendix A: Agency Consultation	Copies of agency correspondence and responses.
Appendix B: Monitoring data and analysis	As above.
Appendix C: Coastal Upland Swamp Risk Assessment Summary	As above.
Appendix D: TARPs	As above.

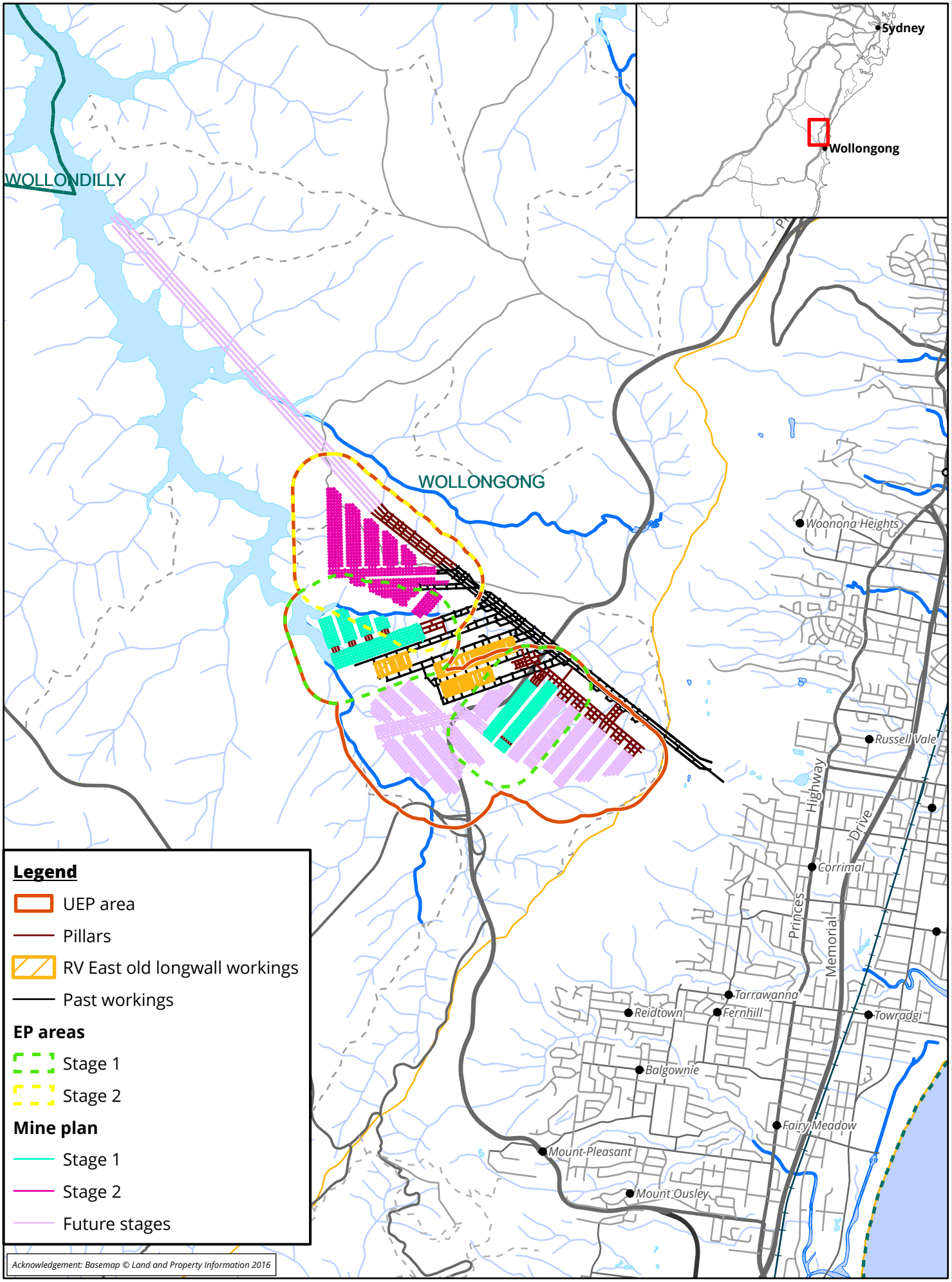

Figure 1 Location of the Russell Vale Colliery

biosis

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Date: 04 April 2022 ,
Prepared for: CBH, Prepared by: AM, Last edited by: amackegard
Layout: 36747_F1_Locality
Project: P:\36700s\36747\Mapping\36747_WCL_Stage2_USMP_figures.aprx

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Metres

Scale: 1:50,000 @ A4
Coordinate System GDA 1994 MGA Zone 56

N

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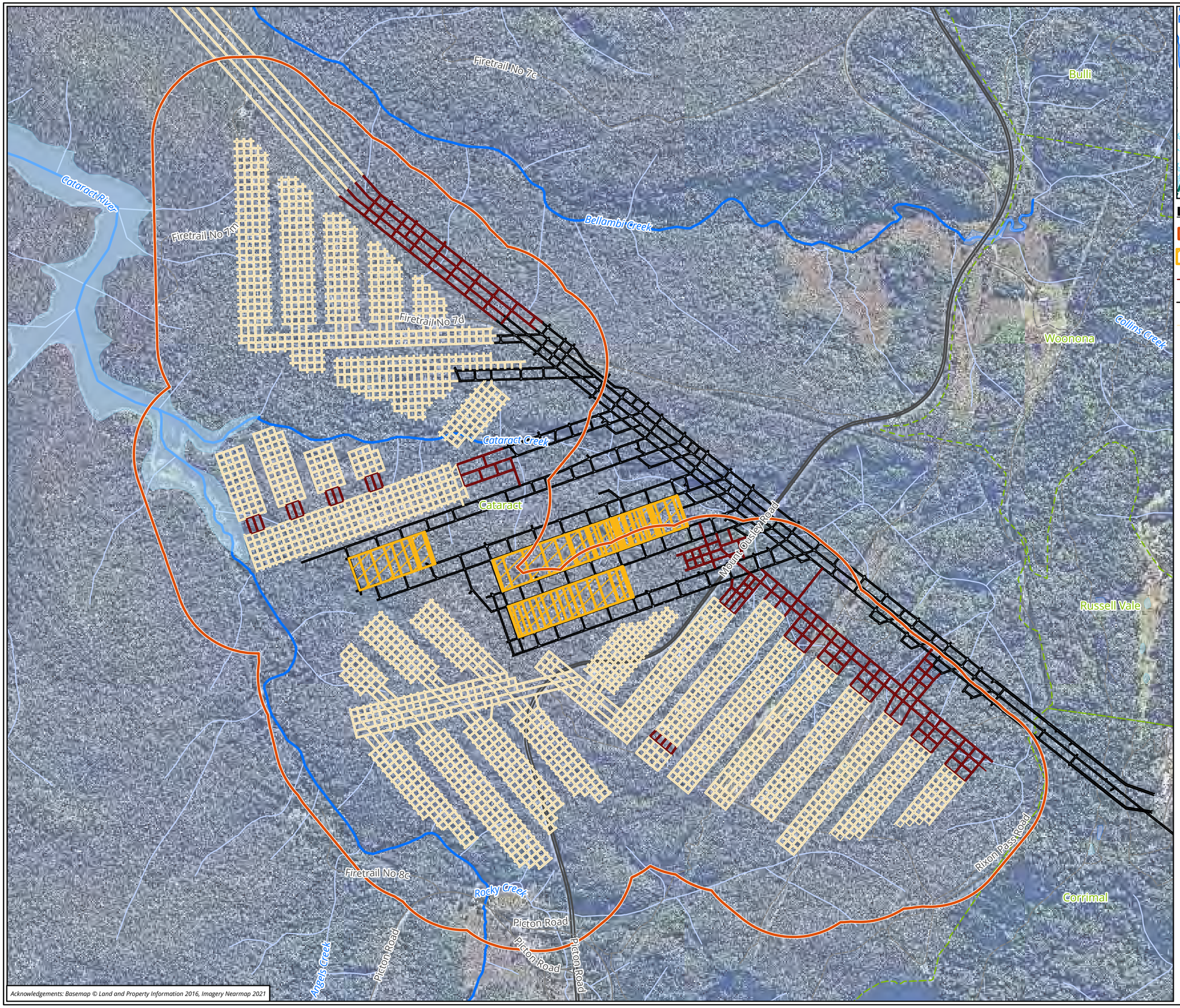

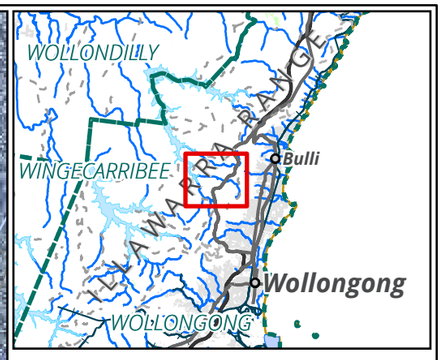

Legend

- UEP area
- RV East old longwall workings
- Pillars
- Past workings
- Mine plan

Figure 2 Revised UEP mine plan

0 120 240 360 480 600

Metres

Scale: 1:15,000 @ A3

Coordinate System: GDA 1994 MGA Zone 56

N

biosis

Matter: 36747,
Date: 06 April 2022 ,
Prepared for: CBH, Prepared by: AM, Last edited by: amackegard
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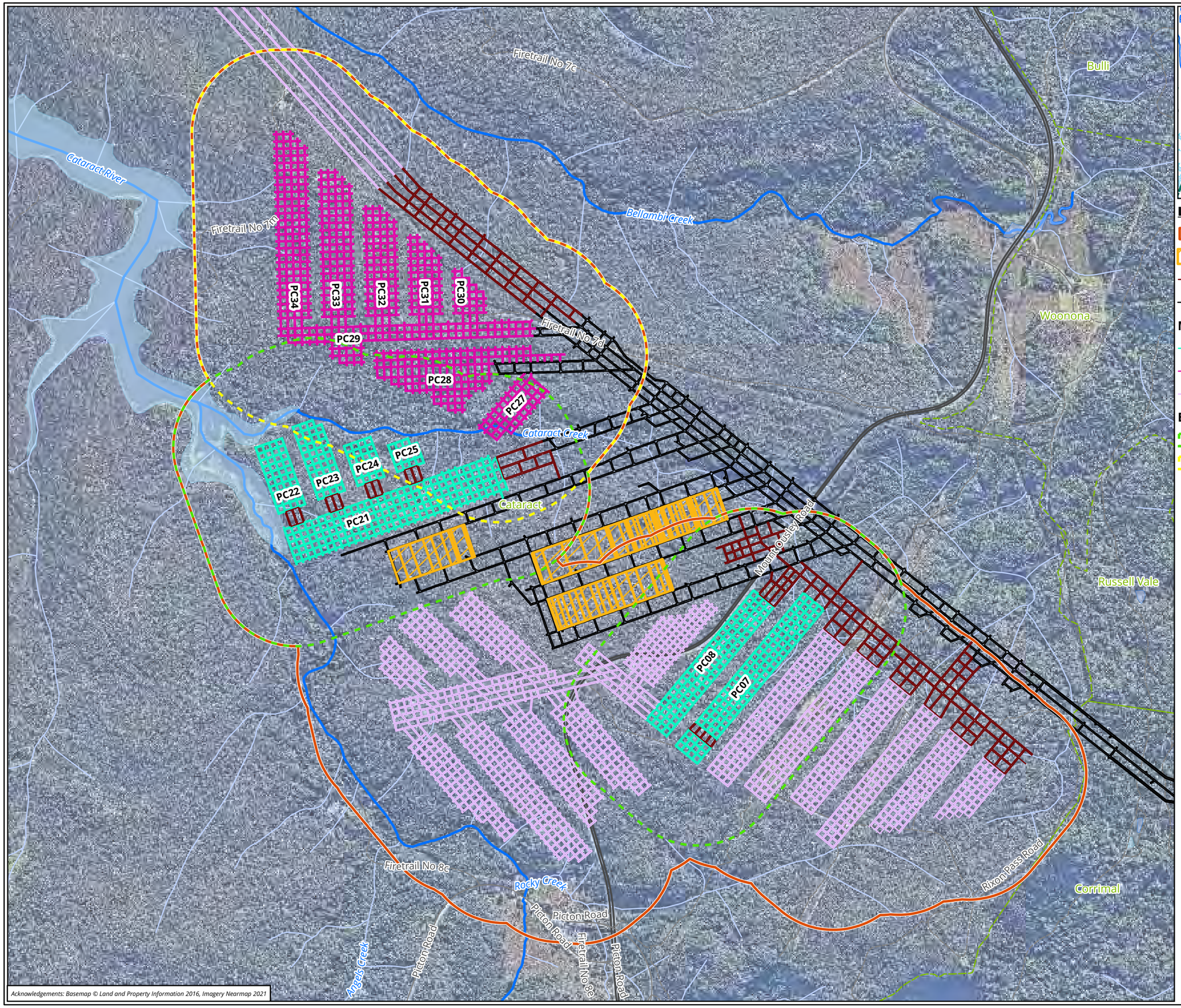

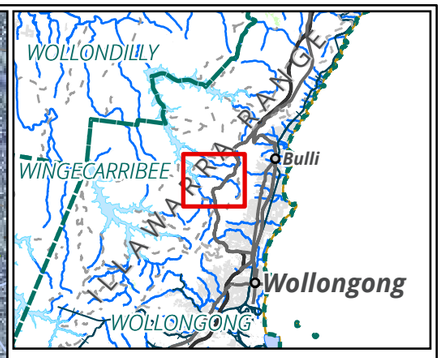

Legend

- UEP area
- RV East old longwall workings
- Pillars
- Past workings

Mine plan

- Stage 1
- Stage 2
- Future stages

EP areas

- Stage 1
- Stage 2

Figure 3 Revised UEP mine plan stages

0 120 240 360 480 600

Metres

Scale: 1:15,000 @ A3

Coordinate System: GDA 1994 MGA Zone 56

N

biosis

Matter: 36747,
Date: 05 April 2022 ,
Prepared for: CBH, Prepared by: AM, Last edited by: amackegard
Layout: F3_Revised_UEP_MinePlan_stages
Project: P:\36700s\36747\Mapping\
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Figure 4 Environmental management structure

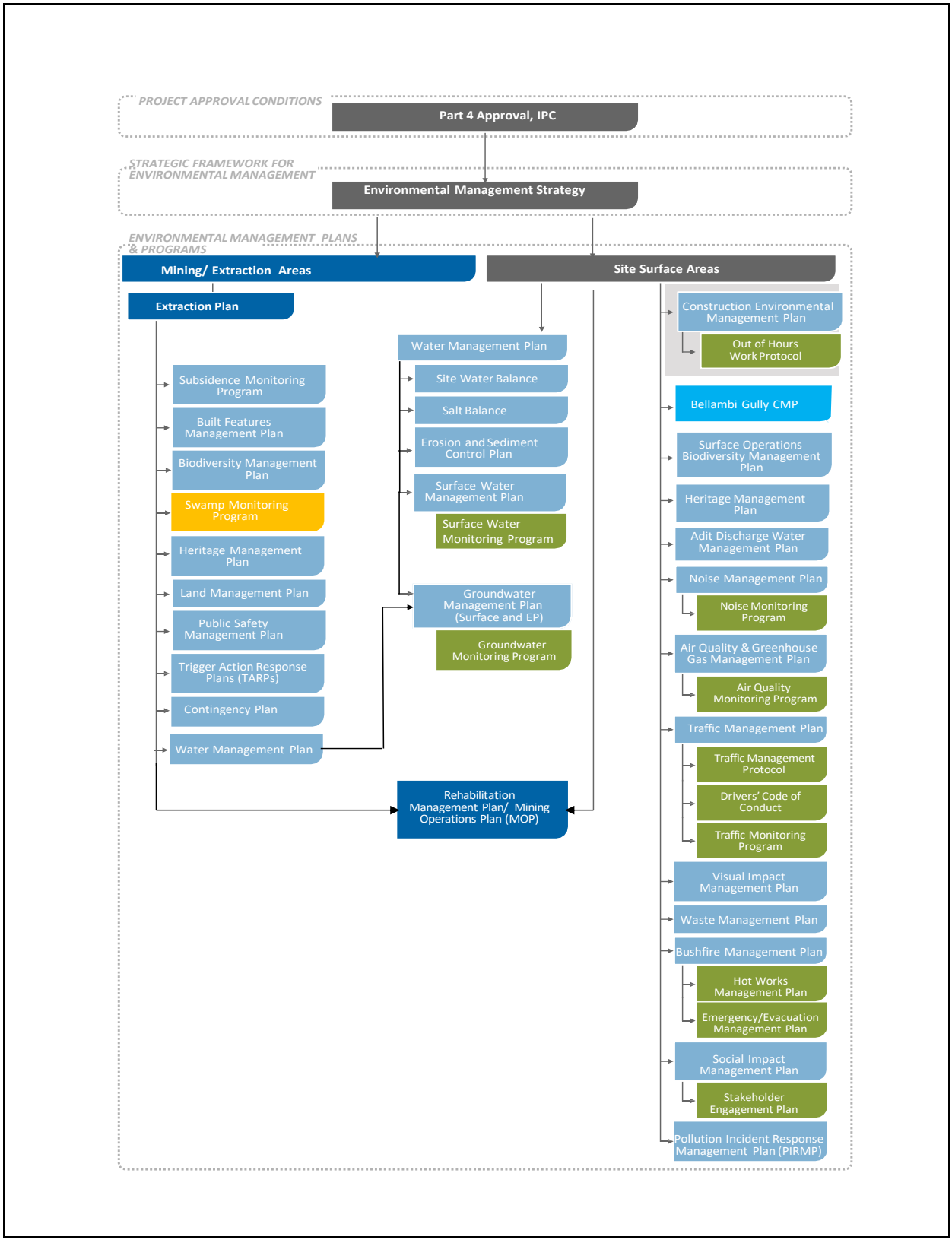
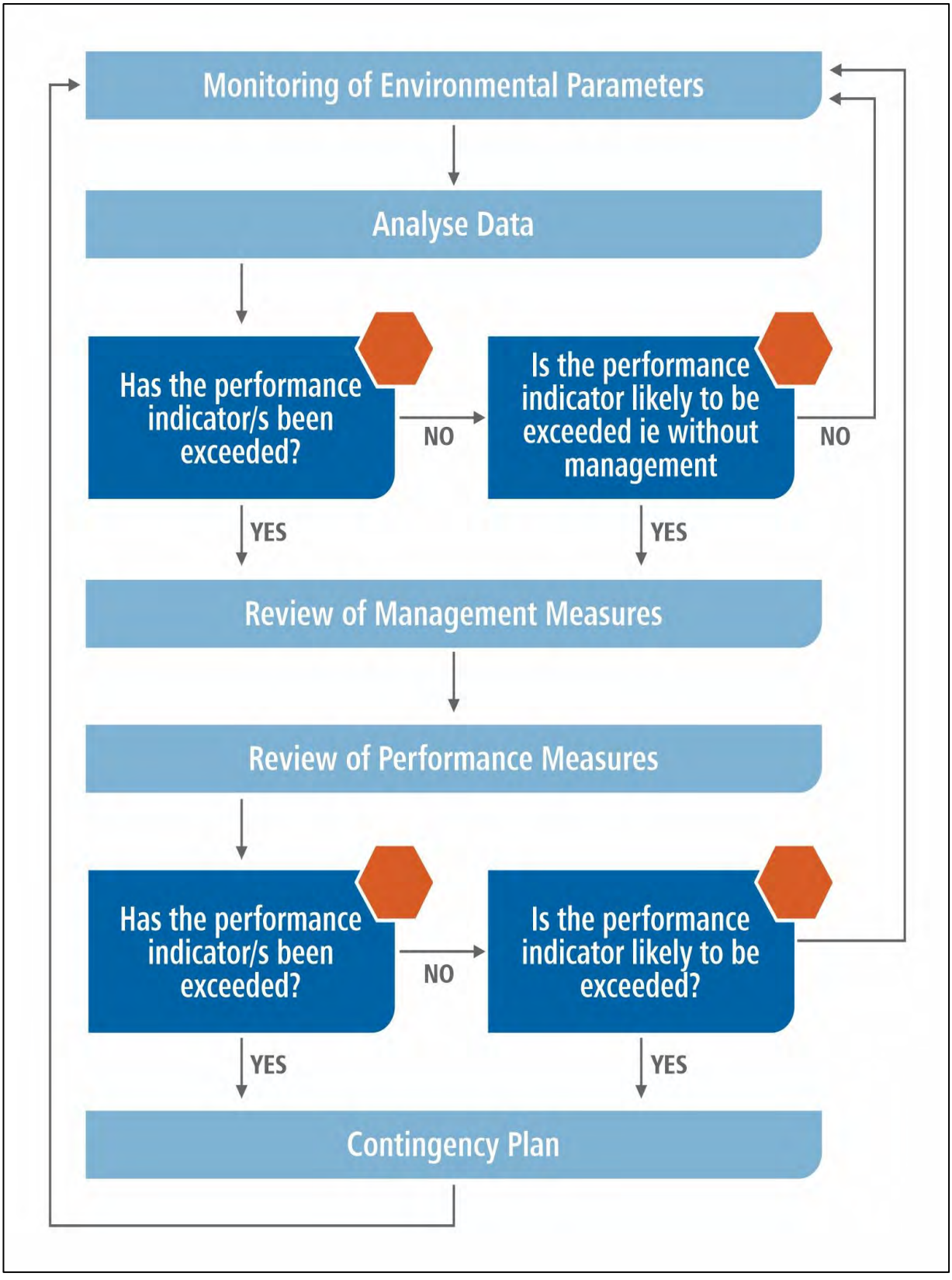


Figure 5 Environmental management process



2 STATUTORY REQUIREMENTS

2.1 Development Consent

The USMP has been prepared in accordance with the DC conditions for a swamp monitoring program, specifically Condition C10(g)(v) of MP09_0013.

Additionally, WRPL is subject to conditions outlined in the EPBC approval 2020/8702 (refer to Section 2.4).

This plan collates the required monitoring actions that are relevant to the monitoring of Coastal Upland Swamps in the project area. This includes:

- The outcome of updated surveys of existing biodiversity, species distribution and swamp condition for potentially impacted and control swamps.
- Further consideration of the location of existing piezometers and the installation of upslope and downslope piezometers in shrub swamps, in order to better understand the down-slope movement of shallow groundwater.
- Installation of flow monitoring points, nested monitoring bores and potential use of environmental water tracers to define hydraulic connection between swamps and associated aquifers.
- Measures to record the nature and condition of terrestrial and aquatic flora and fauna within all swamps.
- Measures to characterise soils or peat layers within the swamps to determine porosity; a basis for relating water levels to rainfall and evapotranspiration; and the presence, or absence, of clay materials at the interface with the underlying bedrock.
- A program for review of the water balance of all monitored swamps based on recorded rainfall, estimated.
- Evapotranspiration and recorded surface and shallow groundwater levels and outflow measurements.
- Detailed performance indicators for the relevant performance measures in Table 10, including performance.
- Indicators relating to surface and shallow groundwater levels and outflow measurements.
- Baseline data for swamp hydrology and swamp vegetation.
- Hydrological and vegetative monitoring which fully satisfies Before-After-Control-Impact (BACI) design principles.
- Consideration of post-mining swamp monitoring, including for the initial 12-month post mining period and longer-term monitoring for inclusion into regional data bases.
- Baseline LiDAR mapping of upland swamps extent and vegetation community confirmation.

The consent conditions relevant to the proposed bord and pillar panels (second workings) are specified in Table 3, with reference to where each component of the condition is addressed within this Plan.

Table 3 Location of addressed components of Schedule 2 Part C and F of MP09_0013 within the USMP

Condition	Requirement	Where addressed
Part C - Specific Environmental Conditions - Underground mining		
C1	The applicant must ensure that the development does not cause any exceedances of the Performance measures in Table 6, to the Satisfaction of the Secretary.	Sections 6, 4 and 7
Offsets		
C4	If the Applicant exceeds the performance measures in Table 6 and the Secretary determines that:	Section 7.8
C4(a)	It is not reasonable or feasible to remediate the subsidence impact or environmental consequence; or	
C4(b)	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. Notes: ▪ Any offset required under this condition must be proportionate with the significance of the subsidence impact or environmental consequence. ▪ Any offset required under this condition does not limit other actions by the Department under the penalty powers or enforcement provisions of the EP&A Act.	
Extraction Plan		
C10	The Applicant must prepare an Extraction Plan for all second workings on site to the satisfaction of the Secretary. The Extraction Plan must:	-
C10(a)	Be prepared in consultation with RR, DPE Water and WaterNSW and by suitably qualified and experienced person/s whose appointment has been endorsed by the Secretary;	Section 2.5
C10(b)	Be approved by the Secretary before the Applicant carries out any second workings covered by the plan;	Noted
C10(f)	Describe in detail the performance indicators that would be implemented to ensure compliance with the performance measures in Tables 5 and 6, and manage or remediate any impacts and/or environmental consequences to meet the rehabilitation objectives in Table 4;	Section 6
Swamp Monitoring Program		
C10(g)	Include a:	-
C10(g)(v)	Swamp Monitoring Program which has been prepared in consultation with BCD, DPI Water and WaterNSW, and which includes (as a minimum):	Section 2.6
	▪ Outcome of updated surveys of existing biodiversity, species distribution and swamp condition for potentially impacted and control swamps.	Section 3 and 4
	▪ Further consideration of the location of existing piezometers and the installation of upslope and downslope piezometers in shrub swamps, in order to better understand the down-slope movement of shallow groundwater.	Section 3.1, 4.2

Condition	Requirement	Where addressed
	▪ Installation of flow monitoring points, nested monitoring bores and environmental water tracers to define hydraulic connection between swamps and associated aquifers.	Section 4.3
	▪ Measures to record the nature and condition of terrestrial and aquatic flora and fauna within all swamps.	Section 3.2.1, 4.3, 4.4, 4.5, Appendix B
	▪ Measures to characterise soils or peat layers within the swamps to determine porosity; a basis for relating water levels to rainfall and evapotranspiration; and the presence, or absence, of clay materials at the interface with the underlying bedrock.	Section 4.3
	▪ A program for review of the water balance of all monitored swamps based on recorded rainfall.	Section 4.3
	▪ Estimated evapotranspiration and recorded surface and shallow groundwater levels and outflow measurements.	Section 3.1
	▪ Detailed performance indicators for the relevant performance measures in Table 5.	Section 4.1
	▪ Performance indicators relating to surface and shallow groundwater levels and outflow measurements.	Appendix D
	▪ Baseline data for swamp hydrology and swamp vegetation.	Section 3, Appendix B
	▪ Hydrological and vegetative monitoring which fully satisfies BACI design principles.	Section 4.3, 4.3
	▪ Consideration of post-mining swamp monitoring, including for the initial 12-month post-mining period and longer-term monitoring for inclusion into regional data bases.	Section 3.2, 4.3
	▪ A program for consideration of long-term monitoring data for swamp hydrology and swamp vegetation (including baseline, during and post mining) to identify any statistically significant changes.	Section 3 and 4
	▪ Provision of raw piezometer and other monitoring data to the Department, BCD and WaterNSW, if requested.	Appendix B
	▪ Incorporation of any relevant findings from swamp research developments into the swamp monitoring program.	Section 4
C10(g)(viii)	Trigger Action Response Plan/s addressing all features in Tables 5 and 6, which contain:	-
	▪ Appropriate triggers to warn of increased risk of exceedance of any performance measure.	Section 7.3
	▪ Specific actions to respond to high risk of exceedance of any performance measure to ensure that the measure is not exceeded.	Appendix D
	▪ Adaptive management where monitoring indicates that there has been an exceedance of any performance measure in Tables 5 and 6, or where any such exceedance appears likely.	Section 7.3.1, Appendix D
	▪ An assessment of remediation measures that may be required if exceedances occur and the capacity to implement those measures.	Section 7.5
C10(g)(ix)	Contingency Plan that expressly provides for:	-
	▪ Adaptive management where monitoring indicates that there has been an exceedance of any performance measures in Tables 5 and 6, or where exceedance appears likely.	Section 7.5

Condition	Requirement	Where addressed
	▪ An assessment of remediation measures that may be required if exceedances occur and the capacity to implement those measures.	Section 7.6 and 7.7
C10(g)(x)	Proposes appropriate revisions to the Rehabilitation Management Plan.	Refer to EP
C10(g)(xi)	Includes a program to collect sufficient baseline data for future Extraction Plans.	Section 3 and 4 (generally), Appendix D
Part F – Environmental Management, Reporting and Auditing		
Incident notification		
F9	The Applicant must immediately notify the Department and any other relevant agencies immediately after it becomes aware of an incident. The notification must identify the development (including the development application number and name) and set out he location and nature of the incident.	Section 7.4 and 8.1
Non-compliance Notification		
F10	Within seven days of becoming aware of a non-compliance, the Applicant must notify the Department of the non-compliance. The notification must set out the condition of this consent that the development is non-compliance with, why it does not comply and the reasons for the non-compliance (if known) and what actions have been, or will be, undertaken to address the non-compliance.	Section 8.2
Annual Review		
F11	By the end of March each year after the commencement of the development under this consent, or other timeframe agreed by the Planning Secretary, a report must be submitted to the Department reviewing the environmental performance of the development, to the satisfaction of the Planning Secretary. This review must:	Section 9 and 11
F11(a)	Describe the development (including any rehabilitation) that was carried out in the previous calendar year and the development that is proposed to be carried out over the current calendar year;	
F11(b)	Include a comprehensive review of the monitoring results and complaints records of the development over the previous calendar year, including a comparison of these results against the:	
F11(b)(i)	Relevant statutory requirements, limits or performance measures/criteria;	
F11(b)(ii)	Requirements of any plan or program required under this consent;	
F11(b)(iii)	Monitoring results of previous years; and	
F11(b)(iv)	Relevant predictions in the document/s listed in Condition A2(c);	
F11(c)	Identify any non-compliance or incident which occurred in the previous calendar year, and describe what actions were (or are being) taken to rectify the non-compliance and avoid recurrence;	
F11(d)	Evaluate and report on:	
F11(d)(ii)	Compliance with the performance measures, criteria and operating conditions of this consent;	
F11(e)	Identify any trends in the monitoring data over the life of the development;	

Condition	Requirement	Where addressed
F11(f)	Identify any discrepancies between the predicted and actual impacts of the development, and analyse the potential cause of any significant discrepancies; and	
F11(g)	Describe what measures will be implemented over the next calendar year to improve the environmental performance of the development.	
F12	Copies of the Annual Review must be submitted to Wollongong City Council, Wollondilly Shire Council and made available to the Community Consultative Committee and any interested person upon request.	Noted
Independent Environmental Audit		
F13	Within one year of commencement of the development under this consent, and three years after, unless the Planning Secretary directs otherwise, the Applicant must commission and pay the full cost of an Independent Environmental Audit of the development. The audit must:	Section 11
F13(a)	Be prepared in accordance with the Independent Audit Post Approval Requirements (Department 2020 or as updated);	
F13(b)	Be led and conducted by a suitably qualified, experienced and independent auditor whose appointment has been endorsed by the Planning Secretary;	
F13(c)	Be conducted by a suitably qualified, experienced and independent team of experts (including any expert in field/s specified by the Planning Secretary) whose appointment has been endorsed by the Planning Secretary;	
F13(d)	Be carried out in consultation with the relevant agencies and the Community Consultative Committee;	
F13(e)	Assess the environmental performance of the development and whether it is complying with the relevant requirements in this consent, water licences and mining leases for the development (including any assessment, strategy, plan or program required under these approvals);	
F13(f)	Review the adequacy of any approved strategy, plan or program required under the abovementioned approvals and this consent;	
F13(g)	Recommend appropriate measures or actions to improve the environmental performance of the development and any assessment, strategy, plan or program required under the abovementioned approvals and this consent; and	
F13(h)	Be conducted and reported to the satisfaction of the Planning Secretary.	
F14	Within three months of commencing an Independent Environmental Audit, or other timeframe agreed by the Planning Secretary, the Applicant must submit a copy of the audit report to the Planning Secretary, and any other NSW agency that requests it, together with its response to any recommendations contained in the audit report, and a timetable for the implementation of the recommendations. The recommendations must be implemented to the satisfaction of the Planning Secretary.	Section 11

Condition	Requirement	Where addressed
Monitoring and Environmental Audits		
F15	Any condition of this consent that requires the carrying out of monitoring or an environmental audit, whether directly or by way of a plan, strategy or program, is taken to be a condition requiring monitoring or an environmental audit under Division 9.4 of Part 9 of the EP&A Act. This includes conditions in respect of incident notification, reporting and response, non-compliance notification, compliance report and independent audit.	Section 11

In addition, to the above, Condition C2 contains specific requirements in relation to the measurement and monitoring of performance measures:

C2 *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 the proposed methods, the Planning Secretary will be the final arbiter.*

2.2 Management Plan requirements

Schedule 2, Part F, Condition F5 of Development Consent MP09_0013 requires the management plans under this consent to be prepared in accordance with the relevant guidelines as detailed. Table 4 details where each component of the condition is addressed within this USMP.

In accordance with Condition C10, WRPL will ensure implementation of this USMP as approved by the Secretary, before carrying out any second workings covered by the plan.

Table 4 Management plan requirements as per Schedule 2 Part F of MP09_0013 within the USMP

Condition	Requirement	Where addressed
F5	Management plans required under this consent must be prepared in accordance with relevant guidelines, and include:	-
F5(a)	A summary of relevant background or baseline data;	Section 3, Appendix B and Appendix D
F5(b)	Details of:	-
F5(b)(i)	The relevant statutory requirements (including any relevant consent, licence or lease conditions);	Section 2
F5(b)(ii)	Any relevant limits or performance measures and criteria; and	Section 6
F5(b)(iii)	The specific performance indicators that are proposed to be used to judge the performance of, or guide the implementation of, the development or any management measures;	Sections 6, Section 7.3 and Appendix D

Condition	Requirement	Where addressed
F5(c)	Any relevant commitments or recommendations identified in the document/s listed in condition A2;	Section 2.3
F5(d)	A description of the measures to be implemented to comply with the relevant statutory requirements, limits, or performance measures and criteria;	Sections 4, 6 and 7
F5(e)	A program to monitor and report on the:	Sections 4, 9 and 11
F5(e)(i)	Impacts and environmental performance of the development; and	
F5(e)(ii)	Effectiveness of the management measures set out pursuant to condition F5(c);	
F5(f)	A contingency plan to manage any unpredicted impacts and their consequences and to ensure that ongoing impacts reduce to levels below relevant impact assessment criteria as quickly as possible;	Section 7.5 (and Section 7 generally)
F5(g)	A program to investigate and implement ways to improve the environmental performance of the development over time;	Section 7.5 (and Section 7 generally)
F5(h)	A protocol for managing and reporting any:	Section 8 and Section 9 The EP (Sections 4 and 5)
F5(h)(i)	Incident; non-compliance or exceedance of any impact assessment criterion or performance criterion;	
F5(h)(ii)	Complaint; or	
F5(h)(iii)	Failure to comply with other statutory requirements;	
F5(i)	Public sources of information and data to assist stakeholders in understanding environmental impacts of the development; and	Sections 11 and 12 Refer also to the EP (Section 5)
F5(j)	A protocol for periodic review of the plan.	

2.3 Statement of commitments

Section 6 of the Revised Preferred Project Report (Biosis 2014a) included a Statement of Commitments for the Revised Preferred Project. As a result of submissions received, WRPL committed to additional environmental management and monitoring measures as outlined in the Submission Report (NRE 2013) – Part A and Part B. Table 5 presents an updated consolidated Statement of Commitments for the Revised Preferred Project (Biosis 2014a).

Table 5 Statement of commitments

Commitment	Timing	Where addressed
WRPL will consult with the NSW Biodiversity and Conservation Division as part of the process to review and update the Biodiversity Management Plan and Upland Swamp Management Plan to reflect the Revised Preferred Project and associated management and monitoring measures.	Within 3 months of approval and ongoing	Section 2.4

Commitment	Timing	Where addressed
Given that no perceptible subsidence impacts are predicted to occur as a result of the Revised Preferred Project, monitoring of potential biodiversity impacts will be focussed on subsidence monitoring and monitoring required to detect primary impacts to groundwater systems associated with upland swamps, and surface water flow and quality in creeks. If subsidence impacts and/or primary impacts in excess of those predicted are detected, the monitoring program will be reassessed.	Ongoing in accordance with the BMP (WRPL 2022)	Section 3, 4 and 7.5 Refer also to the EP

2.4 EPBC Act approval requirements

The Revised Preferred Project for the UEP was referred under the EPBC Act for approval (2020/8702) on 4 August 2020 and subsequently approved by DCCEEW on 31 August 2021.

The relevant conditions of EPBC 2020/8702 relevant to the proposed bord and pillar panels (second workings) and potential impacts on Coastal Upland Swamps are specified in Table 6 with reference to where each component of the condition is addressed within this USMP.

Table 6 Location of addressed components of EPBC 2020/8702 within the USMP

Condition	Requirement	Where addressed
1.	For the protection of water resources, the approval holder must comply with State Development Consent conditions B12-B20, C1-C3, and C10-C11.	The EP generally and other management plans
2.	The approval holder must ensure there is no adverse effect on the function of a water resource as a result of the mining activities of the action.	Section 7
7.	In addition to the monitoring requirements specified in and/or required under condition B17 and condition C10 of the State Development Consent, the approval holder must:	-
7.a.	Establish, at least 12 months prior to any potential impact at each proposed monitoring site, and then maintain, a network of groundwater monitoring bores across the Development Application Area designed to detect changes in groundwater levels in all potentially impacted aquifers, including shallow aquifers used by Coastal Upland Swamps, and any changes in connectivity between aquifers;	Section 4.2
7.b.	Monitor groundwater levels as each monitoring bore (established as required under condition 7a) at least once every three months, from installation until:	Section 4.2
7.b.i.	12 months after the cessation of mining for all monitoring bores within Coastal Upland Swamps;	
7.b.ii.	Five years after the cessation of mining for other monitoring bores excepting those required to monitor groundwater recovery and potential discharge from adits;	

Condition	Requirement	Where addressed
7.b.iii.	For the period for which the approval has effect for any other monitoring site required to monitor groundwater recovery and potential discharge from adits.	
7.c.	Within 20 business days of the end of the three-month monitoring period, publish on the website and submit to the Department, all monitoring data collected in accordance with condition 7.b, updated at least once every three months to include the most recent monitoring data. Maintain the data on the website for:	Sections 4.2, 4.3.3.3 and 9
7.c.i.	At least five years after the cessation of mining for all monitoring bores within Coastal Upland Swamps;	
7.c.ii.	At least five years after the cessation of mining for other monitoring bores excepting those required to monitor groundwater recovery and potential discharge from adits; and	
7.c. (cont.)	The monitoring data must include hydrographs for all bores and be accompanied by an explanation of what the data means in relation to meeting and maintenance of the performance measures relevant to groundwater specified in the State Development Consent;	
7.d.	Establish, at least 12 months prior to second workings being within 350 metres (m) (horizontal distance from the closest boundary) of each Coastal Upland Swamp, and maintain, in all potentially impacted Coastal Upland Swamps, and in multiple reference swamps that demonstrate baseline condition, monitoring capable of determining individual water balances for each potentially impacted Coastal Upland Swamp;	Section 4.2
7.e.	Monitor all components of the network established as required under 7.d, at least once every three months from installation until at least 12 months after the cessation of mining;	Section 4.2
7.f.	Within 20 business days of the end of the three-monthly monitoring period, publish on the website and submit to the Department all monitoring data collected in accordance with condition 7.e, updated at least once every three months to include the most recent monitoring data. Maintain the data on the website for at least five years after the monitoring program has been completed. Include an evaluation of what the data means in relation to meeting and maintenance of the performance measures relevant to water resources specified in the State Development Consent.	Sections 4.2, 4.3.3.3 and 9
7.g.	Include, in each compliance report, the monitoring data collected in accordance with condition 7.b and 7.e, in relation to the period covered by each compliance report. Include an evaluation of performance against the performance measures relevant to water resources specified in the State Development Consent.	Sections 4.2, 4.3.3.3 and 9
15.	In addition to the monitoring requirements specified in and/or required under condition C10 of the State Development Consent, the approval holder must:	-
15.a.	Undertake surveys prior to the commencement of the action, using a method consistent with the requirements of condition C2 of the State Development Consent, to determine the baseline condition in relation to subsidence at each potentially impacted Coastal Upland Swamp;	Section 4.1

Condition	Requirement	Where addressed
15.b.	Monitor for, and measure any, vertical subsidence using an approach consistent with the requirements of condition C2 of the State Development Consent, at least weekly at any potentially impacted Coastal Upland Swamp when second workings are within 350 m (horizontal distance from the closest boundary) of the particular Coastal Upland Swamp, starting at least one week prior to the commencement of second workings within 350 m of the particular Coastal Upland Swamp and continuing until at least 12 months after the cessation of mining;	Section 4.1
15.c.	Publish on the website and submit to the Department the monitoring data collected in accordance with condition 15.b, updated at least once every three months to include the most recent monitoring data, and accompanied by an evaluation of the risk of the subsidence limit being reached or exceeded. Maintain the data and evaluation on the website for at least 5 years after the cessation of mining;	Refer to main EP
15.d.	Include, in each compliance report, the monitoring data collected in accordance with condition 15.b, in relation to the period covered by each compliance report. Include an evaluation of the risk of any subsidence limit being reached or exceeded.	Refer to main EP
16.	If, at any time during the period for which the approval has effect, the approval holder detects that any subsidence limits have been reached or exceeded the approval holder must cease second workings and notify the Department of this within two business days of detecting the exceedance.	Sections 7 (and in particular Section 7.4) and Section 8
17.	If the approval holder has been required to cease second workings pursuant to condition 16, the approval holder must not recommence second workings until it can be demonstrated that new or increased impacts will not occur and the Minister approves, in writing, the recommencement of second workings.	Section 7 (and in particular Section 7.4)
18.	If the approval holder exceeds the performance measure required by State Development Consent condition CI, and the NSW Planning Secretary determines that an offset is required under State Development Consent condition C4, the approval holder must provide the Department with details of the offset(s) approved by the NSW Planning Secretary within 10 business days of the approval by the NSW Planning Secretary.	Section 7.8
Annual compliance reporting		
25.	The approval holder must by the end of each 12-month period following the date of commencement of the action, or as otherwise agreed to in writing by the Minister, prepare a compliance report. The approval holder must:	Section 9
25.a.	Publish each compliance report on the website within 60 business days following the end of the 12-month period for which that compliance report is prepared;	
25.b.	Notify the Department by email that each compliance report has been published on the website and provide the we blink for the compliance report within five business days of the date of publication of each compliance report;	

Condition	Requirement	Where addressed
25.c.	Keep all compliance reports publicly available on the website until this approval expires;	
25.d.	Exclude or redact sensitive ecological data from compliance reports published on the website; and	
25.e.	Where any sensitive ecological data has been excluded from the version published, submit the full compliance report to the Department within 5 business days of publication on the website.	
Reporting non-compliance		
26.	The approval holder must notify the Department in writing of any: incident; non-compliance with the conditions; or non-compliance with the commitments made in plans. The notification must be given as soon as practicable, and no later than two business days after becoming aware of the incident or non-compliance. The notification must specify:	Section 8
26.a.	Any condition which has been or may have been in breach;	
26.b.	A short description of the incident and/or non-compliance; and	
26.c.	The location (including co-ordinates), date, and time of the incident and/or non-compliance. In the event the exact information cannot be provided, provide the best information available.	
27.	The approval holder must provide to the Department the details of any incident or noncompliance with the conditions or commitments made in plans as soon as practicable and no later than 10 business days after becoming aware of the incident or non-compliance, specifying:	Section 8
27.a.	Any corrective action or investigation which the approval holder has already taken or intends to take in the immediate future;	
27.b.	The potential impacts of the incident or non-compliance; and	
27.c.	The method and timing of any remedial action that will be undertaken by the approval holder.	
Independent audit		
28.	The approval holder must ensure that an independent audit of compliance with the conditions is conducted for the three-year period from the date of this approval and subsequently for every three-year period for the life of the approval, or as otherwise requested in writing by the Minister.	Section 11
29.	For each independent audit, the approval holder must:	Section 11
29.a.	Provide the name and qualifications of the independent auditor and the draft audit criteria to the Department;	
29.b.	Only commence the independent audit once the audit criteria have been approved in writing by the Department; and	
29.c.	Submit an audit report to the Department within the timeframe specified in the approved audit criteria.	
30.	The approval holder must publish the audit report on the website within 10 business days of receiving the Department's approval of the audit report and keep the audit report published on the website until the end date of this approval.	Section 11

2.5 Relevant legislation and guidelines

WRPL will conduct approved mining operations consistent with DC MP09_0013 and EPBC 2020/8702 approval conditions and any other legislation that is applicable. The following Acts may be applicable:

- *Biodiversity Conservation Act 2016.*
- *The Crown Land Management Act 2016.*
- *Energy and Utilities Administration Act 1987.*
- *Environmental Planning and Assessment Act 1979.*
- *Environment Protection and Biodiversity Conservation Act 1999* (Commonwealth).
- *Mining Act 1992.*
- *Protection of the Environment Operations Act 1997.*
- *Water Management Act 2000.*
- *Water NSW Act 2014.*
- *Work Health and Safety (Mines and Petroleum Sites) Act 2013.*

Relevant licences or approvals required under these Acts will be obtained as required.

2.5.1 Environment Protection and Biodiversity Conservation Act 1999

The Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) is the Australian Government's key piece of environmental legislation. The EPBC Act applies to developments and associated activities that have the potential to significantly impact on Matters of National Environmental Significance (MNES) protected under the Act.

Coastal Upland Swamp in the Sydney Basin Bioregion is listed as an Endangered Ecological Community (EEC) under the EPBC Act and is a groundwater dependent ecosystem (GDE).

The Coastal Upland Swamps in the EP area are markedly different to other Coastal Upland Swamps on the Woronora plateau in that they are predominantly drier, generally smaller with shallower soils, have less humic material, have more interspersed sandstone outcrops within their outlines, and are less spatially continuous than a "typical" humic, saturated swamp (Biosis 2014b).

The only potential impacts to ecological MNES relating to Coastal Upland Swamps are limited to potential indirect impacts associated with subsidence and hydrological changes affecting surface water regimes or near-surface groundwater, which may potentially impact the Coastal Upland Swamp in the Sydney Basin Bioregion EEC. These potential impacts are discussed further in Section 3.2.1. This Plan has been prepared to monitor and mitigate impacts on the EEC as a result of the UEP project.

In addition, there are two flora species (Leafless Tongue-orchid *Cryptostylis hunteriana* and Prickly Bush-pea *Pultenaea aristata*) and five fauna species (Giant Burrowing Frog *Heleioporus australiacus,* Silver Perch *Bidyanus bidyanus*, Trout Cod *Maccullochella macquariensis*, Macquarie Perch *Macquaria australasica*, and Murray Cod *Maccullochella peelii*) listed under the EPBC Act, that have a moderate or greater likelihood of occurrence in the EP area and are susceptible to impacts from subsidence. One additional species listed under the EPBC Act,

Littlejohn's Tree Frog *Litoria littlejohni*, has been assumed present within the Stage 2 EP area. These species and the potential for sensitive habitats to be impacted are addressed in the BMP (WRPL 2022).

2.5.2 Biodiversity Conservation Act 2016

The *Biodiversity Conservation Act 2016* (BC Act) is the key piece of legislation providing for the protection and conservation of biodiversity in NSW through the listing of threatened species and communities and key threatening processes (KTPs). Impacts to threatened species and communities are assessed under Section 7.3 of the BC Act. The BC Act also establishes the framework for biodiversity offsetting.

Coastal Upland Swamp in the Sydney Basin Bioregion is also listed as an EEC under the BC Act. The Coastal Upland Swamp community also provides known habitat for Giant Dragonfly *Petalura gigantea,* listed as Endangered under the BC Act, within the EP area. There are two flora species (Leafless Tongue-orchid *Cryptostylis hunteriana* and Prickly Bush-pea *Pultenaea aristata*) and three fauna species (Giant Burrowing Frog *Heleioporus australiacus,* Giant Dragonfly *Petalura gigantea*, Red-crowned Toadlet *Pseudophryne australis*) listed under the BC Act that have a moderate or greater likelihood of occurrence in the EP area and are susceptible to impacts from subsidence. One additional species listed under the BC Act, Littlejohn's Tree Frog *Litoria littlejohni*, has been assumed present within the Stage 2 EP area. Of these species, Giant Burrowing Frog, Leafless Tongue-orchid and Prickly Bush-pea are considered to be relevant to Coastal Upland Swamps. These species and the potential for sensitive habitats to be impacted are addressed in the BMP (WRPL 2022).

This Plan has been prepared to monitor and mitigate impacts on the EEC and Giant Dragonfly, as a result of the second workings covered in the EP.

2.6 Consultation

2.6.1 Consultation during the environmental assessment process

Extensive community and government consultation has been carried out prior to and during the preparation of the original environmental assessment, the Revised Preferred Project Report (Biosis 2014a), the Submissions Report (NRE 2013) and other project-related assessment documentation. The primary objective of consultation was to keep the community, government agencies and other stakeholders informed and involved during project development process.

Community engagement was carried out in two phases and is summarised in Section 4.1.2 and Section 4.1.3 of the Revised Preferred Project Report (Biosis 2014a). A complete summary of previous and ongoing government agency and stakeholder consultation is provided in Table 4.5 of the Revised Preferred Project Report (Biosis 2014a).

2.6.2 Consultation during the preparation of the Management Plan

This Plan has been prepared in consultation with, and copies will be distributed to:

- NSW Department of Planning and Environment (DPE) which incorporates NSW Environment, Energy and Science (EES) and the Biodiversity Conservation Division (BCD).
- Commonwealth Department of Climate Change, Energy, the Environment and Water (DCCEEW).
- WaterNSW.

Details of the consultation are provided in Table 7 below, and Appendix A.

Table 7 Project consultation

Agency name and timing of consultation	Subject of consultation	Where addressed
Stage 1		
DPE (Planning) – 9 February 2021	Letter to the department advising on the proposed team for the development of the EP including its sub-plans for Subsidence, Water, Biodiversity and Swamps.	Section 1.1
DPE (includes EES and BCD) - 5 March 2021 and 9 July 2021	Discussed information requirements of the plan to ensure adequacy for monitoring all threatened species and communities potentially affected by the UEP Project. See Appendix A for the details of this feedback.	Section 3.2.1, 4, and Appendix A
DCCEEW and Office of Water Science (OWS) – 2 March 2021	Discussed February 2021 IESC advice regarding potential impacts on water dependent ecosystems and Coastal Upland Swamps.	Section 5, in particular 5.2, and 4.3
OWS – 9 April 2021	Discussed approach to use of reference sites for Coastal Upland Swamp biodiversity monitoring and TARP requirements for threatened species potentially impacted by subsidence or changes in hydrological processes.	Section 4 and Appendix D
DCCEEW May – June 2021	Discussion regarding subsidence and groundwater monitoring requirements for Coastal Upland Swamps. A draft of this plan was provided to DCCEEW in June 2021. Monitoring requirements specified in EPBC 2020/8702 were also established following consultation with DCCEEW in relation to the nature of the swamps. This consultation is also specifically considered in the Minister's Statement of Reasons dated 31 August 2021.	Section 3.1, 4.1 and 4.2
BCS/ESS – 12 November 2021	Discussion regarding Impact and control sites, baseline data, QA/QC and BACI Design.	Section 3 and 4.3
Stage 2		
DPE (Planning)	Regular engagement throughout process. No specific comments provided in relation to Upland Swamps in relation to Stage 2. Plan reviewed by DPE as part of approval process.	TBD
EES – BCD	Initial email correspondence received from BCD on 09 May 2022, which requested specific information and data regarding Stage 1. Further feedback for Stage 2 was received from DPE BCD on 23 May 2022.	Detailed copies of the relevant correspondence are included in Appendix A. Initial response to feedback provided to BCD via letter on 9 June 2022. Following this, a meeting will be held between

Agency name and timing of consultation	Subject of consultation	Where addressed
		WRPL, BCD and DPE on 15 June 2022 to further discuss.
DPE (Water)	Define the water level trigger action thresholds for the nested monitoring bores including the deeper sandstone aquifer.	Addressed in Section 4.2 See also the Groundwater Management Plan (GWMP, (WRPL 2022b))
	Incorporate environmental tracers within the suite of water quality analytes.	Addressed in Section 4.2 See also the Water Management Plan (WMP, (WRPL 2022c)) and GWMP (WRPL 2022b)
	Provide a supplementary statement to the existing "Statement of Commitment "that requires the proponent to identify the cause (natural or mining related) of any identified level 2 or 3 exceedances, and not arrive at an open finding due to insufficient monitoring evidence.	Addressed in WMP
	Consider including a dispute resolution step in the TARP for instances where there may be differing opinions in relation to the cause of any exceedance. Additionally, Figure 15 – Flow chart box should consider a process for dispute resolution in the event there is conflicting opinion between agency and stakeholder as to whether the impact is/isn't mining related.	Addressed in main EP
WaterNSW	WaterNSW does not have any concerns to the approval of the updated EP as: ▪ It has taken into consideration WaterNSW Mining Principles. ▪ Poses low risk to overlying catchment values and water resources. ▪ Is likely to meet the performance measures set in the development consent.	-
DPE (Environment)	Letter provided 24 August 2022 requesting information in relation to threatened frog monitoring undertaken to date. Following a response, further correspondence regarding frog habitat and monitoring was received.	Detailed copies of the relevant correspondence are included in Appendix A. A response to the Request for Information was provided to DPE via letter on 9 September 2022. Threatened frog habitat has been assumed in Stage 2 and Section 5.2.3

Agency name and timing of consultation	Subject of consultation	Where addressed
		updated accordingly.

3 BASELINE DATA

Detailed mapping and characterisation of Coastal Upland Swamps in the Sydney Basin Bioregion EEC (listed under the EPBC Act and BC Act) was undertaken by Biosis (2012) throughout the UEP area. A total of 37 upland headwater swamps (approximately 29.45 hectares in total) were recorded in the Stage 1 and 2 EP area. All 37 swamps are considered to meet the requirements for listing under the EPBC Act and BC Act. The location of Coastal Upland Swamps relative to the second workings covered by this management plan is illustrated in Figure 14.

The Coastal Upland Swamps in the EP area are markedly different to other upland swamps on the Woronora plateau in that they are predominantly drier, generally smaller with shallower soils, have less humic material, have more interspersed sandstone outcrops within their outlines, and are less spatially continuous than a "typical" humic, saturated swamp (Biosis 2014b). Refer to Biosis (2014b) for comprehensive details on the regional and local distribution of Coastal Upland Swamps, historic impacts of mining on Coastal Upland Swamps, including impacts to hydrogeological features.

Coastal Upland Swamps in the EP area also provide potential habitat for a number of threatened species listed under the EPBC Act and/or BC Act, that are susceptible to changes in the ecological functioning of swamps, including:

- Giant Dragonfly.
- Leafless Tongue-orchid.
- Littlejohn's Tree Frog[1].
- Prickly Bush-pea.
- Stuttering Frog[1].

The existing Upland Swamp Monitoring Program for Longwall (LW) 6 was developed to monitor impacts associated with existing approved longwall mining in the Wongawilli Seam and includes baseline monitoring for the previously proposed longwall mining. This monitoring program (which is ongoing) has focussed on the monitoring of the groundwater systems associated with the swamps and vegetation within the swamps. The level of monitoring in swamps above and in the vicinity of longwall panels reflects the significantly higher potential for impacts to occur to swamps from the increased subsidence and groundwater impacts associated with longwall mining. This monitoring framework was developed in consultation with both Commonwealth and NSW agencies.

The Stage 2 EP Plan includes a review of the category of Coastal Upland Swamps, in line with a revised risk assessment (Appendix C). The predicted impacts from the second workings covered by the management plan are significantly less than the potential impacts associated with the approved longwall mining of LWs 4-6 due to the significantly higher subsidence related impacts from longwall mining, compared to bord and pillar mining. As a result of the risk category review, due to the lower levels of predicted impacts from the proposed Stage 1 and Stage 2 workings, the monitoring of swamps associated with the workings covered by this Plan has been modified

[1] Low likelihood of occurrence

to reflect the lower risk profile associated with this mining method. The monitoring ranges from a level similar to that undertaken for past longwall mining operations in swamps which have a higher level of pre-existing impact, to baseline monitoring only for swamps which are assessed as having a negligible risk of any impact from the proposed mining.

The following sections detail the existing baseline groundwater and ecological monitoring undertaken in swamps with Section 4 covering proposed monitoring approach for Stages 1 and 2.

3.1 Groundwater monitoring

The broader groundwater monitoring program is covered in the GWMP (WRPL 2022b). Monitoring of soil moisture within swamps is currently conducted at Coastal Upland Swamps; BCUS4, BCUS11, CCUS1, CCUS2, CCUS3, CCUS4, CCUS5, CCUS6, CCUS10, CCUS11, CCUS12, CCUS14, CCUS20, CCUS21, CRUS1, CRUS2, CRUS3 and CRUS6.

Water level monitoring is also conducted along with soil moisture monitoring at swamps BCUS4, CCUS1, CCUS2, CCUS3, CCUS4, CCUS5, CCUS6, CCUS10, CCUS12, CCUS14, CCUS20 and CRUS1.

Details of soil moisture and groundwater monitoring locations within Coastal Upland Swamps established prior to approval of the UEP and additional monitoring sites are provided as Table 8. The location of these monitoring points is shown in Figure 11.

The Coastal Upland Swamp groundwater monitoring program includes collection of daily time series data of soil moisture changes with depth with the soil moisture probes, recording water levels six-hourly with level loggers in selected piezometers and two monthly manual water level monitoring. When water is present, water quality monitoring is also conducted, including monitoring of environmental water tracers, with two monthly field testing of physiochemical properties (i.e. electrical conductivity and temperature) and quarterly sampling and laboratory analysis for major ions.

In accordance with approvals under the EPBC Act, additional sites will be established in order to collect soil moisture data for each swamp community within the RVE UEP area. The proposed additional sites are included in Table 9. However, the finalised locations will be dependent on accessibility to the sites to minimise disturbance and ensure safety of field staff as well as ground-truthing of swamp extents.

Table 8 Existing groundwater monitoring locations

Site ID	Swamp site	Installed	Easting GDA94 Z56	Northing GDA94 Z56	Ground Level[2] mAHD	TOC[3] magl	Screen mbgl	Intake Lithology[4]	Type[5]
PB4A	BCUS4	Nov-14	302382	6198016	340.8	1.35	1.17 – 1.67	HC / WS	SM and PZ
PB4B	BCUS4	Nov-14	302431	6198020	337.0	1.56	0.35 – 0.77	HC / WS	SM and PZ
PB4C	BCUS4	May-12	302460	6198060	333.0	1.22	0.25 – 0.63	HSC / WS	PZ
PB4D	BCUS4	Nov-14	302526	6198018	333.6	1.45	0.35 – 0.65	HSC / WS	SM and PZ
PCc10A	CCUS10	Nov-14	302625	6197639	329.1	1.62	0.30 – 0.59	HSC / WS	SM and PZ
PCc10B	CCUS10	Nov-14	302691	6197672	337.4	1.57	0.48 – 0.98	HSC / WS	SM and PZ
PCc12A	CCUS12	Nov-14	302047	6197858	361.6	1.65	0.27 – 0.72	CS / WS	SM and PZ
PCc12B	CCUS12	Nov-14	302038	6197964	366.5	1.59	0.11 – 0.27	WS	SM and PZ
PCc2	CCUS2	May-12	303745	6196080	371.4	0.96	1.10 – 1.63	HSC / WS	PZ
PCc3	CCUS3	May-12	302820	6196810	351.9	1.26	0.70 – 1.20	SC / WS	PZ
PCc4A	CCUS4	Oct-14	302678	6196900	342.4	1.35	1.11 – 1.62	HSC / WS	PZ
PCc4B	CCUS4	Oct-14	302604	6196877	342.1	1.04	1.34 – 1.84	HSC / WS	SM and PZ
PCc4C	CCUS4	Oct-14	302579	6196931	340.1	1.71	0.77 – 1.27	HSC / WS	SM and PZ
PCc4D	CCUS4	Mar-12	302615	6196925	339.5	1.60	0.45 – 0.94	SC / WS	SM and PZ
PCc5A	CCUS5	May-12	302110	6197150	315.2	1.41	0.70 – 1.20	HSC / WS	SM and PZ
PCc5B	CCUS5	May-12	302245	6197250	299.2	1.39	0.80 – 1.30	HSC / WS	SM and PZ
PCc5C	CCUS5	Oct-14	302234	6197073	319.5	1.46	0.50 – 0.84	HSC / WS	PZ
PCc5D	CCUS5	Oct-14	302295	6197172	307.7	1.72	0.73 – 1.22	HSC / WS	SM and PZ

[2] Ground level based on DEM

[3] TOC – Top of Casing

[4] WS – weathered sandstone HC – humic clay CS – clayey sand HSC – humic sandy clay SC – sandy clay

[5] SM – soil moisture PZ – piezometer

Site ID	Swamp site	Installed	Easting GDA94 Z56	Northing GDA94 Z56	Ground Level[2] mAHD	TOC[3] magl	Screen mbgl	Intake Lithology[4]	Type[5]
PCc6	CCUS6	Mar-12	303165	6196790	351.0	1.33	0.70 – 1.20	WS	PZ
PCr1A	CRUS1	Mar-12	302330	6196625	349.3	1.70	0.30 – 0.55	HSC / WS	SM and PZ
PCr1B	CRUS1	Oct-14	302247	6196655	337.3	1.57	0.44 – 0.69	HSC / WS	SM and PZ
PCr1C	CRUS1	Oct-14	302229	6196762	341.7	1.32	0.65 – 1.15	HSC / WS	SM and PZ
PCr1D	CRUS1	Oct-14	302263	6196879	346.4	1.36	0.22 – 0.38	SC / WS	PZ
SP1	Near CCUS6	Mar-12	303245	6196955	331.6	1.36	0.10 - 0.57	SC / WS	PZ
SP2	Near CCUS3 and CCUS4	Mar-12	302830	6196905	346.0	1.66	0.55 - 1.05	SC / WS	PZ
PCc1A[6]	CCUS1	Jul-21	303382	6196263	TBC	1.35	0.5 - 2	Swamp	SM and PZ
PCc1B[6]	CCUS1	Jul-21	303512	6196355	TBC	-	-	Swamp	SM
PCc1C[6]	CCUS1	Jul-21	303609	6196292	TBC	1.65	0.5 – 2	Swamp	SM and PZ
PCc11[6]	CCUS11	Jul-21	302531	6197700	TBC	-	-	Swamp	SM
PCc6B[6]	CCUS6	Jul-21	303020	6196609	TBC	0.810	0.5 - 2	Swamp	SM and PZ
PCc6B[6]	CCUS6	Jul-21	303020	6196609	TBC	0.810	0.5 - 2	Swamp	SM and PZ
PCc14A[6]	CCUS14	Jul-21	304311	6195771	TBC	0.895	0.5 – 2	Swamp	SM and PZ
PCc14B[6]	CCUS14	Jul-21	304276	6195820	TBC	-	-	Swamp	SM
PCc20[6]	CCUS20	Jul-21	303513	6196568	TBC	0.925	0.5 – 2	Swamp	SM and PZ
PCc21[6]	CCUS21	Jul-21	303481	6196772	TBC	-	-	Swamp	SM
PCr2[6]	CRUS2	Jul-21	302784	6196158	TBC	-	-	Swamp	SM
PCr3[6]	CRUS3	Jul-21	303177	6195925	TBC	-	-	Swamp	SM
PCr6[6]	CRUS6	Jul-21	301928	6198123	TBC	-	-	Swamp	SM
PB11[6]	BCUS11	Jul-21	302220	6197915	TBC	-	-	Swamp	SM

[6] Locations are indicative. Surveyed details still to be provided.

