

Health Safety & Environment Management System

# Ravensworth South Modification Rehabilitation Strategy

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# **Glossary and abbreviations**

Abbreviation	Description
AEMP	Ash Emplacement Management Plan
AGL	AGL Energy
AGLM	AGL Macquarie
Bayswater	Bayswater Power Station
CCC	Community Consultative Committee
DA	Development Application
DS NSW	Dam Safety NSW
EMS	Environmental Management Strategy
EPA	Environmental Protection Authority
EPL	Environment Protection Licence
Liddell	Liddell Power Station
KPI	Key Performance Indicator
LFA	Landscape Function Analysis
m	Metre
MSC	Muswellbrook Shire Council
RSCM	Ravensworth South Coal Mine
RL	Reduced level
RMP	Rehabilitation Management Plan
RR	Resource Regulator NSW
Strategy	Rehabilitation Strategy
SSD	State Significant Development



### 1. Introduction

#### 1.1 Background and Project Overview

AGL Macquarie Pty Limited (AGLM) owns and operates Ravensworth South Coal Mine (RSCM) in accordance with Development Approval (DA) 86/51. The approval covers the rehabilitation of final voids by filling with ash from the neighbouring power stations. Extraction of coal ceased in 2000, and Void 5 was formed from the incomplete filling of the mined area with overburden.

Under current operations, AGLM fill Void 5 with ash from Bayswater Power Station (the Project). AGLM applied to modify DA 86/51 to enable changes to the operational management of Void 5. The modification was approved by the Department of Planning and Environment (DPE) on 19 April 2023.

The Modification enables changes to a number of operational changes to:

- · Reflect updated estimates of the amount of coal ash available for emplacement
- Reflect the hydrogeological conditions of Void 5
- Make the final landform free draining by provisioning for capping and rehabilitation
- Make provision for establishment of mine spoil borrow pits and stockpiling of surplus spoil from neighbouring mines for use in closure and rehabilitation.

The development, as modified, is substantially the same development as that originally approved under DA 86/51 as it involves the continued rehabilitation of the former RSCM Void 5.

This Rehabilitation Strategy (Strategy) has been prepared specifically for the RSCM Void 5 project for AGLM. This Strategy also builds upon initial modification information provided within the Ravensworth South Mine – Rehabilitation Amendment Modification Report (Jacobs 2022a) and the Response to Submissions (Jacobs 2022b). An overview of the RSCM Void 5 project is shown in Figure 1.1.





#### Figure 1.1 Ravensworth South

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#### 1.2 Purpose and scope

GHD Pty Ltd (GHD) was engaged by AGLM to prepare a Strategy which summarises the proposed approach to rehabilitation for the project to address the Development Approval requirements (DA 86/51). It describes the activities and measures which will be undertaken, if required, to achieve the project's goals. This strategy addresses the relevant criteria in the DA as outlined below and details how AGLM will meet these requirements.

The strategy focuses on the proposed approach to rehabilitation of Void 5 following the approved changes from the Modification Report.

Table 1.1 outlines the requirements of DA 86/51 Condition B22 and where these have been addressed in this Strategy.

#### Table 1.1 Requirements of DA 86/51

Requir	rement	Where addressed	
Condition B22			
The Applicant must prepare a Rehabilitation Strategy for all land disturbed by the development to the satisfaction of the Planning Secretary. This plan must:		This Plan	
a)	be submitted for approval within six months of the approval of Mod 1;	This was completed as required.	
b)	be prepared by a suitably qualified and experienced person/s;	This Plan was prepared by GHD on behalf of AGLM (2023)	
c)	be prepared in consultation with the Resources Regulator and Council;	Section 3.4	
d)	build upon the Rehabilitation Objectives in Table 3, describe the overall rehabilitation outcomes for the site, and address all aspects of rehabilitation including final landform, post- mining land use/s and water management;	Section 4	
e)	align with strategic rehabilitation and mine closure objectives and address the principles of the Strategic Framework for Mine Closure (ANZMEC and MCA, 200);	Section 6, 7, 8 and 12	
f)	describe how the Applicant will ensure that surface water from the free draining final landform will not result in downstream water quality impacts;	Section 8	
g)	include details of target vegetation communities and species to be established within the proposed revegetation areas;	Section 7.3 and 11	
h)	investigate opportunities to refine and improve the final landform outcomes over time;	Section 5	
i)	includes a risks and opportunities assessment and risk register	Section 13	

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Requir	ement	Where addressed
j)	include a post-mining land use strategy to investigate and facilitate post-mining beneficial land uses for the site, that;	Section 5
	<ul> <li>align with regional and local strategic land use planning objectives and outcomes;</li> </ul>	Section 3.3 and 5
	ii. support a sustainable future for the local community;	Section 3.4 and 5
	iii. utilise existing mining infrastructure where practicable; and	Section 5 and 6.1
	<ul> <li>iv. avoid disturbing self-sustaining native ecosystems, where practicable</li> </ul>	Section 6.3
k)	include a stakeholder engagement plan to guide rehabilitation and mine closure planning processes and outcomes;	Section 12
I)	investigate ways to minimise adverse socio-economic effects associated with rehabilitation, and;	Section 5
m)	include a program to periodically review and update this strategy at least every three years.	Section 14.2
Condit	ion C3	
Management plans required under this consent must be prepared in accordance with relevant guidelines, and include:		This Plan
a)	summary of relevant background or baseline data	Appendix C
b)	details of: (i) the relevant statutory requirements (including any relevant approval, licence or lease conditions); (ii) any relevant limits or performance measures and criteria; and (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	Section 3 and 11
c)	any relevant commitments or recommendations identified in the document/s listed in condition A2(c)	Section 6 and 7
d)	a description of the measures to be implemented to comply with the relevant statutory requirements, limits, or performance measures and criteria	Section 6, 7 and 8
e)	a program to monitor and report on the:	Section 9



Requir	ement	Where addressed
	<ul> <li>(i) impacts and environmental performance of the development; and</li> <li>(ii) effectiveness of the management measures set out pursuant to condition C2(c)</li> </ul>	
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 10
g)	a program to investigate and implement ways to improve the environmental performance of the development over time	Section 10
h)	<ul> <li>a protocol for managing and reporting any:</li> <li>(i) incident, non-compliance or exceedance of any impact assessment criterion or performance criterion;</li> <li>(ii) complaint; or</li> <li>(iii) failure to comply with other statutory requirements</li> </ul>	Section 14
i)	public sources of information and data to assist stakeholders in understanding environmental impacts of the development; and	Section 3.3
j)	a protocol for periodic review of the plan	Section 14

#### 1.3 Limitations

This report has been prepared by GHD for AGL Macquarie and may only be used and relied on by AGL Macquarie for the purpose agreed between GHD and AGL Macquarie as set out in Section 1.2 of this report.

GHD otherwise disclaims responsibility to any person other than AGL Macquarie arising in connection with this report. GHD also excludes implied warranties and conditions, to the extent legally permissible.

The services undertaken by GHD in connection with preparing this report were limited to those specifically detailed in the report and are subject to the scope limitations set out in the report.

The opinions, conclusions and any recommendations in this report are based on conditions encountered and information reviewed at the date of preparation of the report. GHD has no responsibility or obligation to update this report to account for events or changes occurring subsequent to the date that the report was prepared.

The opinions, conclusions and any recommendations in this report are based on assumptions made by GHD described in this report. GHD disclaims liability arising from any of the assumptions being incorrect.

GHD has prepared this report on the basis of information provided by AGL Macquarie and others who provided information to GHD (including Government authorities), which GHD has not independently verified or checked beyond the agreed scope of work. GHD does not accept liability in connection with such unverified information, including errors and omissions in the report which were caused by errors or omissions in that information.

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### 2. Project description

The RSCM is located within the Singleton Local Government Area and is authorised under Development Approval 86/51 (DA 86/51). The RSCM was developed in 1987 by the Electricity Commission of NSW to supply coal to the nearby Bayswater Power Station (Bayswater) and Liddell Power Station (Liddell). Mining operations commenced in 1987 and ceased in 2000, leaving a final void (Void 5) behind which was formed from the incomplete filling of the mined area with overburden.