Table 9 Proposed additional groundwater monitoring locations

Site ID	Swamp site	Type[7]	Easting GDA94 Z56[8]	Northing GDA94 Z56[8]	Type[5]
BCUS2	BCUS2	SM	302965	6197914	SM
BCUS3	BCUS3	SM	302916	6198133	SM
BCUS5	BCUS5	SM	302668	6198369	SM
BCUS6	BCUS6	SM	302169	6198359	SM
BCUS7	BCUS7	SM	301988	6198479	SM
BCUS8	BCUS8	SM	302211	6198634	SM
BCUS9	BCUS9	SM	302282	6198702	SM
BCUS12	BCUS12	SM	303890	6200475	SM
BCUS13	BCUS13	SM	303799	6199148	SM
BCUS14	BCUS14	SM	302458	6198185	SM
BCUS15	BCUS15	SM	301907	6198976	SM
BCUS16	BCUS16	SM	301628	6198916	SM
CCUS3	CCUS3	SM	302820	6196810	SM
CCUS7	CCUS7	SM	303747	6197498	SM
CCUS8	CCUS8	SM	303552	6197414	SM
CCUS9	CCUS9	SM	302971	6197735	SM
CCUS13	CCUS13	SM	301715	6198322	SM
CCUS15	CCUS15	SM	303093	6196358	SM
CCUS16	CCUS16	SM	301381	6197979	SM
CCUS17	CCUS17	SM	303156	6196291	SM
CCUS18	CCUS18	SM	303167	6196215	SM
CCUS19	CCUS19	SM	303227	6196149	SM
CCUS22	CCUS22	SM	301612	6198426	SM
CCUS23	CCUS23	SM	302730	6196747	SM
CCUS24	CCUS24	SM	302190	6197796	SM
CRUS4	CRUS4	SM	304427	6195667	SM
CRUS5	CRUS5	SM	304216	6195606	SM
CRUS7	CRUS7	SM	301693	6198563	SM
PB4A	BCUS4	SM	302381	6198016	SM
PCc10a	CCUS10	SM	302624	6197639	SM
PCc12A	CCUS12	SM	302042	6197860	SM
PCc4c	CCUS4	SM	302579	6196931	SM
PCc5B	CCUS5	SM	302243	6197252	SM
PCr1B	CRUS1	SM	302247	6196655	SM

3.1.1 Current Upland Swamp groundwater monitoring – Soil moisture and water levels

Monitoring of the soil moisture and water level within swamp deposits is conducted in RVE UEP at swamps BCUS11, BCUS4, CCUS1, CCUS10, CCUS11, CCUS12, CCUS14, CCUS2, CCUS20, CCUS21, CCUS3, CCUS4, CCUS5, CCUS6, CRUS1, CRUS2, CRUS3 and CRUS6. Soil moisture is measured with

[7] *SM – Soil moisture probe*

[8] *Indicative location only, as installed co-ordinates to be surveyed*

Odyssey SM probe which measures the dielectric constant of moist soil to determine the moisture content. Probes are typically 1 m deep with five sensors typically at 10, 30, 50, 70 and 90 cm below surface. The observed soil moisture trends show a good correlation between increasing moisture content in response to rainfall events, with the highest rainfall generally occurring within the summer to autumn months from February to. Some data gaps are visible intermittently in the graphs due to instrument error related to the age of equipment; the swamp soil moisture probes were replaced across the site in November 2020 to enable ongoing monitoring. Additional soil moisture probes were also installed in 2021 (PCc1A/B/C, PCc11, PCc14A/B, PCc20, PCc21, PCc6B, PCr2, PCr3, PCr6 and PB11); however, as these were only recently installed no data for these new sites is presented in this plan.

Water level trends for site monitoring piezometers show a good correlation to rainfall trends, with water levels in the swamps rising to at or near surface generally in response to rainfall (i.e. over 100 millimetres [mm]/month). The timing of this response varies between sites, with a one to two month lag between the rainfall event and water level response noted when reviewing data obtained to date. Across the RVE swamp monitoring network the available manual dipped water levels indicate unsaturated conditions approximately 47 % of the time. For periods when the swamps are saturated, the median (50th percentile) of readings indicates water present around 0.57 m below surface.

The swamps are recharged from rainfall and shallow surface flow; however, the site data also shows variability in the response to rainfall between the different swamp monitoring locations. Dry bore conditions generally correspond to low rainfall periods (i.e. below 10th percentile of monthly rainfall, 20 mm rainfall per month), and appears to be more prevalent for monitoring points at the edge of swamp clusters. Other factors such as the slope aspect and localised disturbance (i.e. tracks and historical subsidence impacts) also influences water level and soil moisture conditions.

The Coastal Upland Swamps present in the area around the proposed second workings covered by this management plan are perched, meaning they are hydraulically separated from the lower Hawkesbury Sandstone regional water table. There are existing paired bores within the underlying Hawkesbury Sandstone at swamps BCUS4 (PB4C and RV21), CCUS1 (RV42), CCUS2 (PCc2 and NRE A), CCUS6 (PCc6, SP1, RV20, RV39), CCUS14 (RV46), CCU20 (RV41), CRUS1 (PCr1D and RV18) and CRUS2 (RV40). The baseline data for the open standpipes show that the water heads in the Hawkesbury Sandstone are generally 1.5 m to 28.9 m below surface.

Further discussion on the soil moisture and water trends for selected individual swamps is included below. The discussion is included to provide background on the pre-existing impacts to the groundwater regime and the current groundwater conditions, prior to commencement of the RVE UEP.

3.1.1.1 Swamp BCUS4

There are three sites monitoring soil moisture in swamp BCUS4 (PB4A, PB4B and PB4D). All three sites show fluctuations in response to rainfall. PB4B has a constant high soil moisture percentage at depths of 70 and 90 cm below surface. In comparison, PB4A and PB4D fluctuate between moist and dry, likely due to their location on the edge of the swamp whereas PB4B is closer to the centre. Swamp BCUS4 overlies the RVE Stage 2 EP area. A soil moisture profile is shown in Figure 6 for site PB4A near swamp BCUS4 from readings collected in January 2017, and the monthly average soil moisture for data collected since 2014. The figure shows that the soil

moisture content continues to increase with depth up to 75 % at 90 centimetres (cm) below surface. The depth to the water table at swamp BCUS4 recorded at PB4A ranges from 2 to 152 cm below surface. The results show an increase in soil moisture with depth that likely relates to influence of evaporation at surface and evapotranspiration by swamp vegetation. These trends are consistent with trends observed at other swamp locations. The influence of evaporation/evapotranspiration at surface is further demonstrated in the monthly averages (Figure 6) where the soil moisture near surface is lowest in the hotter summer months. This seasonal variability is visible at all depths but does decrease with depth, with readings at 90 cm depth indicating a soil moisture (on average) of between 80 % to 90 %, but can range between 70 % and 94 % (5th/95th percentile).

Groundwater level trends for PB4C and nearby Hawkesbury Sandstone bore RV21 are shown in Figure 7. RV21 is screened within the upper Hawkesbury Sandstone from 9 m to 22 m below surface, with PB4C 0.77 m deep and screened within swamp deposits. Figure 7 shows groundwater levels within the upper Hawkesbury Sandstone have been recorded 8 m to 13 m below surface since monitoring began in 2014. This indicates swamp BCUS4 is hydraulically separated from the Hawkesbury Sandstone water table based on available data. Monitoring at BCUS4 provides a useful reference site of current soil moisture and swamp water level conditions for site swamps unaffected by initial workings under the RVE UEP.

Figure 6 Soil moisture profile: PB4A at BCUS4 for set date (left) and average monthly (right)

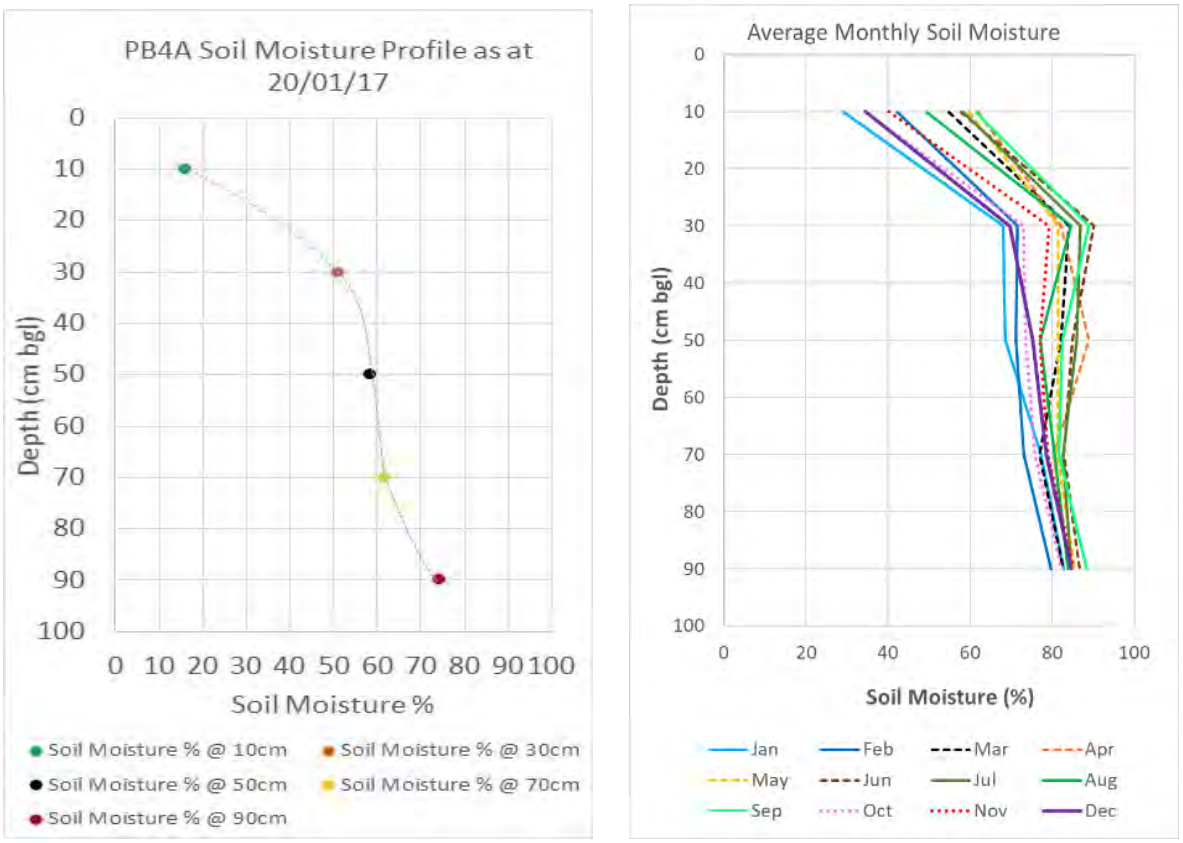
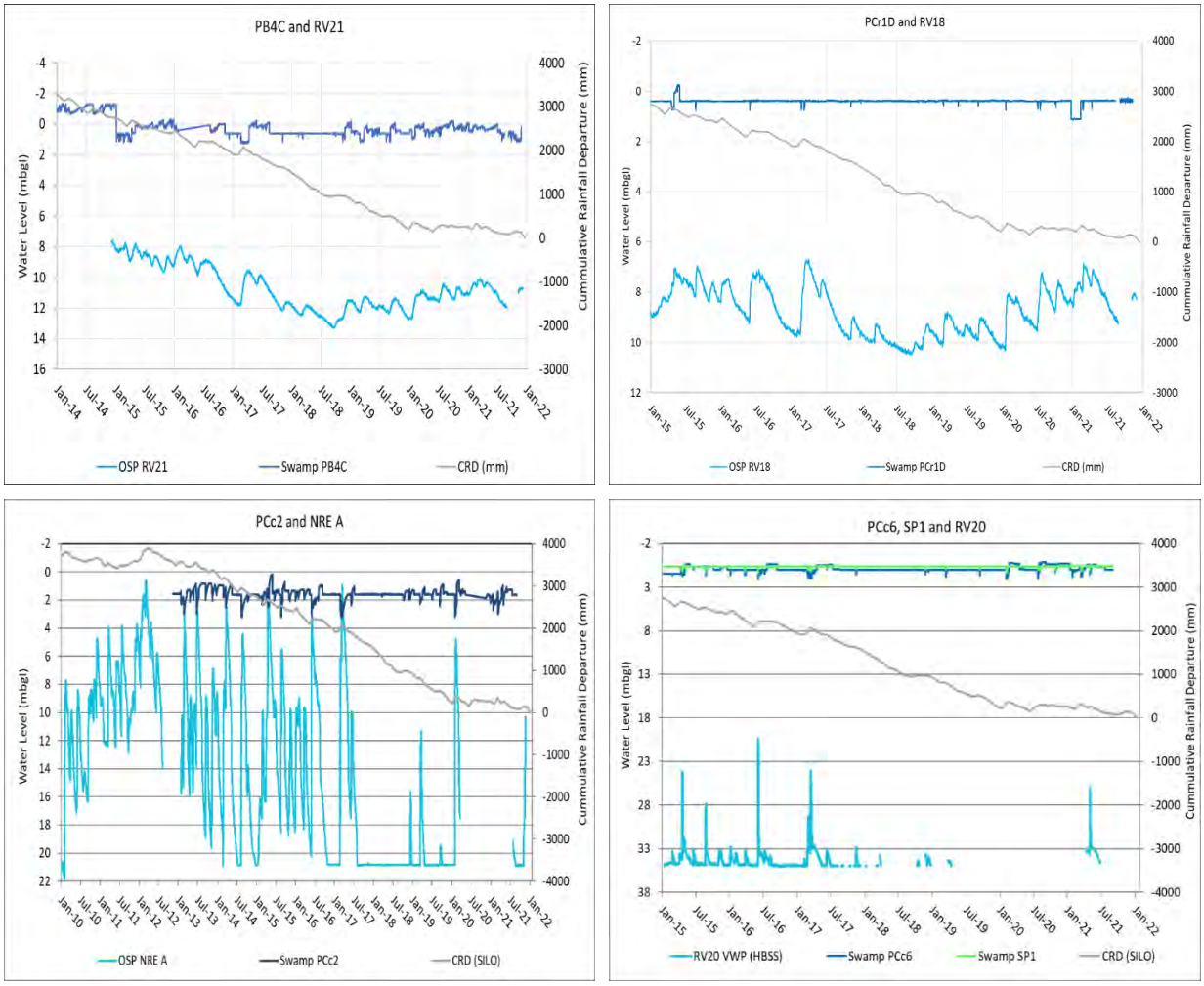


Figure 7 Paired bores in swamps and underlying Hawkesbury Sandstone



3.1.1.2 Swamp CCUS2

There is one water level monitoring site in swamp CCUS2 (PCc2). Groundwater level monitoring is also recorded at nearby monitoring points NRE A and NRE1A (VWP). Water levels within PCc2 are generally at or near the base of the piezometer, with water level rise recorded in response to periods of significant rainfall (i.e. over 100 mm/month).

Groundwater level trends for PCc2 and nearby Hawkesbury Sandstone bore NRE A are shown in Figure 7. NRE A is screened within the upper Hawkesbury Sandstone from 24 m to 47 m below surface, while PCc2 is 1.63 m deep and is screened within swamp deposits. Figure 7 shows groundwater levels within the upper Hawkesbury Sandstone have fluctuated rapidly compared to all other bores, with levels recorded at surface to 22 m below surface since monitoring began in 2009. These trends have previously been reported as being due to pre-existing tension cracks from historical longwall mining that have increased the vertical connectivity in this area and resulted in localised enhanced recharge to the Hawkesbury Sandstone (Geoterra 2020). No new subsidence impacts are predicted for future operations at RVE UEP as WRPL has committed to only using bord and pillar mining methods.

Additional monitoring is now undertaken, with a soil moisture probe installed in 2021, along with a paired bore within the upper Hawkesbury Sandstone near CCUS2 at RV45.

3.1.1.3 Swamp CCUS3

There is one monitoring site in swamp CCUS3 (PCc3). The site has been recorded as dry since installation in 2012. The monitoring piezometer extends to 1.2 m depth within sandy clay and weathered sandstone and the site overlies historical workings, including LW5. There is no pre-mining site data available to verify the cause for these dry conditions. Mining commenced in the area in the 1880's, with Bulli Seam workings active until the 1950's, Balgownie Seam longwall workings until 1982 and Wongawilli Seam workings (LW4 to LW6) active between 2012 and 2015.

Groundwater modelling of historical groundwater conditions by GeoTerra (2020) and HydroAlgorithmics (2020) predicted the presence of shallow water table (within 5 m of surface) in the Hawkesbury Sandstone near PCc3. Swamp water conditions were not modelled due to the perched nature of these systems. The Hawkesbury Sandstone groundwater levels were predicted to have been drawn down over 10 m below surface following longwall mining in the area. Localised drawdown in the Hawkesbury Sandstone was also predicted in the area due to depressurisation with the RVE UEP mine, but no additional impacts on swamp CCUS3 were predicted beyond those already experienced.

3.1.1.4 Swamp CCUS4

There are three sites monitoring soil moisture in swamp CCUS4 (PCc4B, PCc4C and PCc4D). All three sites show fluctuations in response to rainfall. PCc4C and PCc4D are relatively moist ranging between 10 and 90 cm below surface. In comparison, PCc4B is relatively dry, likely due to its location on the edge of the swamp whereas PCc4C and PCc4D are closer to the centre. Swamp CCUS4 will not overlie active RVE UEP workings but does overlie the Wongawilli Seam LW6 that was actively mined until 2015, as well as previous historical mining within the Bulli and Balgownie seams. The soil moisture data has been collected since 2014 and is representative of groundwater conditions pre-commencement of RVE UEP; however, there is no unimpacted pre-mining data is available for comparison.

3.1.1.5 Swamp CCUS5

There are three sites monitoring soil moisture in swamp CCUS5 (PCc5A, PCc5B and PCc5D). All three sites show fluctuations in response to rainfall. PCc5B has a high soil moisture percentage at 30 and 90 cm below surface, but drier at 50 and 70 cm below surface suggesting alternating soil horizons. PCc5D is relatively moist between 30 and 90 cm below surface, with the highest moisture percentage at 30 cm below surface. In comparison, PCc5A is relatively dry, likely due to its location on the edge of the swamp whereas PCc5B and PCc5D are closer to the centre. Swamp CCUS5 will overlie RVE Stage 1 EP area.

3.1.1.6 Swamp CCUS6

There is one monitoring site near swamp CCUS6 (PCc6); however, this monitoring location is not directly within the mapped swamp. An additional two piezometers (SP1 and SP2) are also located near CCUS6 and intersect the surficial Hawkesbury Sandstone.

Site PCc6 has been recorded as dry since installation in 2012. The monitoring piezometer extends to 1.2 m depth within sandy clay and weathered sandstone and the site overlies historical longwall workings including Wongawilli Seam LW4. It is noted that monitoring points SP1 and SP2 near CCUS6 have also been recorded as dry since monitoring commenced in 2012, both overlying LW5. This likely relates to the shallow construction of these piezometers (less than 1 m depth).

There are currently no open standpipes near swamp CCUS6 within the Hawkesbury Sandstone water table. Therefore, trends have been compared to groundwater head readings within the deeper Hawkesbury Sandstone from nearby VWP RV20 (at 35 m depth). The results show a separation of around 30 m between swamp levels and the potentiometric surface in the deeper Hawkesbury Sandstone. Groundwater level trends between the paired sites are shown Figure 7.

Groundwater modelling of historical groundwater conditions conducted by GeoTerra (2020) and HydroAlgorithmics (2020) predicted the presence of shallow water table (within 5 m of surface) in the Hawkesbury Sandstone near PCc6. Swamp water conditions were not modelled due to the perched nature of these systems. Groundwater in the Hawkesbury Sandstone was predicted to have been drawn down over 10 m below surface following longwall mining in the area. Localised drawdown in the Hawkesbury Sandstone was also predicted in the area due to depressurisation with the RVE UEP mine, but no additional impacts on swamp CCUS6 were predicted beyond those already experienced.

Additional monitoring locations have been installed over 2021 for CCUS6 to monitor swamp water levels and moisture levels within an area of mapped swamp (PCc6B). In addition, a proposed standpipe to characterise the water table conditions in the Hawkesbury Sandstone (RV43A) and monitor potential changes with future mining.

3.1.1.7 Swamp CCUS10

There are two sites monitoring soil moisture in swamp CCUS10 (PCc10A and PCc10B). Both sites show fluctuations in response to rainfall, with the highest moisture content between 50 and 90 cm below surface. Swamp CCUS10 will overlie RVE Stage 1 and Stage 2 EP area.

3.1.1.8 Swamp CCUS12

There are two sites monitoring soil moisture in swamp CCUS12 (PCc12A and PCc12B). Both sites show minor fluctuations in response to rainfall and are relatively dry in comparison to other swamps. PCc12A is only moist at 50 to 90 cm below surface, while PCc12B is only moist at 70 to 90 cm below surface. Monitoring at CCUS12 provides a useful reference site of current soil moisture conditions for site swamps unaffected by initial workings under the RVE UEP and are within the Stage 2 EP area.

3.1.1.9 Swamp CRUS1

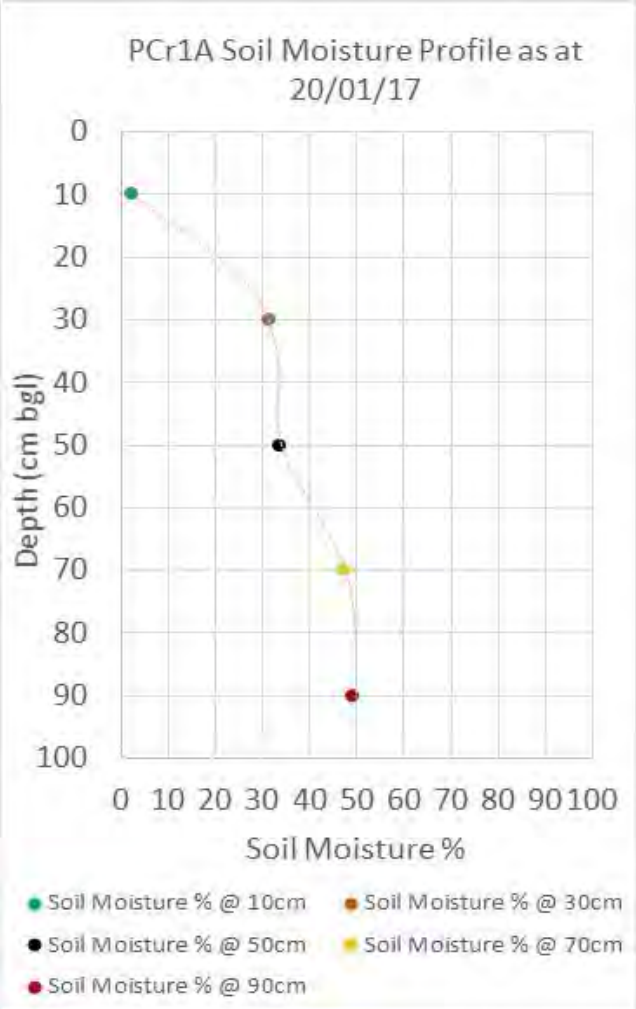
There are three sites monitoring soil moisture in swamp CRUS1 (PCr1A, PCr1B and PCr1C) and water levels are recorded at PCr1D. All three soil moisture sites show fluctuations in response to rainfall. PCr1B has a high soil moisture percentage at 10 and 90 cm below surface. PCr1C is relatively moist between 10 and 90 cm below surface. In comparison, PCr1A has large fluctuations between 100 percent moist and dry conditions, possibly due to its location on the edge of the swamp whereas PCr1B is closer to the centre. Swamp CRUS1 will overlie RVE UEP.

Groundwater level trends for PCr1D and nearby Hawkesbury Sandstone bore RV18 are shown in Figure 7. RV18 is screened within the upper Hawkesbury Sandstone from 8 m to 20 m below surface, and PCr1D is 0.38 m deep and screened within swamp deposits. Figure 7 shows groundwater levels within the upper Hawkesbury Sandstone have been recorded 6 m to 11 m below surface since monitoring began in 2015. This indicates swamp CRUS1 is hydraulically separated from the Hawkesbury Sandstone water table based on available data.

A soil moisture profile is shown in Figure 8 for site PCr1A near swamp CRUS1, which is present above historical mining (i.e. LW6). The figure shows the soil moisture content increases with depth

to 50 cm below surface where it stabilises at 50 %. The depth to the water table at swamp CRUS1 is recorded at the PCr1A piezometer, about 250 m to the north, as being generally unsaturated. When water is present it can range from 23 to 47 cm below surface. The results show an increase in soil moisture with depth that likely relates to influence of evaporation at surface and evapotranspiration by swamp vegetation.

Figure 8 Soil moisture profile - PCr1A at CRUS1



3.1.2 Current Upland Swamp groundwater monitoring – Water quality

Water quality monitoring of the shallow swamp piezometers has occurred since March 2012. A summary of the swamp water quality data is presented in Table 10 and time series pH and EC trends shown in Figure 9 and Figure 10 respectively. The swamp water quality is generally acidic to neutral (pH 3.3 – 8.5) and fresh (EC 23 – 420 µS/cm). Baseline data up to December 2020 has been used for the derivation of the triggers.

Table 10 Swamp water quality data summary to December 2020

Analyte	ANZG 2018 95 % species protection default guideline	Swamp Data				
		Range	Median	5th Percentile	95th Percentile	Population
Field Data						
pH	6.5 - 8.5	3.3 - 8.5	5.0	3.8	6.3	402
EC (µS/cm)	125 - 2200	23 - 420	93	56	193	402
Temp (°C)	-	10.0 - 21.7	15.0	11.3	19.2	402
Total Dissolved Solids (mg/L)	50	18 - 273	60	36	126	377
Dissolved Oxygen (% Sat)	85 - 110	28.2 - 101.3	65.0	34.4	94.8	207
Dissolved Oxygen (mg/L)	-	1.9 - 9.8	6.0	3.0	9.0	402
Oxidation Reduction Potential (E_h) (mV)	-	-6.5 - 553.7	264.0	41.5	405.6	402
Resistivity (Ohms.cm)	-	2840 - 40000	13513	6106	22727	376

Figure 9 Swamp Field pH to December 2021

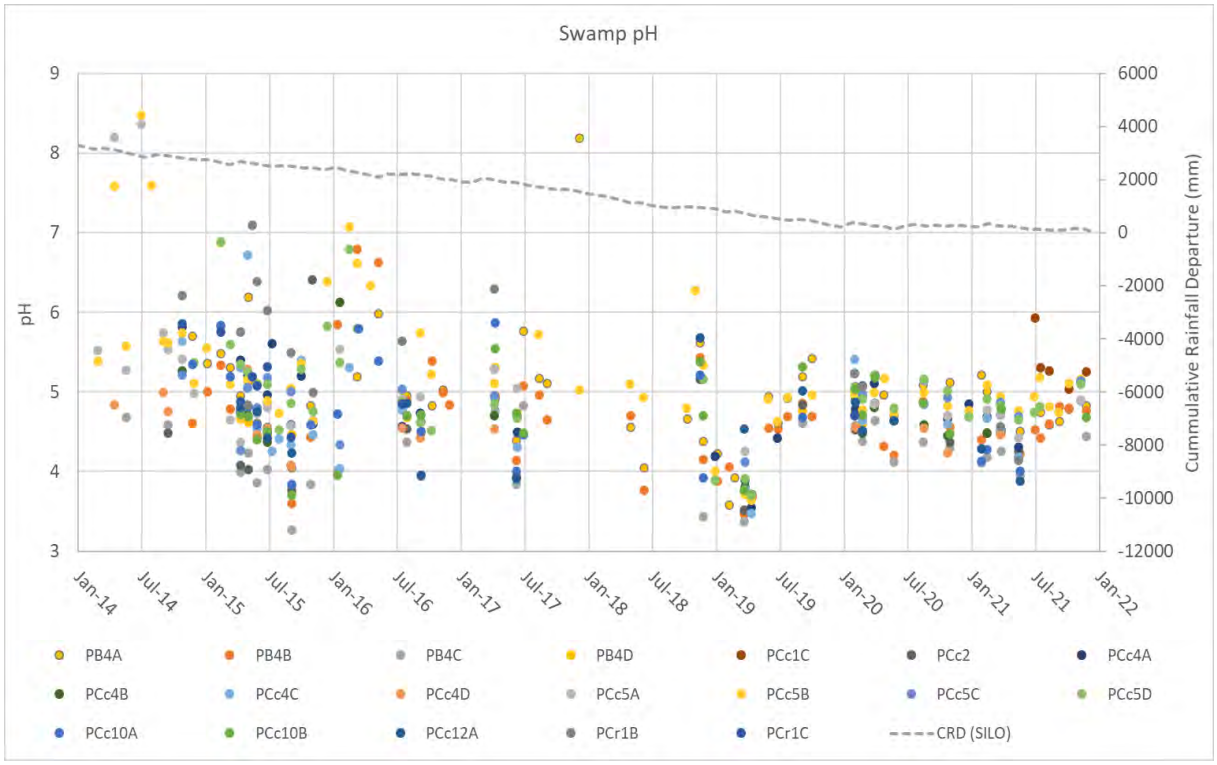
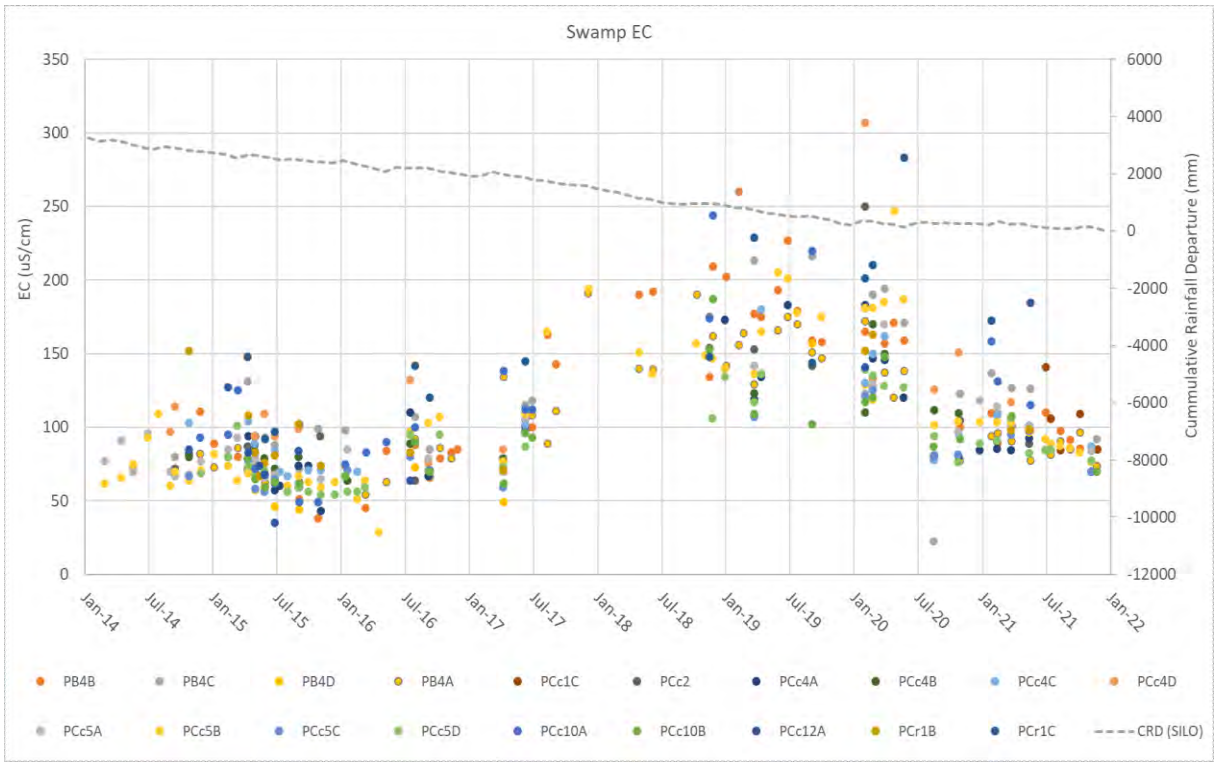
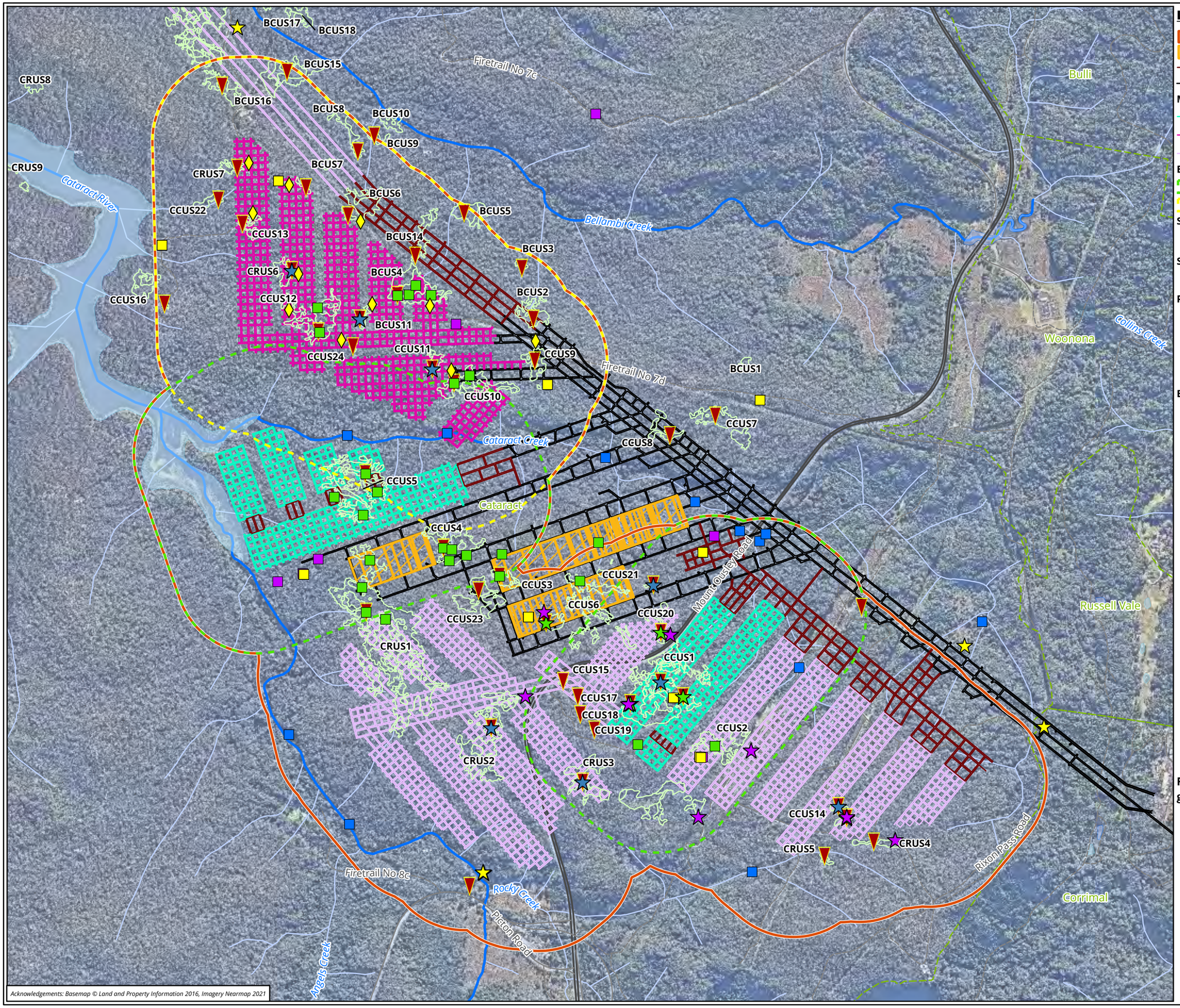


Figure 10 Swamp Field EC to December 2021





Legend

- UEP area
- RV East old longwall workings
- Pillars
- Past workings

Mine plan

- Stage 1
- Stage 2
- Future stages

EP areas

- Stage 1
- Stage 2

Soil moisture monitoring

- Soil moisture probe

Swamp subsidence monitoring

- Swamp subsidence monitoring

Planned bores

- OSP
- SM
- SP
- VWP

Existing groundwater locations

- OSP
- Creek
- SP
- VWP

Figure 11a Coastal Upland Swamp groundwater monitoring

0 100 200 300 400 500

Metres

Scale: 1:15,000 @ A3

Coordinate System: GDA 1994 MGA Zone 56

N

biosis

Matter: 36747,
Date: 06 June 2022 ,
Prepared for: CBH, Prepared by: AM, Last edited by: amackegard
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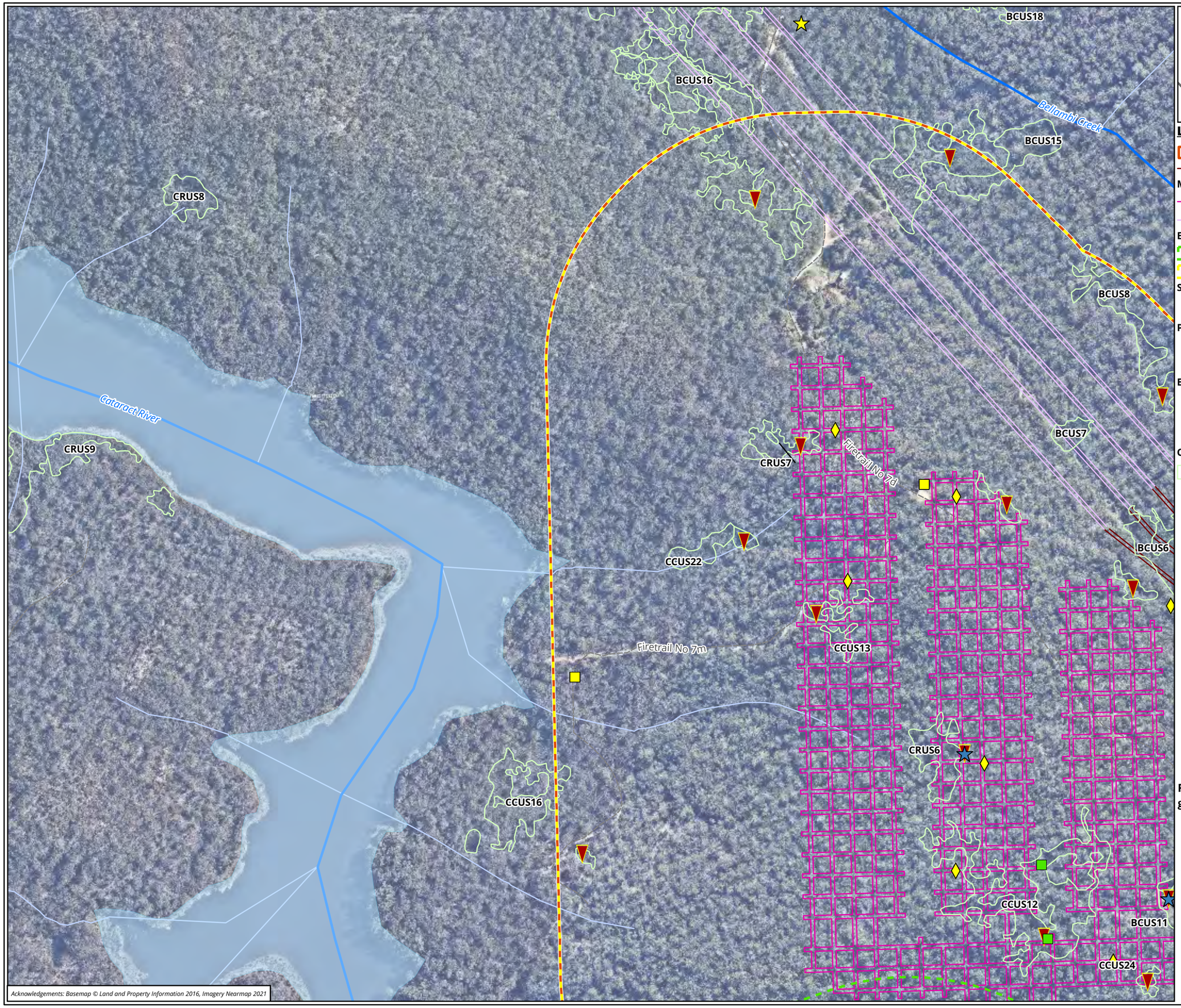

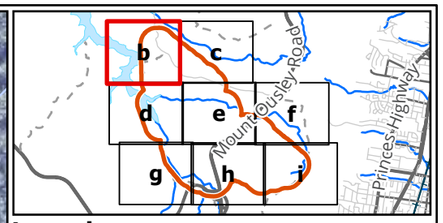

Legend

- UEP area
- Pillars

Mine plan

- Stage 2
- Future stages

EP areas

- Stage 1
- Stage 2

Soil moisture monitoring

- Soil moisture probe

Planned bores

- SM
- VWP

Existing groundwater locations

- OSP
- SP
- VWP

Coastal Upland Swamps

- Swamp extent

Figure 11b Coastal Upland Swamp groundwater monitoring

0 40 80 120 160 200

Metres

Scale: 1:5,000 @ A3

Coordinate System: GDA 1994 MGA Zone 56

N

biosis

Matter: 36747,
Date: 06 June 2022 ,
Prepared for: CBH, Prepared by: AM, Last edited by: amackegard
Layout: F11_CoastalUplandSwampMonitoring_ground
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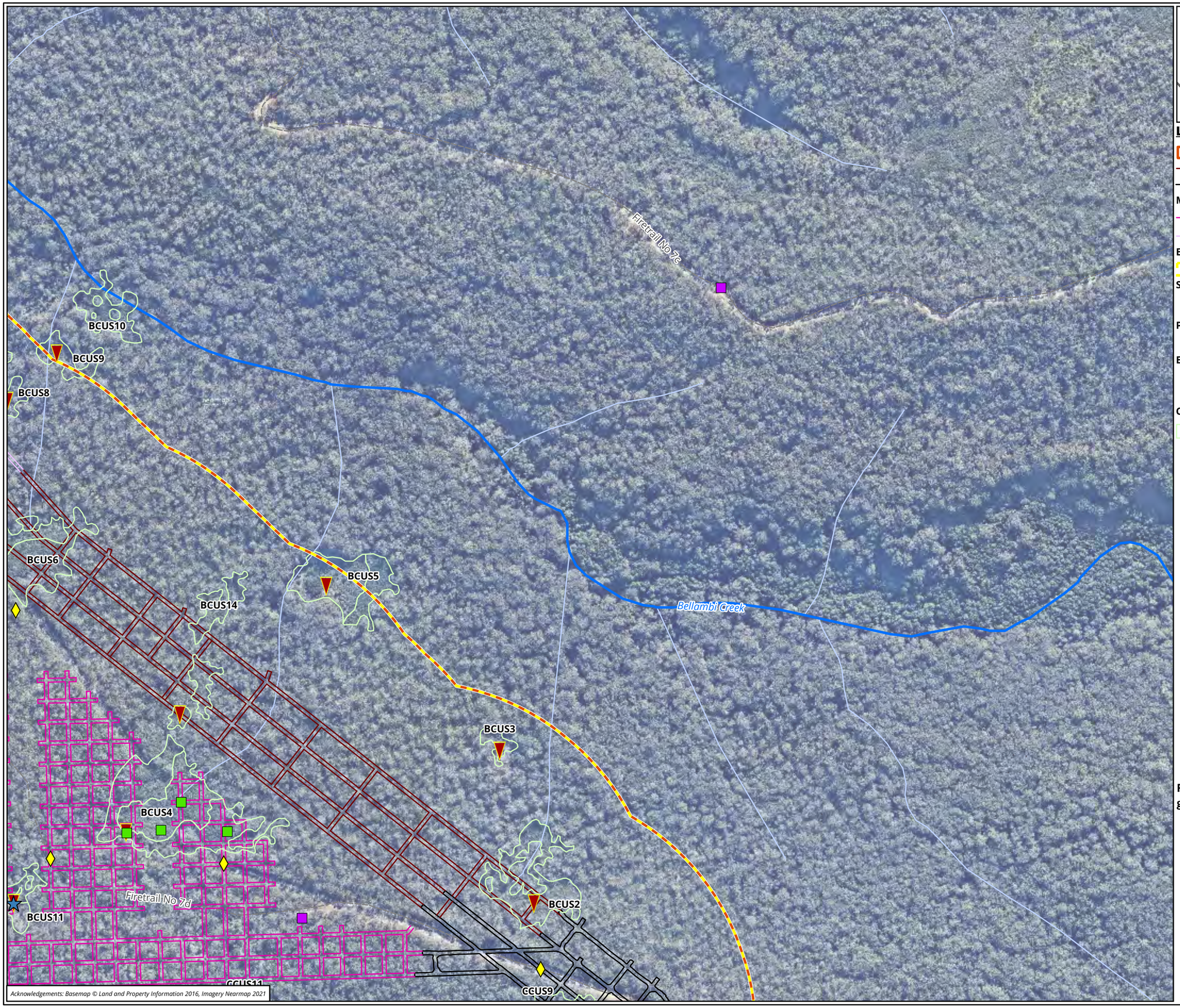

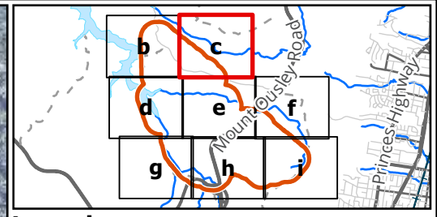

Legend

- UEP area
- Pillars
- Past workings

Mine plan

- Stage 2
- Future stages

EP areas

- Stage 2

Soil moisture monitoring

- Soil moisture probe

Planned bores

- SM

Existing groundwater locations

- OSP
- SP

Coastal Upland Swamps

- Swamp extent

Figure 11c Coastal Upland Swamp groundwater monitoring

0 40 80 120 160 200

Metres

Scale: 1:5,000 @ A3

Coordinate System: GDA 1994 MGA Zone 56

N

biosis

Matter: 36747,
Date: 06 June 2022 ,
Prepared for: CBH, Prepared by: AM, Last edited by: amackegard
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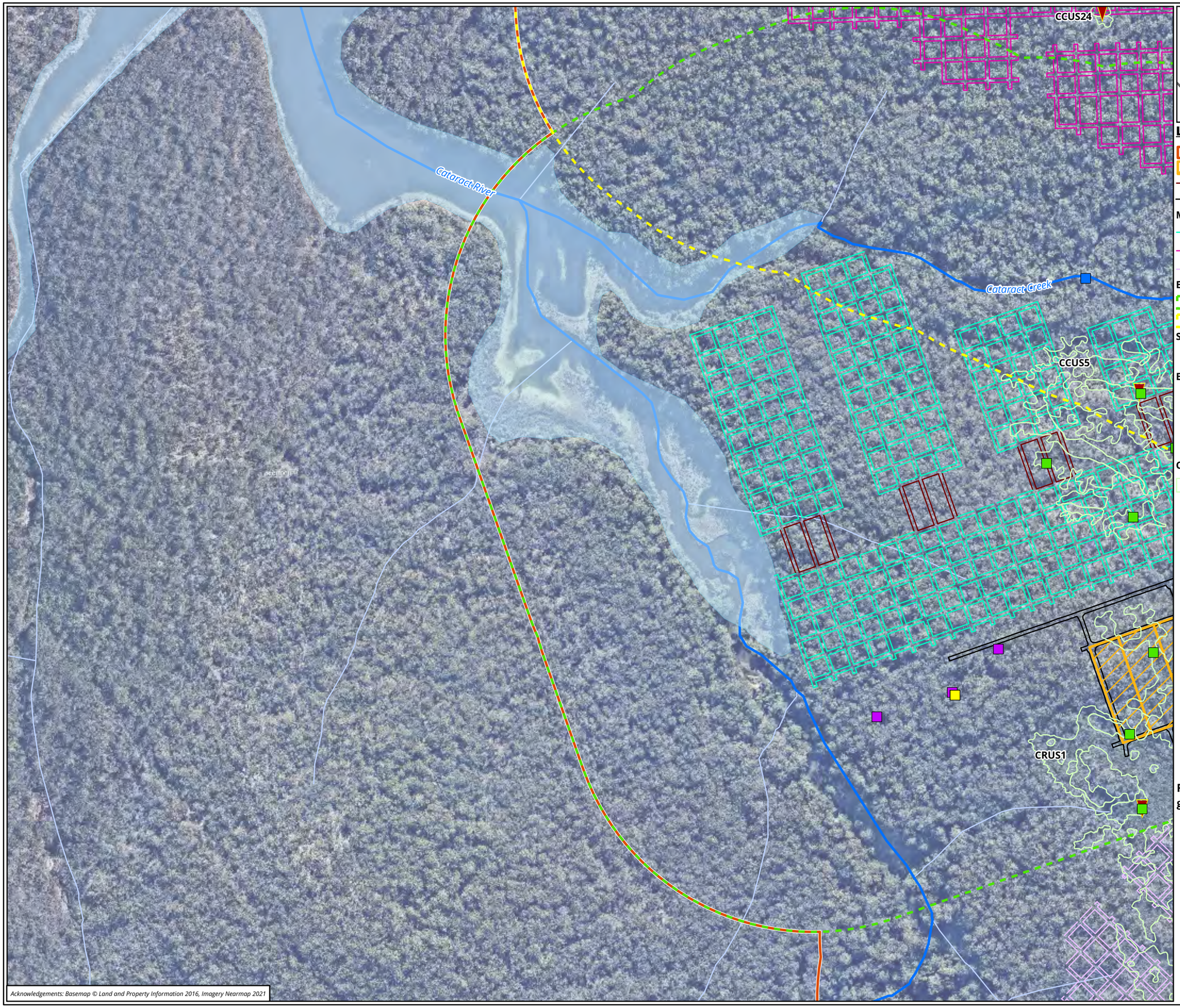

Legend

- UEP area
- RV East old longwall workings
- Pillars
- Past workings

Mine plan

- Stage 1
- Stage 2
- Future stages

EP areas

- Stage 1
- Stage 2

Soil moisture monitoring

- Soil moisture probe

Existing groundwater locations

- OSP
- Creek
- SP
- VWP

Coastal Upland Swamps

- Swamp extent

Figure 11d Coastal Upland Swamp groundwater monitoring

0 40 80 120 160 200

Metres

Scale: 1:5,000 @ A3

Coordinate System: GDA 1994 MGA Zone 56

N

biosis

Matter: 36747,
Date: 06 June 2022 ,
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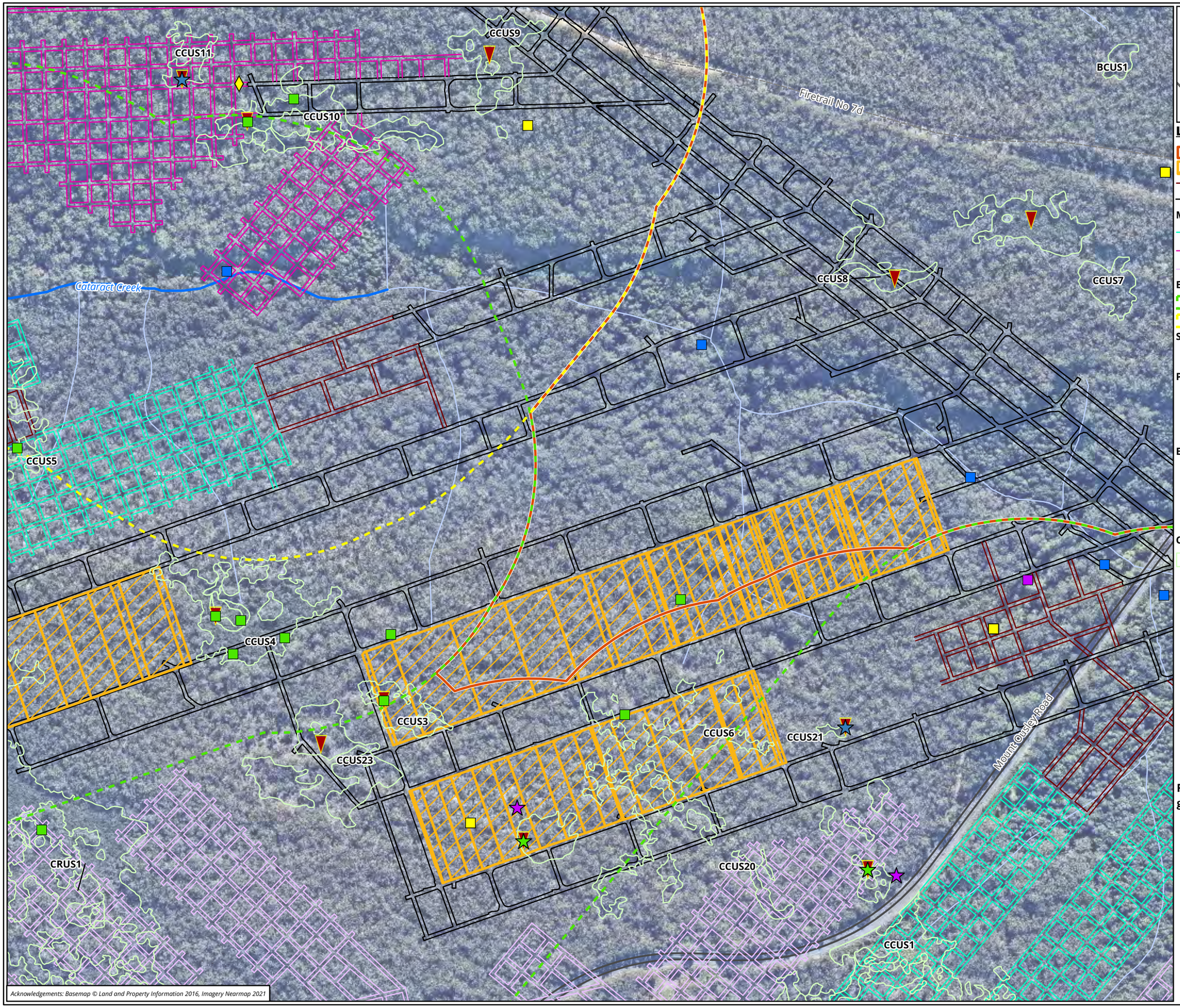


Legend

- UEP area
- RV East old longwall workings
- Pillars
- Past workings

Mine plan

- Stage 1
- Stage 2
- Future stages

EP areas

- Stage 1
- Stage 2

Soil moisture monitoring

- Soil moisture probe

Planned bores

- OSP
- SM
- SP

Existing groundwater locations

- OSP
- Creek
- SP
- VWP

Coastal Upland Swamps

- Swamp extent

Figure 11e Coastal Upland Swamp groundwater monitoring

0 40 80 120 160 200

Metres

Scale: 1:5,000 @ A3

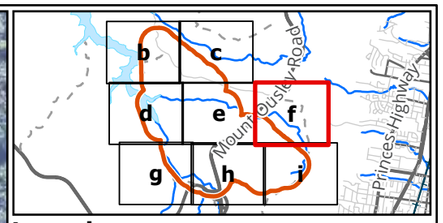
Coordinate System: GDA 1994 MGA Zone 56

N

biosis

Matter: 36747,
Date: 06 June 2022 ,
Prepared for: CBH, Prepared by: AM, Last edited by: amackegard
Layout: F11_CoastalUplandSwampMonitoring_ground
Project: P:\36700s\36747\Mapping\
36747_WCL_Stage2_USMP_figures.aprx

Acknowledgements: Basemap © Land and Property Information 2016, Imagery Nearmap 2021



Legend

- UEP area
- Pillars
- Past workings

Mine plan

- Stage 1
- Future stages

EP areas

- Stage 1

Soil moisture monitoring

- Soil moisture probe

Planned bores

- VWP

Existing groundwater locations

- Creek
- VWP

Coastal Upland Swamps

- Swamp extent

Figure 11f Coastal Upland Swamp groundwater monitoring

0 40 80 120 160 200

Metres

Scale: 1:5,000 @ A3

Coordinate System: GDA 1994 MGA Zone 56

N

biosis

Matter: 36747,
Date: 06 June 2022 ,
Prepared for: CBH, Prepared by: AM, Last edited by: amackegard
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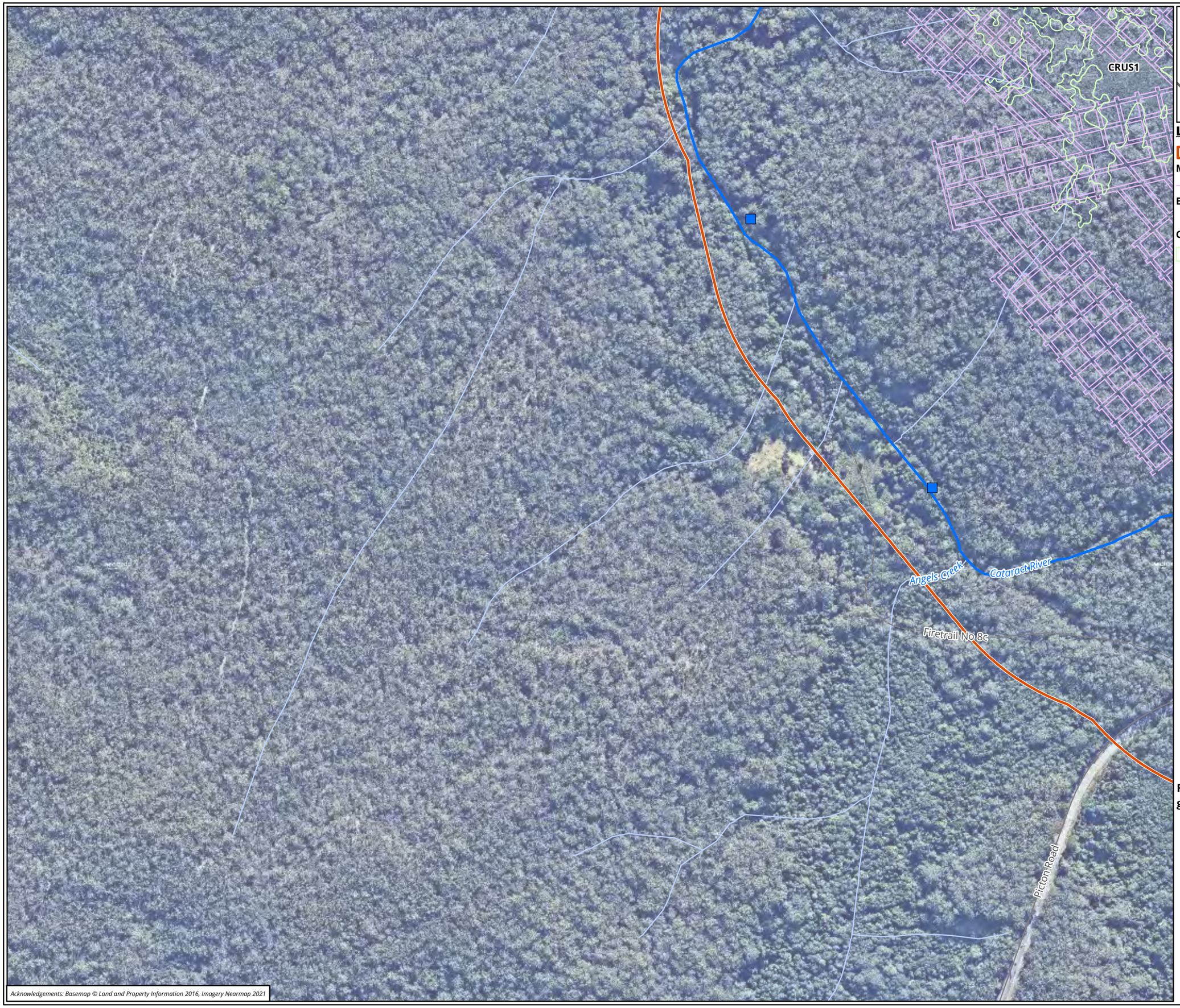
Project: P:\36700s\36747\Mapping\
36747_WCL_Stage2_USMP_figures.aprx



Legend

UEP area

Mine plan

Future stages

Existing groundwater locations

Creek

Coastal Upland Swamps

Swamp extent

Acknowledgements: Basemap © Land and Property Information 2016, Imagery Nearmap 2021

Figure 11g Coastal Upland Swamp groundwater monitoring

0 40 80 120 160 200

Metres

Scale: 1:5,000 @ A3

Coordinate System: GDA 1994 MGA Zone 56

N

Matter: 36747,
Date: 06 June 2022 ,
Prepared for: CBH, Prepared by: AM, Last edited by: amackegard
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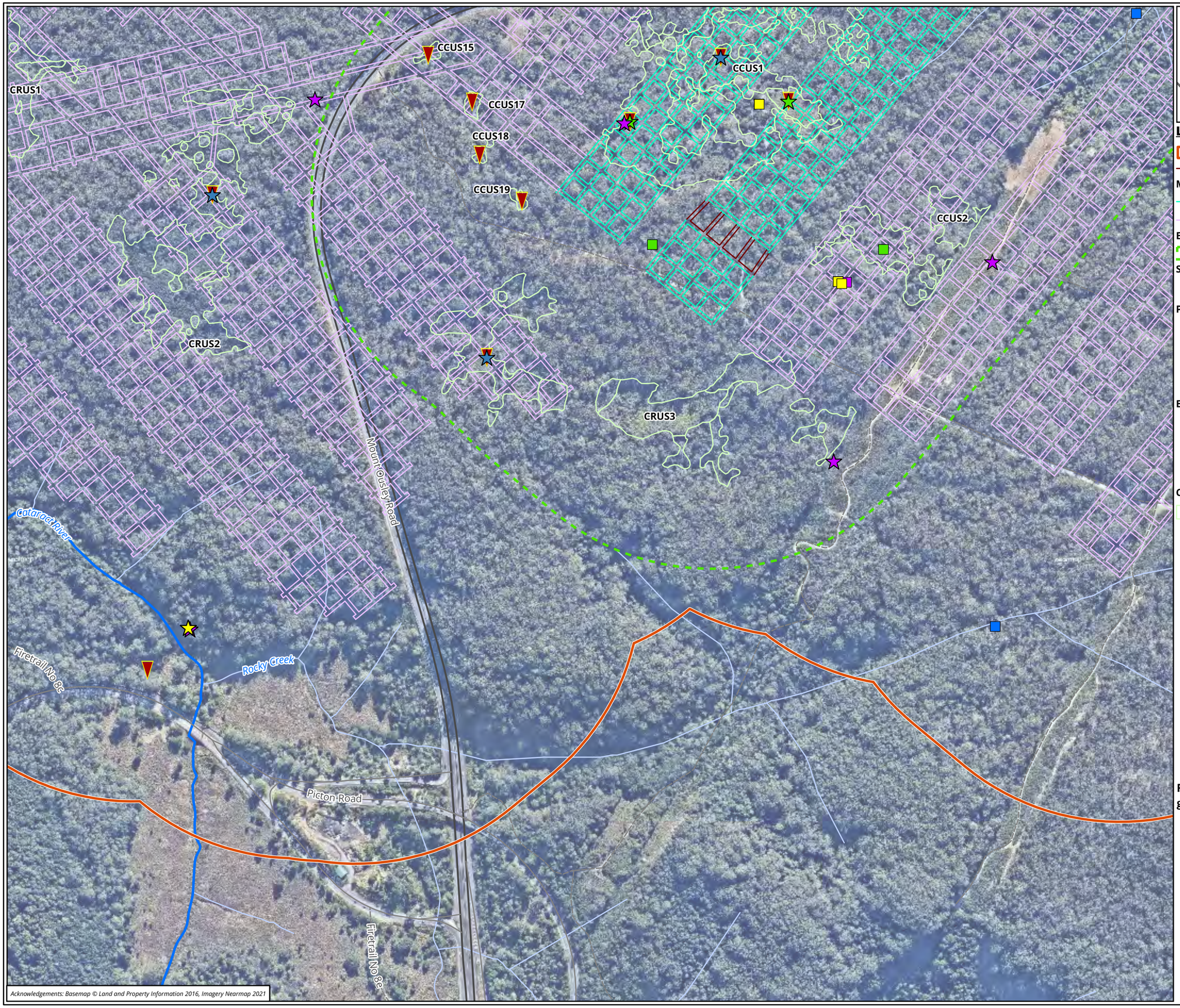
Project: P:\36700s\36747\Mapping\
36747_WCL_Stage2_USMP_figures.aprx



Legend

- UEP area
- Pillars

Mine plan

- Stage 1
- Future stages

EP areas

- Stage 1

Soil moisture monitoring

- Soil moisture probe

Planned bores

- OSP
- SM
- SP
- VWP

Existing groundwater locations

- OSP
- Creek
- SP
- VWP

Coastal Upland Swamps

- Swamp extent

Figure 11h Coastal Upland Swamp groundwater monitoring

0 40 80 120 160 200

Metres

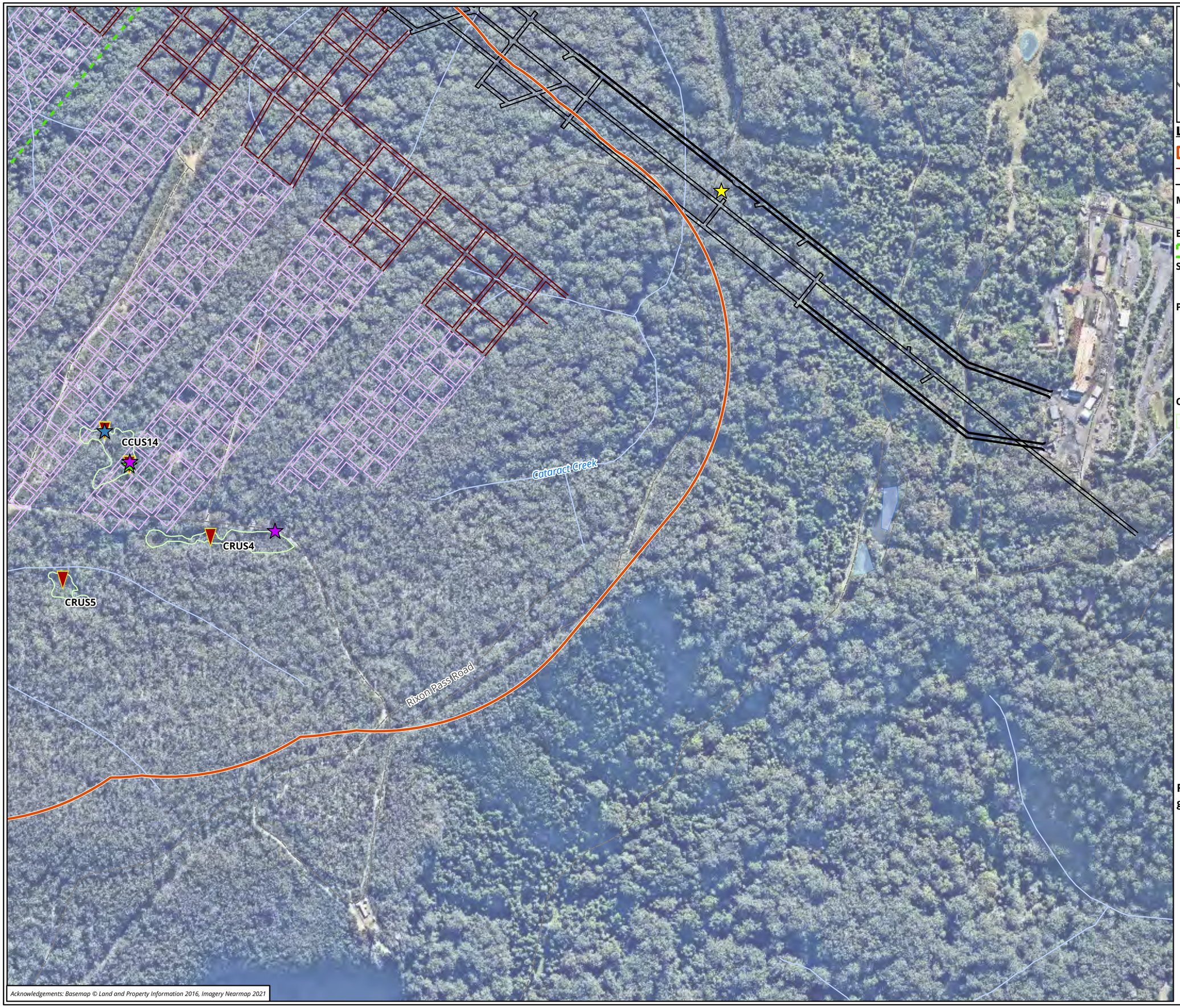
Scale: 1:5,000 @ A3

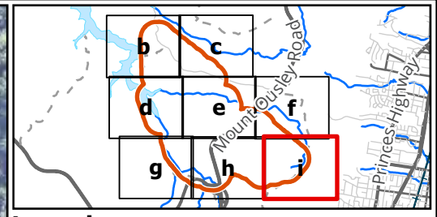
Coordinate System: GDA 1994 MGA Zone 56

N

biosis

Matter: 36747,
Date: 06 June 2022 ,
Prepared for: CBH, Prepared by: AM, Last edited by: amackegard
Layout: F11_CoastalUplandSwampMonitoring_ground
Project: P:\36700s\36747\Mapping\
36747_WCL_Stage2_USMP_figures.aprx





Legend

- UEP area
- Pillars
- Past workings

Mine plan

- Future stages

EP areas

- Stage 1

Soil moisture monitoring

- Soil moisture probe

Planned bores

- OSP
- SM
- SP
- VWP

Coastal Upland Swamps

- Swamp extent

Acknowledgements: Basemap © Land and Property Information 2016, Imagery Nearmap 2021

Figure 11i Coastal Upland Swamp groundwater monitoring

0 40 80 120 160 200

Metres

Scale: 1:5,000 @ A3

Coordinate System: GDA 1994 MGA Zone 56

N

biosis

Matter: 36747,
Date: 06 June 2022 ,
Prepared for: CBH, Prepared by: AM, Last edited by: amackegard
Layout: F11_CoastalUplandSwampMonitoring_ground
Project: P:\36700s\36747\Mapping\
36747_WCL_Stage2_USMP_figures.aprx

3.2 Coastal Upland Swamp ecological monitoring

A significant amount of ecological data for upland swamps in the RVE area has been previously collected as part of previous annual ecological monitoring programs, as described in Section 4.3. Coastal Upland Swamp ecological monitoring has been undertaken in the RVE domain since autumn 2011. Baseline monitoring commenced for Stage 1 in autumn 2021, and Stage 2 in autumn 2022. This provides a strong baseline dataset to base any future comparisons for ongoing monitoring within the RVE area and inform ongoing monitoring methodologies. To ensure comparisons to the significant amount of data previously collected as part of the previous monitoring in the RVE area, the methods are heavily informed by those carried out in prior monitoring.