The rehabilitation of Void 5 was commenced in 2014 by Macquarie Generation, the former owner of the Bayswater Power Station, in accordance with the "Ravensworth South - Final Void Rehabilitation Plan" dated 1 May 2012, approved under condition 2 of DA 86/51. The Rehabilitation Management Plan was updated in 2022.

Modification 1 of DA 86/51 proposed the following changes for the project:

- Change the ash emplacement methodology within Void 5 to facilitate free draining landform and reflect current hydrogeological conditions.
- Removal of redundant pumping infrastructure from Void 5 to allow ash disposal in the area below the current internal terraces.
- Provision for the receipt, stockpiling and use of mine spoil or alternative capping materials to provide the final capping for Void 5 including authorising mine spoil borrow-pits for use in capping and rehabilitation:
  - Vegetation clearing to the west of the north arm of the void to enable ongoing ash deposition in Void 5.
  - Authorise alternative suitable options for the final landform to allow for flexibility should the earlier than previously forecast closure of Bayswater Power Station preclude the generation of sufficient ash to completely fill Void 5; and
  - Updating the proposed final landform associated with the eastern wall of the eastern arm of Void 5 to include works comprising a 5 m downstream raising, if required.

Ash deposits are deposited via pipe infrastructure and are also proposed to be extracted from the Bayswater Ash Dam and hauled by truck to Void 5. Haulage will be conducted via approximately 14 heavy vehicle movements per hour (approximately 120 movements per day). Haulage routes are via the New England Highway and Lemington Road. Material is compacted using a dozer or other suitable equipment. Ash material is tested to ensure sufficient compaction. Potential traffic impacts, specifically on the Lemington Road intersection have been reviewed as part of the update to this Strategy, and the review concluded that there will be negligible impacts to the road network or the intersection. Further details are provided in Section 13 and a copy of the Traffic Assessment is included in Appendix E.



### 3. Legislative and other requirements

The requirements of relevant legislation and guidelines will be applied to all stages of the rehabilitation of RSCM. A list of such requirements is listed below.

#### 3.1 Commonwealth Legislation

• Environment Protection and Biodiversity Conservation Act 1999 (EPBC Act)

#### 3.2 New South Wales Legislation

- Environmental Planning and Assessment Act 1979 (EP&A Act)
- Protection of the Environment Operations Act 1997 (POEO Act)
- The Mining Act 1992
- Biodiversity Conservation Act 2016 (BC Act)
- Water Management Act 2000 (WM Act)
- Fisheries Management Act 1994 (FM Act)
- Biosecurity Act 2015 (BA Act)
- Dam Safety Act 2015 (DS Act)
- National Parks and Wildlife Act 1974 (NPW Act)
- Coal Mine Subsidence Compensation Act 2017 (CMS Act)

#### 3.3 Policies and Guidelines

- DSC3F Guidelines for decommissioning (NSWDSC, 2010).
- Australian National Committee on Large Dams (ANCOLD) Guidelines on Tailing Dams (ANCOLD, 2019).
- Strategic Framework for Mine Closure (MCA; ANZMEC, 2000).
- Leading Practice Sustainable Development Program for the Mining Industry Mine Closure (Australian Government, 2016).
- Managing Urban Stormwater: Soils and construction Volume 1, 4th edition (the 'Blue Book', Landcom 2004).
- Planning for Integrated Mine Closures: Toolkit (ICMM, 2008).
- Form and Way: Rehabilitation management plan for large mines (NSW Resources Regulator, 2021).
- Land Use Development Strategy. Coal Mine Land Use Strategy, A Guide for Strategic Land Use in the Muswellbrook Shire (Muswellbrook Shire Council, 2012).
- Singleton Local Environment Plan 2013.
- Hunter Regional Plan 2036 (Department of Planning and Environment, 2016).
- Singleton Community Strategic Plan 2017-2027 ((Singleton Council, 2017).
- Socio-Economic Development Strategy 2020/2024 (Singleton Council, 2020).
- Singleton Local Strategic Planning Statement 2041.



#### 3.4 Consultation

As per the requirements of DA 86/5, consultation was undertaken with the relevant agencies, as outlined in Table 3.1 below and Appendix A.

#### **Table 3.1 Consultation outcomes**

Strategy Version	Agency Consulted	Date	Comment
0	Resources Regulator NSW	Emailed on 12/09/2023	No comments or response received.
0	Singleton Council	Emailed on 12/09/2023	No comments or response received.
1	Resources Regulator NSW	Emailed on 27/03/2025	No comments or response received.
1	Singleton Council	Emailed on 27/03/2025	No comments or response received.
1	TfNSW	Contacted through WSP (traffic consultants) 1/04/2025.	No comments have been received as at 11/04/2025.

AGLM will continue to consult with key stakeholders to ensure issues our concerns can be addressed.

Drafting note:details and outcomes will be added following current consultation process.

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# 4. Rehabilitation objectives

Rehabilitation objectives for the project are defined by Condition B21 (Table 3) of DA 85/51. These objectives are summarised in Table 4.1.

#### **Table 4.1 Rehabilitation Objectives**

Feature	Objective	
All areas of the site affected by the development	<ul> <li>Safe, stable and non-polluting</li> <li>Fit for the intended post-mining land use/s</li> <li>Establish the final landform and post-mining land use/s as soon as practicable after cessation of the emplacement activities</li> <li>Minimise post-mining and emplacement activity environmental impacts.</li> </ul>	
Areas proposed for native ecosystem re-establishment	<ul> <li>Establish/restore self-sustaining native woodland ecosystems</li> <li>Establish local plant community types</li> <li>Establish: <ul> <li>habitat, feed and foraging resources for threatened fauna species, and</li> <li>vegetation connectivity and wildlife corridors, as far as is reasonable and feasible.</li> </ul> </li> </ul>	
Areas proposed for agricultural land	<ul> <li>Establish/restore grassland areas to support sustainable agricultural activities</li> <li>Use species found in the local area that are suitable for pasture production</li> <li>Achieve land and soil capabilities that are equivalent or better than premining</li> <li>Locate adjacent to surrounding agricultural land, where practicable.</li> </ul>	
Final Landform	<ul> <li>Stable for the intended post-mining land use/s</li> <li>Integrated with surrounding natural landforms and other mine rehabilitated landforms, to the greatest extent practicable</li> <li>Incorporate micro-relief and drainage features that mimic natural topography and mitigate erosion, to the greatest extent practicable</li> <li>Maximise surface water drainage to the natural environment i.e. free draining</li> <li>Minimise visual impacts, where practicable.</li> </ul>	
Surface infrastructure of the development	<ul> <li>To be decommissioned and removed, unless the Resources Regulator agrees otherwise.</li> </ul>	



Feature	Objective	
Rehabilitation materials	• Materials from areas disturbed as a part of works authorised under Mod 1 (including topsoils, substrates and seeds) are to be recovered, managed and reused as rehabilitation resources, to the greatest extent practicable.	
Water quality	<ul> <li>Water retained on the site is fit for the intended post-mining land use/s</li> <li>Water discharged from the site is suitable for receiving waters and fit for aquatic ecology and riparian vegetation.</li> </ul>	
Community	<ul> <li>Ensure public safety</li> <li>Minimise adverse socio-economic effects associated with mine closure.</li> </ul>	



### 5. Land use strategy

The final land use for the project is generally limited to grazing and native woodland landscape that is safe, stable and non-polluting. The final land use for RSCM will limit post closure impacts on the immediate and surrounding areas. Key components of the final land use strategy are:

- Land will be rehabilitated in accordance with the relevant standards applicable at the time of rehabilitation
- Rehabilitated land will represent a minimal source of offsite environmental impacts, such as dust, water pollution, visual amenity and weeds
- Rehabilitated land will require ongoing management inputs no greater than similar adjacent land
- To reinstate a viable drainage network on the site which is hydrologically stable and incorporates erosion controls and sediment collection dams which isolate effectively the rehabilitated area from adjoining area
- Successful design and rehabilitation of landforms to ensure structural stability, revegetation success and containment of wastes, and
- Post-mining land use compatible with surrounding land uses, that provides optimal environmental, economic and community benefits.