The monitoring includes two approaches. First, establishing up to date swamp extent, characterisation and condition data prior to any mining under swamps occurring, through updated LiDAR (or alternative such as InSAR) and field inspection analysis as an update to Biosis (2012). Secondly, ongoing ecological monitoring within the swamps using the same BACI approach and field methods as previous monitoring to ensure valid comparisons to past data collection for vegetation transect, observational and Giant Dragonfly monitoring (Section 4.3). An overview of these methods is provided below with detailed descriptions of field data collection and data analysis detailed in the following sections. The current and proposed monitoring is detailed in Section 4.3 as well as Figure 12 and Figure 13.

Updated LiDAR analysis and field inspection of all swamps within the RVE area will be undertaken before any mining under swamps. This will provide an up to date baseline for swamp extents in the area, as an update to the previous baseline extent mapping completed (Biosis 2012). This baseline survey will provide up to date context to inform the ongoing monitoring methodologies detailed below and inform the selection of additional control sites as required to pair with impact sites that have not previously been monitored. It will also serve as a basis for any further examination over longer time scales that may be required if additional survey of swamp extents is required via the triggering of a TARP process (Section 7.3 and Appendix D). The full methodology is detailed in (Section 3.2.1).

3.2.1 Baseline LiDAR analysis and field inspection

Baseline analysis of swamp extents was undertaken using LiDAR analyses prior to UEP extraction in 2021, for all swamps in the EP area. Previous LiDAR analysis has been undertaken (Biosis 2012) and it is anticipated that swamp extents are likely to have altered due to natural successional processes since 2012, and as a result of the drought that occurred between 2017 and 2019 in the region.

To support the Baseline LiDAR analysis conducted in 2021 a field investigation was undertaken at each swamp. The field inspection included ground-truthing of mapped swamp extents and sub-communities. Mapping of the floristic composition and condition of each swamp was also undertaken. As part of this characterisation, data from a BAM floristic plot was collected in accordance with Section 5 of the NSW Biodiversity Assessment Method 2020 (BAM) (DPIE 2020) for each 'vegetation zone' within each swamp. Photo-points will be established as a reference for any further survey that may be required. This baseline survey will also form a basis for the selection of any additional control sites required for the flora monitoring.

The LiDAR analyses of swamp extents and field inspection is also undertaken once before any mining under swamps. This analysis provides an accurate and up to date basis for any future analysis of change over time. If greater than negligible impacts are identified through other monitoring methods (e.g. subsidence, piezometer or vegetation transect monitoring) additional LiDAR surveys will be undertaken at two to five year intervals, to be defined in consultation with BCD and/or DCCEEW. This information provides a basis for the assessment of any longer term impacts to Coastal Upland Swamps. This assessment is then undertaken via a comparison of proportional swamp extent and sub-community changes between impact and control monitoring sites.

The analysis methodology will follow that described in Biosis (2012) to be directly comparable to past data and is detailed below. A report will be prepared detailing the baseline LiDAR analysis and field inspection findings that will include a characterisation of each swamp including details of swamp extent and sub-community areas along with photo-points and floristics. This report will provide a baseline for future assessment if the need for further assessment is triggered.

3.2.1.1 Detailed mapping of Coastal Upland Swamps

Coastal Upland Swamps will be mapped by Biosis using a combination of Light Detection and Ranging (LiDAR) data, to define areas requiring further investigation, ground-truthing or interrogation of high resolution aerial imagery to define swamp boundaries and map swamp sub-communities and use of a Geographic Information System (GIS) to spatially represent data. The methodology detailed in Biosis (2012) is provided below.

3.2.1.2 Mapping of 'Potential Wetlands'

LiDAR data was obtained using Airborne Laser Scanning (ALS) from a fixed wing aircraft. Initial areas of 'Potential Wetland' will be determined in an automated process using a series of GIS analysis tools in ArcGIS, which are combined into a single ArcGIS Model Builder geoprocessing model.

A CSV file, containing the raw LiDAR non-ground returns, was converted into a point feature class with one point for every captured non-ground return. The points are converted to a raster using the 'Topo to Raster' geoprocessing tool within ArcGIS Spatial Analyst to convert the points to a continuous raster surface. The matching CSV file, containing the raw LiDAR ground points, is then converted to point data. The points are converted to a raster DEM using the same tool and parameters as the non-ground. A Canopy Height Model (CHM) will be developed by subtracting the values of the ground raster from the non-ground raster. This CHM is then run through the 'Focal Statistics' tool in ArcGIS to produce a focal range raster. The output raster created by this tool represents the rate of change in the height of vegetation within a 1 square metre (m^2) neighbourhood. A high rate of change within this relatively small area indicates a distinct difference in the height of vegetation and therefore be likely to signify the boundary of a swamp.

The range values are then reclassified into categories in order to create hard breaklines between what is possibly swamp and what is likely taller, fringing vegetation. Following testing and evaluation of data in areas of known swamp a rate of change greater than 2 m within a 1 m neighbourhood provides the best indication of a potential swamp boundary. This option has been found to provide the closest representation of the boundary of previously mapped control swamps whilst filtering out 'background noise' in the data.

The range raster by itself has previously found many areas where the rate of change was less than 2 metres within a 1 square metre neighbourhood outside swamp areas due to thick canopy coverage of mature trees of similar height. To remove these areas the range raster is run through the Conditional (Con) geoprocessing tool within ArcGIS to only retain areas of the range raster where the total vegetation height was less than 6 metres. This has been considered representative of swamps where vegetation rarely exceeds 6 metres in height. The con raster is then converted to polygons representing a first cut of potential swamp land.

Following the automated process of LiDAR data into potential wetland polygons, further manual 'cleaning' of the polygons is required to further filter out false positives. The polygons are dissolved so any with overlapping or coincident boundaries are treated as a single swamp. After comparison with the known swamp control dataset, only polygons over 1,000 square metres are be kept, in order to filter out further 'background noise'. Any obvious false positives, including areas such as clearings, roads and waterbodies, are manually removed from the dataset using aerial imagery interpretation. The polygons are loaded on GIS enabled tablet devices for field staff to locate and ground-truth.

3.2.1.3 Detailed ground-truthing and mapping of vegetation sub-communities

Following automated mapping of 'Potential Wetlands' these areas were ground-truthed to determine whether areas mapped are representative of Coastal Upland Swamps. A team of botanists experienced with the identification of Coastal Upland Swamps on the Woronora plateau visited all potential Coastal Upland Swamps.

Areas of Coastal Upland Swamp were assessed in detail. Boundaries of all swamps were mapped using a combination of LiDAR data, ground-truthing using a handheld GIS tablet device and aerial photo interpretation (API).

Vegetation sub-communities present within swamps were also mapped using a combination of ground-truthing and API. Sub-communities were mapped according to community profiles contained within The Native Vegetation of the Woronora, O'Hares and Sydney Metropolitan Catchments (NPWS 2003), and included those communities considered part of the Coastal Upland Swamp EEC (NSW Scientific Committee 2012), in order to maintain valid comparisons to Biosis (2012). These include:

- MU42 Upland Swamps: Banksia Thicket.
- MU43 Upland Swamps: Tea-tree Thicket.
- MU44 Upland Swamps: Sedgeland Heath Complex.
- MU44(a) Sedgeland.
- MU44(b) Restioid Heath.
- MU44(c) Cyperoid Heath.

Photos were taken of each swamp and photo-points recorded.

Following field assessment, the results of detailed ground-truthing were digitised in a GIS. Boundaries of Coastal Upland Swamps and of sub-communities within swamps are refined, in collaboration with GIS staff using API.

3.2.1.4 Swamp extent calculations

The detailed mapping of Coastal Upland Swamps prior to potential mining impacts (described above) is used to detect changes in the total swamp size and extent of Coastal Upland Swamp

sub-communities within each swamp. The baseline swamp extent analysis will provide a basis for comparison, in the event that further LiDAR analysis is triggered.

The data is used to determine whether impacts associated with mining have resulted in changes to the extent of Coastal Upland Swamps. The total swamp extent and average (plus and minus the standard error of the mean) size of impact swamps mapped using most recent LiDAR data will be compared with the total size of control swamps (plus and minus the standard error of the mean) during the baseline year. This analysis will also include reference to swamp extents previously mapped (Biosis 2012). Comparisons between control and impact monitoring sites, as well as pre-mining and post-mining data will enable differentiation between catchment scale processes (e.g. rainfall) and mining induced change.

4 COASTAL UPLAND SWAMP MONITORING PROGRAM

The RVE UEP is not anticipated to have any observable impacts on Coastal Upland Swamp communities. This is primarily due to the levels of predicted subsidence being unlikely to affect the holding capacity of swamps due to the low levels of incremental vertical subsidence and tensile strain impacts and the absence of any causal pathway interactions between the confined hardrock aquifers below the swamps and the unconfined aquifers within the swamps.

Potential subsidence impacts provide the most likely (but still highly improbable) impact pathway for potential impacts to Coastal Upland Swamps. Of the swamps potentially undermined or close to proposed mining areas, only CCUS1 and CCUS5 will be directly undermined in Stage 1, and BCUS4, BCUS6, BCUS7, BCUS11, CCUS9, CCUS10, CCUS11, CCUS12, CCUS13, CCUS24, CRUS6, and CRUS7 will be undermined in Stage 2. CCUS6 and CCUS21 are located over areas of predicted groundwater drawdown in the underlying sandstone aquifer. Undermined swamps are considered unlikely to be significantly impacted by subsidence impacts up to 300 mm vertical subsidence (IAPUM 2020) and the levels of subsidence predicted for the Project are generally less than 100 mm for Stage 2 swamps (BCUS4, BCUS11, CCUS10, CCUS11, CCUS12, CRUS6, CRUS7, BCUS6, BCUS7, CCUS9, CCUS13, and CCUS24), 100 mm for Stage 1 swamps (CCUS1 and CCUS5) and <20 mm for CCUS20. These subsidence levels are considered unlikely to have any significant or even observable impacts on these swamps.

Monitoring will therefore be designed to confirm the minimal impact predictions and is based around the monitoring of responses to higher than expected subsidence impacts, areas of increased predicted drawdown in underlying sandstone aquifers and/or the investigation of the causes of any observed changes in vegetation within the swamps. Baseline and ongoing monitoring will be important in monitoring compliance with biodiversity and Coastal Upland Swamp performance measures.

Groundwater monitoring and vegetation monitoring (qualitative and quantitative) will form the basis of the monitoring. Subsidence monitoring will also be used to identify whether additional monitoring may be required. Aspects of the proposed monitoring program will not be directly linked to TARPs but will instead be undertaken to inform investigations into the cause of potential impacts should the identified TARP triggers be exceeded.

Given the extremely low likelihood of any observable impacts at any Coastal Upland Swamps, the potential impacts associated with the installation of monitoring equipment has been considered in the siting of monitoring. The priority of specific monitoring has had regard to a range of factors, informed by a swamp specific risk assessment. Four categories of swamp were determined through a risk assessment process completed by Wollongong Coal, Umwelt and Biosis. This risk assessment considered the potential impact pathway, the level of existing cumulative tensile strain under swamps, location in reference to first workings and swamp size (Appendix C). This risk assessment has considered the monitoring requirements for the UEP areas as a whole with further classification undertaken that considered the potential risks associated with Stage 1 and Stage 2. As outlined in Section 4.3 ecological monitoring will be based on the risk assessment categorisation for the UEP as a whole as this includes consideration of baseline monitoring for future stages as well as performance measure monitoring. Similar considerations apply for swamp groundwater monitoring. The need for specific subsidence monitoring is however informed by the swamp risk categorisation for second workings as the installation of GNSS units have specific satellite line of sight requirements which can limit locations for

installation. In this regard, discussions with WaterNSW have indicated a preference to avoid locating GNSS units within Coastal Upland Swamps and, instead, find proxy locations or monitoring methods which have regard to the location of the swamps and their proximity to the proposed workings.

The swamp categories are detailed below (Table 11). The categorisation of the swamps and rationale for categorisation is contained in Appendix C.

Table 11 Coastal Upland Swamp monitoring categories

Type	Rationale
Category 1A	• Swamps >2.0 ha within 350 m of the UEP. • Partly or directly mined beneath by Wongawilli Seam bord and pillar 'second workings' or would be within subsidence zone for a conceptual Wongawilli Seam Pillar Failure scenario (approx. 50 m from panels). • Pre-existing cumulative tensile strains from Bulli and Balgownie seam workings of >2 mm/m and <10 mm/m.
	• Swamps any size. • Partly or directly mined beneath by Wongawilli Seam bord and pillar 'second workings' or would be within subsidence zone for a conceptual Wongawilli Seam Pillar Failure scenario (approx. 50 m from panels). • Pre-existing cumulative tensile strains from Bulli and Balgownie seam workings of >10 mm/m.
Category 1B	• Swamps any size. • Not directly mined under Wongawilli Seam bord and pillar 'second workings' or within subsidence zone for conceptual Wongawilli Seam Pillar Failure scenario (approx. 50 m from panels). • Swamps located over areas of increased predicted drawdown >1m in the underlying sandstone aquifer.
Category 2	• Swamps >2.0 ha within 350 m of the UEP. • Partly or directly mined beneath by Wongawilli Seam bord and pillar 'second workings' or would be within subsidence zone for a conceptual Wongawilli Seam Pillar Failure scenario (approx. 50 m from panels). • Pre-existing cumulative tensile strains from Bulli and Balgownie seam workings of <2 mm/m.
	• Swamps <2.0 ha within 350 m of the UEP. • Partly or directly mined beneath by Wongawilli Seam bord and pillar 'second workings' or would be within subsidence zone for a conceptual Wongawilli Seam Pillar Failure scenario (approx. 50 m from panels). • Pre-existing cumulative tensile strains from Bulli and Balgownie seam workings between 5 mm/m and 10 mm/m.
Category 3	• Swamps <2.0 ha within 350 m of the UEP. • Partly or directly mined beneath by Wongawilli Seam bord and pillar 'second workings' or would be within subsidence zone for conceptual Wongawilli Seam Pillar Failure scenario (approx. 50 m from panels). • Pre-existing cumulative tensile strains from Bulli and Balgownie seam workings of <5 mm/m.
	• Swamps any size. • Not directly mined under by Wongawilli Seam bord and pillar 'second workings' or within subsidence zone for conceptual Wongawilli Seam Pillar Failure scenario (approx. 50 m from panels).

	• Located within 350 m of Wongawilli Seam bord and pillar 'second workings'. • Pre-existing cumulative tensile strains from Bulli and Balgownie seam workings of >2 mm/m.
Category 4	• Swamps any size. • Not directly mined under by Wongawilli Seam bord and pillar 'second workings' or within subsidence zone for conceptual Wongawilli Seam Pillar Failure scenario (approx. 50 m from panels). • Located within 350 m of Wongawilli Seam bord and pillar 'second workings'. • Pre-existing cumulative tensile strains from Bulli and Balgownie seam workings of <2 mm/m.
	• Swamps are not within 350 m of Wongawilli Seam bord and pillar 'second workings'.
Control	• Swamps are not located within 350 m of active or completed Wongawilli Seam bord and pillar 'second workings'. • Swamps represent suitable comparison swamps for impact swamps.

Further detail in relation to the specific monitoring undertaken for various periods and parameters is provided in the sub-sections below. A full summary of monitoring methods undertaken at each swamp is presented in Table 12. Detail is provided in Section 4.3.

Table 12 Coastal Upland Swamp locations and monitoring summary

Status	Swamp	Easting	Northing	Monitoring methods
Impact	BCUS2	302963.8	6197909	▪ Subsidence monitoring ▪ Groundwater monitoring (Proposed) ▪ Ecological monitoring (Detailed field assessment) ▪ Observational monitoring (Basic field assessment)
Impact	BCUS3	302913.0	6198145	▪ Subsidence monitoring ▪ Groundwater monitoring (Proposed) ▪ Ecological monitoring (Detailed field assessment) ▪ Observational monitoring (Basic field assessment)
Impact	BCUS4	302448.2	6198050	▪ Subsidence monitoring ▪ Groundwater monitoring ▪ Ecological monitoring (Detailed field assessment) ▪ Observational monitoring (Basic field assessment) ▪ Giant Dragonfly monitoring
Impact	BCUS5	302693.2	6198374	▪ Subsidence monitoring ▪ Groundwater monitoring (Proposed) ▪ Ecological monitoring (Detailed field assessment) ▪ Observational monitoring (Basic field assessment)
Impact	BCUS6	302236.0	6198415	▪ Subsidence monitoring ▪ Groundwater monitoring (Proposed) ▪ Ecological monitoring (Detailed field assessment) ▪ Observational monitoring (Basic field assessment)
Impact	BCUS7	302036.3	6198582	▪ Subsidence monitoring ▪ Groundwater monitoring (Proposed) ▪ Ecological monitoring (Detailed field assessment) ▪ Observational monitoring (Basic field assessment)
Impact	BCUS8	302166.2	6198779	▪ Subsidence monitoring ▪ Groundwater monitoring (Proposed) ▪ Observational monitoring (Basic field assessment)

Status	Swamp	Easting	Northing	Monitoring methods
Impact	BCUS9	302296.2	6198697	▪ Subsidence monitoring ▪ Groundwater monitoring (Proposed) ▪ Observational monitoring (Basic field assessment)
Impact	BCUS11	302230.4	6197921	▪ Subsidence monitoring (Proposed) ▪ Groundwater monitoring ▪ Ecological monitoring (Detailed field assessment) ▪ Observational monitoring (Basic field assessment)
Impact	BCUS14	302497.9	6198364	▪ Subsidence monitoring (Proposed) ▪ Groundwater monitoring (Proposed) ▪ Ecological monitoring (Detailed field assessment) ▪ Observational monitoring (Basic field assessment)
Impact	BCUS15	301912.6	6198970	▪ Groundwater monitoring (Proposed) ▪ Observational monitoring (Basic field assessment)
Impact	BCUS16	301536.7	6199114	▪ Groundwater monitoring (Proposed) ▪ Observational monitoring (Basic field assessment)
Impact	CCUS1	303515.1	6196321	▪ Subsidence monitoring ▪ Groundwater monitoring ▪ Ecological monitoring (Detailed field assessment) ▪ Observational monitoring (Basic field assessment) ▪ Giant Dragonfly monitoring
Impact	CCUS2	303775.5	6196092	▪ Subsidence monitoring ▪ Groundwater monitoring ▪ Ecological monitoring (Detailed field assessment) ▪ Observational monitoring (Basic field assessment)
Impact	CCUS3	302846.4	6196799	▪ Subsidence monitoring ▪ Groundwater monitoring ▪ Ecological monitoring (Detailed field assessment) ▪ Observational monitoring (Basic field assessment)
Impact	CCUS4	302622.3	6196941	▪ Subsidence monitoring ▪ Groundwater monitoring ▪ Ecological monitoring (Detailed field assessment) ▪ Observational monitoring (Basic field assessment) ▪ Giant Dragonfly monitoring
Impact	CCUS5	302202.4	6197149	▪ Subsidence monitoring ▪ Groundwater monitoring ▪ Ecological monitoring (Detailed field assessment) ▪ Observational monitoring (Basic field assessment) ▪ Giant Dragonfly monitoring
Impact	CCUS6	303179.5	6196676	▪ Subsidence monitoring ▪ Groundwater monitoring ▪ Ecological monitoring (Detailed field assessment) ▪ Observational monitoring (Basic field assessment)
-	CCUS7	303784.5	6197464	▪ Monitoring not required unless mining proposed within 350 m of the swamp ▪ Not within current Stage 1 or Stage 2 EP areas ▪ Refer to Table 11 and Table 16

Status	Swamp	Easting	Northing	Monitoring methods
-	CCUS8	303519.4	6197446	▪ Monitoring not required unless mining proposed within 350 m of the swamp ▪ Not within current Stage 1 or Stage 2 EP areas ▪ Refer to Table 11 and Table 16
Impact	CCUS9	302979.6	6197731	▪ Groundwater monitoring (Proposed) ▪ Ecological monitoring (Detailed field assessment) ▪ Observational monitoring (Basic field assessment)
Impact	CCUS10	302710.6	6197645	▪ Subsidence monitoring ▪ Groundwater monitoring ▪ Ecological monitoring (Detailed field assessment) ▪ Observational monitoring (Basic field assessment) ▪ Giant Dragonfly monitoring
Impact	CCUS11	302540.4	6197734	▪ Groundwater monitoring ▪ Ecological monitoring (Detailed field assessment) ▪ Observational monitoring (Basic field assessment)
Impact	CCUS12	302022.0	6197885	▪ Subsidence monitoring ▪ Groundwater monitoring ▪ Ecological monitoring (Detailed field assessment) ▪ Observational monitoring (Basic field assessment)
Impact	CCUS13	301747.5	6198287	▪ Subsidence monitoring (Proposed) ▪ Groundwater monitoring (Proposed) ▪ Ecological monitoring (Detailed field assessment) ▪ Observational monitoring (Basic field assessment)
Impact	CCUS14	304287.0	6195789	▪ Groundwater monitoring ▪ Ecological monitoring (Detailed field assessment) ▪ Observational monitoring (Basic field assessment)
Impact	CCUS15	303095.8	6196361	▪ Subsidence monitoring ▪ Groundwater monitoring (Proposed) ▪ Ecological monitoring (Detailed field assessment) ▪ Observational monitoring (Basic field assessment)
Impact	CCUS16	301291.9	6198051	▪ Groundwater monitoring (Proposed) ▪ Ecological monitoring (Detailed field assessment) ▪ Observational monitoring (Basic field assessment)
Impact	CCUS17	303156.7	6196288	▪ Subsidence monitoring ▪ Groundwater monitoring (Proposed) ▪ Ecological monitoring (Detailed field assessment) ▪ Observational monitoring (Basic field assessment)
Impact	CCUS18	303171.4	6196220	▪ Subsidence monitoring ▪ Groundwater monitoring (Proposed) ▪ Ecological monitoring (Detailed field assessment) ▪ Observational monitoring (Basic field assessment)
Impact	CCUS19	303222.5	6196152	▪ Subsidence monitoring ▪ Groundwater monitoring (Proposed) ▪ Ecological monitoring (Detailed field assessment) ▪ Observational monitoring (Basic field assessment)
Impact	CCUS20	303458.9	6196540	▪ Subsidence monitoring ▪ Groundwater monitoring ▪ Ecological monitoring (Detailed field assessment) ▪ Observational monitoring (Basic field assessment)

Status	Swamp	Easting	Northing	Monitoring methods
Impact	CCUS21	303464.7	6196767	▪ Subsidence monitoring ▪ Groundwater monitoring ▪ Ecological monitoring (Detailed field assessment) ▪ Observational monitoring (Basic field assessment)
Impact	CCUS22	301566.7	6198419	▪ Subsidence monitoring ▪ Groundwater monitoring (Proposed) ▪ Ecological monitoring (Detailed field assessment) ▪ Observational monitoring (Basic field assessment)
Impact	CCUS23	302734.5	6196749	▪ Subsidence monitoring ▪ Groundwater monitoring (Proposed) ▪ Ecological monitoring (Detailed field assessment) ▪ Observational monitoring (Basic field assessment)
Impact	CCUS24	302191.6	6197796	▪ Subsidence monitoring (Proposed) ▪ Groundwater monitoring (Proposed) ▪ Ecological monitoring (Detailed field assessment) ▪ Observational monitoring (Basic field assessment)
Impact	CRUS1	302344.8	6196330	▪ Subsidence monitoring ▪ Groundwater monitoring ▪ Ecological monitoring (Detailed field assessment) ▪ Observational monitoring (Basic field assessment) ▪ Giant Dragonfly monitoring
Impact	CRUS2	302757.6	6196030	▪ Subsidence monitoring ▪ Groundwater monitoring ▪ Ecological monitoring (Detailed field assessment) ▪ Observational monitoring (Basic field assessment) ▪ Giant Burrowing Frog monitoring
Impact	CRUS3	303374.1	6195888	▪ Subsidence monitoring ▪ Groundwater monitoring ▪ Ecological monitoring (Detailed field assessment) ▪ Observational monitoring (Basic field assessment)
Impact	CRUS4	304454.7	6195663	▪ Subsidence monitoring ▪ Groundwater monitoring (Proposed) ▪ Ecological monitoring (Detailed field assessment) ▪ Observational monitoring (Basic field assessment)
Impact	CRUS5	304220.9	6195594	▪ Subsidence monitoring ▪ Groundwater monitoring (Proposed) ▪ Observational monitoring (Basic field assessment)
Impact	CRUS6	301890.9	6198118	▪ Subsidence monitoring (Proposed) ▪ Groundwater monitoring ▪ Ecological monitoring (Detailed field assessment) ▪ Observational monitoring (Basic field assessment)
Impact	CRUS7	301657.3	6198566	▪ Subsidence monitoring (Proposed) ▪ Groundwater monitoring (Proposed) ▪ Ecological monitoring (Detailed field assessment) ▪ Observational monitoring (Basic field assessment)
Control site	ACUS	303449.7	6201481	▪ Subsidence monitoring ▪ Ecological monitoring (Detailed field assessment) ▪ Observational monitoring (Basic field assessment)

Status	Swamp	Easting	Northing	Monitoring methods
Control site	BCUS12	303840.0	6200394	▪ Subsidence monitoring ▪ Groundwater monitoring (Proposed) ▪ Ecological monitoring (Detailed field assessment) ▪ Observational monitoring (Basic field assessment)
Control site	BCUS13	303781.6	6199195	▪ Subsidence monitoring ▪ Groundwater monitoring (Proposed) ▪ Ecological monitoring (Detailed field assessment) ▪ Observational monitoring (Basic field assessment)
Control site	S15A(1)	292556.3	6191672	▪ Subsidence monitoring ▪ Ecological monitoring (Detailed field assessment) ▪ Observational monitoring (Basic field assessment)
Control site	S22	292971.4	6188148	▪ Subsidence monitoring ▪ Ecological monitoring (Detailed field assessment) ▪ Observational monitoring (Basic field assessment)
Control site	S33	291778.9	6191125	▪ Subsidence monitoring ▪ Ecological monitoring (Detailed field assessment) ▪ Observational monitoring (Basic field assessment)
Control site	WACUS	295534.0	6200921	▪ Subsidence monitoring ▪ Ecological monitoring (Detailed field assessment) ▪ Observational monitoring (Basic field assessment)
Control site	WCUS	298233.4	6195892	▪ Subsidence monitoring ▪ Ecological monitoring (Detailed field assessment) ▪ Observational monitoring (Basic field assessment)

4.1 Subsidence monitoring

Details of subsidence monitoring developed for the Stage 1 and Stage 2 second workings is contained within the Subsidence Monitoring Program. The core assumption in the design of this monitoring program in relation to Coastal Upland Swamps is that measured subsidence levels of less than 100 mm vertical subsidence are unlikely to result in any adverse impacts to Coastal Upland Swamps in the RVE area based on historical observations (IAPUM 2020).

Table 13 Subsidence monitoring relevant to Coastal Upland Swamps

Monitoring Method	Relevance/Purpose
LiDAR	Provides a baseline for terrain against which future LiDAR runs can be compared to measure subsidence impacts across the entire EP area. Individual point accuracy is in the order of +/- 200 mm however high-density point capture (e.g. 4 points per square metre) provides a much higher degree of accuracy when averaged over larger areas. LiDAR results can be validated through underground monitoring or results at GNSS units (i.e. false positives can be ruled out if there is no supporting evidence). The primary purpose of LiDAR in the monitoring program is to detect areas of subsidence in areas not directly monitored by GNSS Units, to be assessed by Wollongong Coal Pty Ltd. LiDAR data for the EP area will be captured within 3 months of completion of each panel. Additional LiDAR capture may also be undertaken to inform the investigation process for Level 3 triggers where considered appropriate.
GNSS Units	Provide high accuracy (<20 mm)/ near real-time monitoring of subsidence impacts at specific locations. GNSS data is reported daily but typically averaged over a week of data to smooth out anomalous results. These monitors are used to inform adaptive management measures in underground operations where monitoring indicates higher than anticipated levels of subsidence and relevant Level 2 and 3 triggers are exceeded. GNSS Units located over second workings provide information about subsidence occurring within that panel. GNSS Units located within or at the edge of swamps provide an indication of subsidence levels within the swamp. Where possible, these monitors are to be located at a point within the swamp or at a point between the swamp and the second workings. Where located between the second workings and the swamp, the observed levels will be less than would be occurring at the swamp which is located further form the workings (e.g. an observation of <100 mm vertical subsidence at a GNSS monitor located between the Stage 1 or 2 second workings and the swamp required to be monitored will indicate levels of subsidence at the swamp which are also below the 100 mm performance measure. The use of these proxy monitors will not enable real time measurements of actual levels of subsidence within the swamps but will provide evidence of subsidence which is below performance measures. Monitored levels of subsidence above 100 mm at these proxy monitors may trigger a requirement for further monitoring within particular swamps to understand if performance measures have been exceeded.

Monitoring Method	Relevance/Purpose
Underground Observations	Monitoring of underground strata integrity will be a key means of detecting potential exceedances of vertical subsidence criteria. The absence of any strata failure events will be a key indicator that subsidence levels on the surface will be close to those predicted in the Stage 1 Subsidence Assessment (SCT 2019) and Stage 2 Subsidence Assessment (SCT 2022). As discussed in Section 5.2, the Stage 1 and Stage 2 second workings can only result in levels of subsidence in excess of 100 mm in swamps which are not directly undermined if there is a significant underground strata failure (for example, a pillar failure). These events are readily observable underground. The absence of any such events is evidence that subsidence impacts above are going to be generally consistent with those predicted in the Stage 1 Subsidence Assessment (SCT 2019) and Stage 2 Subsidence Assessment (SCT 2022). To supplement the GNSS monitoring, daily monitoring of active mining areas will be undertaken. The Subsidence Monitoring Program includes specific details of underground monitoring arrangements and associated TARPs. For all Coastal Upland Swamps located outside the immediate mining footprint but within 350 m of second workings, this underground monitoring will be a key indication of conditions which may give rise to subsidence impacts in excess of the 100 mm performance measures. Conversely, the absence of any such strata failure events will also be indicative of vertical subsidence levels at Coastal Upland Swamps located outside the immediate mining footprint as being well below the adopted 100 mm performance measure.

The approach to monitoring the 100 mm performance criteria for Coastal Upland Swamps located within 350 m of the Stage 1 and Stage 2 second workings is set out in Table 14.

Table 14 Approach to subsidence monitoring in Coastal Upland Swamps within the EP area

Swamp	Relevant stage	Subsidence monitoring	Comments
BCUS2	Stage 2	GNSS #28	Level 2 Trigger: ▪ >80 mm[9] subsidence at nearest GNSS unit. Level 3 Trigger: ▪ >100 mm subsidence at nearest GNSS unit. ▪ Strata failure observed underground in workings within 350 m of swamp extent. ▪ Validated[10] LiDAR survey results indicate >100 mm subsidence relative to pre-mining data collected by WRPL.

[9] 50 mm Level 2 trigger adopted as a practical indication of greater than predicted levels of subsidence at this location and includes allowance for natural ground movement and accuracy of GNSS Units.

[10] LiDAR typically has an accuracy of +/- 200 mm. LiDAR survey results indicating subsidence >100 mm and <200 mm can be validated through underground monitoring and/or relevant GNSS units.

Swamp	Relevant stage	Subsidence monitoring	Comments
BCUS3	Stage 2	GNSS #25, #28 (proxy)	Level 2 Trigger: ▪ >80 mm[9] subsidence at nearest GNSS unit. Level 3 Trigger: ▪ >100 mm subsidence at nearest GNSS unit. ▪ Strata failure observed underground in workings within 350 m of swamp extent. ▪ Validated[10] LiDAR survey results indicate >100 mm subsidence relative to pre-mining data collected by WRPL.
BCUS4	Stage 2	GNSS #24, #25	Level 2 Trigger: ▪ >80 mm[9] subsidence at adjacent GNSS unit. Level 3 Trigger: ▪ >100 mm subsidence at adjacent GNSS unit. ▪ Strata failure observed underground in workings within 350 m of swamp extent. ▪ Validated[10] LiDAR survey results indicate >100 mm subsidence relative to pre-mining data collected by WRPL.
BCUS5	Stage 2	GNSS #25 (proxy)	Level 2 Trigger: ▪ >80 mm[9] subsidence at nearest GNSS unit. Level 3 Trigger: ▪ >100 mm subsidence at nearest GNSS unit. ▪ Strata failure observed underground in workings within 350 m of swamp extent. ▪ Validated[10] LiDAR survey results indicate >100 mm subsidence relative to pre-mining data collected by WRPL.
BCUS6	Stage 2	GNSS #21	Level 2 Trigger: ▪ >80 mm[9] subsidence at adjacent GNSS unit. Level 3 Trigger: ▪ >100 mm subsidence at adjacent GNSS unit. ▪ Strata failure observed underground in workings within 350 m of swamp extent. ▪ Validated[10] LiDAR survey results indicate >100 mm subsidence relative to pre-mining data collected by WRPL.
BCUS7	Stage 2	GNSS #20	Level 2 Trigger: ▪ >80 mm[9] subsidence at adjacent GNSS unit. Level 3 Trigger: ▪ >100 mm subsidence at adjacent GNSS unit. ▪ Strata failure observed underground in workings within 350 m of swamp extent. ▪ Validated[10] LiDAR survey results indicate >100 mm subsidence relative to pre-mining data collected by WRPL.

Swamp	Relevant stage	Subsidence monitoring	Comments
BCUS8	Stage 2	GNSS #20 GNSS #21 (proxy)	Level 2 Trigger: ▪ >80 mm[9] subsidence at nearest GNSS unit. Level 3 Trigger: ▪ >100 mm subsidence at nearest GNSS unit. ▪ Strata failure observed underground in workings within 350 m of swamp extent. ▪ Validated[10] LiDAR survey results indicate >100 mm subsidence relative to pre-mining data collected by WRPL.
BCUS9	Stage 2	GNSS #20 GNSS #21 (proxy)	Level 2 Trigger: ▪ >80 mm[9] subsidence at nearest GNSS unit. Level 3 Trigger: ▪ >100 mm subsidence at nearest GNSS unit. ▪ Strata failure observed underground in workings within 350 m of swamp extent. ▪ Validated[10] LiDAR survey results indicate >100 mm subsidence relative to pre-mining data collected by WRPL.
BCUS11	Stage 2	GNSS #24, #27	Level 2 Trigger: ▪ >80 mm[9] subsidence at adjacent GNSS unit. Level 3 Trigger: ▪ >100 mm subsidence at adjacent GNSS unit. ▪ Strata failure observed underground in workings within 350 m of swamp extent. ▪ Validated[10] LiDAR survey results indicate >100 mm subsidence relative to pre-mining data collected by WRPL.
BCUS14	Stage 2	Adjacent GNSS unit (anticipated to be installed June 2022)	Level 2 Trigger: ▪ >80 mm[9] subsidence at adjacent GNSS unit. Level 3 Trigger: ▪ >100 mm subsidence at adjacent GNSS unit. ▪ Strata failure observed underground in workings within 350 m of swamp extent. ▪ Validated[10] LiDAR survey results indicate >100 mm subsidence relative to pre-mining data collected by WRPL.
BCUS15	Stage 2	GNSS #18, #20 (proxy)	Level 2 Trigger: ▪ >80 mm[9] subsidence at nearest GNSS unit. Level 3 Trigger: ▪ >100 mm subsidence at nearest GNSS unit. ▪ Strata failure observed underground in workings within 350 m of swamp extent. ▪ Validated[10] LiDAR survey results indicate >100 mm subsidence relative to pre-mining data collected by WRPL.

Swamp	Relevant stage	Subsidence monitoring	Comments
BCUS16	Stage 2	GNSS #18 (proxy)	Level 2 Trigger: ▪ >80 mm[9] subsidence at nearest GNSS unit. Level 3 Trigger: ▪ >100 mm subsidence at nearest GNSS unit. ▪ Strata failure observed underground in workings within 350 m of swamp extent. ▪ Validated[10] LiDAR survey results indicate >100 mm subsidence relative to pre-mining data collected by WRPL.
CCUS1	Stage 1	GNSS#2 and GNSS#3	Both monitoring points located within CCUS1. Exceedances of 100 mm in monitoring will be indicator of exceedance of performance criteria. Level 2 Trigger: ▪ >100 mm subsidence at GNSS#1, >80 mm at GNSS#2 and GNSS#3 relative to baseline. Level 3 Trigger: ▪ >100 mm subsidence at GNSS#2 and GNSS#3 relative to baseline. ▪ Validated[10] LiDAR survey results >100 mm subsidence relative to pre-Stage 1 data collected by WRPL.
CCUS2	Stage 1	GNSS#3 and GNSS#15 Underground observations	Installation points for a GNSS monitor between PC07 and CCUS2 are not readily available. GNSS#3 and GNSS#15 are located in areas above or close to PC07 which will provide an indication of potential exceedances of the 100 mm performance criteria at CCUS2. Exceedances of 100 mm in monitoring at either monitor will be indicator of potential exceedance of performance criteria at CCUS2. Absence of major strata failure event in areas of PC07 within 350 m of CCUS2 will be strong evidence that exceedance of the 100 mm vertical subsidence performance criteria has not occurred. End of panel LiDAR survey will provide further detail regarding extent of subsidence observed in GNSS#14 and #15. Level 2 Trigger: ▪ >80 mm subsidence at GNSS#3, >50 mm subsidence at GNSS#15 Level 3 Trigger: ▪ Strata failure observed underground in PC07 or PC08 workings within 350 m of swamp extent. ▪ Validated[10] LiDAR survey results >100 mm subsidence relative to pre-Stage 1 data collected by WRPL.

Swamp	Relevant stage	Subsidence monitoring	Comments
CCUS3	Stage 1	GNSS#13 LiDAR	No plausible mechanism for subsidence in excess of performance criteria to occur as a result of Stage 1 second workings. Note: GNSS#13 is located between PC21 (the nearest second working panel) and CCUS3 and will also operate as a proxy for potential impacts. Level 2 Trigger: ▪ As per CCUS4 Level 3 Trigger: ▪ As per CCUS4
CCUS4	Stage 1 and 2	GNSS#13	GNSS#13 is located between PC21 and CCUS4 near the edge of CCUS4. Exceedances of 100 mm in monitoring will be indicator of exceedance of performance criteria at CCUS4. Level 2 Trigger: ▪ >50 mm at GNSS#13 relative to Stage 1 baseline. Level 3 Trigger: ▪ >100 mm subsidence at GNSS#13 relative to baseline. ▪ Validated[10] LiDAR survey results >100 mm subsidence relative to pre-Stage 1 data collected by WRPL.
CCUS5	Stage 1 and 2	GNSS#11	Located within CCUS5. Exceedances of 100 mm in monitoring will be indicator of exceedance of performance criteria. Level 2 Trigger: ▪ >80 mm at GNSS#11 relative to Stage 1 baseline. Level 3 Trigger: ▪ >100 mm subsidence at GNSS#11 relative to baseline. ▪ Validated[10] LiDAR survey results >100 mm subsidence relative to pre-Stage 1 data collected by WRPL.
CCUS6	Stage 1	GNSS#13 LiDAR	No plausible mechanism for subsidence in excess of performance criteria to occur as a result of workings. Note: GNSS#13 is located between PC21 (the nearest second working panel) and CCUS6 and will also operate as a proxy for potential impacts. Level 2 Trigger: ▪ As per CCUS4 Level 3 Trigger: ▪ As per CCUS4
CCUS9	Stage 2	GNSS #28	Level 2 Trigger: ▪ >80 mm[9] subsidence at adjacent GNSS unit. Level 3 Trigger: ▪ >100 mm subsidence at adjacent GNSS unit. ▪ Strata failure observed underground in workings within 350 m of swamp extent. ▪ Validated[10] LiDAR survey results indicate >100 mm subsidence relative to pre-mining data collected by WRPL.

Swamp	Relevant stage	Subsidence monitoring	Comments
CCUS10	Stage 1 and 2	GNSS #26 Underground observations LiDAR	No plausible mechanism for subsidence in excess of performance criteria to occur as a result of Stage 1 second workings. To be undermined by Stage 2 second workings. The absence of any strata failure at the start of PC21 will be evidence that there is no exceedance of the 100 mm vertical subsidence performance criteria at CCUS10 Level 2 Trigger: ▪ Strata failure in first 300 m of PC21. ▪ >80 mm[9] subsidence at adjacent GNSS unit. Level 3 Trigger: ▪ Validated[10] LiDAR survey results >100 mm subsidence relative to pre-Stage 1 data collected by WRPL.
CCUS11	Stage 2	GNSS #26	Level 2 Trigger: ▪ >80 mm[9] subsidence at adjacent GNSS unit. Level 3 Trigger: ▪ >100 mm subsidence at adjacent GNSS unit. ▪ Strata failure observed underground in workings within 350 m of swamp extent. ▪ Validated[10] LiDAR survey results indicate >100 mm subsidence relative to pre-mining data collected by WRPL.
CCUS12	Stage 2	GNSS #23, #27	Level 2 Trigger: ▪ >80 mm[9] subsidence at adjacent GNSS unit. Level 3 Trigger: ▪ >100 mm subsidence at adjacent GNSS unit. ▪ Strata failure observed underground in workings within 350 m of swamp extent. ▪ Validated[10] LiDAR survey results indicate >100 mm subsidence relative to pre-mining data collected by WRPL.
CCUS13	Stage 2	GNSS #19	Level 2 Trigger: ▪ >80 mm[9] subsidence at adjacent GNSS unit. Level 3 Trigger: ▪ >100 mm subsidence at adjacent GNSS unit. ▪ Strata failure observed underground in workings within 350 m of swamp extent. ▪ Validated[10] LiDAR survey results indicate >100 mm subsidence relative to pre-mining data collected by WRPL.

Swamp	Relevant stage	Subsidence monitoring	Comments
CCUS15	Stage 1	GNSS#14 Underground observations LiDAR	No plausible mechanism for subsidence in excess of performance criteria to occur as a result of Stage 1 second workings. Note: GNSS#14 is located between PC21 (the nearest second working panel) and CCUS15 and will also operate as a proxy for potential impacts. Level 2 Trigger: ▪ >50 mm[9] at GNSS#14 relative to pre-Stage 1 data collected by WRPL. Level 3 Trigger: ▪ >100 mm subsidence at GNSS#14 relative to pre-Stage 1 data collected by WRPL. ▪ Validated[10] LiDAR survey results >100 mm subsidence relative to pre-Stage 1 data collected by WRPL.
CCUS16	Stage 2	Underground observations LiDAR	The absence of any strata failure at the start of PC21 will be evidence that there is no exceedance of the 100 mm vertical subsidence performance criteria at CCUS16. Level 2 Trigger: ▪ Strata failure in PC34. Level 3 Trigger: ▪ Validated[10] LiDAR survey results >100 mm subsidence relative to pre-Stage 2 data collected by WRPL.
CCUS17	Stage 1	GNSS#14 Underground observations LiDAR	GNSS#14 is located between PC08 and CCUS17. Exceedances of 100 mm in monitoring at GNSS#13 will be indicator of a potential exceedance of performance criteria at CCUS17. Absence of major strata failure event in areas of PC08 within 350 m of CCUS17 will be strong evidence that exceedance of the 100 mm vertical subsidence performance criteria *has not* occurred. End of panel LiDAR survey will provide further detail regarding extent of subsidence observed within CCUS17. Level 2 Trigger: ▪ >50 mm[9] at GNSS#14 relative to pre-Stage 1 data collected by WRPL. Level 3 Trigger: ▪ >100 mm subsidence at GNSS#14 relative to pre-Stage 1 data collected by WRPL. ▪ Validated[10] LiDAR survey results >100 mm subsidence relative to pre-Stage 1 data collected by WRPL.

Swamp	Relevant stage	Subsidence monitoring	Comments
CCUS18	Stage 1	GNSS#14 Underground observations LiDAR	GNSS#14 is located between PC08 and CCUS19. Exceedances of 100 mm in monitoring at GNSS#13 will be indicator of a potential exceedance of performance criteria at CCUS19. Absence of major strata failure event in areas of PC08 within 350 m of CCUS19 will be strong evidence that exceedance of the 100 mm vertical subsidence performance criteria *has not* occurred. End of panel LiDAR survey will provide further detail regarding extent of subsidence observed within CCUS19. Level 2 Trigger: ▪ >50 mm[9] at GNSS#14 relative to pre-Stage 1 data collected by WRPL. Level 3 Trigger: ▪ >100 mm subsidence at GNSS#14 relative to pre-Stage 1 data collected by WRPL. ▪ Validated[10] LiDAR survey results >100 mm subsidence relative to pre-Stage 1 data collected by WRPL.
CCUS19	Stage 1	GNSS#14	GNSS#14 is located between PC07 and PC08 and CCUS19 near the edge of CCUS19. Exceedances of 100 mm in monitoring will be indicator of exceedance of performance criteria at CCUS19. Level 2 Trigger: ▪ >50 mm[9] at GNSS#14 relative to pre-Stage 1 data collected by WRPL. Level 3 Trigger: ▪ >100 mm subsidence at GNSS#14 relative to pre-Stage 1 data collected by WRPL. ▪ Validated[10] LiDAR survey results >100 mm subsidence relative to pre-Stage 1 data collected by WRPL.

Swamp	Relevant stage	Subsidence monitoring	Comments
CCUS20	Stage 1	GNSS#1 GNSS#2 LiDAR Underground observations	GNSS#1 is located above PC08 in an area mined before potential impacts on CCUS290. Higher than expected levels of subsidence at this GNSS location may indicate potential for higher impacts at CCUS20. GNSS#2 is located above PC08 and will provide an indication of potential exceedances of the 100 mm performance criteria at CCUS20. Exceedances of 100 mm in monitoring at GNSS#2 will be indicator of potential exceedance of performance criteria at CCUS20. Absence of major strata failure event in areas of PC08 within 350 m of CCUS20 will be strong evidence that exceedance of the 100 mm vertical subsidence performance criteria has not occurred. End of panel LiDAR survey (particularly along Mt Ousley Road between PC08 and CCUS20) will provide further detail regarding extent of subsidence observed at CCUS20. Level 2 Trigger: ▪ >80 mm subsidence at GNSS#1. Level 3 Trigger: ▪ >100 mm subsidence at GNSS#2 relative to pre-Stage 1 data collected by WRPL. ▪ Strata failure observed underground in PC07 or PC08 workings within 350 m of swamp extent. ▪ Validated[10] LiDAR survey results >100 mm subsidence relative to pre-Stage 1 data collected by WRPL.
CCUS21	Stage 1	LiDAR Underground observations	No plausible mechanism for subsidence in excess of performance criteria to occur as a result of Stage 1 second workings. The absence of any strata failure in areas of PC08 will be evidence that there is no exceedance of the 100 mm vertical subsidence performance criteria at CCUS21. Level 2 Trigger: ▪ Strata failure within PC08. Level 3 Trigger: ▪ Validated[10] LiDAR survey results >100 mm subsidence relative to pre-Stage 1 data collected by WRPL.
CCUS22	Stage 2	GNSS #18, #19 (proxy)	Level 2 Trigger: ▪ >80 mm[9] subsidence at nearest GNSS unit. Level 3 Trigger: ▪ >100 mm subsidence at nearest GNSS unit. ▪ Strata failure observed underground in workings within 350 m of swamp extent.Validated[10] LiDAR survey results indicate >100 mm subsidence relative to pre-mining data collected by WRPL.

Swamp	Relevant stage	Subsidence monitoring	Comments
CCUS23	Stage 1	GNSS#13 LiDAR	No plausible mechanism for subsidence in excess of performance criteria to occur as a result of Stage 1 second workings. Note: GNSS#13 is located between PC21 (the nearest second working panel) and CCUS23 and will also operate as a proxy for potential impacts. Level 2 Trigger: ▪ As per CCUS4 Level 3 Trigger: ▪ As per CCUS4
CCUS24	Stage 2	GNSS #27	Level 2 Trigger: ▪ >80 mm[9] subsidence at adjacent GNSS unit. Level 3 Trigger: ▪ >100 mm subsidence at adjacent GNSS unit. ▪ Strata failure observed underground in workings within 350 m of swamp extent. ▪ Validated[10] LiDAR survey results indicate >100 mm subsidence relative to pre-mining data collected by WRPL.
CRUS1	Stage 1	GNSS#12	GNSS#12 is located between PC21 and CRUS1 near the edge of CRUS1. Exceedances of 100 mm in monitoring will be indicator of exceedance of performance criteria at CRUS1. Level 2 Trigger: ▪ >50 mm[9] at GNSS#12 relative to pre-Stage 1 data collected by WRPL. Level 3 Trigger: ▪ >100 mm subsidence at GNSS#12 relative to pre-Stage 1 data collected by WRPL. ▪ Validated[10] LiDAR survey results >100 mm subsidence relative to pre-Stage 1 data collected by WRPL.

Swamp	Relevant stage	Subsidence monitoring	Comments
CRUS3	Stage 1	GNSS#15, GNSS#14 Underground observations End of panel LiDAR survey.	GNSS#15 is located between PC07 and CRUS3. GNSS#14 is located between PC08 and CRUS3. Exceedances of 100 mm in monitoring at either monitor will be indicator of *potential* exceedance of performance criteria at CRUS3. Absence of major strata failure event in southern end of either panel will be strong evidence that exceedance of the 100 mm vertical subsidence performance criteria *has not* occurred. End of panel LiDAR survey will provide further detail regarding extent of subsidence observed within CRUS3. Level 2 Trigger: ▪ >50 mm[9] subsidence at GNSS#14. ▪ >50 mm[9] subsidence at GNSS#15. Level 3 Trigger: ▪ Strata failure observed underground in PC07 or PC08 workings within 350 m of swamp extent. ▪ Validated[10] LiDAR survey results >100 mm subsidence relative to pre-Stage 1 data collected by WRPL.
CRUS6	Stage 2	GNSS #22	Level 2 Trigger: ▪ >80 mm[9] subsidence at adjacent GNSS unit. Level 3 Trigger: ▪ >100 mm subsidence at adjacent GNSS unit. ▪ Strata failure observed underground in workings within 350 m of swamp extent. ▪ Validated[10] LiDAR survey results indicate >100 mm subsidence relative to pre-mining data collected by WRPL.
CRUS7	Stage 2	GNSS #19	Level 2 Trigger: ▪ >80 mm[9] subsidence at adjacent GNSS unit. Level 3 Trigger: ▪ >100 mm subsidence at adjacent GNSS unit. ▪ Strata failure observed underground in workings within 350 m of swamp extent. ▪ Validated[10] LiDAR survey results indicate >100 mm subsidence relative to pre-mining data collected by WRPL.

It is noted that an exceedance of the 100 mm Coastal Upland Swamp subsidence performance measure is not an indication that actual harm has occurred to a Coastal Upland Swamp. An exceedance of this performance measure will trigger a review of swamp groundwater and biodiversity monitoring to determine where more targeted monitoring is required to assess whether the higher than predicted levels of subsidence are having an adverse impact on the swamp. This review processes is as set out as part of the TARP processes.

Exceedances of the 100 mm subsidence performance criteria at a Coastal Upland Swamp will trigger adaptive management measures, including a requirement to halt underground mining operations in the area where the exceedance has been observed. The exceedance will also

trigger a review of both underground mining conditions and subsidence predictions to identify the potential cause of the exceedance and adaptive management measures to prevent a reoccurrence.

4.2 Groundwater monitoring

4.2.1 Stage 1 (a and b)

Monitoring of groundwater levels within the Coastal Upland Swamps of the Stage 1 EP area has been undertaken since 2012 by WRPL. Monitoring of soil moisture has been conducted in the Stage 1 EP area at swamps CCUS4, CCUS5, CCUS10 and CRUS1. Monitoring water levels in the shallow sandstone open standpipe piezometers SP1, SP2, paired with piezometers in Coastal Upland Swamps, is also conducted in conjunction with soil moisture monitoring at swamps CCUS1, CCUS4, CCUS5, CCUS6, CCUS10, CCUS20 and CRUS1. These methods are currently used to assess surface water/shallow groundwater interactions and to monitor water depth in surficial lithologies in the Cataract Creek and Cataract River catchments (Table 8).

Additional groundwater monitoring sites (standpipe piezometers and soil moisture probes) were installed at swamps CCUS1, CCUS6, CCUS14, CCUS20, CCUS21, CRUS2, CRUS3, CRUS6 and BCUS11 in July 2021. While no new impacts to these swamps are predicted due to the approved mining method and design, second workings (non-conforming pillars) will not be undertaken within 350 m of these swamps until at least 12 months monitoring data is available for the relevant site. Locations of these monitoring points are provided as Table 8 and Figure 11.

4.2.2 Stage 2

Monitoring of groundwater levels within the Coastal Upland Swamps of the Stage 2 EP area has been undertaken since 2012 by WRPL. Monitoring of soil moisture has been conducted in RVE UEP at swamps BCUS4, CCUS4, CCUS5, CCUS10, CCUS12 and CRUS1. Monitoring water levels in the shallow sandstone open standpipe piezometers SP1, SP2, paired with piezometers in Coastal Upland Swamps, is also conducted in conjunction with soil moisture monitoring at swamps BCUS4, CCUS4, CCUS5, CCUS10 and CCUS12. These methods are currently used to assess surface water/shallow groundwater interactions and to monitor water depth in surficial lithologies in the Cataract Creek and Cataract River catchments (Table 8).

Additional groundwater monitoring sites (standpipe piezometers and soil moisture probes) were installed in July 2021. Additional soil moisture probes will also be installed in 2022. The finalised locations will be dependent on accessibility to the sites to minimise disturbance and ensure safety of field staff as well as ground-truthing of swamp extents. While no new impacts to these swamps are predicted due to the approved mining method and design, second workings (non-conforming pillars) will not be undertaken within 350 m of these swamps until at least 12 months monitoring data is available for the relevant site. Locations of these monitoring points are provided as Table 8 and Figure 11.

4.2.3 Additional sites

Soil moisture monitoring sites were established at CCUS14 and CRUS2 in July 2021. These swamps are not within the Stage 1 or Stage 2 EP area but are within the approved EP area.