RSCM has moderate to high limitation for high impact land uses such as cropping, high-intensity grazing and horticulture due to historic mining activities and presence of material susceptible to spontaneous combustion. Therefore, the final land use of grazing and native woodland is considered the most suitable final landform that is safe, stable and non-polluting.

Final land use was informed by stakeholder consultation and a number of key site considerations pertaining to:

- · High risk of degradation if cultivation were to occur
- Sodic and saline nature of the soils
- Cultivation would bring the rock present in the overburden to the surface creating problems for equipment
- Climatic data for the area shows that the rainfall is highly variable with an unreliable pattern that would create a significant risk if cultivation were to occur due to failure from reduced rainfall and erosion risk associated with bare ground
- Steep topography
- Presence of mining infrastructure
- Current use for composting facility
- Areas affected by spontaneous combustion

The final land use strategy is consistent with current regional policy context in relation to mine rehabilitation, as policy preferences for mine voids avoided or rehabilitated where economic uses are not viable and to ensure that post mining landforms are stable and productive. The final landform authorises the filling of Void 5 with ash within the upper and lower bounds of expected ash generation rates, providing flexibility and opportunity to refine the final landform dependent on Bayswater Power Station operation. The final landform consistent with the surrounding environment of coal mining and agricultural land use.

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A composting facility has been established at the site in agreement with AGL. This facility operates under a separate Environment Protection Licence and Development consent. The compost facility is expected to operate for at least 20 years with the operator recently upgrading their facility to enable processing of food organics. This facility supplies organics to AGL and the surrounding area for activities such as mine site rehabilitation. Going forward it is also likely that the facility will support local councils as they shift to Food Organics Garden Organics recycling. The compost facility operator is also looking to augment operations and is investigating other technologies such as biodigesters.

AGL is also investigating suitable opportunities for the site associated with the proposed Industrial Energy Hubs planned for the Liddell Power Station, Bayswater Power Station and other AGL land holdings.



### 6. Landform establishment

#### 6.1 Ash emplacement

Ash emplacement in Void 5 will occur in a manner which creates a free draining surface with a fall from the northern boundary of the Void 5 North Arm to the eastern boundary of the East Arm. To achieve this landform, the following ash emplacement strategy will be implemented:

- Discontinuing the establishment of internal walls including sealer wall rises
- Retrieval of redundant water management infrastructure
- Commencement of deposition of ash into decant basin and continuation until ash levels reach existing levels within the eastern and northern arms of the Void 5
- Ongoing deposition from various relocatable points within the North and East Arms of Void 5 and over the decant basin, as well as any necessary ash contouring once stabilised, to best achieve a free draining final landform. The estimated maximum RL of ash will remain approximately RL 101 m and will be generally at the level with the existing top of void at the north of the northern arm. Ash will be placed to establish a landform with a minimum estimated 0.5% gradient down to the existing Wall 1A RL of 85 m, and
- Localised re-contouring of the tops of void walls to establish a safe and stable tie-in to the final void landform.

This ash emplacement strategy will enable flexibility and allow AGLM to account for the future operation of Bayswater Power Station and subsequent ash generation quantities. The final landform will be reviewed and revised, if necessary, once the final ash level is known to ensure the final landform requirements will be meet.

#### 6.2 Infrastructure removal

Following the closure of Bayswater Power Station, the following infrastructure will be removed from RSCM:

- Ash transfer pipelines
- Return water pipelines
- Pumping infrastructure including pumps, water tanks and pontoons
- Powerlines and power infrastructure related to AGLM's operations that is no longer required
- Access roads no longer required following rehabilitation of the site.

Any demolition will be undertaken in accordance with Australian Standard AS2601: The demolition of structures (AS 2601). All structures will be inspected for the presence of hazardous materials prior to demolition.

Boundary fencing and main access routes to the site will remain in the final landform.

#### 6.3 Capping and borrow areas

A capping layer will be established over Void 5 following completion of ash deposition. The ash will be capped with a minimum 500 mm depth of inert material and have a low permeability layer to reduce potential infiltration into the ash filled void. Capping material will be sourced from Borrow Areas from the following areas:

• Stockpiling of spoil material from outside AGLM's landholdings (if available) in an area immediately north of Void 5, situated between Void 5 and Void 4



- If sufficient spoil material from offsite cannot be utilised, then two borrow areas will be established:
  - Borrow area 1: located between Void 5 and Void 4, approximately 10.28 ha in size with an intended supply volume of 360,000 m<sup>3</sup>.
  - Borrow Area 2 and to the south of the eastern arm of Void 5, approximately 37 ha in size with an intended supply volume of 1,300,000 m<sup>3</sup>.

To be able to transfer material from stockpile/borrow area 1 and 2 to Void 5, two haul roads will be constructed and linked to existing haul roads. Some vegetation clearing is required to create these areas. Vegetation clearing will be restricted to the approved limits outlined in DA 86/51. The Borrow areas will be reshaped and blended into the surrounding landform following the completion of extraction.

#### 6.4 Growth medium establishment

Following the completion of ash deposition and capping of Void 5, the landform will be prepared for revegetation. Growth medium will be approximately 100 mm in depth and have a minimum 0.5% gradient flowing north to south and then to the east as per the final landform.



### 7. Revegetation and landform development

#### 7.1 Capping and progressive rehabilitation

Following the completion of filling the voids with fly ash a low permeability capping layer (refer to Section 6.3) will be constructed over the ash to limit infiltration, support vegetation growth and control the generation of dust. Once capping has been completed, the area would be ameliorated with compost and seeded with pasture species as described in the following sections.

#### 7.2 Growth medium

There is limited topsoil at RSCM due to historical mining practices. Growth medium will be predominantly sought from third party composting companies located within the AGLM land boundary. This material has been used for the past five years with the results from the rehabilitation monitoring showing its benefit. The composts consist of a mix of biosolids, garden organics and paper crumble. If available, the food organics will also be added to the compost material. The compost will be incorporated into rehabilitation areas at allowable rates as directed by soil analysis. Weed management will be undertaken to reduce the risk of weed infestation prior to compost placement.

#### 7.3 Revegetation species

The final land use for RSCM is grazing and native woodland to create a safe, stable and non-polluting landscape. Native and exotic pasture grasses will be used as a vegetation cover on the capped areas of Void 5 as trees and shrubs are not a suitable vegetation cover, as they have the potential to penetrate and damage the capping and make it ineffective.

The recommended pasture species list used by AGLM for rehabilitation are indicated in Table 7.1. Recommended native woodland species are included in Table 7.2. Note that the native species listed are a guide only and will be subject to availability. Where species are not available, appropriate alternatives will be substituted.

Pasture	Seeding Rate (kg/ha)
Japanese millet (spring/summer only)	10
Coolabah oats (autumn/winter only)	10
Brassica – Hunter - autumn	0.75
Brassica – Rangi - autumn	0.75
Consul Lovegrass	1
Couch grass - Hulled	5
Kikuyu	3
Medic - Sephi	1
Perennial rye grass – Kangaroo Valley	6
Rhodes Grass	3

#### Table 7.1 Recommended Pasture Species Direct Seeding and Rate

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Pasture	Seeding Rate (kg/ha)
Rye - Eclipse	5
Sub-clover - Seaton Park	3
White clover - Haifa	3
Woolly Pod vetch - Namoi	4

#### Table 7.2 Recommended Woodland Species Direct Seedling Rates

Cover crop species	Seeding Rate (kg/ha)
Japanese millet (spring/summer only)	10
Coolabah oats (autumn/winter only)	10
Low Shrub Species	Seeding Rate (kg/ha)
Acacia amblygona	0.4
Acacia falcata (Sickle wattle)	0.8
Acacia decora (Western Silver Wattle)	05
Bursaria spinosa (Blackthorn)	0.5
Daviesia genistifolia, D. ulicifolia	1
Mid Shrub Species	Seeding Rate (kg/ha)
Acacia paradoxa	0.4
Acacia implexa (Hickory Wattle)	0.8
Acacia parvipinnula (Silver Stemmed Wattle)	0.4
Acacia salicina (Cooba)	1
Tree Species	Seeding Rate (kg/ha)
Angophora floribunda (Rough Barked Apple)	0.6
Corymbia maculata (Spotted Gum)	1.2
Eucalyptus crebra (Narrow Leafed Ironbark)	1.0
Eucalyptus melliodora	0.5
Eucalyptus moluccana (Grey Box)	1.0
Eucalyptus tereticornis (Forest Red Gum)	0.5



# 8. Surface Water management

During rehabilitation, disturbed areas will be progressively rehabilitated to minimise the amount of exposed soil. Stabilisation work in areas of high erosion hazard such as the borrow pits, steep slopes on the project site and drainage lines will be ameliorated with gypsum, where required to reduce erodibility as part of the soil amelioration.