4.2.4 Monitoring methodology

The paired swamp piezometers, shallow sandstone piezometers, as well as gully flow and/or pool level monitoring (where installed) will be used to assess potential changes to the swamp water budget (i.e. rainfall, soil moisture, interaction with groundwater and outflow). As outlined within Office of Water Science (2020) fact sheet on *Environmental water tracers in environmental impact assessments for coal seam gas and large coal mining developments*, environmental water tracers include physiochemical properties (i.e. EC, temperature), major ions as well as environmental isotopes and radioisotopes. The monitoring program includes water quality analysis to help identify changes in recharge sources using physio-chemical properties and major ions for routine compliance monitoring, as well as targeted investigations using isotopes if determined necessary as part of the investigation.

Where impacts to ecological condition through other monitoring methods are identified, this information can be used to assess any water level reductions in the perched and ephemeral aquifers (hydraulically isolated from the regional Hawkesbury Sandstone) as a result of mining. The piezometers have been installed with pressure transducers to monitor water depth at a minimum of every six hours and will be downloaded every two months pre-mining and then monthly during the period of mining. The data will enable correlation between Coastal Upland Swamps or shallow sandstone water levels and any direct leakage.

Where long periods of base data in swamps is not available, the monitoring undertaken at other impact sites which are yet to be mined under can be used to calibrate the short period of pre-impact data at the new sites and enable changes to be identified. Trend changes in swamp water levels can also be compared to sites in other swamps being monitored to detect changes between swamps. In this regard, swamps which are yet to be directly undermined can be used as reference swamps for the swamps which are mined under. Additionally, swamps which have been mined under but which show no adverse effects from this mining can be used as part of the reference site network where there is confidence that potential impacts are unlikely to occur post mining[11]. Swamps which are yet to be mined under, or which have been considered appropriate to be used for reference sites following mining under, are referred to as being *non-impact sites* for the period when these classifications apply. It is noted that previous mining in the Bulli or Balgownie seams below these swamps do not disqualify them from being considered non-impact sites for the purposes of assessing potential impacts associated with the Stage 1 second workings, Stage 2 second workings or future UEP stages. Observations from swamps being mined under (or recently mined under) which are statistically different to other, non- or less-impacted swamps will trigger further investigation of potential causes as set out in Section 7.

During the logger downloads, the field pH and EC (electrical conductivity) will be measured with calibrated hand-held meters, whilst regular sampling will be conducted for laboratory analysis where water samples are available. Monitoring will be conducted for the following parameters:

- Physio-chemical water tracer parameters, including field pH, EC, DO, ORP and temperature.
- Total dissolved solids and total suspended solids.

[11] Where the use of data from swamps which have been mined under as part of the UEP is considered as a reference site, statistical analysis of this data will be required to confirm the appropriateness of the use of this data. Analysis against other non-impact sites will be required as part of this process.

- Major ions (Na / Ca / Na / K / SO4 / Mg / Cl / F).
- Total alkalinity.
- Dissolved organic carbon.
- Total / filterable Fe, Mn, Al.
- Total / filterable Al, P, Ni, As, Li, Ba, Sr, Cu, Pb, Zn, Sb, Fe, Mn, Mo, Li, Ba.
- Total nitrogen and total phosphorous.

All samples will be collected in appropriately cleaned and prepared equipment, stored in cleaned and rinsed sample containers, then transported and analysed according to ANZECC (2000) standards. Samples for metals require 0.45 µm filtering and nitric acid preservation to less than pH 2. The location of relevant surface water monitoring sites is shown in Figure 11. Further details of surface water monitoring is as provided as Table 8 and Table 15.

The operations use bord and pillar mine method to minimise the potential for subsidence impacts. Therefore, the lead indicator for impacts beyond those predicted relates to subsidence monitoring. While not a lead indicator, groundwater monitoring provides supporting data and information on changes to the groundwater and swamp water regime in response to natural variability and mine activities. In conjunction with the subsidence monitoring and ecological monitoring, the groundwater monitoring program will enable analysis of the cause of any potential changes and learnings to inform adaptive management.

The role for each of the groundwater monitoring techniques is summarised below:

- Shallow Swamp Piezometer: Existing piezometers indicate the swamps are often unsaturated, and the occurrence of groundwater varies between and within the swamp clusters. Some swamps, particularly those in the middle of a large swamp cluster, show a good response to rainfall events. Monitoring will be conducted at all monitoring points, and site-specific water level triggers assigned for the more saturated monitoring locations to enable analysis of any changes in conditions during mining, to inform adaptive management practices.
- Moisture Probes: Assist in investigation of any observed changes to vegetation or water levels. Not used as triggers due to the variability within and between swamp clusters, but potential for use as a trigger in subsequent EPs if able to be used to detect trend changes relative to other sites.
- Water Quality Data – Swamp Piezometers: Assist in identifying any changes in groundwater quality within the swamp which may indicate an impact. This includes changes in environmental water tracers, including physiochemical properties and major ions that may indicate a change in recharge source. Additional sampling of environmental water isotopes can also be undertaken to inform targeted field investigations if considered warranted.
- Paired Bores: Refers to bores near swamp monitoring sites that intersect the shallow weathered and deeper Triassic age sandstone units. Data from these bores and vibrating wire piezometers (VWPs) is used to assess potential changes in interactions between swamp aquifers and the deeper water table within underlying sandstone aquifer. Triggers have been assigned to the groundwater bores as presented in the Groundwater Management Plan (RVC EC PLN 006), which includes water level and vertical head profile triggers.
- Water Quality Data – Shallow sandstone (paired) bores: Routine water quality analysis is undertaken within the shallow sandstone bores, including two monthly sampling of

physiochemical properties and major ions. In conjunction with the swamp water quality data, this assists with identifying any changes in recharge sources/groundwater mixing. Additional sampling of environmental water isotopes can also be undertaken to inform targeted field investigations if considered warranted.

Data collected in accordance with this Plan will be reviewed by a suitably qualified person and reported quarterly to support early detection of trigger exceedances and potential impacts related to mine activities. The review includes details on any reporting requirements in accordance with the TARP. If changes in swamp water levels and water quality are observed for the specified triggers at the trigger sites, further investigation into the cause will be undertaken. The triggers for such investigations are detailed in Section 7. The subsidence monitoring program, ecological monitoring program and monitoring of water levels, water quality and moisture within swamps will inform these investigations. This can also be supported through the use of targeted isotope tracer analysis, where appropriate, to assess the potential for any leakage from a swamp or humic soils to the underlying sandstone, and/or assess direct rain recharge to adjacent sandstone followed by lateral groundwater flow to beneath a swamp or shallow soils.

Swamp specific water balances can be developed based on the data collected if these are considered to be of benefit to the investigation of potential causes of any observed changes in swamp groundwater regimes.

Table 15 Water monitoring requirements and locations

Monitoring requirement	Monitoring location	Timing/frequency			Parameters	Purpose
		Prior to mining	During mining[12]	Post mining		
Monitoring of swamp soil moisture and shallow water	Swamp sites with soil moisture probes and piezometers: Moisture probes and piezometers: ▪ PB4 (A/B/D) near swamp BCUS4 ▪ PCc10 (A/B) at CCUS10 ▪ PCc12 (A/B) at CCUS12 ▪ PCc4 (B/C/D) at CCUS4 ▪ PCc5 (A/B/D) at CCUS5 ▪ PCr1 (A/B/C) at CRUS1 ▪ PCc1 (A/C) at CCUS1 ▪ PCc14A at CCUS14 ▪ PCc20 at CCUS20 ▪ PCc6B at CCUS6 Piezometers only: ▪ PB4C near swamp BCUS4 ▪ PCc2 at CCUS2 ▪ PCc3 at CCUS3 ▪ PCc4A at CCUS4 ▪ PCc5C at CCUS5 ▪ PCc6 near CCUS6 ▪ PCr1D at CRUS1	Daily – water level monitoring with logger set at 6 hourly interval and downloaded and dipped once every two months. 2 monthly – field analysis Quarterly – discrete analysis Annual – full metals suite analysis	Daily – water level monitoring with logger set at 6 hourly interval and downloaded and dipped monthly during mining. 2 monthly – field analysis Quarterly – discrete analysis Annual – full metals suite analysis	Daily – water level monitoring with logger set at minimum 12 hourly interval and downloaded and dipped for an agreed period (minimum 1 year) after the completion of the underground mining 2 monthly – field analysis Quarterly – discrete analysis	Field analysis[13] Discrete[14]	Verify predicted swamp water level/moisture response and water quality changes to existing operations and inform future model iterations and updates. Verify predicted swamp water level/moisture response to mine closure.

Monitoring requirement	Monitoring location	Timing/frequency			Parameters	Purpose
		Prior to mining	During mining[12]	Post mining		
	Shallow piezometers near swamp locations, including: ▪ SP1 near CCUS6 ▪ SP2 near CCUS3 and CCUS4	Daily – water level monitoring with logger set at 6 hourly interval and downloaded and dipped 2 monthly (once every two months) 2 monthly – field analysis Quarterly – discrete analysis	Daily – water level monitoring with logger set at 6 hourly interval and downloaded and dipped monthly during mining 2 monthly – field analysis Quarterly – discrete analysis	Daily – water level monitoring with logger set at minimum 12 hourly interval and downloaded and dipped for an agreed period (minimum 1 year) after completion of the underground mining 2 monthly – field analysis Quarterly – discrete analysis	Field analysis[11] Discrete[12]	Identify if current dry conditions may change with the cessation of longwall mining and recovery, and changes in climatic conditions.
	Installation of additional swamp soil moisture probes and water piezometers at identified swamp locations: ▪ PCc1 A/BC at CCUS1 ▪ PCc6 B at CCUS6	Daily – water level monitoring with logger set at 6 hourly interval and downloaded and dipped	Daily – water level monitoring with logger set at 6 hourly interval and downloaded and dipped monthly in	Daily – water level monitoring with logger set at minimum 12 hourly interval and downloaded and dipped for an agreed	Field analysis[11] Discrete[12]	Verify predicted swamp water level/moisture response to existing operations and inform

[12] During mining means the period of approximately three months prior to the individual swamp being mined under and during which mining is occurring directly below the swamp or within 350 metres (horizontal distance) of the swamp.

[13] Field analysis: includes field analysis of pH, EC, DO, ORP and temp

[14] Discrete: includes field analysis of pH, EC, DO, ORP and temp. As well as laboratory analysis of TDS, TSS, major ions (Na, K, Ca, Mg, Cl, SO4), F, HCO_3, $CaCO_3$, NO_3, Total N, Total P, Total alkalinity, filtered DOC and dissolved metals Al, P, Cu, Pb, Zn, Ni, Sb, Fe, Mn, Mo As, Li and Ba.

Monitoring requirement	Monitoring location	Timing/frequency			Parameters	Purpose
		Prior to mining	During mining[12]	Post mining		
	▪ PCc14 at CCUS14 ▪ PCc20 at CCUS20 ▪ PCc21 at CCUS21 ▪ PCr2 at CRUS2 ▪ PCr6 near CRUS6	2 monthly – field analysis of piezometers Quarterly – discrete analysis of piezometers	swamps being actively undermined. 2 monthly – field analysis of piezometers Quarterly – discrete analysis of piezometers Annual – full metals suite analysis	period (minimum 1 year) after the swamp is undermined. 2 monthly – field analysis of piezometers Annual – discrete analysis of piezometers	Full metals suite[15]	future model iterations and updates. Verify predicted swamp water level/moisture response to mine closure

[15] Full metals suite: includes field analysis of pH, EC, DO, ORP and temp. As well as discrete laboratory analysis suite plus laboratory analysis of additional dissolved metals B, Cd, Co, Hg, Se and Ag.

Monitoring requirement	Monitoring location	Timing/frequency			Parameters	Purpose
		Prior to mining	During mining[12]	Post mining		
Monitoring of groundwater levels and head gradients near swamps	Swamp monitoring paired open standpipes and VWPs at existing locations: ▪ NRE1A_R and NREA near CCUS2 ▪ RV16 within CCUS1 ▪ RV20 near CCUS6 ▪ RV19 near CRUS1 ▪ RV21 near BCUS4	Daily – water level monitoring with logger set at 6 hourly interval and downloaded and dipped (for open standpipes) 2 monthly – field analysis for open standpipes Quarterly – discrete analysis for open standpipes Annual – full metals suite analysis	Daily – water level monitoring with logger set at 6 hourly interval and downloaded and dipped (for open standpipes) monthly in areas being actively undermined 2 monthly – field analysis for open standpipes Quarterly – discrete analysis for open standpipes Annual – full metals suite analysis	Daily – water level monitoring with logger set at 12 hourly interval and downloaded and dipped (for open standpipes) two monthly for an agreed period (minimum 1 year) after the area is undermined Quarterly – field analysis for open standpipes for an agreed period (minimum 1 year) after mining is completed Annual – discrete analysis for open standpipes for an agreed period (minimum 1 year) after mining is completed	Field analysis[11] Discrete[12] Full metals suite[13]	Verify predicted groundwater level and swamp water level/moisture response to existing operations and inform future model iterations and updates. Assess head gradients and recharge/discharge processes in relation to the swamps. Verify predicted groundwater level and swamp water level/moisture response to mine closure. Assess head gradient changes and recharge/discharge processes in relation to the swamps post closure
	Installation of additional paired monitoring points near swamps: ▪ RV39 near CCUS6 ▪ RV40 near CRUS2	Daily – water level monitoring with logger set at 6 hourly interval and downloaded	Daily – water level monitoring with logger set at 6 hourly interval and downloaded and	Daily – water level monitoring with logger set at 6 hourly interval and downloaded and dipped (for open	Field analysis[11] Discrete[12] Full metals suite[13]	Verify predicted groundwater level and swamp water level/moisture response to existing

Monitoring requirement	Monitoring location	Timing/frequency			Parameters	Purpose
		Prior to mining	During mining[12]	Post mining		
	▪ RV41 near CCUS20 ▪ RV42 near CCUS1 ▪ RV44 near CRUS3 ▪ RV46 near CCUS14	and dipped (for open standpipes) two monthly 2 monthly – field analysis for open standpipes 2 monthly – discrete analysis for open standpipes within first 12 months of installation, reducing to quarterly frequency Annual – full metals suite analysis	dipped (for open standpipes) monthly in areas being actively undermined 2 monthly – field analysis for open standpipes 2 monthly – discrete analysis for open standpipes within first 12 months of installation, reducing to quarterly frequency Annual – full metals suite analysis	standpipes) two monthly for an agreed period (minimum 1 year after the area is undermined) 2 monthly – field analysis for open standpipes for an agreed period (minimum 1 year) after mining is completed Annual – discrete analysis for open standpipes for an agreed period (minimum 1 year) after mining is completed		operations and inform future model iterations and updates. Assess head gradients and recharge/discharge processes in relation to the swamps. Verify predicted groundwater level and swamp water level/moisture response to mine closure. Assess head gradient changes and recharge/discharge processes in relation to the swamps post closure

4.3 Coastal Upland Swamp ecological monitoring

The Coastal Upland Swamps vegetation monitoring approach has been developed to address four categories of swamp. These categories were determined through a risk assessment process completed by WRPL, Umwelt and Biosis. This risk assessment considered the potential impact pathway, the level of existing cumulative tensile strain under swamps, location in reference to first workings and swamp size (Appendix C). The flora monitoring design aligns with these swamp categories as part of the risk-based approach, with those swamps considered to be most at risk, from any impacts, subject to the greatest amount of monitoring. The swamp categories are detailed in Table 11.

The method and frequency of monitoring defined for each category of impact swamp is summarised in Table 16 and Figure 12. The key role for each of the vegetation monitoring techniques is summarised in Table 17. The field monitoring methods and data analysis procedures are detailed in Sections 4.3.2 to 4.5.

Giant Dragonfly monitoring will continue in those swamps identified as providing known breeding habitat as part of previous monitoring (Table 18) and considered to be potentially at risk of impacts from the UEP. The full Giant Dragonfly monitoring methodology is detailed in Section 4.5.

Eight control sites have been previously monitored as part of the swamp ecological monitoring program include; ACUS, BCUS12, BCUS13, S22, S33, S15A, WACUS, and WCUS (Figure 13). These sites will continue to be monitored as paired controls for the ongoing vegetation monitoring, under the same methodology and timing as category 1 swamps. Additional control sites (non-impact) will be included in the program as paired controls for sites that have not be part of the previous ecological monitoring program. These additional control sites will be defined during the updated baseline LiDAR assessment and field inspection process to ensure the controls are representative of any additional impact monitoring sites.

Data will be collected at the control sites in the same manner and for the same duration as impact sites. Control sites will not have been mined beneath during the monitoring period being investigated. These sites will provide data for comparison against data from impact sites. The use of control sites allows us to distinguish between impacts associated with the project (observed only at impact sites) and those associated with broader environmental and anthropomorphic variables (observed at both control and impact sites). Existing open standpipe NRE1C will be used to characterise shallow groundwater conditions near BCUS13. However, it is noted that the Bulli Sill Complex is mapped in this area, which may influence groundwater trends.

Additionally, swamps which have been mined under but which show no adverse effects from this mining can be used as part of the reference site network where there is confidence that potential impacts are unlikely to occur post mining[16]. Swamps which are yet to be mined under, or which have been considered appropriate to be used for reference sites following mining under, are referred to as being *non-impact sites* for the period when these classifications apply.

[16] Where the use of data from swamps which have been mined under as part of the UEP is considered as a reference site, statistical analysis of this data will be required to confirm the appropriateness of the use of this data. Analysis against other non-impact sites will be required as part of this process.

Table 16 Coastal Upland Swamp ecological monitoring requirements

Category	Rationale	Relevant swamps	Monitoring[17]	Timing and frequency
1A	▪ Swamps with >2.0 ha within 350 m of the UEP. ▪ Partly or directly mined beneath by Wongawilli Seam bord and pillar 'second workings' or would be within subsidence zone for a conceptual Wongawilli Seam Pillar Failure scenario (approx. 50 m from panels). ▪ Pre-existing cumulative tensile strains from Bulli and Balgownie seam workings of >2 mm/m and <10 mm/m.	Stage 1 ▪ CCUS5 ▪ CRUS1 ▪ CRUS3 Stage 2 ▪ BCUS4 ▪ CCUS5	Pre-mining ▪ Swamp extent review and update. ▪ Baseline condition assessment. ▪ Detailed field assessment. During Mining ▪ Detailed field assessment. ▪ Further monitoring only required if other TARP levels exceeding negligible impacts are triggered e.g. subsidence monitoring. Post-mining ▪ Detailed field assessment. ▪ Further monitoring only required if other TARP levels exceeding negligible impacts	Pre-mining ▪ Swamp extent review and update prior to any 'second workings' within 50 m of the swamp. ▪ Baseline condition assessment prior to any 'second workings' within 50 m of the swamp. ▪ A minimum of two spring and two autumn detailed field assessments to be undertaken prior to any 'second workings' within 50 m of the swamp. During Mining ▪ Detailed field assessments undertaken in spring and autumn while 'second workings' are within 50 m of the swamp. Post-mining ▪ A minimum of one spring and one autumn detailed field assessment to be undertaken once 'second workings' have progressed more than 50 m from the swamp.

[17] Refer to Table 17 for a detailed description of the monitoring methodology.

Category	Rationale	Relevant swamps	Monitoring[17]	Timing and frequency
	▪ Swamps any size. ▪ Partly or directly mined beneath by Wongawilli Seam bord and pillar 'second workings' or would be within subsidence zone for a conceptual Wongawilli Seam Pillar Failure scenario (approx. 50 m from panels). ▪ Pre-existing cumulative tensile strains from Bulli and Balgownie seam workings of >10 mm/m.	Stage 1 ▪ CCUS1 ▪ CCUS6 ▪ CCUS20	are triggered e.g. subsidence monitoring.	Pre-mining ▪ Swamp extent review and update prior to any 'second workings' within 350 m of the swamp. ▪ Baseline condition assessment prior to any 'second workings' within 350 m of the swamp. ▪ A minimum of two spring and two autumn detailed field assessments to be undertaken prior to any 'second workings' within 350 m of the swamp. During Mining ▪ Detailed field assessments undertaken in spring and autumn while 'second workings' are within 350 m of the swamp. Post-mining ▪ A minimum of one spring and one autumn detailed field assessment to be undertaken once 'second workings' have progressed further than 350 m from the swamp.

Category	Rationale	Relevant swamps	Monitoring[17]	Timing and frequency
1B	▪ Swamps any size. ▪ Not directly mined under Wongawilli Seam bord and pillar 'second workings' or within subsidence zone for conceptual Wongawilli Seam Pillar Failure scenario (approx. 50 m from panels). ▪ Swamps located over areas of increased predicted drawdown >1m in the underlying sandstone aquifer.	Stage 1 ▪ CCUS3 ▪ CCUS21	Pre-mining ▪ Swamp extent review and update. ▪ Baseline condition assessment. ▪ Detailed field assessment. During Mining ▪ Detailed field assessment. ▪ Further monitoring required if other TARP levels exceeding negligible impacts are triggered e.g. subsidence monitoring. Post-mining ▪ Detailed field assessment. ▪ Further monitoring required if other TARP levels exceeding negligible impacts are triggered e.g. subsidence monitoring.	Pre-mining ▪ Swamp extent review and update before any 'second workings' within 350 m of the swamp. ▪ Baseline condition assessment before any 'second workings' within 350 m of the swamp. ▪ A minimum of one spring and one autumn detailed field assessment before any 'second workings' within 350 m of the swamp. During Mining ▪ Detailed field assessments undertaken in spring and autumn while 'second workings' are within 350 m of the swamp. Post-mining ▪ A minimum of one spring and one autumn detailed field assessment for swamps that show negligible impacts once 'second workings have progressed more than 350 m from the swamp.

Category	Rationale	Relevant swamps	Monitoring[17]	Timing and frequency
2	▪ Swamps with >2.0 ha within 350 m of the UEP. ▪ Partly or directly mined beneath by Wongawilli Seam bord and pillar 'second workings' or would be within subsidence zone for a conceptual Wongawilli Seam Pillar Failure scenario (approx. 50 m from panels). ▪ Pre-existing cumulative tensile strains from Bulli and Balgownie seam workings of <2 mm/m.	No applicable swamps	Pre-mining ▪ Swamp extent review and update. ▪ Baseline condition assessment. ▪ Detailed field assessment. During Mining ▪ Detailed field assessment. Further monitoring only required if other TARP levels exceeding negligible impacts are triggered e.g. subsidence monitoring. Post-mining ▪ Detailed field assessment. ▪ Further monitoring only required if other TARP levels exceeding negligible impacts are triggered e.g. subsidence monitoring.	Pre-mining ▪ Swamp extent review and update before any 'second workings' within 50 m of the swamp. ▪ Baseline condition assessment before any 'second workings' within 50 m of the swamp. ▪ A minimum of one spring and one autumn detailed field assessment before any 'second workings' within 50 m of the swamp. During Mining ▪ Detailed field assessments undertaken in spring and autumn while 'second workings' are within 50 m of the swamp. Post-mining ▪ A minimum of one spring and one autumn detailed field assessment for swamps that show negligible impacts once 'second workings have progressed more than 50 m from the swamp.
	▪ Swamps with <2.0 ha within 350 m of the UEP. ▪ Partly or directly mined beneath by Wongawilli Seam bord and pillar 'second workings' or would be within subsidence zone for a conceptual Wongawilli Seam Pillar Failure scenario (approx. 50 m from panels). ▪ Pre-existing cumulative tensile strains from Bulli and Balgownie seam workings between 5 mm/m and 10 mm/m.	Stage 1 ▪ CCUS2		

Category	Rationale	Relevant swamps	Monitoring[17]	Timing and frequency
3	▪ Swamps with <2.0 ha within 350 m of the UEP. ▪ Partly or directly mined beneath by Wongawilli Seam bord and pillar 'second workings' or would be within subsidence zone for conceptual Wongawilli Seam Pillar Failure scenario (approx. 50 m from panels). ▪ Pre-existing cumulative tensile strains from Bulli and Balgownie seam workings of <5 mm/m.	Stage 1 ▪ CCUS10 ▪ CCUS15 ▪ CCUS17 ▪ CCUS18 ▪ CCUS19 ▪ CCUS23 Stage 2 ▪ BCUS6 ▪ BCUS7 ▪ BCUS11 ▪ BCUS14 ▪ CCUS9 ▪ CCUS10 ▪ CCUS11 ▪ CCUS12 ▪ CCUS13 ▪ CCUS22 ▪ CCUS24 ▪ CRUS6 ▪ CRUS7	Pre-mining ▪ Swamp extent review and update. ▪ Baseline condition assessment. ▪ Detailed field assessment. During Mining ▪ Basic field assessment. ▪ Further monitoring only required if other TARP levels exceeding negligible impacts are triggered e.g. subsidence monitoring. Post-mining ▪ Basic field assessment. ▪ Further monitoring only required if other TARP levels exceeding negligible impacts are triggered e.g. subsidence monitoring.	Pre-mining ▪ Swamp extent review and update prior to any 'second workings' within 50 m of the swamp. ▪ Baseline condition assessment prior to any 'second workings' within 50 m of the swamp. ▪ A minimum of one spring and one autumn detailed field assessments to be undertaken prior to any 'second workings' within 50 m of the swamp. During Mining ▪ Basic field assessments to be undertaken while 'second workings' are within 50 m of the swamp. Post-mining ▪ A minimum of one spring and autumn survey post mining for swamps that show negligible impacts, to be undertaken once 'second workings' have progressed further than 50 m from the swamp.

Category	Rationale	Relevant swamps	Monitoring[17]	Timing and frequency
	▪ Swamps any size. ▪ Not directly mined under by Wongawilli Seam bord and pillar 'second workings' or within subsidence zone for conceptual Wongawilli Seam Pillar Failure scenario (approx. 50 m from panels). ▪ Located within 350 m of Wongawilli Seam bord and pillar 'second workings'. ▪ Pre-existing cumulative tensile strains from Bulli and Balgownie seam workings of >2 mm/m.	Stage 1 ▪ CCUS4 Stage 2 ▪ BCUS2 ▪ BCUS3 ▪ BCUS5 ▪ CCUS4 ▪ CCUS16		Pre-mining ▪ Swamp extent review and update prior to any 'second workings' within 350 m of the swamp. ▪ Baseline condition assessment prior to any 'second workings' within 350 m of the swamp. ▪ A minimum of one spring and one autumn detailed field assessments to be undertaken prior to any 'second workings' within 350 m of the swamp. During Mining ▪ Basic field assessments to be undertaken while 'second workings' are within 350 m of the swamp. Post-mining ▪ A minimum of one spring and autumn survey post mining for swamps that show negligible impacts, to be undertaken once 'second workings' have progressed further than 350 m from the swamp.

Category	Rationale	Relevant swamps	Monitoring[17]	Timing and frequency
4	▪ Swamps any size. ▪ Not directly mined under by Wongawilli Seam bord and pillar 'second workings' or within subsidence zone for conceptual Wongawilli Seam Pillar Failure scenario (approx. 50 m from panels). ▪ Located within 350 m of Wongawilli Seam bord and pillar 'second workings'. ▪ Pre-existing cumulative tensile strains from Bulli and Balgownie seam workings of <2 mm/m.	Stage 2 ▪ BCUS8 ▪ BCUS9 ▪ BCUS15 ▪ BCUS16	Pre-mining ▪ Swamp extent review and update. ▪ Baseline condition assessment. During Mining ▪ Further monitoring only required if other TARP levels exceeding negligible impacts are triggered e.g. subsidence monitoring. Post-mining ▪ Further monitoring only required if other TARP levels exceeding negligible impacts are triggered e.g. subsidence monitoring.	Pre-mining ▪ Swamp extent review and update prior to any 'second workings' occurring within 350 m of the swamp. ▪ Baseline condition assessment prior to any 'second workings' occurring within 350 m of the swamp.
	▪ Swamps are not within 350 m of Wongawilli Seam bord and pillar 'second workings'.	▪ CCUS7 ▪ CCUS8		

Category	Rationale	Relevant swamps	Monitoring[17]	Timing and frequency
Control	▪ Swamps are not located within 350 m of active or completed Wongawilli Seam bord and pillar 'second workings'. ▪ Swamps represent suitable comparison swamps for impact swamps.	▪ ACUS ▪ BCUS12 ▪ BCUS13 ▪ S15A(1) ▪ S22 ▪ S33 ▪ WACUS ▪ WCUS ▪ CRUS2[18]	Pre-mining ▪ Detailed field assessment. During Mining ▪ Detailed field assessment. ▪ Further monitoring only required if other TARP levels exceeding negligible impacts are triggered at impact sites e.g. subsidence monitoring. Post-mining ▪ Detailed field assessment. ▪ Further monitoring only required if other TARP levels exceeding negligible impacts are triggered at impact sites e.g. subsidence monitoring.	Pre-mining ▪ A minimum of one spring and one autumn detailed field assessment coinciding with monitoring period for impact swamp prior to any 'second workings' within relevant distances (as defined above) from impact swamps. During Mining ▪ Spring and autumn detailed field assessments during 'second workings' within relevant distances (as defined above) of impact swamps. Post-mining ▪ A minimum of one spring and one autumn detailed field assessment post mining for swamps that show negligible impacts.

[18] Available as a reference swamp for bord and pillar second workings only up until mining is within 350 m of swamp extent. If used as a reference swamp, monitoring would be as per Category 2 swamps.

Table 17 Coastal Upland Swamp ecological monitoring methodology

Monitoring component	Detailed description
Swamp extent review and update	▪ LiDAR: Baseline analysis of swamp extents was undertaken using LiDAR analyses prior to Underground Expansion Project extraction in 2021, for all swamps in the Extraction Plan area. Previous LiDAR analysis has been undertaken (Biosis 2012) and it is anticipated that swamp extents are likely to have altered due to natural successional processes since 2012. Refer to Section 3.2.1. ▪ Physical inspection and mapping: Provide updated mapping via ground-truthing of mapped LiDAR swamp extents, including walking the perimeter of swamps and recording extents via hand-held tablets and/or GPS. Refer to Section 3.2.1, in particular Section 3.2.1.3.
Baseline condition assessment	▪ BAM plots (vegetation community only): Provide baseline for any offsetting requirements in unlikely event of observed impacts attributable to mining. For small swamps without permanent transects, BAM sites also provide quantitative data to assess vegetation changes that may be observed in photo-points (e.g. dieback in specific plants, changes in extent of woody vegetation species). ▪ Condition assessment: Use of BAM plots to determine conditions as per BioNet vegetation community benchmarks.
Detailed field assessment	▪ Vegetation transect monitoring: Quantitative data for statistical analysis of changes in Total Species Richness and Species Composition. Three linear 15 m transects containing 30 quadrats measuring 0.5 m x 0.5 m within each swamp. The presence of all plant species in each quadrat is recorded. Monitoring surveys are conducted once in spring and once in autumn. Refer to Section 4.3.3. ▪ Observational monitoring via photo points: Enable visual assessment of vegetation condition to be assessed and detect any senescence/dieback. Three photo-points are established within swamps. Photos are taken to the north, east, south and west at these points. Refer to Section 4.3.3.3.
Basic field assessment	▪ Observational monitoring via photo points: Enable visual assessment of vegetation condition to be assessed and to provide qualitative control for comparison against impact sites in the case of control sites. Refer to Section 4.3.3.3.

Table 18 Giant Dragonfly monitoring sites

Impact monitoring sites	Control monitoring sites	Timing	Methodology
Stage 1 ▪ CCUS1 ▪ CCUS4 ▪ CCUS5 ▪ CRUS1 Stage 2 ▪ BCUS4 ▪ CCUS10	▪ BCUS12 ▪ BCUS13 ▪ WACUS ▪ WCUS	Pre-mining ▪ A minimum of one year prior to any 'second workings' occurring within 350 m of the swamp. During Mining ▪ Surveys to be undertaken while 'second workings' are within 350 m of the swamp. Post-mining ▪ A minimum of one year post mining for swamps that show negligible impacts.	Giant Dragonfly exuviae monitoring: Monitoring is conducted during the breeding season (summer) by searching all ground layer, sedgeland and shrub vegetation within suitable Giant Dragonfly habitat, along a linear transect of fixed length at each site. Each site is surveyed twice in summer.

BCUS17
BCUS18
BCUS16
BCUS15
BCUS8
BCUS10
BCUS9
CRUS8
CRUS9
CRUS7
BCUS7
BCUS6
BCUS5
CCUS22
CCUS13
BCUS14
BCUS3
CRUS6
BCUS4
BCUS2
CCUS16
CCUS12
BCUS11
CCUS24
CCUS11
BCUS1
CCUS10
CCUS9
CCUS7
CCUS8
CCUS5
CCUS4
CCUS3
CCUS21
CCUS23
CCUS6
CCUS20
CRUS1
CCUS15
CCUS18
CCUS1
CCUS17
CCUS19
CRUS2
CRUS3
CCUS2
CCUS14
CRUS4
CRUS5
Firetrail No 7c
Firetrail No 7m
Firetrail No 7d
Firetrail No 8c
Cataract River
Bellambi Creek
Cataract Creek
Cataract
Rocky Creek
Angel Creek
Picton Road
Mount Ousley Road
Princes Highway
Rixon Pass Road
Bulli
Woonona
Collins Creek
Russell Vale
Corrimal

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Legend

- RV East old longwall workings
- Pillars
- Past workings

Mine plan

- Stage 1
- Stage 2
- Future stages

EP areas

- Stage 1
- Stage 2

Flora monitoring

- Photo Point
- Photo Point - proposed
- Transect End
- Transect End - proposed
- Transect Start
- Transect Start - proposed

Giant Dragonfly monitoring

- Transect End
- Transect Start

Swamp survey status

- 1A
- 1B
- 2
- 3
- 4

Vegetation Sub-Communities

- MU42,Upland Swamps: Banksia Thicket
- MU43,Upland Swamps: Tea-Tree Thicket
- MU44,Upland Swamps: Sedgeland-Heath Complex
- MU44a,Upland Swamps: Sedgeland-Heath Complex (Sedgeland)
- MU44b,Upland Swamps: Sedgeland-Heath Complex (Restioid Heath)
- MU44c,Upland Swamps: Sedgeland-Heath Complex (Cyperoid Heath)

Figure 12a Coastal Upland Swamp ecological monitoring

0 100 200 300 400 500

Metres

Scale: 1:15,000 @ A3

Coordinate System: GDA 1994 MGA Zone 56

N

biosis

Matter: 36747,
Date: 10 June 2022 ,
Prepared for: CBH, Prepared by: AM, Last edited by: amackegard
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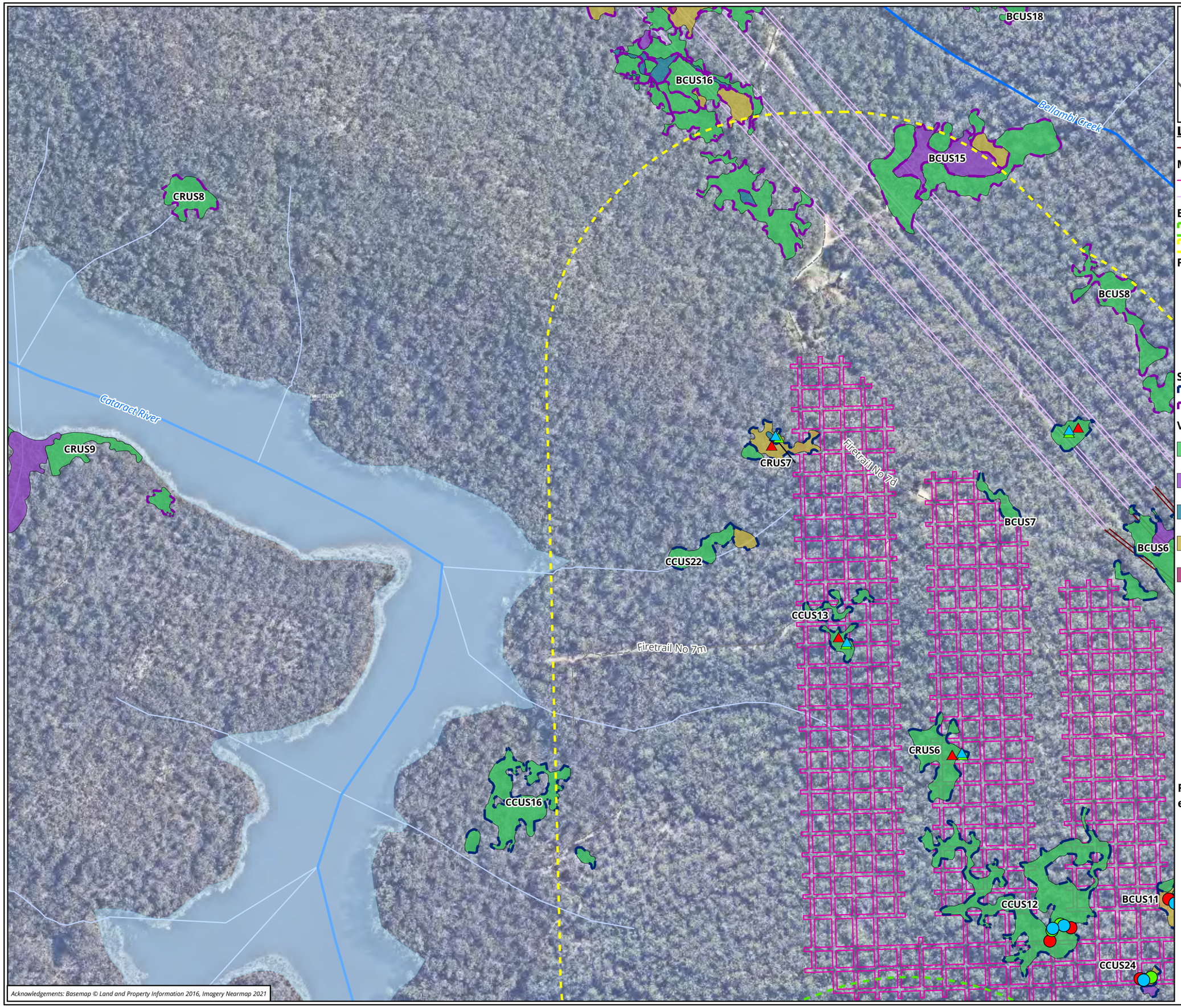

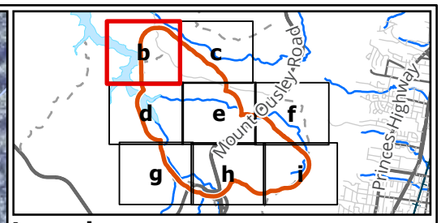

Legend

Pillars

Mine plan
- Stage 2
- Future stages

EP areas
- Stage 1
- Stage 2

Flora monitoring
- Photo Point
- Photo Point - proposed
- Transect End
- Transect End - proposed
- Transect Start
- Transect Start - proposed

Swamp survey status
- 3
- 4

Vegetation Sub-Communities
- MU42,Upland Swamps: Banksia Thicket
- MU43,Upland Swamps: Tea-Tree Thicket
- MU44a,Upland Swamps: Sedgeland-Heath Complex (Sedgeland)
- MU44b,Upland Swamps: Sedgeland-Heath Complex (Restioid Heath)
- MU44c,Upland Swamps: Sedgeland-Heath Complex (Cyperoid Heath)

Figure 12b Coastal Upland Swamp ecological monitoring

0 40 80 120 160 200

Metres

Scale: 1:5,000 @ A3

Coordinate System: GDA 1994 MGA Zone 56

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Matter: 36747,
Date: 10 June 2022 ,
Prepared for: CBH, Prepared by: AM, Last edited by: amackegard
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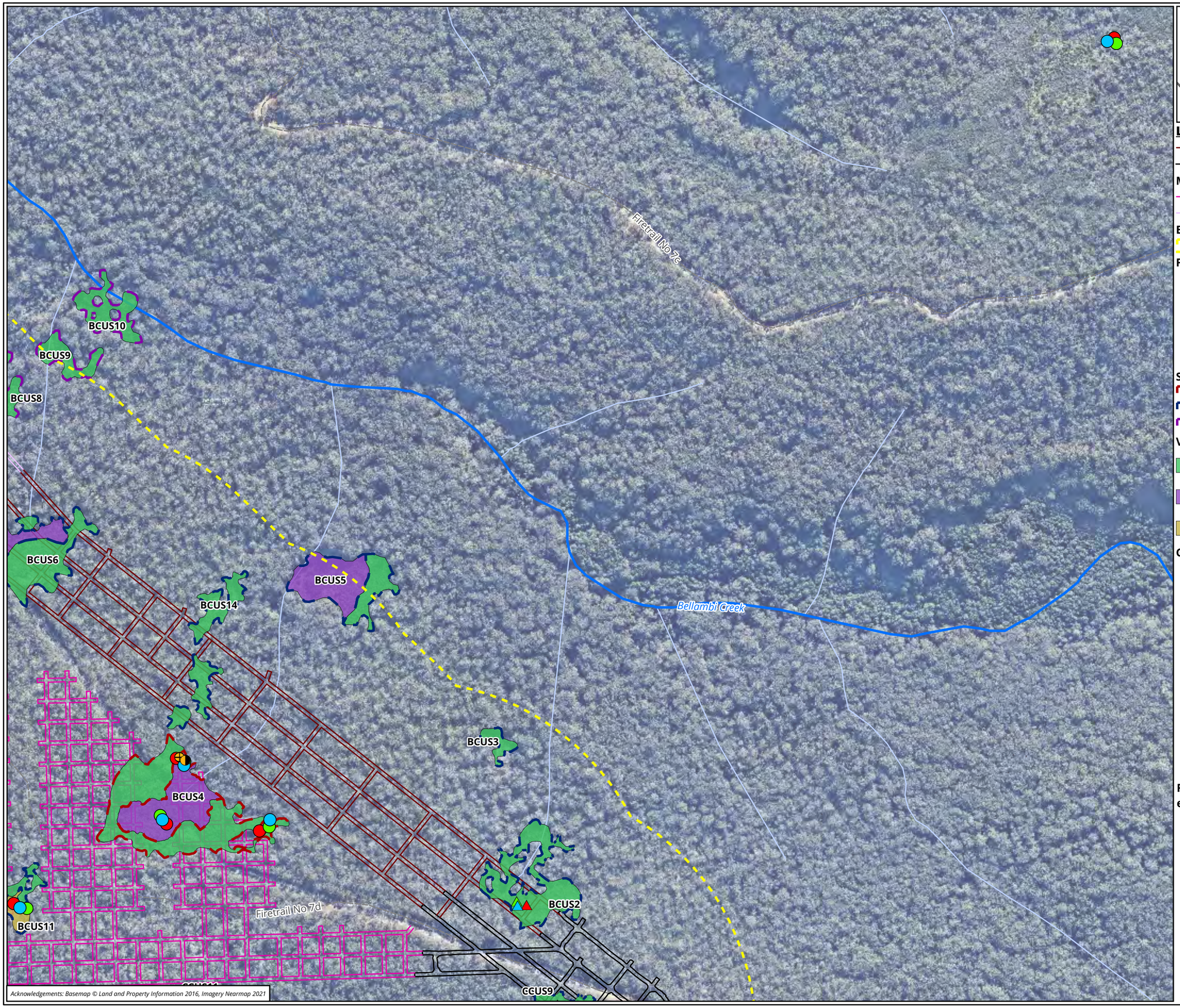

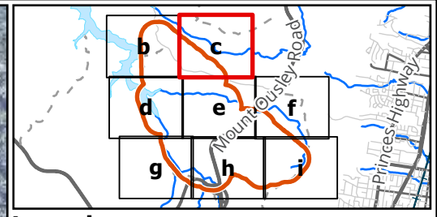

Legend

- Pillars
- Past workings

Mine plan

- Stage 2
- Future stages

EP areas

- Stage 2

Flora monitoring

- Photo Point
- Photo Point - proposed
- Transect End
- Transect End - proposed
- Transect Start
- Transect Start - proposed

Swamp survey status

- 1A
- 3
- 4

Vegetation Sub-Communities

- MU42,Upland Swamps: Banksia Thicket
- MU43,Upland Swamps: Tea-Tree Thicket
- MU44b,Upland Swamps: Sedgeland-Heath Complex (Restioid Heath)

Giant Dragonfly monitoring

- Transect End
- Transect Start

Figure 12c Coastal Upland Swamp ecological monitoring

0 40 80 120 160 200

Metres

Scale: 1:5,000 @ A3

Coordinate System: GDA 1994 MGA Zone 56

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Matter: 36747,
Date: 10 June 2022 ,
Prepared for: CBH, Prepared by: AM, Last edited by: amackegard
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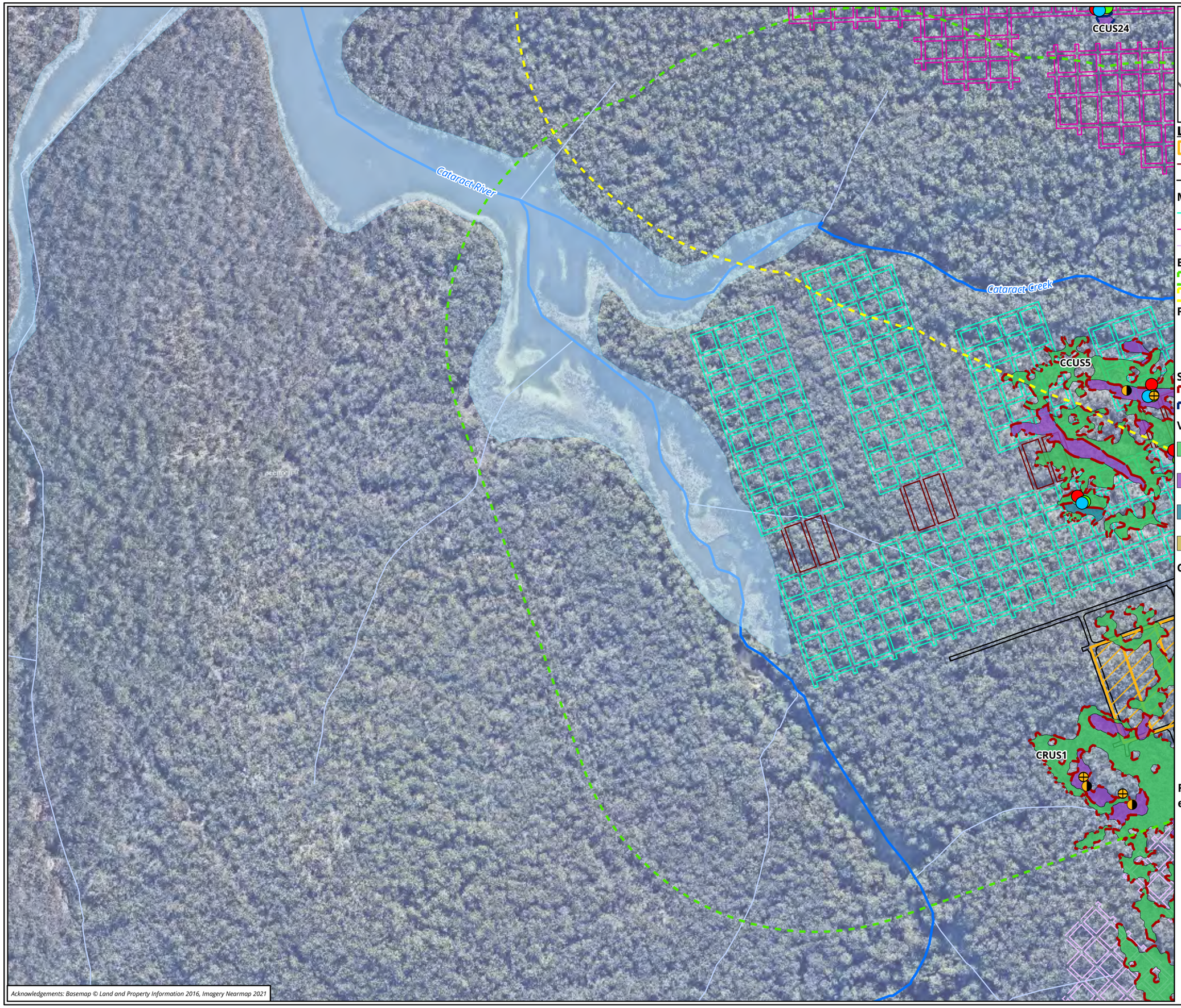

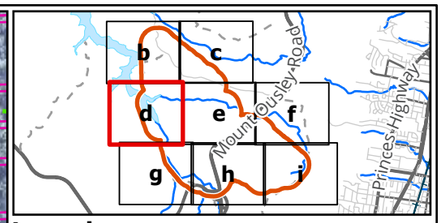

Legend

- RV East old longwall workings
- Pillars
- Past workings

Mine plan

- Stage 1
- Stage 2
- Future stages

EP areas

- Stage 1
- Stage 2

Flora monitoring

- Photo Point
- Transect End
- Transect Start

Swamp survey status

- 1A
- 3

Vegetation Sub-Communities

- MU42,Upland Swamps: Banksia Thicket
- MU43,Upland Swamps: Tea-Tree Thicket
- MU44a,Upland Swamps: Sedgeland-Heath Complex (Sedgeland)
- MU44b,Upland Swamps: Sedgeland-Heath Complex (Restioid Heath)

Giant Dragonfly monitoring

- Transect End
- Transect Start

Figure 12d Coastal Upland Swamp ecological monitoring

0 40 80 120 160 200

Metres

Scale: 1:5,000 @ A3

Coordinate System: GDA 1994 MGA Zone 56

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Matter: 36747,
Date: 10 June 2022 ,
Prepared for: CBH, Prepared by: AM, Last edited by: amackegard
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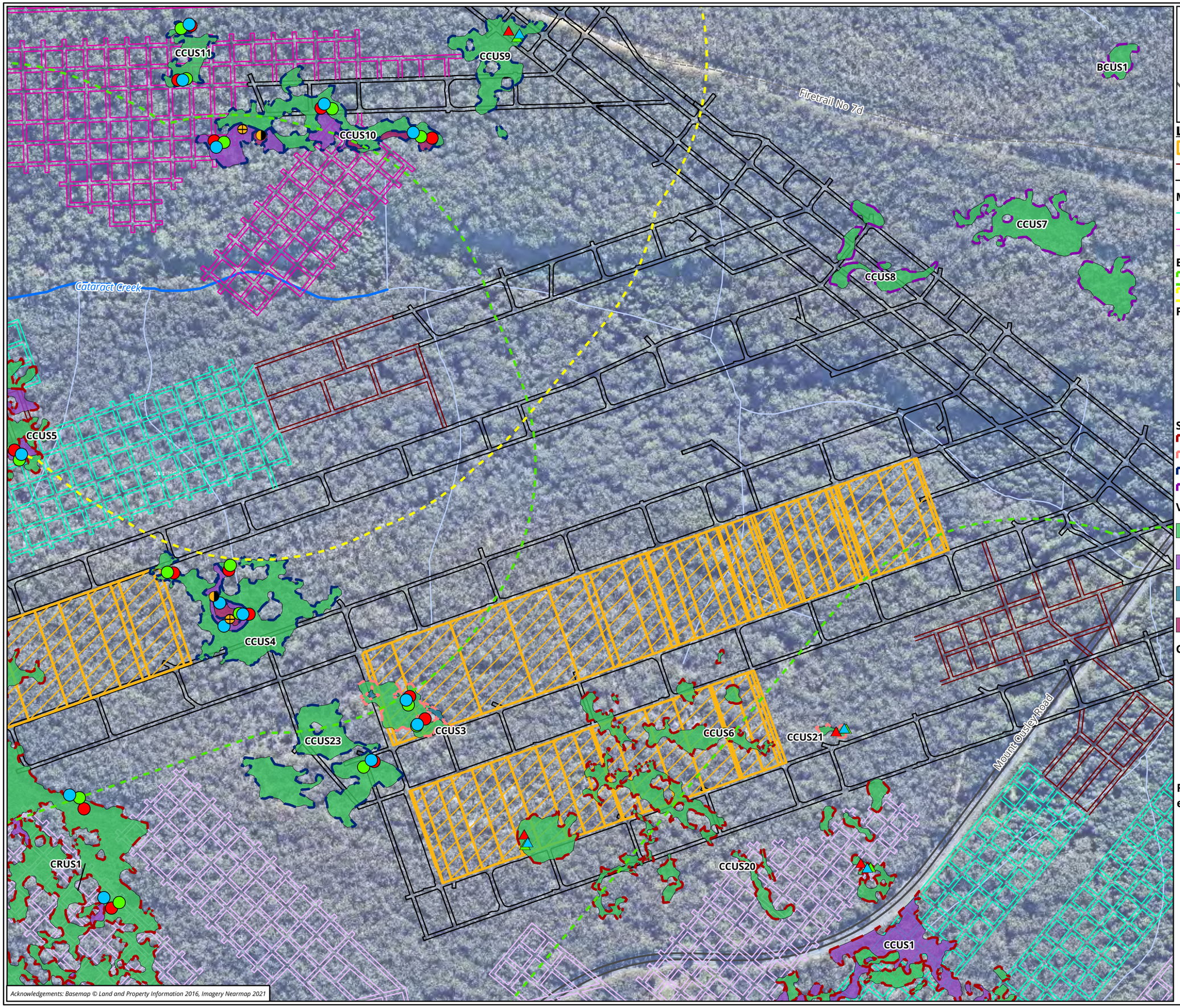

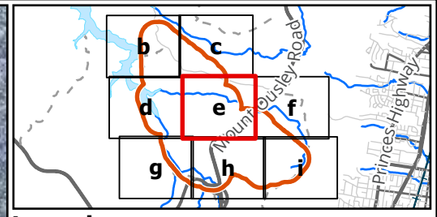

Legend

- RV East old longwall workings
- Pillars
- Past workings

Mine plan

- Stage 1
- Stage 2
- Future stages

EP areas

- Stage 1
- Stage 2

Flora monitoring

- Photo Point
- Photo Point - proposed
- Transect End
- Transect End - proposed
- Transect Start
- Transect Start - proposed

Swamp survey status

- 1A
- 1B
- 3
- 4

Vegetation Sub-Communities

- MU42,Upland Swamps: Banksia Thicket
- MU43,Upland Swamps: Tea-Tree Thicket
- MU44a,Upland Swamps: Sedgeland-Heath Complex (Sedgeland)
- MU44c,Upland Swamps: Sedgeland-Heath Complex (Cyperoid Heath)

Giant Dragonfly monitoring

- Transect End
- Transect Start

Figure 12e Coastal Upland Swamp ecological monitoring

0 40 80 120 160 200

Metres

Scale: 1:5,000 @ A3

Coordinate System: GDA 1994 MGA Zone 56

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Matter: 36747,
Date: 10 June 2022 ,
Prepared for: CBH, Prepared by: AM, Last edited by: amackegard
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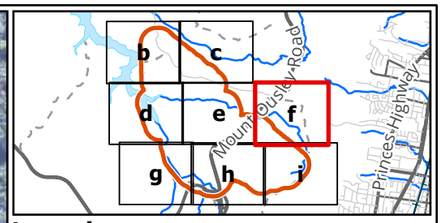

Legend

- Pillars
- Past workings

Mine plan

- Stage 1
- Future stages

EP areas

- Stage 1

Figure 12f Coastal Upland Swamp ecological monitoring

0 40 80 120 160 200

Metres

Scale: 1:5,000 @ A3

Coordinate System: GDA 1994 MGA Zone 56

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Matter: 36747,
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Layout: F12_CoastalUplandSwampMonitoring_eco
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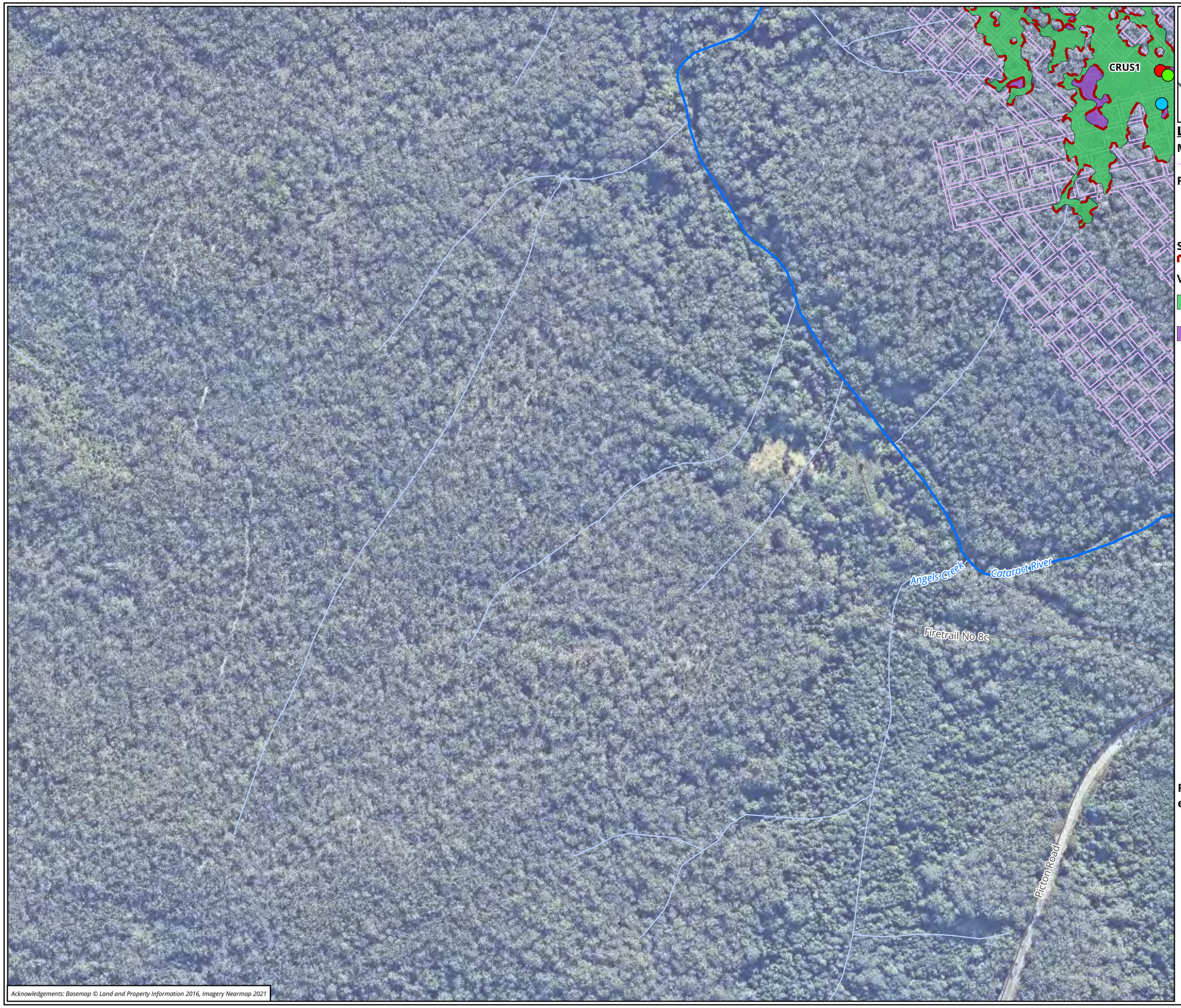

Legend

Mine plan

Future stages

Flora monitoring

Photo Point

Transect End

Transect Start

Swamp survey status

1A

Vegetation Sub-Communities

MU42,Upland Swamps: Banksia Thicket

MU43,Upland Swamps: Tea-Tree Thicket

Figure 12g Coastal Upland Swamp ecological monitoring

0 40 80 120 160 200

Metres

Scale: 1:5,000 @ A3

Coordinate System: GDA 1994 MGA Zone 56

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biosis

Matter: 36747,
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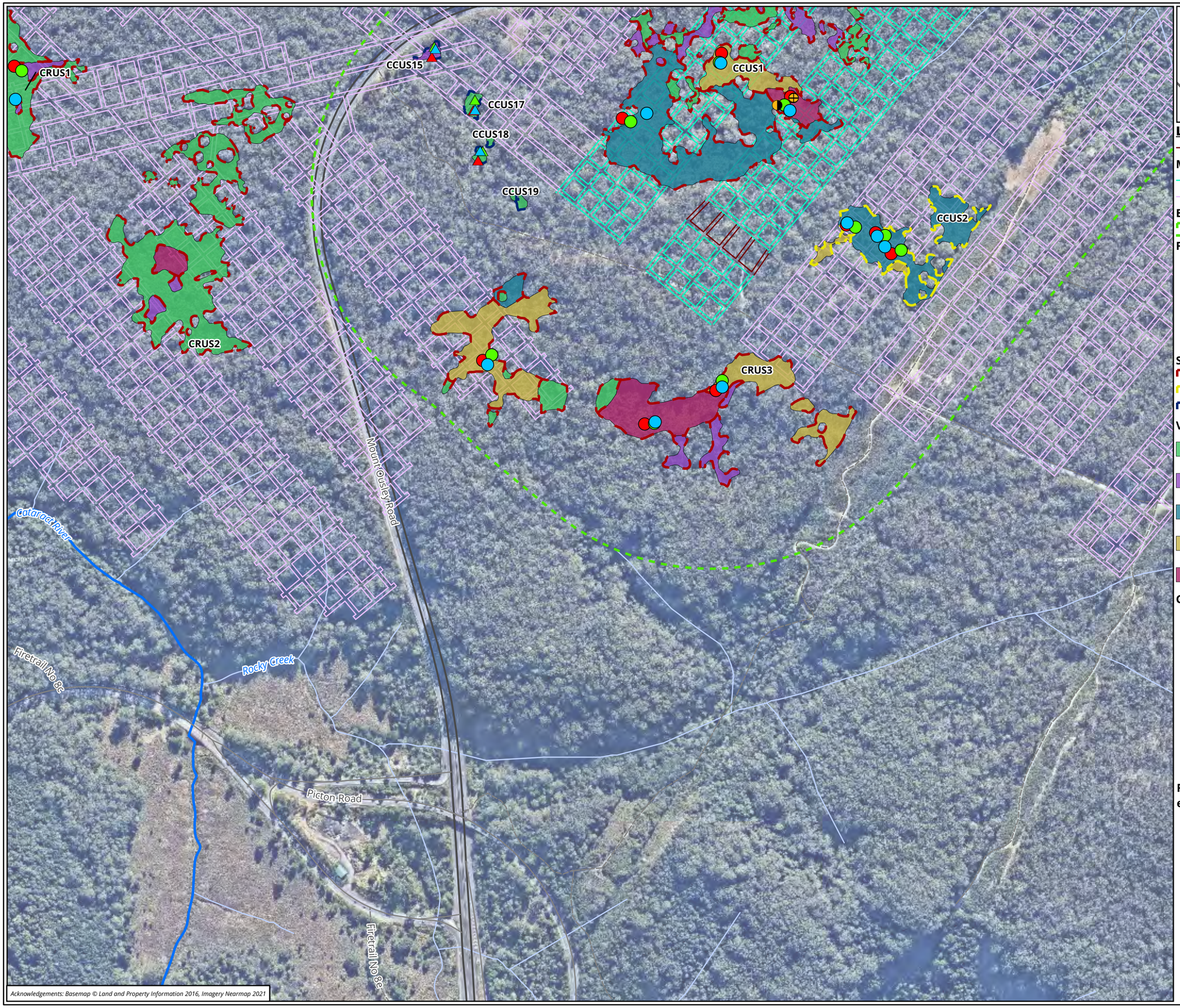

Legend

- Pillars

Mine plan

- Stage 1
- Future stages

EP areas

- Stage 1

Flora monitoring

- Photo Point
- Photo Point - proposed
- Transect End
- Transect End - proposed
- Transect Start
- Transect Start - proposed

Swamp survey status

- 1A
- 2
- 3

Vegetation Sub-Communities

- MU42,Upland Swamps: Banksia Thicket
- MU43,Upland Swamps: Tea-Tree Thicket
- MU44a,Upland Swamps: Sedgeland-Heath Complex (Sedgeland)
- MU44b,Upland Swamps: Sedgeland-Heath Complex (Restioid Heath)
- MU44c,Upland Swamps: Sedgeland-Heath Complex (Cyperoid Heath)

Giant Dragonfly monitoring

- Transect End
- Transect Start

Figure 12h Coastal Upland Swamp ecological monitoring

0 40 80 120 160 200

Metres

Scale: 1:5,000 @ A3

Coordinate System: GDA 1994 MGA Zone 56

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Matter: 36747,
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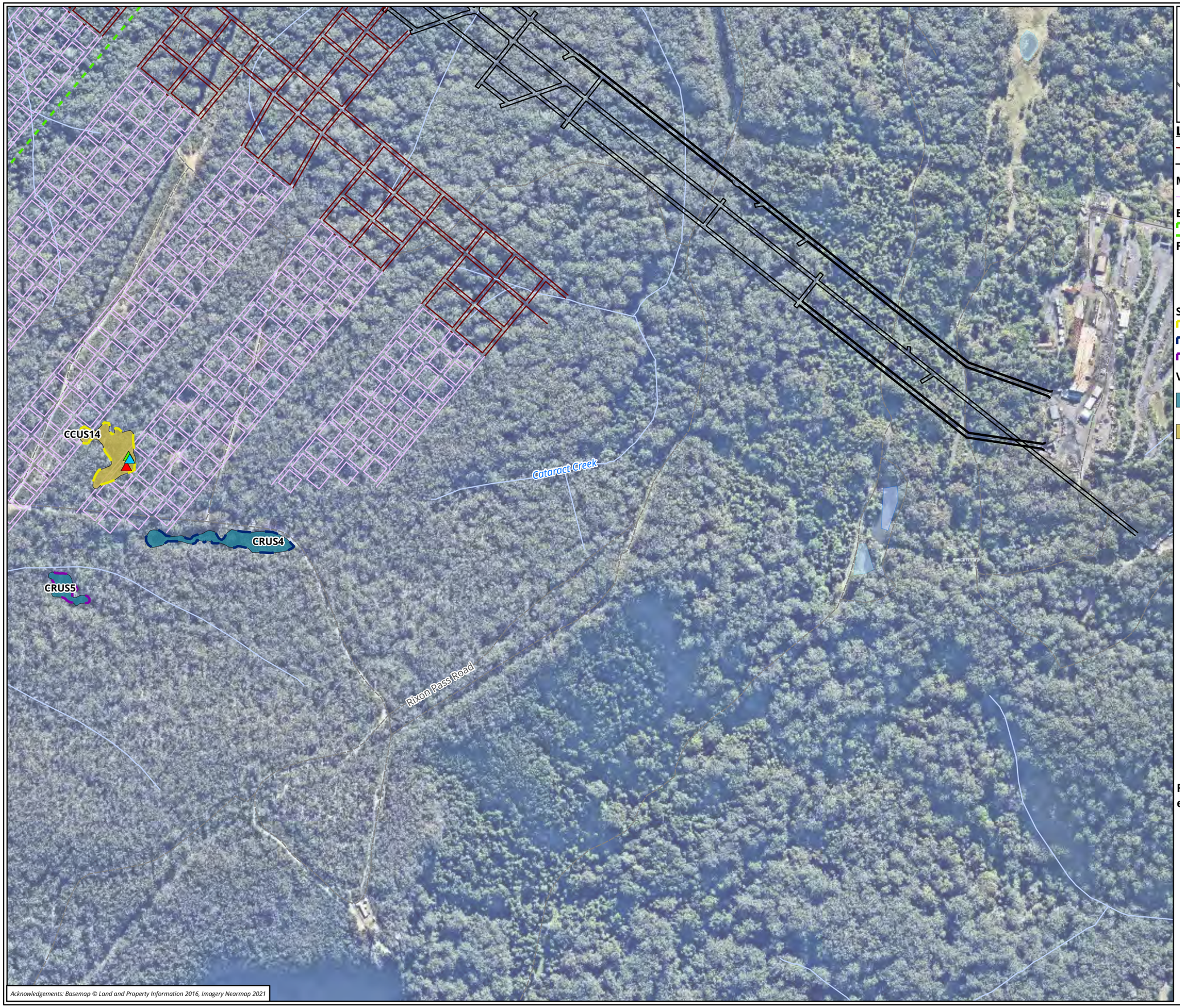

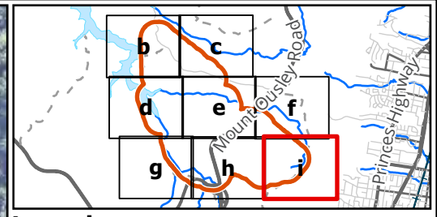

Legend

- Pillars
- Past workings

Mine plan

- Future stages

EP areas

- Stage 1

Flora monitoring

- Photo Point - proposed
- Transect End - proposed
- Transect Start - proposed

Swamp survey status

- 2
- 3
- 4

Vegetation Sub-Communities

- MU44a,Upland Swamps: Sedgeland-Heath Complex (Sedgeland)
- MU44b,Upland Swamps: Sedgeland-Heath Complex (Restioid Heath)

Figure 12i Coastal Upland Swamp ecological monitoring

0 40 80 120 160 200

Metres

Scale: 1:5,000 @ A3

Coordinate System: GDA 1994 MGA Zone 56

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biosis

Matter: 36747,
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36747_WCL_Stage2_USMP_figures.aprx

Legend

- UEP area
- RV East old longwall workings
- Pillars
- Past workings

Mine plan

- Stage 1
- Stage 2
- Future stages

EP areas

- Stage 1
- Stage 2

Existing groundwater locations

- Creek
- SP

Flora monitoring

- Photo Point
- Transect Start
- Transect End

Figure 13 UEP Coastal Upland Swamp control sites

0 500 1,000 1,500 2,000 2,500

Metres

Scale: 1:60,000 @ A3

Coordinate System: GDA 1994 MGA Zone 56

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biosis

Matter: 36747,
Date: 08 June 2022 ,
Prepared for: CBH, Prepared by: AM, Last edited by: amackegard
Layout: F13_Control_sites
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4.3.1 Prior and ongoing monitoring

Coastal Upland swamp ecological monitoring has been undertaken in the RVE domain since autumn 2011. This monitoring continued in various forms until longwall extraction ceased in 2015 and included up to two years of post-mining data as collected in spring 2017. The monitoring includes both impact (sites with the potential to be impacted) and control (reference) sites. Monitoring re-commenced in 2019 with the years of relevant pre-mining data collection to date summarised in Table 19.