The final landform will direct surface water flows from north to south then to the east via the 0.5% fall incorporated into the final landform. This will ensure that the landform is free draining, and that ponding does not occur. All clean water surface flows will flow to the east of Void 5 where it will then flow to the existing settlement dams. During larger rainfall events, the clean water will flow through settlement dam/s prior to leaving site.



### 9. Rehabilitation monitoring and maintenance

Rehabilitation monitoring activities include:

- Rehabilitation monitoring occurring annually including:
  - landscape function analysis
  - · vegetation dynamics assessment
  - species abundance counts
  - habitat monitoring
  - pasture assessments
  - soil sampling and analysis
  - photographic monitoring
  - · comparison to analogue sites
- Vegetation strike and survival surveys though visual inspections and random quadrat sampling at four to eight week intervals at the completion of vegetation in new area (weather permitting)
- Random area monitoring and photography of rehabilitation conditions, weeds, pest animal and erosion
- Spontaneous combustion monitoring (thermal scans and visual monitoring) occurring on a five yearly basis
- Inspections of the dam walls as required by the Dam Safety Act.

Rehabilitation monitoring will be undertaken to track RSCM progress towards completion criteria and to determine if corrective action is required to areas that have been rehabilitated.

A summary of the baseline monitoring data is provided in Appendix C.



## 10. Continuous improvement

A number of mechanisms to investigate and implement ways to improve the environmental performance of the rehabilitation at RSCM in addition to the monitoring and maintenance outlined in Section 9 include:

- Future growth media trials outlined in Section 9.2 of the RMP. These trials are used to record the success of various blends in order the replicate the blend as best as possible to enable the most beneficial results to be achieved with the proposed topsoil substitutes.
- Measuring performance against rehabilitation objectives and rehabilitation completion criteria in Section 8.3 of the RMP. The rehabilitation monitoring program objective is to track the progress of rehabilitation and document any changes and trends in relation to rehabilitation objectives and completion criteria.
   If deficiencies are found at monitoring locations, then the Trigger Action Response Plan/s (TARPs) outlined in Section Error! Reference source not found. of the RMP will be enacted.



### 11. Completion criteria

Completion criteria for RSCM was developed in the Rehabilitation Management Plan (RMP) dated 2 July 2022. Completion criteria provides a defined end point at which rehabilitation can be deemed to be successful and the mining lease can be relinquished. The rehabilitation completion criteria have been developed to be consistent with the proposed final land use for the site and is shown in Table 11.1.



#### Table 11.1 Conceptual Completion Criteria

Operational Areas	Objective	Completion criteria
Ash	Retention of infrastructure:	Hazards isolated and secured.
Emplacement Area Water Management	All infrastructure that is to remain as part of the final land use is safe and does not pose any hazard to the community.	The location of the infrastructure remaining has been marked on a plan and registered with the relevant local authority and Dial Before You Dig.
Infrastructure Borrow/Stockpile Areas		Formal acceptance from the subsequent landowner that underground infrastructure has been left in a condition that is suitable for the intended final land use in accordance with formal agreement.
		Damage to access tracks has been repaired and stabilised.
	Removal of infrastructure:	All relevant utility infrastructure removed.
	All infrastructure that is not to be used as part of the final land use is removed to ensure the site is safe and free of hazardous materials.	Pipes removed and appropriately recycled reused or disposed. No ash slurry present.
		Footings removed and or removed to specific depths to avoid impacting pathways to subsequent final land use.
		Removal of all water management infrastructure (including pumps, pipes and power).
		All hazardous materials removed from site.
	Land Contamination: There is no residual soil contamination on site that is incompatible with the final land use or that poses a threat of environmental harm.	There are no visible signs of contamination following the removal of plant, equipment and materials. All rubbish/ waste materials removed from site.
		Contamination will be appropriately remediated so that appropriate guidelines for land use are met, e.g. Health Investigation Level of the National Environment Protection (Assessment of Site Contamination) Measure (1999) or other relevant guideline/s. Excess sludge/material has been removed from surface water dams.
	Management of waste and process materials	Visual – verification that capping, type and placement consistent with design.

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Operational Areas	Objective	Completion criteria		
- Noue		Visual – no signs of compromised capping performance indicated by vegetation health.		
		Visual – no areas of unexpected seepage.		
		Survey verifies that capping placement consistent with design and settlement and/or material loss is within predicted limits and will not compromise final landform drainage via differential settlement.		
		Quality assurance records verify capping constructed and in accordance with design specifications relevant to site risks and target final land use. For example: • Ash Capping depth – 400mm		
		Capping material type as per specification		
		Groundwater and surface monitoring verify capping function e.g. 'store and release' and design performance permeability/seepage.		
		Groundwater and surface water monitoring surface and groundwater quality consistent with predicted quality.		
	Landform Stability: The final landform is stable for the long-term and does not present a risk of environmental harm downstream/downslope of the site or a safety risk to the public/stock/native fauna. Landform that is commensurate with surrounding natural landform and where appropriate, incorporates geomorphic design principles	Visual- minimal erosion that would not require moderate to significant ongoing management and maintenance works.		
		Visual – no signs of land instability such as mass movement.		
		Visual - no areas of active gully erosion. No gullies greater than 20cm depth over transects.		
	F	Visual - no evidence of tunnel erosion.		
		Visual – no evidence of active scour likely to compromise surface water management structure.		
		Survey verifies final landform complies with final landform construction in accordance with Final Landform and Rehabilitation Plan.		



Operational Areas	Objective	Completion criteria
		Survey verifies that settlement and/or material loss is within predicted limits and will not compromise final landform drainage via differential settlement.
		Significant surface water management structures have been constructed in accordance with hydrological design.
	Bushfire:	Bushfire controls implemented.
	The risk of bushfire and impacts to the community, environment and infrastructure has been addressed as part of rehabilitation.	
	Spontaneous Combustion:	No areas show up on thermal scan.
	The risk of spontaneous combustion and impacts on rehabilitated areas has been addressed.	All subsidence cracking repaired by filling or ripping.
	Surface Water: Runoff water quality from mine site is similar to, or better than the pre-disturbance runoff water quality.	Water quality discharged from rehabilitated mining operation meet specifications in Environment Protection Licence.
	Water Approvals: Structures that take or divert water such as final voids, dams etc. are appropriately licensed (e.g. under the <i>Water Management</i> <i>Act 2000</i> ) and where required ensure sufficient licence shares are held in the water source(s) to account for water take.	Water approvals / licences are granted by relevant NSW Government Agency.
	Groundwater Quality: Groundwater quality is similar to, or better than the predicted/modelled Water quality parameters included in environmental a groundwater quality in relevant assessment documents.	Water quality discharged from rehabilitated mining operation meet specifications in environmental assessment and/or Environment Protection Licence.
	Agricultural Revegetation:	Rural land classification system criteria
	Revegetation is sustainable for the long-term and only requires maintenance that is consistent with the intended final land use. Land use capability is capable of supporting the target agricultural land use.	specified in environmental assessments met. Routine soil testing indicates no key deficiencies that could prevent or affect pasture vegetation establishment, health and production.

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Operational Areas	Objective	Completion criteria
		Minimum 70% productive groundcover (live and litter cover.
		Less than 20% of foliage cover of pasture weeds (weeds listed Weedwise, Hunter Region).
		>75%of herbage cover is provided by grasses and legumes suitable for grazing.
		Total herbage mass of pasture areas – >1,500 kg DM/ha pre introduction of cattle for grazing or comparable to reference sites (biomass of desirable pasture species only).