The current terrestrial biodiversity monitoring program includes:

- Vegetation transect monitoring in Coastal Upland Swamps, undertaken biannually during spring and autumn.
- Observational monitoring of Coastal Upland Swamps, to be undertaken biannually during spring and autumn.
- Giant Dragonfly *Petalura gigantea* monitoring.

Table 19 Vegetation transect, observational and Giant Dragonfly monitoring data collection to date

Status	Swamp	Stage	Vegetation transect and observational monitoring data		Giant Dragonfly monitoring data	
			Years	Date range	Years	Date range
Impact	BCUS2	Stage 2	-	Autumn 2022	-	-
Impact	BCUS3	Stage 2	-	Autumn 2022	-	-
Impact	BCUS4	Stage 2	2.5	Spring 2013 - Autumn 2015 Autumn 2022	1	2014/2015
Impact	BCUS5	Stage 2	-	Autumn 2022	-	-
Impact	BCUS6	Stage 2	-	Autumn 2022	-	-
Impact	BCUS7	Stage 2	-	Autumn 2022	-	-
Impact	BCUS8	Stage 2	-	Autumn 2022[19]	-	-
Impact	BCUS9	Stage 2	-	Autumn 2022[19]	-	-
Impact	BCUS11	Stage 2	2.5	Spring 2013 - Autumn 2015 Autumn 2022	-	-
Impact	BCUS14	Stage 2	-	Autumn 2022	-	-
Impact	BCUS15	Stage 2	-	Autumn 2022[19]	-	-
Impact	BCUS16	Stage 2	-	Autumn 2022[19]	-	-
Impact	CCUS1	Stage 1	9	Autumn 2012 - Spring 2017 Autumn 2019 - Spring 2021 (Autumn only 2016)	8	2014/2015 –2021/2022

[19] Category 4 – Observational monitoring only.

Status	Swamp	Stage	Vegetation transect and observational monitoring data		Giant Dragonfly monitoring data	
			Years	Date range	Years	Date range
Impact	CCUS2	Stage 1	2.5	Spring 2015 - Autumn 2016 Autumn 2021- Spring 2021	-	-
Impact	CCUS3	Stage 1	9	Autumn 2012 - Spring 2019 Autumn 2021- Spring 2021 (Autumn only 2016, Spring only 2018)	-	-
Impact	CCUS4	Stage 1 and 2	9	Autumn 2012 - Autumn 2021 (Autumn only 2017, Spring only 2018) Autumn 2022	8	2014/2015 –2021/2022
Impact	CCUS5	Stage 1 and 2	8	Autumn 2013 - Spring 2021 (Autumn only 2016, Spring only 2018) Autumn 2022	8	2014/2015 – 2021/2022
Impact	CCUS6	Stage 1	1	Autumn 2021-Spring 2021	-	-
Impact	CCUS9	Stage 2	4.5	Spring 2013 - Autumn 2016, Autumn 2019 - Spring 2021 Autumn 2022	-	-
Impact	CCUS10	Stage 1 and 2	4.5	Spring 2013 - Autumn 2016, Autumn 2019 - Spring 2021 Autumn 2022	1	2014/2015
Impact	CCUS11	Stage 2	4.5	Spring 2013 - Autumn 2016, Autumn 2019 - Spring 2021 Autumn 2022	-	-
Impact	CCUS12	Stage 2	2	Spring 2015 - Autumn 2015 Autumn 2021- Spring 2021 Autumn 2022	-	-
Impact	CCUS13	Stage 2	2.5	Spring 2013 - Autumn 2015 Autumn 2022	-	-
Impact	CCUS15	Stage 1	0.5	Autumn 2021	-	-
Impact	CCUS16	Stage 2	-	Autumn 2022	-	-
Impact	CCUS17	Stage 1	1	Autumn 2021-Spring 2021	-	-

Status	Swamp	Stage	Vegetation transect and observational monitoring data		Giant Dragonfly monitoring data	
			Years	Date range	Years	Date range
Impact	CCUS18	Stage 1	1	Autumn 2021-Spring 2021	-	-
Impact	CCUS19	Stage 1	0.5	Autumn 2021	-	-
Impact	CCUS20	Stage 1	1	Autumn 2021-Spring 2021	-	-
Impact	CCUS21	Stage 1	1	Autumn 2021-Spring 2021	-	-
Impact	CCUS22	Stage 2	-	Autumn 2022	-	-
Impact	CCUS23	Stage 1	9	Autumn 2012 - Spring 2019 Autumn 2021- Spring 2021 (Autumn only 2016, Spring only 2018)	-	-
Impact	CCUS24	Stage 2	1	Spring 2015 - Autumn 2016 Autumn 2022	-	-
Impact	CRUS1	Stage 1	10	Autumn 2011 - Spring 2019 Autumn 2021- Spring 2021 (Autumn only 2016)	8	2014/2015-2021/2022
Impact	CRUS3	Stage 1	6.5	Autumn 2012 - Autumn 2016 Autumn 2021 - Spring 2021	-	-
Impact	CRUS6	Stage 2	-	Autumn 2022	-	-
Impact	CRUS7	Stage 2	-	Autumn 2022	-	-
Control	ACUS	-	9	Autumn 2012 - Spring 2017, Autumn 2019 - Spring 2021	-	-
Control	BCUS12	-	9	Autumn 2012 - Spring 2021 (Autumn only 2017, Spring only 2018)	8	2014/2015 - 2021/2022
Control	BCUS13	-	9	Autumn 2012 - Spring 2021 (Autumn only 2016, Spring only 2018)	8	2014/2015 –2021,2022
Control	S15A	-	15.5	Spring 2005 - Spring 2019 Autumn 2021 - Spring 2021 (Autumn only 2018)	-	-
Control	S22	-	10.5	Spring 2009 - Spring 2019	-	-

Status	Swamp	Stage	Vegetation transect and observational monitoring data		Giant Dragonfly monitoring data	
			Years	Date range	Years	Date range
				Autumn 2021 - Spring 2021		
Control	S33	-	10.5	Spring 2009 - Spring 2019 Autumn 2021 - Spring 2021 (Autumn only 2018)	-	-
Control	WACUS	-	8.5	Spring 2012 - Spring 2021 (Autumn only 2016, Spring only 2017, 2018)	8	2014/2015-2021/2022
Control	WCUS	-	9	Autumn 2012 - Spring 2021 (Autumn only 2016, Spring only 2018)	8	2014/2015-2021/2022

4.3.1.1 Results to date

Annual reports have been provided to Wollongong Coal since the ecological monitoring program has commenced. At the completion of the 2017 ecological monitoring program, 4.5 years of post-mining data had been collected for those sites that were at risk of impacts from LW4 and LW5. LW6 was mined during the 2015 monitoring period, and therefore three seasons (two and a half years) of post-mining data had been collected for those sites at risk of mining related impacts associated with that longwall. The most recent published annual report covered the 2020 monitoring (Biosis 2021). These reports evaluate the first two years of the recommencement of the ecological monitoring in RVE in the context of the previous years of data, and in response to the TARP trigger levels previously developed for longwall extraction.

The findings of the 2020 iteration of the RVE terrestrial ecological monitoring program (Biosis 2021) were made in the context of extended drought conditions across the region from 2017 to 2020. For upland swamp vegetation monitoring in 2019, impact monitoring swamps CCUS1 and CCUS5 were deemed to be consistent with the predicted (level 1) TARP levels, on the basis of no statistically significant change in TSR or species composition being attributable to previous longwall mining and no observations of swamp vegetation dieback being recorded.

Swamp CCUS4 was determined to be consistent with the predicted (level 2) TARP levels for upland swamp vegetation monitoring, on the basis that the two areas of vegetation dieback previously observed in 2019 had increased over the 2020 monitoring period, with an additional two areas of die back noted, predominantly restricted to the *Gleichenia dicarpa / microphylla* species complex and Heath-leaved Banksia. Similar areas of dieback were observed at control swamps BCUS12 and BCUS13, however the areas of dieback at the impact monitoring sites were identified to have occurred earlier and be more acute than that at the control sites. This indicated that CCUS4 may have a reduced level of resilience to environmental stressors such as drought (with no mining occurring since 2015). While no statistically significant change in TSR or species composition was detected at these sites (Analytical Edge 2020), at CCUS3 transects that had been mined beneath appeared to show lower TSR values than transects that had not been mined beneath. In addition, at CCUS4, the test for yearly trends in species composition at

swamp CCUS4 was approaching the adopted significance level in 2019. This indicated that while not meeting the specified significance level of the statistical analyses, these swamps may be to a degree reflecting differing responses to the environmental conditions than other swamps.

The 2020 report (Biosis 2021) found that all impact monitoring sites assessed as part of the Giant Dragonfly monitoring were determined to be consistent with the within prediction (level 1) TARP level. The exuviae – remnant exoskeleton of larvae - detected at the impact monitoring sites was comparable with the control sites and was within the range of results previously recorded at these sites.

4.3.2 Current monitoring program

The following sections summarise the ongoing Coastal Upland Swamp ecological monitoring program that is underway in the RVE area, following the recommencement of ecological monitoring in 2019. Monitoring recommenced in order to collect pre-extraction baseline data for the UEP. The relevant trigger levels from the Trigger Action Response Plans (TARPs) developed for LW4 and LW5 (Wollongong Coal 2012) and LW6 and LW7 (Wollongong Coal 2015) in the RVE area form the basis for which the results of the 2019 to 2021 monitoring results are currently assessed against. The assessments against these TARPs have been completed in order to establish pre-UEP baseline conditions and assess any ongoing levels of impacts following the completion of longwall mining in 2015.

Monitoring is undertaken according to a modified BACI design where data is collected before (baseline) and after impact at control and impact sites. Data collected during baseline monitoring was used for comparison to data collected during and after mining (the before-after component) and data collected at impact sites is compared to data collected at control sites (the control-impact component). The duration of post-mining monitoring is determined based on results of annual analysis of data as well as observed impacts to surface features and other monitoring (e.g. groundwater) but includes a minimum of one year post-mining at sites where data from all monitoring programs shows negligible impacts.

The type, location, seasonality and methodology for vegetation and Giant Dragonfly monitoring as part of the current program is summarised in Section 4.3 (Table 17 and Table 18) with monitoring locations and control sites shown in Table 16 and Table 18, as well as Figure 12 and Figure 13.

4.3.3 Swamp vegetation transect monitoring

Three linear 15 m transects containing 30 quadrats measuring 0.5 m x 0.5 m are surveyed within each swamp during autumn and spring. Where swamps are smaller, the number of transects may be reduced in line with the size of the swamp. The presence of all plant species in each quadrat is recorded and is used as part of statistical analysis (detailed below). Photo-point monitoring is also undertaken at each transect.

The vegetation statistical analysis is undertaken at the swamp level. Three vegetation monitoring transects that are located in each swamp are considered to represent one site. As such the same treatment (described below) is applied to each transect within a site. In other words, an impact monitoring swamp cannot contain individual transects that are treated as pre-mining and post-mining regardless of their location within a swamp or relative to the location of extraction. Each site is analysed based on the following treatments with the treatment

determined by relevance to the swamp as a whole, not based on individual transects. The treatment for each swamp has been identified in Table 12. An explanation for each treatment is provided below.

- Control or pre-mining: sites not mined beneath and not at risk of mining related impacts. Includes both established control sites as well as sites that may be impacted in the future (non-impact sites).
- Post-mining – mined beneath: sites that have been directly mined beneath and are at greatest risk of being impacted.

The swamp vegetation data monitoring will be analysed in partnership with a specialist statistical consultant using suitable tests for change most applicable to the sites and data collected. The analyses will make use of the up-to-date baseline data, data from control monitoring sites and past data collected as part of the previous ecological monitoring in the area. This will provide a comprehensive basis upon which to detect change. The analysis will provide a statistical comparison of pre-mining and post-mining data at impact and control sites with the aim to identify, understand and manage any mining impacts. The following statistical analysis methodology is included below.

Following collection in the field, vegetation data are entered into a master dataset and validated prior to analysis. Control sites selected for analysis are chosen for impact sites based on ecological similarity in the field, and then compared using exploratory data analysis to confirm that the data were statistically suitable and available for the same period of time as impact sites.

Impacts to vegetation may be evidenced by a change to the number of species at different sites, or an overall change in the species composition, as some species may be less affected than others. In affected areas, these impacts may manifest as the following:

- Change in floristic Total Species Richness (TSR): the number of individual species calculated by summing the total number of unique species detected at each monitoring point during each season and year. This is a simple presence-absence measure and does not account for the relative abundance of each species.
- Changes in the floristic species composition: the assemblage of different individual plant species that make up a vegetation community.

4.3.3.1 Total Species Richness (TSR)

A change in TSR or species composition following mining at an impact site that does not occur at a control site may indicate a potential impact. In order to detect changes in indicator variables, particular trends must be identified. These trends may occur suddenly, as a pulse event, or more likely, gradually over time.

TSR is calculated for swamps by summing the number of species detected at each transect for each survey. Species detections are tallied to obtain TSR at each transect at each monitoring location. Exploratory data analysis included plotting TSR for each survey year from when monitoring first commenced, split by mining status for swamps, representing TSR across all survey locations and sites. For swamps, this averaging process may mask individual swamp-level effects of mining status (i.e. richness at some swamps might go up, others might go down, but on average total richness appears stable). Hence the TSR in each year, across each of the three

transects, for each swamp are individually plotted. The aim is to determine whether the trend in TSR pre-mining is different to the trend in TSR post-mining (or mined beneath).

Comparison of TSR between sites and years is undertaken graphically using box plots which allow visualisation of the median distribution including the underlying variability and distribution of the data. To formally quantify whether trends detected visually represent actual changes in TSR, generalised linear mixed models (Bolker et al. 2009) will be tested for all impact sites. The models will test the influence of season, year and mining status (pre, post or mined beneath) on TSR. The use of season as a factor in analysis allows for the identification of any cyclical trends; calendar year allows for the identification of trends in time across all sites; while mining status allows for the identification of observed trends that are different at mining and non-mining sites.

An assumption of generalised linear mixed models is that observations are independent, which in this program is violated both temporally (since sites are visited multiple times) and spatially (since some sites within regions are closer together). That is, it would be expected that observations collected at the same swamp, regardless of year or season, would be more correlated than observations collected at different swamps; and similarly, observations collected at swamps near each other would be more similar to observations collected at swamps further away. To account for this correlation within sites and the nesting of sample points within the area, a random-effect term was included. Akiake's Information Criteria (AIC) was used to select between competing models, whereby the model with the lowest AIC was considered the 'best' of all models fitted, and models that had an AIC less than or equal to two from the AIC of the best model were considered equivalent.

4.3.3.2 Species composition

Flora data is used to determine species composition, or community composition at each transect within swamps (i.e. a species list of all unique species detected in each visit).

The 'manyglm' function in the 'mvabund' package is used to fit presence-absence models to each detected species. These models correct the correlation between species (thus violating an assumption of standard generalised linear models) by using generalized estimating equations. Analysis of variance (ANOVA) are used to formally test the significance of explanatory variables (i.e. year, season and mining status). If the mining status explanatory variable was found to be significant, univariate tests were completed to determine which individual species were driving the change in flora community composition.

Generalised linear mixed models of TSR are fitted using the 'glmer' function in the 'lme4' package in the statistical software program R.

4.3.3.3 Analysis

Data analysis of swamp vegetation monitoring data is undertaken to assess any changes in Total Species Richness (TSR) and changes in Flora Community Composition. The statistical analysis methodology (as set out in Sections 2.1 and 3.1 of '*Analysis of flora data set 2 at Russell Vale East - Data collected up to, and including, 2021'* (Analytical Edge, 2021), See Appendix B) is applied to the data collected.

This analysis considers variation within and between swamps and also between impact swamps and control swamps. This methodology is described in further detail in Section 4.3.2 and 4.5.

4.4 Observational monitoring

A minimum of one photo-point, additional to the vegetation transect photo-point monitoring is to be established within the swamps. Photos are taken to the north, east, south and west at these points. Monitoring surveys are conducted once in spring and once in autumn. The swamps are also traversed using random meanders to make observations of any dieback or transitional processes occurring.

4.5 Giant Dragonfly monitoring

Giant Dragonfly exuviae monitoring is conducted twice during the breeding season (summer) by searching all ground layer, sedgeland and shrub vegetation within suitable Giant Dragonfly habitat, along a linear transect of fixed length at each site. A 1.5 m belt is surveyed along each transect, with the length of each transect determined by the available habitat. The number of adults identified along the transect is also recorded, along with any incidental sightings of Giant Dragonflies.

For each exuviae identified along the transect, the sex, height above ground level, perch plant species, distance to burrow (if identified) and seepage water will be recorded. Exuviae will then be removed to avoid recounts in subsequent surveys. The data analysis procedure is outlined in the following section.

Impacts to Giant Dragonfly may be evidenced by a decline in populations or disruption of the breeding cycle following changes to key breeding habitat features. The impacts are measured quantitatively through Giant Dragonfly exuviae detections. In this case, 'detection' has been used as a surrogate for 'abundance'. Changes in Giant Dragonfly exuviae detection may be due to mining impacts or unrelated landscape effects; for example local climate changes, bushfire etc.

A BACI experimental design has been employed to increase confidence in the interpretation of observed changes. Data analysis for the Giant Dragonfly includes visual representation of the data and determination of trends from graphs. All the results of the monitoring and Giant Dragonfly have been plotted using frequency histograms to compare detection rate of exuviae between control and impacts sites. Like many fauna surveys, the dataset is not normally distributed and is skewed by a high number of zero counts at the transect level. Due to these limitations, the scope to conduct statistical analysis on this data is limited due to very low degrees of freedom.

4.6 Reporting

Annual ecological monitoring reports will be provided to WRPL detailing the findings of the autumn and spring surveys.

Progress against the requirements of this plan will be reported regularly to the BCD and other relevant agencies by Wollongong Coal as required by the BCD and DCCEEW.

DC MP09_0013 and EPBC 2020/8702 require monitoring data to be submitted to DCCEEW and BCD at least every three months.

Updated data and compliance reports are to be made available on the Wollongong Coal website.

5 POTENTIAL IMPACTS

5.1 Direct impacts

No direct impacts to Coastal Upland Swamps will result from the proposed second workings covered by this management plan. The second workings covered by this management plan will not result in the direct removal or clearing of any vegetation other than minor localised and temporary impacts associated with the installation of soil moisture probes and swamp piezometers and GNSS subsidence monitoring points.

As such there will be no direct impacts to terrestrial and aquatic biodiversity (threatened species and ecological communities), listed under the EPBC Act and/or BC Act, as a result of the UEP second workings.

5.2 Indirect impacts

Potential impacts to the Coastal Upland Swamps associated with subsidence from underground mining generally, include:

- Alteration of hydrological regimes through fracturing of bedrock beneath Coastal Upland Swamps or shearing.
- Changes in concentration of water due to changes in water distribution resulting from changes in tilts.
- Increased scour and erosion potential due to changes in water distribution due to changes in tilts.

Vertical subsidence impacts will be limited to the area within the angle of draw from the edge of the proposed mining area. The 2014 IESC Background Review: Subsidence from coal mining activities (IESC 2014) defines angle of draw as being:

> *The angle of inclination from the vertical of the line connecting the edge of the workings and the limit of subsidence, which is usually taken as 20 mm of subsidence.*

For longwall mining, an angle of draw of 35º is traditionally used. As detailed in Appendix A of *Russell Vale Colliery: Subsidence Assessment for Proposed Workings in Wongawilli Seam at Russell Vale East* (SCT 2019) (Subsidence Assessment), the observed angle of draw for subsidence from the mining of the Longwall 4 and 5 panels in the Wongawilli Seam was approximately 32-35º (Section A1.1.2). Significantly smaller angles of draw are expected from the proposed second workings covered by this plan due to the lower predicted subsidence and lack of goaf formation (SCT 2022, SCT 2019, SCT 2021). However, in the event of a large-scale pillar failure within the Wongawilli Seam workings or the failure of a remnant pillar within areas of Bulli Seam Goaf, a higher level of subsidence could be expected; however this would still be significantly less than would be observed from longwall mining and a 35º angle of draw is a conservative assumption for the limit of vertical subsidence impacts that could arise from the proposed workings in the remote chance that these unanticipated events arise.

Condition 7d of EPBC 2020/8702 for the UEP requires that monitoring capable of determining individual water balances for each potentially impacted Coastal Upland Swamp be undertaken. This includes potentially impacted swamps and swamps within 350 m of second workings.

Appendix C details the swamps located within 350 m of the Stage 1 and Stage 2 second workings and the potential impact pathways. The predicted vertical subsidence is based on predictions within the EP Subsidence Assessments (SCT 2022, SCT 2021). These swamps, and their relative position to the second workings covered by this plan are shown in Figure 14.

5.2.1 Stage 1 (a and b)

The maximum depth of cover for second workings within the Stage 1 EP area is approximately 350 m which occurs at the southern ends of panels PC07 and PC08 (SCT 2021). Adopting the conservative 35º angle of draw for mining at this depth means that *any* vertical subsidence impacts (i.e. even assuming a worst case pillar failure scenario) will be limited to within 245 m in horizontal extent from the edge extent of these Stage 1 second workings. This distance would be reduced in other areas of the proposed second workings where depth of cover is less.

There is no potential for subsidence to occur at Coastal Upland Swamps; CCUS3, CCUS6, CCUS 10, CCUS 15 CCUS 21 and CCUS 23 from the proposed Stage 1 second workings, as these swamps will not be directly mined beneath, but are within the Stage 1 EP area. The predicted levels of vertical subsidence at CCUS1, and CCUS5 from mining covered by the EP are in the order of up to 100 mm (SCT 2021). All other swamps are predicted to experience less than 20 mm vertical subsidence (SCT 2021). These low levels of subsidence are not predicted to result in any observable impacts to these Coastal Upland Swamps and no subsidence impacts to any swamps outside the EP area are anticipated as a result of the mining of PC07-08 and PC21-25.

There is no predicted increase in drawdown below any swamps located above the proposed Stage 1 mining areas, however long-term drawdown in the water table is predicted below CCUS3 CCUS6, CCUS21 and near CCUS4. Existing water table levels are already modelled to be below the base of these three swamps and the predicted impacts from previously approved operations would result in water table reductions further in these areas in the absence of any impacts associated with the development approved under the Development Consent. The mining proposed for Stage 1 second workings is not predicted to have any subsidence effects on these three swamps, even under conservative assumptions which have regard to pillar failure. Accordingly, any observed impacts to these swamps associated with reduced connectivity with underlying Permian systems would not be due to impacts associated with proposed mining.

5.2.2 Stage 2

The maximum depth of cover for second workings within the Stage 2 EP area is approximately 390 m which occurs above PC32 and 33 (SCT 2022). Adopting the conservative 35º angle of draw for mining at this depth means that any vertical subsidence impacts (i.e. even assuming a worst case pillar failure scenario) will be limited to within 275 m in horizontal extent from the edge extent of these Stage 1 second workings. This distance would be reduced in other areas of the proposed second workings where depth of cover is less.

There is no potential for subsidence to occur at Coastal Upland Swamps; BCUS2, BCUS3, BCUS5, BCUS8, BCUS9, BCUS14, BCUS15, BCUS16, CCUS4, CCUS16, and CCUS22, from the proposed Stage 2 second workings, as these swamps will not be directly mined beneath, but are within the Stage 2 EP area. The predicted levels of vertical subsidence at Coastal Upland Swamps; BCUS4, BCUS6, BCUS7, BCUS11, CCUS9, CCUS10, CCUS11, CCUS12, CCUS13, CCUS24, CRUS6, and CRUS7

are in the order of up to 100 mm (SCT 2022). These low levels of subsidence are not predicted to result in any observable impacts to these Coastal Upland Swamps and no subsidence impacts to any swamps outside the EP area are anticipated as a result of the mining of PC27-34.

There is no predicted increase in drawdown below any swamps located above the proposed Stage 2 mining areas.

5.2.3 Implications for threatened species

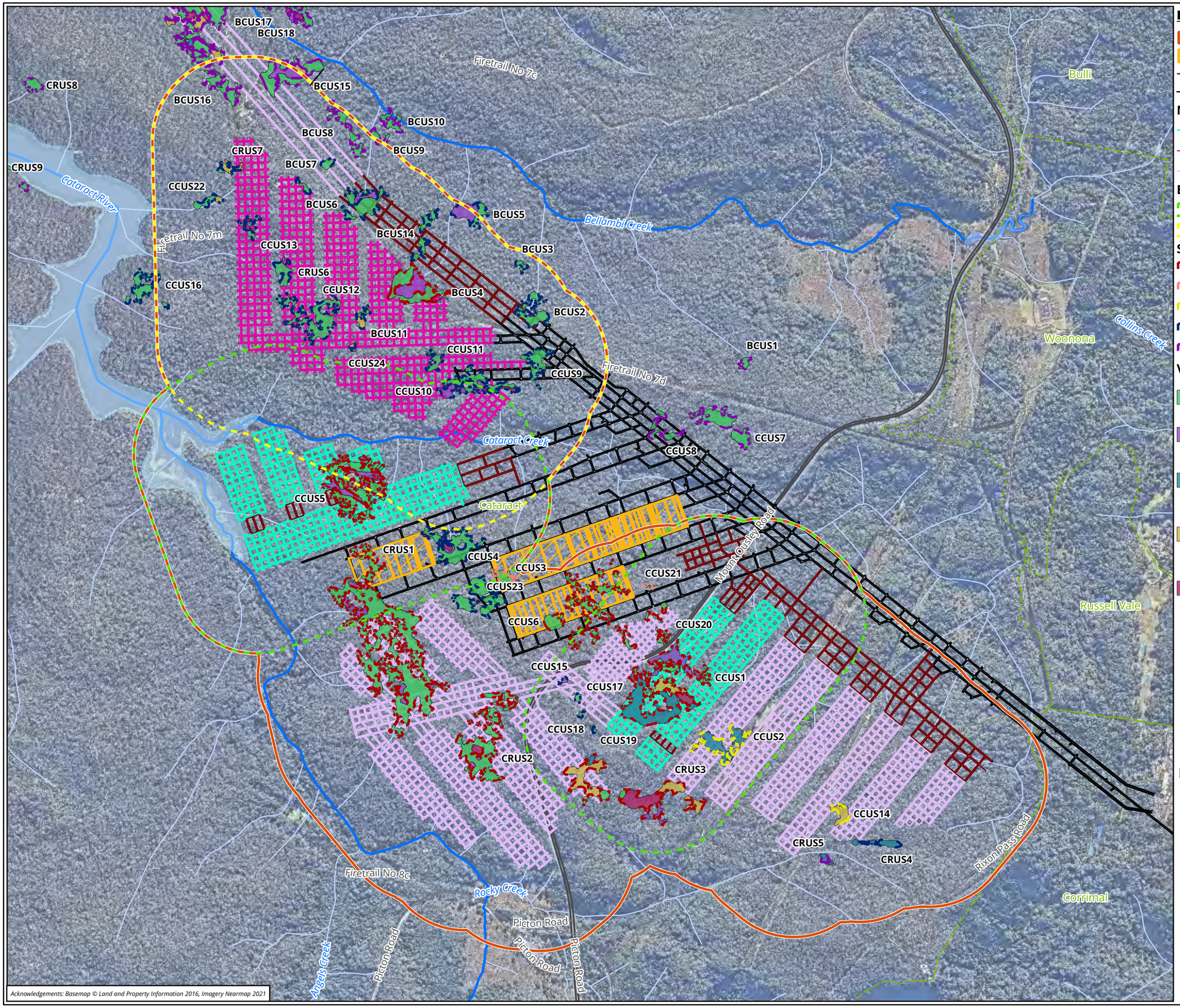
In the absence of any likely impacts to the Coastal Upland Swamp vegetation, even in swamps where there is a potential impact pathway, surface water or groundwater attributes, the mining of PC07-08, PC21-25 and PC27-34 are not predicted to have any impacts on species associated with these swamps, including:

- Giant Burrowing Frog.
- Giant Dragonfly.
- Leafless Tongue-orchid.
- Littlejohn's Tree Frog[20].
- Prickly Bush-pea.
- Stuttering Frog[20].

As detailed in Appendix C there is no plausible impact pathway between the Stage 1 and Stage 2 second workings and Coastal Upland Swamps. Refer to the BMP (WRPL 2022) for further consideration of impacts to threatened species.

Due to the low likelihood of occurrence of Stuttering Frog, this species is not considered further. Littlejohn's Tree Frog has a low likelihood of occurrence, however habitat has been assumed present within the Stage 2 EP area for the purposes of offsetting (WRPL 2022). Existing and additional baseline monitoring for Giant Burrowing Frog and Littlejohn's Tree Frog is described in the BMP (WRPL 2022). Monitoring for Giant Dragonfly is described in Section 4.5. Monitoring for Leafless Tongue-orchid and Prickly Bush-pea is undertaken as part of ecological monitoring (detailed field assessment), which is described in Section 4.3.3.

[20] Low likelihood of occurrence



Legend

- UEP area
- RV East old longwall workings
- Pillars
- Past workings

Mine plan

- Stage 1
- Stage 2
- Future stages

EP areas

- Stage 1
- Stage 2

Swamp survey status

- 1A
- 1B
- 2
- 3
- 4

Vegetation Sub-Communities

- MU42,Upland Swamps: Banksia Thicket
- MU43,Upland Swamps: Tea-Tree Thicket
- MU44a,Upland Swamps: Sedgeland-Heath Complex (Sedgeland)
- MU44b,Upland Swamps: Sedgeland-Heath Complex (Restioid Heath)
- MU44c,Upland Swamps: Sedgeland-Heath Complex (Cyperoid Heath)

Figure 14 Coastal Upland Swamps

0 100 200 300 400 500

Metres

Scale: 1:15,000 @ A3

Coordinate System: GDA 1994 MGA Zone 56

N

biosis

Matter: 36747,
Date: 10 June 2022 ,
Prepared for: CBH, Prepared by: AM, Last edited by: amackegard
Layout: F14_CoastalUplandSwamp_EParea
Project: P:\36700s\36747\Mapping\
36747_WCL_Stage2_USMP_figures.aprx

6 PERFORMANCE MEASURES AND CRITERIA

Performance measures for the EP area and broader UEP are outlined in Schedule 2 Condition C1 Table 5 of the Development Consent. Performance measures relevant to Coastal Upland Swamps are the same performance measures relevant to Biodiversity and are reproduced in Table 20 below.

Table 20 Coastal Upland Swamp Performance Measures

Feature	Performance Measures	Performance Indicators	Monitoring
Swamps			
Coastal Upland Swamps identified in the figure in Appendix 5 of DC MP09_0013	Negligible environmental consequences including negligible change to the structural integrity of the bedrock base or any controlling rockbar of the swamp	▪ Observed land subsidence above threshold level. ▪ Change in species abundance. ▪ Change in vegetation condition. ▪ Change in species composition. ▪ Water holding capacity of swamp.	▪ GNSS and LiDAR subsidence monitoring and analysis. ▪ Baseline LiDAR and aerial imagery analysis. ▪ Observational monitoring. ▪ BAM plots. ▪ Vegetation transect monitoring. ▪ Soil moisture. ▪ Groundwater levels within swamps. ▪ Groundwater quality within swamps. ▪ Swamp outflow (quality and quantity).
All Coastal Upland Swamps (EPBC 2020/8702)	Vertical subsidence not to exceed 100 mm at any swamp	▪ Vertical subsidence relative to pre-mining.	▪ GNSS and LiDAR. ▪ Absence of any change in underground condition which would indicate greater than predicted levels of subsidence.
Biodiversity			
Threatened species, threatened populations, or EECs	Negligible environmental consequences	▪ Change in species abundance. ▪ Change in swamp size.	▪ Vegetation transect monitoring. ▪ BAM Plots. ▪ Observational monitoring. ▪ Giant Dragonfly targeted surveys. ▪ Amphibian monitoring (Giant Burrowing Frog, Refer to the BMP). ▪ LiDAR survey and swamp extent mapping.

Negligible environmental consequences are defined by the DC MP09_0013 as '*small and unimportant, such as not worth considering*'. The detection of changes to shallow groundwater or swamp vegetation as a result of UEP extraction beyond that considered negligible at any Coastal Upland Swamp would trigger the need for additional ecological assessment and monitoring and adaptive management measures detailed in Section 7.3 and Appendix D.

Triggers that indicate a potentially greater than negligible change are outlined below:

- Coastal Upland Swamp vegetation monitoring:
  - Significant statistical difference between control and impact sites or between before and after mining at the control sites (one year duration – first year after mining commences).
  - Minimal dieback recorded during observational monitoring.
- Giant Dragonfly monitoring:
  - Decline in exuviae numbers observed when compared to control sites. Decline is one year duration, and in the absence of changes in other parameters.
- Swamp groundwater quality (two consecutive readings above the trigger, or below for pH):
  - pH 3.8 – 6.3 (based on 5th/95th percentile of combined baseline swamp water quality data).
  - EC max 193 uS/cm (based on 95th percentile of combined baseline swamp water quality data).
- Swamp groundwater level (two consecutive readings outside the trigger level, for periods with monthly rainfall exceeding 20 mm):
  - For existing swamp sites - 95th percentile of site-specific baseline depth to groundwater, calculated with dry readings excluded.
  - For new swamp sites – default standing water level (water depth) trigger of 0.57 mbgl, based on 50th percentile baseline data for saturated RVE swamps water level (below groundwater level).
- Swamp surface water outflow quality (one sample outside the trigger range):
  - pH 4.8 - 6.3 (based on 5th/95th percentile of combined baseline swamp water quality data).
  - EC 30-350 µS/cm (ANZG 2018) (DGV – upland rivers).
  - These swamp piezometer triggers can be directly applied to any newly installed piezometers as they are based on grouped swamp baseline data.

If greater than negligible impacts are identified during subsidence, groundwater or ecological monitoring, the swamp vegetation transect, Giant Dragonfly monitoring will continue (as applicable) for a suitable duration to be determined in consultation with DCCEEW, the BCD and relevant authorities. This additional monitoring will assist in determining the magnitude of any impact to Coastal Upland Swamps and identifying whether impacts are ongoing to assess the need for any further monitoring and to inform suitable environmental management responses (Section 7.3, Table 23).

If triggered, in line with the above, additional LiDAR analysis would be undertaken at two or five years post extraction, to be determined in consultation with BCD or DCCEEW. This will assist in enabling an assessment of any impact to swamp extents over longer term timescales and

evaluate the need for continued or further monitoring and management actions. Performance measures to assess impacts to swamp extent or sub-community extents are detailed in Section 7.3 and Table 23 should the need for further assessment be triggered.

7 MITIGATION AND MANAGEMENT STRATEGIES

The second workings will not result in any direct impacts to the ecological features identified in the EP area other than minor impacts associated with the installation of monitoring equipment. The management of these minor impacts will be undertaken through the approval process from WaterNSW associated with activities carried out in the WaterNSW Special Area.

Any potential indirect impacts to biodiversity have been avoided by careful mine planning with the current mine plan unlikely to result in significant or detectable impacts to any threatened species or community listed under the EPBC Act or BC Act. It should be noted that the bord and pillar mining method is flexible, can be adapted to different strata conditions and be revised to mitigate or avoid potential surface impacts in response to ongoing hazard assessments and monitoring of strata conditions.

Rehabilitation and remediation measures to remedy subsidence impacts have been outlined in NSW Planning Assessment Commission (2010) and NSW Department of Planning (2008). In creeks or watercourses with naturally high sediment loads it is likely that fracture networks will fill naturally and require little, if any, intervention. However, creeks, watercourses or swamps without naturally high sediment loads will require intervention. Rehabilitation and remediation options for Coastal Upland Swamps are further outlined below.

7.1 Proposed measures to avoid or reduce impacts on swamps

The proposed measures to avoid and reduce potential impacts on Coastal Upland Swamps and associated biodiversity values from the UEP Extraction area include:

- Selected mining methodology (revision from longwall to bord and pillar mining methods) and a pillar design that is long term stable and has a high factor of safety.
- Flexibility in bord and pillar mining method allows for rapid response to changes in loading and other circumstances, providing a more responsive adaptive management system to protect environmental values.
- Monitoring and implementation of contingency actions and remediation measures, as necessary, if observed impacts are greater than predicted.

7.2 RVC Environmental Management Strategy

RVC operate under the RVC Environmental Management Strategy (RVC EMS, RVC EC STD 001) which provides a framework to ensure activities at WRPL are undertaken in an environmentally responsible manner and in general accordance with the following:

- Russell Vale Revised Preferred Underground Expansion Project Development Consent MP09_0013.
- ISO14001 Environmental Management Standard.
- Legislative and other requirements.

While the EMS includes general requirements for the reporting and management of incidents, the EP provides specific requirements in relation to the management of subsidence related impacts associated with the mining of the second workings covered by the EP (i.e. PC07-08, PC21-25 and PC27-34) and the EP requirements (including the requirements set out in this management plan) prevail to the extent of any inconsistency between documents.

7.3 TARPs

In accordance with Schedule 2 Condition C10(g)(viii) of the DC MP09_0013, the EP and associated sub plans will identify TARPs to be implemented to manage potential impacts associated with underground mining.

These TARPs include the following:

- Monitoring requirements (may include different locations).
- Trigger levels that indicate a potential non-compliance or flag implementation of contingency measures.
- Management and contingency actions (i.e. corrective and preventative actions) and reporting requirements.
- Responsibilities.
- Timing.

TARPs for upland swamps, as presented in Appendix D, have been designed specifically in consideration of baseline conditions and predicted subsidence impacts. These TARPs detail how the various predicted subsidence impacts, monitoring components, performance measures, and responsibilities are structured to achieve compliance with the relevant statutory requirements. They also form the framework for adaptive management and contingency actions. These TARPs relate to subsidence related impacts and are based on the management of predicted impacts associated with subsidence up to the 300 mm permitted under the DC MP09_0013. As noted earlier, this level of vertical subsidence is predicted to have no more than negligible impacts on any sites. The USMP includes specific TARPs associated with the monitoring and management of subsidence impacts and these include a requirement to halt operations in certain circumstances, including where observed subsidence impacts are approaching the 300 mm vertical subsidence limit.

The TARP system provides a simple, transparent and useable reference of the monitoring of environmental performance and the implementation of management and/or contingency measures. Due to the nature of predicted impacts associated with the proposed second workings, Performance Measure TARPs have been established under this USMP.

The Performance Measure TARPs are designed with consideration of baseline conditions and predicted negligible subsidence impacts from the mine design and or the Russell Vale surface facilities design. The TARPs for the upland swamps are comprised of trigger levels associated with monitoring to assess performance, and identify where there is a need for further investigation and, if required, the implementation of contingency measures (Table 23 in Appendix D). Table 21 below outlines the trigger level definitions to be applied to the TARPs provided within Appendix D.

Table 21 Extraction Plan Trigger Levels

Trigger Level	Description
Level 1	Monitoring indicates performance criteria are satisfied. Operations continue as normal.
Level 2	Minor or persistent changes in monitoring results indicate potential alteration of the environment (could be natural or mining related) or impacts outside of predictions.

Trigger Level	Description
	Internal investigation of potential causes required to determine if there is potential to cause material harm due to mining operations. Exceedances of subsidence triggers may result in implementation of adaptive management measures.
Level 3	Significant change in monitoring results indicate a likely alteration of the environment (could be natural or mining related) or impacts outside of predictions. Investigation into potential causes required to determine if material harm has been caused due to mining operations. External notification of *potential* incident required for Performance Measures TARPs. Exceedances of subsidence triggers likely to result in implementation of adaptive management measures, including the temporary cessation of mining operations in the area where subsidence triggers are exceeded.

If monitoring indicates a Level 2 or 3 trigger has been reached, an investigation will occur in all circumstances. The nature of the investigation will depend on the feature being monitored, the location of the trigger exceedance and Trigger level exceeded among other matters. Different investigation options are discussed in detail in the management plans specific to the feature being monitored.

Note: Level 3 TARP triggers do not, of themselves, constitute an incident or non-compliance under the Development Consent. Investigations following a Level 3 trigger will determine whether an exceedance or non-compliance of the performance measures or Development Consent conditions is likely or has occurred.

Whilst significant impacts are not predicted, the TARPs provide a process of tiered and escalating trigger levels/performance triggers for performance measures should subsidence and associated impacts be greater than predicted/approved. Exceedances of both Level 2 and Level 3 triggers MAY indicate a change in environmental conditions that constitutes material harm. The material harm threshold would also be a performance measure exceedance if the investigation indicates that the change in environmental condition observed is attributable to the mining approved under the UEP. The TARPs will also include adaptive management measures associated with action to prevent future exceedances from occurring or mitigating the extent of any harm cause if associated with mining but these are largely reactive measures. The TARPs addressing subsidence do however include an element of proactive control as these TARPs are based around subsidence predictions and frequent monitoring of observed underground conditions and surface subsidence against those predictions.

Figure 15 below provides a flow chart covering the TARP process. If monitoring indicates a Level 2 or 3 trigger has been reached, an investigation will occur in all circumstances. The starting point in any investigation will be confirmation of monitoring data. The nature of the investigation will depend on the feature being monitored, the location of the trigger exceedance and trigger level exceeded among other matters. Different investigation options are discussed in detail in the management plans specific to the feature being monitored.

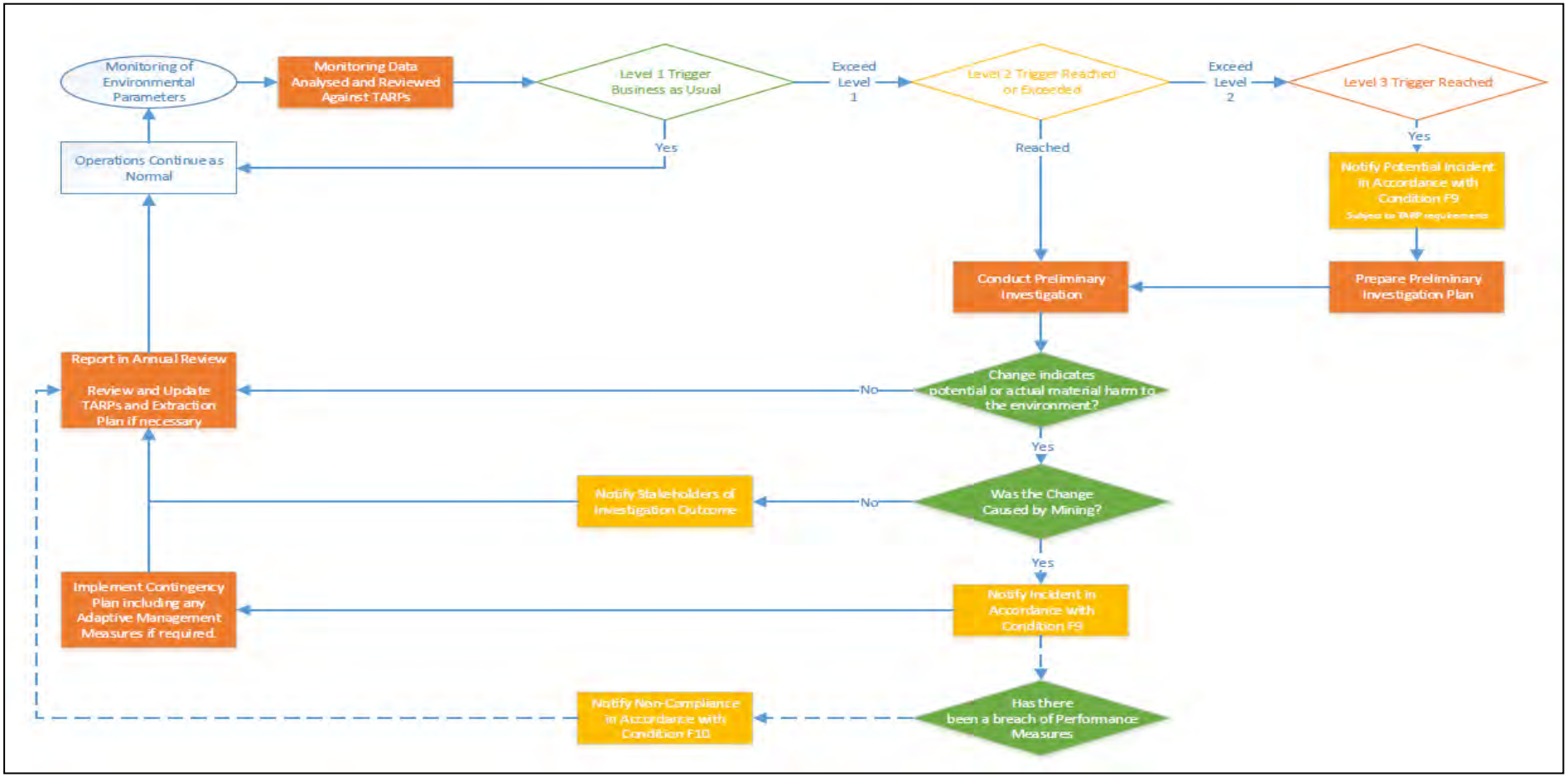
In the unlikely event that investigations of Level 3 TARP trigger exceedances determine that material harm has occurred *and* is attributable to the development approved under DC MP09_0013, the contingency plan and adaptive management measures outlined within Section 7.3.1 will be implemented. Adaptive management measures will also be implemented in most instances of an exceedance of Level 3 subsidence TARP triggers, even in the absence of

material harm. In certain cases, management measures may be implemented in the absence of any clear link between the approved development and the observed impact to mitigate adverse environmental outcomes. Response to matters which are identified as Incidents or Non-Compliances will be implemented in consultation with relevant stakeholders.

Investigations regarding potential causes of any observed changes in swamps may include a range of different methods which will be identified based on the particular swamp and data available. Additional monitoring may also be required to supplement the existing monitoring and could include additional monitoring sites and/or increased monitoring frequency. Separate Level 2 and Level 3 triggers for a review of swamp monitoring or increased frequency of data collection or analysis are also established in relation to exceedances of subsidence criteria. These investigation triggers are established under the subsidence TARPs contained in the Plan and the Subsidence Monitoring Plan. The TARP criteria set out in Appendix D will be applied to any additional or increased frequency of monitoring data.

Following the completion of the monitoring period associated with mining under CCUS1, the ongoing need for a TARP related to the Giant Dragonfly will be reviewed given the impacts on this species will be a lagging indicator relative to both the vegetation and groundwater monitoring being undertaken. Giant Dragonfly monitoring will however be maintained for the course of the UEP and will be reported in annual reporting and as part of any Level 3 investigation of impacts observed to swamps of swamp vegetation.

Figure 15 Performance TARP Process



7.3.1 Adaptive management

Where investigations triggered by the Performance Measure TARPs indicate that the changed conditions of sites have been, or are likely to have been, caused by mining operations, the response to these impacts include adaptive management measures to ensure further impacts to the site will not occur or be mitigated or that impacts to future sites do not occur in the future.

Due to the nature of the proposed mining and low likelihood of underground mining resulting in any impacts to the site provided subsidence impacts remain within predictions, these adaptive management measures that will be implemented, will be considered in the investigation process. Adaptive management measures to be implemented in the event of a clear linkage between the mining authorised under Development Consent MP09_0013 and potential impacts to upland swamps will include a review of the design and layout of future mining within areas that may potentially impact on such items to avoid a recurrence of any such impacts. These adaptive management measures include:

- Stop mining and investigate causes of the exceeding of subsidence predictions.
- Undertake a review of the panel design parameters in consultation with the resource regulator.

The Contingency Planning process set out in Section 7.5 also covers this process.

The TARPs in Appendix D contain adaptive management measures for subsidence which inform decisions regarding underground mining operations, should higher than predicted vertical subsidence effects be observed. The purpose of this adaptive management measures are to implement additional measures where necessary to:

- Enable potential impacts associated with higher than predicted subsidence impacts to be monitored.
- The implementation of changes in mining operations to prevent performance criteria from being exceeded.

WRPL will assess and manage development-related risks to ensure that there are no exceedances of the criteria and/or performance measures in Development Consent MP09_0013 in accordance with Condition F4 of Schedule 2. Any exceedance of the Subsidence criteria and/or performance measures constitutes a breach of Development Consent MP09_0013 and may be subject to penalty or offence provisions under the EP&A Act or EP&A Regulation, notwithstanding offsetting actions taken. Where any exceedance of these criteria and/or performance measures has occurred, WRPL will at the earliest opportunity to the satisfaction of the Secretary:

- Take all reasonable and feasible steps to ensure the exceedance ceases and does not re-occur.
- Consider all reasonable and feasible options for remediation (where relevant) and submit a report to the Department describing those options and any preferred remediation measures or other course of action.
- Within 14 days of the exceedance occurring, submit a report to the Secretary describing these remediation options and any preferred remediation measures or other course of action.
- Implement remediation measures as directed by the Planning Secretary.

In the event of Level 3 Subsidence TARP exceedances, mining in the immediate area of the observed trigger exceedance must cease. Consistent with obligations under EPBC 2020/8702, operations must not recommence in that area unless it can be demonstrated that further exceedances of the Level 3 subsidence TARP criteria will not occur. Such an exceedance will also trigger a review of Level 2 Subsidence TARP Triggers.

7.4 Potential incident notifications

Level 3 triggers in TARP are set at a level that may indicate more than trivial environmental harm. Where monitoring indicates a Level 3 TARP trigger has been exceeded but the cause of the trigger being exceeded is unclear, DPE (and other relevant stakeholders) will be notified of a *potential* Incident. The notification will include the same matters required to be included in an Incident Notification as required by Condition F9 including the development (including the development application number and name) and set out the location and nature of the potential incident.

Unless the cause of the exceedance is clearly identifiable at the time the exceedance, the first step will be to investigate the likely cause or causes of the exceedance. A preliminary investigation plan will be developed to guide this investigation process and a copy provided to DPE and other relevant stakeholders. This is discussed further in Section 7.3.

The exception to this is an exceedance of a Level 3 Subsidence TARP exceedance over, in in the near vicinity of active second workings. In such an event, the presumption will be that the TARP exceedance does constitute an exceedance of a Performance Criteria and is an Incident. Consistent with TARP requirements, an investigation of the potential cause of the exceedance will still be undertaken.

The investigation process will also consider any remedial action that may be required.

7.5 Contingency plan

In the event that the observed parameters or impacts exceed or are considered likely to exceed the performance measures detailed in Section 3.2.1 and the TARPs within Appendix D of this Plan, WRPL will implement the following contingency plan:

- The observation will be reported to the Group Environment Manager within 24 hours.
- The observation will be recorded.
- An investigation will be undertaken to identify the cause of the observed impacts.
- WRPL will report any exceedance of the performance measure to the BCD, DCCEEW and other relevant stakeholder as soon as practicable after Wollongong Coal becomes aware of the exceedance.
- WRPL will assess the exceedances referred to in the TARP (Appendix D) and where appropriate, implement safety measures in accordance with the appropriate Management Plan/s.
- The Group Environment Manager will investigate any potential contributing factors and identify an appropriate action plan to manage the identified impact(s), in consultation with specialists and/or relevant agencies if necessary.
- Wollongong Coal will develop an appropriate action plan to manage the identified impact(s), in consultation with other specialists and/or key stakeholders.

- Wollongong Coal will submit the proposed course of action to the BCD, DCCEEW for approval.
- Wollongong Coal will implement the approved course of action to the satisfaction of the BCD and DCCEEW.
- Wollongong Coal will continue to monitor performance with the new action plan in place and, if successful, will formalise these actions as part of the Management Plan.

Contingency measures will be developed in consideration of the specific circumstances of the issue and the assessment of consequences.

If either it is not reasonable or feasible to remediate the impact, or remediation measures implemented by WRPL have failed to satisfactorily remediate the impact, WRPL will provide a suitable offset to compensate for the impact, to the satisfaction of the Secretary of DPE in accordance with Section 7.8.

7.6 Investigation tools

In the event that Level 2 or 3 TARP Triggers are exceeded, an investigation into the potential cause of trigger exceedances will be undertaken.

Unless the cause of the exceedance is clearly identifiable at the time the exceedance, the first step will be to investigate the likely cause or causes of the exceedance.

A preliminary investigation plan will be developed to guide this investigation process and a copy provided to DPE and other relevant stakeholders.

There is a suite of monitoring undertaken than can inform the investigation into potential causes of level 2 and 3 trigger exceedances including:

- Subsidence monitoring, including review of historical LIDAR/DInSAR/GNSS data.
- Groundwater monitoring.
- Soil moisture monitoring.
- Vegetation monitoring and observational monitoring, including photo-points.
- Water quality and flow monitoring.
- Observation of underground mining conditions.

A comparison of impact swamp data with control site swamp data relevant to potential causal pathways of any observed changes will be a key aspect of identifying whether any observed changes in a swamp are attributable to the mining below or adjacent to the swamp.Only the swamp piezometers installed within CCUS1, CCUS 5 and CCUS 20 will be used for swamp groundwater performance indicator trigger monitoring. If changes in swamp water levels are observed which differ to those in non or less impacted monitoring sites, further investigation into the cause of such change may be required depending of the location and extent of change observed. The monitoring of water levels, water quality and moisture within swamps will inform these investigations. Further soil moisture probes and shallow swamp piezometers can also be installed if required to provide further data regarding water and moisture levels within the swamps where changes have been observed. This analysis can also be supported through the use of environmental water tracers, where appropriate, to assess the potential for any leakage

from a swamp or humic soils to the underlying sandstone, and/or assess direct rain recharge to adjacent sandstone followed by lateral groundwater flow to beneath a swamp or shallow soils.

Swamp specific water balances can be developed based on the data collected if these are considered to be of benefit to the investigation of potential causes of any observed changes in swamp groundwater regimes.

7.7 General mitigation measures

Due to the low levels of predicted subsidence, significant mitigation efforts are considered unlikely. Even in the event of an exceedance of subsidence performance measures, the likely surface impacts as a result of such an exceedance are unlikely to be significant given the nature of mining proposed. The absence of any likely causal impact pathways means the identification of specific management measures that will be implemented under specific scenarios is not reasonable or feasible but will instead be investigated at the time of any identified impact and confirmation of causation attributable to mining.

The specific mitigation of any impacts will depend on a range of factors including:

- The location of the impact.
- Nature and magnitude of the impact.
- Risk of further adverse impacts (including downstream impacts) that may arise from the observed impact and potential mitigation options.
- Approval requirements and timeframe for different mitigation options.

These factors will be considered as part of the impact mitigation process discussed with stakeholder as a part of the Incident and investigation processes.

7.8 Offsets

The Development Consent MP09_0013 states under Condition C4 that if the performance measures (Section 6) are exceeded and the Secretary determines that it is not reasonable or feasible to remediate the subsidence impact or environmental consequence; or remediation measures have failed to satisfactorily remediate the subsidence impact or environmental consequence, then Wollongong Coal must provide a suitable offset. Under Condition C5 any offsets for biodiversity and swamps must be undertaken in accordance with the Biodiversity Offsets Scheme of the BC Act.

In the event that offsets are required. Wollongong Coal will prepare a Biodiversity Offset Plan that will fulfil the requirements of Condition C4, C5 and C6 of MP09_0013. This plan will be informed by the updated baseline data collected during the LiDAR analysis and field inspection including the BAM plot data collected prior before any mining under swamps, as well and any ongoing monitoring data collected.

As required by EPBC Consent Condition 18, Wollongong Coal will provide details of the offsets approved by the NSW Planning Secretary to DCCEEW within 10 days of the approval being given.

8 INCIDENTS, COMPLAINTS AND NON-CONFORMANCES

8.1 Incidents

The Consent defines an 'incident' to be "An occurrence or set of circumstances that causes or threatens to cause material harm and which may or may not be or cause a non-compliance". Incidents will be managed through established WRPL procedures. In accordance with Condition F9 WRPL must "immediately notify the DPE and any other relevant agencies immediately after it becomes aware of an incident". The notification must identify the following items:

- The development application number and name.
- The location and nature of the incident.

A detailed report of the incident shall be provided to DPE within 7 days of the incident occurring.