### 12. Stakeholder engagement

A stakeholder engagement plan has been developed for the project, which is attached in Appendix B. The objectives of this plan are to give opportunities for stakeholders to guide rehabilitation activities at the site. The stakeholder engagement plan also will enable AGLM to identify ways to minimise adverse socio-economic effects associated with rehabilitation.

AGLM will update the stakeholder engagement plan at least every three years, and will seek feedback from BCD, Dams Safety NSW, DPE Water, EPA, Heritage NSW, MEG, Subsidence Advisory and Resources Regulator every three years in the preparation of updated versions of this plan. As the site progresses towards closure, detailed consultation will be undertaken with relevant government agencies to inform the closure reporting and preparation process.



### 13. Risks and opportunities

A risk assessment was undertaken in accordance with Form and Way: Rehabilitation Management Plans for Large Mines guideline (NSW Resources Regulator, 2021) during the preparation of the rehabilitation management plan (refer to Appendix D for full bow tie risk assessment). The key risk identified was the failure to relinquish site and successfully rehabilitate the project. The risk assessment identified two critical controls for rehabilitation, being:

- Progressive rehabilitation (annually)
- Environmental monitoring

A further 50 controls were identified, including both existing and potential future controls.

The risk assessment found that financial and environmental risks remained the highest risk consequence with the implementation of controls, followed by regulatory, social licence and reputational impacts.

Opportunities created by the project include reduction of legacy impacts though proper rehabilitation, creation of pasture and improving habitat value of the site.

#### 13.1 Ash Haulage – Traffic Assessment

AGLM has approval to rehabilitate Void 5 by transporting and filling the void with ash from the neighbouring power stations. Ash is currently transported and deposited via pipe infrastructure, and it is proposed to extract ash from the Bayswater Ash Dam and haul by truck to Void 5. In consultation with the Department of Planning, Housing and Infrastructure (DPHI) on future developments in the area and potential additional traffic volumes, and as part of the ongoing review of risk and opportunities required by this Strategy, an assessment has been undertaken to review traffic impacts from the haulage of ash to Void 5 and specifically to identify any impacts on the performance of the Lemington Road/ New England Highway intersection.

AGLM engaged WSP to assess the traffic impacts at the New England Highway and Lemington Road intersection as result of the transport of ash by truck to the Ravensworth Voids. A full copy of this assessment is provided in Appendix E.

Proposed ash haulage will be undertaken between the hours of 7am to 8pm on Monday to Saturday and 8am to 6pm on Sundays. There will be approximately 120 heavy vehicle movements per day (approximately 14 truck movements per hour - 7 in and 7 out) in both directions (in the busiest hour). Ash will be hauled for the duration of the life of the power station (approximately 5-7 years). The assessment concluded that the proposed ash haulage does not result in a substantive reduction in the Lemington Road/New England Highway intersection performance and there will be negligible impacts on network capacity, delays or road safety.

AGLM will continue to monitor and manage the proposed haulage of ash to ensure there are no detrimental impacts on the road network or on the performance of the Lemington Road intersection.



### 14. Reporting and revision

#### 14.1 Reporting

A reporting schedule for the project is presented in Table 14.1.

#### Table 14.1 Reporting schedule

Report type	Frequency	Reference
Rehabilitation report and Forward program	Annually, submitted to Resources Regulator.	Clauses 9 and 13 of Schedule 8A to the <i>Mining Regulation 2016</i>
Incident reporting	Immediately following becoming aware of an incident.	Condition C7 of DA 86/51
Non-compliance reporting	Within seven days of becoming aware of a non-compliance.	Condition C8 of DA 86/51
Independent Environmental Audit	Within one year of approval of Mod 1, and every three years after.	Condition C9 and C10 of DA 86/51

#### 14.2 Revision of this strategy

This strategy will be reviewed at a minimum frequency of three years, or in accordance with the requirements of Condition C5 which requires AGLM to review and, if necessary, revise this strategy within three months of the following circumstances:

- a) the submission of an incident report under condition C7 or C8
- b) the submission of an audit report under condition C9
- c) the approval of any modification to the conditions of this consent, (unless the conditions require otherwise).

Where this review leads to revisions in this Strategy, then within six weeks of the review the revised document will be submitted to the Secretary for approval, unless otherwise agreed with the Secretary.

Operational activities will be subject to regular review to ensure conformance with commitment made in the Environmental Management Strategy (EMS) and subordinate plans and strategies.



### 15. References

AECOM (2016). Ravensworth Mining Operations Plan for Ravensworth Ash Disposal Area (Rehabilitation Management Plan) (MOP). AGL Macquarie – ABN: 18167859494.

Aurecon (2015). Ravensworth Void 5 Ash Emplacement Management Plan (AEMP). AGL Macquarie. Reference – 243776.

Department of Planning and Environment, 2016. Hunter Regional Plan (Hunter Regional Plan).

GHD (2022). Ravensworth Ash Disposal Area Rehabilitation Management Plan.

Jacobs, 2018. Void 5 Water Loss Investigation - Seepage Investigation Report.

Jacobs 2022a, *Ravensworth South Mine – Rehabilitation Amendment Modification Report*. AGL Macquarie Pty Limited. Reference - IS349200.

Jacobs 2020b, Ravensworth South Mine – Rehabilitation Amendment Modification Report Response to Submissions Report. AGL Macquarie Pty Limited. Reference – IA334000.

Kleinfelder, 2022 Ravensworth South Mine -Biodiversity Development Assessment Report.

Landcom, 2004. Managing Urban Stormwater: Soils and construction - Volume 1, 4th edition.

Macquarie Generation, 2012. Ravensworth South - Final Void Rehabilitation Plan.

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### Appendix A – Consultation correspondence

This section will be updated upon the completion of the consultation.



### Appendix B – Stakeholder engagement plan



### Appendix C – Summary of baseline monitoring data



### Summary of baseline monitoring data

Three analogue sites were established in 2017. All sites were established in areas of native pasture communities with a history of active cattle grazing and were located within the buffer lands of the Bayswater Power Station approximately 10 km west of the Ravensworth ash disposal area. The sites were selected to be representative of the pasture condition in the area whilst covering different slopes and aspects.

The data derived from the analogue sites are to be used to provide sensible comparisons to the completion criteria defined for the rehabilitated pastures, and will be used for benchmark targets, particularly in relation to pasture feed quality and potential carrying capacities.

Site name	GPS Coordinates		Final land use	Spontaneous combustion area	Slope	Aspect
	Easting	Northing				
ANA_Past01	306,025	6,409,810	Pasture analogue	N/A	13%	SE
ANA_Past02	305,909	6,410,129	Pasture analogue	N/A	10%	W
ANA_Past03	305,215	6,409,270	Pasture analogue	N/A	7%	SW

Table 1 : Analogue monitoring sites

A total of 24 rehabilitation monitoring sites were established in 2016 which consisted of 14 sites located in areas of pasture rehabilitation (including four sites in areas impacted by spontaneous combustion) and ten sites located in areas of woodland rehabilitation (including four sites in areas impacted by spontaneous combustion).

However, some changes occurred to the monitoring sites between the 2016 and 2017 monitoring events as a function of rehabilitation treatment works and other activities occurring at the site. 2016 and 2017 are considered the baseline surveys for rehabilitation at RSCM.

Table 2 : 2017 Rehabilitation monitoring program	m – Monitoring sites
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Site Name	Geographic Location*		Spon com	Final land	Treatment	Slope	Slope Aspect
			area #		works completed	(70)	Aspect
	315,116	6,411,283	No	Pasture	No	5	N
	315,652	6,411,383	No	Pasture	No	13	NE
	315,021	6,409,874	No	Pasture	No	10	SE
	316,410	6,410,237	No	Pasture	No	9	E

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316,099	6,410,102	Yes	Pasture	No	5	E
316,533	6,409,329	Yes	Pasture	Yes	15	N
316,602	6,408,427	Yes	Pasture	No	7	W
315,734	6,411,052	No	Woodland	No	1	N
315,253	6,410,065	No	Woodland	No	9	SW
316,946	6,408,708	No	Woodland	No	10	E
316,214	6,409,473	Yes	Woodland	No	2	W
316,741	6,409,748	Yes	Woodland	No	6	SSE
316,783	6,409,423	Yes	Woodland	No	6	N
316,063	6,408,441	No	Pasture	No	4	W
316,735	6,407,914	Yes	Pasture	Yes	10	W
316,795	6,406,542	No	Pasture	No	11	S
317,351	6,406,707	No	Pasture	No	8	W
318,114	6,406,820	No	Pasture	No	1	SE
316,848	6,408,098	Yes	Pasture	Yes	5	NW
316,870	6,407,863	No	Woodland	No	1	N
316,873	6,406,757	No	Woodland	No	1	E
317,178	6,406,815	No	Woodland	No	10	E
316,328	6,407,974	Yes	Woodland	Yes	4	W
317,086	6,407,471	No	Woodland	No	4	SE



306,025	6,409,810	N/A	Pasture analogue	N/A	13	SE
305,909	6,410,129	N/A	Pasture analogue	N/A	10	W
305,215	6,409,270	N/A	Pasture analogue	N/A	7	SW

\* Geographic Coordinate System: GDA\_94\_MGA\_Zone\_56

<sup>#</sup> This site was previously studied as 'RAVSTH P3' in 2016 and experienced a change in final land use following rehabilitation works.

Table 3 : 2016 R	Results and Discus	ssion of Rehabilitatio	n Monitoring sites
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Monitoring parameter	Results and Discussion
Woodland sites	
Groundcover	<ul> <li>Ground Cover Distribution:</li> <li>High levels of exposed bare ground at RAVSTH W2 and RAVSTH W4 with 47% and 61.6% of total area.</li> <li>Perennial ground cover was high - achieved the &lt;10% bare ground criteria at remaining monitoring sites.</li> <li>Largely dominated by organic and live grass cover.</li> <li>Small proportion of surface rocks and woody debris accounted total ground cover.</li> <li>RAVSTHW1 had significant amounts of woody debris present.</li> <li>No surface rocks greater than 200mm were present.</li> <li>No significant difference in amount of exposed bare ground present between Sponcom and non-sponcom sites.</li> <li>Ground Cover Species:</li> <li>Diversity ranged from 7 to 19 species</li> <li>High: RAVNo2 W5, RAVSTH W1, and RAVSTH W3 (≥16species)</li> <li>Moderate: RAVNo2 W1, RAVNo2 W3 and RAVSTHW4 (12-14 species)</li> <li>Lowest: RAVNo2 W2, RAVNo2 W4, RAVNo2 W6, RAVSTH W2 and RAVSTH W2 (7-9 species).</li> <li>RAVSTH W1 - exotic species were dominating the biomass.</li> </ul>
	<ul> <li>All other sites - both exotic and native species were recorded as components of the ground layer.</li> </ul>



	<ul> <li>Most common exotic species: naturalised Guinea grass (<i>Megathyrsus maximus</i>), Rhodes grass (<i>Chloris Guyana</i>) and Hairy panic (<i>Panicum effusum</i>) as well as the environmental weeds Galenia (<i>Galenia pubescens</i>) and Paddy's Lucerne (<i>Sida rhombifolia</i>).</li> <li>Common native species : Couch grass (<i>Cynodon dactylon</i>) and Pitted bluegrass (<i>Bothriochloa decipiens</i>).</li> </ul>
Landscape function	<ul> <li>Landscape function</li> <li>Landscape function - efficient at most locations.</li> <li>8/10 have efficient spatial arrangement of patches and run on zones (i.e. perennial ground cover).</li> <li>RAVSTH W2 and RAVSTH W4 showed poor and sparse ground cover with resources readily lost from due to runoff events.</li> <li>Soil surface stability was high at those same eight sites with stability index scores around or above 60%.</li> <li>Soil infiltration index scores ranged from 24.2% to 43.3%</li> </ul>
Slope	Gentle and comprised between 1-11%.
Woody Vegetation	<ul> <li>Species Diversity</li> <li>Overall, relatively low diversity, with between 2 and 9 species recorded (and only four sites with more than 5 species).</li> <li>RAVNo2 W4 and RAVNo2 W6 showed particularly poor diversity with a total of only two and three woody species recorded, respectively.</li> <li>Species composition was generally dominated by over-storey local native species, with the most commonly occurring species consisting of <i>Acacia salicina</i> (Sally wattle), <i>Casuarina cristata</i> (Belah), <i>Corymbia maculata</i> (Spotted gum), <i>Eucalyptus crebra</i> (Narrow-leaved ironbark), <i>E. moluccana x albens</i> (Grey/white box) and <i>E. tereticornis</i> (Forest red gum).</li> <li>Stem Densities</li> <li>Ranged from 140 stems/ha (RAVNo2 W6) to 3,060 stems/ha (RAVSTH W1).</li> <li>Completion criteria of 400 stems/ha by year 10 was not achieved at RAVNo2 W2 (260 stems/ha), RAVNo2 W5 (360 stems/ha) and RAVNo2 W6 (140 stems/ha), but achieved at all other sites.</li> <li>At several locations the total stem densities were declining as a result of tree dieback, with several dead standing (or fallen) trees recorded.</li> <li>Three sites (RAVSTH W1, RAVSTH W2 and RAVSTH W4) achieved high densities of woody plants (~3,000 stems/ha).</li> <li>Vegetation Stratification</li> <li>Good vegetation stratification with individuals recorded in several height strata.</li> <li>Natural recruitment</li> </ul>



	<ul> <li>Natural recruitment was observed at all sites except at RAVNo2 W1 and RAVNo2</li> </ul>						
	W2.						
	<ul> <li>BAVSTH W1 · five or more species with many young eucalypt saplings present</li> </ul>						
	Other sites: one or two species showed signs of recruitment, consisting Acacia						
	salicina and/or Casuarina cristata.						
	Foliage Protective Cover						
	Protective cover : Generally high for most monitoring locations and comprised						
	between ~38% and 82% (total cover).						
	RAVNo2 W6 and RAVSTH W4 recorded lower foliage canopy with ~12-15% cove						
	Vegetation Health Condition						
	Five monitoring sites indicated good to						
	excellent health condition.						
	Other five sites showed a moderate to good health condition.						
	Sponcom sites showed an average health condition score slightly lower than those						
	non-sponcom sites						
Habitat Complexity	<ul> <li>Habitat complexity scores: low (≤5) to moderate (≤7) at all sites.</li> </ul>						
Habitat Complexity	Sponcom showed poorer habitat complexity.						
	Habitat complexity was provided in the way of ground herbage, leaf litter and tree						
	cover / canopy.						
	• Lack of suitable habitat features for ground dwelling fauna (i.e. rock structures, logs,						
	water features/ponds, mulch layer etc.) and arboreal fauna (hollows, nest boxes,						
	etc.).						
	Erosion issues were not a major concern across the site, most areas appeared						
Disturbance	stable during monitoring.						
	Good stability was observed (due to gentle landform and good ground cover and						
	tree density).						
	Weed incursion represented an issue at most monitoring locations:						
	Mederate: DAV(Ne2 W/1, DAV(Ne2 W/2, DAV(Ne2 W/2 and DAV(Ne2 W/5 (16 200)						
	weed cover),						
	High: RAVNo2 W6 (30-50% weed cover)						
	Severe: RAVNo2 W4 (>50% weed cover)						
	Meet eksemied woode. Associa selienes Driskkumsen Dadabis kusema Ostavis as k						
	• Most observed weeds: Acacia saligna, Prickly pear, Paddy's Lucerne, Galenia and						
	Beggar s Tick (Bidens pilosa).						
	Listed noxious weeds recorded: <i>Opuntia</i> species (Prickly pear and/or Liger pear)						
	and Senecio madagascarensis (Fireweed).						
Growing Media	Topsoil Cover:						
	Uneven across sites (range : no topsoil - 150mm of topsoil).						
	Where present, topsoil was silty or loamy light clays, with varying amounts or						
	carbonaceous material and ash.						