As discussed in Section 3, the proposed 'second workings' which trigger the requirement for this EP are long term stable bord and pillar workings which are predicted to have only negligible subsidence effects. The Performance Management TARP Process will be implemented with a *Potential* Incident notification being made and an investigation being carried out to determine whether the impacts has been caused by development approved under Development Consent MP09_0013. Formal incident notification, as required by Condition F9 will occur if the investigation indicates that the event has likely been cause by the development and has caused material harm (i.e. more than trivial) to the feature.

All incident notification related to Coastal Upland Swamps will be sent to DPE, and BCD. Incident notifications related to surface or groundwater impacts or which may have consequent impacts of groundwater or surface water will also be provided to WaterNSW.

Exceedances of the 100 mm Coastal Upland Swamps vertical subsidence performance criteria will be notified to the DCCEEW within two days of the exceedance being detected.

8.2 Non-compliance protocol

A non-compliance is defined as an occurrence or set of circumstances that is a breach of Development Consent MP09_0013. Except in the case where a non-compliance has been notified as an incident, WRPL will, within seven days of becoming aware of the non-compliance, notify DPE of the non-compliance.

The notification must set out:

- The condition of this consent that the development is non-compliant with.
- Why it does not comply, and the reasons for the non-compliance (if known).
- What actions have been, or will be, undertaken to address the non-compliance.

WRPL will manage and report non-compliances against statutory requirements in accordance with an established protocol developed as a component of the EMS (in the case of pit top and associate activities) and/or the EP.

8.3 Complaints handling

Complaints will be managed through established WRPL procedures as described in Section 4.7 of the EMS as required by Condition F5(h) of the Consent. All complaints will be logged with the Group environment manager responsible for ensuring that all complaints are appropriately investigated, actioned and that information is fed back to the complainant, unless requested to the contrary. A copy of a complaints register (updated on a monthly basis) will be kept on the WRPL website.

A summary of complaints will be available to regulatory authorities on request and provided in the Annual Environmental Management Reports (AEMRs).

9 REPORTING

The Reporting Framework set out in Section 5.2 of the EP will apply to the implementation of this Plan. This reporting framework includes:

- Incident reporting.
- Quarterly groundwater and surface water reporting.
- Six monthly reporting.
- Impact reporting (in the event of an observed impact associated with the development covered by the EP).
- Annual Review reporting requirements.

Data collected in accordance with this Plan will be reviewed to support early detection of trigger exceedances and potential impacts related to mine activities. The review includes details on any reporting requirements in accordance with the TARP, and any recommendations for additional data collection or review (if required) to support a targeted trigger investigation.

This annual ecological monitoring report will be provided to WRPL by their ecological consultants in July each year for incorporation into annual reporting, as required below.

An annual review of the environmental performance of the project is required under Condition F11 of Development Consent MP09_0013. This review is to include a comprehensive assessment of monitoring results to date and analyses of data collected to date. Within three months of the submission of the annual report a review of the management plans, including this USMP, must be undertaken. This review will be used to modify any monitoring requirements of the project, including outlining monitoring locations for terrestrial and aquatic species.

10 PLAN ADMINISTRATION

10.1 Roles and responsibilities

Environment and community management is regarded as part of the responsibilities of all Colliery personnel. The roles and function of the main personnel responsible for the implementation of environmental and community management including the plans, procedures and action plans contained in this USMP are outlined in WRPLs Management Operating System and the site EMS Section 9.1.3. and 9.1.4 which notes the Monitoring Coordinator to undertake or coordinate monitoring as required.

10.2 Resources required

In accordance with the WRPL SYS POL 003 Environmental Policy, the Operations Manager shall ensure that the appropriate resources are made available to achieve the implementation of this Plan in addition to the authority to stop and/or recommence works.

It is the role of the Group Environment Manager to ensure that these requirements are communicated to WRPL Management, investigate any potential items and identify an appropriate action plan to manage the identified impact(s), in consultation with specialists and/or relevant agencies if necessary, and/or DPE.

10.3 Training and awareness

All training and inductions conducted are to be undertaken as per the WRPL Training procedures.

As per Condition A28, WRPL must ensure that all employees, contractors and their subcontractors be made aware of, and are instructed to comply with, the consent conditions relevant to activities they carry out in respect of the development.

Project Leads and Surface Staff will inform the Group Environment Manager of any actual or potential finds and stop work immediately. Undertake biodiversity training as part of the risk assessment process, including:

- Training will be provided as deemed necessary to contractors to provide them with the knowledge, skills and awareness with regard to any potential for impact to Coastal Upland Swamps.
- Requirements of this USMP, the management and mitigation measures, and relevant legislation.
- Penalties associated with non-compliance with this USMP.
- Specific measures to avoid or otherwise protect the sites from impact.

10.3.1 Staff training

Staff training will be undertaken as detailed in the EMS to ensure all workers receive suitable biodiversity training relative to their level and their intended activities prior to carrying out any activities which may cause impacts to Coastal Upland Swamps. Suitable records would be kept of such training in line with WRPL training procedures.

Training includes:

- Level 1 – High level training regarding environmental requirements – Management, including awareness of the requirement to ensure suitable training for all workers whose activities have the potential to cause impacts to Coastal Upland Swamps.
- Level 2 – Operational level training – Project Managers, Supervisors, Surface Personnel, Contractors including awareness of the requirement to ensure suitable training for all workers whose activities have the potential to cause impacts to Coastal Upland Swamps.
- Level 3 – Basic environmental awareness – All staff.

10.3.2 Inductions

All contractors and associated subcontractors will be required to participate in site induction prior to the commencement of work as described in Section 5.2 of the EMS.

As a minimum, the induction is to include:

- An overview of the mandatory site HSECQ Rules, Environment Policy and PEMS requirements.
- Environmental incident and community compliant reporting requirements.
- Environmental emergency contact details.

Induction records, which detail the attendees, content of the induction/training as well as any additional information provided, will be maintained onsite.

11 AUDIT AND REVIEW

In accordance with Condition F11 of the DC, an Annual Review of the environmental performance of the UEP is prepared.

The Annual Review will act to investigate and implement ways to improve the environmental performance of the development over time by:

- Describing the development (including any rehabilitation) that was carried out in the previous calendar year and the development that is proposed to be carried out over the current financial/calendar year.
- Including a comprehensive review of the monitoring results and complaints records of the Project over the past year, including a comparison of these results against the:
  - Relevant statutory requirements, limits or performance measures/criteria.
  - Requirements of any plan or program required under this consent.
  - Monitoring results of previous year/s.
  - Relevant predictions in the document/s listed in Condition A2(c).
  - Identify any non-compliance over the last year, and describe what actions were (or are being) taken to ensure compliance.
- Identify any non-compliance or incident which occurred in the previous calendar year, and describe what actions were (or are being) taken to rectify the non-compliance and avoid reoccurrence.
- Evaluate and report on:
  - The effectiveness of the noise and air quality management systems; and
  - Compliance with the performance measures, criteria and operating conditions of this consent.
- Identify any trends in the monitoring data over the life of the Project.
- Identify any discrepancies between the predicted and actual impacts of the UEP and analyse the potential cause of any significant discrepancies.
- Describe what identified measures will be implemented over the next calendar year to improve the environmental performance of the development.

Copies of the annual review will be submitted to WCC, WSC and made available to the CCC and any interested person upon request and will be made public via listing on the website.

11.1 Auditing

In accordance with Condition F13, an Independent Environmental Audit will be undertaken by a suitably qualified auditor and include experts in any field specified by the Secretary. The timeframe and scope of the audit are defined in Section 5.2 of the EMS.

11.2 Plan revision

In accordance with Condition F7, this USMP will be reviewed within three months of:

- The submission of an incident report under Condition F9.
- The submission of an annual review under Condition F11.
- The submission of an independent environmental audit under Condition F13.
- The approval of any modification of the conditions of the Development Consent (unless the conditions require otherwise).
- In accordance with the future Extraction Plan staging, i.e. prior to Stage 3 EP.

The suitability of existing strategies, plans and programs required under Development Consent MP09_0013 will be reviewed by WRPL.

In accordance with Condition F8, if necessary, to either improve the environmental performance of the project, cater for a modification or comply with a direction, the strategies, plans and programs required under Development Consent MP09_0013 will be revised, to the satisfaction of the Planning Secretary.

Where revisions are required to ensure the required updates are included as required, the revised document incorporating the relevant updates as above will be submitted to the Planning Secretary for approval within 6 weeks of the review.

Revisions to any documents listed within this Plan will not necessarily constitute a revision of this document.

12 RECORDS AND DOCUMENT CONTROL

12.1 Document control

Any material revisions undertaken will be the responsibility of WRPL and any notifications will be sent accordingly to DCCEEW, BCD, DPI Water, Water NSW and DPE.

During the next major update of the plan as would likely be associated with subsequent EPs, further consultation with the identified stakeholders will be sought and the plan will be amended accordingly.

WRPL will not be responsible for maintaining uncontrolled copies beyond ensuring the most recent version is maintained on WRPLs computer system, website, and hard copy at the RVC, 7 Princes Highway, Corrimal NSW 2518.

12.2 Record keeping and control

Environmental records are to be managed in accordance with the WRPL SYS PRO 001 Document and Data Control procedure.

All records of the EMS will be stored so that they are readily retrievable and suitably protected from deterioration or loss. Archiving will be managed in accordance with the WRPL SYS PRO 001 Document and Data Control procedure.

A master copy of each EMS document including all appendices and supporting information is to be held in the office of the E&C Department.

12.3 Information access

Before the commencement of construction until the completion of all rehabilitation required under Development Consent MP09_0013 WRPL will ensure the information and documents as stipulated in Condition F17 and the EMS, are made publicly available on its website as they are obtained, approved or as otherwise stipulated within the conditions of Development Consent MP09_0013.

This information must be kept up to date to the satisfaction of the planning secretary.

12.4 Public sources of information

To assist the public and other stakeholders understand the impacts from the development, including monitoring results, newsletters and updates, and in accordance with Condition F5(i), WRPL will:

- Publish information on the company website.
- Notify the local community through the Russell Vale CCC.
- Contact individuals by direct notification (email subject to registration of interest) where relevant.

Information required to be published in accordance with Condition F17, such as CCC minutes, current statutory approvals and complaints register will also be included on the company website.

This information will be updated as required.

13 REFERENCES

Analytical Edge 2020. *Analysis of flora data set 2 at Russell Vale East - Data collected up to, and including, 2019*, Potts, J. The Analytical Edge Statistical Consulting.

Analytical Edge 2021. *Analysis of RV East flora data for Biosis*, Potts, J. The Analytical Edge Statistical Consulting.

ANZECC & ARMCANZ 2000. *Australian and New Zealand Guidelines for Fresh and Marine Water Quality 2000*, Australian and New Zealand Environment and Conservation Council and Agriculture and Resource Management Council of Australia and New Zealand, Canberra, ACT. https://www.waterquality.gov.au/sites/default/files/documents/anzecc-armcanz-2000-guidelines-vol1.pdf.

ANZG 2018. *Australian and New Zealand Guidelines for Fresh and Marine Water Quality*, Australian and New Zealand Governments and Australian state and territory governments, Canberra ACT, Australia. Available at www.waterquality.gov.au/anz-guidelines.

Biosis 2012. *NRE No. 1 Colliery Major Expansion: Upland Swamp Impact Assessment*, Report prepared for Gujarat NRE Coking Coal Ltd. Authors: Garvey. N, Biosis Research Pty Ltd, Wollongong, NSW. Project no. 15094.

Biosis 2014a. *Russell Vale Colliery – Underground Expansion Project: Preferred Project Report - Biodiversity*, Report prepared for Wollongong Coal Ltd. Authors: Garvey. N, Beyer. K, Biosis Pty Ltd, Wollongong, NSW. Project no. 16646.

Biosis 2014b. *Underground Expansion Project EPBC Referral (EPBC2014/7268): Coastal Upland Swamp Impact Assessment Report*, Report prepared for Wollongong Coal Ltd. Authors: Garvey. N, Biosis Pty Ltd, Wollongong, NSW. Project no. 14860.

Biosis 2020. *Russell Vale East terrestrial ecological monitoring program: Annual Report 2019*, Report for Wollongong Coal Limited. Author: Stone, L. Biosis Pty Ltd, Wollongong, New South Wales. Project no. 29636.

Biosis 2021. *Russell Vale East Terrestrial Ecological Monitoring Program 2020*, Report prepared for Wollongong Coal Ltd. Authors: Stone. L, Price. P, Cerato. S, Biosis Pty Ltd, Wollongong, NSW. Project no. 31686.

Bolker BM, Brooks ME, Clark CJ, Geange SW, Poulsen JR, Stevens MHH, & White JSS 2009. 'Generalized linear mixed models: a practical guide for ecology and evolution', *Trends in Ecology and Evolution*, 24, 3: 127–135.

DoP 2008. Impacts of underground coal mining on natural features in the Southern Coalfield: Strategic review, State of NSW through the NSW Department of Planning.

DPIE 2020. *Biodiversity Assessment Method (BAM)*, Department of Planning, Industry & Environment, https://www.environment.nsw.gov.au/research-and-publications/publications-search/biodiversity-assessment-method-2020.

Geoterra 2020. *Russell Vale Colliery Underground Expansion Project Russell Vale East first workings groundwater assessment*, Report prepared for Wollongong Coal Pty Ltd, Bellambi NSW.

Hydroalgorithmics 2020. *Russell Vale Colliery Underground Expansion Project - Groundwater Uncertainty Analysis*, Report prepared for Wollongong Coal Pty Ltd, Hawker ACT.

IAPUM 2020. *Advice Re: Russell Vale underground expansion project*, Report prepared by Independent Advisory Panel for Underground Mining, Available at: https://www.ipcn.nsw.gov.au/resources/pac/media/files/pac/projects/2020/08/russell-vale-underground-extension-project/statement-from-the-commission/additional-material/201123-in-iapum-advice.pdf.

IESC 2014. *Background Review: Subsidence from coal mining activities*, Independent Expert Scientific Committee on Coal Seam Gas and Large Coal Mining Development, Available at https://www.environment.gov.au/system/files/resources/1ebc143e-e796-453d-b9d6-00cdbbabdee3/files/background-review-subsidence-coal-mining.pdf.

NPWS 2003. *Native vegetation of the Woronora, O'Hares and Metropolitan catchments*, New South Wales National Parks and Wildlife Service, Sydney.

NRE 2013. *Underground Expansion Project: Preferred Project Report - Including Response to Submissions*, Report prepared by Natural Resources Environment on behalf of Gujarat NRE Coking Coal Ltd.

NSW Scientific Committee 2012. Coastal Upland Swamp in the Sydney Basin Bioregion - endangered ecological community listing final determination.

Office of Water Science 2020. *Environmental water tracers in environmental impact assessments for coal seam gas and large coal mining developments*, Prepared for the Independent Expert Scientific Committee on Coal Seam Gas and Large Coal Mining Development, http://iesc.environment.gov.au/publications/environmental-water-tracers.

PAC 2010. The PAC review of the Bulli Seam Operations Project, State of NSW through the NSW Planning and Assessment Commission.

SCT 2019. *Russell Vale Colliery: Subsidence Assessment for Proposed Workings in Wongawilli Seam at Russell Vale East*, Report to Wollongong Coal Pty Ltd, SCT Operations Pty Ltd, SCT report number: UMW4609, Wollongong.

SCT 2021. *Russell Vale Colliery: Subsidence Assessment for PC07-08 and PC21-25 Extraction Plan*, Report to Wollongong Coal Pty Ltd, SCT Operations Pty Ltd, SCT report number: WCRV5285_Rev3, Wollongong.

SCT 2022. *Russell Vale Colliery: Subsidence Assessment for PC27-34 (Stage 2) Extraction Plan*, Report to Wollongong Coal Pty Ltd, SCT Operations Pty Ltd, SCT report number: WCRV5385, Wollongong.

Wollongong Coal 2012. *NRE No. 1 Colliery Wonga East - Longwalls 4 & 5 SMP Subsidence Monitoring Plan*, Gujarat NRE Coking Coal Limited.

Wollongong Coal 2015. Russell Vale Colliery, Russell Vale East – Longwalls 6 & 7 Biodiversity Management Plan Rev06, Wollongong Coal Ltd, Russell Vale.

Wollongong Coal 2021a. *Russell Vale Colliery – Russell Vale East Pit Top – Revised Underground Expansion Project - Biodiversity Management Plan*, Wollongong Coal Ltd. Russell Vale, NSW.

WRPL 2022. *Russell Vale Colliery – Revised Underground Expansion Project – Extraction Plan – Upland Swamp Monitoring Plan*, Version 2-5, Wollongong Resources Pty Ltd. Russell Vale, NSW.

WRPL 2022b. *Russell Vale Colliery – Revised Underground Expansion Project – Water Management Plan – Groundwater Management Plan RVC EC PLN 006*, Wollongong Resources Pty Ltd, Russell Vale, NSW.

WRPL 2022c. *Russell Vale Colliery – Revised Underground Expansion Project – Water Management Plan RVC EC PLN 010*, Wollongong Resources Pty Ltd, Russell Vale, NSW.

14 GLOSSARY OF TERMS AND ABBREVIATIONS

Abbreviations

Abbreviations	
BACI	Before After Control Impact
BCD	Biodiversity Conservation Division within the DPE
BMP	Biodiversity Management Plan
DAWE	Commonwealth Department of Agriculture, Water and the Environment (now Commonwealth Department of Climate Change, Energy, the Environment and Water)
DC	Development Consent
DCCEEW	Department of Climate Change, Energy, the Environment and Water (formerly Commonwealth Department of Agriculture, Water and the Environment)
DPE	Department of Planning & Environment (formerly Department of Planning, Industry & Environment)
DPIE	Department of Planning, Industry & Environment (now Department of Planning & Environment)
EEC	Endangered Ecological Community
EES	NSW Environment, Energy and Science
E&C	Environment and Community
EP&A Act	Environmental Planning and Assessment Act 1979
EP	Extraction Plan
EPA	Environmental Protection Authority
EPL	Environmental Protection Licences
GDE	Groundwater Dependent Ecosystems
DInSAR	Differential Interferometric Synthetic Aperture Radar
IPC	Independent Planning Commission
LGA	Local Government Area
LiDAR	Light Detection and Ranging
Mtpa	Million tonnes per annum
NRAR	Natural Resources Access Regulator
NRE	Gujarat NRE Coking Coal Limited
OEH	Office of Environment and Heritage

Abbreviations	
OWS	Office of Water Science
PCT	Plant Community Type
ROM	Run of Mine
RVC	Russell Vale Colliery
TARP	Trigger Action Response Plan
USMP	Upland Swamp Monitoring Plan
WCC	Wollongong City Council
WCL	Wollongong Coal Limited (now Wollongong Resources Pty Ltd)
WRPL	Wollongong Resources Pty Ltd (formerly Wollongong Coal Limited)

Terms	
Bord and pillar mining method	Mining method comprising of a series of self-supporting roadways (or bords) within the coal seam leaving a grid of pillars of unmined coal which are designed to be stable in the long term.
Environmental Consequences	The environmental consequences of subsidence impacts, including: damage to built features; loss of surface water flows to the subsurface; adverse water quality impacts; development of iron bacterial mats; cliff falls; rock falls; landslides; damage to Aboriginal heritage sites; impacts on aquatic ecology; and ponding.
First Workings	Development of main headings, gate roads, related cut throughs and other workings for mine access and ventilation.
Incident	An occurrence or set of circumstances that causes or threatens to cause material harm and which may or may not be or cause a non-compliance.
Material Harm	Is harm to the environment that: ▪ Involves actual or potential harm to the health or safety of human beings or to the environment that is not trivial. ▪ Results in actual or potential loss or property damage of an amount, or amounts in aggregate, exceeding $10,000 (such loss includes the reasonable costs and expenses that would be incurred in taking all reasonable and practicable measures to prevent, mitigate or make good harm to the environment). This definition excludes "harm" that is authorised under either this consent or any other statutory consent.
Minor	Not very large, important or serious.
Mitigation	Activities associated with reducing the impacts of the project prior to or during those impacts occurring.
Negligible	Small and unimportant, such as to be not worth considering.

Terms	
Non-compliance	An occurrence, or set of circumstances, or development, that is a breach of the Revised UEP Development Consent.
Second Workings	Extraction of coal from bord and pillar workings.
Subsidence	The totality of subsidence effects, subsidence impacts and environmental.
Subsidence effects	Consequences of subsidence impacts.
Subsidence impacts	Deformation of the ground mass due to mining, including all mining induced.
Surface Facilities Site	Location of main surface infrastructure, including stockpiles and truck loading facilities (lower level) and administration offices, workshops and mine entries (upper level).
Planning Secretary	The Planning Secretary of the Department of Planning, Industry and Environment under the EP&A Act, or nominee.

APPENDIX A – AGENCY CONSULTATION

Our ref: DOC21/36991
Senders ref: Upland Swamp Ecological Monitoring Plan

Rebecca Dwyer
Team Leader- Ecology
Biosis
E-mail: RDwyer@biosis.com.au

Dear Ms Dwyer

Subject: Russell Vale Underground Expansion Project – Upland Swamp Ecological Monitoring Plan

Thank you for your referral dated 14 April 2021 via the NSW Major Projects Planning Portal. In response, we have prepared comments which are detailed at Attachment A.

In general, there are inconsistencies in the descriptions of the study design between the different sections of the report regarding control treatment and impact status. We consider that the report would be improved by consistency of these terms throughout. Furthermore, the descriptions of Trigger Action Response Plans (TARPs) and what monitoring parameters are being proposed is lacking clarity and in need of further explanation.

If you have any questions about this advice, please do not hesitate to contact Mr Calvin Houlison, Senior Conservation Planning Officer, via calvin.houlison@environment.nsw.gov.au or 4224 4179.

Yours sincerely

Chris Page 11 May 2021

Senior Team Leader. Planning (Illawarra)
Biodiversity & Conservation Division
Environment, Energy and Science

Attachment A: EES Detailed comments on Russell Vale UEP Upland Swamp Ecological Monitoring Plan

ATTACHMENT A: EES DETAILED COMMENTS ON RUSSELL VALE UEP UPLAND SWAMP ECOLOGICAL MONITORING PLAN

Section 3.1 Groundwater Monitoring

- Page 17: Please fix error in text reference to Table 3 and check the table is complete and contains all water monitoring locations and details.

Section 3.22 Results to date

- This section is poorly written and difficult to follow. Some graphs or tables of results or summary findings could be provided.
- Page 24: Please add in text reference to TARP level definitions at each mention and provide better explanation of the TARP trigger levels in this section.

Section 4.1 Groundwater Monitoring

- Page 25 “Aspects of the proposed monitoring program will not be directly linked to TARPs but will instead be undertaken to inform investigations into the cause of potential impacts should the identified TARP triggers be exceeded.”

  This statement is unclear. Please explain what you are monitoring and what TARPS you are proposing to use as triggers. If you are not using the previously defined TARPS, please provide a clear explanation of what has changed and why in this section of the report. Linking monitoring to TARPs is important for transferability of results between prior studies and ongoing monitoring results. The relationship between TARPs and what is being proposed to be monitored in the monitoring plan is unclear and needs to be better defined and justified throughout.
- Page 25: Please fix reference errors
- Page 25: “It is to be noted that there are currently no groundwater monitoring sites at swamps CCUS1, CCUS14, CCUS20, CCUS21, CRUS2 and CRUS6. Additional monitoring sites for these locations have been proposed and will be installed at least 2 months prior to each swamp being mined under.”

  This project identified that there was likely to be negligible environmental consequences for upland swamps as a result of predictions of negligible total subsidence. As a result, DPIE concurs that application of the “Upland Swamp Offset Policy” is highly unlikely to be triggered.

  However, swamps CCUS1, CCUS20, CCUS21 have been identified as most likely to be affected by subsidence as a result of undermining. Therefore, collecting adequate baseline data for these swamps should be a priority of the monitoring program. The installation of groundwater monitoring piezometers 2 months prior to commencement is insufficient to provide adequate data to describe baseline groundwater regime in these swamps. The “Upland Swamps Offset Policy” requires a minimum of two years baseline data on which to assess compliance with negligible impacts on groundwater level and swamp water balance. This also contradicts minimum monitoring periods stated in the following sections of the report. Please clarify minimum pre-mining monitoring periods.
- Page 26: Please include minimum monitoring periods for pre-impact, during mining and post mining monitoring in this section and ensure it matches the information provided in Table 7 and references the “Upland Swamps Offset Policy”. As currently written, it is difficult to determine the total monitoring periods suggested for the study.

- Page 26: “In this regard, swamps which are yet to be directly undermined can be used as reference swamps for the swamps which are mined under. Additionally, swamps which have been mined under but which show no adverse effects from this mining can be used as part of the reference site network where there is confidence that potential impacts are unlikely to occur post mining.”

  Reference sites should be independent from impacted sites and assigned to control treatments prior to commencement of study period in order to comply with BACI monitoring standards.

  Please outline the methods and statistical analysis you will undertake to assess the suitability of "less impacted sites" to be considered as a reference sites. Include details on the minimum time frame for monitoring of prior impacted sites to be considered reference condition and the specific criteria assessed.
- Page 27: Swamp specific water balances should be developed for swamps to be directly undermined in order to comply with the consent conditions and requirement for negligible environmental consequences. Please see previous comments regarding requirements for baseline data in individual swamps.
- Page 32: replace “prior” with period

Section 4.21 Impact Monitoring Sites

- Page 35 Table 9: Swamps to be used as control sites need to be subject to the same baseline monitoring prior to mining as impacted sites. Baseline data needs to be collected and directly comparable between control and impact categories. Will these additional control sites have the same baseline monitoring durations and ecological monitoring as the impacted sites?
- Page 35: “Control sites will not have been mined beneath during the monitoring period being investigated.”
- Will swamps that have been mined beneath or in close proximity to undermining outside of the monitoring period be excluded as control sites?
- Please provide additional details on the requirements and criteria for additional sites to be considered control swamps.

Section 4.4 Swamp Vegetation Transect Monitoring

- Page 39: The definitions of treatments provided here are unclear.

  Please use the same terminology as Table 5 which refers to 'Control' and 'impact' swamps. Pre-mining and Post-mining monitoring should occur at both control and impacted sites. Pre-mining impact sites and pre-mining control sites data should not be pooled.
- Page 40: Please give more details on the methods and analysis that will be performed to determine suitability of control sites for inclusion in the study, including the minimum number of control sites needed for the study.

  What constitutes ecological similarity? You should define the parameters used to determine this prior to analysis.

Section 4.42 Species Composition

- Page 41: A measure of relative abundance of each species would enable more analysis options and diversity could also be calculated which would address the consent condition

for negligible consequences for biodiversity - the current monitoring plan is not measuring diversity in swamps.

- Page 41: When describing the statistical analysis performed you refer to 'mining status' as a predictor rather than the previously defined 'control/impact' treatment and this is confusing. It would be clearer if you used the same terminology to refer to treatment groups (Control versus impact) in your study design throughout the document.

Section 5 Performance Measures

- Page 56: "Significant statistical difference between control and impact sites or between before and after mining at the control sites (one year duration – first year after mining commences)."

  This should read: significant statistical difference between control and impact sites or between before and after mining at the impact sites

  No change in control sites is expected. A change in impact sites indicates greater than negligible impact has occurred.
- Page 56: Swamp water quality (two consecutive readings above the trigger, or below for pH)

  The relevance of these trigger values needs to be justified especially with the inclusion of new control sites in the study design. Data should be provided to validate these. Will these values be revised after the inclusion of new control sites in the study?

  Ideally the 20th and 80th percentile values of baseline water quality in control swamps should be used as a trigger – you should identify which TARP this relates to.
- Page 56-58 & Appendix D Triggers for Performance measures and TARPS: The description of triggers for performance measures here does not match the triggers described in following section, and their relationship to the TARPS in Appendix D is confusing. Please revise these sections and state clearly which triggers will be used in the proposed monitoring plan – are you using all of the TARPS in Appendix D as triggers for further monitoring or just those mentioned in the triggers for performance measures section? A Table in the body of the report would help. If you are proposing different triggers for the revised monitoring plan then consider including a section in the report where you explain this. The reference to triggers and TARPs in sections 3 & 4 of the report should likewise be clarified and consistent throughout.

Planning, Industry & Environment

Richard Sheehan
Environmental Manager
NRE NO. 1 Colliery 7
Princes Highway
Corrimal, NSW, 2518

09/02/2021

Dear Mr Sheehan

Russell Vale Underground Expansion (MP09_0013)
Extraction Plan

I refer to your request (MP09_0013-PA-3) for the Planning Secretary's approval of suitably qualified persons to prepare the Extraction Plan for the Russell Vale Underground Expansion (MP09_0013).

The Department has reviewed the nominations and information you have provided and is satisfied that these experts are suitably qualified and experienced. Consequently, I can advise that the Planning Secretary approves the appointment of the experts to prepare the Extraction Plan.

Accordingly, the following experts are approved as authors for the Extraction Plan.

Consent Condition	Extraction Plan Requirement	Expert/Author
Schedule C Condition 10	Extraction Plan	Warwick Lidbury – RVC Mine Manager Luke Bettridge – Umwelt David Holmes – Umwelt
Schedule C Condition 10 (g)(i)	Subsidence Monitoring Plan	Dr Ken Mills – SCT Stephen Wilson - SCT
Schedule C Condition 10 (g)(ii)	Built Features Management Plan	Dr Ken Mills – SCT Stephen Wilson - SCT
Schedule C Condition 10 (g)(iii)	Water Management Plan	Susan Shield – Engeny Clare Stephenson - Umwelt
Schedule C Condition 10 (g)(iv)	Biodiversity Management Plan	Paul Price - Biosis
Schedule C Condition 10 (g)(v)	Swamp Monitoring Plan	Luke Stone - Biosis
Schedule C Condition 10 (g)(vi)	Land Management Plan	Luke Bettridge – Umwelt David Holmes – Umwelt
Schedule C Condition 10 (g)(vi)	Heritage Management Plan	Dr Amanda Markham - Biosis
Schedule C Condition 10 (g)(vii)	Public Safety Management Plan	Warwick Lidbury – RVC Mine Manager
Schedule C Condition 10 (g)(viii)	Trigger Action Response Plan/s	Warwick Lidbury – RVC Mine Manager Luke Bettridge – Umwelt David Holmes – Umwelt
Schedule C Condition 10 (g)(ix)	Contingency Plan	Warwick Lidbury – RVC Mine Manager Luke Bettridge – Umwelt David Holmes – Umwelt

If you wish to discuss the matter further, please contact Daniel Martin at daniel.martin@dpie.nsw.gov.au

Yours sincerely

Stephen O'Donoghue
Director
Resource Assessments
As nominee of the Planning Secretary

Department of Planning and Environment

Our ref: DOC22/397326
Senders ref: MP09_0013-PA-45

23 May 2022

Simon Pigozzo
Wollongong Coal
E-mail: simon.pigozzo@wcl.net.au

Dear Simon

Subject: Russell Vale Underground Expansion – Extraction Plan Stage 2– Comments on Biodiversity Management Plan and Swamp Monitoring Plan

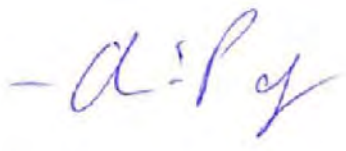
Thank you for referring the above post-approval matter to the Biodiversity and Conservation Division (BCD) of the Department of Planning and Environment (DPE). We apologise for the delay and appreciate the extra time to respond.

The Plan was prepared in accordance with Condition C10 of the Project Approval. You have requested our input on the Biodiversity Management Plan and the Swamp Management Plan which are sub-plans of the broader Extraction Plan. The Biodiversity Management Plan (BMP) focuses on monitoring ecological values that have been determined to be most at risk as part of the Underground Expansion Project (UEP) while the Swamp Management Plan (SMP) has been prepared to manage potential subsidence and groundwater impacts on Coastal Upland Swamps.

We provide a detailed summary of comments and actions required to update the Plan in Attachment 1. We also refer you to our previous comments in relation to Stage 1 (our reference DOC21/1002718).

If you have any questions or require further advice, please do not hesitate to contact Vanessa Allen, Senior Conservation Planning Officer, via Vanessa.Allen@environment.nsw.gov.au or 4224 4186.

Yours sincerely



Chris Page
Senior Team Leader (Planning Illawarra)
Biodiversity and Conservation Division

Attachment 1: BCD comments on the Swamp Management Plan and Biodiversity Management Plan

Reference	Comments
1. Biodiversity Management Plan	
Condition of Approval C10(g)(iv) Page 17	This condition requires a BMP which establishes baseline data for the existing habitat on the site, including **vegetation condition** and **threatened species habitat**, Table 8 describes monitoring methods, including "Photo-point monitoring". How will vegetation data (including baseline data) be collected and analysed for non-swamp vegetation, noting that a Briefing Note sent to BCD, dated 4/6/2021, described the use of BAM plots for baseline data to inform offsetting requirements? BAM plots are mentioned in the SMP but not the BMP. Please clarify when and how BAM plots will be used.
Threatened frogs	Habitat mapping and occupancy of frogs needs to be done more accurately in the possibly impacted areas. Likelihood of detection needs to be considered for all monitoring proposals – frog breeding periods will mean tadpoles are present at different times. Consider using eDNA monitoring techniques for screening streams (note this should not be used as a replacement for normal monitoring, for further advice, consult BCD). The BMP should discuss how monitoring data is to be collected in accordance with current Threatened Frog Survey Guidelines: https://www.environment.nsw.gov.au/-/media/OEH/Corporate-Site/Documents/Animals-and-plants/Threatened-species/nsw-survey-guide-for-threatened-frogs-200440.pdf
Littlejohn's tree frog	Habitat is not limited to tributaries only. It is unclear what remediation will be worthwhile if monitoring detects an impact. Further information required.
Red-crowned toadlet	Red-crowned toadlet is a localised species that appears to be largely restricted to the immediate vicinity of suitable breeding habitat. Due to this tendency for discrete populations to concentrate at particular sites, a relatively small, localised disturbance may have a significant impact on a local population if it occurs on a favoured breeding or

	refuge site. Mining impacts (eg changes to soil moisture) could adversely impact this species.
Giant burrowing frog Section 6.4.2	Giant burrowing frogs only breed February to May and therefore tadpoles are only present during that time. Only a 245 metre section of a tributary of Cataract River has been identified as habitat when other similar areas of habitat exist. Section 6.4.2 states that "giant burrowing frog monitoring is not required within the stage 2 EP area as no habitat is considered to be present". Based on information provided in the BMP, adequate surveys have not been carried out for this species to be able to exclude Stage 2 areas as non-habitat. Consider using eDNA screening as part of the monitoring program.
Section 3.4 Page 39 Section 6.4.2 Page 69	Overall, it is not clear that adequate survey has been done to determine whether certain threatened species occur within the Stage 2 Extraction Plan area and thus whether baseline data requirements in accordance with CoA 10(g)(iv) are met. The Preferred Project Report identified a number of threatened species which have potential to occur and may be impacted by subsidence. Further monitoring has occurred, but no detail is provided.
Figure 6 Page 46	It is unclear why swamps in Stage 2 do not contain habitat for giant dragonfly? None of the swamps mapped in Stage 2 are mapped as habitat.
2. Swamp Management Plan	
Figure 11a	All swamp monitoring sites should be identified in a Table with co-ordinates or provide BCD with an excel file of latitude/longitude or easting/northing for each identified swamp. A shapefile of all swamps should be provided. We could not find the following swamps: ACUS, BCUS12, BCUS13. WACUS, WCUS, S22, S33, S15A.
	A table is required that clearly demonstrates whether all swamps potentially affected by the mining are monitored and what monitoring takes place in those swamps (ie water level, soil moisture, vegetation quadrat, giant dragonfly) and their choice of accompanying reference swamps for comparison in a rigorous BACI design. If a swamp is within the defined

	mining footprint and is not monitored, a justification for this is required.
	Rationale should be provided underlying the choice of swamps for dragonfly monitoring and the justification for not monitoring all swamps that could potentially be affected by the mining (bearing in mind cumulative impacts form previous mining in the area).
Attached document: *Analysis of RV East flora data for Biosis,* prepared by The Analytical Edge Statistical Consulting Page 150	This document analyses vegetation data in terms of total species richness (TSR). This document states: *"TSR is not a good metric to reflect the complex nature of community composition and species turnover, since some species may become locally extinct or invade a region, yet the TSR can remain stable."* We agree with this conclusion which clearly indicates that community composition data should be the focus for any BACI Assessment. The Plan does not include the use of community composition data as a means of identifying impact (or lack thereof) in a rigorous BACI design. This needs rectification.
	All piezometer, soil moisture, vegetation quadrat, flow, pool level and water quality data should be provided to BCD so an independent analysis can be conducted and the appropriateness/rigour of the proposed BACI design tested.

Department of Planning and Environment

Our ref: OUT22/6132

Simon Pigozzo

Email: simon.pigozzo@wcl.net.au

23 May 2022

Subject: **Russell Vale Underground Expansion - Extraction Plan, Water Management Plan (incorporating Groundwater Management Plan) & Swamp Monitoring Program**

Dear Mr Pigozzo,

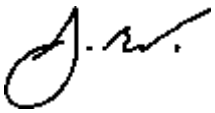
I refer to your email of 13 April 2022 to the Department of Planning and Environment (DPE) Water about the above matter.

The Department of Planning and Environment- Water has reviewed the Extraction Plan, Water Management Plan (incorporating Groundwater Management Plan) & Swamp Monitoring Program and requests further information regarding:

- Performance criteria
- environmental tracers
- accountability of an impact change
- dispute resolution.

Should you have any further queries in relation to this submission please do not hesitate to contact DPE Water Assessments at water.assessments@dpie.nsw.gov.au

Yours sincerely,



Luke McIver

Acting Manager, Assessments, Knowledge Division
Department of Planning and Environment: Water

Attachment A

Detailed advice regarding the Russell Vale Underground Expansion - Extraction Plan, Water Management Plan (incorporating Groundwater Management Plan) & Swamp Monitoring Program

1.0 Performance Criteria

1.1 Recommendation

Define the water level trigger action thresholds for the nested monitoring bores including the deeper sandstone aquifer.

1.2 Explanation

This is required for assessing and taking action against issues relating to the hydraulic connection between swamps and associated aquifers, as specified under condition C10(g)(v).

2.0 Environmental Tracers

2.1 Recommendation

Incorporate environmental tracers within the suite of water quality analytes.

2.2 Explanation

Environmental tracers are a specific requirement under condition C10(g)(v) and will assist in objective evaluation in the event performance criteria exceeds trigger levels 2 or 3.

3.0 Accountability of an Impact Change

3.1 Recommendation

Provide a supplementary statement to the existing “Statement of Commitment “ that requires the proponent to identify the cause (natural or mining related) of any identified level 2 or 3 exceedances, and not arrive at an open finding due to insufficient monitoring evidence.

3.2 Explanation

Section 7.3 of the WMP refers the reader to Appendix D which objectively should be modified to reflect the emphasis is on the proponent to demonstrate Level 2 or Level 3 change in the performance criteria is not due to mining, as opposed to if the change is due to mining operations. The implication is to ensure the responsibility of proof sits with the proponent to collect appropriate data sufficient to rule out an impact from mining activities, as opposed to stating that there is no evidence of a mining related impact potentially as a consequence due to in-effective baseline dataset(s) and inability to draw a scientifically robust conclusion. A Statement of Commitment should be provided that the monitoring program is sufficiently designed to differentiate between mining and natural impacts.

4.0 Dispute Resolution

4.1 Recommendation

Consider including a dispute resolution step in the TARP for instances where there may be differing opinions in relation to the cause of any exceedance. Additionally, Figure 15 – Flow

chart box should consider a process for dispute resolution in the event there is conflicting opinion between agency and stakeholder as to whether the impact is/isn't mining related.

End Attachment A

PO Box 398, Parramatta NSW 2124
Level 14, 169 Macquarie Street
Parramatta NSW 2150
www.waternsw.com.au
ABN 21 147 934 787

27 April 2022

Contact: Ravi Sundaram
Telephone: 0428226152
Our ref: *D2022/31435*

Jessie Evans, Director Resource Assessments, DPE
Email: Jessie Evans@DPIE.nsw.gov.au

Dear Jessie

Russell Vale Colliery Underground Expansion Project – Stage 2 (PC27-PC34) Extraction Plan

WaterNSW appreciates the opportunity to review the updated extraction plan (EP) which now include Stage 2 (PC27-34) of underground mining expansion project. WaterNSW has previously provided feedback on the Stage 1 (PC07-08 and 21 -25) (our reference - D2021/116712). Both Stage 1 and Stage 2 mining areas are located within the Metropolitan Special Area and the Upper Nepean Catchment (specifically within the upper catchment of the Cataract Reservoir).

WaterNSW has an important statutory role "*to protect and enhance the quality and quantity of water in declared catchment areas*". It also has a set of 'Mining Principles' which underpin WaterNSW decision making in relation to managing mining impacts in the declared Sydney catchment area and on catchment infrastructure.

Wollongong Coal Limited (WCL) has consulted with WaterNSW in preparing several key management plans required under the approval including Water Management Plan, Land Management Plan, Swamp Monitoring Program, and the Public Safety Management Plan. The EP has addressed feedback provided by WaterNSW to these plans.

Proposed mining in the Wongawilli seam in the Stage 2 area underlie parts of the previously mined Bulli and Balgownie seam workings area. The subsidence assessment has comprehensively addressed the pillar stability and pillar failure issues, and the potential risk of 'pillar run' for proposed extraction in a multi-seam area where overlying seams have been extracted previously.

Subsidence assessment predicts:

- vertical subsidence to be less than 100mm and generally imperceptible over most of the area, and
- the impacts, and consequences to natural, surface, and sub-surface features to be negligible and imperceptible in the undeveloped bushland setting over most of the Stage 2 extraction area.

WaterNSW considers that:

- The mining method and mine design adopted by WCL to the proposed mining in Stage 2 is likely to result in negligible impacts on water resources, biodiversity, and catchment environmental values.
- The proposed monitoring and management measures are appropriate for the planned mining method and subsidence predictions.
- The underground mine water balance monitoring system is expected to be effective as a guide to any unexpected inflows and inrush events from previously mined overlying seams and from Cataract Reservoir.
- The Trigger Action Response Plans (TARPs) for water and swamp monitoring including stream and swamp triggers developed based on baseline monitoring of performance indicators and anticipated subsidence effects are reasonable and appropriate.

WaterNSW does not have any concerns to the approval of the updated EP as:

- It has taken into consideration WaterNSW Mining Principles;
- Poses low risk to overlying catchment values and water resources; and
- Is likely to meet the performance measures set in the development consent.

Please contact Dr. Ravi Sundaram if you would like to discuss any of the above matters further.

Yours sincerely

Daryl Gilchrist
Manager, Catchment Protection

Department of Planning and Environment

Our ref: MP09_0013-PA-45

Tom McMahon

NRE No.1 Colliery 7

Princes Highway

Corrimal NSW 2518

24 August 2022

Subject: Russell Vale Underground Coal Mine Stage 2 Extraction Plan – Request for Information

Dear Tom

I refer to the Russell Vale Underground Expansion Stage 2 Extraction Plan submitted to the Department of Planning and Environment (the department) as required under the conditions of consent for the Russell Vale Underground Expansion. After careful consideration, the department is requesting that you provide additional information.

You are requested to submit the additional information detailed in **Attachment A**.

You are requested to provide the information, or notification that the information will not be provided, to the department by 7 September 2022. If you are unable to provide the requested information within this timeframe, you are requested to provide, and commit to, a timeframe detailing the provision of this information.

If you have any questions, please contact Allison Sharp on 4345 4403 or via email at Allison.Sharp@planning.nsw.gov.au.

Yours sincerely,

JEvans

Jessie Evans

Director
Energy and Resources Assessments

Attachment A – Request for information

Russell Vale Underground Coal Mine – Stage 1 and 2 Extraction Plan

Biodiversity Management Plan

Giant Burrowing Frog Monitoring

The Biodiversity Management Plan (BMP) describes 13 surveys undertaken along a 245 m section of a tributary of Cataract River below swamp CRUS2. The BMP states that detailed surveys indicate that other tributaries are unlikely to support the species, and the species is not present within the Stage 2 extraction area.

BCD has provided the attached advice. The department has reviewed WCL's response to similar advice in Appendix E – Attachment 4 of the Biodiversity Management Plan. Appendix B of the 2022 BMP details the year of the most recent record, the number of records, and the distance of the records from the Study Area. The data included in Appendix B does not sufficiently justify the exclusion of the Giant Burrowing Frog from baseline data collection surveys prior to mining in the Stage 2 EP area.

The preferred project report biodiversity assessment (Umwelt, 2019) draws a conclusion regarding the potential for impact on the Giant Burrowing Frog stating:

"Although often associated with upland swamps, this association is not direct, rather that upland swamps are associated with minor drainage lines that provide suitable breeding pools and burrowing habitat for this species (DECC 2007). SCT (2018) predicts that the imperceptible levels of subsidence resulting from the revised UEP mine plan will not result in perceptible impacts to creeks. As such, the Giant Burrowing Frog is considered at negligible risk of impact."

The department acknowledges to low risk of impact. However, conditions C4-C6 of MP09_0013 provide for biodiversity impact offsetting if WCL exceeds the performance measures. If required, offsets must be undertaken in accordance with the Biodiversity Offsets Scheme (BOS). The BOS requires a suitable baseline dataset collected in accordance with the Biodiversity Assessment Method. To justify the exclusion of the Giant Burrowing Frog from the baseline dataset, the department requires the following:

- maps demonstrating the survey effort conducted for the Giant Burrowing Frog other than at CRUS2
- survey data associated with the mapped survey effort
- detailed outline of any other criteria used for each swamp to justify the exclusion of the species from further survey

Frog Species Monitoring

Threatened frog monitoring listed in Appendix B-Attachment 1 of the Biodiversity Monitoring Plan includes:

- two transects for *Litoria littlejohni* and *Heleioporus australiacus*, and
- four transects for *Mixophyes balbus*

The department requests more information including:

- maps of the transect locations references in Appendix B-Attachment 1 and any other survey transects completed for threatened frog species
- details of survey effort at the monitoring transect locations, and any other locations including date, number of days/hours
- detailed outline of any other criteria used for each swamp to justify the exclusion of the above species from further survey

Subsidence Monitoring

Explanation of GNSS monitoring locations

The proposed GNSS locations are mapped on Figure 11a of the Upland Swamp Monitoring Plan (USMP). Table 13 of the USMP details the subsidence monitoring relevant to Coastal Upland Swamps. The relevance/purpose of GNSS units is described as:

- located over second workings to provide information about subsidence occurring within that panel
- located within or at the edge of swamps provide an indication of subsidence levels within the swamp
- where possible, located at a point within the swamp or at a point between the swamp and the second workings

The department requests WCL identify which GNSS units are intended for one or more of the purposes outlined in Table 13 of the USMP.

Subsidence baseline monitoring

All GNSS units require a baseline monitoring period of 12 months prior to mining. The Subsidence Monitoring Plan (SMP) provides baseline monitoring results for GNSS units #1 - #17. The department does not consider GNSS units #1 - #17 provide a representative baseline data set for GNSS units within the Stage 2 extraction plan area.

The SMP and Master TARP must define the timeframe for baseline subsidence data collected ‘prior to mining’.

The department requests confirmation from WCL that subsidence monitoring by GNSS units will be conducted for a minimum of 12 months prior to undermining.

LiDAR

The Stage 2 Subsidence Assessment (SCT, July 2022) states "Broad-area remote monitoring (LiDAR) across the entire area is to check for unexpected movements, particularly any that may be associated with instability of remnant pillars in or in the vicinity of Bulli Seam goaf areas." The subsidence monitoring plan (Section 4.1) re-states this and details that the planned LiDAR surveys have an accuracy of +/- 200mm over the majority of the survey area. The accuracy and purpose of LiDAR is also detailed in Table 5 of the SMP.

The Master Trigger Action Response Plan (Master TARP) is inconsistent with the proposed subsidence monitoring outlined in Table 5 of the SMP. The Master TARP lists a LiDAR survey trigger level of >100mm of subsidence. The TARPs of >100mm of subsidence appear to be inconsistent with the Subsidence Assessment (SCT, July 2022) and the SMP.

The department requires clarification of how LiDAR can be used for subsidence levels <200mm, or alternatively, align TARPs measured by LiDAR with the limitations of the method.

GNSS Units #31 and #32

Please clarify the locations of GNSS Units 31 and 32

Groundwater Monitoring

The department requires an outline of groundwater monitoring undertaken at control sites. The outline must include the location name, month, and year of data collection and whether monitoring is ongoing or has ceased.

Caragh Heenan

From: no-reply@majorprojects.planning.nsw.gov.au
Sent: Tuesday, 27 September 2022 12:33 PM
To: richard.sheehan@wcl.net.au
Cc: Allison.Sharp@planning.nsw.gov.au
Subject: Russell Vale Underground Expansion - MP09_0013 RussellVale Stage 2 Extraction Plan MP09_0013-PA-45 - Request for Additional Information

Dear Richard Sheehan,

The Department is requesting that you provide additional information in relation to the Russell Vale Underground Expansion - MP09_0013 RussellVale Stage 2 Extraction Plan .

Please access your profile for details of this request and to upload your response. You are requested to provide this response by 11/10/2022 .

If you have any enquiries, please contact Allison Sharp on 02 4345 4403 /at Allison.Sharp@planning.nsw.gov.au .

To sign in to your account click here or visit the Major Projects Website.

Please do not reply to this email.

Kind regards

The Department of Planning and Environment

Subscribe to our newsletter

Russell Vale Underground Expansion - MP09_0013 RussellVale Stage 2 Extraction Plan

More Information Required

Upload RFI Response

Actions

Details of Request

Message

Thankyou for your recent response to RFI dated 9 September 2022.
The department requests that WCL submit a revised version of the final Stage 1 and 2 UEP. The revised version needs to include the changes proposed in the 9 September response to RFI, including TARPs/LiDAR, mapping of GNSS units #31 and #32.
The department is likely to condition the Stage 1 and 2 UEP to require WCL to assume the Giant Burrowing Frog and Little John's Treefrog are present in the Stage 2 area. The department is also likely to require WCL to include both frog species in the biodiversity monitoring program, including baseline monitoring. Alternatively, WCL have the option revise the Stage 1 and 2 UEP to assume both frog species are present and revise the monitoring program and relevant TARPs.

Russell Vale East Stage 2 Extraction Plan

Biodiversity Management Plan Response to Request for Information

FINAL REPORT

Prepared for Umwelt on behalf of Wollongong Resources Pty Ltd

9 September 2022

Biosis offices

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Document information

Report to:	Umwelt on behalf of Wollongong Resources Pty Ltd
Prepared by:	Dr Caragh Heenan Rosie Gray
Biosis project no.:	36746
File name:	36746.Stage2.BMP.DPE.RFI.Response.FIN01.20220909
Citation:	Biosis 2022. Russell Vale East Stage 2 Extraction Plan Biodiversity Management Plan Request for Information. Report for Umwelt on behalf of Wollongong Resources Pty Ltd. Heenan. C, Gray. R, Biosis Pty Ltd., Wollongong, NSW. Project no. 36746

Document control

Version	Internal reviewer	Date issued
Draft version 01	Jane Raithby-Veall	7/9/2022
Final version 01	Caragh Heenan	9/9/2022

Acknowledgements

Biosis acknowledges the contribution of the following people and organisations in undertaking this study:

- Wollongong Resources Pty Ltd.
- Umwelt: Matthew Copeland, David Holmes.

Biosis staff involved in this project were:

- Astrid Mackegard (mapping).

Contents

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Figures

1. Introduction

Biosis was engaged by Umwelt on behalf of Wollongong Resources Pty Ltd (WRPL, formerly Wollongong Coal Limited) to prepare a Biodiversity Management Plan (BMP) (Wollongong Coal 2021) to inform the Russell Vale East (RVE) Underground Expansion Project (UEP) Extraction Plan (EP).

Biosis has received a request for information from the NSW Department of Planning and Environment (DPE) regarding survey methodology and results for threatened frogs in the RVE area, as undertaken by Biosis. The request for information is detailed in Table 1 below.

Table 1 Request for information from DPE

Consultation	Biosis' response
Giant Burrowing Frog Monitoring	
The BMP describes 13 surveys undertaken along a 245 m section of a tributary of Cataract River below swamp CRUS2. The BMP states that detailed surveys indicate that other tributaries are unlikely to support the species, and the species is not present within the Stage 2 extraction area. **NSW Biodiversity Conservation Division (BCD) has provided the attached advice. The department has reviewed WRPLs response to similar advice in Appendix E – Attachment 4 of the Biodiversity Management Plan. Appendix B of the 2022 BMP details the year of the most recent record, the number of records, and the distance of the records from the Study Area. The data included in Appendix B does not sufficiently justify the exclusion of the Giant Burrowing Frog from baseline data collection surveys prior to mining in the Stage 2 EP area.** **The preferred project report biodiversity assessment (Umwelt 2019) draws a conclusion regarding the potential for impact on the Giant Burrowing Frog stating:** **"Although often associated with upland swamps, this association is not direct, rather that upland swamps are associated with minor drainage lines that provide suitable breeding pools and burrowing habitat for this species (DECC 2007). SCT (2018) predicts that the imperceptible levels of subsidence resulting from the revised UEP mine plan will not result in perceptible impacts to creeks. As such, the Giant Burrowing Frog is considered at negligible risk of impact."**	Noted. Refer to discussion below regarding adequacy of survey effort.
The department acknowledges to low risk of impact. However, conditions C4-C6 of MP09_0013 provide for biodiversity impact offsetting if WCL exceeds the performance measures. If required, offsets must be undertaken in accordance with the Biodiversity Offsets	Noted. The Biodiversity Assessment Method (BAM) was originally released in 2017 (OEH 2017) and has since been updated in 2020 (DPIE 2020a). Threatened frog surveys undertaken prior to the

Consultation	Biosis' response
Scheme (BOS). The BOS requires a suitable baseline dataset collected in accordance with the Biodiversity Assessment Method.	initial BAM release (OEH 2017) were not undertaken in line with the BAM, however methodology had been designed to meet the requirements of *Threatened species survey and assessment guidelines: field survey methods for fauna - Amphibians* (DECC 2009). Giant Burrowing Frog Surveys undertaken in 2021 were conducted in line with the BAM (DPIE 2020a), including: • *NSW Survey Guide for Threatened Frogs: A Guide for the Survey of Threatened Frogs and their Habitats for the Biodiversity Assessment Method* (DPIE 2020b). • *Survey guidelines for Australia's threatened frogs* (DEWHA 2010). • *Threatened species survey and assessment guidelines - Field survey methods for fauna - Amphibians 2009* (DECC 2009). • *Environmental Impact Assessment Guideline: Giant Burrowing Frog* (NPWS 2001a). • *Environmental Impact Assessment Guideline: Red-crowned Toadlet* (NPWS 2001b). All future threatened frog surveys will also be undertaken in line with BAM and relevant survey guidelines.
To justify the exclusion of the Giant Burrowing Frog from the baseline dataset, the department requires the following:	Refer to individual items below.
• **Maps demonstrating the survey effort conducted for the Giant Burrowing Frog other than at CRUS2.**	Map detailing survey type and sites for each species is provided in Figure 1.
• **Survey data associated with the mapped survey effort.**	Survey data from prior reports provided herein.
• **Detailed outline of any other criteria used for each swamp to justify the exclusion of the species from further survey.**	An assessment of habitat suitability for the species is provided in Section 2.1 below, as per the BMP. There is a long period of monitoring within the UEP area, commencing largely in 2012, that has been used to assess the likelihood of occurrence for threatened species. The monitoring within Cataract Creek and Bellambi Creek and downstream of BCUS2 and BCUS3 (refer to Figure 1 and Section 2.1 below) support the assessment that suitable habitat for the Giant Burrowing Frog does not occur within Stage 2. Similarly, the monitoring within CCUS1, CCUS2, CCUS4, CCUS23, CRUS1 and CRUS3 support the conclusion that the Giant Burrowing Frog is not present in the areas potentially impacted by Stage 1. As an additional commitment by WRPL since the preparation of the Stage 2 BMP, an additional round

Consultation	Biosis' response
	of Giant Burrowing Frog monitoring will be undertaken at CRUS2 to confirm presence in spring 2022 and autumn 2023. Mining in Stages 1 and 2 will not impact on CRUS2 or the tributary where Giant Burrowing Frog has been observed.
Frog Species Monitoring	
Threatened frog monitoring listed in Appendix B-Attachment 1 of the Biodiversity Monitoring Plan includes: • **Two transects for *Litoria littlejohni* and *Heleioporus australiacus.*** • **Four transects for *Mixophyes balbus.***	Appendix E of the BMP includes the prior BCD EES Response regarding the BMP, which includes a letter dated 19 November 2021 from Wollongong Resources Pty Ltd, to Department of Planning and Environment, as well as Appendix B *DPIE NSW – RFI Attachment B Request for clarifications,* Attachment 1. Attachment 1 states that Biosis has undertaken: • 2 x Giant Burrowing Frog transects. • 2 x Littlejohn's Tree Frog transects. • 4 x Stuttering Frog transects. The above threatened frogs, as well as Red-crowned Toadlet were surveyed for in 2012 (Biosis 2012), 2013 (Biosis 2013, Biosis 2014b), 2014-2015 (Biosis 2016). Red-crowned Toadlet has also been surveyed for in 2016 (2017) and Giant Borrowing Frog in 2021 (2022). More information is provided below on these and other surveys undertaken to date.
The department requests more information including:	Refer to individual items below.
• **Maps of the transect locations referenced and any other survey transects completed for threatened frog species.**	Map detailing survey type and sites for each species is provided in Figure 1.
• **Details of survey effort at the monitoring transect locations, and any other locations including date, number of days/hours.**	Survey data from prior reports provided herein.
• **Detailed outline of any other criteria used for each swamp to justify the exclusion of the above species from further survey.**	An assessment of habitat suitability for the species is provided in Section 2.1 below, as per the BMP. The Russell Vale Colliery – Underground Expansion Project: Preferred Project Report – Biodiversity (Biosis 2014a) report identified 13 fauna species listed under the EPBC Act and/or BC Act, that have the potential to occur or are known to occur in the EP area, of which nine fauna species are considered susceptible to subsidence impacts. An assessment of the likelihood of occurrence of these species, based on additional monitoring data collected since 2011, and the risk of impact from mining was provided in Table 11 of the Stage 2 BMP. There is a long period of monitoring within the UEP area that

Consultation	Biosis' response
	has been used to assess the likelihood of occurrence for threatened species. Species with a low likelihood of occurrence are not represented on Figure 6 and are not addressed further in the BMP. This includes Littlejohn's Tree Frog and Stuttering Frog, which are now considered a low likelihood of occurrence based on the results of additional monitoring (reported herein). No monitoring for Red-crowned Toadlet has been included in the BMP as habitat for this species within the study area is considered to be widespread and potential indirect impacts from subsidence are unlikely to affect the species. There is a negligible risk of any impact to threatened frogs within the UEP area from the bord and pillar mining method. Potential indirect impacts are limited to subsidence (such as surface cracking) and hydrological changes affecting surface water regimes or near-surface groundwater, which are in turn considered to have a low likelihood of occurring under the bord and pillar mining method. Potential remediation options for threatened species with a low likelihood of occurrence would only be investigated in the unlikely event that habitat for the species is detected and impacts to habitat (Coastal Upland Swamps / aquatic environments) associated with mining are higher than anticipated (i.e. subsidence TARPs level 3 are triggered, greater than 100 mm of subsidence at Coastal Upland Swamps).

2. Project background

2.1. Threatened frogs

Threatened frogs identified previously as having a moderate or greater likelihood of presence within the RVE locality and potentially susceptible to subsidence include:

- Giant Burrowing Frog *Heleioporus australiacus*.
- Littlejohn's Tree Frog *Litoria littlejohni*.
- Stuttering Frog *Mixophyes balbus*.
- Red-crowned Toadlet *Pseudophryne australis*.

Giant Burrowing Frog is known to inhabit ephemeral and intermittent streams in the locality. Habitat for the Giant Burrowing Frog within the study area consists of small sections of upper tributaries above the Stage 1 and future stages workings. Despite extensive survey across the RVE area, GBF has only been identified along a 245 metre section of a tributary of Cataract River below swamp CRUS2 only. This area is outside the Stage 1 and Stage 2 mining areas and potential impacts from mining in these two areas do not have a feasible causal pathway to have any impact on CRUS2 and the downstream catchment where the Giant Burrowing Frog has been observed. Additional baseline survey within the Stage 1 and Stage 2 mining areas is therefore not considered to be warranted. As the Giant Burrowing Frog has not been observed in the Stage 1 and Stage 2 mining areas or in catchments immediately downstream of these areas, the absence of this species in any post-mining monitoring in these areas would not be indicative of any adverse impacts on this species from mining. Other than below CRUS2, this species is assumed **not** to be present for the purposes of offsetting requirements in the unlikely event that the proposed mining does impact on swamps or creeks.

Littlejohn's Tree Frog is known to inhabit ephemeral and intermittent streams in the locality. The species is however considered a low likelihood of occurrence in the Stage 1 and Stage 2 mining areas based on the results of additional monitoring (detailed herein) since the Preferred Project Report (Biosis 2014a). Suitable habitat is limited in the study area and targeted surveys undertaken have not detected the species. This species is assumed **not** to be present for the purposes of offsetting requirements in the unlikely event that the proposed mining does impact on swamps or creeks.

Stuttering Frog is known to inhabit streams in the locality. The species is rare in the locality. Stuttering Frog is considered a negligible likelihood of occurrence based on the results of additional monitoring (detailed herein) since the Preferred Project Report (Biosis 2014a). Targeted surveys undertaken between August 2013 and February 2016 did not detect the species in the study area. The Stuttering Frog is not known from localities with disturbed riparian vegetation or significant human impacts upstream, which may indicate that the species is highly sensitive to perturbations in the environment (Mahony, Knowles, & Pattinson 1997). Identified habitat in Cataract Creek shows it was found to exhibit levels of pollution due to run-off from Mount Ousley Road, as well as high levels of iron flocculent from past mining. Although the habitat is suitable, these impacts result in sub-optimal conditions for the species which occur irrespective of the proposed mining. This species is assumed **not** to be present for the purposes of offsetting requirements in the unlikely event that the proposed mining does impact on swamps or creeks.

The Red-crowned Toadlet is fairly common in preferred ridgetop habitat and first order ephemeral creeks below ridges (DECC 2007) and has been recorded, using drainage lines, sheltering under bushrock on ridgetops and in depressions along fire trails (Biosis pers. obs.). Habitat for this species within the study area

has not been mapped, as it is widely distributed and common. Targeted surveys for the Red-crowned Toadlet have been undertaken by Biosis as a part of the ecological monitoring program for Wonga East (Biosis 2013) and the species was recorded. This species is therefore assumed to be present for the purposes of offsetting requirements in the unlikely event that the proposed mining does impact on swamps or creeks. However, given the wide diversity in habitat of this species and the nature of subsidence impacts that may (unlikely) occur, this species is not predicted to be adversely impacted even if higher than predicted levels of subsidence were to occur.