	<ul> <li>RAVNo2 W3, RAVNo2 W5, RAVNo2 W6, and RAVSTH W3 have at least a 100mm deep layer of topsoil (or organic substitute).</li> <li>Topsoil layer was altogether absent at RAVSTH W1 and RAVSTH W4, where vegetation grew directly on overburden.</li> <li>Thin layer of topsoil was present (4-8cm) at RAVNo2 W1, RAVNo2 W2, RAVNo2 W4 and RAVSTH W2</li> <li>Soil Analyses Results</li> <li>Soil pH: Ranged from slightly acidic (5.6 at RAVNo2 W6) to slightly alkaline (8.48 at RAVNo2 W3)</li> <li>Salinity: Low at all sites except at RAVNo2 W3, RAvNo2 W5 and RAVNo2 W6 but won't impact plant growth</li> <li>Cation exchange capacity: Moderate to High (comprised within 12-31meq/100g) and achieving completion criteria 7/10 monitoring sites.</li> <li>Organic Matter Levels: High at all sites, despite not meeting the completion criterion of 4.5% (it is noted that the value is particularly high, as 2-3% are accepted as adequate).</li> </ul>
Pasture Sites	
Slope	<ul> <li>Ranged from flats or very gentle incline (1-5%) to moderate inclines (15%).</li> <li>All rehabilitated slopes were &lt;18% and the consistent with land capability class definitions.</li> </ul>
Landscape Function	<ul> <li>High level of perennial protective ground cover - all pasture sites returned good to excellent LOI scores.</li> <li>Higher scores were driven by a greater coverage of perennial grass cover and litter.</li> </ul>
Ground Cover	<ul> <li>Ground Cover Distribution</li> <li>Total ground cover protection was excellent at all sites with &gt;90%.</li> <li>Completion criterion of &gt;70% vegetation cover was achieved at all sites.</li> <li>Ground cover consisted of live grasses (or weeds) and litter occurring in varying proportions</li> <li>Most sites recorded a moderate to high occurrence of litter cover (ranging from ~20% to ~50%).</li> <li>Ground Cover Species</li> <li>Total species diversity range was from 4 to 19 species (highly desirable). The diversity of desirable pasture species.</li> <li>10 out of the 14 sites have at least 5 species suited to the district.</li> <li>Leguminous species were generally absent (or occurring in very low cover / densities) from the pasture composition at most sites.</li> </ul>



Biomass	<ul> <li>Pasture biomass was highly variable across sites.</li> <li>Green biomass ranged from ~750 kg/ha to &gt;17,000 kg/ha.</li> <li>Pasture yields achieved the relevant completion criterion of 2,500kg DM/ha at six of the monitoring sites with RAVSTH P5 returning the highest yield (~5,100kg DM/ha).</li> </ul>						
Feed Quality and Potential Carrying Capacity	<ul> <li>Feed quality was relatively consistent across all monitoring sites.</li> <li>Digestibility of the dry matter (DMD) was between 45-62% at all sites.</li> <li>Crude Protein (CP) more variable amongst monitoring sites with values ranging from 2.6 to 11.9%. Only one site (RAVSTH P7) returned a CP &lt;2%.</li> <li>Metabolizable energy (ME) was above 6.0MJ/kg DM, with results between 6.2-9.0 MJ/kg DM.</li> <li>Rehabilitated pasture sites could support between 0.5 and 13.3 animals per hectare (dry stock) over a period of a month.</li> </ul>						
Grass Tetany	<ul> <li>Nitrogen and Potassium levels were at concentrations not associated with promoting grass tetany.</li> <li>Sulphur levels were low and potentially concerning (in relation to the risk for grass tetany) at RAVNo2</li> <li>P5, RAVNo2 P6 and RAVNo2 P7, but adequate at RAVSTH P7).</li> <li>Magnesium and Calcium levels were low and potentially concerning (in relation to the risk for grass tetany) at RAVNo2 P6, RAVNo2 P7, and RAVSTH P7, but adequate at RAVSTH P7, but adequate at RAVNo2 P5.</li> <li>Danger of grass tetany is present at RAVSTH P7</li> <li>Should cattle grazing be considered within the area containing RAVSTH.</li> </ul>						
Disturbance	<ul> <li>Erosion was a concern at RAVSTH P6 due to large subsidence cracks were present.</li> <li>Severe weed infestations (i.e. exceeding the acceptable completion criteria) were observed at the following sites: <ul> <li>Moderate: RAVNo2 P7 (16-30% weed cover)</li> <li>High: RAVSTH P6 (30-50% weed cover)</li> <li>Severe: RAVNo2 P1 and RAVNo2 P3 - (&gt; 50% weed cover</li> </ul> </li> <li>Listed noxious weeds recorded: <i>Opuntia</i> (pear) species and Fireweed</li> </ul>						
Growing Media	<ul> <li>Topsoil cover</li> <li>Soil profiles varied greatly amongst the monitoring sites.</li> <li>RAVSTH P6 &amp; RAVSTH P1: deep layer (300mm+) of sandy loam topsoil.</li> <li>Relevant completion criteria of ≥100mm of topsoil (or substitute) was not achieved at RAVNo2 P2, RAVNo2 P5, RAVNo2 P6 and RAVNo2 P7 (only 40m and 80mm of topsoil was present).</li> <li>Topsoil cover was adequate at the remaining eight sites (comprised between 100-200mm). At these sites the topsoil.</li> <li>Soil Analyses Results</li> </ul>						



• Soil pH: was within the 5.5-7.5 at all sites except at four sites where it was marginally exceeded. Deemed adequate for pasture species establishment and growth.
<ul> <li>Salinity: Was generally satisfactory except at RAVNo2 P7 and RAVSTH P7 where high readings indicate salinity issues of spontaneous combustion.</li> </ul>
<ul> <li>Cation Exchange Capacity: Moderate to High (comprised within 14-26meq/100g) and relevant completion criteria was achieved only at six of the 14 monitoring sites. Low (7.5-12meq/100g) at other sites.</li> <li>Organic Matter: Generally acceptable. Fertility was generally adequate at six of the 14 sites.</li> </ul>

Table 4 : 2017 Results and Discussion of Rehabilitation Monitoring sites

Monitoring parameter	Results and Discussion					
Woodland sites						
Groundcover	<ul> <li>2017 results showed overall stability compared to 2016. Protective ground cover remained excellent at &gt;90% at nine of the eleven sites.</li> <li>Completion criterion of 70% was not achieved only at two sites where high levels of bare ground remained (RAVSTH W2 and RAVSTH W4).</li> <li>Ground cover was typically dominated by deposited leaf litter.</li> </ul>					
Landscape function and Soils	<ul> <li>Landscape Organisation Index (LOI) - excellent at most locations.</li> <li>Unsatisfactory LOI and poor ground cover was observed at two sites.</li> </ul>					
Floristics	• Ground cover species diversity was comprised between 5-16 species, with moderately high diversity (>15 species) at four sites, moderate diversity (10-15 species) at two sites and moderately low diversity (5-10 species) at five sites.					
Community structure, health and resilience	<ul> <li>Plant Densities: Ranged from 120 stems/ha to 2,100 stems/ha (Figure 15). MOP completion criteria of 400 stems/ha was achieved at eight of the eleven woodland sites.</li> <li>Habitat complexity: Four sites recorded moderate levels of habitat complexity, five sites high levels of complexity and two sites very high levels of complexity.</li> <li>A lack of suitable habitat features for ground dwelling fauna and arboreal fauna was observed.</li> <li>Observed improvement in complexity scores at the sites was attributed to spontaneous combustion and an increase in ground herbage.</li> <li>Vegetation Health: Seven monitoring sites</li> </ul>					