2.2. Threatened frog surveys of relevance

A summary of Biosis' projects involving threatened frog surveys at RVE is detailed in Table 2 below.

Table 2 Current and prior projects in relation to threatened frog surveys or habitat assessment

Matter	Notes	Project mentions or includes survey of threatened frogs of relevance			
		Giant Burrowing Frog	Littlejohn's Tree Frog	Stuttering Frog	Red-crowned Toadlet
Wonga East Lease Area Ecological Monitoring Program Annual Monitoring Report Year 1 (2011) **(Biosis 2012); Project no. 11853**	Terrestrial flora and fauna monitoring for RVE in 2011, including targeted threatened frog survey.	✓	✓	✓	✓
Wonga East and V-Mains Ecological Monitoring Program. Autumn 2011 through to autumn 2013 **(Biosis 2013); Project no. 14511**	Terrestrial flora and fauna monitoring for RVE in 2012, including targeted threatened frog survey.	✓	✓	✓	✓
Russell Vale East and V Mains 2013 Ecological Monitoring Program **(Biosis 2014b); Project no. 16940**	Terrestrial flora and fauna monitoring for RVE in 2013-2014, including targeted threatened frog survey. Non-breeding Habitat: • Auditory and quadrat survey: Auditory surveys at fixed points throughout each swamp identified as suitable habitat. This will be followed by a Visual Encounter exhaustively checked and all frog species will be recorded. • In addition, non-standardised transect surveys will be undertaken. Call recognition surveys conducted	✓	✓	✓	✓

Matter	Notes	Project mentions or includes survey of threatened frogs of relevance			
		Giant Burrowing Frog	Littlejohn's Tree Frog	Stuttering Frog	Red-crowned Toadlet
	simultaneously to detect those species that are hard to see. Breeding Habitat: • Standardised transects in breeding habitat conducted in areas considered to be suitable breeding habitat for the various frog species. • Tadpole counts undertaken as part of the breeding habitat monitoring transects. Acoustic Surveys: • Use of Song meters to collect auditory data during favourable breeding conditions.				
***Russell Vale East terrestrial ecological monitoring program: Annual Report 2015* (Biosis 2016); Project no. 20492**	Terrestrial flora and fauna monitoring for RVE in 2015-2016, including targeted threatened frog survey. Breeding Habitat Monitoring: • Standardised transects conducted in areas considered to be suitable breeding habitat for the various frog species. • Tadpole counts. Acoustic Surveys: • Use of Song Meters to collect auditory data during favourable breeding conditions.	✓	✓	✓	✓
***Russell Vale East Terrestrial ecological monitoring program Annual report for 2016* (Biosis 2017); Project no. 23086**	Terrestrial flora and fauna monitoring for RVE in 2016-2017, including targeted threatened frog survey. Acoustic Surveys: • Use of Song Meters to collect auditory data during favourable breeding conditions. • The results of these surveys were assessed by comparing impact and control sites with a presence/absence approach.	✗	✗	✗	✓
Russell Vale East	Terrestrial flora and fauna	✓	✗	✗	✗

Matter	Notes	Project mentions or includes survey of threatened frogs of relevance			
		Giant Burrowing Frog	Littlejohn's Tree Frog	Stuttering Frog	Red-crowned Toadlet
***Terrestrial Ecological Monitoring Program 2021* (Biosis 2022); Project no. 34919**	monitoring for RVE in 2021-2022, including targeted threatened frog survey. Giant Burrowing Frog survey included searches along a tributary below swamp CRUS2.				

3. Survey method and effort

The survey methodology to identify and/or discount habitat for these species is detailed below and in Figure 1.

3.1. Biosis (2012) – Project no. 11853 (Giant Burrowing Frog, Littlejohn's Tree Frog, Stuttering Frog and Red-crowned Toadlet)

Threatened frog auditory and habitat survey

Creekline surveys consisted of 50 metre nocturnal stream searches for 30 person-minutes at fixed locations. Upland swamp surveys consist of area and stream searches at fixed locations. Each site had three replicates.

Sites surveyed within RVE (Figure 1) include; CC-F1, CC-F2, CC-F3, CRS-F1, CRS-F2, CRS-F3, CRS-F1 and CRS-F2, and CRS-F3.

Threatened frog breeding habitat assessment

A diurnal assessment of threatened frog habitat in the Cataract River tributaries was completed in winter 2011. This area was mapped as potential habitat by ERM (2011). Those areas considered to contain suitable Littlejohn's Tree Frog or Giant Burrowing Frog breeding pools were mapped.

One day of threatened frog habitat assessment was conducted by two zoologists in the Cataract River Tributaries down-swamp from Cataract River Swamp (CRHS1). A total of three tributaries were walked and areas containing suitable breeding pools for Littlejohn's Tree Frog, Giant Burrowing Frog, Red-crowed Toadlet and Stuttering Frog were mapped. The sites assessed are identified in Table 3 below.

Table 3 Threatened frog habitat assessment sites

Location Description	Coordinates
Walked down from CRS-F3 monitoring point down towards Cataract River (245 m transect)	CRWP-7 – CRWP-8
Second western tributary at Cataract River Swamp	CRWP-6 – CRWP-5
Walked down from CRS-F1 monitoring point down towards Cataract River	CRWP-1 – half way between CRWP-3 and CRWP-3
Upstream from fire road 7C/Bellambi Creek crossing	BCWP1 – BCWP2

3.2. Biosis (2013) – Project no. 14511 (Giant Burrowing Frog, Littlejohn's Tree Frog, Stuttering Frog and Red-crowned Toadlet)

Surveys were undertaken between 25-28 February 2013.

Threatened frog auditory monitoring

Auditory monitoring surveys for the Red-crowned Toadlet have been undertaken at two locations within RVE, where locations were chosen based on suitable breeding habitat along two ephemeral creeks located

below ridgelines above Longwalls (Figure 1). Two control sites were also established in the Cordeaux catchment where the species has previously been observed or heard. Surveys were undertaken at two fixed-point locations for four hours across four nights (equal to 32 hours of survey).

Surveys were undertaken using a passive acoustic monitoring device (SM2+ Song Meter (Wildlife Acoustics)), to monitor the presence of Red-crowned Toadlet breeding males calling within the area above Longwall 4 and Longwall 5 at RVE and at control sites. Data was then analysed using Audacity by scanning the spectrogram for the characteristic signature of the Red-crowned Toadlet.

The survey methodology has been designed to meet the requirements of the guidelines outlined in the *Threatened species survey and assessment guidelines: field survey methods for fauna - Amphibians* (DECC 2009).

Audio strip transects (and quadrats) have also been incorporated into both the threatened frog breeding and non-breeding habitat monitoring (targeting Giant Burrowing Frog, Littlejohn's Tree Frog and Stuttering Frog) which can be particularly effective for species that are hard to see, either because they blend in with their habitat, or because their habitat may be inaccessible (for example in the thick vegetation of upland swamps). This technique used a combination of both call-playback of the male advertisement call and set listening periods to estimate relative abundances of calling males, species composition, breeding habitat and microhabitat use.

Sites surveyed within RVE (Figure 1) include LW5A-F1 and LW5A-F2.

Threatened frog breeding habitat monitoring

An initial diurnal habitat assessment was undertaken across RVE. All areas of potential habitat were mapped and used to inform the location and extent of future monitoring. Potential habitat identified by topography maps and aerials along streams was ground-truthed and all suitable breeding pools were marked using a GPS.

Following diurnal habitat assessments, locations considered to be suitable habitat of varying quality for the Stuttering Frog, Littlejohn's Tree Frog and Giant Burrowing Frog were then incorporated into the ongoing monitoring program through a transect sampling survey technique.

Transects are surveyed by zoologists familiar with the target species, counting all amphibians seen and/or heard along the transect. The timing of surveys has taken into consideration the seasonal movements of each species, with monitoring undertaken in both the breeding season, to detect calling males and higher period of activity for adult frogs and following the breeding season to target tadpoles and metamorphs.

Active Visual Encounter Surveys (VES) for adults, tadpoles and egg mass were completed in peak breeding times for each species to allow for a higher probability of detecting adult frogs. Spotlighting and call detection was undertaken along transects in those areas assessed to contain suitable habitat for each of the species.

The location of any individuals detected during the targeted nocturnal surveys, or any other significant incidentals is recorded using a GPS.

Sites surveyed that are within RVE (Figure 1) that were considered controls for this survey include the following transects; CC(1)-T, CC(2)-T, CCUS4-T, CRUS1(1)-T, CRUS1(2)-T, CRUS2-T.

Control sites (not mapped) include WAC-T and WACT-T.

Sites surveyed that are not within RVE (not mapped) include; DC13, LA4, LC7, NDC, ND2, ND1, SC7(1), SC7(2), SC7A (rep 1), SC7A, SC8, WC11, WC15 and WC10.

Threatened frog non-breeding habitat monitoring

A combination of both randomised transects and permanent quadrat survey techniques have been established within the non-breeding habitat of upland swamps throughout RVE.

Quadrat surveys for threatened frogs in upland swamps are conducted within a 25 metre by 25 metre (625 metre square area centralised around a fixed point. An initial listening period is followed by active searching by zoologists familiar with the target species of all natural features including rocks, vegetation and leaf litter within the transect for 25 person minutes. The length of the initial listening period varies depending on the target species. Five minutes is allocated to those habitats suitable for Littlejohn's Tree Frog, whereas a 30 minute listening period is allocated for those sites containing habitat for the Giant Burrowing Frog given the time it can take for the species to re-commence calling following disruption.

The presence and abundance of threatened species within each quadrat is recorded. An inventory of incidental species, namely non-threatened frogs, is also recorded.

Between fixed quadrat survey points, randomised transects are surveyed by walking a specific distance through a randomly chosen route. This design allows for detection of threatened and non-threatened species across habitat gradients of RVE.

Sites surveyed within RVE (Figure 1) include; CCUS1, CCUS2, CCUS3, CCUS4, CRUS1, CRUS2, and CRUS3; which are associated with quadrats; CCHS1-V2-S, CCHS1-V3-S, CRHS3-V1-S, CRHS3-V3-S, CRHS2-V2, CRHS2-V3, CCHS3-V1, CCHS3-V2, CCHS4-V2, CCHS4-V3, and CCHS2-V2.

Control sites (not mapped) include; 33 and 15A(1).

3.3. Biosis (2014b) – Project no. 16940 (Giant Burrowing Frog, Littlejohn's Tree Frog, Stuttering Frog and Red-crowned Toadlet)

Surveys were undertaken 9-18 December 2013, 24 January-2 February 2014.

Threatened frog auditory monitoring

See Biosis (2013) above (Section 3.2).

In addition to the above methodology, data was then analysed using a call recogniser built in Song Scope bioacoustics software (Wildlife Acoustics). Confirmed Red-crowned Toadlet calls were sourced from previous Biosis recordings combine with David Stewarts Nature Sounds (2002) and were annotated into a call library to be used in the recogniser. The final recogniser had a total training value of 71.5 +-6.36 %, which indicates an adequate power of detection for the species. Recordings from the field were then run through the recogniser to detect potential Red-crowned Toadlet calls. An ecologist then reviewed these calls to confirm their identity.

Sites surveyed within RVE (Figure 1) that differ to Biosis (2013) include LW6A-F1 instead of LW5A-F2.

Control sites (not mapped) include FT6FA and WC11.

Threatened frog breeding habitat monitoring

See Biosis (2013) above (Section 3.2).

Threatened frog non-breeding habitat monitoring

See Biosis (2013) above (Section 3.2).

3.4. Biosis (2016) – Project no. 20492 (Giant Burrowing Frog, Littlejohn's Tree Frog, Stuttering Frog and Red-crowned Toadlet)

Monitoring for Stuttering Frog along Cataract Creek was completed between 2012 and the summer of 2014/2015. Given that no individuals were detected over three years of monitoring, this component of the threatened frog program ceased during the 2015/2016 monitoring.

Threatened frog auditory monitoring

See Biosis (2013) (Section 3.2) and Biosis (2014b) (Section 3.3) methods above.

Threatened frog breeding habitat monitoring

See Biosis (2013) above (Section 3.2).

Sites surveyed within RVE (Figure 1) that differ to Biosis (2013) include; BCUS2(1), BCUS2(2), CCUS4, CRUS1(1), CRUS1(2) and CRUS2.

3.5. Biosis (2017) – Project no. 23086 (Red-crowned Toadlet)

Threatened frog auditory monitoring

See Biosis (2013) (Section 3.2) and Biosis (2014b) (Section 3.3) methods above.

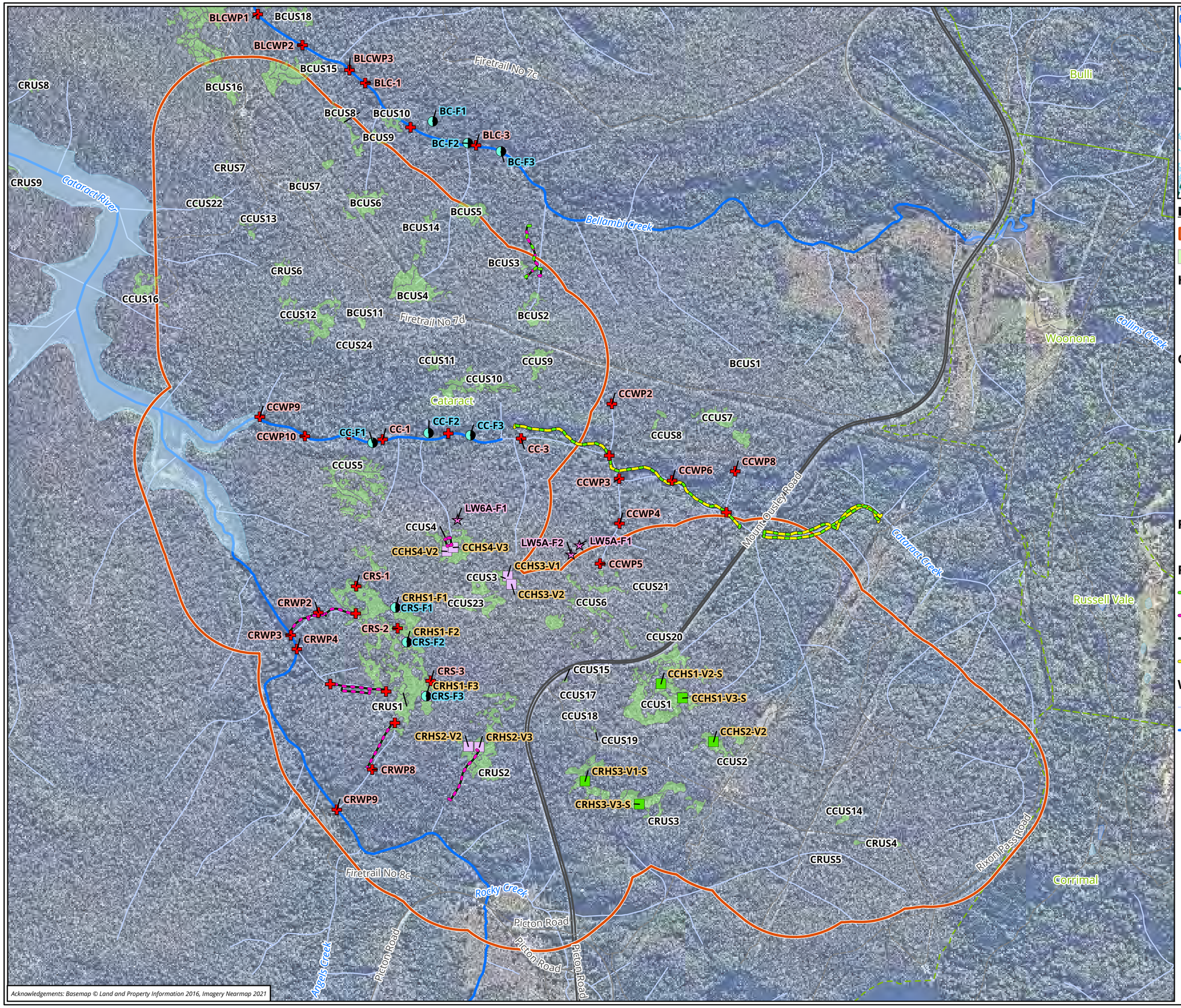
As per the recommendations outlined in the *Russell Vale East Terrestrial Ecological Monitoring Program Annual Report for 2015* (Biosis 2016), two additional sites were established downstream from the existing impact sites within RVE, in an attempt to identify whether or individuals were still present along the ephemeral drainage lines (Figure 1).

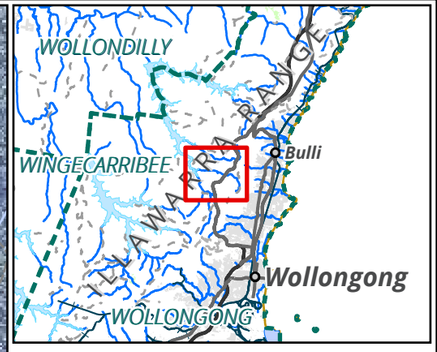
Sites surveyed within RVE (Figure 1) that differ to Biosis (2013) and Biosis (2014b) include LW5A-F1 and LW6A-F1 additional sites.

3.6. Biosis (2022) – Project no. 34919 (Giant Burrowing Frog)

Targeted surveys for Giant Burrowing Frog tadpoles were undertaken over two days along a tributary below swamp CRUS2 (Figure 1). The initial survey was undertaken in line with the previous survey methodology undertaken in the area to detect the species, see Biosis (2013) above and according to the methodology outlined in the BMP (Wollongong Coal 2021), developed following consultation with the NSW BCD.

The 2021 surveys were undertaken by Luke Stone (Senior Aquatic Ecologist), assisted by Zoe Goold (Project Zoologist) and Rosie Gray (Research Assistant) on 13 and 21 October 2021. Active VES for adults, tadpoles and egg mass were undertaken using spotlighting and call detection along a set transect identified as containing suitable habitat the species.





Legend

- UEP area
- Swamp extent

Habitat assessment sites

- Giant Burrowing Frog, Stuttering frog, Red-crowned Toadlet, Littlejohn's Tree Frog

Call playback

- Giant Burrowing Frog, Stuttering frog, Red-crowned Toadlet, Littlejohn's Tree Frog

Area search

- Giant Burrowing Frog
- Giant Burrowing Frog and Littlejohn's Tree Frog

Frog auditory monitoring

- Red-crowned Toadlet

Frog survey transects

- Stuttering Frog
- Littlejohn's Tree Frog
- Giant Burrowing Frog
- Red-crowned Toadlet

Waterways

- Non-perennial
- Perennial

Figure 1 Threatened frog targeted survey effort in the RVE UEP

0 100 200 300 400 500

Metres

Scale: 1:15,000 @ A3

Coordinate System: GDA 1994 MGA Zone 56

N

biosis

Matter: 36746,
Date: 09 September 2022 ,
Prepared for: CBH, Prepared by: AM, Last edited by: amackegard
Layout: 36746_F1_TFM
Project: P:\36700s\36746\Mapping\
36746_WCL_Stage2_BMP.aprx

4. Timing of survey

Recommended survey periods for threatened frogs surveyed at RVE are outlined in Table 4.

Table 4 Recommended survey periods for threatened frogs surveyed at RVE

Species	EPBC Act	BC Act	Recommended survey period
Heleioporus australiacus **Giant Burrowing Frog**	VU	VU	September-May
Litoria littlejohni **Littlejohn's Tree Frog**	VU	VU	July-November
Mixophyes balbus **Stuttering Frog**	VU	EN	September-March
Pseudophryne australis **Red-crowned Toadlet**	-	VU	Year-round

Surveys were conducted with the following timing:

- Biosis (2012) – Project no. 11853 (Giant Burrowing Frog, Littlejohn's Tree Frog, Stuttering Frog and Red-crowned Toadlet):
  - Frog surveys were conducted in creeklines and upland swamps in autumn and spring. The remaining surveys were undertaken in winter 2011 during the active period for frogs (Table 4).
- Biosis (2013) – Project no. 14511 (Giant Burrowing Frog, Littlejohn's Tree Frog, Stuttering Frog and Red-crowned Toadlet):
  - Surveys were undertaken during optimal conditions for each of the targeted species and during the active period for most species (Table 4) between 25-28 February 2013.
  - The survey period is not within the recommended survey period for Littlejohn's Tree Frog, however the species was consistently detected at control sites during this period (see Section 5.2, Table 8).
- Biosis (2014b) – Project no. 16940 (Giant Burrowing Frog, Littlejohn's Tree Frog, Stuttering Frog and Red-crowned Toadlet):
  - Surveys were undertaken during optimal conditions for each of the targeted species and during the active period of most species (Table 4) between the 9-18 December 2013 above Longwall 5, and 24 January to 2 February 2014 above Longwall 6.
  - The survey period is not within the recommended survey period for Littlejohn's Tree Frog, however the species was consistently detected at control sites during this period (see Section 5.3).
- Biosis (2016) – Project no. 20492 (Giant Burrowing Frog, Littlejohn's Tree Frog, Stuttering Frog and Red-crowned Toadlet):
  - Monitoring along Cataract Creek was completed between 2012 and the summer of 2014/2015 (see Section 5.4), during optimal conditions for each of the targeted species and during the active period of the species (Table 4).

- Biosis (2017) – Project no. 23086 (Red-crowned Toadlet):
  - Surveys were undertaken during optimal conditions for the targeted species and during the active period of the species (Year-round, Table 4) between February to April 2017.
- Biosis (2022) – Project no. 34919 (Giant Burrowing Frog):
  - Surveys were undertaken in CRUS2 during optimal conditions for each of the targeted species and during the active period of the species (September – March, Table 4) on 13 and 21 October 2021.
  - As the species was detected during the initial nocturnal survey, the second survey was undertaken under diurnal conditions, focusing on describing pools where the species was detected, to better record detailed habitat descriptions. Species observations were also collected during this survey, although water surface visibility was hampered due to tannin staining and glare. As the primary focus of the surveys are to determine the ongoing presence of the species within the previously identified area of habitat this is not considered a major limitation. Diurnal survey was required to ensure the most appropriate recording of habitat conditions could be collected, including the collection of photographs of the pools occupied by the species.

5. Results

5.1. Biosis (2012) – Project no. 11853 (Giant Burrowing Frog, Littlejohn's Tree Frog, Stuttering Frog and Red-crowned Toadlet)

The results of this survey are shown in Table 5 and Table 6 below.

Table 5 Species detected at newly established sites during the autumn and spring surveys 2011

Location	Common Name	Scientific Name	Total Count over 3 Replicates
Impact Creekline			
Cataract Creek	Lesueur's Tree Frog	*Litoria lesueuri*	1
	Leaf Green Tree Frog	*Litoria nudidigita/Litoria phyllochroa*	35
	Leaf Green Tree Frog	*Litoria phyllochroa*	33
Reference Creeklines			
Bellambi Creek	Lesueur's Tree Frog	*Litoria lesueuri*	-
	Leaf Green Tree Frog	*Litoria nudidigita/Litoria phyllochroa*	37
	Leaf Green Tree Frog	*Litoria phyllochroa*	17
Flying Fox Creek #3	Common Eastern Froglet	*Crinia signifera*	32
	Jervis Bay Tree Frog	*Litoria jervisiensis*	1
	Leaf Green Tree Frog	*Litoria nudidigita/Litoria phyllochroa*	10
	Peron's Tree Frog	*Litoria peronii*	1

Table 6 Results of diurnal threatened frog habitat assessment

Location Description	Habitat Notes
Walked down from CRS-F3 monitoring point down towards Cataract River (245 m transect)	Width: 0 – 1.5 metres Depth: 0 – 0.25 metres Defined creekline with very little water present. Only one suitable breeding pool present however, the surrounding terrain is steep. Around CRWP-8, creekline vegetation consists of mesic species with bare ground. **No tadpoles observed in diurnal surveys.**
Second western tributary at Cataract River Swamp	Width: 0 – 2 metres Depth: 0 – 0.2 metres Slow flowing rocky stream. Several sections stagnant with no water flow apparent for some time. Mossy/rainforest environment. **Possible Stuttering Frog habitat. Not considered to be potential Littlejohn's Tree Frog or Giant Burrowing Frog habitat. No tadpoles observed in diurnal surveys.**

Location Description	Habitat Notes
Walked down from CRS-F1 monitoring point down towards Cataract River	Width: 0 – 5 metres Depth: 0 – 0.25 metres Fast flowing rocky stream with few breeding pools present. Stream widens and becomes slightly deeper toward CRWP-2. Although there are a few breeding pools present, the terrain is very steep and minimal overhanging vegetation. **Considered to be sub-optimal habitat for Littlejohn's Tree Frog. No tadpoles observed in diurnal surveys. Red-crowned Toadlet may be heard from adjacent ephemeral drainage lines.**
Upstream from fire road 7C/ Bellambi Creek crossing	Width: 1.5 – 6 metres Depth: 0.1 – 2 metres Fast Flowing rocky stream. From BCWP1 and upstream, vegetation turns into Moist Gully Gum Forest. **Not ideal vegetation type for Littlejohn's Tree Frog however structurally suitable with flat slope, deep permanent pools present and fringing vegetation. No tadpoles observed in diurnal surveys.**

5.2. Biosis (2013) – Project no. 14511 (Giant Burrowing Frog, Littlejohn's Tree Frog, Stuttering Frog and Red-crowned Toadlet)

Threatened frog auditory monitoring

The Red-crowned Toadlet was recorded calling at Site F1 on 25-27 of February 2013 and at Site 2 on 25 of February 2012.

Table 7 Summary of Red-crowned Toadlet auditory monitoring, including numbers of calls and calling time for each site

Site	Date	Calls (24 hour time)
LW5A-F1	25 February 2013	1 adult calling at 19:54
	26 February 2013	3 adults calling between 18:08 and 19:35
	27 February 2013	3 adults calling between 17:23 and 19:04
	28 February 2013	Nil - Heavy rain precluded analysis of calls
LW5A-F2	25 February 2013	5 adults calling between 16:14 and 17:54
	26 February 2013	-
	27 February 2013	-
	28 February 2013	Nil - Heavy rain precluded analysis of calls

Threatened frog breeding habitat monitoring

Following the commencement of the threatened frog breeding habitat monitoring program in winter 2012, no adult Littlejohn's Tree Frog, Giant Burrowing Frog or Stuttering Frog adults have been detected at RVE.

Despite no records of Littlejohn's Tree Frog located in suitable habitats at RVE, the species was recorded at 12 of the 14 control sites surveyed within the same seasons. All three lifecycle stages (adult, tadpole and egg

mass) were recorded at four sites; adults and tadpoles at six sites; and adults only at an additional two sites. A summary of the results is provided in Table 8 below.

The Giant Burrowing Frog was recorded, as tadpoles only, at only one site (CRUS2 transect) during the winter and summer targeted surveys. A total of 17 tadpoles were observed over three breeding pools located along the 245 metre long transect.

Of the transects surveyed as part of the breeding habitat monitoring program at RVE, the CRUS2 transect is considered to be of highest habitat value for both the Giant Burrowing Frog and Littlejohn's Tree Frog and was ranked "good" in habitat assessments (although Littlejohn's Tree Frog has not been recorded).

Finally, no records of the Stuttering Frog have been recorded following the spring and summer targeted surveys for this species along two transects of Cataract Creek.

Threatened frog non-breeding habitat monitoring

Seven swamps potentially impacted by mining in RVE and two control sites were also monitored for non-breeding individuals in seasons where each frog is most active, and therefore easiest to detect. No threatened frog presence was recorded at any of the non-breeding habitat monitoring survey sites within RVE.

Table 8 Summary of results of threatened frog species surveys 2012-2013 (maximum number of recorded individuals is displayed)

Species	Control														Pre-impact and impact sites													
	SC8	SC7(1)	SC7(2)	SC7A (rep 1)	SC7A	NDC	ND2	ND1	LA4	DC13	WC11	WC15	LC7	WC10	CC(1)-T	CC(2)-T	CCUS2	CRUS1	CRUS1(1)-T	CRUS1(2)-T	CRUS2	CRUS2-T	CRUS3	WAC-T	WACT-T	CCUS1	CCUS3	CCUS4	CCUS4-T
Littlejohn's Tree Frog																												
Adults	4	9	14	8	15	4	3	1	-	9	6	2	-	23	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Tadpoles	4	-	70	86	185	7	-	2	-	19	2	4	-	57	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Egg Mass	4	-	4	-	-	-	-	-	-	4	-	-	-	4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Breeding Pools	3	4	6	-	10	7	2	2	-	4	1	2	-	15	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Giant Burrowing Frog																												
Adults	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Tadpoles	-	-	-	-	-	-	-	-	-	-	3	-	-	-	-	-	-	-	-	-	-	17	-	-	-	-	-	-	-
Egg Mass	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Breeding Pools	-	-	-	-	-	-	-	-	-	-	2	-	-	-	-	-	-	-	-	-	-	11	-	-	-	-	-	-	-
Stuttering Frog																												
Adults	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Tadpoles	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Egg Mass	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Pools	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

5.3. Biosis (2014b) – Project no. 16940 (Giant Burrowing Frog, Littlejohn's Tree Frog, Stuttering Frog and Red-crowned Toadlet)

Threatened frog auditory monitoring

The Red-crowned Toadlet was recorded calling at LW5A-F1 on 13 and 16 December 2013, however there were no records detected at LW5A-F2. This is the second season that the threatened species has been recorded calling in this ephemeral drainage line, following data collected at the same point in February 2013 (specific details provided in Biosis (2013). There has been no indication of a change in habitat at LW5A-F2 and the lack of calls is likely to be a result of environmental factors rather than longwall mining.

Song Meter data collected at LW6A did not detect the species this season despite being recorded at the control site (WC11A) within this same timeframe. This is the first season of monitoring at this site collecting pre-mining data. Data collected from the summer 2013/2014 auditory monitoring program are provided in Table 9 below.

Table 9 Summary of Red-crowned Toadlet auditory monitoring, including numbers of calls and calling time for each site

Site	Date	Calls (24 hour time)
LW5A-F1	9/12/2013	-
	10/12/2013	-
	11/12/2013	-
	12/12/2013	-
	13/12/2013	1 adult calling at 19:54
	14/12/2013	-
	15/12/2013	-
	16/12/2013	1 adult calling within 0:50:52 and 1:15:44
	17/12/2013	-
	18/12/2013	-
LW5A-F2	9/12/2013	-
	10/12/2013	-
	11/12/2013	-
	12/12/2013	-
	13/12/2013	-
	14/12/2013	-
	15/12/2013	-
	16/12/2013	-
	17/12/2013	-
	18/12/2013	-

Site	Date	Calls (24 hour time)
LW6A-F1	24/1/2014	-
	25/1/2014	-
	26/1/2014	-
	27/1/2014	-
	28/1/2014	-
	29/1/2014	-
	30/1/2014	-
	31/1/2014	-
	1/2/2014	-
	2/2/2014	-

Threatened frog breeding habitat monitoring

Following the commencement of the threatened frog breeding habitat monitoring program in winter 2012, no adult Littlejohn's Tree Frog or Stuttering Frog adults have been detected at RVE.

Despite no records of Littlejohn's Tree Frog located in suitable habitats at Russell Vale East, the species was recorded at 12 of the 14 control sites surveyed within winter 2013. All three lifecycle stages (adult, tadpole and egg mass) were recorded at four sites; adults and tadpoles at six sites; and adults only at an additional two sites.

No records of the Stuttering Frog have been recorded following the spring 2013 and summer 2013/2014 targeted surveys along two transects of Cataract Creek.

The Giant Burrowing Frog was recorded, as adults, metamorphs and tadpoles at only one monitoring site (CRUS2 Tributary) during the summer 2013/2014 targeted surveys. A total of 17 tadpoles (including 11 metamorphs) were observed within one breeding pool located along the 245 metre long transect on the first replicate conducted for the season on 13 January 2014. The second replicate completed on the 21 January 2014 detected nine tadpoles (including 3 metamorphs) within the same breeding pool. One adult was also identified to be calling from a burrow upstream of the known breeding pools. This is the first time an adult and metamorphs have been detected within this monitoring transect. The species was first detected as tadpoles in winter 2012 when ecological monitoring commenced.

Table 10 Summary of Giant Burrowing Frog observations at CRUS2-Trib in summer 2013/2014 monitoring season

Date recorded	Life Stage	Habitat	Number recorded
13/1/2014	Tadpoles	In water	8
	Metamorphs	In water	8
	Metamorphs	On Ground	1
21/1/2014	Tadpoles	In water	6
	Metamorphs	In water	3
	Adult	Calling	1

Of the transects surveyed CRUS2 is considered to be of highest habitat value for both the Giant Burrowing Frog and Littlejohn's Tree Frog and was ranked "good" in habitat assessments (although Littlejohn's Tree Frog has not been recorded).

Threatened frog non-breeding habitat monitoring

A total of seven sites were also monitored for non-breeding individuals in seasons where each frog is most active, and therefore easiest to detect. No threatened frog presence was recorded at any of the survey sites.

5.4. Biosis (2016) – Project no. 20492 (Giant Burrowing Frog, Littlejohn's Tree Frog, Stuttering Frog and Red-crowned Toadlet)

Threatened frog auditory monitoring

The Red-crowned Toadlet was again not recorded at either of the two impact sites (LW5A-F1 and LW6A-F1) during summer 2015/2016 auditory monitoring despite having been detected at the control sites. The site inspection again confirmed that the surface fracture intersecting the LW5A drainage line, first detected in 2014, is still present. The fracture is located approximately 30 meters upstream of the monitoring point and remains to be approximately eight meters long, two meters wide and one and a half meters deep. For the second consecutive year, no Red-crowed Toadlet were detected at LW5A-F1 downstream which may be a result of disrupted surface flows down the drainage line.

Data for the 2015 monitoring period is summarised in Table 11.

Table 11 Summary of Red-crowned Toadlet auditory monitoring, including numbers of calling adults and calling time for each site

Site status	Site	Date	Calls (24 hour time)
Impact	LW5A-F1	4/02/2016	-
		5/02/2016	-
		6/02/2016	-
		7/02/2016	-
		8/02/2016	-
	LW6A-F1	4/02/2016	-
		5/02/2016	-
		6/02/2016	-
		7/02/2016	-
		8/02/2016	-
Control	FT6FA	4/02/2016	2 adults calling between 18:43 and 22:00
		5/02/2016	2 adults calling between 18:05 - 22:00
		6/02/2016	1 adult calling between 18:01 - 22:00
		7/02/2016	1 adult calling between 19:07 - 21:42
	WC11	4/02/2016	1 adult calling between 20:25 – 21:42
		5/02/2016	1 adult calling between 20:22 - 21:40

Site status	Site	Date	Calls (24 hour time)
		6/02/2016	1 adult calling between 20:17 - 22:00
		7/02/2016	-

Threatened frog breeding habitat monitoring

During 2015, no Littlejohn's Tree Frogs were detected in RVE. Since the commencement of the program in winter 2012 this species has not yet been detected at any of monitoring sites at RVE. The species was however recorded at seven control sites surveyed within winter 2015. All three lifecycle stages (adult, tadpole and egg mass) were recorded at each site.

The Giant Burrowing Frog was again recorded as adult, metamorphs and tadpoles at the CRUS2 tributary monitoring site during 2015. Throughout the monitoring year of 2015 Giant Burrowing Frog tadpoles were recorded in three breeding pools in CRUS2. Giant Burrowing Frog tadpoles were recorded across all three monitoring seasons during 2015, with the largest numbers of tadpoles being observed during autumn (117) and at the end of winter/early spring (119). Metamorphs were only recorded during the two monitoring seasons completed in summer 2015/2016. Three adults were detected along the transect during the December 2015 monitoring survey, observed on the warmest evening of the month (minimum temperature of 20.4˚C) the night before a rainstorm. This is the third year where metamorphs and adult frogs have been detected at CRUS2. Data for the 2015 monitoring period is summarised in Table 12, Table 13 and Table 14.

Table 12 Summary of Giant Burrowing Frog observations at CRUS2-Trib in 2015 monitoring program (autumn 2015 – summer 2015/2016)

Date recorded	Life stage	Habitat	Number recorded	Breeding pool
09/04/2015	Tadpoles	In water	3	Pool 12
	Tadpoles	In water	19	Pool 13
	Tadpoles	In water	49	Pool 14
21/05/2015	Tadpoles	In water	4	Pool 12
	Tadpoles	In water	16	Pool 13
	Tadpoles	In water	26	Pool 14
21/12/2015	Adult	On Ground	1	On banks of transect
	Adult	On Ground	1	Pool 14
	Adult	On Ground	1	Pool 16
	Metamorphs	In water	2	Pool 12
	Tadpoles	In water	2	Pool 12
	Tadpoles	In water	11	Pool 13
	Tadpoles	In water	16	Pool 14
18/02/2016	Tadpoles	In water	2	Pool 13
	Tadpoles	In water	57	Pool 14
	Metamorphs	In water	1	Pool 12
	Metamorphs	In water	2	Pool 14

Table 13 RVE threatened frog breeding habitat 2015 data

Species	Life Stage	BCUS2(1) (07/05/2015)	BCUS2(1) (14/05/2015)	BCUS2(1) (20/08/2015)	BCUS2(1) (11/08/2015)	BCUS2(2) (07/05/2015)	BCUS2(2) (14/05/2015)	BCUS2(2) (20/08/2015)	BCUS2(2) (11/08/2015)	CCUS4 (09/04/2015)	CCUS4 (21/05/2015)	CCUS4 (19/08/2015)	CCUS4 (09/09/2015)	CRUS1(1) (09/04/2015)	CRUS1(1) (21/05/2015)	CRUS1(1) (19/08/2015)	CRUS1(1) (09/09/2015)	CRUS1(2) (09/04/2015)	CRUS1(2) (21/05/2015)	CRUS1(2) (19/06/2015)	CRUS1(2) (09/09/2015)	CRUS2 (09/04/2015)	CRUS2 (21/05/2015)	CRUS2 (19/08/2015)	CRUS2 (09/09/2015)	CRUS2 (21/12/2015)	CRUS2 (18/02/2016)
Giant Burrowing Frog	Adult	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3	-
	Eggmass	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Tadpoles	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	71	46	59	60	29	59
	Metamorph	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	3
	Number of Breeding pools	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3	3	3	3	5	3
Littlejohn's Tree Frog	Adult	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Eggmass	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Tadpoles	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Metamorph	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Number of Breeding pools	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Stuttering Frog	Adult	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Eggmass	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Tadpoles	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Metamorph	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Number of Breeding pools	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Table 14 Control threatened frog breeding habitat 2015 data

Species	Life Stage	SC6	SC7A	SC7(1)	SC7(2)	SC8	NDC	ND1	ND2	WC10	WC11
		10/08/2015	10/08/2015	10/08/2015	28/07/2015	5/08/2015	3/08/2015	8/09/2015	3/08/2015	4/08/2015	12/08/2015
Giant Burrowing Frog	Adult	-	-	-	-	-	-	-	-	-	-
	Eggmass	-	-	-	-	-	-	-	-	-	-
	Tadpoles	11	-	-	-	-	-	-	-	-	7
	Metamorph	-	-	-	-	-	-	-	-	-	-
	# Breeding pools	10	-	-	-	-	-	-	-	-	4
Littlejohn's Tree Frog	Adult	7	19	6	14	1	8	7	-	11	4
	Eggmass	7	18	9	7	4	-	11	-	13	2
	Tadpoles	5	5	-	5	3	3	4	-	1	2
	Metamorph	-	-	-	-	-	-	-	-	-	-
	# Breeding pools	12	16	8	9	4	6	10	-	12	4

The species was first detected as tadpoles in winter 2012 when ecological monitoring commenced with the first adult frog and metamorphs detected in the summer surveys of 2013/2014. During the period of monitoring, adults continue to be detected on warm nights following or prior to thunderstorms during the summer and autumn months. Following this the highest numbers of tadpoles also continue to be observed during the autumn and winter months. As tadpole abundance declines in summer, metamorph abundance increases with peak metamorph abundances during summer. Metamorph detection was comparably low in 2015 when compared to 2014 (Figure 2).

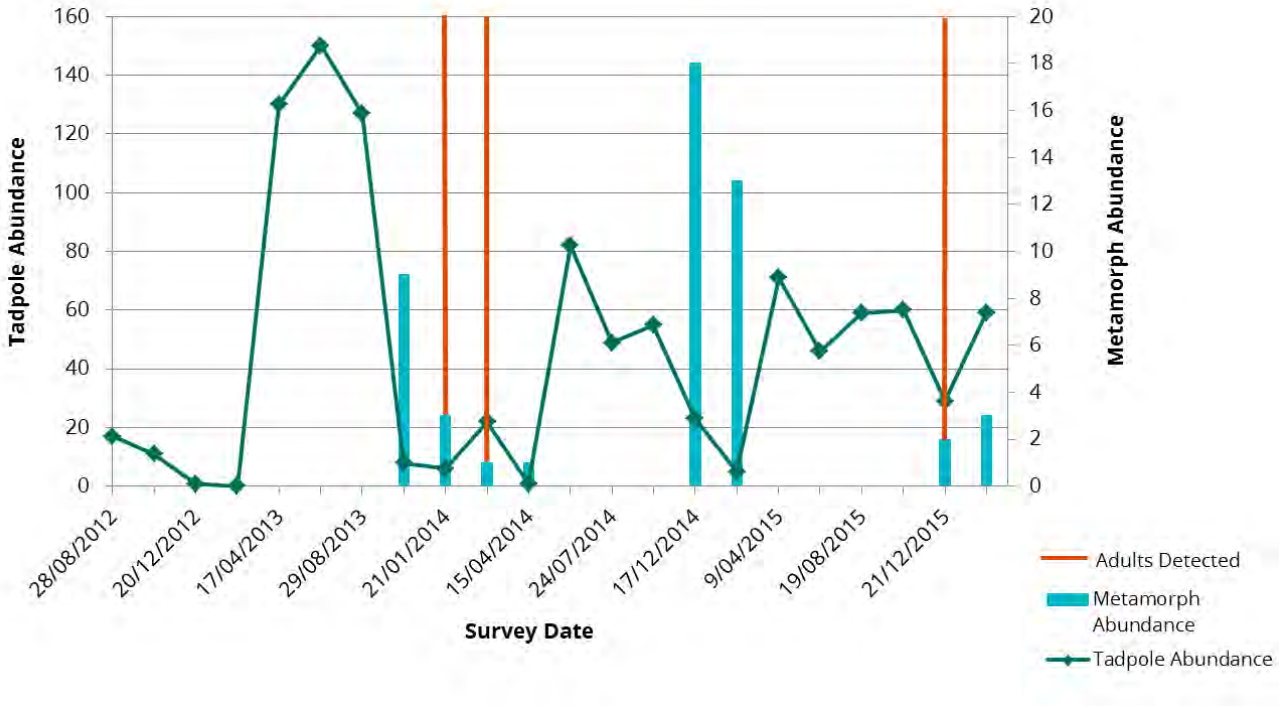


Figure 2 **Giant Burrowing Frog observations at CRUS2-Trib across time since monitoring commenced (spring 2012 – summer 2015/2016)**

Of the seven transects surveyed at RVE as part of the breeding habitat monitoring program, the CRUS2 transect is considered to be of highest habitat value for both the Giant Burrowing Frog and Littlejohn's Tree Frog. However, Littlejohn's Tree Frog has not been recorded at this site to date.

5.5. Biosis (2017) – Project no. 23086 (Red-crowned Toadlet)

Threatened frog auditory monitoring

Due to the two previous years of auditory monitoring resulting in the apparent absence of the Red-crowned Toadlet from the impact sites (LW5A-F1 and LW6A-F1), additional monitoring sites were established for the 2016/2017 monitoring period. These sites were located within the impact area of Longwalls 5 and 6 in an attempt to determine if the species may have relocated to more suitable habitat downstream of the initial monitoring sites. Analysis of the recordings resulted in the presence of the Red-crowned Toadlet at the additional site downstream from LW6A-F1, where habitat was thought to be more suitable. In addition to this, during the setup of the original monitoring site at LW5A-F1, a qualified zoologist identified the presence of the Red-crowned Toadlet, as the species is known to call back to clapping and ambient noises created from using tools during installation of the songmeter.

Data collected from the summer 2013/2014 auditory monitoring program are provided in Table 15 below. Trends in call activity at these sites from the beginning of monitoring are represented in Table 16.

Table 15 Summary of Red-crowned Toadlet auditory monitoring, including numbers of calling adults and calling time for each site

Site	Site status	Date	Calls (24 hour time)
LW5A-F1	Impact	23/02/2017 - 03/03/2017	One individual recorded during the installation of the Songmeter
LW6A-F1	Impact	23/02/2017 - 09/04/2017	-
LW5A-F1 Additional Site	Impact	24/02/2017 - 5/03/2017	-
LW6A-F1 Additional Site	Impact	24/02/2017 - 09/04/2017	At least two individuals calling between 16:18 – 16:21
FT6FA	Control	23/02/2017 - 14/05/2017	At least two individuals calling between 19:36 – 19:39
WC11	Control	23/02/2017 - 01/03/2017	At least two individuals calling between 16:59 – 17:46

Table 16 Summary of Red-crowned Toadlet auditory monitoring, including all monitoring years

Treatment	Site	2012/2013	2013/2014	2014/2015	2015/2016	2016/2017
RVE	LW5A-F1	Present	Present	Absent	Absent	Present
	LW6A-F1	Absent	Absent	Absent	Absent	Absent
	LW5A-F1 - Additional	-	-	-	-	Absent
	LW6A-F1- Additional	-	-	-	-	Present
Control	FT6FA	Present	Present	Present	Present	Present
	WC11	Present	Present	Present	Present	Present

5.6. Biosis (2022) – Project no. 34919 (Giant Burrowing Frog)

The spring 2021 surveys have focussed on identifying the continued presence of the species within mapped habitat along the CRUS2 transect. Giant Burrowing Frog tadpoles were identified at pools 12 and 13 along transect CRUS2 during the spring surveys.

A summary of the Giant Burrowing Frog tadpoles recorded from transect CRUS2 since monitoring commenced in 2012 is summarised in Table 17 (Biosis 2022). While the spring surveys cannot be directly compared to any previous surveys during spring, the 2021 results broadly align with results of previous surveys which show greatest detection during winter and lowest levels of detection during summer and demonstrate the ongoing presence of this species in this waterway.

Table 17 Giant Burrowing Frog records summary from CRUS2 transect

Survey date	Round	Adults	Metamorphs	Tadpoles
28/08/2012	Winter	-	-	17
30/08/2012	Winter	-	-	11
17/04/2013	Autumn	-	-	130
27/05/2013	Autumn	-	-	50
27/08/2013	Winter	-	-	100
29/08/2013	Winter	-	-	127
20/12/2013	Summer	-	-	1
13/01/2014	Summer	-	9	8
21/01/2014	Summer	1	3	6
19/03/2014	Autumn	1	1	22
15/04/2014	Autumn	-	1	82
24/07/2014	Winter	-	-	49
29/07/2014	Winter	-	-	55
17/12/2014	Summer	-	18	23
13/01/2015	Summer	-	13	5
9/04/2015	Autumn	-	-	71
21/05/2015	Autumn	-	-	46
19/08/2015	Winter	-	-	59
9/09/2015	Winter	-	-	60
21/12/2015	Summer	3	2	29
18/02/2016	Summer	-	3	59
13/10/2021	Spring	-	-	21
21/10/2021	Spring*	-	-	18

**diurnal habitat survey*

Previous monitoring has been undertaken in winter, autumn and summer and has predominantly encountered tadpoles at pools 12, 13 and 14. A detailed breakdown of detection per pool is provided in Table 18. The monitoring data indicate that pools 12 and 13 represent the most permanent habitat for Giant Burrowing Frog tadpoles. Pool 14 has also reliably recorded relatively high number of tadpoles, although there is a greater number of zero counts for this pool. Indicating that habitat conditions are less permanent or utilisation is less frequent, but that abundances tend to be greater when tadpoles are present. The 2021 results are consistent with these findings.

Table 18 Giant Burrowing Frog tadpole detection in identified pools along the CRUS2 transect

Year	Season	CRUS2-P10	CRUS2-P11	CRUS2-P12	CRUS2-P13	CRUS2-P14	CRUS2-P15	CRUS2-P16
2012	Winter	-	-	15	8	5	-	-
2013	Autumn	-	-	130	20	30	-	-
2013	Summer	-	-	1	-	-	-	-
2013	Winter	-	2	102	50	73	-	-
2014	Autumn	1	-	22	59	-	12	10
2014	Summer	-	-	-	37	-	-	-
2014	Winter	-	-	-	104	-	-	-
2015	Autumn	-	-	7	35	75	-	-
2015	Summer	-	-	2	16	16	-	-
2015	Winter	-	-	16	34	69	-	-
2016	Summer	-	-	-	2	57	-	-
2021	Spring	-	-	19	20	-	-	-

References

Biosis 2012. *Wonga East Lease Area Ecological Monitoring Program Annual Monitoring Report Year 1 (2011)*, Prepared for Gujarat NRE Coking Coal Limited. Author: Reed, K. Biosis Research Pty Ltd. Project no. 11853.

Biosis 2013. *Wonga East and V-Mains Ecological Monitoring Program. Autumn 2011 through to autumn 2013*, Report prepared for Gujarat NRE Coking Coal Ltd. Authors: Reed. K, Biosis Research Pty Ltd, Wollongong, NSW. Project no. 14511 and 16015.

Biosis 2014a. *Russell Vale Colliery – Underground Expansion Project: Preferred Project Report - Biodiversity*, Report prepared for Wollongong Coal Ltd. Authors: Garvey. N, Beyer. K, Biosis Pty Ltd, Wollongong, NSW. Project no. 16646.

Biosis 2014b. *Russell Vale East and V Mains 2013 Ecological Monitoring Program*, Report for Wollongong Coal Pty Ltd. Author: J. Cooper, Biosis Pty Ltd, Wollongong. Project no. 16940.

Biosis 2016. *Russell Vale East terrestrial ecological monitoring program: Annual Report 2015*, Report for Wollongong Coal Limited. Authors: Reed K & Dunne C, Biosis Pty Ltd, Wollongong, New South Wales. Project no. 20492.

Biosis 2017. *Russell Vale East Terrestrial ecological monitoring program Annual report for 2016*, Report for Wollongong Coal Limited. Authors: Christina Faddy-Vrouwe, James Lidsey and Luke Stone, Biosis Pty Ltd, Wollongong. Project no. 23086.

Biosis 2022. *Russell Vale East Terrestrial Ecological Monitoring Program 2021*, Prepared for Wollongong Resources Pty Ltd. Authors: Goold. Z, Cerato. S, Price, P. Biosis Pty Ltd, Wollongong. Project no. 34919.

DECC 2007. Submission of the strategic review of the impacts of underground mining in the Southern Coalfield, NSW Department of Environment and Climate Change.

DECC 2009. *Threatened Species Survey and Assessment Guidelines: Field Survey methods for Fauna - Amphibians*, New South Wales Government Department of Environment and Climate Change, Sydney, NSW.

DEWHA 2010. *Survey Guidelines for Australia's Threatened Frogs: Guidelines for detecting frogs listed as threatened under the Environment Protection and Biodiversity Conservation Act 1999*, Department of the Environment Water Heritage and the Arts.

DPIE 2020a. *Biodiversity Assessment Method (BAM)*, Department of Planning, Industry & Environment, https://www.environment.nsw.gov.au/research-and-publications/publications-search/biodiversity-assessment-method-2020.

DPIE 2020b. *NSW Survey Guide for Threatened Frogs: A Guide for the Survey of Threatened Frogs and their Habitats for the Biodiversity Assessment Method*, Department of Planning, Industry and Environment.

ERM 2011. *No. 1 Colliery Stage 2 Environmental Assessment*, Report to Gujarat NRE Coking Coal Ltd.

Mahony M, Knowles R, & Pattinson L 1997. Stuttering Barred Frog, Mixophyes balbus. In Threatened Frogs of New South Wales: Habitats, Status and Conservation pp 66-71. Ed H Ehmann.

NPWS 2001a. *Environmental Impact Assessment Guideline: Giant Burrowing Frog*, New South Wales National Parks and Wildlife Service.

NPWS 2001b. *Environmental Impact Assessment Guideline: Red-crowned Toadlet*, NSW National Parks and Wildlife Service.

OEH 2017. *Biodiversity Assessment Method (BAM)*, New South Wales Office of Environment and Heritage, https://www.environment.nsw.gov.au/-/media/OEH/Corporate-Site/Documents/Animals-and-plants/Biodiversity/biodiversity-assessment-method-170206.pdf.

Wollongong Coal 2021. *Russel Vale Colliery Extraction Plan - Biodiversity Management Plan*, Wollongong Coal. Wollongong, NSW.

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APPENDIX B – MONITORING DATA AND ANALYSIS

Vegetation transect monitoring data from the current ecological monitoring program is provided as an electronic appendix titled *36747.Russelvale.Flora.Annual.2021.20210719.*

The 2020 statistical analysis report (Analytical Edge 2021) addressing the 2020 Russell Vale East dataset (data collected up to, and including, 2020) is provided in this appendix.

THE ANALYTICAL EDGE
STATISTICAL CONSULTING

Analysis of RV East flora data for Biosis

Joanne M. Potts

23rd February 2021

Version control

Date	Amendments	Person
10.Feb.2021	Submitted draft analysis to Luke Stone	JP
23.Feb.2021	Submitted final report	JP

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1 Background

1.1 Data summary

Data were provided to The Analytical Edge (hereafter, TAE), by Luke Stone (Biosis) via e-mail on 19th January 2021. One data set was relevant to the Russell Vale East study region: *"Russelvale.Flora.Annual.2020.20210119"* (421 KB). This file contained flora data collected between 2005 and 2020 at eight control swamps and five impact swamps. All five of the swamps due to be impacted (termed 'impact swamps') have actually been impacted (i.e., mining has commenced within the RMZ). See Table 1 for summary.

Errors: I noticed that the sites visited in 2019 were called "[site] - [transect]" whereas previously they were called "[site]-[transect]". For the purpose of this analysis, the extra spaces were removed via find/replace but this should also be corrected in the parent database.

Disclaimer: Excluding the error highlighted above, these data are assumed to be error-free. Any further errors detected by Biosis may invalidate the results and conclusions made in this report, and will require the analysis to be re-run under the proviso of new contract agreements.

Table 1: Summary table of survey sites.

Site	Type	Years Surveyed
ACUS	Control	2012, 2013, 2014, 2015, 2016, 2017, 2019, 2020
WACUS	Control	2012, 2013, 2014, 2015, 2016, 2017, 2019, 2020
BCUS12	Control	2012, 2013, 2014, 2015, 2016, 2017, 2019, 2020
BCUS13	Control	2012, 2013, 2014, 2015, 2016, 2017, 2019, 2020
WCUS	Control	2012, 2013, 2014, 2015, 2016, 2017, 2019, 2020
S22	Control	2009, 2010, 2011, 2012, 2013, 2014, 2015, 2016, 2017, 2019
S33	Control	2009, 2010, 2011, 2012, 2013, 2014, 2015, 2016, 2017, 2019
S15A(1)	Control	2005, 2006, 2007, 2008, 2009, 2010, 2011, 2012, 2013, 2014, 2015, 2016, 2017, 2019
CCUS1	Impact	2012, 2013, 2014, 2015, 2016, 2017, 2019, 2020
CCUS3	Impact	2012, 2013, 2014, 2015, 2016, 2017, 2019
CCUS4	Impact	2012, 2013, 2014, 2015, 2016, 2017, 2019, 2020
CCUS5	Impact	2013, 2014, 2015, 2016, 2017, 2019, 2020
CRUS1	Impact	2011, 2012, 2013, 2014, 2015, 2016, 2017, 2019

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1.2 Data collection

At each of the 13 surveyed swamps, between one and three unique transects were established. Each transect was essentially a 15 m long belt-transect consisting of 30 0.5 m^2 contiguous quadrats. For each unique species detected along the surveyed transect, the total number of quadrats within which it was detected was recorded. That is, for each transect, a number between 1 and 30 was recorded, representing the number of quadrats that contained that species (it follows that a 0 was recorded if the species was not detected in any quadrat).

The value, between 0 and 30, reflects relative occupancy: a low cumulative total means the species was not widespread along each transect (but may still be locally abundant, e.g., a patchy species). A high score means the species may be widespread but not necessarily abundant (i.e., a single individual in each of the 30 quadrats). Consequently, these cumulative totals cannot be considered a surrogate for abundance or percentage cover for each species. These data can be used to calculate total species richness for each transect. Species composition at each site based on species presence, not relative abundance, can be investigated.

1.3 Trigger Action Response Plan (TARP)

As per previous analyses, the same interpretation on the Trigger Action Response Plan (TARP) was used, based on two files called “RVC EC TAR 008 Longwalls 6 & 7 Upland Swamp TARP - Rev 6_DoE approved.docx” (115KB) and "RVC EC TAR 004 Longwalls 6 & 7 Biodiversity TARP - Rev 6 _DoE approved.docx" (103KB) e-mailed to TAE by Sam Luccitti (Biosis) on 4th April 2016. The TARP relating to the “Vegetation Monitoring” is poorly defined. The “Within Prediction (Level 1)” trigger is: “Negligible change to the composition or distribution of species, as illustrated by no statistically significant difference between control and impact sites or between impact sites before and after mining.”

The parameters used to assess this TARP are: “Initially, community composition is analysed looking for changes in species composition at each site. Following this, changes in species richness and diversity are measured to determine if changes have occurred over time, or between control and impact sites.” The data analysed here represent relative occupancy in each quadrat along the transects, so can be used to assess total species richness, but are not appropriate for calculation of diversity indices.

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2 Assessing changes in Total Species Richness (TSR)

2.1 Methods

Total species richness (TSR) was calculated for each transect, for each survey, by simply summing up the total number of unique species detected.

Exploratory data analysis was carried out by plotting TSR between 2005 when surveys first commenced up to 2020, split by year and mining status ("Control", "Pre-Mining", "Post-Mining" or "Mined beneath"), pooled across all transects and swamps surveyed within a year. This pooling process may mask individual swamp-level effects of mining status (i.e., richness at some swamps might go up, others might go down, but on average total richness appears stable). Hence the TSR in each year for each unique transect, at each swamp, were individually plotted.

Generalised linear mixed models (GLMMs, for example see Bolker et al. 2009) were used to investigate whether there was any detectable difference in TSR before and after any mining impacts (either within the RMZ, or mined beneath). That is, six different models were fitted to the data, with the response variable being TSR, and the explanatory variables increasing in complexity from a simple null model (i.e., TSR did not change over time or between swamps), to including additive and interactive effects for Pre- and Post- mining (PrePost) and Year. Observations of TSR were not independent, temporally (since transects are visited multiple times) or spatially (since there are three transects within each swamp). That is, it would be expected that observations collected at the same swamp, regardless of year or season, would be more correlated than observations collected at different swamps; and similarly, observations collected at swamps near each other would be more similar to observations collected at swamps further away. Hence, a random-effect term was included here to account for this correlation within swamps.

Akiake's Information Criteria (AIC) was used to select between competing models, whereby the model with the lowest AIC was considered the "best" of all models fitted, and models that had an AIC less than or equal to 2 from the AIC of the best model were considered equivalent (Burnham and Anderson, 2003).

All modeling was completed in the statistical software program R (v.4.0.2, R Core Team 2020). GLMMs of TSR were fitted using the "glmer" function in the "lme4" package (v.1.1-25, Bates et al. 2015).

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2.2 Results

Exploratory data analysis

Exploratory analysis of the TSR data suggests that richness is highly variable between years, and mining status ("Control", "Pre-mining", "Post-mining", or "Mined beneath", Figure 1). When pooled over swamp, it appears there is high variability in TSR, regardless of year or mining status (Figure 1). There is no obvious visual difference in the TSR trend between Control and Pre-mining swamps, albeit the sample size for Pre-mining swamps diminishes with time (as they transition to Post-mining swamps). TSR is similar, but perhaps has less variability, in post-mining areas compared to pre-mined areas (Figure 1). There are a few transects at only one swamp (CCUS3) that have been mined beneath.

When accounting for TSR within each swamp (Figure 2 and Figure 3, for control and impact swamps, respectively), variability within and between swamps was large, regardless of year effects and mining status. For the eight control swamps (Figure 2), swamp S15A(1) was particularly variable in comparison to the other control swamps, but there does not appear to be any strong visual trend (e.g., decreasing yearly) at any of the swamps.

At the five impact swamps (Figure 3), all have actually been impacted (i.e., mined within the RMS, or mined beneath). Similarly to the control swamps, variability in TSR is large both within the same swamp and between swamps, regardless of mining status. In particular, for the swamps monitored in 2020:

1. At CCUS1, data from pre-mining transects was limited; however TSR increased slightly over time, and variance was large.
2. No pre-mining data exists for CCUS4. The TSR at post-mining transects (within the RMZ) was variable.
3. At CCUS5, where mining commenced in 2015, the range of the observed TSR seemed comparable between transects that had been mined within the RMZ compared to pre-mining.