	<ul> <li>showed good to excellent tree health, whilst four sites showed an average to good tree health condition.</li> <li>Natural regeneration: Natural recruitment) was identified at all but one monitoring site (RAVNo2 W2). However, RAVSTH W1 met the relevant MOP completion criterion with recruitment evidenced for more than five species</li> </ul>					
Erosion	Excellent soil and slope stability were recorded across most locations due to high protective ground cover and the generally gentle slope gradients					
Weeds & Vertebrate pests	<ul> <li>Weed prevalence was generally limited. Weed cover was moderate at three sites (15-25%) and high (25-50%) at one site</li> <li>Key weed species observed: <i>Hyparrhenia hirta</i> (Coolatai grass), <i>Galenia pubescens</i> (Galenia)</li> <li>and <i>Opuntia spp.</i> (Prickly pear cactus) and <i>Acacia saligna</i>.</li> <li>Rabbits were sighted but no negative impact on vegetation and growth was observed</li> </ul>					
Soil	<ul> <li>Topsoil Cover: Generally low and ranged from 50-120mm at untreated areas, with an average for all sites of ~90mm which is lower than the MOP completion criterion of 100mm.</li> <li>Soil pH: Ranged from moderately acidic (pH of 5.5-6.5 at four sites) to slightly alkaline (pH&gt;7.2 at three sites). All were within the completion criteria and within the ideal pH range for plant establishment and growth.</li> <li>Soil Salinity: Levels at the untreated sites were low and generally below the completion criteria of 0.15dS/m, recorded as non-saline and with negligible effects on plant establishment and Growth. Soil salinity was overall not an issue across the site.</li> <li>Soil Sodicity: 10 of 11 samples returned exchangeable sodium percentage (ESP) levels defined as non-sodic (i.e. &lt;5%)</li> <li>Cation exchange capacity: Rehabilitated woodland sites demonstrated moderate to high CEC levels which accounts to average to good soil structural condition and decent capacity to retain and absorb water and nutrients.</li> <li>Nutrient levels: Non-treated woodland sites showed low, poor soil fertility except at the treated RAVSTH W5 which showed very high soil fertility.</li> <li>Organic Carbon: Most samples returned high to very high levels of OC (with the exception of RAVSTH W2 which showed very low levels), demonstrating good soil structural condition and stability.</li> </ul>					
Pasture Sites						
Ground cover	<ul> <li>Excellent ground cover protection was achieved at all pasture rehabilitation sites and comprised between 85-100%, i.e. well exceeding the relevant MOP completion criterion of 70% cover.</li> <li>Ground cover performance at the rehabilitation sites was very comparable to that recorded at the analogue sites.</li> </ul>					
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Londonno Frantina	• the LOI scores remained satisfactory at all and consistently achieved the relevant
Landscape Function	<ul> <li>completion criterion.</li> <li>Landscape function performance at the rehabilitated sites compared very positively against that recorded at the analogue sites.</li> </ul>
Floristics	<ul> <li>Desirable species diversity was low to moderate across the rehabilitated sites and comprised between 1-9 species, with an average of ~5.5 desirable species per site. This was above the relevant MOP completion criterion of 5 desirable species. In contrast, native pastures at the analogue sites contained between 13 and 17 desirable species for an average of ~15.7 species per site</li> <li>Moderate to high diversity of weeds occurred in most rehabilitated pastures, their abundance cover was generally limited at 10 of the 13 monitoring sites</li> <li>Three sites are dominated by weeds:</li> </ul>
	<ul> <li>RAVNo2 P3: consistently with 2016, this site sustained a severe infestation of Galenia.</li> <li>RAVSTH P1: experienced a marked decrease in desirable species cover in 2017 due to further encroachment of Coolatai grass in the area.</li> <li>RAVSTH P7: following the treatment works at this site, annual broadleaf weeds and Galenia had established in the area.</li> </ul>
	<ul> <li>Rehabilitated pastures tended to be largely dominated by introduced grasses. This contrasted with the pasture composition observed at the analogue sites where species assemblages were dominated by native grasses</li> <li>Leguminous species were lacking or only occurring at very low diversity and abundance, which is likely to greatly limit overall pasture productivity</li> </ul>
Pasture performance	<ul> <li>Herbage biomass (i.e. amount of feed available to cattle) was typically low in 2017 and the relevant MOP completion criterion (i.e. 2,500 kg DM/ha) was only achieved at RAVSTH P5. All sites recorded a decreased herbage biomass from the 2016 results.</li> <li>Average pasture yield recorded for the rehabilitated pastures in 2017 (~900kg DM/ha) exceeded the yields recorded at the analogue sites (~400 kg DM/ha average).</li> <li>Satisfactory quality of the feed was present at all rehabilitated pastures, and the associated MOP completion criteria (i.e. for DMD, CP and ME) were consistently achieved.</li> <li>Rehabilitated pastures could support between ~0.3 and 10.6 animals per hectare for a dry stock enterprise (average ~3.43 animals/ha), which is well above the average stocking rates calculated for the analogue sites and can be defined as a satisfactory performance.</li> </ul>
Grass tetany	• The 2017 results indicated that the danger of grass tetany was present at RAVNo2 P6 (where treatment works were implemented) as a function of the combined high levels of potassium and low levels of calcium but absent at the other three monitoring sites.



	• Monitoring results from both 2016 and 2017 indicate that the risk of grass tetany exist from forage growing in areas impacted by spontaneous combustion (both treated and non-treated)
Erosion	<ul> <li>Excellent soil and slope stability were recorded across most monitoring locations and were achieved as a function of the high protective ground cover and the generally gentle slope gradients</li> <li>Erosion concerns were recorded was at RAVSTH P6 where large subsidence cracks were present</li> </ul>
Weeds & Vertebrate pests	<ul> <li>Weed incursion and prevalence remained a key issue at the site with several areas supporting moderate to extremely severe infestations.</li> <li>7 of the 13 pasture monitoring sites supported weed infestations of &gt;15% cover (i.e. exceeding the associated MOP completion criterion).</li> <li>Key weed species recorded: Galenia, Prickly pear and Coolatai grass.</li> <li>Rabbits were sighted at the sites however no negative impact on vegetation establishment and growth was recorded.</li> <li>Moderate to severe grazing impact from kangaroos occurred, particularly in areas impacted by spontaneous combustion.</li> </ul>
Soils	<ul> <li>Soil Cover: Ranged from 50mm to 400mm, with an average soil cover of ~200mm which is double the required MOP completion criterion.</li> <li>Soil cover was unsatisfactory (i.e. &lt;100mm) at three monitoring sites but satisfactory at all other sites.</li> <li>Treated areas showed an excellent soil profile consisting of three superimposed layers of topsoil, biosolids and garden organics (respectively), for a total soil profile depth of 250-400mm.</li> <li>Soil Acidity: Ranged from moderately acidic (pH of 5.0-5.5 at five sites) to slightly alkaline (pH&gt;7.2 at one sites). All sites were within the MOP completion criteria. Soils at the pasture analogue sites were moderately to slightly acidic (pH - 4.0 to 5.7).</li> <li>Soil Salinity: Sites in untreated areas returned salinity levels well below the relevant MOP completion criterion of 0.15dS/m which was comparable to levels recorded at the analogue sites.</li> <li>Results for the treated sites clearly demonstrated higher EC levels associated with the improved growing medium.</li> <li>EC levels are defined as being non-saline with negligible effects on plant establishment and growth.</li> <li>Soil Sodicity: was an issue across the pasture sites</li> </ul>



<ul> <li>Cation exchange capacity: Moderate to high CEC levels comparable to those obtained at the analogue sites.</li> </ul>
<ul> <li>Highlights an average to good soil structural condition and ability to retain water and nutrients.</li> </ul>
• Nutrient levels: Levels at the treated sites were consistently high, demonstrating the positive effect of the improved growing medium on soil fertility.
<ul><li>Levels were consistently low in untreated areas.</li><li>Nutrient levels at the analogue sites were also very low.</li></ul>
Organic carbon: Levels were moderate to very high at all monitoring sites.



### Appendix D – Bow Tie Risk Assessment

#### **Document status**

Status	Revision	Author	Reviewer		Approved for issue		
Code			Name	Signature	Name	Signature	Date
S4	0	E Luscombe	S Murphy		M Kiejda		18/10/23
			0.14		0.14		
	1	M Kiejda	SMurphy		SMurphy		

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Ravensworth South Modification Rehabilitation Strategy