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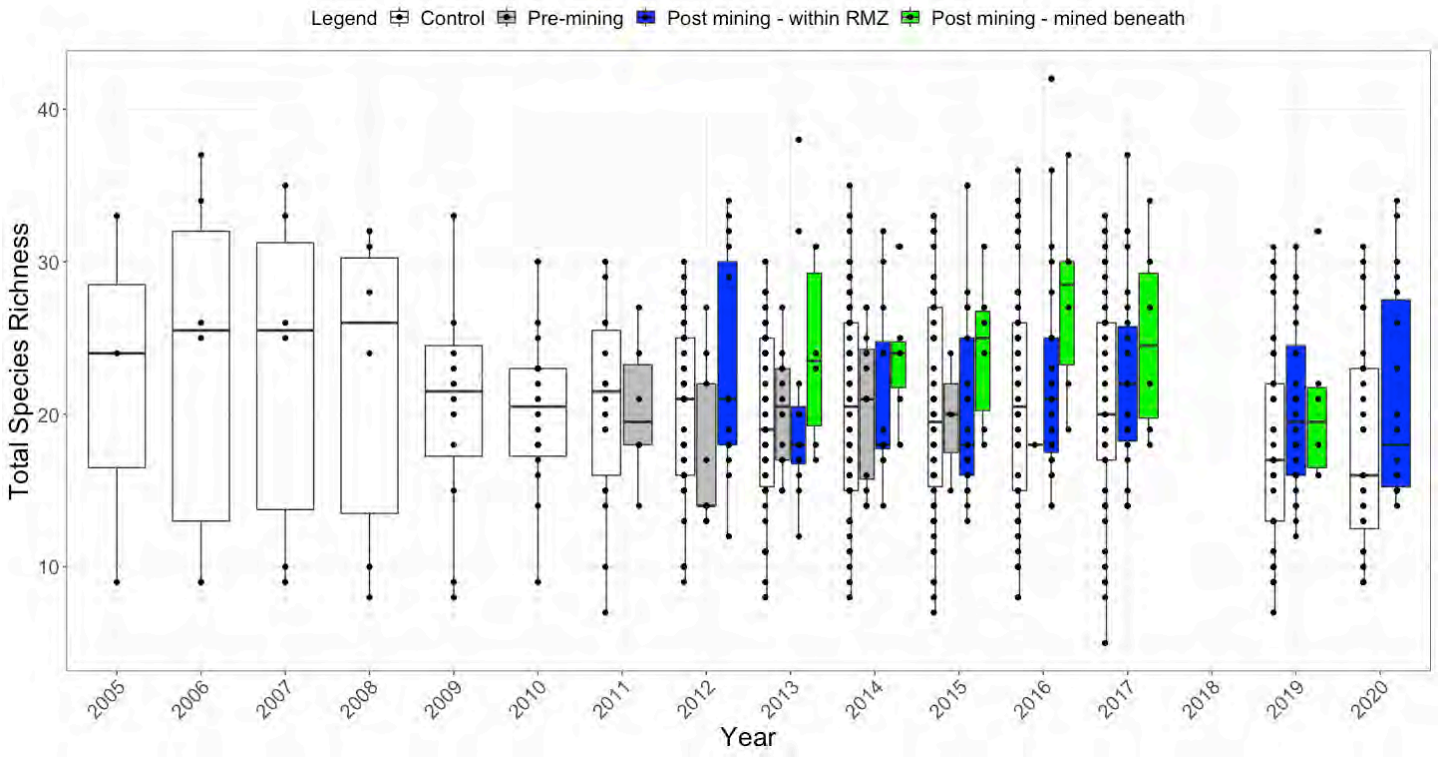

Figure 1: Boxplot of the total species richness at all surveyed swamps within the Russell Vale East Region, each year. The solid line within the boxes is the median (i.e., the 50th percentile), the margins of the box are the interquartile range (IQR, i.e, the 25th and 75th percentile), and the whiskers of the boxplot cover 1.5 times the IQR of the data. White shaded boxes are the control swamps. Grey, blue and green shaded boxes: either impact sites, that are either Pre-mining, Post mining - within RMZ, or Post mining - mined beneath, respectively. Solid black points represent the observed TSR from each transect. N.B., the break in the x-axis at 2018, when no monitoring took place.

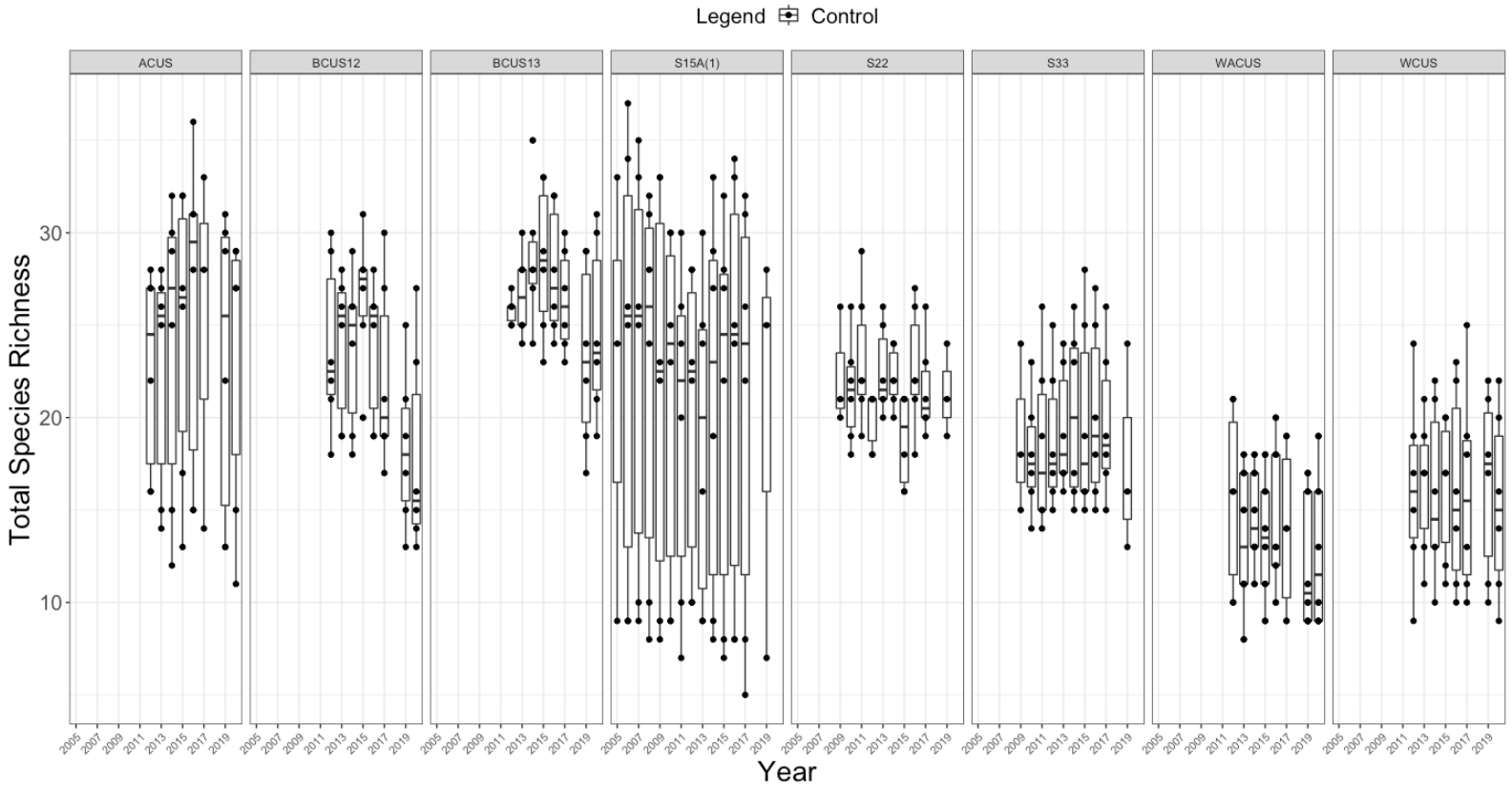

Figure 2: Boxplot of total species richness for each control swamp site (swamp name given in grey box above each panel). The solid line within the boxes is the median (i.e., the 50th percentile), the margins of the box are the interquartile range (IQR, i.e, the 25th and 75th percentile), and the whiskers of the boxplot cover 1.5 times the IQR of the data. Solid black points represent the observed TSR from each transect. N.B., the break in the x-axis at 2018, when no monitoring took place.

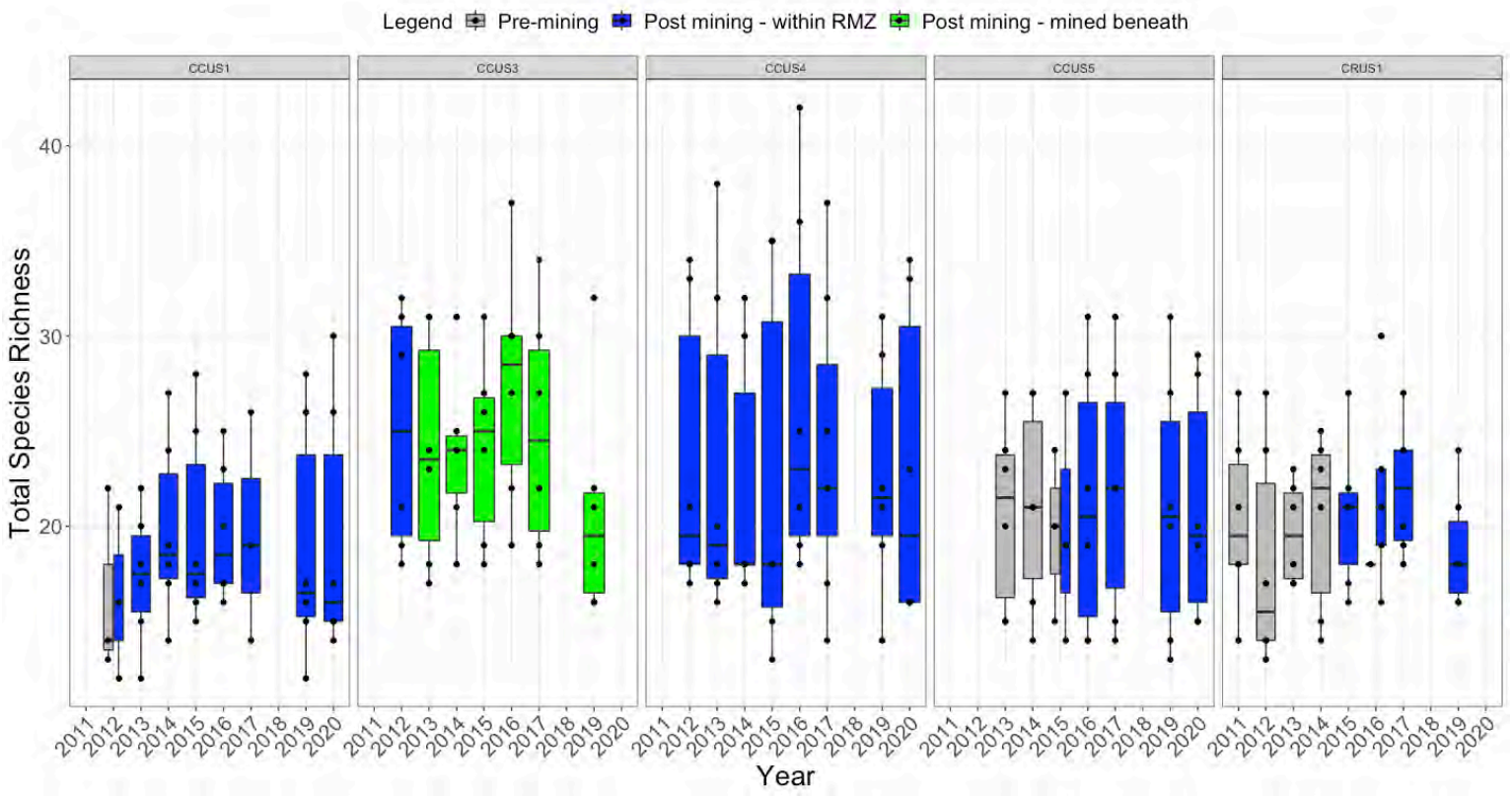

Figure 3: Boxplot of total species richness for each impact swamp site (swamp name given in grey box above each panel). The solid line within the boxes is the median (i.e., the 50th percentile), the margins of the box are the interquartile range (IQR, i.e, the 25th and 75th percentile), and the whiskers of the boxplot cover 1.5 times the IQR of the data. Grey, blue and green shaded boxes are the impact sites: either Pre-mining, Post mining - within RMZ, or Post mining - mined beneath, respectively. Solid black points represent the observed TSR from each transect. N.B., the break in the x-axis at 2018, when no monitoring took place.

Determining difference in TSR due to mining impacts

Generalised linear mixed models (GLMMs) fit to the TSR data suggested that model M3, which accounted for Pre- and Post-mining effects (PrePost) and Year was the best fit to the data, i.e., post-mining was detected to have an impact on the total species richness in a swamp (Table 2).

Model M3 (Table 2) showed that the increase in TSR at post-mining (within the RMZ) swamps is very small and not significant (est. = 0.08, s.e. = 0.04, p-value = 0.06). That is, we are 95% confident that post-mining sites have between a -0.002 and 0.169 increase in TSR, compared to pre-mining/control sites. The yearly effect on TSR is statistically significant; however the magnitude of the impact is very small and not considered biologically significant (est. = -0.008, s.e. = 0.003).

Importantly, model selection results are uncertain, with two other models (M4 and M2) having a difference in AIC of less than 2, meaning they are essentially equivalent (Burnham and Anderson, 2002).

Table 2: Model selection results, ranked by AIC.

Model name	Model structure	D.f.	AIC	dAIC
M3	Pre.post.mining + Year + (1|Site)	4	3657.096	0.00
M4	Pre.post.mining * Year + (1|Site)	5	3658.055	0.96
M2	Year + (1|Site)	3	3658.721	1.63
M0	Null	2	3660.958	3.86
M1	Pre.post.mining + (1|Site)	3	3661.278	4.18
M5	Treatment + (1|Site)	3	3662.494	5.40

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3 Assessing changes in Flora Community Composition

3.1 Methods

TSR is not a good metric to reflect the complex nature of community composition and species turnover, since some species may become locally extinct or invade a region, yet the TSR can remain stable. Consequently, these vegetation data were used to determine species assemblages – or community composition – at each transect, within each swamp, during each survey (i.e., simply a species list of all unique species detected each visit). These multivariate data have been traditionally analysed within a distance-based framework, using methods like principal components analysis or non-metric multidimensional scaling (e.g., Symbolix 2014). However, amongst other problems, these methods cannot offer a formal framework in which to test the hypothesis that treatment-effects influence species assemblages (Warton, Wright and Wang, 2012; Wang et al. 2012).

There has been a recent trend toward model-based approaches when dealing with complex, multivariate data such as species assemblages. Here, multivariate presence-absence models were fitted using the "manyglm" function in the "mvabund" package (v.4.1.3, Wang 2017) in program R (v.4.0.2, R Core Team 2020). These models fit multiple presence-absence models to each detected species, correcting for the correlation between species (that otherwise violates an assumption of standard generalised linear models) using generalised estimating equations (GEEs). Analysis of variance (ANOVA) was used to formally test the significance of explanatory variables (i.e., "Year", "Season" and "Mining Status"). Separate models were fitted to data collected at each impact swamp surveyed in 2020. If "Mining Status" was found to be significant, univariate tests were completed to determine which species were driving the detected change in flora community composition.

3.2 Results

A large number of unique species were detected at each swamp, the lowest being 61 at sites CCUS1 and CCUS5, and CCUS4 had 75 unique species (Table 3). Between 9 and 18% of the unique species at these swamps were only detected once during the entire survey period (Table 3).

A yearly trend in species composition was not detected at the $\alpha = 0.05$ level of statistical significance, for any swamp (Table 3). Although TSR doesn't measure species composition, the findings of the TSR analysis (please see Section 2.2 and also Table 2) suggesting no strong biologically significant yearly trend, corroborate the findings here that there probably isn't a substantial change in TSR or species composition over the years.

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A PrePost mining impact was not found to be significant at CCUS1 (Wald = 3.82, p-value = 0.26) or CCUS5 (Wald = 3.19, p-value = 0.98, Table 3).

Table 3: The total number of unique species, proportion of species detected only once and the output of the full model for each impact swamp monitored in 2020.

Site	Number of species detected	Proportion of species detected once	ANOVA test of full model
CCUS1	61	18.0	## wald value Pr(>wald) ## (Intercept) 6.859 0.095. ## as.numeric(Year) 8.120 0.127 ## SeasonSpr 4.433 0.941 ## Pre.post.miningPost 3.818 0.257
CCUS4	75	9.3	## wald value Pr(>wald) ## (Intercept) 10.36 0.0935. ## as.numeric(Year) 10.35 0.0955. ## SeasonSpr 5.07 0.9775
CCUS5	61	13.1	## wald value Pr(>wald) ## (Intercept) 5.206 0.719 ## as.numeric(Year) 5.290 0.714 ## Pre.post.miningPost 3.188 0.984

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4 References

Bates D., Mächler, M., Bolker, B. and Walker, S. (2015). Fitting Linear Mixed-Effects Models using lme4. *Journal of Statistical Software, 67*(1): 1–48.

Bolker, B. M., Brooks, M.E., Clark, C.J., Geange, S.W., Poulsen, J.R., Stevens, M.H.H. and White, J.S.S. (2009). Generalized linear mixed models: a practical guide for ecology and evolution. *Trends in Ecology and Evolution, 24*(3): 127–135.

R Core Team (2020). R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. Retrieved from https://www.R-project.org/

Wang, Y., Naumann, U., Wright, S.T. and Warton, D.I. (2012). mvabund - an R package for model-based analysis of multivariate abundance data. *Methods in Ecology and Evolution, 3*: 471–474.

Wang, Y., Naumann, U., Wright, S.T., Eddelbuettel, D. and Warton, D.I. (2017). mvabund: Statistical Methods for Analysing Multivariate Abundance Data. R package version 3.12.3. Retrieved from https://CRAN.R-project.org/package=mvabund.

Warton, D. I., Wright, S.T. and Wang, Y. (2012). Distance-based multivariate analyses confound location and dispersion effects. *Methods in Ecology and Evolution, 3*(1): 89–101.

APPENDIX C – COASTAL UPLAND SWAMP RISK ASSESSMENT SUMMARY

Table 22 Coastal Upland Swamp risk assessment summary

Swamp	Size (ha)	Stage 1		Stage 2		Wholly or partly overlying second workings in seams			Predicted vertical subsidence (mm)	Estimated maximum tensile strain under swamp (mm/m)[21]	Within area of increased predicted drawdown	Potential impact pathway	Swamp category[22]	Comments
		Located over Stage 1 EP second workings	Located within 350 m of Stage 1 EP second workings	Located over Stage 2 EP second workings	Located within 350 m of Stage 2 EP second workings	Bulli Seam	Balgownie Seam	Wongawilli Seam						
BCUS2	0.89	No	No	No	PC27-30	Yes	No	No	-	2.6	No	Subsidence (Low)	3	Not directly undermined. No risk of subsidence impacts. Not in area of predicted incremental water table drawdown.
BCUS3	0.12	No	No	No	PC29-30	Yes	No	No	-	2.8	No	-	3	Not directly undermined. No risk of subsidence impacts. Not in area of predicted incremental water table drawdown.
BCUS4	2.23	No	No	PC30-31	PC28-29, 32	Yes	Mains Headings only	Yes	<100	3.1	No	Subsidence - (Low)	1A	Rating due to swamp size and unconfirmed Bulli Goaf area status. Located over Stage 2 second workings. Low risk of subsidence impacts. Not in area of predicted incremental water table drawdown.
BCUS5	0.62	No	No	No	PC30-31	Yes	No	No	-	2.7	No	-	3	Not directly undermined. No risk of subsidence impacts. Not in area of predicted incremental water table drawdown.
BCUS6	1.30	No	No	No	PC30-33	Yes	No	No (within 50 m)	<100	0.5	No	Subsidence (Low)	3	Not located over Stage 2 second workings. Low risk of subsidence impacts. Not in area of predicted incremental water table drawdown.
BCUS7	0.30	No	No	PC33	PC31-34	Yes	No	Yes	<100	0.5	No	Subsidence (Low)	3	Partly located over Stage 2 second workings. Low risk of subsidence impacts. Not in area of predicted incremental water table drawdown.
BCUS8	0.65	No	No	No	PC32-33	Yes	No	No	-	0.5	No	-	4	Not directly undermined. No risk of subsidence impacts from Stage 2. Not in area of predicted incremental water table drawdown.

[21] Based on predictions made during Longwall 6 assessment.

[22] Rating in parenthesis indicates higher Category rating for approved works which are not covered by the Stage 1 and Stage 2 works.

Swamp	Size (ha)	Stage 1		Stage 2		Wholly or partly overlying second workings in seams			Predicted vertical subsidence (mm)	Estimated maximum tensile strain under swamp (mm/m)[21]	Within area of increased predicted drawdown	Potential impact pathway	Swamp category [22]	Comments
		Located over Stage 1 EP second workings	Located within 350 m of Stage 1 EP second workings	Located over Stage 2 EP second workings	Located within 350 m of Stage 2 EP second workings	Bulli Seam	Balgownie Seam	Wongawilli Seam						
BCUS9	0.07	No	No	No	PC33	Yes	No	No	-	Not assessed[23]	No	-	4	Not directly undermined. No risk of subsidence impacts from Stage 2. Not in area of predicted incremental water table drawdown.
BCUS11	0.26	No	No	PC31-32	PC28-30, 33	Yes	No	Yes	<100	2.2	No	Subsidence - (Low)	3	Located over Stage 2 second workings. Low risk of subsidence impacts. Not in area of predicted incremental water table drawdown.
BCUS14	0.55	No	No	No	PC29-32	Yes	No	No (within 50 m)	-	1.0	No	-	3	Not directly undermined. No risk of subsidence impacts from Stage 2. Not in area of predicted incremental water table drawdown.
BCUS15	1.50	No	No	No	PC34	Yes	No	No	-	Not assessed[23]	No	-	4	Not directly undermined as part of current EP, proposed future mining only. No risk of subsidence impacts from Stage 2. Not in area of predicted incremental water table drawdown.
BCUS16	0.87	No	No	No	PC34	Yes	No	No	-	Not assessed[23]	No	-	4	Not directly undermined as part of current EP, proposed future mining only. No risk of subsidence impacts from Stage 2. Not in area of predicted incremental water table drawdown.
CCUS1	4.81	PC07-08	No	No	No	Yes	Yes	Yes	<100	10.5	No	Subsidence (Low)	1A	Rating due to swamp size and levels of existing predicted tensile strain. Directly undermined by PC07 and PC08. High levels of existing predicted tensile strain. Not over Bulli Seam Goaf risk area. Not in area of predicted incremental water table drawdown.
CCUS2	1.21	No	PC07-08	No	No	Yes	Yes	Yes	<20	5.8	No	Subsidence (Low)	2	Rating due to relative size and higher predicted pre-existing tensile strains. Not directly undermined. No risk of Bulli Goaf collapse. Low risk of subsidence impacts (requires pillar failure). Not in area of predicted incremental water table drawdown.

[23] Not assessed. Likely to be less than 0.5 mm/m.

Swamp	Size (ha)	Stage 1		Stage 2		Wholly or partly overlying second workings in seams			Predicted vertical subsidence (mm)	Estimated maximum tensile strain under swamp (mm/m)[21]	Within area of increased predicted drawdown	Potential impact pathway	Swamp category [22]	Comments
		Located over Stage 1 EP second workings	Located within 350 m of Stage 1 EP second workings	Located over Stage 2 EP second workings	Located within 350 m of Stage 2 EP second workings	Bulli Seam	Balgownie Seam	Wongawilli Seam						
CCUS3	0.55	LW5, Past workings	PC21	No	No	Yes	Yes	Yes[24] (LW 5)	<20	5.5	Yes	Drawdown	1B and 2	Located at periphery of 350 m EP area. No risk of subsidence impacts from any UEP workings. Located close to area where incremental water table drawdown predicted. Rating only due to predicted water table drawdown. No risk from subsidence impacts due to UEP workings.
CCUS4	1.77	LW6, Past workings	PC21	No	PC21	Yes	Yes	Yes[21] (LW 6)	<20	4.7	No (Nearby)	Subsidence (Low)	3	Not directly undermined. Near area located close to end of LW6. No risk of subsidence impacts from Stage 2.
CCUS5	3.45	PC21, 24-25	PC22-23	No	PC27-28	Yes	Development Headings only	Yes	<100	3.3	No	Subsidence (Low)	1A	Located over second working area. Not over Bulli Seam Goaf risk area. Rating due to swamp size and location over proposed second workings. Not in area of predicted incremental water table drawdown.
CCUS6	2.05	LW4, Past workings	PC08	No	No	Yes	Yes	Yes[21] (LW 4)	<20	10.5	Yes	Drawdown and Subsidence (low)	1A and 1B	Located at periphery of 350 m EP area. No risk of subsidence impacts. Located close to area where incremental water table drawdown predicted. Rating due to swamp size, levels of existing predicted tensile strain and proximity to drawdown
CCUS7	1.32	No	No	No	No	Yes	No	No	-	5.6	No	Subsidence (Low)	4	Not directly undermined and not within 350 m EP area. No risk of subsidence impacts from Stage 2. Not in area of predicted incremental water table drawdown.
CCUS8	0.23	No	No	No	No	Mains Headings only	Mains Headings only	No	-	0.6	No	Subsidence (Low)	4	Not directly undermined and not within 350 m EP area. No risk of subsidence impacts from Stage 2. Not in area of predicted incremental water table drawdown.

[24] Completed Wongawilli Seam workings – no additional mining in the Wongawilli Seam proposed under swamp.

Swamp	Size (ha)	Stage 1		Stage 2		Wholly or partly overlying second workings in seams			Predicted vertical subsidence (mm)	Estimated maximum tensile strain under swamp (mm/m)[21]	Within area of increased predicted drawdown	Potential impact pathway	Swamp category [22]	Comments
		Located over Stage 1 EP second workings	Located within 350 m of Stage 1 EP second workings	Located over Stage 2 EP second workings	Located within 350 m of Stage 2 EP second workings	Bulli Seam	Balgownie Seam	Wongawilli Seam						
CCUS9	0.76	No	No	No	PC27-28	Mains Headings only	Mains Headings only	No (within 50 m)	<100	0.5	No	Subsidence (Low)	3	Located over main headings and adjacent to Stage 2 second workings. Low risk of subsidence impacts. Not in area of predicted incremental water table drawdown.
CCUS10	1.63	No	PC21	PC27-28	PC21, PC29	Yes	Development Headings only	Yes	<100	3.2	No	Subsidence (Low)	3	Directly undermined. Located over Stage 2 second workings. Low risk of subsidence impacts. Not in area of predicted incremental water table drawdown.
CCUS11	0.34	No	No	PC28	PC29-31	Yes	No	Yes	<100	4.4	No	Subsidence - standing pillar failure	3	Located over Stage 2 second workings. Low risk of subsidence impacts. Not in area of predicted incremental water table drawdown.
CCUS12	1.84	No	No	PC29, 32-33	PC28, 31, 34	Yes	No	Yes	<100	2.1	No	Subsidence - standing pillar failure	3	Rating due to unconfirmed goaf status. Located over Stage 2 second workings. Low risk of subsidence impacts. Not in area of predicted incremental water table drawdown.
CCUS13	0.26	No	No	PC34	PC32-33	Yes	No	Yes	<100	0.4	No	Subsidence - standing pillar failure	3	Located over Stage 2 second workings. Low risk of subsidence impacts. Not in area of predicted incremental water table drawdown.
CCUS14	0.37	No	No	No	No	Yes	Yes	Yes	-	6.5	No	Subsidence - standing pillar failure	4(2)	Not directly undermined or located within 350 m of Stage 1 and Stage 2 workings. Higher rating for subsequent stages due to higher pre-existing predicted tensile strains. Not in area of predicted incremental water table drawdown.
CCUS15	0.06	No	PC08	No	No	Yes	No	Yes	<20	0.9	No	Subsidence (Low)	3	Very small swamp with limited pre-existing impacts. No risk of subsidence impacts from Stage 1. Not in area of predicted incremental water table drawdown.
CCUS16	0.09	No	No	No	PC34	Yes (Cordeaux Colliery)	No	No	-	2.5	No	Subsidence (Low)	3	Not directly undermined. No risk of subsidence impacts from Stage 2. Not in area of predicted incremental water table drawdown.

Swamp	Size (ha)	Stage 1		Stage 2		Wholly or partly overlying second workings in seams			Predicted vertical subsidence (mm)	Estimated maximum tensile strain under swamp (mm/m)[21]	Within area of increased predicted drawdown	Potential impact pathway	Swamp category [22]	Comments
		Located over Stage 1 EP second workings	Located within 350 m of Stage 1 EP second workings	Located over Stage 2 EP second workings	Located within 350 m of Stage 2 EP second workings	Bulli Seam	Balgownie Seam	Wongawilli Seam						
CCUS17	0.07	No	PC07-08	No	No	No	No	Yes	<20	0.5	No	Subsidence (Low)	3	Very small swamp with limited pre-existing impacts. Low risk of subsidence impacts (requires pillar failure). Not in area of predicted incremental water table drawdown.
CCUS18	0.05	No	PC07-08	No	No	No	No	Yes	<20	0.5	No	Subsidence (Low)	3	Very small swamp with limited pre-existing impacts. Low risk of subsidence impacts (requires pillar failure). Not in area of predicted incremental water table drawdown.
CCUS19	0.04	No	PC07-08	No	No	Yes	Yes	No (within 50 m)	<20	0.5	No	Subsidence (Low)	3	Very small swamp with limited pre-existing impacts. Low risk of subsidence impacts (requires pillar failure). Not in area of predicted incremental water table drawdown.
CCUS20	0.55	No	PC07-08	No	No	Yes	Yes	Yes	<20	10.3	No	Subsidence (Low)	1A	Rating due to swamp size and high levels of existing predicted tensile strain. Not over Bulli Seam Goaf risk area. Low risk of subsidence impacts (requires pillar failure). Not in area of predicted incremental water table drawdown.
CCUS21	0.05	No	PC08	No	No	Yes	Yes	No	<20	10.7	Yes	Drawdown and Subsidence (Low)	1B	Rating due to levels of existing predicted tensile strain and proximity to drawdown. Not over Bulli Seam Goaf risk area. No risk of subsidence impacts from Stage 1. Low risk of incremental subsidence impacts.
CCUS22	0.31	No	No	No	PC31	Yes	No	No (within 50 m)	-	2.4	No	Subsidence (Low)	3	Not directly undermined. No risk of subsidence impacts from Stage 2. Not in area of predicted incremental water table drawdown.
CCUS23	1.43	No	No	No	No	Yes	Yes	No (within 50 m)	<20	4.4	No (Nearby)	Subsidence (Low)	3	Not directly undermined. Located at periphery of 350 m EP area. No risk of subsidence impacts from Stage 1. Located close to area where incremental water table drawdown predicted. Higher levels of water table drawdown predicted at CCUS3.

Swamp	Size (ha)	Stage 1		Stage 2		Wholly or partly overlying second workings in seams			Predicted vertical subsidence (mm)	Estimated maximum tensile strain under swamp (mm/m)[21]	Within area of increased predicted drawdown	Potential impact pathway	Swamp category[22]	Comments
		Located over Stage 1 EP second workings	Located within 350 m of Stage 1 EP second workings	Located over Stage 2 EP second workings	Located within 350 m of Stage 2 EP second workings	Bulli Seam	Balgownie Seam	Wongawilli Seam						
CCUS24	1.21	No	No	PC29	PC28, PC30-34	Yes	No	Yes	<100	1.3	No	Subsidence - standing pillar failure	3	Located over Stage 2 second workings. Low risk of incremental or cumulative subsidence impacts. Small swamp with low complexity. Not in area of predicted incremental water table drawdown.
CRUS1	9.84	No	PC21, 23-25	No	No	Yes	No	Yes	<20	2.5	No	Subsidence - standing pillar failure	1A	Rating due to swamp size and historical impacts from LW6 and multi seam mining. Not directly undermined. Near areas located over LW6. Low risk of incremental or cumulative subsidence impacts from Stage 1 and Stage 2 workings (requires pillar failure). Not in area of predicted incremental water table drawdown.
CRUS2	3.12	No	No	No	No	Yes	No	Yes	-	4.3	No	Subsidence - standing pillar failure	4(1A)	Not directly undermined or located within 350 m of Stage 1 and Stage 2 workings. Higher rating for subsequent stages due to swamp size. Not in area of predicted incremental water table drawdown.
CRUS3	3.42	No	PC07-08	No	No	Yes	No	Yes	<20	3.1	No	Subsidence - standing pillar failure	1A	Rating due to swamp size. Not directly undermined. Near areas located over LW6. Low risk of subsidence impacts (requires pillar failure). Not in area of predicted incremental water table drawdown.
CRUS4	0.37	No	No	No	No	Yes	No	No (within 50 m)	-	Not assessed[23]	No	Subsidence (Low)	3	Not directly undermined. No risk of subsidence impacts from Stage 2. Not in area of predicted incremental water table drawdown.
CRUS5	0.13	No	No	No	No	Yes	No	No	-	Not assessed[23]	No	Subsidence (Low)	4	Not directly undermined. No risk of subsidence impacts from Stage 2. Not in area of predicted incremental water table drawdown.
CRUS6	0.49	No	No	PC33	PC29, 32, 34	Yes	No	Yes	<100	0.4	No	Subsidence - standing pillar failure	3	Located over Stage 2 second workings. Low risk of incremental or cumulative subsidence impacts. Not in area of predicted incremental water table drawdown.

Swamp	Size (ha)	Stage 1		Stage 2		Wholly or partly overlying second workings in seams			Predicted vertical subsidence (mm)	Estimated maximum tensile strain under swamp (mm/m)[21]	Within area of increased predicted drawdown	Potential impact pathway	Swamp category [22]	Comments
		Located over Stage 1 EP second workings	Located within 350 m of Stage 1 EP second workings	Located over Stage 2 EP second workings	Located within 350 m of Stage 2 EP second workings	Bulli Seam	Balgownie Seam	Wongawilli Seam						
CRUS7	0.31	No	No	PC34	PC33	Yes	No	Yes	<100	1.3	No	Subsidence - standing pillar failure	3	Partly located over Stage 2 second workings. Low risk of incremental or cumulative subsidence impacts. Not in area of predicted incremental water table drawdown.

APPENDIX D – TARPS

Performance Measure TARPs

Table 23 Coastal Upland Swamps Ground Water Quality TARPs

Feature	Trigger Monitoring Location	Unit/ Parameters	Monitoring Frequency	Purpose	Criteria	Action/ Reporting	Reporting	Responsibility
Ground Water Quality	Existing swamp piezometers: PB4 B near swamp BCUS4 PCc10 (A/B) at CCUS10 PCc12 A at CCUS12 PCc2 at CCUS2 PCc4 (C) at CCUS4 PCc5 (B) at CCUS5 PCr1 (B) at CRUS1 Newly installed swamp	EC	Field analysis when piezometers are manually dipped: Prior to mining Every two months prior to and after swamp is mined under. During Mining Monthly during period when swamp is mined under. After mining Every two months	Detection of potential impact to swamp water conditions due to mine activities	Level 1:			
					No exceedance of Level 2 or Level 3 triggers	Continue monitoring.	Report negligible impact in routine reporting.	Russell Vale Colliery (Group environment manager)
					Level 2:			
					One reading above the trigger level of 193 µS/cm	Review sampling methodology/ equipment to verify if the reading is representative. If not, resample and test within seven days of the result. If the data is representative, review weather station data, groundwater quality and level data and	1. One week 2. Two weeks to assess whether further investigation is required. Commence investigation. If exceedance of Level 3 criteria identified see Level 3 reporting requirements.	Russell Vale Colliery (Group Environment Manager)

Feature	Trigger Monitoring Location	Unit/ Parameters	Monitoring Frequency	Purpose	Criteria	Action/ Reporting	Reporting	Responsibility
	piezometers, which may include: PCc1 A/C at CCUS1 PCc6 B at CCUS6 PCc14A at CCUS14 PCc20 at CCUS20					subsidence monitoring to identify whether further investigation is warranted. If an impact due to mining is identified progress to Level 3.	3. One to two months depending on timing of review of second data period.	
					Level 3:			
					Two consecutive readings above the trigger level - 193 µS/cm	1. Inform DPE and WaterNSW 2. Investigate and report on the cause of the trigger exceedances (e.g. climatic; systemic; failure) 3. Inform DPE and WaterNSW of investigation outcomes 4. Identify mitigation options 5. Review monitoring	1. One week 2. Commence within one week 3. One month 4. Commence works within two months 5. One month 6. Six monthly reporting in accordance with EP approval	Russell Vale Colliery (Group Environment Manager)

Feature	Trigger Monitoring Location	Unit/ Parameters	Monitoring Frequency	Purpose	Criteria	Action/ Reporting	Reporting	Responsibility
						frequency and parameters 6. Report potential impact, and response, within six monthly reporting		

Table 24 Coastal Upland Swamp Water Quality/Levels TARPs

Feature	Trigger Monitoring Location	Unit/ Parameters	Monitoring Frequency	Purpose	Criteria[25]	Action/ Reporting	Reporting	Responsibility
Swamp water quality	Existing swamp piezometers: PB4 B near swamp BCUS4 PCc10 (A/B) at CCUS10 PCc12 A at CCUS12 PCc2 at CCUS2 PCc4 (C) at CCUS4 PCc5 (B) at CCUS5 PCr1 (B) at CRUS1 Newly installed	pH	Field analysis when piezometers are manually dipped: Every two months prior to and after swamp is mined under; Monthly during period when swamp is mined under.	Detection of potential impact to swamp water conditions due to mine activities	Level 1:			
					No exceedance of Level 2 or Level 3 triggers	Continue monitoring.	Report negligible impact in routine reporting.	Russell Vale Colliery (Group Environment Manager)
					Level 2:			
					One reading outside of the trigger range of 3.8 to 6.3	Review sampling methodology/ equipment to verify if the reading is representative. If not, resample and test within seven days of the result. If the data is representative, review climate data, groundwater quality and level data to identify any adverse trends that may indicate an impact.	1. One week 2. Two weeks to assess whether further investigation is required. Commence investigation. If exceedance of Level 3 criteria identified see Level 3 reporting requirements. 3. One to two months depending on timing of review	Russell Vale Colliery (Group Environment Manager)

[25] *Swamp Water Level Triggers: Water level trigger - (in mbgl). PB4A: 1.29, PCc10A: 0.56, PCc10B: 0.90, PCc12A: 0.70, PCc2: 1.60, PCc4C: 1.05, PCc5B: 1.13, PCr1B: 0.68. Newly installed piezometers: Default standing water level (water depth) trigger of 0.57 mbgl, based on 50th percentile baseline data for RVE swamps water level (below groundwater level).

Feature	Trigger Monitoring Location	Unit/ Parameters	Monitoring Frequency	Purpose	Criteria[25]	Action/ Reporting	Reporting	Responsibility
	swamp piezometers, which may include: PCc1 A/C at CCUS1 PCc6 B at CCUS6 PCc14A at CCUS14 PCc20 at CCUS20					If an impact due to mining is identified progress to Level 3.	of second data period.	
					Level 3:			
					Two consecutive readings outside of the trigger range of 3.8 to 6.3	1. Inform DPE and WaterNSW 2. Investigate and report on the cause of the trigger exceedances (e.g. climatic; systemic; failure) 3. Inform DPE and WaterNSW of investigation outcomes 4. Identify mitigation options 5. Review monitoring frequency and parameters 6. Report potential impact, and response, within six monthly reporting	1. One week 2. Commence within one week 3.One month 4. Commence works within two months 5. One month 6. Six monthly reporting in accordance with EP approval	Russell Vale Colliery (Group Environment Manager)

Table 25 Coastal Upland Swamp Water Levels TARPs

Feature	Trigger Monitoring Location	Unit/ Parameters	Monitoring Frequency	Purpose	Criteria[26]	Action/ Reporting	Reporting	Responsibility
Swamp water levels	Existing swamp piezometers: PB4 B near swamp BCUS4 PCc10 (A/B) at CCUS10 PCc12 A at CCUS12 PCc2 at CCUS2 PCc4 (C) at CCUS4 PCc5 (B) at CCUS5 PCr1 (B) at CRUS1 Newly installed swamp	Water level	Daily – water level monitoring with logger set at 6 hourly interval. Data downloaded and manually dipped: Every two months prior to and after swamp is mined under; monthly during period when	Detection of potential impact to swamp water conditions due to mine activities	Level 1:			
					Water level readings consistently above the water level trigger or levels below trigger during periods of low rainfall (<20 mm/month)	Continue monitoring.	Report negligible impact in routine reporting.	Russell Vale Colliery (Group environment manager)
					Level 2:			
					One monthly water level reading below the water level trigger of: PCc10A: 0.56 mbgl; or	1. Review sampling methodology/ equipment to verify if the reading is representative. If not, resample and test within seven days of the result.	1. One week 2. Two weeks to assess whether further investigation is required. Commence investigation. If	Russell Vale Colliery (Group environment manager)

[26] *Swamp Water Level Triggers: Water level trigger - (in mbgl). PB4A: 1.29, PCc10A: 0.56, PCc10B: 0.90, PCc12A: 0.70, PCc2: 1.60, PCc4C: 1.05, PCc5B: 1.13, PCr1B: 0.68. Newly installed piezometers: Default standing water level (water depth) trigger of 0.57 mbgl, based on 50th percentile baseline data for RVE swamps water level (below groundwater level).

Feature	Trigger Monitoring Location	Unit/ Parameters	Monitoring Frequency	Purpose	Criteria[26]	Action/ Reporting	Reporting	Responsibility
	piezometers, which may include: PCc1 A/C at CCUS1 PCc6 B at CCUS6 PCc14A at CCUS14 PCc20 at CCUS20		swamp is mined under.		PCc2: 1.6 mbgl; or PCc4C: 1.05 mbgl; or PCc5B: 1.13 mbgl; or PCr1B: 0.68 mbgl; or and the trigger is recorded following a month of rainfall above 20 mm/month	2. If the data is representative, review climate data, groundwater quality and level data to identify any adverse trends that may indicate an impact. If an impact due to mining is identified progress to Level 3.	exceedance of Level 3 criteria identified see Level 3 reporting requirements. 3. One to two months depending on timing of review of second data period.	
					Level 3:			
					Two consecutive monthly water level readings below the water level trigger of: PCc10A: 0.56 mbgl; or PCc2: 1.6 mbgl; or PCc4C: 1.05 mbgl; or	1.Inform DPE and WaterNSW 2.Investigate and report on the cause of the trigger exceedances (e.g. climatic; systemic; failure) 3.Inform DPE and WaterNSW of investigation outcomes	1. One week 2. Commence within one Week 3.One month 4. Commence works within two months 5. One month 6. Six monthly reporting in accordance with EP approval	Russell Vale Colliery (Group environment manager)

Feature	Trigger Monitoring Location	Unit/ Parameters	Monitoring Frequency	Purpose	Criteria[26]	Action/ Reporting	Reporting	Responsibility
					PCc5B: 1.13 mbgl; or PCr1B: 0.68 mbgl; or and the trigger is recorded following a month of rainfall above 20 mm/month	4.Identify mitigation options 5.Review monitoring frequency and parameters 6. Report potential impact, and response, within six monthly reporting		

Table 26 Coastal Upland Swamp vegetation monitoring and observational monitoring TARPs

Feature	Trigger Monitoring Location	Unit/ Parameters	Monitoring Frequency	Purpose	Criteria	Action/ Reporting	Reporting	Responsibility
Vegetation monitoring and observational monitoring	Category 1A or 1B: BCUS4 CCUS1 CCUS3 CCUS5 CCUS6 CCUS20 CCUS21	TSR and species composition	Category 1 & 2: Collection of data on all species observed in 30 0.5 m x 0.5 m quadrats along 15 m transects. Statistical analysis of TSR and	To determine if the project results in changes to vegetation composition within Coastal	Level 1:			
					No exceedance of Level 2 or Level 3 triggers	Continue monitoring. Report negligible impact in six monthly reports.	Six monthly reporting in accordance with EP approval.	Russell Vale Colliery (Group environment manager)
					Level 2:			

Feature	Trigger Monitoring Location	Unit/ Parameters	Monitoring Frequency	Purpose	Criteria	Action/ Reporting	Reporting	Responsibility
	CRUS1 CRUS2 CRUS3 Category 2 (if triggered): CCUS2 CCUS14		species composition. Category 1, 2 & 3: Observational monitoring will be undertaken across the EP area opportunistically during surveys including photo-point monitoring.	Upland Swamps exceeding negligible levels	Negligible change to the composition or distribution of Negligible change to the composition or distribution of species, as illustrated by a short term (less than one-year duration – first year after mining commences) significant statistical difference between control and impact sites or between before and after mining at the impact sites or minimal dieback recorded during observational monitoring.	Continue monitoring. Review frequency and location of monitoring and determine if additional monitoring is required. Report potential impact in six monthly reports.	Six monthly reporting in accordance with EP approval Monitoring plan reviewed within one month of potential impact being identified.	Russell Vale Colliery (Group environment manager)
					Level 3:			
					Change to the composition or distribution of species as illustrated by a long term (greater than one year) significant statistical difference between	Engage ecologist to investigate and report on the cause of trigger exceedances	BCD, and DCCEEW notified of potential impact within one week of	Russell Vale Colliery (Group environment manager)

Feature	Trigger Monitoring Location	Unit/ Parameters	Monitoring Frequency	Purpose	Criteria	Action/ Reporting	Reporting	Responsibility
					control and impact sites or between before and after mining at the impact sites or significant dieback in more than one area recorded during observational monitoring.	and advise of potential impacts. Inform BCD and DCCEEW of investigation outcomes. Review monitoring program, including frequency and location, and modify if necessary. Develop and implement impact mitigation and remediation measures in consultation with BCD and DCCEEW. Develop a monitoring	impact being identified. Investigation initiated within one week of impact being identified. Investigation results reported to BCD and DCCEEW within one week of completion. Monitoring plan reviewed within one week of impact being identified. Commence preparation	

Feature	Trigger Monitoring Location	Unit/ Parameters	Monitoring Frequency	Purpose	Criteria	Action/ Reporting	Reporting	Responsibility
						plan to determine the success of mitigation / remediation measures. If mitigation / Remediation measures are unsuccessful or not feasible, determine whether offsets will be required. An offset strategy/offset management plan will be developed in consultation with BCD and DCCEEW. Report in annual reviews and six monthly	of mitigation/ action and monitoring plan within one week of impact being identified, if required. Monthly updates of investigation progress to BCD and DCCEEW, if required. Six monthly reporting in accordance with EP approval.	

Feature	Trigger Monitoring Location	Unit/ Parameters	Monitoring Frequency	Purpose	Criteria	Action/ Reporting	Reporting	Responsibility
						reports to inform relevant agencies of results of monitoring.		

Table 27 Coastal Upland Swamp Giant Dragonfly Monitoring TARP

Feature	Trigger Monitoring Location	Unit/ Parameters	Monitoring Frequency	Purpose	Criteria	Action/ Reporting	Reporting	Responsibility
Giant Dragonfly monitoring	BCUS4 CCUS1 CCUS4 CCUS5 CCUS10 CRUS1	Number of exuviae recorded within a 1.5 m wide belt transect of variable length through suitable habitat. Sex, height above ground level, perch plant species, and distance to burrow (if identified) and seepage	A minimum of one year baseline data collection before any mining under the swamp. Monitoring annually during mining. A minimum of one year post mining monitoring at Coastal	To determine if the project results in changes to Giant Dragonfly breeding within Coastal Upland Swamps exceeding negligible levels.	Level 1:			
					No exceedance of Level 2 or Level 3 triggers	Continue monitoring. Report negligible impact in six monthly reports.	Six monthly reporting in accordance with EP approval.	Russell Vale Colliery (Group environment manager)
					Level 2:			
					Decline in exuviae numbers observed when compared to control sites. Decline is one year duration, and in the absence of changes in other parameters	1. Continue monitoring. 2. Review frequency and location of monitoring and determine if additional monitoring is required.	1. Six monthly reporting in accordance with EP approval. 2. Monitoring plan reviewed within one month of potential impact being identified.	Russell Vale Colliery (Group environment manager)
					Level 3:			
					Decline in exuviae numbers observed when	Engage ecologist to investigate and report on the cause of trigger	BCD, and DCCEEW notified of potential impact within one week of impact	Russell Vale Colliery (Group environment manager)

Feature	Trigger Monitoring Location	Unit/ Parameters	Monitoring Frequency	Purpose	Criteria	Action/ Reporting	Reporting	Responsibility
		water will be recorded for all exuviae sighted. Exuviae will then be removed	Upland Swamps showing negligible impacts (level 1). Surveys are undertaken in summer with two replicates per year.		compared to control sites. Decline is for greater than one year duration, in conjunction with declines in soil moisture or piezometer data as available.	exceedances and advise of potential impacts. Inform BCD and DCCEEW of investigation outcomes. Review monitoring program, including frequency and location, and modify if necessary. Develop and implement impact mitigation and remediation measures in consultation with BCD and DCCEEW. Develop a monitoring plan to determine the success of mitigation / remediation measures. If mitigation / Remediation measures are unsuccessful or not	being identified. Investigation initiated within one week of impact being identified. Investigation results reported to BCD and DCCEEW within one week of completion. Monitoring plan reviewed within one week of impact being identified. Commence preparation of mitigation/ action and monitoring plan within one week of impact being identified, if required. Monthly updates of investigation progress to BCD and DCCEEW, if required. Six monthly reporting in accordance with EP approval.	

Feature	Trigger Monitoring Location	Unit/ Parameters	Monitoring Frequency	Purpose	Criteria	Action/ Reporting	Reporting	Responsibility
						feasible, determine whether offsets will be required. An offset strategy/offset management plan will be developed in consultation with BCD and DCCEEW. Report in annual reviews and six monthly reports to inform relevant agencies of results of monitoring.		

Table 28 Coastal Upland Swamp within EP area TARPs

Feature	Trigger Monitoring Location	Unit/ Parameters	Monitoring Frequency	Purpose	Criteria	Action/ Reporting	Reporting	Responsibility
Swamps within EP area	Coastal Upland Swamp extent size and sub-community composition is mapped using LiDAR and field inspection.	TSR and species composition	One baseline survey prior to mining. Not required during mining. If greater than negligible impacts are identified through other monitoring methods, e.g. subsidence, piezometer or	To determine if the project results in changes to Coastal Upland Swamp extent or sub-community composition within Coastal Upland Swamps exceeding negligible levels.	Level 1:			
					No exceedance of Level 2 or Level 3 triggers	Continue monitoring. Report negligible impact in six monthly reports.	Six monthly reporting in accordance with EP approval.	Russell Vale Colliery (Group environment manager)
					Within prediction (Level 2):			
					Minor change in swamp extent or sub-community composition within a Coastal Upland Swamp. One year of decline in swamp extent or change in community composition greater than the mean (±SE) decline of the control group, taking into	Continue monitoring. Review frequency and location of monitoring and determine if additional monitoring is required. Report potential impact in six monthly reports.	Six monthly reporting in accordance with EP approval Monitoring plan reviewed within one month of potential impact being identified.	Russell Vale Colliery (Group environment manager)

Feature	Trigger Monitoring Location	Unit/ Parameters	Monitoring Frequency	Purpose	Criteria	Action/ Reporting	Reporting	Responsibility
			vegetation transect monitoring, additional LiDAR surveys will be undertaken at two to five year intervals.		account any differences in variation between control and impact groups			
					Level 3:			
					Trending reduction in swamp extent or sub-community composition within an Coastal Upland Swamp A multi-year of decline in swamp extent or change in community composition greater than the mean (±SE) decline of the control group,	Engage ecologist to investigate and report on the cause of trigger exceedances and advise of potential impacts. Inform BCD and DCCEEW of investigation outcomes. Review monitoring program, including frequency and location, and	BCD, and DCCEEW notified of potential impact within one week of impact being identified. Investigation initiated within one week of impact being identified. Investigation results reported to BCD and DCCEEW within one week of completion. Monitoring plan reviewed within one week of impact being identified. Commence preparation of	Russell Vale Colliery (Group environment manager)

Feature	Trigger Monitoring Location	Unit/ Parameters	Monitoring Frequency	Purpose	Criteria	Action/ Reporting	Reporting	Responsibility
					taking into account any differences in variation between control and impact sites.	modify if necessary. Develop and implement impact mitigation and remediation measures in consultation with BCD and DCCEEW. Develop a monitoring plan to determine the success of mitigation / remediation measures. If mitigation / Remediation measures are unsuccessful or not feasible, determine whether offsets will be required. An offset strategy/offset	mitigation/ action and monitoring plan within one week of impact being identified, if required. Monthly updates of investigation progress to BCD and DCCEEW, if required. Six monthly reporting in accordance with EP approval.	

Feature	Trigger Monitoring Location	Unit/ Parameters	Monitoring Frequency	Purpose	Criteria	Action/ Reporting	Reporting	Responsibility
						management plan will be developed in consultation with BCD and DCCEEW. Report in annual reviews and six monthly reports to inform relevant agencies of results of monitoring.		

Subsidence TARPs

Table 29 Vertical Subsidence – Stage 1 Upland Swamps (Direct GNSS monitoring)

Feature	Trigger Monitoring Location	Unit/ Parameters	Monitoring Frequency	Purpose	Criteria	Action	Reporting	Responsibility
CCUS1 CCUS4 CCUS5 CRUS1	GNSS#1 GNSS#2 GNSS#3 GNSS#13 GNSS#11 GNSS#12	mm (vertical subsidence)	Daily (weekly average)	Monitor levels of vertical subsidence	Level 1:			
					No exceedance of Level 2 or Level 3 triggers. (< 50mm)	Continue monitoring.	Six monthly reporting in accordance with EP approval.	Russell Vale Colliery (Group environment manager)
					Level 2:			

Feature	Trigger Monitoring Location	Unit/ Parameters	Monitoring Frequency	Purpose	Criteria	Action	Reporting	Responsibility
CCUS15 CCUS17 CCUS18 CCUS19	GNSS#14				▪ >50 mm observed subsidence at all GNSS other than GNSS#1 and GNSS#14 ▪ >50mm at GNSS#14 ▪ >100 mm at GNSS#1	Review potential cause Determine need for any changes to mine plan or mining method. Review subsidence predictions. Continue monitoring. Review frequency and location of monitoring and determine if additional monitoring is required. Report potential impact in six monthly reports.	Six monthly reporting in accordance with EP approval USMP Monitoring plan reviewed within one month of potential impact being identified.	Russell Vale Colliery (Group environment manager)
					Level 3:			

Feature	Trigger Monitoring Location	Unit/ Parameters	Monitoring Frequency	Purpose	Criteria	Action	Reporting	Responsibility
					▪ >100 mm observed subsidence at GNSS (other than GNSS#1 – no Level 3 swamp trigger for GNSS#1)	Immediately cease operations in any near active mining areas. Inform DPE and DCCEEW of performance criteria exceedance[27] Investigate cause of potential exceedance. Revise underground mine plan/mining methods (if necessary). Inspect areas of swamp to identify any material surface impacts including slumping	BCD, and DCCEEW notified of potential impact within 24 hours of impact being identified. Investigation of cause initiated within 24 hours week of impact being identified. Investigation results reported to BCD and DCCEEW within one week of completion. Groundwater and biodiversity monitoring plan for affected swamp reviewed within one week of impact being identified.	Russell Vale Colliery (Group environment manager)

[27] Level 3 TARP Exceedance at GNSS#14 does not constitute a performance criteria exceedance at swamps CCUS17 and 18. Strata failure does not necessarily constitute an exceedance of performance criteria. Potential exceedance to be notified with magnitude of actual subsidence experienced at Coastal Upland Swamp nearest to strata failure to be confirmed through LiDAR survey.

Feature	Trigger Monitoring Location	Unit/ Parameters	Monitoring Frequency	Purpose	Criteria	Action	Reporting	Responsibility
						or surface cracking. Develop and implement impact mitigation and remediation measures in consultation with BCD, WaterNSW and DCCEEW. Review need for more frequent monitoring of groundwater and biodiversity features within affected swamp. Report in annual reviews and six monthly reports to inform relevant agencies of results of monitoring.	Commence preparation of mitigation/ action and monitoring plan within one week of impact being identified (if required). Monthly updates of investigation progress to BCD and DCCEEW, if required. Six monthly reporting in accordance with EP approval.	

Table 30 Vertical Subsidence – Stage 1 Upland Swamps (Indirect GNSS monitoring)

Feature	Trigger Monitoring Location	Unit/ Parameters	Monitoring Frequency	Purpose	Criteria	Action	Reporting	Responsibility
CCUS2	GNSS#3 GNSS#15 Underground observations in PC07 and PC08	mm (vertical subsidence)	Daily (weekly average)	Monitor levels of vertical subsidence	Level 1:			
					No exceedance of Level 2 or Level 3 triggers (< 50 mm)	Continue monitoring.	reporting in accordance with EP approval.	Russell Vale Colliery (Group environment manager)
CCUS20	GNSS#1 GNSS#2 Underground Observations in PC08 LiDAR				Level 2:			
					▪ >50mm observed subsidence at GNSS#14, GNSS#15 ▪ >80mm observed at GNSS#2 and GNSS#3 ▪ >100mm at GNSS#1	Review potential cause and need for any changes to mine plan or mining method. Review subsidence predictions. Continue monitoring. Review frequency and location of monitoring and determine if additional monitoring is required.	reporting in accordance with EP approval Monitoring plan reviewed within one month of potential impact being identified.	Russell Vale Colliery (Group environment manager)
CRUS3	GNSS#14 GNSS#15 Underground observations in PC07 and PC08				Level 3:			

Feature	Trigger Monitoring Location	Unit/ Parameters	Monitoring Frequency	Purpose	Criteria	Action	Reporting	Responsibility
					▪ Strata failure in second workings within 250m of swamp. ▪ > 100 mm subsidence observed in LiDAR relative to pre-mining baseline (validated through underground monitoring or GNSS).	Immediately cease operations in any near active mining areas. Inform DPE and DCCEEW of performance criteria exceedance[27]. Investigate cause of strata failure. Revise underground mine plan/mining methods (if necessary). Inspect areas of swamp to identify any material surface impacts including slumping or surface cracking. Develop and implement impact mitigation and remediation measures in consultation with BCD, WaterNSW and DCCEEW. Undertake LiDAR Survey to investigate where subsidence	BCD, and DCCEEW notified of potential impact within 24 hours of impact being identified. Investigation of cause initiated within 24 hours week of impact being identified. Investigation results reported to BCD and DCCEEW within one week of completion. Groundwater and biodiversity monitoring plan for affected swamp reviewed within one week of impact being identified. Undertake LiDAR survey of potentially	Russell Vale Colliery (Group environment manager)

Feature	Trigger Monitoring Location	Unit/ Parameters	Monitoring Frequency	Purpose	Criteria	Action	Reporting	Responsibility
						performance criteria exceeded. Review need for more frequent monitoring of groundwater and biodiversity features within affected swamp.	affected area at soonest reasonable opportunity. Commence preparation of mitigation/ action and monitoring plan within one week of impact being identified (if required). Monthly updates of investigation progress to BCD and DCCEEW, if required. Six monthly reporting in accordance with EP approval.	

Table 31 Vertical Subsidence – Stage 2 Upland Swamps (Direct GNSS monitoring)

Feature	Monitoring Location	Unit/ Parameters	Monitoring Frequency	Purpose	Criteria	Action	Reporting	Responsibility
BCUS4 BCUS6 BCUS7 BCUS11 CCUS4 CCUS5 CCUS9	Adjacent GNSS units	mm (vertical subsidence)	Daily (weekly average)	Monitor levels of vertical subsidence	Level 1:			
					No exceedance of Level 2 or Level 3 triggers. (< 50mm)	Continue monitoring.	Six monthly reporting in accordance with EP approval.	Russell Vale Colliery (Group environment manager)
					Level 2:			

Feature	Monitoring Location	Unit/ Parameters	Monitoring Frequency	Purpose	Criteria	Action	Reporting	Responsibility
CCUS10 CCUS11 CCUS12 CCUS13 CCUS24 CRUS6 CRUS7					▪ >50 mm observed subsidence at adjacent GNSS units	Review potential cause Determine need for any changes to mine plan or mining method. Review subsidence predictions. Continue monitoring. Review frequency and location of monitoring and determine if additional monitoring is required.	Six monthly reporting in accordance with EP approval USMP Monitoring plan reviewed within one month of potential impact being identified.	Russell Vale Colliery (Group environment manager)
					Level 3:			

Feature	Monitoring Location	Unit/ Parameters	Monitoring Frequency	Purpose	Criteria	Action	Reporting	Responsibility
					• >100 mm observed subsidence at adjacent GNSS units • Strata failure observed underground in workings within 350 m of swamp extent • LiDAR survey results indicate >100 mm subsidence relative to pre-mining data (validated through underground monitoring or GNSS)	Immediately cease operations in any near active mining areas. Inform DPE and DCCEEW of performance criteria exceedance Investigate cause of potential exceedance. Revise underground mine plan/mining methods (if necessary). Inspect areas of swamp to identify any material surface impacts including slumping or surface cracking. Develop and implement impact mitigation and remediation measures in consultation with	BCD, and DCCEEW notified of potential impact within 24 hours of impact being identified. Investigation of cause initiated within 24 hours week of impact being identified. Investigation results reported to BCD and DCCEEW within one week of completion. Groundwater and biodiversity monitoring plan for affected swamp reviewed within one week of impact being identified. Commence preparation of mitigation/ action and monitoring plan within one week of impact being identified (if required).	Russell Vale Colliery (Group environment manager)

Feature	Monitoring Location	Unit/ Parameters	Monitoring Frequency	Purpose	Criteria	Action	Reporting	Responsibility
						BCD, WaterNSW and DCCEEW. Review need for more frequent monitoring of groundwater and biodiversity features within affected swamp. Report in annual reviews and six monthly reports to inform relevant agencies of results of monitoring.	Monthly updates of investigation progress to BCD and DCCEEW, if required. Six monthly reporting in accordance with EP approval.	

Table 32 Vertical Subsidence – Stage 2 Upland Swamps (Indirect GNSS monitoring)

Feature	Trigger Monitoring Location	Unit/ Parameters	Monitoring Frequency	Purpose	Criteria	Action	Reporting	Responsibility
BCUS2 BCUS3 BCUS5 BCUS8 BCUS9 BCUS14 BCUS15 BCUS16 CCUS16 CCUS22	Nearest GNSS units	mm (vertical subsidence)	Daily (weekly average)	Monitor levels of vertical subsidence	Level 1:			
					No exceedance of Level 2 or Level 3 triggers (< 50 mm)	Continue monitoring.	Reporting in accordance with EP approval.	Russell Vale Colliery (Group environment manager)
					Level 2:			
					>50 mm observed subsidence at nearest GNSS units	Review potential cause and need for any changes to mine plan or mining method. Review subsidence predictions. Continue monitoring. Review frequency and location of monitoring and determine if additional monitoring is required.	Reporting in accordance with EP approval Monitoring plan reviewed within one month of potential impact being identified.	Russell Vale Colliery (Group environment manager)
					Level 3:			

Feature	Trigger Monitoring Location	Unit/ Parameters	Monitoring Frequency	Purpose	Criteria	Action	Reporting	Responsibility
					• >100 mm observed subsidence at nearest GNSS units • Strata failure observed underground in workings within 350 m of swamp extent • LiDAR survey results indicate >100 mm subsidence relative to pre-mining data (validated through underground monitoring or GNSS)	Immediately cease operations in any near active mining areas. Inform DPE and DCCEEW of performance criteria exceedance. Investigate cause of strata failure. Revise underground mine plan/mining methods (if necessary). Inspect areas of swamp to identify any material surface impacts including slumping or surface cracking. Develop and implement impact mitigation and remediation measures in consultation with BCD, WaterNSW and DCCEEW. Undertake LiDAR Survey to investigate where subsidence	BCD, and DCCEEW notified of potential impact within 24 hours of impact being identified. Investigation of cause initiated within 24 hours week of impact being identified. Investigation results reported to BCD and DCCEEW within one week of completion. Groundwater and biodiversity monitoring plan for affected swamp reviewed within one week of impact being identified. Undertake LiDAR survey of potentially affected area at	Russell Vale Colliery (Group environment manager)

Feature	Trigger Monitoring Location	Unit/ Parameters	Monitoring Frequency	Purpose	Criteria	Action	Reporting	Responsibility
						performance criteria exceeded. Review need for more frequent monitoring of groundwater and biodiversity features within affected swamp.	soonest reasonable opportunity. Commence preparation of mitigation/ action and monitoring plan within one week of impact being identified (if required). Monthly updates of investigation progress to BCD and DCCEEW, if required. Six monthly reporting in accordance with EP approval.	